(5) July 21st; 10. 47. 40 p.m.
(6) Aug. 15th; 4. 42. 50 a.m.
(7) „ 20th; 3. 38. 59 „
(8) Aug. 29th; 8. 35. 53 p.m.
(9) Sept. 9th; 11. 49. 21 a.m. and 11. 49. 59 a.m.

(iii) *Small Eruptions in* 1912:—

(1) July 1st; 5. 33. 50 p.m.
(2) „ 2nd; 5. 30. 07 a.m.
(3) Aug. 3rd; 7. 20. 58 p.m.
(4) „ „; 7. 51. 03 „
(5) Aug. 7th; 8. 14. 48 a.m.
(6) „ „; 9. 43. 13 „
(7) „ 22nd; 5. 25. 50 „
(8) „ 23rd; 3. 14. 01 p.m.

The tromometer observations in Tokyo of the Asama-yama eruptions are considered in a later Chapter.

CHAPTER IV. ASAMA-YAMA EXPLOSIONS OBSERVED AT ASAMA PASTURE GROUND.**
[TREMOR-RECORDER DIAGRAMS]

34. *Explosion of Sept. 21st, 1913, at 1. 50. 59 p.m.* According to the report of Mr. Kawazoe, who witnessed the eruption from Yuno-taira, the detonation was like that of blast of a boisterous wind and lasted 3 or 4 sec. According to Mr. T. Kato, who saw the eruption from the foot of the Ko-Asama the detonation was very loud and like that of a gun discharge; the column of black smokes, which rose vertically high up, being gradually carried towards the NE. Several lava blocks fell to the E and N slopes of the Asama-yama, continuing to throw up vapours for some time. At the Wakasare Cottage there were precipitated platy lava fragments 2 cm in dimension, and at the Asama Pasture Ground those of the size of peas.

Total Duration=4 min. (Fig. 51.)

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* Also registered at the Asama Pasture Ground.

** The times of occurrence of the explosions on Oct. 7th and Nov. 14th were registered by the tremor-recorder at the Asama Pasture Ground, while those of the 4 others considered in this chapter are the results determined by a similar instrument at Ashino-taira.

Longitudinal component. [Preliminary and principal portions: duration=35.5 sec.] The commencement was perfectly sharp, and the preliminary motion, 0.61 sec. in duration, was directed outwards and was very small, its amount being only 0.0018 mm. The "initial vibration" of T=1.8 sec., was composed of the 1st, or outward, displacement of 0.035 mm (duration=0.66 sec.), and of the 2nd, or inward, displacement of 0.043 mm (duration=1.12 sec.). The latter and the next small vibration may be regarded as together forming a slow motion of 1.84 sec. in duration. Then followed two well-defined large displacements of 2a=0.122 and 0.118 mm respectively, making up the maximum vibration of T=2.56 sec. The next displacement (duration=1.1 sec.) was 0.051 mm in range. So far, during the first 6.9 sec. of the earthquake, the motion was gentle and practically free from the superposition of minute movements. For the next 28.6 sec., the motion was made up of quick vibrations of T=0.25 sec., and of max. 2a=0.031 mm, mixed more or less distinctly with those of T=0.70 sec. and of max. 2a=0.02 mm. During this interval, the pointer of the instrument was thrown into slow movements of T=4.4 sec. (max range=0.035 mm), due to the proper oscillation of the pendulum mass. [Sound Shock]. 17.3 sec. after the earthquake commencement, or 16.1 sec. from the end of the 1st displacement of the "initial vibration," there occurred quite abruptly sharp vibrations, which began with the maximum motion of 0.047 mm and lasted about 2.5 sec. These were evidently due to the arrival of the "sound shock," or the volcanic detonation. [End portion.] The motion was composed of the vibrations of T=0.96 sec. (max. 2a=0.015 mm), mixed with some slower movements, but free from the superposition of quick vibrations.

