

Seismological Investigations.—Fourteenth Report of the Committee, consisting of Professor H. H. TURNER (Chairman), Dr. J. MILNE (Secretary), Mr. C. VERNON BOYS, Sir GEORGE DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Dr. R. T. GLAZE BROOK, Mr. M. H. GRAY, Professor J. W. JUDD, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Professor J. H. POYNTING, Mr. CLEMENT REID, and Mr. NELSON RICHARDSON. (Drawn up by the Secretary.)

[PLATE I.]

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I. *General Notes.*

LAST year, early in November, my assistant, Mr. H. C. O'Neill, left me for an appointment in London. The last work on which he was

¹ With this object the Committee are authorised to issue as an Appendix to the Report of the Conference, Notes detailing the methods which have been adopted

engaged when in the Isle of Wight was a catalogue of the Shide collection of papers bearing upon seismology written in foreign languages. Although he continued this compilation while in London, I regret to say that the completion of the same has for the time being been interfered with by ordinary routine work. As illustrative of this latter I may take the map which accompanies each report and shows the distribution of earthquake centres for the previous twelve months. Inasmuch as the production of this sheet involves the consideration and usually a calculation based upon each of the entries of all co-operating stations, it will be understood that much time is spent in the production of what is shown as a single plate. Correspondence with stations and those interested in our work occasionally occupies a morning. Each day films and other record-receiving surfaces have to be renewed. Films have to be developed, measured, and records reduced to a form suitable for publication. The registers from all co-operating stations have to be recopied and classified. Accurate time has to be kept, and attention has to be given to the ordinary meteorological instruments found in most observatories. Between the hours of 8 A.M. and 10 P.M. we are usually able to give information bearing upon our work. My assistants work in the morning and again in the evening, and, when occasion requires, also in the afternoon. The amount of original work done in the laboratory is outlined in the Reports.

Registers.—During the past year the registers issued are contained in Circulars Nos. 18 and 19. These refer to Shide, Kew, Bidston, Edinburgh, Paisley, Haslemere, San Fernando (Spain), Valetta (Malta), Cairo, Beirut, Ponta Delgada, Cape of Good Hope, Calcutta, Bombay, Kodikanal, Irkutsk, Batavia, Trinidad, Lima, Baltimore, Toronto, Victoria, B.C., Honolulu, Perth, Sydney, Christchurch, and Mauritius.

High-speed (24 cm. per hour) record-receiving apparatus has been sent to Edinburgh and to Lima. Similar apparatus will be sent to San Fernando (Spain). It is expected that the Naturalists' Society of Cardiff will shortly put up a seismograph.

For a continuation of financial support I again thank the Royal Society, the British Association, the administrators of the Gray Fund, and Mr. Richard Cooke. I regret to say the support I received from the 'Daily Mail' has ceased. The chief expenditure relates to salaries and material. With the latter there is included the cost of photographic films required at Bidston.

The Committee ask for reappointment and a grant of 60*l*.

II. Sites of Stations.

Eskdalemuir Magnetic Observatory, Dumfriesshire, Scotland.

Main Building, Latitude	55° 18'	42·2" N.
" Longitude	3° 12'	19·7" W.
" Height	775·29 feet.	
Level of Davington Burn about 700 feet.		

Geological formation consists of rocks of the Tarannon Llandoverly series transversed by igneous dykes.

in the Standardising Laboratories of the various countries to realise the International Ohm and the International Ampere, and to set up the Weston normal cell.

The seismograph room is situated on the ground floor of the main office building. The principal pier is built of solid cubes of sandstone, and passes directly to the rock at a depth of 21 feet. The pier is enclosed in a brick well to isolate it from local surface movements. The Milne twin-boom instrument is mounted on this pier, so as to give N.S. and E.W. components. The period of the booms is about 18 seconds, and at this period the scale is 1 mm. = 0''391.

A spare pier is also situated in the room, and will be used for research work on the behaviour of other forms of seismographs.

Toronto, Canada.—When the magnetometers, on account of interference with electric trains, were moved from Toronto to Agincourt the seismograph was moved also. The underlying rocks at Agincourt are the same as those at Toronto, about nine miles distant. These are Hudson River shales, covered with a thick deposit of alluvium. These latter drift deposits no doubt differ to a certain degree, but there are no sections at Agincourt which can be compared with those at Toronto. It may be mentioned that when the magnetometers were in Toronto they did not appear to have been disturbed at the time of large earthquakes. Now that these instruments are removed to Agincourt from time to time they show irregularities which may be due to teleseismic movement (see 'B. A. Reports,' 1898, p. 237; 1899, p. 170).

