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# TIMES OF TRANSMISSION
## OF EARTHQUAKE WAVES

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### I. — INTRODUCTION

The times of transmission of the P and S waves recently given by one of us for distances up to 105° seemed, as far as one could judge from the residuals, to be reliable within about a second. A rediscussion of the available earthquakes has now been undertaken. The original objects were to ascertain whether the earth's departures from symmetry, especially the difference between continents and oceans, have any seismic effects, and to obtain empirical tables for the various derived waves, including those reflected at the surface and those influenced by the central core. It was expected that the reflected waves would give information about the depth where reflexion takes place.

The method adopted previously for P and S was based on a classification of the residuals given in the International Seismological Summary according to amount and distance, means being taken for the residuals in each range of distance after the numbers of observations in the various groups had been corrected to allow for abnormal observations. The residuals, however, depended on the I. S. S. epicentres and times of occurrence, which in turn depended on the Zöppritz-Turner tables used in the I. S. S. reductions. It has consequently been suspected (notably by Miss I. Lehmann and Dr E. A. Hodgson) that since these parameters were chosen to give the best possible fit with the Z. T. tables, the errors of these tables would persist in the corrections inferred. Some discussion will therefore be needed of the grounds for this suspicion, which will be seen to be partly justified.

1. 1. The problem of the determination of time curves may be considered in the first place as one of least squares. Suppose that the number of parameters needed to determine the times to the requisite accuracy is $n$. These parameters may be the times to a finite number of distances, sufficiently close for the times to intermediate distances to be derived by linear interpolation ; or, if the curve is smooth enough to be represented by a polynomial, they may be the coefficients in that polynomial. It appears that $n$ is about 50. For each earthquake, further, there are three parameters relevant to that earthquake alone, namely, the latitude and longitude of the epicentre and the time of occurrence. If depth of focus is considered this number must be increased to four. If then we have $m$ earthquakes, the total number of parameters to be found is $3\,m + n$. If the average number of observations for each earthquake is 100, we have $100\,m$ equations of condision, which have to be adjusted by the method of least squares. But the formation and direct solution of about 350 normal equations mean an entirely prohibitive amount of labour.

We can however proceed by a method of successive approximation, which has a wide, though not a general, application. Suppose that the quadratic form

$$\tfrac{1}{2}\, a_{rs}x_r x_s - e_r x_r \tag{1}$$

is to be made a minimum, the summation convention being understood. The normal equations are

$$a_{rs}x_s = e_r \tag{2}$$

and the formal solution is

$$A x_m = A_{rm} e_r \qquad (3)$$

where $A$ is the determinant of the $a_{rs}$ and $A_{rs}$ is the minor of $a_{rs}$ in it. But we may proceed as follows. In each equation we transfer all terms but one to the right, thus :

$$a_{rr} x_r = e_r - \Sigma' a_{rs} x_s \qquad (4)$$

where the summation includes now all values of $s$ except $r$. We first omit all the $x_s$ on the right and obtain the first approximations

$$x_r = e_r / a_{rr}. \qquad (5)$$

We substitute these in the right side of the equations and obtain a second approximation, and proceed by iteration. If the process is convergent we obtain the required solution. The method is equivalent to expanding $A_{rm}/A$ in descending powers of the elements of the leading diagonal, and will succeed provided the other elements are small enough. If there are only two equations,

$$A = a_{11} a_{22} - a_{12}^2 \qquad (6)$$

and $1/A$ converges provided $a_{12}^2$ is less than $a_{11} a_{22}$ ; that is, provided the form $a_{rs} x_r x_s$ is essentially positive, and this condition is always satisfied. If however there are more than two unknowns, the condition that $a_{rs} x_r x_s$ is essentially positive is not sufficient. For let us consider the form (suggested to us by Mr M. H. A. Newman)

$$\tfrac{1}{2} (x_1^2 + x_2^2 + x_3^2) + k (x_2 x_3 + x_3 x_1 + x_1 x_2),$$
$$= \tfrac{1}{2} k (x_1 + x_2 + x_3)^2 + \tfrac{1}{2} (1 - k)(x_1^2 + x_2^2 + x_3^2) \qquad (7)$$

which is essentially positive if $0 < k < 1$. Then

$$A = \begin{vmatrix} 1 & k & k \\ k & 1 & k \\ k & k & 1 \end{vmatrix} = 1 - 3k^2 + 2k^3 = (1 - k)^2 (1 + 2k) \qquad (8)$$

The expansion of $1/A$ in ascending powers of $k$ diverges if $k > \tfrac{1}{2}$. The method is therefore not general except for the case of two unknowns ; but it is clear that there are many cases where it will succeed.

We see that our first approximations to the $x_r$ are simply the values of each on the supposition that the others are zero ; and that by repeating the process we may arrive at the correct solution of the normal equations. Now it appears that this is what has been partially carried out. The I. S. S. epicentres and times of occurrence being found on the basis of the Z. T. tables, the mean residual in any range of distance is the first approximation to the correction needed by the tables in that range of distance. It is not, however, necessarily the final correction, because we should then have to use the corrected tables to obtain corrections to the epicentres and $T_0$, and then reclassify the residuals to get second approximations, the process stopping when the results repeat themselves.

Now three parameters for each earthquake are special to that earthquake alone, and do not enter into the normal equations in products with the corresponding parameters for other earthquakes. Hence if we have a preliminary time curve we can obtain approximations to these parameters by considering each earthquake separately. In this way we avoid the task of having to form and solve 350 simultaneous normal equations. On the other hand, with each approximation to the time curve, every shock has to be discussed afresh.

The process just outlined will clearly give most rapid convergence if the coefficients $a_{rs}$ are small for $r$ and $s$ unequal. In the extreme case where the determinant A vanishes, one of the unknowns can be assigned arbitrarily, and the solution fails altogether. This case can arise in our problem. Suppose that we have stations to north and south of the epicentre, all within 10° of it, but that there are no stations to the east, and those to the west are all at distances over 60°. Then with an approximate time curve we can obtain a determination of the epicentre by least squares ; but it gives no further information about the corrections to the time curve. If the times at distances over 60° need positive corrections, the epicentre determined will be further east than the true one, and we have no means of checking this. To obtain a determination useful for our purpose, there must be stations in three different directions at nearly the same distance; since otherwise the epicentre can be chosen so that the observations will fit any tables within a certain range. If however the time curve is well determined this condition is no longer necessary.

1. 2. The preliminary time curves used in the present investigation were those recently published [1] (henceforward referred to as the J. tables). P alone was used in fixing epicentres, since there was a doubt about the identification of S in some ranges of distance, especially between 10° and 20°, and over 80°. The uncertainty of an S observation is in any case greater than that of a P observation, even when there is no doubt about the identification. The difference S-P is quite unsatisfactory, because it involves the errors of both S and P, and is less sensitive to variations of distance than is P. This was not true formerly, when a large part of the residuals was due to clock errors, which affect S and P equally, but it appears now that at the majority of the stations reporting regularly the clock errors are small. The earthquakes considered were, in the first place, those used in the previous investigation; to these were added others up to March 1929 from numbers of the I. S. S. published later, and two later ones from special studies. They were found to fall into the following groups, according to the position of the epicentre.

1. The Mediterranean region and Central Asia. These are henceforward referred to as 'European' shocks, not so much from the positions of the epicentres as because they have many of the European stations at distances under 30°.

1. British Association, Gray-Milne Trust, 1932.

2. North and Central America. These are comprehensively referred to as 'North American'.

3. South America.

4. Japan, with the island arcs to the north and south.

5. The Pacific and Indian Oceans. These are generally described as 'Oceanic'.

6. The North Atlantic.

It appeared that only the first two groups were of much use in determining the P curve. In them it was usually possible to find good stations in at least three widely different azimuths at short distances. In the South American shocks the distribution was less good and the near stations fewer, but they were retained to give additional information about P at distances over 95°, and about the derived waves. In the Japanese shocks there were many near stations to NE and SW, but seldom any to NW and SE, the nearest being usually Irkutsk and Honolulu, and even these were often not available. Consequently an error in the tables at distances of 30° and more would be masked by a displacement of the epicentre in a northwesterly direction, and would escape detection. In the Oceanic shocks there was usually a dearth of near stations, and the epicentre had to depend largely on the more distant ones. These however were of first-rate importance in studying the times of the waves that travel through the central core, since the European stations observe them. The few North Atlantic shocks also have the American and European stations at different distances, so that the epicentres cannot be found until the P curve has been corrected. On the other hand when the P curve has been found from the first two groups, it can be used to find the epicentres of the others, and we can then proceed to determine the other curves. In the Japanese shocks there are stations to NE and SW over a fair range of distance, and the times at these are on the whole unaffected by the uncertainty of the displacement of the epicentre at right angles to this direction ; hence those shocks will give independent information about the times of P at short distances.