Transverse Component. [Preliminary and principal portions:

duration=29.2 sec.] For the 1st 2.3 sec., there was practically no motion. Then took place a displacement of 0.0087 mm toward the NW, and there were during the next 11.6 sec., 9 vibrations of T=1.3 sec., grouped into those of double period; the greatest motion (absolute maximum) of 0.058 mm occurring 11.1 sec. after the earthquake commencement. So far, the vibrations were simple and almost entirely free from the superposition of quick movements. The latter began to appear from 13.6 sec. after the earthquake commencement; the motion consisting, for the remaining 15.4 sec., of the vibrations of T=0.29 sec. (max. 2a=0.028 mm), mixed with the slower ones of T=1.0 sec., max. 2a=0.030 mm. [End portion.] The motion consisted principally of vibrations of T=1.03 sec., max. 2a=0.023 mm. [Sound Shock.] The quick vibration of 2a=0.049 mm due to the sound shock occurred 17.2 sec. after the earthquake commencement, simultaneously with the corresponding movement in the longitudinal component.

Comparison of Longitudinal and Transverse Diagrams. The 1st well defined motion in the transverse component occurred 1.7 sec. later than the 1st displacement of the "initial vibration" in the longitudinal component. Again the absolute maximum motion in the transverse component, which was accompanied by no special maximum phase in the longitudinal component, occurred 8.0 sec. later than the large slow vibration in the latter. The times of appearance of the conspicuous quick vibrations in the two directions were separated also by nearly an equal interval, namely, 7.0 sec. The average period of the large vibrations in the earlier part of the transverse component was 1.3 sec., which is equal to half of the period of the maximum motion in the longitudinal component, namely, 2.6 sec. The movements of T=1.0 sec. and the quick vibrations of T=$\frac{1}{4}$ sec. (approx.) existed in both components.

The "initial vibration" was entirely in the longitudinal component, i.e., the inward and the outward displacements directly due to the explosion moved in the line joining the observing place with the crater centre. The large (absolute maximum) slow oscillation of $2a=0.122$ mm, which occurred only 2.4 sec. after the "initial vibration," was also purely longitudinal, being mixed only with two small vibrations of $2a=0.009$ mm in the transverse direction.

35. *Explosion of Oct. 7th, 1913, at 11. 32. 32 a.m.* * This was a comparatively small explosion. At Ashino-taira, the building was glightly shaken, followed by a rushing sound. At the Asama Pasture Ground, noises continued to be heard for about 25 sec. after the explosion.

Total Duration $=2^m\ 10^s$. The explosion was small.

Longitudinal Component. The motion was made up principally of slow vibrations of $T=1.0$ sec., max. $2a=0.0072$ mm, mixed with those of $T=0.61$ sec., there being practically no superposition of quick movements.

Transverse Component. The vibrations were regular: $T=1.05$ sec., max. $2a=0.0093$ mm.

36. *Explosion of Oct. 15th, 1913, at 10. 43. 13 p.m.* ** At Ashino-taira, a detonation like that of a gun discharge was heard. At the Asama Pasture Ground the detonation was very loud.

Total Duration $=2^m\ 20^s$.

Transverse Component. (Fig. 47.) The preliminary portion was very small and lasted 0.62 sec. Then there took place a slow vibration of $T=1.6$ sec., whose 1st and 2nd displacements were 0.0063 and 0.0128 mm respectively. For the next 4.5 sec.,

* Time at Ashino-taira.

** Time at Ashino-taira.

there were 5 regular vibrations of T=0.89 sec., of which the 3rd one had the max. 2a of 0.0218 mm. For the next 3.4 sec., the motion was slightly smaller and irregular: T=0.48 sec., max. 2a 0.0088 mm. So far, for the 1st 10.1 sec., the movements were comparatively small. During the next 9.5 sec., the motion was most active and composed of 9 large well defined vibrations of T=1.05 sec., the last but one of which had the absolutely greatest 2a of 0.068 mm. It was just immediately after the commencement of this maximum movement, that the effect of the sound shock (Fig. 47) was indicated in a perfectly definite manner. Thus the detonation arrived at the Asama Pasture Ground 17.5 sec. later than the commencement of the earthquake motion. For the next 13.7 sec., the motion was much smaller and composed principally of the vibrations of T=0.93 sec., max. 2a=0.0244 mm; there being during the 1st 3.3 sec. a superposition of the quick movements caused by the detonation. For the next 12.4 sec., the motion again decreased, and consisted of 15 regular vibrations of T=0.83 sec., max. 2a=0.0091 mm. The subsequent motion was very small.