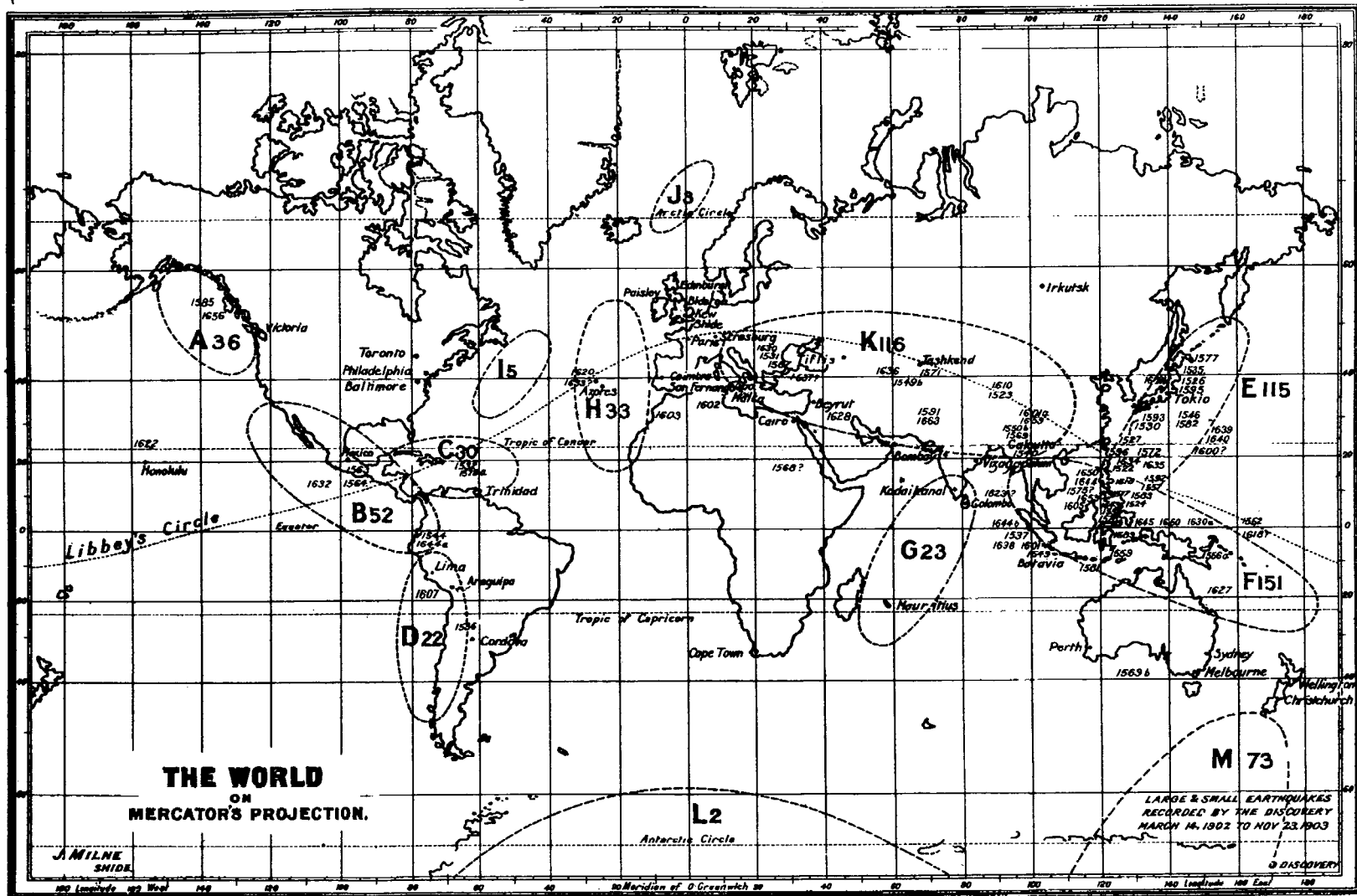
Porto Rico, W. Indies.—The instrument at this station is of the Bosch-Ömori type and forms part of the equipment of the United States Coast and Geodetic Survey. It is established at the Magnetic Observatory situated on Vieques Island, east of the island of Porto Rico. It is mounted in the north-east corner room on the ground floor of the old Spanish fort 'Isabel.' The floor of the room consists of 3 inches of cement underlaid with 3 inches of hard clay, which in turn is underlaid by stone. The piers, four in number, on which the seismograph parts are mounted are each 20 inches square by $32\frac{1}{2}$ inches deep. Each consists of three pieces of dressed stone. These are laid in cement and extend 30 inches below floor-level; the space round each pier is filled with cement within 4 inches of the floor. The instrument consists of two pendulums recording north-south and east-west motion. It is possible to obtain the time of any effect within one or two seconds. The paper moves 15 mm. to the minute. The period of north-south pendulum is 26.36 seconds; east-west pendulum 24.7 seconds. The multiplication of the tracing points is 10.

Stonyhurst, near Blackburn, North Lancashire, England.—The latitude of the observatory is $53^{\circ} 50' 40''$ N; longitude, $0^{\circ} 52' 68''$ W of Greenwich. The seismograph is the one which was used for two years in the Antarctic regions by the officers of the s.s. *Discovery*. The standard and other parts of the instrument are made of gunmetal and non-magnetic materials. At Stonyhurst it is installed in the underground magnetic chamber, which is dry and does not suffer from variations of temperature. It is placed on a pillar composed of two cut stones firmly cemented together. On the top of these there is a slate slab also cemented to the uppermost stone. The pillar is embedded in and rests upon 12 inches of concrete below the stone floor of the chamber. The concrete rests on hard clayey soil. The height of the top of the slab from the floor is $3\frac{1}{2}$ feet, and its height above sea-level is 364 feet.

P.50a

Origins for 1908 are indicated by their B.A. Shide Register number.

Earthquake districts are indicated A, B, C, &c., and the number of Earthquakes since 1899 which originated from these is expressed in large numerals.



Illustrating the Report on Seismological Investigations.

III. *The Large Earthquakes of 1908.*

The distribution of origins for the large earthquakes of 1908 is very similar to that of 1907. The greatest activity has been at the overlap of districts E and F. In the totals for districts the earthquakes for the E F overlap have been regarded as belonging to E and not to F. Earthquake No. 1603 is included in the total for H, and Nos. 1568 and 1602 in those for K. The correct number of District C for 1906 is 27 and not 29 (see map and Report for 1907).

In studying these districts it must be remembered that they merge one into the other, and cannot be regarded as so many strictly defined isolated elliptical areas. C, H, K, and F may, for example, be looked upon as districts of marked activity along a band which extends nearly round the world, while D, B, A, E represent areas of marked intensity on a band which fringes a great part of the Pacific Ocean.

The total number of earthquakes which have occurred in 1908 on the east side of the Pacific is slightly greater than those which occurred in 1907. A similar increase is noted for the west side of the same ocean.

A table published in the 'B. A. Reports,' 1908, p. 63, shows that for the years 1899 to 1907 inclusive the greatest megaseismic activity has prevailed in the East Indian Archipelago, and the least on the West Coast of South America. If, instead of comparing the activity in the large districts which are indicated on the accompanying map (Plate I.) by the letters A, B, C, &c., we compare the number of large earthquakes which have originated during the last ten years within areas each about five degrees radius, the results arrived at are as follow:—

Centre 120° E. 5° N.	gave 75 large earthquakes.
" 140° E. 40° N.	" 68 " "
" 70° E. 25° N.	" 40 " "
" 145° W. 45° N.	" 33 " "

These figures indicate that at the present time the most pronounced centres of seismic activity are to be found in the centre of the East Indian Archipelago and from the East Coast of Central Japan south-westwards towards Formosa. The first of these is near to the junction of two pronounced lines of folding in the earth's crust.

IV. *After-shocks of the Earthquake at Jamaica, January 14, 1907.*

In the Report for 1908, p. 64, reference is made to 148 after-shocks which in 1907 were recorded between January 14 and July 5, in Jamaica; ninety-two of these appear to have been recorded in the Isle of Wight. The time taken for earth waves to travel from Jamaica to the Isle of Wight, a distance of 67 degrees, would be about forty-three minutes, and it is at this interval of time subsequent to shocks in Jamaica that we find thickenings and sinuosities in seismograms obtained in Britain. A large number of these records are also to be found on seismographic traces obtained at Bidston, Kew, Paisley, and Edinburgh. This concurrence of records from different stations and the particular times at which they occur in reference to the times of origin of shocks in Jamaica lead us to the conclusion that comparatively small shocks may with suitable instruments be recorded at localities several thousands of miles distant from their origin. The