The three parameters associated with each earthquake are the latitude and longitude of the epicentre, with a moment of time $T_0$. The latter is to be chosen so that $T_0$ + the tabular time of transmission of a pulse to distance $\Delta$ is the actual time of arrival. The tabular times involve an additive constant which can be assigned by convention. The convention we choose is that the times of P for small $\Delta$ shall be proportional to $\Delta$. Il another convention is chosen, such as that $T_0$ is to the actual time of the shock, the tabular times will differ for each earthquake, the differences depending on the focal depth. But so long as the focus is within the upper layers the difference varies little with $\Delta$, and since we have to combine a number of earthquakes it appears best to choose a convention that enables us to absorb this unknown correction into $T_0$. The method of determining the parameters was as follows. The I. S. S. gives the observed times of arrival after subtracting an estimated $T_0$. From these differences, recorded as P, the tabular times from the J. tables were subtracted, giving a series of residuals $P_\mu$, which were in most cases found to show some correlation with azimuth, implying a need for a displacement of the epicentre. These residuals were then plotted roughly on a polar diagram and divided into groups according to azimuth. If then the epicentre needs an angular displacement $x$ to the south and $y$ to the east, and the azimuth of the station is $\alpha$, measured from north through east, the true distance is

$$\Delta = \Delta_0 + x \cos\alpha - y \sin\alpha \qquad (9)$$

where $\Delta_0$ is the I. S. S. estimate of the distance. If the I. S. S. estimate of $T_0$ needs an increase Y, the equations of condition are

$$Y + T_p (\Delta_0 + x \cos\alpha - y \sin\alpha) - T_p (\Delta_0) = P_\mu \qquad (10)$$

or, to the first order,

$$Y + \left(\frac{dT_p}{d\Delta}\right)_{\Delta_0} (x \cos\alpha - y \sin\alpha) = P_\mu \qquad (11)$$

These could be solved by least squares; but it was more practicable to group the stations according to azimuth and distance, such that mean values of $dT_p/d\Delta$ and $\alpha$ could be significantly taken for each group. Then each group was averaged in the form

$$Y + \left(\frac{dT}{d\Delta}\right)_{\bar{\Delta}_0} (x \cos\bar{\alpha} - y \sin\bar{\alpha}) = \bar{P}_\mu. \qquad (12)$$

It was found best for $x$ and $y$ to rely wholly on the nearer stations; in European shocks, those within 20°, in North American ones, within 30°. If there were three useful groups these three equations were solved directly; if more, least squares were used, each average equation as a rule receiving weight unity. The latitude and longitude of the revised epicentre were then found from $x$ and $y$, and revised distances found. In the first instance these were calculated under the supervision of Dr L. J. Comrie, the expenses being covered by a grant from the Department of Geodesy and Geophysics, Cambridge. Values of the direction cosines of the stations to four figures were computed (by K. E. B.)[1] and these were used in calculating the distances from the formulae

$$\cos\Delta = Aa + Bb + Cc \qquad (13)$$

or

$$2(1 - \cos\Delta) = (A - a)^2 + (B - b)^2 + (C - c)^2 \qquad (14)$$

The latter, recommended by Turner, was used for $\Delta < 10°$; but the former was used for $\Delta > 10°$, as it then gives $\Delta$ to 0°·1 when four-figure tables are available, and is easier to use with a calculating machine. In the later stages of the work the distances were calculated directly only for the nearer stations, the corrections at more distant ones being found either by interpolation according to azimuth, when possible, or from (9). Equations (12) give Y, and the value found from them was used for the European shocks. But for other

1. British Association, Gray-Milne Trust, 1933.

regions Y as thus found usually had a probable error of some seconds, whereas the residuals at more than half the European stations agreed within one or two seconds. It was therefore thought best to take Y equal to the mean residual at the European stations after adjusting the epicentre. This of course has the effect of altering all the residuals by the error of the tables at the European distances, but as this is nearly the same for all shocks in the same region it can be dealt with later.

With the revised distances, then, a new set of residuals $P_\mu$ were found, and from these Y was subtracted, giving $P_\nu$, the residuals after the best adjustment with the J. tables. These were then classified according to $\Delta$ and a mean found for each range of distance. These means should be the first corrections to the J. tables. A precaution was however needed since the mean residual had not been adjusted to vanish always at the same distance, and if there are errors in the tables the mean residuals found for North American and European shocks would not be expected to be the same. This difficulty was treated as follows. Suppose we have observations at distances $\Delta_1, \Delta_2, \ldots \Delta_r, \ldots \Delta_n$ and that the corresponding corrections needed by $T_p$, with our actual convention, are $y_1, y_2 \ldots y_n$. The number of observations at distance $\Delta_r$ is $m_r$ in the first series of shocks, $m_1'$ in the second. The respective means are $T_r$ and $T_r'$, which involve unknown systematic errors $a$ and $a'$. Then the equations of condition are

$$y_r + a = T_r \text{ (weight } m_r) \,;\; y_r + a' = T_r' \text{ (weight } m_r') \quad (15)$$

and the function to be made a minimum is

$$\Sigma\, m_r\,(y_r + a - T_r)^2 + \Sigma\, m_r'\,(y_r + a' - T_r')^2, \quad (16)$$

where $y_r$, $a$ and $a'$ are to be found. Hence

$$m_r\,(y_r + a - T_r) + m_r'\,(y_r + a' - T_r') = 0 \quad (17)$$

$$\Sigma\, m_r\,(y_r + a - T_r) = 0 \qquad \Sigma\, m_r'\,(y_r + a' - T_r') = 0 \quad (18)$$

The sum of the two equations (18) is the same as that of the $n$ equations (17), so that the conditions are not independent, as we should of course expect ; so we omit the second of (18). Then

$$(m_r + m_r') \, y_r = m_r \, (T_r - a) + m_r' \, (T_r' - a') \qquad (19)$$

and by substituting in (18) we have

$$\Sigma \, \frac{m_r \, m_r'}{m_r + m_r'} \, (a - a' - T_r + T_r') = 0 \qquad (20)$$

Thus $a$-$a'$ is a weighted mean of the differences of the values of $T_r$ and $T_r'$ at the various distances, the weights being $m_r m_r' / (m_r + m_r')$. Thus $a - a'$ is found and can be applied as a correction to make the two series comparable ; then they may be combined. Finally a cube formula can be found to fit the time for $\Delta < 20^o$, and the constant in this subtracted from the whole, thus making the new tabular time vanish at $\Delta = 0$ and satisfying our other convention.

The corrections obtained in this way reached — 6s. at 30° ; the J. table for P required little change up to 20°, but negative corrections were needed to about 50°, positive ones up to + 1s. as far as 70°, and negative ones at greater distances, reaching —3s. at 100°. With the corrected table the epicentres were corrected again where necessary, but the further corrections needed to the P table were negligible, and the degree of approximation needed appeared to have been attained.

