28. *Seasonal Distributions of Earthquakes in the World.*

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The "Index Catalogue of Epicentres for 1913–1930" recently compiled by E. F. Bellamy which contains the times of occurrence, and the co-ordinates of epicentres, of 6738 earthquakes that occurred in the world during the said period, is a storehouse of valuable material from which reliable statistics can be made relating to the occurrences of earthquakes. Although the seasonal distributions of earthquakes have been the subject of many classical studies, it may not be profitless to discuss this problem with the newly arranged materials in view.

By plotting the epicentres on maps separately, for each month, it became clear that the geographical distributions of earthquakes differ

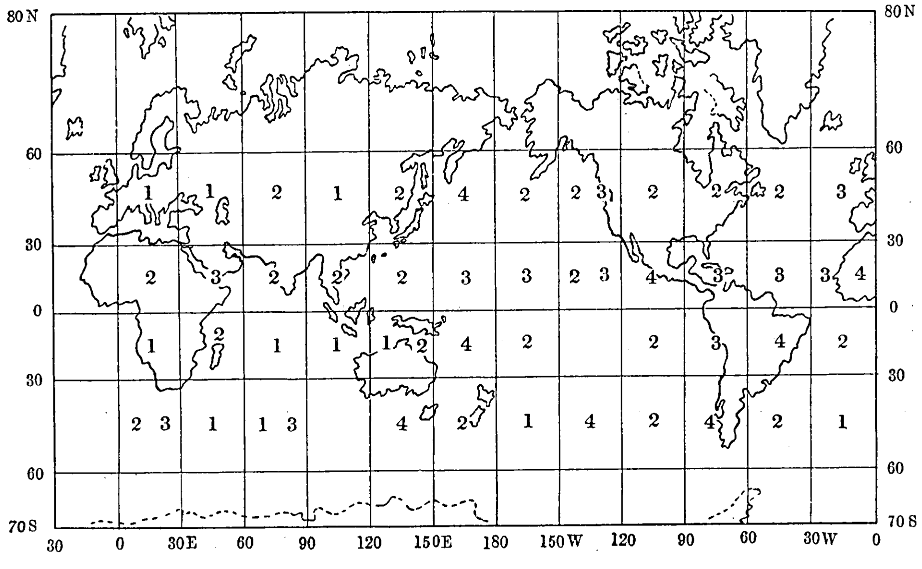

Fig. 1*a*. Season Number with Maximum Earthquake Frequency.
1: March～May, 2: June～Aug., 3: Sept.～Nov., 4: Dec.～Feb.

from month to month. The maps were divided into compartments by parallel latitudes and longitudes, which were drawn for every 30 degrees, and the number of earthquakes that fell into each compartment a month was counted. In order to see the changes in earthquake frequencies for varions times of the year, the 12 months were divided into four groups, viz. (1) March∼May, (2) June∼August, (3) September∼

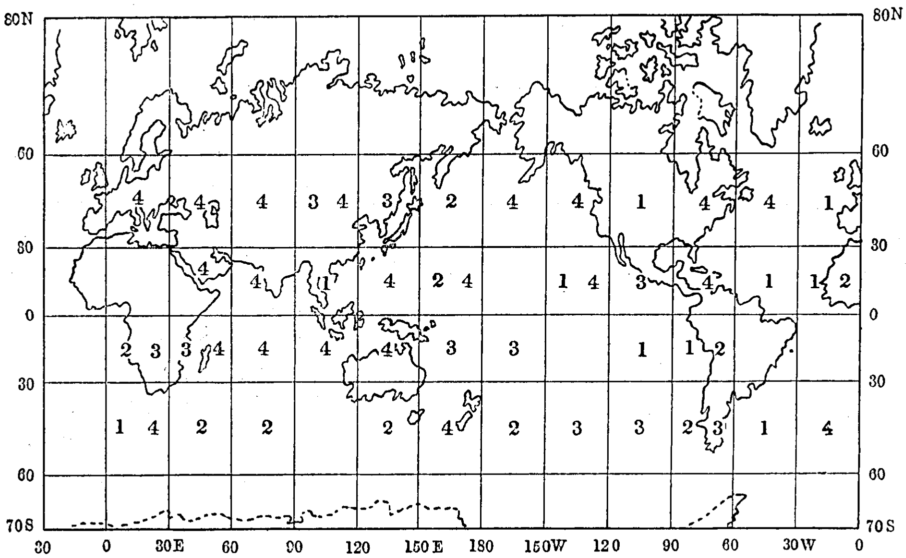

Fig. 1 *b*. Season Number with Minimum Earthquake Frequency.