Longitudinal Component. The record is unfortunately imperfect, as, at the time of the explosion, the writing stile remained suspended up and was not recording on the smoked paper, being first caused to drop down on the latter by the sound shock. The quick movements due to the latter appeared then for about 5.6 sec: T=0.22 sec., max. 2 a=0.0315 mm. The period of the slower vibrations, which occurred throughout the rest of the motion, was 1.02 sec.

37. *Explosion of Oct. 17th, 1913, at 3. 27. 47 p.m.* At Ashino-taira, the detonation was feeble and much less intense than that on the 15th; the amplitude of the earthquake vibration

being, however, greater on the present occasion. At the Asama Pasture Ground, the detonation was very loud and of a long duration, and was followed for some time by rushing noises. The smokes were carried by S. winds past over the last named place, where, however, there was no precipitation of ashes.

Total Duration$=1^m\ 50^s$.

Longitudinal Component. [Preliminary and principal portions: duration=36 sec.] The earthquake began with an inward displacement of 0.0062 mm and of duration=1.27 sec., the preliminary outward motion being small and consequently not separately indicated. The 2nd and outward displacement was 0.0206 mm (duration=1.26 sec.), forming together with the preceding the "initial vibration" of T=2.54 sec. Again, the 2nd displacement and the next small vibration may be regarded as together forming a slow movement of 2a=0.0312 mm and of duration=1.76 sec. There followed two nearly equal well defined displacements forming a vibration of T=2.4 sec., 2a=0.087 mm. Then took place a slow inward displacement of 0.062 mm (duration=2.1 sec.), mixed with smaller movements. For the next 5.3 sec., there were two slow vibrations of T=2.65 sec., the 1st of which had the absolutely maximum 2a of 0.112 mm, and which were mixed amongst the others with quick movements of T=0.36 sec.; these latter becoming prominent from about 10.3 sec. after the earthquake commencement. During the next 10.6 sec., there were 15 well defined regular vibrations of T=0.71 sec., of which the 1st had the 2a of 0.0644 mm, and the 6th the max. 2a of 0.0717 mm, on account of the superposition of the effect of the detonation wave; this latter having appeared 17.2 sec. after the earthquake commencement, or 16.0 sec. after the end of the 1st displacement of the "initial vibration." During the remaining 11.3 sec., the

motion was less, being composed of $14\frac{1}{2}$ vibrations of T=0.78 sec., 2a=0.0312 mm, mixed with some quick movements. [End portion.] Motion was very much smaller.

Transverse Component. [Preliminary and principal portions: duration=27.3 sec.] The motion, whose commencement was clearly marked, was very small during the 1st 1.36 sec. Then took place a movement of 0.0079 mm (duration=0.64 sec.), toward NNW, followed by a vibration of T=2.53 sec. composed of the two displacements respectively of 0.0352 and 0.0692 mm. The next 4.4 sec. was made up of a single slow vibration mixed with smaller ones of T=0.50 sec. (2a=0.013 mm); the superposed quick movements beginning to appear at the end of this interval, namely, from about 8.8 sec. after the earthquake commencement. Then took place a large vibration of T=2.48 sec., and of 2a=0.106 mm, mixed with smaller ones. For the remaining 18.4 sec., the motion was most active and was composed of well defined vibrations of T=1.03 sec., max. 2a=0.0715 mm, and of T=0.79 sec., max. 2a=0.0664 mm. [End portion.] During the 1st 14.1 sec., the motion was small: T=1.1 sec., 2a=0.012 mm, and of T=0.7 sec., max. 2a=0.0173 mm. The subsequent motion was very small. [Sound Shock.] The effect due to the sound shock occurred 17.0 sec. after the earthquake commencement.

Comparison of Longitudinal and Transverse Components. The 1st or inward displacement of the "initial vibration" (resultant 2a=0.0062 mm) was entirely longitudinal, while the 2nd, or outward, displacement (resultant 2a=0.021 mm) deviated about 22° from the radial direction. The slow period large (absolute maximum) displacement of 0.106 mm in the transverse component took place 1.05 sec. later than the corresponding dis-

placement of 0.112 mm in the longitudinal. In the subsequent portion, there was no great difference in the amplitude of motion between the two components.

38. *Explosion of Oct. 22nd, 1913, at 3. 55. 42 a.m.* A small explosion, which caused the precipitation of sands at the Asama Pasture Ground for about 10 minutes.