particular group of records to which we refer are given in the accompanying table. The entry of July 5 may have been recorded at Göttingen, but with this exception the remaining disturbances do not appear in registers from Göttingen, Strassburg, or Laibach. The difference in the number of records obtained at different stations where the instruments are of one type, viz., that adopted by the British Association, partly finds an explanation in differences in foundation, see p. 60. The reasons that stations provided with apparatus of the Reuber-Ehlert type do not appear to pick up very small movements is possibly due to a want of definition in the photographic trace; but here again the question of foundation cannot be overlooked. Directly we come to apparatus where the record is obtained upon a smoked surface, which is the case at many European and American stations, a new factor has to be considered. The slight freedom in the connections between the joints of multiplying indices, and the elasticity of the same, suggests a loss of motion, the result being that the writing pointers do not move until a certain amplitude of earth movement has been reached. Whether this explanation be correct or not, my own experience is that instruments writing on a smoked surface, although they may yield excellent seismograms of a large earthquake, are very unsatisfactory as recorders of very slight disturbances. Records of large earthquakes may be obtained by many types of instruments, but directly we wish to record feeble movements at considerable distances from their origin, the best results appear to come from the instrument adopted by the British Association with the photographic surface moving at the rate of about 240 mm. per hour. As illustrative of this we find that the number of records obtained at Shide, Hamburg, Göttingen, and Laibach between January 1 and April 30 of this year were respectively 98, 65, 61, and 33. At the first of these stations the instrument employed is of the B.A. type, whilst at the three latter stations records are obtained on smoked paper or by photographic arrangements with a high multiplication. All the records referred to were noted at more than one station, and therefore their reality as representing widespread earth disturbances cannot be doubted. The number of records obtained at Bidston, Kew, and Edinburgh, where the photo-receiving surface only moves at the rate of 60 mm. per minute, were not so numerous as those obtained at Shide.

After-shocks of the Jamaica Earthquake apparently recorded in Great Britain.

Date	Due in England	Shide	Kew	Bidston	Paisley	Edinburgh
1907						
Jan. 15	0.55	—	—	—	—	0.48?
"	1.53	1.52	—	1.52	—	—
"	2.52	2.53	—	2.52	2.52	2.48
"	3.50	3.51	—	3.51	—	3.51
"	5.5	5.4	—	4.58?	—	—
"	7.30	7.40	—	7.27	7.25	7.25
"	8.50	8.50	8.44	8.52	8.50	—
"	9.20	9.19	9.29	9.19	—	9.21
"	11.50	11.45	—	11.43	11.45	—
"	15.50	15.45	—	—	15.45	—
"	17.15	17.14	—	17.14	17.15	—
"	17.48	18.12	17.48	18.16	18.12	—
"	21.52	—	—	—	—	—

After-shocks of the Jamaica Earthquake—continued.

Date	Due in England	Shide	Kew	Bidston	Paisley	Edinburgh
1907						
Jan. 15	22.31	22.35	—	—	—	—
Jan. 16	5.19	—	—	—	—	—
"	8.45	8.45	—	—	—	8.46
"	17.24	17.19	17.18	17.20	17.17	—
"	22.24	22.48	—	22.23	—	—
Jan. 17	2.50	2.45	—	—	—	—
"	6.5	6.6	—	—	—	—
"	13.40	13.37	—	13.44	—	—
"	17.20	17.19	17.18	17.20	17.18	—
"	22.47	—	—	—	—	—
Jan. 18	3.25	Ats.	—	?	—	—
"	7.20	"	—	7.25?	—	—
"	11.50	"	—	11.44	—	—
"	12.24	"	—	12.30?	—	—
"	14.20	"	—	—	—	—
"	17.20	17.20	—	17.20	17.20	17.21
"	18.20	—	—	—	—	—
"	19.50	19.55	—	19.59	—	—
"	21.50	—	—	22.21?	—	—
Jan. 19	8.50	8.50	—	8.50	8.49	8.48
"	10.59	?	—	11.0	—	—
"	11.20	11.22	—	11.22	—	—
"	15.20	15.22	—	—	—	—
"	16.40	16.35	16.36	16.34	16.40	—
Jan. 20	1.20	1.24	—	1.26?	—	—
"	3.10	3.7	—	3.3?	—	—
"	3.50	3.53	—	—	—	—
"	4.20	4.12	—	4.16	—	—
"	9.5	9.6	—	—	—	—
"	12.12	—	—	—	—	—
"	17.50	17.45	—	—	—	—
"	20.22	—	—	—	—	—
"	21.20	—	—	—	—	—
"	22.35	—	—	—	—	—
Jan. 21	4.50	—	—	—	—	—
"	18.45	—	—	—	—	—
"	23.50	23.45	—	—	—	—
Jan. 22	3.20	3.21	—	3.24?	—	—
"	13.50	13.52	—	—	—	—
"	20.5	Ats.	—	—	—	—
"	20.25	"	—	—	—	—
"	22.0	22.3	—	21.56	—	—
Jan. 23	3.10	3.9	—	—	—	—
"	6.50	6.52	—	6.49	—	—
"	10.45	10.36	—	—	—	—
"	15.13	15.12	—	—	—	—
Jan. 24	9.50	—	—	—	—	—
"	15.35	—	—	15.50?	—	—
"	16.10	16.18	—	—	—	—
"	20.25	—	—	—	—	—
Jan. 25	16.55	16.50	—	—	—	—
"	19.35	—	—	—	—	—
Jan. 27	14.50	14.50	—	—	—	—
Jan. 28	9.30	—	—	—	—	—
"	10.23	10.18	10.23	10.18	10.18	10.25
"	13.50	13.53	—	13.53	13.52	—
Jan. 29	4.1	—	—	4.2?	—	—
"	18.55	—	—	18.53	—	—
Jan. 30	3.10	—	—	—	—	—

After-shocks of the Jamaica Earthquake—continued.

Date	Due in England	Shide	Kew	Bidston	Paisley	Edinburgh
1907						
Jan. 30	3.30	3.38	—	—	—	—
"	4.10	—	—	?	—	—
"	13.11	13.11	—	—	13.10	—
"	14.10	14.11	—	14.9	14.10	14.13
Feb. 1	1.50	—	—	—	—	—
Feb. 2	5.50	—	—	?	—	—
Feb. 3	5.45	5.44	—	—	—	—
"	5.55	6.7	—	—	—	—
"	8.2	8.0	—	—	—	—
Feb. 4	9.50	9.45	—	—	9.45	—
"	11.50	—	—	?	—	—
"	12.50	12.55	12.44	—	12.53	12.52
Feb. 5	7.20	7.11	7.25	—	7.10	—
"	11.5	11.15	—	—	11.14	11.5
Feb. 6	4.49	4.48	—	4.48	4.48	—
"	8.45	8 to 9	8.0	—	8 to 9	—
"	21.15	21.17	—	?	—	—
Feb. 7	4.50	4.52	—	4.54	—	—
Feb. 10	6.10	6.10	—	6.15	6.10	6.10
"	19.50	19.48	19.45	19.56	19.47	19.49
Feb. 11	6.20	—	—	?	—	—
"	23.20	23.22	23.24	23.20?	23.21	23.23
Feb. 18	3.40	3.41	—	—	—	—
Feb. 19	5.45	5.44	—	—	—	—
Feb. 22	14.33	—	—	14.22	—	—
Feb. 23	0.5	0.5	—	0.8	0.5	0.5
Feb. 26	23.30	—	—	—	—	—
Feb. 27	2.35	—	—	2.30	—	—
Feb. 28	5.30	—	—	5.25	—	—
"	13.30	13.35	—	—	13.31	—
Mar. 1	10.5	10.7	—	10.7	10.6	—
"	11.45	—	—	11.40	—	—
Mar. 2	6.35	—	—	—	—	—
"	5.35	—	—	—	—	—
Mar. 6	3.45	3.42	—	3.43	—	—
Mar. 7	12.2	12.3	—	?	—	—
"	13.50	13.58	—	—	—	—
Mar. 8	10.5	10.4	10.9	—	—	—
Mar. 9	11.35	11.30	11.23	—	11.29	—
Mar. 11	7.40	7.42	—	—	7.43	—
Mar. 15	4.50	4.53	—	—	4.53	—
Mar. 17	12.20	12.15	12.16	—	12.17	—
Mar. 18	1.35	1.20	—	1.35	1.19	1.30
Mar. 19	12.0	12.7	12.4	—	—	—
Mar. 21	5.49	—	—	—	—	—
Mar. 23	0.32	—	—	—	—	—
"	19.27	19.20	—	—	—	—
Mar. 24	4.25	—	—	—	—	—
Mar. 25	6.0	—	—	—	—	—
Mar. 27	14.45	14.40	14.41	—	14.40	—
Mar. 28	14.20	14.25	14.25	—	14.25	—
Mar. 31	13.0	—	—	13.4	—	—
April 2	10.50	—	—	?	—	—
April 9	8.35	—	—	8.30	—	—
April 10	3.20	—	—	—	—	—
April 11	12.4	12.4	—	12.1	—	—
April 13	4.50	—	—	—	—	—
"	12.58	12.58	—	12.50	—	—
April 16	12.50	12.52	12.49	—	12.55	—