November and (4) December∼February, which we shall here call seasons, in the same way that is done in the temperate zones, and the number of earthquakes for the 3 successive months belonging of that season were added to each compartment. The seasons with maximum and minimum earthquake frequencies that were found in this way are shown in Fig. 1, *a* and *b* respectively. On the average, the maximum frequency occurs in the second season of the year; to be more precise, the season number with maximum frequency seems to increase from western to eastern longitudes and from northern to southern latitudes, with the second season as the mean. In Fig. 3, the earthquake frequencies for different zones are plotted against the months: N_1, N_2, …… $N_{7\sim9}$, S_1, S_2, …… $S_{5\sim9}$ being the zones bounded by latitudes, 0°∼10° N, 10°∼20° N, …… 70°∼90° N, 0°∼10° S, 10°∼20° S, …… 50°∼90° S respectively. In Fig. 4, the earthquake frequencies for the four quadrants are also plotted against the months. In every figure, the thick lines indicate overlapping means. What is remarkable is that the curves for the NE and NW quadrants are approximately opposite in phase.

In order to get results that are likely to prove of more geophysical

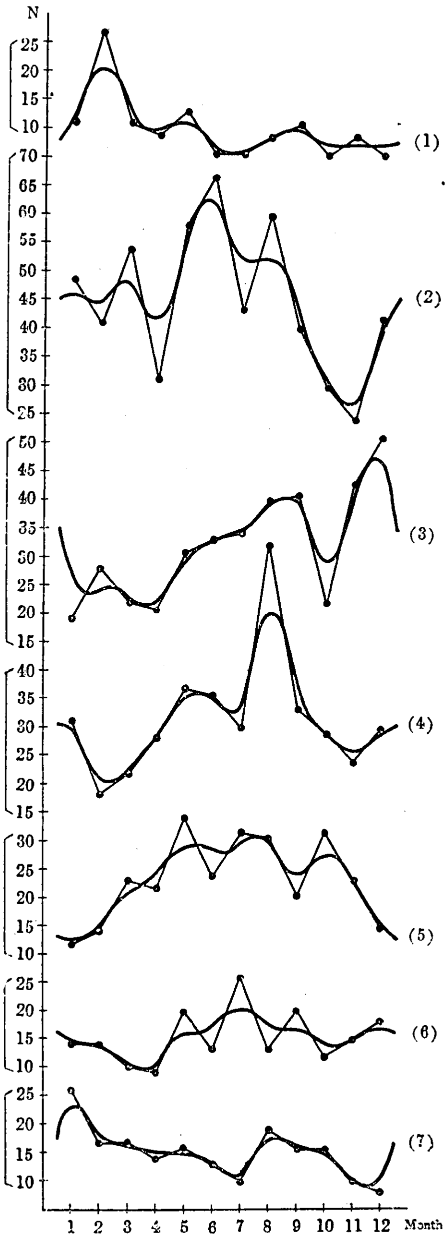

Fig. 2*a*. Monthly Earthquake Frequencies in Various Compartment along Zone, (*a*).

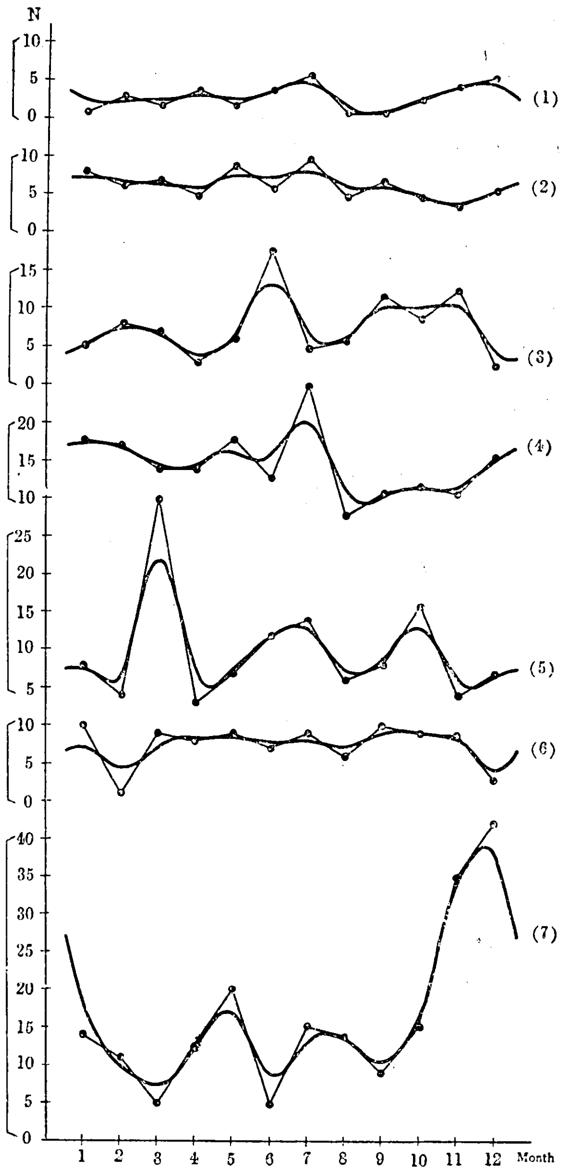

Fig. 2*b*. Monthly Earthquake Frequencies in Various Compartment along Zone, (*b*).