1. 3. It had been thought that the comparison of the times of transmission for shocks in different regions would reveal differences for paths of the same length but under different parts of the surface ; it would be a matter of some surprise if for instance the time of P to 105°, which is about 14 minutes, should not be affected by some seconds by differences of structure. If we compare for instance the times of arrival of the waves from a European shock in North America and Japan, the distance being the same, and there is a difference in the velocities under the North Atlantic and under Eurasia, there will be a systematic difference between

the times. The possible effects of depth of focus and error in $T_0$ are thus eliminated. Unfortunately it proved that such differences of velocity, if they exist, are not the most important cause of differences in the observed times. It was found that when we compare European observations of North American shocks with North American observations of European shocks, the latter are systematically late by a few seconds ($T_0$ in each case being chosen to fit the near stations) and there seems to be no ground for attributing the difference to focal depth. It seems probable therefore that the difference is due to the European shocks being comparatively small and therefore being read systematically late at distant stations on account of the weakness of the movement. Such a systematic error may well have different values in America and in Japan ; hence we cannot disentangle the possible real difference in travel time from the systematic errors. Considering North American shocks, these are well observed in Europe, but the Japanese observations are few and irregular ; often the whole of Japan is at distances over 105°. P from Japanese shocks again is well observed in Europe, but usually at only a few American stations, and it seldom happens that the distribution of near stations is such as to give a good determination of the epicentre. Hence it was not possible to establish definitely any variation of travel time with the region traversed ; all that could be stated is that such variation, if it exists, does not exceed a few seconds, and that our only reliable source of information regarding travel times at great distances is the European observations of North and South American shocks, possibly supplemented by a few exceptional Japanese ones.

It seemed possible that owing to differences of local crustal structure there might be systematic differences in the times of arrival at oceanic and continental stations ; but the oceanic stations are few, and some of them very unreliable, and all that could be ascertained is that such differences are within the uncertainty of the observations.

1. 4. The first step in treating other waves was to construct preliminary tables, accurate enough to be used as a means of identification. The previous work gave a table of S ; trial values for PP, PPP, PS, SS, and SSS (phases whose existence is already certain from general wave theory) were computed from the J. tables by the formulae

$$T_{PP}(\Delta) = 2\,T_P\left(\tfrac{1}{2}\Delta\right) \qquad (21)$$

$$T_{PS}(\Delta) = T_P(\Delta_1) + T_S(\Delta - \Delta_1) \qquad (22)$$

with analogous expressions ; where in (22) $\Delta_1$ is chosen so as to make $T_{PS}$ stationary for small variations of $\Delta_1$. The other waves[1] considered were P ($\Delta > 105^o$), S($\Delta > 105^o$), SKS = $S_c\,P_c\,S$ = [S], SKKS = $(S_c\,P_c)(P_c\,S) = \Sigma$, PKP = $P_c\,P_c\,P$ = [P] = P′, $P_2'$, PKS, and SKSP. For SKS the trial times were taken from Lehmann's readings up to 100°. Gutenberg gives the times at greater distances to 0.1 minute ; these were smoothed to give times to 1 second, and then reduced uniformly by 5s. to bring them into accordance with Lehmann's. The reduction corresponds presumably to Gutenberg's different convention regarding $T_0$. Gutenberg's table for SKKS was treated similarly. For the diffracted P ($\Delta > 105^o$) and P′ trial times were derived roughly from a selection of the present set of earthquakes. In earthquakes that appeared normal as regards P, the final value of Y that suited P was subtracted from all the readings in the S column of the I. S. S., from all queried readings and readings at distances over 105° in the P column, and

1. We use the notation for waves through the central core given by Sohon in vol. 2 of Macelwane and Sohon's *Theoretical Seismology*. Since all waves through the core are of P type it is unnecessary to indicate this fact in every case separately ; it is enough to use the letter K to denote that for the relevant part of the path the wave is through the core. The K for Kernwellen acknowledges the great contributions to the study of these waves made by Gutenberg. Sohon's simplification of the notation is a great convenience in typing and printing. The suffix *c* is still required in the waves $P_cP$ and $S_cS$ to distinguish them from PP and SS.

from all the additional readings. These corrected times were then compared with the tabulated times of the various pulses under consideration, and all possible identifications were indicated. The residuals compared with the tables were then found.

No attention was paid to the identifications printed in the I. S. S. These identifications are for the most part given by the stations themselves, and what the station observes is that at certain moments new movements begin on the record. To identify these movements with definite phases traceable over a range of distance is essentially a matter of the comparison of records at a number of stations, and therefore for the central organization or a coordinating study. The identifications at the stations may make this easier, since they are as a matter of fact often right, but they can in no case be regarded as final.

1. 5. Some discussion is needed of the relation between a study such as this, based on the I. S. S., and intensive studies of original records of individual earthquakes, such as have been made by Byerly, Macelwane, Lehmann, and Hodgson. Accuracy of reading hardly comes into the question ; in several cases the readings obtained in such studies have been compared directly with those in the I. S. S., and the agreement is usually within 1s. The difference is that in a special study all records are read by the same person, who reads numerous phases on each, and traces each phase over a range of distance by the principle that the time of arrival must be a continuous function of the distance. Here all the records are read by different persons, and the tracing is a matter for the central organization. This procedure has the great advantage that the slowest parts of the work, the actual reading and the computation of the distances from a preliminary epicentre, have already been done, and consequently that a study of 100 earthquakes can be carried out in a time that would be utterly inadequate if the whole of the readings had to be done *de novo*. It has however the disad-

vantage that the majority of the stations report only some of the phases actually present (many only what they believe to be P and S) so that only a portion of the material existing is accessible. This is not, however, wholly a drawback. It has often been suspected, correctly or not, that workers making special studies allow their impressions of what they see on one record to be influenced by what they have already found on another, or by preconceptions about the times of transmission. Here these considerations do not arise because every observer reads only the records at one station, without knowing the distance or $T_0$. Consequently if a pulse can be traced among the I. S. S. readings we know that it is a matter of general observation and may have additional confidence that it is real. On the other hand if a pulse cannot be so traced it does not follow that it does not exist ; it is quite possible that real phenomena may escape detection unless special care is exercised. A study of the present kind can therefore say what phenomena are plain enough to strike the average observer in the course of routine work ; and it can say that other phenomena, indicated either by theoretical or observational means, are less striking but may repay special study. In the former field it is definitely better than the method of special study, because the material used is more abundant, gives a smaller standard error for the mean, and provides comparisons between different earthquakes.

1.6. Depth of focus is one of the causes of systematic error. The earthquakes discussed here would ordinarily all be considered normal ; they show large surface waves, and focal depth is not inferred by the methods used in the I. S. S. But this is not sufficient for our purpose. It would not be expected that the surface waves would be much affected by focal depths less than about 50 km., and the I. S. S. seldom determines a focal depth as small as 0.01R, or 64 km. But a depth of 50 km. would affect the time of P at great distances by 6s., which proved in the later stages of the work to be directly recognizable from the P residuals alone. In obtaining the revised P table earthquakes showing this abnormality were excluded ; but in treating other waves it proved to be necessary to include them and to apply corrections for focal depth.

As we have said, there are earthquakes in which the P residuals, in comparison with the tables, show a steady decrease with distance attributable to depth of focus. In all such the S residuals show a similar tendency and SKS arrives systematically early ; so does P′ when it is observed. This would be expected if both P and S movement are primitive, that is, sent out from the focus at the same moment. But there are other earthquakes that show no abnormality in P, but nevertheless have early SKS. It has already been noticed by Lehmann that in different earthquakes the interval between P and SKS has different values, the difference being much too great to attribute to any admissible error in the epicentres adopted, or to depth of focus on the hypothesis that P and S movement are both primitive. But the variation can be explained on an alternative hypothesis, analogous to one that seems necessary in some near earthquakes, namely that there are earthquakes involving no perceptible primitive P movement, but only S, and that P is generated from S by reflexion at the outer surface. In this case the recorded P is really sP, in Scrase's notation. There is no doubt, after the work of Scrase and Stechschulte, which is here confirmed, that there are earthquakes with primitive P movement ; but there appear to be others with none, or at least without enough to be observed.

Focal depth raises new problems regarding the best definition of $T_0$ : for the linear form for the time of transmission of P at short distances can hold only for a focus in the upper layers. There are obvious advantages in making our final tables correspond to a focus in these layers ; indeed the best plan would probably be to make them correspond to a surface focus. If P is recorded at all distances however small, as would be true in an oceanic shock if there are no surface layers, then if we know the times for a surface focus we can infer those for a focus at any other depth. The maximum amount of information is therefore contained in tables for the smallest depth of focus possible. Our problem is then, given tables for zero depth, to find what difference in the times would be caused by a small, but appreciable, depth. It breaks up, however, into two problems according as the focus is in the lower (olivine) layer or one of the upper ones.