After-shocks of the Jamaica Earthquake—continued.

Date	Due in England	Shide	Kew	Bidston	Paisley	Edinburgh
1907						
April 25 .	1.15	—	—	0.35	—	—
" .	9.50	—	—	?	—	—
April 28 .	2.53	—	—	—	—	—
" .	23.0	—	—	?	—	—
April 29 .	1.30	—	—	?	—	—
May 1 .	21.35	21.25	—	—	21.31	21.30
May 2 .	2.20	2.20	—	2.22	2.21	—
May 3 .	17.0	17.2	16.54	—	17.3	—
May 4 .	2.42	2.43	—	—	—	—
May 11 .	1.30	—	—	1.25	—	—
June 13 .	7.8	7.1	7.8	—	—	—
June 14 .	7.20	7.24	—	—	—	—
June 16 .	16.15	16.56	16.57	16.55	—	—
June 18 .	13.20	13.30	—	—	—	—
June 29 .	20.4	—	—	—	—	—
July 1 .	11.0	11.1	—	—	—	—
July 5 .	20.0	20.3	—	20.0?	—	—
Total .	148	92	22	58	39	18

The movements recorded at Kew are referred to as being very small and ill-defined, and in the ordinary way would have been passed over as being due either to air tremors or some other non-seismic cause.

The records from Bidston are spoken of as 'doubtful,' 'possible,' 'very evident,' 'very pronounced,' and 'clearly marked.'

Paisley records were much interfered with by air tremors; it is therefore possible that some of the entries are non-seismic in character.

The Edinburgh records are spoken of as 'slight thickenings,' 'small notches,' 'roughness of line,' 'slight tremors.'

In the Report for this year the Shide list has been increased by 41 entries. These have been added because they have been confirmed by records from other stations.

V. Quick Vibrators as applied to Seismometry.

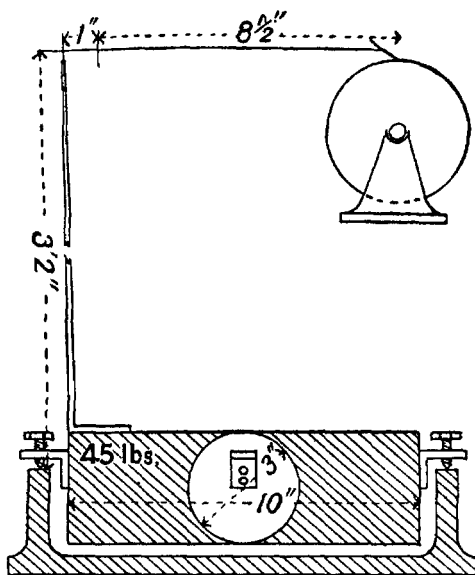
In a paper on 'A Neglected Principle that may be employed in Earthquake Measurements,' by Professors J. Perry and W. E. Ayrton (see 'Trans. Asiatic Soc. of Japan,' May 23, 1877), it is suggested that the essential feature in a seismograph should be a heavy mass so suspended by stiff springs that its own free period would be about five times as fast as that of an earthquake. This was to take the place of the steady point in modern seismographs. Inasmuch as this instrument was never constructed, we can only surmise about the character of the record it would furnish.

In a paper on 'Experiments in Observational Seismology' (see 'Trans. Seis. Soc.,' vol. iii. 1881) I make reference to pendulums the periods of which were a small fraction of a second. They were only used as tremor-indicators.

Notes on these and on other quick vibrators are referred to in the chapter on 'Seismometry' in a small volume on 'Earthquakes' published in the 'International Science Series,' 1883. All these instruments were intended to record earthquakes which could be felt, the periods of which varied between one and three or four seconds. As they merely

acted as seismoscopes, they quickly fell into disuse. To record unfelt teleseismic motion where the periods varied from about five to thirty seconds, I last year made the following experiment:—

A cylinder of lead 10 inches in length and $\frac{3}{8}$ inch in diameter, weighing 45 lb., was suspended as shown in the accompanying sketch. From one end of the cylinder a light deal rod projected upwards. At its



upper end this engaged a light aluminium lever carrying a glass style resting on a drum covered with smoked paper. This multiplied the motion of the rod, which was 3 feet 2 inches in length, $8\frac{1}{2}$ times. By this arrangement the equivalent of a rod 27 feet in length was obtained. The period of this pendulum with the style resting on the smoked paper was 0.6 second, or from eight to thirty times the period of the ground. During twenty-two days commencing November 26, although there were several earthquakes, two of which were distinctly large, no record was obtained. Possibly the multiplication was too small.

VI. *On a possible Synchronism between Seismic Activity in Different Districts.*

In the Report for 1908, p. 64, I pointed out that since 1902 seismic activity on the two sides of the North Pacific had fluctuated similarly. For example, registers show that when large earthquakes had been numerous on the East side of the Pacific they had also been numerous on the West side. To extend this inquiry, I have drawn up the following table giving the number of destructive earthquakes which have occurred between A.D. 1000 and A.D. 1650. They are grouped in periods of fifty years. Columns A, B, C, and D respectively refer to Japanese, Chinese, European, and Italian records. The letter 'a' indi-

states that in two given districts seismic activity has been constant or has varied similarly, *i. e.*, there has been an *agreement*. The letter 'd' indicates that there has been *disagreement*. For example, seismic activity may have increased in one district while it has decreased in another. As to whether an entry should be 'a' or 'd,' no account has been taken of the greatness of increase or decrease in the number of earthquakes in the given period, but only whether it was a marked increase, decrease, or a period of quiescence. The columns in which the letters 'a' and 'd' occur are headed A to B, A to C, &c. If written more fully these would become A compared with B, A compared with C, &c.