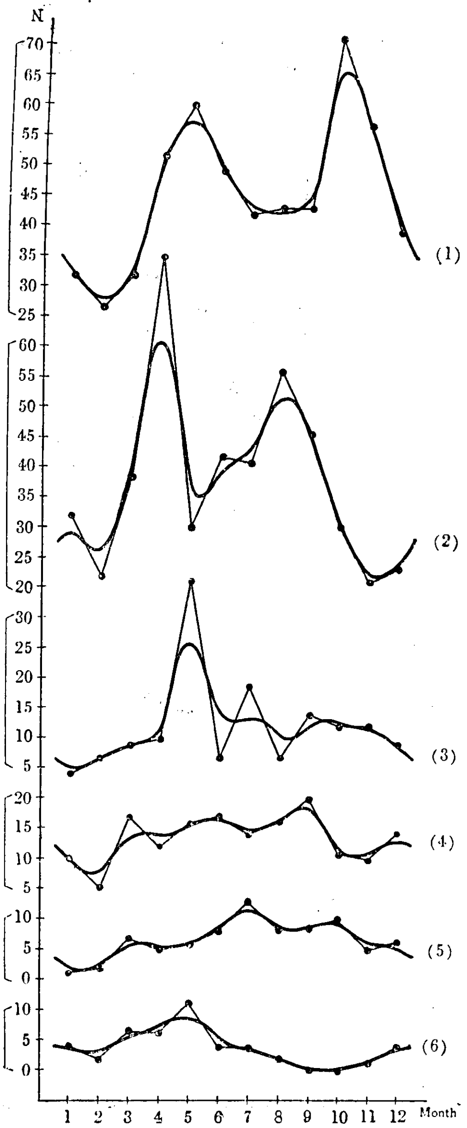

Fig. 2 *c*. Monthly Earthquake Frequencies in Various Compartment along Zone, (*c*).

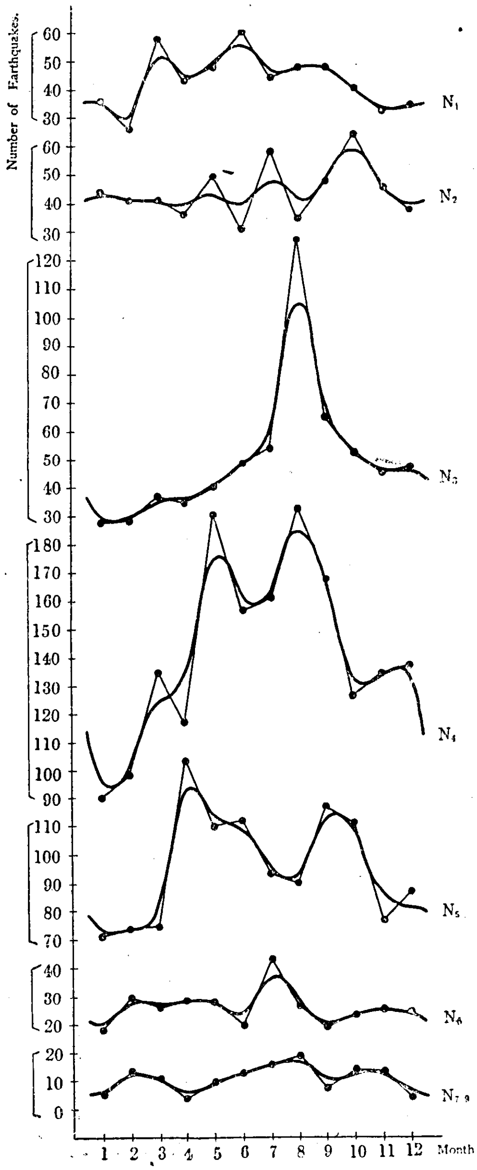

Fig. 3 *a*. Monthly Earthquake Frequencies in Various Zones in the Northern Hemisphere.