In the figures E is the epicentre, H the focus, and F the place where the radius to the focus intersects the top of the lower layer. P is an observing station at distance $\Delta$. We want the difference between the times of transit of a wave along EP and HP; but it is convenient to compare both with the time along FP. The time of travel in any case is $\int ds/c$, taken along the path, where $c$ is the local velocity and $ds$ the element of length.

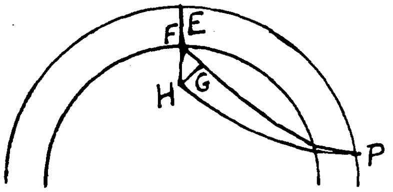


Fig. 1.

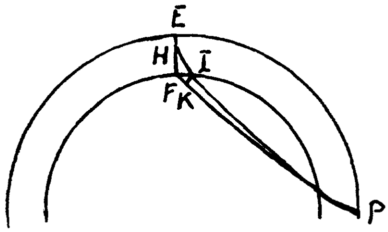


Fig. 2.

It is known that the path is such that $(r/c) \sin i$ is constant, where $r$ is the distance from the centre and $i$ the angle of incidence on a concentric sphere. In all our shocks the focal depth is small compared with the radius and we neglect its square. Now in Figure 1 draw HG normal to FP. The times along HP and GP are equal to the first order. Hence

$$\text{Time along FP} - \text{time along HP} = \text{time along FG}$$
$$= \frac{\text{FH}}{c_0} \cos i_0 \qquad (23)$$

where $c_0$ is the velocity at the top of the lower layer.

In figure 2, let the ray HP enter the lower layer at I, and draw IK normal to FP. Then

$$\text{time along HP} - \text{time along FP} = \text{time along HI} - \text{time along FK} = \left[\int ds/c\right]_H^I - \left[\int ds/c\right]_F^K \qquad (24)$$

If $z$ is the depth below the free surface,

$$ds = \sec i \; dz\,;\ FI = \left[\int \tan i \; dz\right]_H^F;\ FK = FI \sin i_0\,;$$

$$\left[\int \frac{ds}{c}\right]_H^I = \int \frac{\sec i \; dz}{c} = \int_H^F \frac{\sec i}{\sin i} \frac{\sin i_0}{c_0} \, dz. \qquad (25)$$

Hence (24) is equivalent to

$$\frac{\sin i_0}{c_0} \int_H^F \left(\frac{\sec i}{\sin i} - \tan i\right) dz = \frac{\sin i_0}{c_0} \int_H^F \cot i \; dz$$

$$= \int_H^F \left(\frac{1}{c^2} - \frac{\sin^2 i_0}{c_0^2}\right)^{\frac{1}{2}} dz \qquad (26)$$

For zero depth of focus H must be replaced by E. Hence in case 2, if EH $= h$,

$$\text{time along HP} = \text{time along EP} - \int_0^h \left(\frac{1}{c^2} - \frac{\sin^2 i_0}{c_0^2}\right)^{\frac{1}{2}} dz \qquad (27)$$

In case 1, if EF $=$ H, FH $= h -$ H,

$$\text{time along HP} = \text{time along EP} - \int_0^H \left(\frac{1}{c^2} - \frac{\sin^2 i_0}{c_0^2}\right)^{\frac{1}{2}} dz - \frac{h\text{-}H}{c_0} \cos i_0. \qquad (28)$$

We can evaluate $i_0$ from the time curve, since

$$c_0 \operatorname{cosec} i_0 = R \, d\Delta/dT \qquad (29)$$

where R is the earth's radius. If $i_0 = 0$, the first integral in (28) is half the apparent delay of starting of P with respect to $P_g$ in near earthquakes, about 3.5s. If $i_0 = 90^o$, it is the time needed to traverse the upper layers vertically ; the contribution from the granitic and intermediate layers is about 5s. Thus the effect of the upper layers does not vary with $\Delta$ to any extent that we can determine for a single earthquake, at least so long as the focus is above the base of the layers that transmit P*. It will however have different values for P and S. The second term is easily evaluated :

$$\frac{\cos i_0}{c_0} = \left\{ \left( \frac{dT}{Rd\Delta} \right)^2_0 - \left( \frac{dT}{Rd\Delta} \right)^2 \right\}^{\frac{1}{2}} \qquad (30)$$

where the first term is to be evaluated at the smallest value of $\Delta$ where the wave exists. This expression varies considerably with $\Delta$ ; hence we may say that when the P residual or the S residual varies by more than 2 or 3 seconds respectively with $\Delta$, the focus is in the lower layer. On the other hand, if the focus is in the upper layers and P and S movement are both primitive, the second term in (28) for S is about 1.73 times what it is for P, and the difference may reach 4 seconds. This is much less than the range of variation found in earthquakes where P follows the normal curve.

If however P is not primitive, but is derived from S by reflexion at the free surface, S still satisfies these relations, but for P we must add portions corresponding to the passage in the S type from the focus to the free surface, while the range of $z$ in the P phase is from 0 to H. Then if the focus is in one of the upper layers and we use $\alpha$ for the velocity of P and $\beta$ for that of S, we have for S

$$\text{Time along HP} = \text{time along EP} - \int_0^h \left( \frac{1}{\beta^2} - \frac{\sin^2 i_0}{\beta_0^2} \right)^{\frac{1}{2}} dz \qquad (31)$$

and for P

$$\text{Time along HP} = \text{time along EP} + \int_0^h \left( \frac{1}{\beta^2} - \frac{\sin^2 i_0}{\alpha^2_0} \right)^{\frac{1}{2}} dz \qquad (32)$$

In (32) the second term hardly varies with $i_0$, and therefore with $\Delta$; hence in these conditions P, studied by itself, will appear to follow the normal curve. But S is systematically early, and P systematically late, in comparison with a shallow focus shock occurring at the same time. The difference may reach about 13 s., which is about the range of variation observed.

It appears therefore that in studying S we shall do best to determine Y specially and not adopt the value found for P.

1. 7. It was found in all cases that there were abnormal observations. The ordinary causes of errors may be considered to be (1) inaccuracy of reading (2) irregularity in the rates of the drums (3), in the case of instruments recording photographically, indistinctness of the edges of the trace (4) in the case of Galitzin instruments, delay in visible response to the ground movement, due to the fact that if the ground starts to move with a finite velocity the mirror in a Galitzin instrument starts to move with a finite acceleration. Of these, (1) and (2) are unsystematic and will average themselves out in a statistical discussion. The third and fourth may give systematic error, but there seems to be no reason why the error should vary with distance or from one pulse to another, and so long as they are constant they do not concern us, since we are dealing only with differences. The stations with Galitzin instruments were not as a matter of fact found to be systematically late; the error evidently does not exceed about a second. The abnormal sources of error are clock errors and misidentifications. The former, when they do not exceed a second or so, may be considered normal. It was clear, however, that there were many stations where larger clock errors occurred occasionally, and some where they were habitual.

This applies particularly to the stations in Central America. The possibility of misidentification arises with regard to P if microseisms are present, when the true beginning of the movement may be masked and a sharp microseism read instead ; this may happen at any station, whatever care is taken in reading. Further, as will be seen later, P is followed by other movements, which may be stronger, and may be mistaken for P if the movement is weak ; since we are dealing with large earthquakes it is only at the great distances that this effect arises. With S and other phases the difficulty is greater because they never start from rest. We are familiar with the trouble introduced by the existence of SKS before S at distances over $85^{\circ}$ or so ; but though this difficulty is quite well known it does not seem so far to have stimulated many stations to read both phases, and the readings of S in this range are scanty. It was, however, sometimes found that, though the observation given as S was really SKS, the true S was among the additional readings, sometimes labelled PS. But at all distances, especially between $10^{\circ}$ and $20^{\circ}$, S seems to be followed by larger movements, as has been noticed already in Byerly's readings of the Montana earthquake, and the majority of the stations record these as S.