Inasmuch as the Italian records are included in and form a large portion of those which refer to Europe generally, the comparison of C to D is of slight value. The general result indicates that in a period of 650 years we have had forty-four instances of agreements against twenty-eight instances of disagreements in the fluctuations in seismic activity in widely separated districts. This suggests that for the most part periods

Date	A	B	C	D	A to B	A to C	A to D	B to C	B to D	C to D	Totals.
1000 to 1050	8	28	7	1							a d
1100	8	27	9	2	a	a	a	a	a	a	6 0
1150	3	11	8	5	a	d	d	d	d	d	1 5
1200	12	22	13	7	a	a	a	a	a	a	6 0
1250	7	13	7	6	a	a	a	a	a	a	6 0
1300	4	8	7	10	a	d	d	d	d	d	1 5
1350	8	64	12	3	a	a	d	a	d	d	3 3
1400	9	37	11	6	d	a	a	d	d	d	2 4
1450	13	16	18	5	d	a	d	d	a	d	2 4
1500	16	50	14	9	a	d	a	d	a	d	3 3
1550	6	49	16	9	d	d	d	a	a	a	3 3
1600	5	52	16	10	a	a	d	a	a	a	5 1
1650	10	60	25	13	a	a	a	a	a	a	6 0
					9a 3d	8a 4d	6a 6d	7a 5d	8a 4d	6a 6d	44a 28d

of seismic quiescence or of activity in various parts of the globe occur about the same time. This result does not, however, appear to be shown if we take eleven or thirty-three year periods. Of fifty-three periods of eleven years, A.D. 1000 to A.D. 1583, a comparison of the earthquakes of Europe with those of China and Japan respectively indicate that agreements and disagreements are about equally divided. A similar result is obtained when thirty-three year periods were taken for comparison of European and Japanese and Chinese and Japanese earthquakes.

Another method of determining whether there has been a time agreement in seismic activity in distant districts has been to plot year by year the large earthquakes of Japan and Italy on squared paper. The interval considered for each of these countries has been the last three hundred years. England and many other countries have been excluded because their records are few in number and only refer to comparatively feeble shocks. The two Americas have been omitted because their

registers are incomplete; Australia and New Zealand, because prior to 1850 we were without knowledge; and China, because its accessible registers end about 1644.

All materials prior to A.D. 1600 have been discarded on account of their fragmentary character, and it is often impossible to say whether certain entries refer to destructive earthquakes or only to comparatively small tremors. The only earthquakes considered are those which have been destructive, and these are divided into the following three classes: (I.) shocks which have cracked walls or damaged chimneys; (II.) shocks which have destroyed a few buildings; (III.) shocks which have caused widespread disaster. For Italy and for Japan these three classes have been taken separately, in pairs, and *en bloc*. Which ever way we have plotted them one result is clear, viz., in each of these two widely separated districts during the last three hundred years there have been periods of activity and periods of comparative rest. When the zigzag lines which show frequency from year to year are smoothed to curves you obtain a series of undulations the crests of which are separated from each other by periods varying between five and twenty years. There is no indication of a recurrence of activity after regular or equal intervals of time. The following table gives dates for the crests of these waves. In comparing any two of these dates it must be remembered that either of them might be increased or decreased by a year. The reason for this is twofold. First, an earthquake or earthquakes which occurred at the end of a year might, for the purposes of this investigation, have been assigned to the year following. Similarly, those which occurred in January of a given year might have been referred to the previous year. Also, it is difficult to determine the exact position for the crest of a wave. An inspection of the table shows for Italy eighteen dates for wave-crests, and fourteen of these agree very closely with dates indicating periods of seismic activity in Japan. These coincidences suggest that a relief of seismic strain in one part of the world either brings about a relief in some other part, or that relief is governed by some general internal or external agency.

Periods of Seismic Activity.

Japan	Italy	Differences	Japan	Italy	Differences
		Year			Year
1613	1612	1	1751	1755	4
—	1626	—	1765	1767	2
1644	1642	2	1782	1784	2
1663	1660	3	—	1798	—
1697	1693	4	1803	1806	3
1704	1703	1	1834	1833	1
1717	1717	0	1856	1856	0
1728	1728	0	—	1873	—
—	1744	—	1898	1896	2

VII. *The Time of Maximum Motion as indicated by Three differently installed Horizontal Pendulums.*

The three pendulums are the Milne type (see 'B.A. Report,' 1902, p. 60). Pendulum A records east-west motion; it stands on a brick column, the cross-section of which is 18 inches by 18 inches.

Pendulum B also records east-west motion; it stands near to A on another brick column. The cross-section of this is 18 inches by 37 inches.

Pendulum C records north-south motion; it is installed on the same column as B. The stiffness of these two piers, as might be inferred from their dimensions, are very different. In an east and west direction the B-C column is approximately four times as stiff as A column (see 'B.A. Report,' 1902, p. 60).

For certain intervals of time, each of several months' duration, these pendulums have been adjusted to have the same or different periods. When A and B had the same period, had they been loaded equally and installed on the same support we should expect that they would have attained a maximum swing at the same time. The following analyses show how far this was the case, notwithstanding the absence of this equality of conditions. With the object of comparing similar phases of motion, in all instances where time measures are concerned, reference has been made to the original seismograms. The earthquakes considered are indicated in the Shide Registers by the following numbers:—

666, 671, 672, 674, 676, 679, 686, 690, 694, 704, 705, 794, 806, 876, 832, 839, 859, 860, 861, 863, 872, 877, 884, 886, 900, 903, 904, 924, 952, 975, 977, 982, 990, 994, 1001, 1020, 1021, 1031, 1038, 1045, 1046, 1048, 1057, 1064, 1065, 1070, 1074, 1087, 1111, 1118, 1135, 1145, 1164, 1182, 1190, 1208, 1225, 1242, 1257, 1266, 1281, 1284, 1293, 1303, 1319, 1320, 1322, 1323, 1362, 1363, 1375, 1387, 1390, 1393, 1408, 1412, 1419, 1422, 1425, 1428, 1431, 1433, 1439, 1450, 1460, 1463, 1468, 1471, 1475, 1495, 1496, 1515, 1522, 1526, 1532, 1540, 1544, 1549, 1563, 1564, 1568, 1575, 1577, 1585, 1591.

No. 1.—For thirty-seven earthquakes A and B have had the same periods. For twenty-five of these a maximum motion was recorded at the same time; for the remaining twelve earthquakes the difference in time for the maximum swing was two minutes or over.

No. 2.—For twenty earthquakes A or B had the same period as C. For eleven of these maximum for north and south motion occurred at the same time as the maximum for east and west motion; for the remaining nine earthquakes there was a difference in time for the maximum motion of two or more minutes.