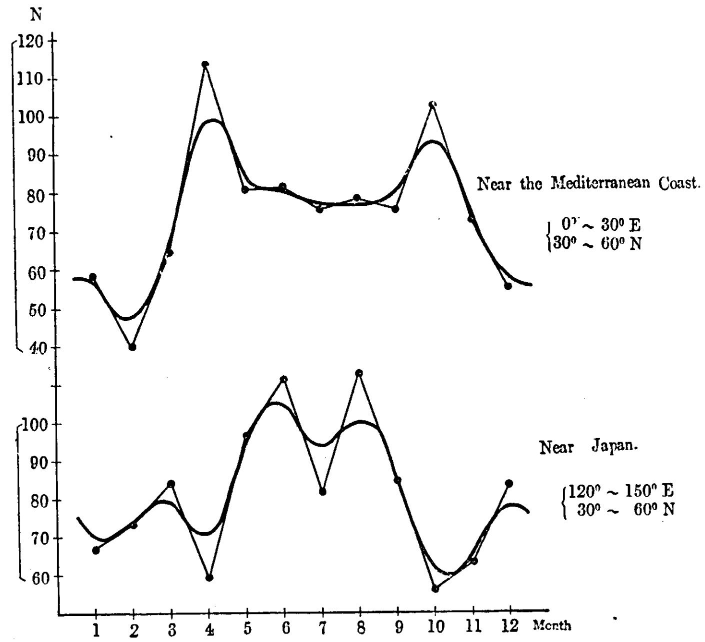

Fig. 2 *d*. Monthly Earthquake Frequencies along the Mediterranean Coast and Near Japan.

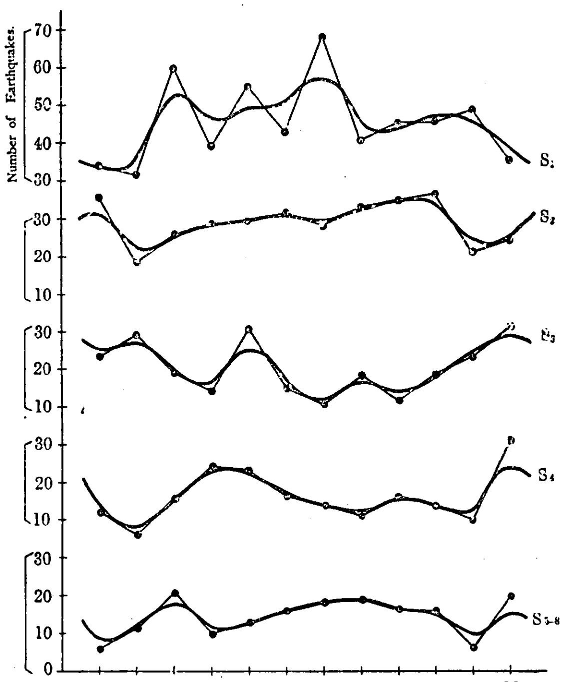

Fig. 3 *b*. Monthly Earthquake Frequencies in Vavious Zones in the Southern Hemisphere.

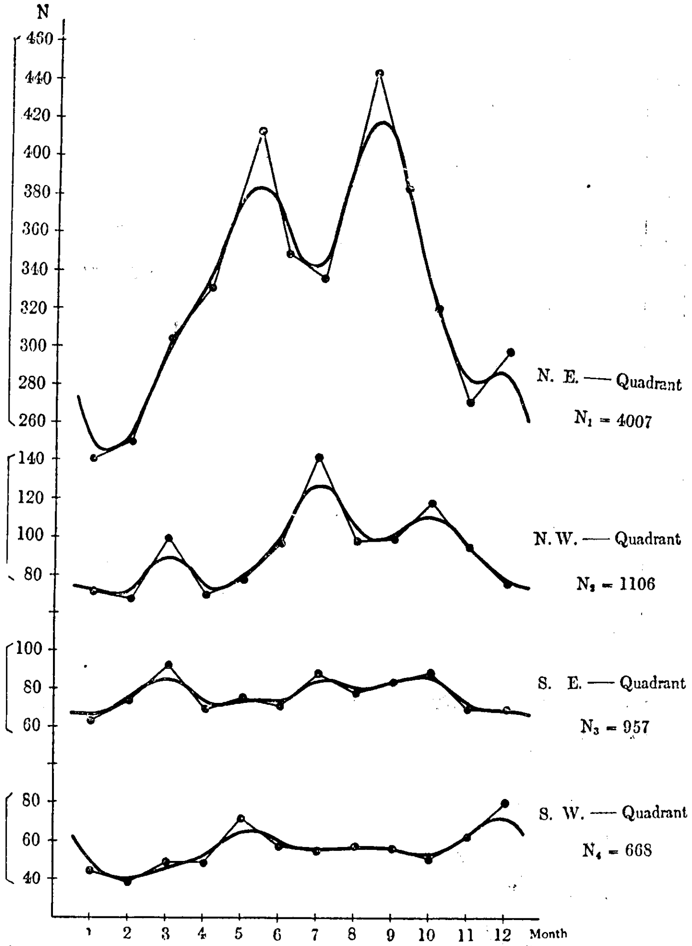

Fig. 4. Monthly Earthquake Frequencies in the Four Quadrants.