Our problem is therefore not purely one of least squares, but needs a technique for dealing with abnormal errors. This has already been done for the case where the errors fall into two groups, the normal one with a small standard error, and the other, affecting only a fraction of the observations, with a larger standard error and an unknown systematic error. The complete solution was prohibitively laborious, but a good approximation could be obtained fairly easily[1]. The readings are grouped according to their values, and if they show more large deviations than would be expected from the central groups, we apply to all the groups a uniform reduction sufficient to isolate the central groups. A mean is then taken for the central groups. It is best to apply this reduction right through the central groups as well, and the standard error computed from the numbers in the groups so reduced

1. Jeffreys, *Proc. Roy. Soc. A.*, 137, 1932, 78-87.

is a good approximation to that of the normal observations. This amounts effectively to estimating roughly how many abnormal observations occur in each group and removing them. There proved to be some difficulty about this method in this case. At many distances for P there was a well marked concentration of the deviations from the J. table about some particular value, and the process was straightforward. But at others the number of observations was small. The correction needed varies rapidly from 20° to 30°, and it was necessary to group the observations at intervals of 1°; a little arbitrariness was then inevitable in deciding which observations were to be regarded as normal. The only clear rule that can be stated is that if observations within a given class habitually show abnormal deviations, they do not belong to the normal distribution even when, judged by their values alone, they appear normal. It was found that the Central American observations have a much larger standard deviation than the majority of the others, and therefore they were all automatically omitted from the statistical discussion. This involves rejecting them even when they are good, but the risk involved in this is less than that of retaining them when they are bad. This is particularly striking when the number of observations is small, for the presence of a few abnormal deviations may then entirely destroy the appearance of concentration about a central value.

1. 8. For S the difficulties were greater. When the European residuals were first classified for distances up to 20°, it was quite impossible to detect any concentration that would make it possible to distinguish the normal observations; at most distances the deviations from the J. table were distributed from about —10 s. to + 20 s. with hardly any sign of concentration about particular values that would help to identify the true S. Beyond 80°, again, the deviations, when classified at 5° intervals, were sometimes positive but showed a drift to about — 20 s. with no concentration anywhere. The reason for the latter phenomenon was soon reco-

gnized when the deviations were taken, not from the S curve, but from the trial SKS curve. It was then found that they did show a concentration about one or two values ; where two concentrations were shown it seemed probable that the earlier were readings of the true SKS and the later of Scrase's sSKS or perhaps of SKKS. These readings were thus indicated as not referring to S and could be removed. Those remaining were then found to show reasonably regular deviations from the S curve.

All readings in the S column and in the additional readings were combined in this treatment. There are some readings indicated as SKS or SKKS where these arrive *after* S, but no evidence was obtained to confirm these identifications, and it seems more probable that they are really later swings in the S phase.

The fundamental difficulty about S is to ensure that we are dealing with the same phase at all distances, and this involves finding earthquakes that show a continuous variation of the S deviation over a great range of distance. The majority of the shocks show great irregularity of the S residuals, which made it impossible to say directly which were the true S ; but a number of North American and European shocks were found with a series of observations showing a very steady variation of the deviations. These were discussed separately.

In this way an S curve was obtained that could be used for purposes of identification. Then a method of successive approximation was applied to the whole of the shocks. Y, as we have stated, must be determined separately for S and for P, but the epicentres are already known from P. The differences obtained by subtracting the time of S according to the approximate table from the time given in the I. S. S. were grouped for each earthquake, and a suitable average of the central group taken as Y ; this was subtracted from the whole of the residuals, which were then classified according to distance to obtain further corrections to the curve, and the process was repeated until no appreciable change was found.

In the following reductions the quantity Z is defined by

$$Y_S = Y_P + Z. \qquad (1)$$

It should, as we have said, be intimately related to the focal depth. $P_v$ and $S_v$ are given by

$$P_v = P\,(\text{obs.}) - P\,(\text{J.}) - Y_P \qquad (2)$$
$$S_v = S\,(\text{obs.}) - S\,(\text{J.}) - Y_S. \qquad (3)$$

$Y_P$ and $Y_S$ have their final values. In most cases the trend of the residuals is sufficiently striking to indicate the nature of the corrections on inspection. $P_\omega$ and $S_\omega$ are obtained by subtracting the final corrections from $P_v$ and $S_v$ ; they should be unsystematic.

2. 1. At the greater distances the readings of P often seemed to lie on two parallel curves 4 or 5 seconds apart. The interpretation offered for these is that the earliest is the true P and the later a reflexion. The observed fact is the same as has been noticed already by A. Mohorovičić, namely that the P movement often consists of a series of swings, each larger than the previous one, so that stations with specially sensitive instruments, or perhaps specially undisturbed by microseisms, record the first, and other stations the later ones. We differ however in interpretation, for Mohorovičić, followed by Gutenberg, considers the largest to be the true P, and the earlier movements to be the result of dispersion ; whereas we take the earliest to be the true P and the later ones to be the result of reflexion. There is no disagreement about the observational data, but the interpretation is a theoretical question, and must be considered in relation to other evidence relating to the theoretical possibilities. It appears that all the possible causes of dispersion that have been suggested have been examined [1], and that none of

1. Jeffreys, *M. N. R. A. S. Geoph. Suppl.* 2, 1931, 407-416 ; *Proc. Roy. Soc. A.*, 138, 1932, 283-297.

them is capable of converting a single pulse into a series of swings a few seconds apart. Reflexion in the upper layers, on the other hand, provides ample opportunities for producing later pulses, which may well give movements larger than the true P if several of them arrive simultaneously, as is theoretically to be expected. It was found, however, that when numerous shocks were combined, the separation of the groups corresponding to P and its successors was not sufficiently clear, so a selection was made of the stations that had given the impression of being specially reliable, namely Scoresby Sund, Eskdalemuir, Kew, Copenhagen, Hamburg, De Bilt, Uccle, Paris, Strasbourg, Zürich, Göttingen, Jena, Vienna, Pulkovo, Leningrad, Algiers, Helwan, Makeyevka, Kucino, Baku, Tashkent, Tiflis, Ekaterinburg, and Irkutsk. With these the identification of P became much clearer. A few South American shocks were included so as to make the determination at the greater distances depend less exclusively on the Russian stations.

In the following tables square brackets [ ] indicate the range of residuals retained in forming the final average. Some arbitrariness is inevitable in choosing this range, but actually it was found that any reasonable change made very little difference to the final mean.

## TABLE I

### Summaries of $P_\gamma$. European shocks

| Δ | Value of $P_\gamma$ | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 0-3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1] | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 3.1-6.0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | [1 | 0 | 2] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.1-9.0 | 0 | 0 | 0 | 2 | 0 | [3 | 6 | 3 | 4 | 6 | 3 | 1 | 3 | 1] | 1 | 3 | 1 |
| 9.1-12.0 | 1 | 1 | 0 | [1 | 0 | 3 | 6 | 4 | 13 | 4 | 4 | 2 | 2 | 1] | 0 | 0 | 0 |
| 12.1-15.0 | 1 | 0 | 0 | [1 | 2 | 3 | 6 | 12 | 15 | 4 | 6 | 2 | 4 | 2 | 4 | 1] | 0 |
| 15.1-18.0 | 1 | 1 | 2 | [0 | 4 | 5 | 5 | 7 | 12 | 13 | 9 | 8 | 5 | 3 | 2] | 2 | 2 |
| 18.1-19.0 | 0 | 0 | 1 | 0 | 0 | 0 | [2 | 2 | 4 | 1 | 5 | 2 | 3 | 2 | 1] | 0 | 0 |
| 19.1-20.0 | 0 | 0 | 1 | 1 | 0 | 0 | [2 | 1 | 2 | 10 | 2 | 2 | 2 | 1] | 0 | 0 | 0 |
| 20.1-21.0 | 0 | 0 | 0 | [0 | 1 | 2 | 1 | 5 | 6 | 1 | 3 | 2 | 0 | 3 | 1] | 0 | 0 |
| 21.1-22.0 | 0 | 0 | 0 | [1 | 0 | 2 | 5 | 2 | 5 | 2 | 0 | 2] | 0 | 0 | 0 | 1 | 0 |
| 22.1-23.0 | 0 | 0 | 0 | 0 | 0 | 0 | [2 | 2 | 3 | 1 | 3 | 4] | 0 | 0 | 2 | 0 | 2 |