No. 3.—Out of 103 earthquakes A and B have had the same period for thirty-seven earthquakes; for the remainder they had different periods. Taking these *en bloc*, A and B have recorded maximum swing at the same time in fifty-one cases; in the remaining fifty-two cases the times for this movement have differed by two or more minutes.

No. 4.—Pendulum C (north-south motion) indicates a maximum motion very frequently before a maximum motion is recorded by A and B.

I do not see that the district from which an earthquake originates has any relationship to the pendulum which first records its apparent maximum motion.

VIII. *The Number of Earthquake Records obtained at British Stations.*

In the 'British Association Report,' 1901, pp. 44-50; 1902, p. 73; and 1903, p. 82, references are made to the number of records obtained at

Bidston, Shide, Kew, and Edinburgh. These stations are respectively situated on sandstone, chalk, alluvium, and volcanic rock. In the following table we reproduce records of frequency as given in the Report for 1902 and 1903, together with records for 1908:—

Year	Bidston	Shide	Kew	Edinburgh
1901 (11 months)	133	107	73	94
1901, 1902	228	168	127	155
1908	105	114	49	44

We may add that in 1908 Paisley recorded forty-eight shocks—*i.e.*, its number of records closely accorded with those obtained at Kew and Edinburgh. The subsoil at Paisley is clay (' B.A. Report,' 1905, p. 89).

At all these stations similar horizontal Milne pendulums are in use, but the adjustment of these have from time to time only been approximately similar. In 1908 at Shide 1 mm. displacement of the outer end of the boom corresponded to a tilt of $0''\cdot44$. The corresponding values at Kew, Bidston, and Edinburgh were $0''\cdot56$, $0''\cdot53$, and $0''\cdot53$, or $0''\cdot54$. The table shows that the Shide instrument, with the greatest sensitiveness in 1908, gave the greatest number of records. The difference between it and Bidston, however, is only nine. If we consider the latter half of 1908 only, we find that Bidston had sixty-one records and Shide had fifty-seven—*i.e.*, the result is reversed. In 1901 and 1902, when the Bidston instrument had for twelve months greater sensitiveness than the one at Shide, the number of records at the former place greatly exceeded that at the latter.

The very marked difference in the number of records obtained at Bidston and Kew, Edinburgh and Paisley, does not seem to depend upon differences in sensitiveness of the instrument, inasmuch as these differences are very slight. If we except Edinburgh and Bidston, which are founded on hard rock, there is a great difference between this and the softer materials which act as foundations for other stations.

IX. *Luminous Effects obtained from Rock Surfaces.*

In the ' British Association Report ' for 1907, pp. 87-91, a long series of experiments are described which apparently show that from time to time surfaces of chalk and killas affect a photographic surface in the same way it is affected when exposed to light. Several control experiments are described, and the conclusion arrived at was that the markings on the photographic films were not due to radio-activity, but they might be due to a very feeble brush or glowlike electrical discharge. Since the publication of the above an attempt has been made to determine whether micro-organisms play any part in the phenomena observed. With the assistance of my friend, Dr. R. C. Brown, M.D., of Parkhurst, cultures were made from scrapings from the surface of the chalk, in front of which the cylinder, covered with bromide, had been placed. This was underground. Cultures were also made from scrapings taken from the chalk outside. Micro-organisms were found in both. These have been exposed to a moving photographic surface similar to that used in the pit, but they gave no evidence of luminosity. Dr. M. H. Gordon, M.D., suggests that before excluding a biological factor special media should be tried. This we hope to do.

X. *A Catalogue of Destructive Earthquakes.*

(Still in preparation; see 'B.A. Report,' 1908, p. 78.)

During the last twelve months, as opportunity presented itself, additions have been made to a catalogue of destructive earthquakes commenced in 1907. Very many entries have been made from 'I Terremoti d'Italia,' by Mario Barata. The catalogues of C. W. C. Fuchs published in the 'Mineralogische und Petrographische Mitteilungen' have been an assistance in extending those of Alex. Perrey; while translations from Tung-Hwa-Lu, by Professor E. H. Parker (see p. 62), have extended the catalogue of Chinese earthquakes contained in the 'British Association Report,' 1908, p. 82. With these additions the compilation is at present represented by about 250 typed folios.

One result towards which its analysis points relates to the synchronism of seismic activity (see p. 56).

With the expectation of finding much material which might be used in this catalogue, I wrote to Comte F. de Montessus de Ballore, at the present time in Chile, asking whether it would be permissible to use his compilation of earthquake registers now stored at the Société de Géographie, 184 Boulevard Saint-Germain, Paris. He most willingly put this at my disposition. The catalogue is composed of about six hundred parts, which are in MSS. and in the language of the country to which they refer. They occupy a length of 26 metres of bookshelves, and for the convenience of those who wish to make researches a catalogue is provided. I understand from Comte Montessus that a number of destructive earthquakes which are recorded are but little known and difficult of access. Dr. F. Du Bois, who takes a practical interest in seismology, suggests that when using the Montessus catalogue it may often be necessary for the particular purpose in view to seek for details in the original works on which it is founded. The following are a few examples of the entries:—

1597, July 23, Perth and other parts of Scotland, Thompson's 'Annals of Philosophy,' vol. viii. p. 365; Mallet, 1852, p. 66.

1845, August 7, 14h. 15m., A. Comrie (Ecosse), 1 secousse violente; MacFarlane; Perrey Cat. 1845-46, p. 407, 13h. 15m., &c.

1880, November 28, 17h. 30m., Scotland Proc. Roy. Soc. Edinb. XI., pp. 176-187, followed by observations . . . at different places. Remarks extend over twelve pages of MS.

XI. *Developing, Fixing, and Copying a Film.*

The developer is made up as follows:—

Metol-hydroquinone Developer.

Metol	30 grains or	7.0 grammes.
Hydroquinone	60	14.0 "
Sodium Sulphite (cryst.)	1 oz. "	100.0 "
Sodium Carbonate (cryst.)	1 "	100.0 "
Water	20 "	2000 c.c.

For use, dilute with an equal volume of water.

The bromide paper after removal from the drum is rolled up film side inwards. A small quantity of dilute developer is put into a half-plate dish, then commence to unroll the film in the dish and at the same

time roll up the portion that has passed through the developer. Repeat this rolling and unrolling until development is complete. It is then transferred to a solution of hyposulphite of soda (1 hypo to 4 water) for about ten to fifteen minutes. The record is then washed, &c.

Any particular portion of a film may be reproduced by photographic printing. For the latter process place the film with its back on a piece of glass or the glass face of a printing frame. A piece of bromide paper is placed with its sensitive surface in contact with the film, and over this a strip of wood or the back of the printing frame, when the whole four are clamped together with spring clips.