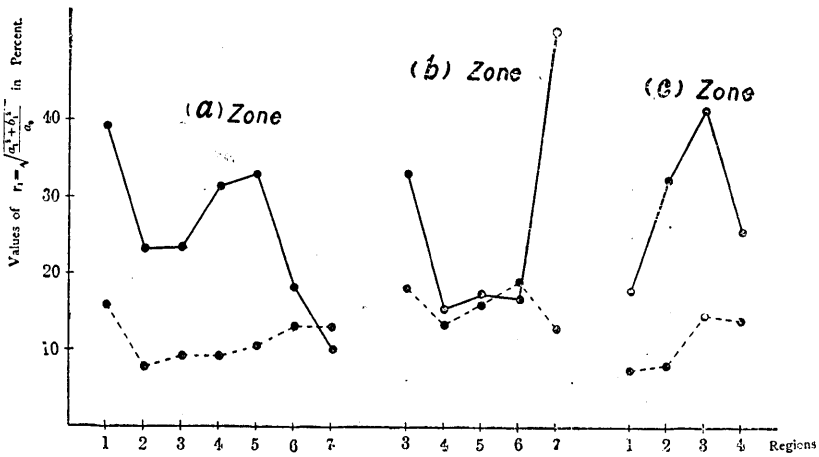

Fig. 5. Amplitudes of the Annual Term (Full Line) and Corresponding Expectancy (Dotted Line).

significance, three zones *a*, *b*, *c* were taken along the three principal earthquake belts, each of these zone being divided into several compartments as shown in Fig. 8. Zone (*a*) runs along Japan, the Philippines, and Australia, Zone (*b*) along the Pacific coast of North and South America, while Zone (*c*) runs along the Mediterranean coast of Eurasia. In Fig. 2. the earthquake frequencies for each of the small compartments are plotted against the months. It is notable that the curves for Japan and for the Mediterranean coast are opposite in phase.

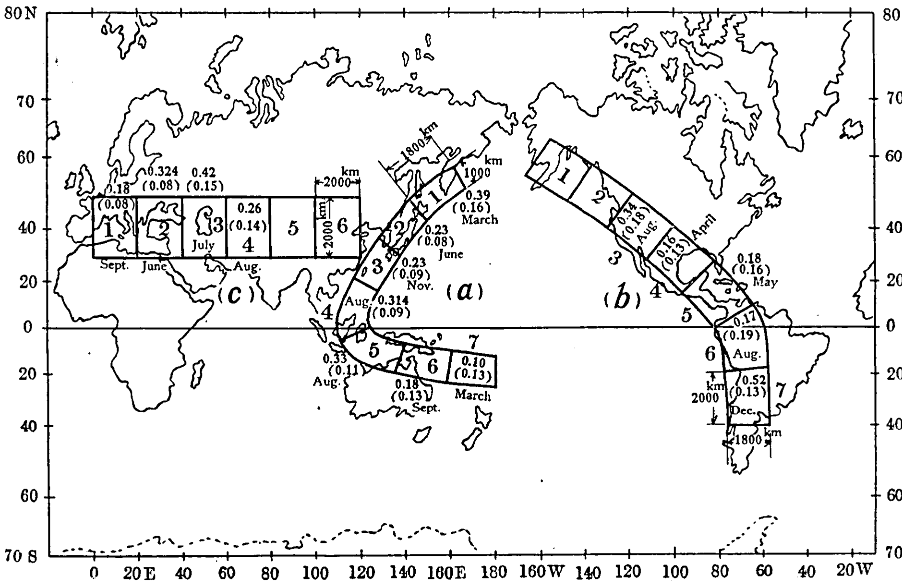

Fig. 8. Divisions of Compartments, Month with Maximum Earthquake Frequency, Amplitude of Annual Term, Expectancy (Bracket).

In order to get more concrete results, Fourier's analysis was resorted to in arriving at the annual distributions of earthquake frequencies. Given 12 values, of monthly frequencies, the Fourier coefficients a_0 $a_1 \cdots\cdots a_6$, $b_1 \cdots\cdots b_5$ for the annual distribution were determined in the usual way. From the values found, the relative amplitude of the annual term $(r_1=\sqrt{a_1^2+b_1^2}/a_0)$ and the phase of maximum, $\varepsilon=\tan^{-1}\frac{b_1}{a_1}$ were calculated and plotted in Figs. 5, 6, 7. To enable a comparison of these values with what may be expected as the result of fortuitous happenings, the expectancy of the annual amplitude $r=\sqrt{\frac{\pi}{N}}$ is also shown by the dotted lines in Fig. 5, where N is the number of earthquakes taken in the calculation. In the same figure, the months with maximum earthquake frequencies are also indicated. The times of maximum

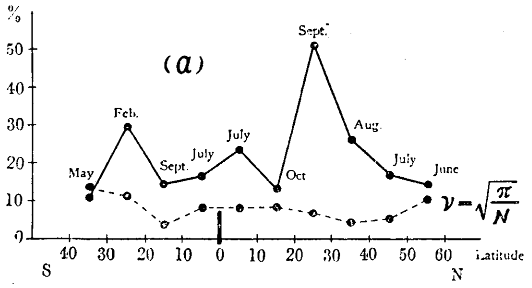

Fig. 6 *a*. Amplitudes of the Annual Term (Full Line) and Corresponding Expectancy (Dotted Line).