| | −11 | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23.1-24.0 | 0 | 0 | 1 | 0 | 0 | [1 | 0 | 1 | 6 | 2 | 3 | 4 | 1 | 1] | 0 | 0 | 0 |
| 24.1-25.0 | 0 | 0 | 0 | 1 | 0 | [2 | 3 | 3 | 0 | 2 | 2] | 0 | 0 | 1 | 0 | 0 | 0 |
| 25.1-26.0 | 0 | 0 | [1 | 0 | 2 | 0 | 3 | 3 | 3 | 2 | 1] | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.1-27.0 | 0 | 1 | 0 | 0 | [1 | 1 | 2 | 2 | 0 | 3 | 2] | 0 | 1 | 1 | 0 | 0 | 0 |
| 27.1-28.0 | 0 | 0 | [1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2] | 0 | 0 | 1 | 0 | 0 | 0 |
| 28.1-30.0 | 0 | [1 | 1 | 1 | 6 | 2 | 2 | 1 | 2 | 1 | 1] | 0 | 0 | 0 | 0 | 0 | 1 |
| 30.1-33.0 | 0 | [2 | 2 | 2 | 1 | 4 | 5 | 1 | 4 | 1 | 2] | 0 | 0 | 0 | 0 | 0 | 0 |
| 33.1-36.0 | 0 | 0 | [4 | 1 | 3 | 2 | 5 | 2 | 0 | 0 | 1] | 0 | 0 | 0 | 0 | 1 | 0 |
| 36.1-39.0 | 0 | 0 | [1 | 2 | 0 | 2 | 2 | 1 | 1 | 1 | 1 | 1] | 0 | 0 | 0 | 0 | 0 |
| 39.1-42.0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 1 | 3 | 1 | 1 | 2] | 0 | 0 | 0 | 0 | 0 |
| 42.1-45.0 | 0 | 0 | 1 | 0 | 0 | 0 | [3 | 1 | 5 | 1] | 0 | 0 | 0 | 1 | 2 | 0 | 0 |
| 45.1-48.0 | 0 | 0 | [2 | 0 | 1 | 1 | 3 | 1 | 4 | 3 | 2 | 1 | 1 | 1] | 0 | 0 | 0 |
| 48.1-51.0 | 0 | 0 | 0 | 0 | 0 | [2 | 0 | 3 | 2 | 0 | 0 | 1 | 1] | 0 | 0 | 0 | 0 |

| | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51.1-54.0 | [1 | 0 | 0 | 4 | 1 | 0 | 2 | 2 | 3 | 1] | 0 | 0 | 0 | 0 |
| 54.1-57.0 | 0 | 0 | 0 | [1 | 1 | 3 | 0 | 2 | 0 | 3 | 0 | 1] | 0 | 0 |
| 57.0-60.0 | 0 | 0 | 0 | 0 | [1 | 1 | 1 | 1 | 0 | 2 | 0 | 1] | 0 | 0 |
| 60.1-65.0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 1 | 1 | 0 | 3 | 1] | 0 | 0 |
| 65.1-70.0 | 0 | 0 | 0 | 0 | 0 | [2 | 0 | 0 | 4 | 0 | 1 | 0 | 1 | 1] |
| 70.1-75.0 | 0 | 2 | 0 | 0 | [1 | 1 | 2 | 1 | 6 | 1 | 3 | 2 | 1 | 2] |
| 75.1-80.0 | 0 | 0 | 0 | 0 | [2 | 1 | 1 | 2 | 5 | 1] | 0 | 1 | 1 | 3 |
| 80.1-85.0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 0 | 3 | 2 |
| 85.1-90.0 | 1 | 0 | 2 | 0 | [2 | 1 | 1 | 2 | 1] | 0 | 0 | 2 | 1 | 0 |
| 90.1-95.0 | 0 | 0 | 0 | 0 | [1 | 0 | 1] | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 95.1-100.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| 100.1-105.0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# TABLE II

## Summaries for $P_y$. N. American shocks

| Δ | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.1-6.0 | 0 | 0 | 0 | [1 | 1 | 0 | 1 | 0 | 0 | 1] | 0 | 0 | 0 | 0 |
| 6.1-9.0 | 0 | 1 | 0 | 0 | 0 | 0 | [1 | 3] | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.1-12.0 | 0 | 0 | 0 | 0 | 0 | [2 | 1 | 2] | 0 | 0 | 0 | 0 | 0 | 0 |
| 12.1-15.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 2 | 1] | 0 | 0 | 0 |
| 15.1-18.0 | 1 | 0 | 0 | 0 | 0 | 0 | [1 | 1 | 0 | 0 | 0 | 2 | 1] | 0 |
| 18.1-19.0 | | | | | | none | | | | | | | | |
| 19.1-20.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.1-21.0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 21.1-22.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 22.1-23.0 | 0 | 0 | 0 | [1 | 0 | 1 | 1 | 1] | 0 | 0 | 0 | 1 | 0 | 0 |
| 23.1-24.0 | 0 | 0 | [1 | 0 | 0 | 3 | 1] | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 24.1-25.0 | 0 | [1 | 0 | 1 | 0 | 1 | 0 | 1] | 0 | 0 | 1 | 0 | 0 | 0 |

| | −11 | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25.1-26.0 | 0 | 0 | 0 | [1 | 1 | 0 | 1 | 0 | 0 | 3 | 1] | 0 | 1 | 0 |
| 26.1-27.0 | 0 | 0 | [1 | 0 | 2 | 0 | 0 | 1 | 2 | 2] | 0 | 1 | 0 | 0 |
| 27.1-28.0 | 1 | 0 | 0 | [1 | 1 | 1 | 0 | 2 | 2 | 0 | 2] | 0 | 1 | 0 |

| | −11 | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28.1-30.0 | [1 | 0 | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 1 | 1 | 1] | 0 | 0 |
| 30.1-33.0 | [1 | 1 | 1 | 1 | 6 | 1 | 4 | 2 | 2 | 1 | 1 | 1] | 2 | 1 |
| 33.1-36.0 | 0 | [1 | 4 | 1 | 1 | 7 | 2 | 2 | 2 | 3 | 2] | 0 | 0 | 0 |
| 36.1-39.0 | 0 | [1 | 1 | 3 | 1 | 2 | 0 | 3 | 2 | 3 | 1 | 2] | 0 | 0 |
| 39.1-42.0 | 1 | 0 | 0 | [1 | 1 | 1 | 1 | 2 | 3 | 1] | 0 | 0 | 0 | 1 |
| 42.1-45.0 | 0 | 0 | [1 | 1 | 0 | 1 | 0 | 1 | 3 | 2] | 0 | 0 | 0 | 0 |
| 45.1-48.0 | 0 | 0 | [1 | 0 | 2 | 0 | 1 | 3 | 2 | 1 | 1] | 0 | 0 | 0 |
| 48.1-51.0 | 0 | 0 | 1 | [0 | 1 | 2 | 2 | 2 | 2 | 4 | 1] | 0 | 0 | 1 |

| | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51.1-54.0 | [1 | 0 | 1 | 1 | 4 | 0 | 1 | 0 | 1] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 54.1-57.0 | 1 | 0 | 0 | 0 | [2 | 0 | 3 | 0 | 3] | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 57.1-60.0 | 0 | 0 | 0 | 0 | [1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1] | 0 | 0 | 0 | 0 |
| 60.1-65.0 | 0 | 1 | 0 | 0 | [1 | 1 | 0 | 1 | 1 | 2 | 4 | 1] | 0 | 0 | 0 | 0 | 0 |
| 65.1-70.0 | 0 | 0 | 0 | [1 | 0 | 1 | 0 | 1 | 1 | 3 | 3 | 2 | 2 | 2] | 0 | 0 | 0 |
| 70.1-75.0 | 0 | 1 | 1 | 0 | [1 | 3 | 2 | 5 | 3 | 3 | 1 | 1 | 1] | 0 | 0 | 0 | 0 |
| 75.1-80.0 | 0 | 2 | 4 | 0 | [5 | 8 | 5 | 5 | 6 | 7 | 9 | 1 | 3 | 1] | 0 | 1 | 0 |
| 80.1-85.0 | 1 | 1 | 2 | 2 | [4 | 7 | 8 | 20 | 19 | 15 | 8 | 7] | 5 | 2 | 2 | 1 | 2 |
| 85.1-90.0 | 1 | 4 | 3 | [3 | 4 | 12 | 13 | 20 | 15 | 9 | 7 | 7] | 9 | 2 | 3 | 2 | 1 |
| 90.1-95.0 | 1 | 4 | 2 | 3 | 5 | 4 | 5 | 2 | 5 | 6 | 3 | 2 | 3 | 3 | 3 | 0 | 1 |
| 95.1-100.0 | 0 | 1 | 0 | 1 | 0 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100.1-105.0 | 0 | 0 | 1 | 1 | 2 | 0 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