Total duration=2^m 0^s. The commencement was slightly indistinct.

Longitudinal Component. [Preliminary and principal portions: duration=26.9 sec.] The diagram is, on the whole, similar almost vibration for vibration to that of the explosion on Oct. 17th. In the present case, however, the motion was much smaller, and began with the preliminary portion of 1.6 sec. duration, followed by an inward displacement of 0.0018 mm (duration=1.44 sec.), and the outward one of 0.0099 mm (duration=1.69 sec.); the two forming a slow vibration of T=3.1 sec., corresponding to the "initial vibration." The next vibration, of T=2.2 sec., was composed of the two displacements respectively of 0.0176 and 0.0422 mm; quick superposed movements of 2a=0.0154 mm appearing from about 4.4 sec. after the earthquake commencement. For the remaining 20.0 sec., the motion was active and consisted of the well defined vibrations of T=0.80 sec., of which the 2nd had the absolutely maximum 2a of 0.073 mm; the max. 2a of the superposed quick movements (T=0.27 sec.) being 0.0277 mm. [End portion.] The motion was small, being composed of the vibrations of T=1.4 sec. (2a=0.0107 mm), T=0.74 sec. (2a=0.012 mm), etc. The sound effect was indicated somewhat doubtfully 16.5 sec. after the end of the 1st displacement of the "initial vibration."

Transverse Component. [Preliminary and principal portions:

duration=24.5 sec.] The motion was practically *nil* during the 1st 2.5 sec. Then took place a vibration of T=2.0 sec., composed of the two displacements of 0.0036 and 0.010 mm respectively toward NNW and SSE. For the next 6.6 sec., there were $2\frac{1}{2}$ slow vibrations of T=2.6 sec., of which the 2nd had the max. 2a of 0.078 mm; there being superpositions of quicker movements of T=0.81 sec. (2a=0.035 mm), and some smaller ones. For the next 13.4 sec., the motion consisted of $14\frac{1}{2}$ regular vibrations of T=0.92 sec., of which the 2nd had the max. 2a of 0.049 mm. The subsequent motion was much smaller: T=1.1 sec., 2a=0.015 mm.

Comparison of Longitudinal and Transverse Components. The 1st, or inward, displacement of the "initial vibration" was entirely longitudinal. The absolute maximum 2a of 0.078 mm in the transverse component occurred 8.6 sec. after the earthquake commencement, or about 0.7 sec. after the corresponding motion of 0.073 mm in the other. The regular vibrations in the transverse component between 11.2 and 23.5 sec. after the commencement were on the whole distinctly larger than the movements in the corresponding interval in the longitudinal; although the quick superposed movements, which were markedly shown in the latter, were practically *nil* in the former component.

39. *Explosion of Nov. 14th, 1913, at 11. 11. 55 a.m.* At the Asama Pasture Ground, the detonation was very loud and like a thunder peal, followed by rushing noises for about 3 minutes. (See Fig. 9.)

Total Duration=3 min. (Fig. 49.)

Longitudinal Component. [Preliminary and principal portions: duration=22.3 sec.] The motion was very slight during the 1st 1.9 sec., after which a small outward displacement of 0.0057 mm

Fig. 47. Asama-yama Explosion of Oct. 15th, 1913, observed at Asama Pasture Ground.