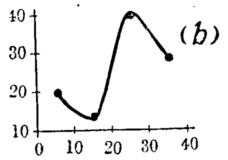

Fig 6 *b*. Mean of Amplitudes for Northern and Southern Latitudes.

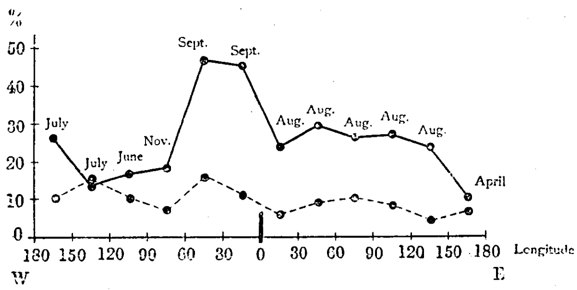

Fig. 7. Amplitudes of the Annual Term (Full Line) and Corresponding Expectancy (Dotted Line).

frequency change in the northern hemisphere from June to November, successively, according to latitudes– a succession that is too regular to be attributed to chance.

It is also noteworthy that, whereas the maximum in September takes place in N_3–zone, in February it does so in the S_3–zone, a difference of about half a year separating them.

The amplitudes of the annual term differ considerably with the particular compartments. They are large along the Mediterranean Sea, Japan, the Philippines; and also along the southern Pacific coast of South America where the amplitude exceeds four times the expectancy.

The coefficients for the higher harmonics were similarly calculated, the values $r_n = \sqrt{a_n^2 + b_n^2}/a_0$ of which will be found in Tables I and II. Certain periods seem to predominate in certain compartments, although whether this fact has any real physical meaning or not is not clear.

In conclusion, I wish to express my best thanks to Dr. C. Tsuboi, who has given me many useful suggestions in the course of these studies.

Table I. For 3 Principal Earthquake Zones.

(a) Earthquake Zone, through Japan, the Philippines, and Australia.

Regions	Coefficients in Fourier's Harmonic Analysis.												$r_n=\frac{\sqrt{a_n^2+b_n^2}}{a_0}$					$\nu=\sqrt{\frac{\pi}{N}}$
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	b_1	b_2	b_3	b_4	b_5	r_1	r_2	r_3	r_4	r_5	
(1)	10·3	1·4	- 2·7	- 2·5	- 1·8	1·05	0·17	3·8	2·3	1·5	- 3·75	- 2·3	0·39	0·34	0·28	0·40	0·25	0·16
(2)	44·8	-10·0	3·4	- 0·83	5·9	- 1·65	0·33	2·98	7·1	4·2	- 4·5	8·2	0·23	0·18	0·10	0·17	0·19	0·08
(3)	32·1	1·7	4·8	4·8	4·6	2·5	0·40	- 7·3	0·55	- 1·3	- 6·6	- 3·5	0·23	0·15	0·16	0·25	0·13	0·09
(4)	31·9	- 6·6	-20·0	6·7	18·7	- 3·1	2·4	- 7·6	3·75	4·2	- 3·75	6·3	0·31	0·64	0·25	0·60	0·22	0·09
(5)	23·6	- 6·5	- 0·7	- 0·3	- 2·8	2·4	- 0·6	- 4·3	- 3·2	- 1·8	- 0·6	3·5	0·33	0·14	0·08	0·12	0·18	0·11
(6)	15·3	- 1·3	2·4	0·2	- 0·1	3·6	- 2·2	- 2·5	1·6	0·5	- 0·15	- 1·97	0·18	0·19	0·04	0·01	0·27	0·13
(7)	15·2	0·61	- 2·34	- 0·83	- 1·67	- 2·28	- 0·67	1·4	2·3	3·5	0·6	2·6	0·10	0·22	0·24	0·12	0·23	0·13

(b) Earthquake Zone, Through North America, Central America, and South America.