## N. American shocks. Selected stations

| | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70.1-75.0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 1 | 0 | 0 | 0 | 0 |
| 75.1-80.0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 3 | 1 | 0 | 1 | 0 | 0 | 0 |
| 80.1-85.0 | 0 | 1 | 1 | 1 | 3 | 4 | 4 | 14 | 7 | 13 | 3 | 3 | 1 | 1 |
| 85.1-90.0 | 0 | 1 | 0 | 1 | 1 | 7 | 13 | 14 | 9 | 3 | 1 | 1 | 1 | 0 |
| 90.1-95.0 | 0 | 1 | 1 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 0 | 0 | 0 |
| 95.1-100.0 | 0 | 0 | 0 | [1 | 0 | 2 | 1 | 1] | 0 | 0 | 1 | 0 | 0 | 0 |
| 100.1-105.0 | 0 | 0 | 1 | 1 | 2 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |

## Table III

### Means

| | Europe | | N. America | | | | |
|---|---|---|---|---|---|---|---|
| Δ | Number | Mean | Number | Mean | Weight | Difference (Amer.-Eur.) | Final mean |
| 0-3.0 | 1 | +1.0 | 1 | −1.0 | 0.5 | −2.0 | +0.1 |
| 3.1-6.0 | 3 | +0.3 | 4 | −1.5 | 1.7 | −1.8 | −0.6 |
| 6.1-9.0 | 30 | +0.3 | 4 | −0.2 | 3.5 | −0.5 | +0.3 |
| 9.1-12.0 | 40 | 0.0 | 5 | −1.0 | 4.4 | −1.0 | −0.1 |
| 12.1-15.0 | 62 | +0.5 | 4 | +1.7 | 3.8 | +1.2 | +0.6 |
| 15.1-18.0 | 73 | +0.8 | 5 | +2.4 | 4.7 | +1.6 | +0 9 |
| 18.1-19.0 | 22 | +1.4 | 0 | | 0 | | +1.4 |
| 19.1-20.0 | 22 | +0.9 | 1 | 0.0 | 0.9 | −0.9 | +0.9 |
| 20.1-21.0 | 25 | +0.7 | ? | | 0 | | +0.7 |
| 21.1-22.0 | 19 | −0.7 | ? | | 0 | | −0.7 |

| Δ | Europe Number | Europe Mean | N. America Number | N. America Mean | Weight | Difference (Amer.-Eur.) | Final mean |
|---|---|---|---|---|---|---|---|
| 22.1-23.0 | 15 | +0.9 | 4 | –1.7 | ? | | –1.4 |
| 23.1-24.0 | 21 | –1.5 | 5 | –2.4 | 4.0 | –0.9 | –1.6 |
| 24.1-25.0 | 12 | –3.7 | 4 | –3.0 | 3.0 | +0.7 | –3.5 |
| 25.1-26.0 | 15 | –4.3 | 7 | –3.9 | 4.8 | +0.4 | –4.1 |
| 26.1-27.0 | 11 | –3.5 | 8 | –4.6 | 4.6 | –0.9 | –3.9 |
| 27.1-28.0 | 4 | –4.0 | 9 | –4.1 | 2.8 | –0.1 | –3.9 |
| 28.1-30.0 | 18 | –5.8 | 18 | –5.3 | 9.0 | +0.5 | –5.4 |
| 30.1-33.0 | 24 | –5.4 | 22 | –5.6 | 11.5 | –0.2 | –5.4 |
| 33.1-36.0 | 18 | –6.2 | 25 | –5.4 | 10.5 | +0.8 | –5.6 |
| 36.1-39.0 | 12 | –4.7 | 19 | –4.6 | 7.3 | +0.1 | –4.5 |
| 39.1-42.0 | 9 | –2.3 | 10 | –4.5 | 4.8 | –2.2 | –3.3 |
| 42.1-45.0 | 10 | –3.6 | 9 | –4.4 | 4.8 | –0.8 | –3.8 |
| 45.1-48.0 | 20 | –3.3 | 11 | –4.5 | 7.1 | –1.2 | –3.6 |
| 48.1-51.0 | 9 | –3.2 | 14 | –3.7 | 5.5 | –0.5 | –3.3 |
| 51.1-54.0 | 14 | –1.6 | 9 | –4.1 | 5.5 | –2.5 | –2.4 |
| 54.1-57.0 | 11 | –0.3 | 8 | –1.7 | 4.6 | –1.4 | –0.8 |
| 57.1-60.0 | 7 | +0.3 | 3 | –0.3 | 2.1 | –0.6 | +0.2 |

| | Europe Number | Europe Mean | N. America Number | N. America Mean | Selected stations Number | Selected stations Mean | Weight | Difference (Amer.-Eur.) | Final mean |
|---|---|---|---|---|---|---|---|---|---|
| 60.1-65.0 | 8 | +1.2 | 11 | +0.5 | | | 4.6 | –0.7 | +1.0 |
| 65.1-70.0 | 9 | +1.6 | 16 | +1.5 | | | 5 8 | –0.1 | +1.7 |
| 70.1-75.0 | 20 | +1.7 | 20 | –0.5 | 8 | –1.2 | | | +0.7 |
| 75.1-80.0 | 12 | –0.2 | 50 | –0.2 | 10 | –1.4 | | | 0.0 |
| 80.1-85.0 | ? | ? | 88 | –0.3 | 56 | –0.5 | | | –0.2 |
| 85.1-90 0 | 7 | –1.1 | 110 | –0.9 | 52 | –1.2 | | | –0.9 |
| 90.1-95.0 | 2 | –2.0 | ? | ? | 18 | –2.5 | | | –2.2 |
| 95.1-100.0 | 2 | 0.0 | 7 | –3.0 | 5 | –2.8 | | | –2.5 |
| 100.1-105.0 | 1 | –2.0 | 11 | –2.0 | 10 | –2.1 | | | –1.8 |

The weighted mean of the differences (N. Amer.-Europe) is — 0.3 s. We therefore subtract this from the values in the column (N. America, Mean) and form a mean of this with the data for European shocks, weighted according the number of observations. For distances over 80° we use the selected stations for the North American shocks, to avoid the probable systematic errors that have already been mentioned. For the range 22°.1 to 23°.0 the American value is taken became there seems to be some anomaly about the European one.

The final means differ at no distance by as much as a second from those found in the previous approximation, and it may therefore be decided that the convergence is complete.

But as the number of observations beyond 90° is small, it was thought desirable to combine them with those of the four available South American shocks. The summaries for these, beyond 70°, were as follows.