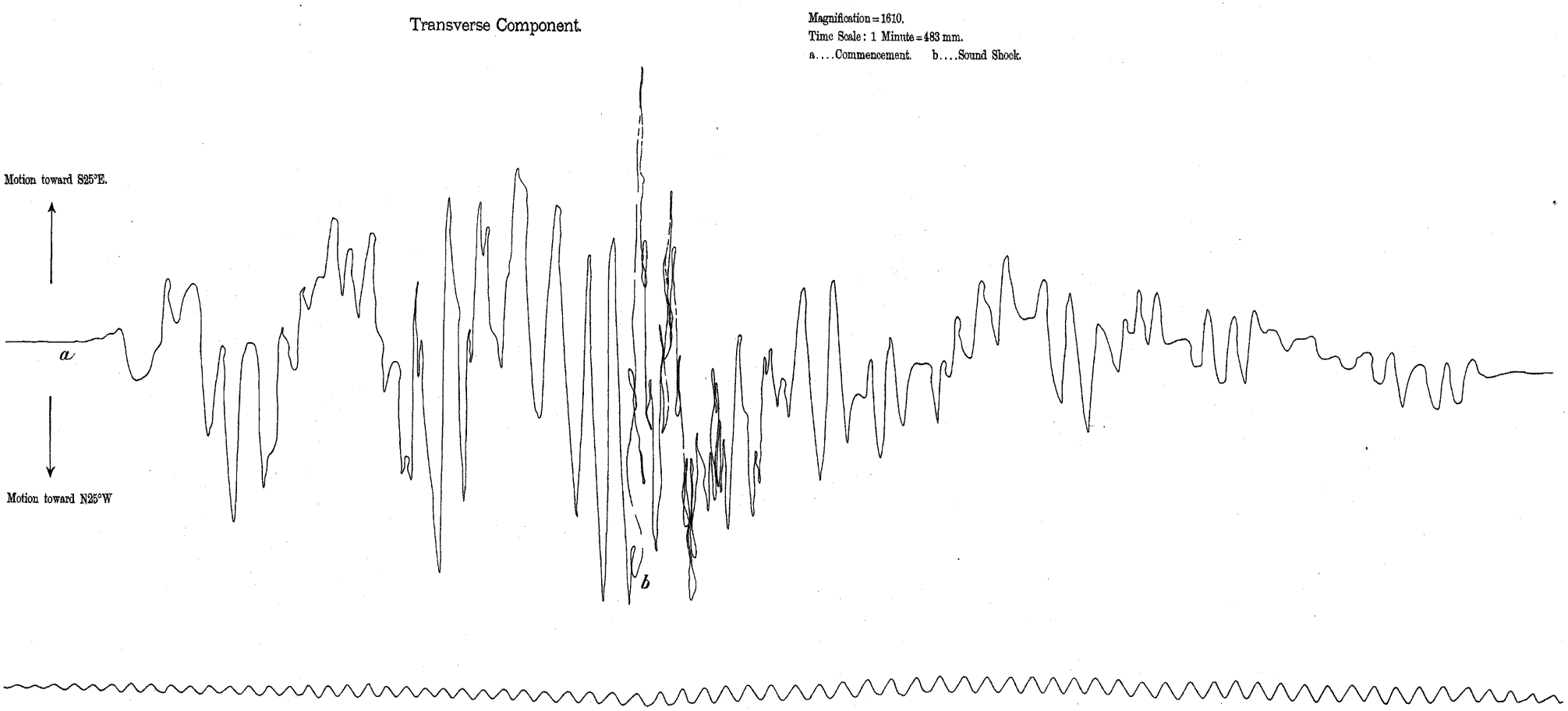


Fig. 48. Micro-Pulsations, observed on Aug. 12th, 1913, at about 1½ p.m.
Yuno-taira Tromometer Record: Longitudinal Component.

Magnification = 1130
Time Scale: 1 Minute = 282 mm.

Fig. 49. Asama-yama Explosion of Nov. 14th, 1913, observed at Asama Pasture Ground. Tremor-recorder Diagram.