This is held up to the light of an oil lamp or an ordinary gas-burner at a distance of 18 inches for about 10 seconds. Next it is developed in a little fresh but dilute developer. If the developer appears too strong, add water and a few drops of a 10-per-cent. solution of bromide of potassium. Too long exposure causes the parts which should be white to become grey. A weak acid bath (citric acid 1 part in 40 of water) tends to remove stains. In warm climates a saturated alum bath may be used. If blisters appear, weaken the hypo-bath.

XII. *Catalogue of Chinese Earthquakes, A.D. 1638-1891.*

By Professor E. H. PARKER.

The facts contained in the following Register are extracted, and in most cases are word for word translations, from the 'Tung-Hwa-Lu,' a well-known work which gives textually an account of most of the important disasters, prodigies, decrees, and memorials, &c., as news arrives day by day at the Peking Court of the reigning Manchu Dynasty. The list may be regarded as a continuation of the catalogue published in the Reports of the British Association for 1908. Neither of these lists is to be looked upon as complete, but if it were possible to refer to the local records of the various provincial cities each list might be considerably extended. The rendering of Chinese names follows pretty closely the system of Sir Thomas Wade, but without such extreme localisms (*e.g.*, *hsi*, *hü*, *chi*, *chü*, instead of *si*, *hi*, *tsi*, *tsü*, *ki*, *kü*) as would render these groups of initials, whether used alone or followed by a nasal final, unintelligible to persons only conversant with more southerly dialects.

Mr. Parker supplies only Chinese dates, but these have been replaced by English dates, and, it is hoped, correctly.

Catalogue.

- | | | |
|--------|-----------|---|
| 1639 | Jan. 4. | 'Earthquake' (evidently in the Mukden region). |
| 1643 | Mar. 24. | 'Earthquake from N.W. corner to S.E. with sound' (evidently S. Manchuria-N. Corea region). |
| 1643 | Nov. 12. | 'Earthquake between 9 and 11 A.M. from N.W. to S. with sound' (evidently in S. Manchuria region). |
| 1644 | April 14. | 'Earthquake at Mukden.' |
| 1644 | April 16. | 'Again quaked' (<i>i.e.</i> , two days later; evidently Mukden). |
| 1649 | Nov. 10. | 'Earthquake at the Metropolis' (evidently Peking, probably end of December). |
| 1652-3 | | Ditto (probably end of January or beginning of February, 1653, the ninth year of the reign covering the greater part of 1652). |
| 1653-4 | 'Relief,' | 'When his Majesty returned to the Palace: this night there was an earthquake with sound' (probably January 1654. I cannot think why 'relief' or 'alms' should precede statement). |

- 1654 June 6. 'Earthquake at the Metropolis' (*i.e.*, Peking).
 1654 July 21. 'There were earthquakes at the Fu (cities) of Si-an, Yen-an, P'ing-liang, K'ing-yang, and Han-chung in Shen Si' (province; possibly this means 'we heard this day at Peking about it').
- 1654 between 'Earthquake with sound, at the *hien* (cities) of Kwan-ch'eng, Sept. 10 and 15. Fan, Ch'ao-ch'eng, Yang-kuh, and at the *chou* (city of) P'uh in Shan Tung (province of).'
- 1655 June 9. 'Exemption of the fixed taxes granted to the five Shen Si, *fu* of Yen-an, &c. (see above) on account of damage done by the earthquake.'
- 1655 June 22. 'Earthquake with sound at Ling-k'iu *hien* in Shan Si' (province).
 1656 Aug. 1. 'Earthquake with sound at Kū-shou in Shan Tung (province).'
- 1657 Mar. 2. 'Earthquake at Yün-chên in Shan Si (province), with sound.'
 1657 June 11. 'Big earthquake at the two *chou* of Wei and Mao belonging to the *fu* of Pao-ning in Sz-ch'wan (province).'
- 1665 April 16. 'Noon (*i.e.*, 11-1), earthquake with noise at the Metropolis.'
 1668 June 11. 'Earthquake at the Metropolis.'
 1669 Sept. 27. 'Earthquake at the Metropolis with noise.'
 1673 Oct. 18. Ditto.
 1679 Aug. 11 or 22. 'Earthquake at the Metropolis; commands to the Ministers, &c., to examine their consciences, as also the provincial high authorities, &c., stating what they may consider to be defects, or the reverse, in Government.'
- 1679 Oct. 11. 'His Majesty, on account of the earthquake, goes at the head of his princes and ministers to pray at the Altar of Heaven' (outside gates, where British troops encamped, 1900).
- 1682 Oct. 10. 'Earthquake at the Metropolis.'
 1687 Oct. 17. Ditto.
 1688 Oct. 3. 'Earthquakes at places in Hoh-k'ing and Kien-ch'uan in Yün Nan. His Majesty orders quick relief in rice and money to be sent.'
- 1692 June 12. 'Kalends. The President, Ma Tai, charged with the duty of conveying relief to P'ing-yang, &c., in Shan Si, asks instructions. His Majesty orders: "You may command Governor Galdu in view of the fact that houses have been destroyed by an earthquake, and people crushed to death, that he ought personally to have repaired to the places concerned and established a compound for residences in succour of the people who are victims to the disaster, awaiting my further orders. Instead of that he takes upon himself to go back to his capital—an exceedingly improper proceeding. Apart from what Galdu says in his own report, you must make careful inquiry and compare notes yourself, distributing our gracious relief. The land tax for this year will not be collected there at present. When you get there, at once issue a proclamation explaining to the people how deeply his Majesty the Emperor feels for them, and stating that he has specially sent a high officer to relieve them; also that they must not foolishly think of migrating and thus losing their homes. Further, as evil-disposed persons and the Brigadier's troops may take advantage of the earthquake to rob and harass the people under this or that pretext, you must order the Brigadier-General, Chou Fu-hing, to proceed in person with the Government troops under his command to take good precautionary measures in the whole region concerned. As to the victims of the disaster in Hung-tung *hien* under P'ing-yang *fu*, you must go thither in person in company with the Governor Galdu, and administer relief, seeing that all share in *bonâ-fide* kindness."
- 1696 Jan. 21. 'In view of the (last mentioned) Shan Si P'ing-yang *fu* earthquake, the following manifesto to the Empire is given out:— (A long philosophical discussion on 'destiny,' &c., and relief from land tax, &c.)
- 1696 Feb. 3. 'Slight earthquake at the Metropolis.'
 1696 Oct. 23. Ditto.
 1696 Dec. 10. Ditto.
 1697 Dec. 29. Ditto.