Regions	Coeficients in Fourier's Harmonic Analysis.												$r_n=\frac{\sqrt{a_n^2+{}_n^2}}{a_0}$					$\nu=\sqrt{\frac{\pi}{N}}$
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	b_1	b_2	b_3	b_4	b_5	r_1	r_2	r_3	r_4	r_5	
(3)	7·9	- 1·73	0·58	- 3·83	2·08	- 1·94	- 0·08	- 1·99	- 1·01	- 0·33	- 1·59	- 0·84	0·34	0·15	0·49	0·33	0·27	0·18
(4)	14·8	- 0·93	2·42	- 0·67	- 1·25	3·1	- 1·42	2·09	1·87	- 0·5	2·16	- 1·09	0·16	0·21	0·06	0·17	0·22	0·13
(5)	9·9	- 1·22	- 5·58	- 2·67	7·08	1·38	- 1·92	1·25	0·29	- 4·17	2·89	5·58	0·18	0·56	0·50	0·77	0·58	0·16
(6)	7·5	- 0·86	- 0·42	0·0	- 0·25	- 1·15	- 1·83	- 0·95	- 1·3	0·33	1·59	0·78	0·17	0·18	0·04	0·21	0·19	0·19
(7)	16·5	8·1	8·1	6·33	- 1·25	4·07	0·17	- 2·72	- 4·18	- 2·0	- 3·32	- 1·28	0·52	0·55	0·40	0·22	0·26	0·13

(c) Earthquake Zone, Through the Coast of the Mediterranean Sea.

Regions	Coefficients in Fourier's Harmonic Analysis.												$r_n=\frac{\sqrt{a_n^2+b_n^2}}{a_0}$					$\nu=\sqrt{\frac{\pi}{N}}$
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	b_1	b_2	b_3	b_4	b_5	r_1	r_2	r_3	r_4	r_5	
(1)	45·6	- 3·3	-13·9	- 2·2	11·1	0·47	1·25	- 7·5	-13·8	0·67	1·45	2·6	0·18	0·43	0·05	0·25	0·06	0·08
(2)	3·8	-12·3	- 8·1	1 0	- 0·75	- 7·2	3·3	0·25	- 0·73	1·3	7·1	- 2·9	0·32	0·21	0·27	0·19	0·20	0·08
(3)	12·2	- 5·1	1·8	0·0	- 2·4	6·1	- 3·5	- 0·37	- 4·8	2·3	- 2·5	0·2	0·42	0·42	0·19	0·28	0·50	0·15
(4)	13·4	- 3·03	- 0·42	1·67	3·59	- 0·14	- 1·08	- 1·78	- 0·58	0·83	0·0	1·11	0·26	0 05	0·14	0·27	0·08	0·14

Table II. For Various Latitude Zones, and Various Longitude Sectors.

(a) Latitude Zones.

Zones	Coefficients in Foulier's Harmonic Analysis.												$r_n=\frac{\sqrt{a_n^2+b_n^2}}{a_0}$					$\nu=\sqrt{\frac{\pi}{N}}$
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	b_1	b_2	b_3	b_4	b_5	r_1	r_2	r_3	r_4	r_5	
N_1	43·7	- 9·9	- 1·58	- 0·17	7·08	- 2·95	- 1·17	- 1.03	- 1·3	- 0·5	1·3	5·03	0·23	0·05	0·01	0·17	0·13	0·08
N_2	44·6	1·37	- 1·58	- 4·5	- 4·58	7·14	- 3·42	- 5·32	- 2·72	- 1·0	4·46	1·32	0·12	0·07	0·11	0·14	0·16	0·08
N_3	50·8	-10·2	- 7·42	13·3	- 1·25	- 4·13	5·92	-23·9	9·68	- 0·5	-10·5	9·46	0·51	0·24	0·26	0·21	0·20	0·07
N_4	141·5	-27·8	3·08	9·5	7·91	8·84	- 5·08	-23·2	- 2·43	3·0	-19·2	9·66	0·26	0·03	0·07	0·15	0·09	0·04
N_5	96·1	-15·3	1·83	2·33	- 3·67	0·52	5·42	- 5·07	-15·0	8·83	8·34	- 7·09	0·17	0·16	0·10	0·09	0·07	0·05
N_6	26·2	- 3·68	0·25	1·0	- 3·92	4·68	- 0·5	0·57	1·59	- 4·66	0·43	- 1·74	0·14	0·06	0·18	0·15	0·19	0·10
$N_{7\sim9}$	11·0	- 2·21	- 0·75	- 1·83	- 1·75	0·07	0·5	- 2·84	1·59	- 2·84	- 2·16	1·5	0·33	0·16	0·31	0·25	0·14	0·15
S_1	45·8	- 7·1	- 0·5	- 0·83	0·5	4·43	- 6·25	- 2·3	- 2·02	- 7·0	1·45	2·3	0·16	0·05	0·15	0·03	0·11	0·08
S_2	29·1	- 1·52	- 0·75	- 0·17	0·42	- 1·81	- 0·25	- 3·72	3·9	4·0	- 0·14	3·22	0·14	0·14	0·14	0·02	0·13	0·03
S_3	20·5	4·75	3·33	0·17	- 1·0	3·59	0·67	3·7	- 0·87	2·17	- 4·9	1·97	0·29	0·17	0·11	0·24	0·20	0·11
S_4	16·3	- 1·08	2·84	4·83	4·0	3·25	0·92	1·47	- 4·04	2·0	2·02	0·03	0·11	0·30	0·32	0·28	0·20	0·13
$S_{5\sim9}$	14·7	- 1·78	0·25	0·67	2·08	3·12	0·92	- 1·77	1·3	- 1·5	0·14	2·26	0·17	0·09	0·11	0·14	0·26	0·13

(b) Sectors Bounded by Longitudes.