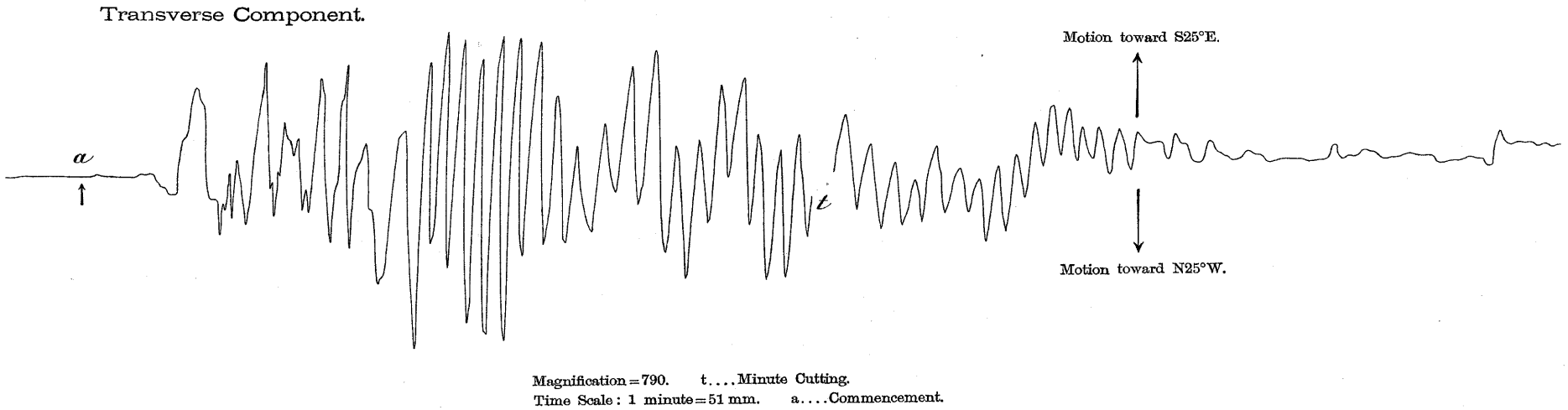
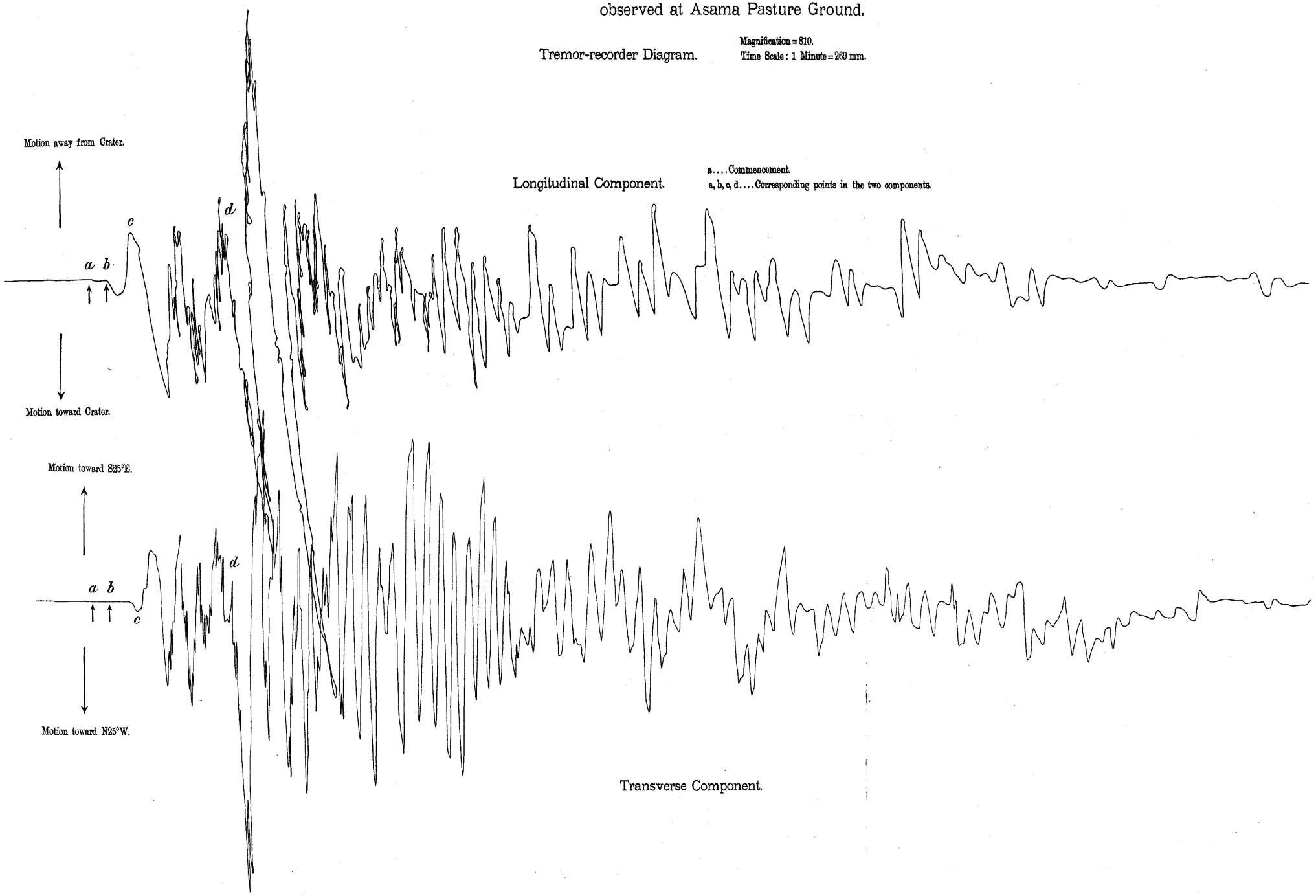