- 1700 Mar. 12. 'Earthquake at the capital of Kwei Chow (province).
 1702 Dec. 7. 'Slight earthquake at the Metropolis.'
 1705 Oct. 19. Ditto.
 1706 March 24. Ditto.
 1713 Aug. 13. 'Earthquakes at Mao *chou* and at the P'ing-fan Camp in Sz-Ch'wan. Relief distributed.'
 1718 July 31. 'Earthquakes at places belonging to the *fu* (cities) of P'ing-liang and Kung-ch'ang in Shen Si. Two high officers (named) sent to distribute relief.'
 1718 Sept. 22. 'Emperor alludes to (? same) earthquake in Chwang-liang and other places, and lets off the land taxes, &c., for next year in Shen Si and Kan Suh provinces.'
 1720 July 25. 'Emperor says that having heard of the earthquakes at Pao-an (*fu* in Chih Li) Hwai-lai (N.W. of Peking), &c., he now sends high officer (named) to these parts to examine with a view to relief.'
 1721 Jan. 14. 'Alludes in decree to last year's earthquake in Shen Si province, and damage to people; also to this year's earthquake at Sha-ch'eng (N. of Peking, where commissioners sent as above), and even slight earthquakes at Peking.'
 1730 Oct. 12. 'On account of the earthquake, the soldiers of the eight banner corps were given 30,000 ounces of silver each banner for house repairs, and each banner detachment in the Yüan-ming-yüan (park N.W. of Peking) 1,000 ounces.'
 1730 Oct. 23. 'Half a year's extra official salary given to various other officials' (on the same ground as the above).
 1730 Nov. 15. ('Long heart-searching decree. Theory of Heaven's warning, &c. Emperor did not feel it because he happened to be in a boat. Evidently protected by Heaven. The earth is still ill at ease. "My late Father" used to say small shocks always followed a big shock. In 1679 (18th K II.) the shocks lasted over a month, and history says that in 1465-1487 the shocks lasted 23 days. We must *all* try to be good, I showing example.')
- 1738 Dec. 13. (Possibly Jan. 1739.) The Tartar General of Ning-hia (in Kan Suh) reports an earthquake, and that water rushes in the New Cut (a well-known ancient irrigation canal); the *hien* city of Pao-fêng has sunk away. Two hundred thousand taels given in relief from the Lan-chou (provincial capital) treasury, and a high officer despatched from Peking to superintend relief operations.
- 1739 April 13. 'The above-mentioned high officer reports that the New Cut and Pao-fêng belonging to Ning-hia (*fu*) have become a vast icy marsh, and that it is not possible to build thereon in the old style. He suggests that the two *hien* (cities) be abolished (., at that time there was also a "New Cut *hien*"), and that liberal relief be administered. Approved.' (Pao-fêng also no longer exists there.)
- 1744 (Seems to have been an earthquake, but my notes are defective.—E. H. P.).
- 1746 July 30. 'Slight earthquake at the Metropolis. Orders issued for corrective advice.'
- 1755 April 17. 'Orders given that extra liberal relief be administered to the families crushed during the earthquake last year in the two districts of Yih-mên (*hien*) and another *chou* (not mentioned by name) in Yün Nan (province).'
- 1764 Jan. 1? 'Earthquake in the five *chou* and *hien* districts of Kiang-ch'wan, &c.' (presumably Yün Nan).
- 1765 April 4? 'Earthquake at Tih-tao *chou* in Kan Suh.'
 1765 June 7. 'Slight earthquake at the Metropolis.'
 1765 Aug. 6. 'Earthquakes (? when) at the twelve *chou* and *hien* districts of Lung-si, &c., in Kan Suh.'
- 1785 May 30. 'Earthquake at the Hwei-hwei township and the Peh-yang Ho (River [? or township]) belonging to Suh *chou* and Yüh-mên *hien*.'
 1786 Aug. 7? 'Earthquake at Ili' (near Kuldja).

- 1815 Nov. 11. 'Earthquakes at places belonging to Shen *chou* and other places in Ho Nan (province). Fang Shou-ch'ou (? the Governor) ordered to show his sympathy.'
- 1820 Sept. 'During this month relief was administered *re* the earthquake damage done in Hù *chou* of Ho Nan (province).'
- 1823¹ Feb. 'During this month relief to (&c., &c., and) *re* the earthquake in seventeen *chou* and *hien* districts, Tsing-ning, &c., of Kan Suh (province).'
- 1831¹ May. 'During this month grace granted to the land-tax payments due from three *chou* and *hien* districts of Ts'z *chou*, &c., in Chih Li, and the *hien* of Ngan-yang and Lin-chang in Ho Nan *re* damage done by earthquakes.'
- 1839¹ June. 'During this month relief on account of earthquake damage to the two *chou* and *hien* districts of Lang-k'ung and Têng-ch'wan in Yün Nan, besides grace *re* payment of this year's taxes.'
- 1842 Aug. 'During this month relief to (&c., &c., and) Barkul on the High Road West, on account of earthquake damage.'
- 1849 (probably) Mar. 28. 'Liu Yün-k'o (? Governor of Fuh Kien or ? *taotai* of Formosa) ordered to institute inquiry and administer relief *re* the damage done by flooding (? tidal wave) and earthquake in the various *t'ing* and *hien* (sub-prefectures and districts) in the Northern parts of Formosa.'
- 1850² Oct. 16. Long decree *re* great earthquake on the 17th day of the 8th month within the walls of Si-ch'ang *hien* city in Sz-Ch'wan province. Public buildings, prisons, &c., all down. Many people crushed to death, including two Mandarins. Viceroy ordered to despatch a virtuous man to make inquiry and give relief. (Fund indicated.)
- 1850 Nov. 28. Decree. Sü Tséh-ch'ên (the Viceroy) reports all public buildings down, and over 20,600 persons of both sexes crushed to death. 'It is all my fault as Lord of the World. Let the Viceroy make strict inquiry, &c., &c.'
- 1852³ Aug. 17. Long decree *re* great earthquake on the 8th day of the 4th moon in the city of Chung-wei *hien* of Kan Suh. There were continuous successive shocks up to the 23rd day. The Viceroy reports over 20,000 dwellings destroyed, and over 300 killed of both sexes, besides over 400 injured. Most of the public buildings down, and much of the people's food, clothing, domestic animals, &c., crushed out of sight, so that there is great destitution. Orders for inquiry, relief, &c., &c.
- 1852 Nov. 13. Decree *re* Chung-wei earthquake. Emperor feels it. Viceroy's report received. 'Let him act in accordance with my sympathetic feelings, &c.'
- 1859 Dec. 2. Relief (? sent) to the injured and distressed people who have suffered from the earthquake at Kai-chou and New-chwang in Fêng-t'ien (S. Manchuria).
- 1870⁴ June 8. Decree. 'Then, again, Wu T'ang (Viceroy of Sz Ch'wan) represents that there has been an earthquake at Bathang, and that he is taking relief measures, &c. During the earthquake which took place this year during the 3rd moon, at and around Bathang, the flames shot forth, and numbers of the people's dwellings were crushed and destroyed. That the place in question should have suffered this disaster, indeed gives him pain,' &c., &c. (Relief steps.)
- 1872⁵ Earthquake in Shanghai (? summer).
- 1891⁵ Long description of the great earthquake in Japan.

¹ These are the *probable* months.

² '17th day of 8th month' = September 22.

³ The earthquake was probably on May 28.

⁴ The earthquake was probably in April.

⁵ These last two taken from Mr. Parker's private notes.