Sectors	Coefficients in Foulier's Harmonic Analysis.												$r_n=\frac{\sqrt{a_n^2+b_n^2}}{a_0}$					$\nu=\sqrt{\frac{\pi}{N}}$
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	b_1	b_2	b_3	b_4	b_5	r_1	r_2	r_3	r_4	r_5	
E_1	65	-12·7	- 5·58	4·83	- 4·92	- 5·16	16·4	- 8·22	-16·3	- 0·33	10·5	1·88	0·23	0·27	0·03	0·19	0·09	0·06
E_2	34·1	- 8·64	- 4·75	1·5	- 2·58	6·63	- 3·25	- 5·0	- 6·5	9·0	- 0·14	2·5	0·29	0·24	0·27	0·08	0·21	0·09
E_3	24·7	- 5·63	8·66	0·67	- 7·83	4·46	- 2·0	- 3·24	- 1·16	- 3·33	1·45	3·4	0·26	0·35	0·14	0·32	0·23	0·10
E_4	40·4	- 8·56	- 2·0	9·17	2·84	4·38	- 0·25	- 6·58	2·88	0·33	- 3·75	6·41	0·27	0·09	0·23	0·12	0·19	0·08
E_5	176	-33·7	- 1·17	8·5	13·0	- 6·83	2·66	-22·1	12·5	1·83	-22·6	16·9	0·23	0·07	0·05	0·15	0·10	0·04
E_6	48	- 0·37	- 3·08	- 3·33	- 1·75	0·21	- 2·67	4·6	5·06	5·5	- 6·21	- 2·6	0·10	0·12	0·13	0·13	0·05	0·07
W_1	23·2	- 2·72	- 3·25	0·33	- 0·92	1·88	2·5	-10·1	1·3	- 1·33	- 2·45	1·75	0·45	0·15	0·06	0·11	0·11	0·11
W_2	10·1	- 0·13	- 1·25	2·17	0·92	2·47	- 0·25	- 4·69	1·59	- 2·0	1·01	- 1·81	0·47	0·20	0·29	0·14	0·30	0·16
W_3	45·6	6·02	0·92	- 0·83	3·42	6·32	- 5·42	- 5·78	- 3·02	- 7·66	1·58	4·62	0·18	0·07	0·17	0·08	0·17	0·08
W_4	25·5	- 3·78	5·83	- 3·33	2·5	- 0·89	- 1·83	2·16	2·9	- 1·0	1·17	- 0·16	0·17	0·26	0·14	0·11	0·04	0·10
W_5	12	- 1·41	2·34	- 2·84	0·0	- 0·26	- 0·83	- 0·74	- 0·58	- 2·83	0·58	0·41	0·13	0·20	0·33	0·05	0·04	0·15
W_6	27	- 6·83	4·08	- 0·67	- 0·25	2·99	0·67	- 1·39	- 2·45	- 2·33	2·45	0·06	0·26	0·18	0·09	0·09	0·11	0·10

28. 世界地震の季節的分布

地震研究所 山口生知

1913年から1930年に至る滿18年間に世界中に起つた6738個の主なる地震に就いて其地方的並に季節的分布を調べて見た。

其結果或る特定の場所に於いては或る季節に地震の起る回數が非常に多く，又或る他の特定の場所に於いては地震の起る回數が少ないと云ふことは面白いことゝ思ふ。殊に南緯北緯共20° から 30° の間の所に地震回數の最大があり，而も北半球に於いては九月に，南半球に於いては約半年の差を有する二月に最大回數を有すると云ふことは著しい事實であつて，之には何か或る物理的意義の存在することを暗示するものと思はれる。

概して世界中を通じて夏季に地震回數の最大になる傾向が見受けられる。

又各地に於ける地震回數の月々の分布を見ると日本附近に起る地震と地中海沿岸に起る地震とは位相が反對であり，又全世界を四つの象限に分けると北東の象限と北西の象限に起る地震とは位相が互に反對である傾向を認める

各地の地震を夫々十二ケ月に分けて調和分析を試ると，場所に依つては一年週期の外に，半年週期及び三ケ月週期の目立つ場所も有る樣に思はれる。これは更に將來の研究を待つことにしたいと思ふ。