Fig. 50. Non-Detonative Eruption of Asama-yama of Nov. 20th, 1913,
observed at Asama Pasture Ground.

Tremor-recorder Diagram.

Magnification = 810.
Time Scale: 1 Minute = 269 mm.



(duration=1.2 sec.) took place. Then there followed the "initial vibration" of T=3.05 sec., composed of the inward displacement of 0.038 mm and of the outward one of 0.063 mm. The latter and the 3rd motion of 0.059 mm together formed a large vibration of T=2.7 sec. For the remaining 14.6 sec., the motion became quick and was composed of 15 well defined vibrations of T=0.97 sec., max. 2a=0.046 mm. [End portion.] During the 1st 17.3 sec., the vibrations were: T=1.47 sec., max. 2a=0.024 mm. Thereafter the motion became much smaller, being composed of the movements of T=1.3 sec., max. 2a=0.007 mm. Towards the very end, the period was 1.05 sec.

Transverse Component. [Preliminary and principal portions: duration=37.7 sec.] The motion was practically *nil* for the 1st 3.6 sec., after which took place a SSE'ward displacement of 0.0048 mm (duration=1.2 sec.) corresponding to the 1st, or inward, movement of the "initial vibration" in the longitudinal component. The two next displacements, respectively of 0.025 and 0.035 mm formed a slow vibration of T=2.57 sec. For the next 10.1 sec., there were 7 slow vibrations of T=1.44 sec., (with some superposition of small quick movements), the last having the max. 2a of 0.052 mm. Then there took place a slight quickening of period, and, for the next 7.8 sec., the motion was most active, being composed of 8 regular vibrations of T=0.98 sec., max. 2a=0.073 mm. For the remaining 12.8 sec. of the principal portion, the motion was nearly uniform: T=1.16 sec., max. 2a=0.048 mm. [End portion.] During the 1st 17.4 sec., the vibrations were regular: T=1.03 sec., max. 2a=0.017 mm. Thereafter the motion became much smaller.

Comparison of Longitudinal and Transverse Components. The introductory small motion phase lasted in the transverse component

3.6 sec., or 1.7 sec. longer than in the longitudinal. The two displacements composing the "initial vibration" were much greater in the latter than in the former, the resultants being 0.038 mm toward S55° W and 0.068 mm toward N40°E. Thus, in the present case, the directions of the "inward" and the "outward" movements deviated leftwards from the line joining the observing place with the crater centre respectively by the amounts of 7° and 22°. In the transverse component, large (absolute maximum) regular vibrations set in 17.2 sec. after the earthquake commencement, while in the longitudinal component there was in the same epoch no marked corresponding amplification of the vibrations.

CHAPTER V. STRONG ASAMA-YAMA EXPLOSIONS OBSERVED AT ASHINO-TAIRA.*

[TREMOR-RECORDER DIAGRAMS.]

40. *Explosion of Sept. 21st, 1913, at 1. 50. 59 p.m.* Total duration=97 sec.

Longitudinal Component. [Preliminary and principal portions: duration=24.8 sec.] The preliminary motion of 0.0025 mm (duration=0.49 sec.) was followed by the "initial vibration" of T=2.2 sec., composed of the 1st or inward displacement of 0.030 mm (duration=0.97 sec.), and of the 2nd or outward displacement of 0.077 mm (duration=1.22 sec.). The latter was followed by the inward and maximum 2a of 0.093 mm, the two together forming a well defind vibration of T=2.43 sec. Then followed a slow outward displacement (duration=2.1 sec.) of 0.057 mm. So far, for the first 6.1 sec. the motion was gentle, there being practically no superposition of the quick movements.

* The times of occurrence of the explosions considered in this chapter are those registered by a tremor-recorder at Ashino-taira.