### TABLE IV

Summaries of $P_v$ : South American shocks

| Δ | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70.1-75.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 2 | 1 | 0 | 1] | 0 |
| 75.1-80.0 | 0 | 0 | 0 | 0 | 0 | [1 | 1 | 0 | 1 | 0 | 0 | 0 | 1] | 0 |
| 80.1-85.0 | 0 | 0 | 0 | 0 | 0 | [1 | 2 | 2 | 2 | 0 | 1] | 0 | 0 | 1 |
| 85.1-90.0 | 0 | 0 | 0 | 0 | [2 | 0 | 2 | 5 | 4 | 2 | 2 | 1] | 0 | 0 |
| 90.1-95.0 | 0 | 0 | [2 | 0 | 3 | 3 | 2 | 3 | 3 | 2 | 2] | 0 | 1 | 0 |
| 95.1-100.0 | [2 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 2 | 0 | 1] | 0 | 0 | 0 |
| 100.1-105.0 | [1 | 2 | 1 | 4 | 2 | 3 | 2 | 1] | 0 | 0 | 0 | 0 | 2 | 0 |

### TABLE V

| | S. Amer. Number | S. Amer. Mean | Mean with N. America |
|---|---|---|---|
| 70.1-75.0 | 5 | +1.6 | |
| 75.1-80.0 | 4 | −0.2 | |
| 80.1-85.0 | 8 | −0.9 | |
| 85.1-90.0 | 18 | −0.4 | −0.8 |
| 90.1-95.0 | 20 | −1.8 | −2.0 |
| 95.1-100.0 | 13 | −3.8 | −3.5 |
| 100.1-105.0 | 16 | −4.3 | −3.3 |

The South American shocks are too few to make any useful contribution to the table up to 85° ; all that can be said here is that they show no significant difference from the North American and European ones. Beyond that distance, however, they are well observed in Europe and provide useful information.

The final values still need a little smoothing, but an inspection of the final means shows that the smoothing needed is very slight and that the results are correct within a small fraction of a second except perhaps in the last two lines of the table, where the uncertainty may reach a second. The smoothing could be done by Comrie's method, but the latter assumes the groups of observations all to have the same weight, which is not true. An attempt was made to construct a numerical method of smoothing on the same principle, allowing for the differences in weight, but it proved to be too laborious, and a graphical method was used instead. With this some allowance for weighting could be made in drawing the curve, and in any case the corrections are small.

2. 2. We recall that the J. curve was a smoothed one, and that in constructing it a suspected discontinuity in the neighbourhood of 20° was smoothed out. It now appears that this discontinuity in the slope was certainly genuine; but when we have a smooth curve to use as a starting point it is easier to locate a discontinuity with it than if we use a curve with a bend in it, probably at the wrong place. From inspection of the corrections, it seems that the J. curve is practically correct to 12°, but needs from there to 19° such positive corrections as would correspond to a slight reduction in the coefficient of the cube term. The bend seems to be between 19° and 20°, and implies a rapid increase of velocity with depth at a depth of about 400 km. (A more accurate determination would be possible, but is not made here.) It remains uncertain, however, whether the change is a true discontinuity in velocity or a continuous but rapid transition. In the former case we should expect a triplication of the pulse, as for a surface layer resting on a medium where the velocity is greater : there would be a direct wave in the upper layer, an indirect one in the lower, and a reflexion at the interface. At some distance, depending on the depth of the interface, the indirect wave arrives first and is recorded as P. The reflected wave arrives later than the direct one at all distances, and is probably smaller and escapes detection; but the direct wave may be traceable where it arrives after the indirect one. This may be the explanation of the positive residuals noticeable between 20° and 25°. A rapid continuous change produces a caustic surface, which with a sufficiently rapid transition lies within the earth for some angles of emer-

gence ; within this range there is a triplication of the pulse, so that the effects of a true discontinuity are qualitatively imitated. There is, however, a quantitative difference. The late branch of the curve, corresponding to $de/d\Delta$ negative, ends at two points there the caustic meets the surface, and there will be abnormally large amplitudes there, which would be recognizable from a study of the original records. The I. S. S. does not record amplitudes, and therefore cannot settle this question. We understand that Miss Lehmann, who detected the bend in the P curve independently, has it under examination, and has failed to find any distances with abnormal amplitudes.

Beyond 19° the corrections vary smoothly, and there is no sign of any further discontinuity.

It appears that both European and North American earthquakes follow the J. curve within a second up to 12° ; this corresponds to a surface velocity, at short distances, of 7.77 km/sec, and would be inconsistent with one greater than about 7.82 km/sec. This is curious, because the $P_n$ of some well-observed European near earthquakes has had a velocity over 8.0 km/sec[1]. The difference seems undoubtedly real, and may correspond to some peculiarity of the Alpine region, where the near earthquakes in question had their foci.

2. 3. The Japanese shocks were discussed similarly ; the summaries are as follows. From 70° to 95° a uniform reduction was applied to the numbers of observations in the groups retained, but it was only in one case that it affected the mean by as much as 0.2 s. The number of observations given allows for the reduction. The differences from the means for Europe and North and South America are shown in the last column. Up to 42° they are within the uncertainty. It should be noticed that up to 6° the Japanese observations are more numerous than the European and American ones, so that this part of the curve is better determined from Japa-

1. Jeffreys, *M. N. R. A. S. Geoph. Suppl.* 3, 1933, 131-156.

nese shocks. The agreement of the Japanese shocks with the final curve is in any case good. From 54° onwards the times for Japanese shocks are mostly between 1 and 2 seconds shorter than for the European and American ones, and the difference much exceeds the standard errors, which can hardly exceed 0.2 s. There seems to be in this respect a systematic difference between the arrival of P in Europe from Japanese and American shocks. We are not in a position to interpret the difference, which does not show in all the shocks where epicentres are determined by near stations. It might mean focal depth, but this seems to be excluded by the near stations. The most likely cause seems to be a slight difference in the velocities under the Atlantic and under Asia, but it is only 1 part in 400. But it is possible that the American shocks are smaller and read slightly late, so that we cannot say at once that the difference is real. In the great Tokyo earthquake of 1923 Sept. 1 most of the best European stations show P 1 to 4 seconds early, and in this case the near stations are well distributed in azimuth and the epicentre therefore well determined locally.

The Tango earthquake of 1927 March 7, considered by Hodgson, was examined here, but though the near stations were well distributed in azimuth it was found impossible to bring the I. S. S. observations into agreement with any hypothesis about the epicentre and the focal depth. This shock was therefore omitted from our discussion.

## TABLE VI

SUMMARIES FOR $P_{\gamma}$. JAPANESE SHOCKS

| Δ | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-3.0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 1 | 2 | 2] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.1-6.0 | 0 | 0 | 0 | 0 | [1 | 0 | 0 | 1 | 2 | 3 | 3 | 1 | 1 | 1 | 1] | 0 | 0 | 1 | 0 |
| 6.1-9.0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | [1 | 4 | 11 | 5 | 1] | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9.1-12.0 | 0 | 0 | 0 | 0 | 0 | [2 | 1 | 2 | 1 | 0 | 2 | 1 | 4] | 0 | 0 | 0 | 0 | 0 | 0 |
| 12.1-15.0 | 0 | 1 | 1 | 0 | [1 | 0 | 1 | 0 | 3 | 2 | 0 | 2 | 2 | 1 | 1] | 0 | 0 | 1 | 1 |
| 15.1-18.0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | [1 | 1 | 3 | 1 | 3 | 3 | 1 | 1] | 0 | 0 | 0 | 0 |

| Δ | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18.1-19.0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | [1 | 2 | 0 | 2 | 0 | 1 | 0 | 1] | 0 | 0 | 0 |
| 19.1-20.0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 1 | 0 | 0 | 1] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.1-21.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 21.1-22.0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.1-23.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.1-24.0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 24.1-25.0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.1-26.0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.1-27.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | −12 | −11 | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.1-28.0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28.1-30.0 | 0 | 1 | 0 | 0 | 0 | [1 | 1 | 1 | 1] | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 0 |
| 30.1-33.0 | 0 | [1 | 0 | 0 | 2 | 2 | 1 | 0 | 3 | 2 | 0 | 1] | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 33.1-36.0 | 0 | 0 | [1 | 0 | 2 | 1 | 1 | 0 | 0 | 1] | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 36.1-39.0 | 0 | 0 | 0 | 0 | [1 | 2 | 0 | 0 | 1 | 0 | 3] | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 39.1-42.0 | 0 | 0 | [1 | 0 | 1 | 0 | 1 | 0 | 2 | 1] | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| 42.1-45.0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 45.1-48.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 48.1-51.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 51.1-54.0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 3 | 0 | 3 | 1 | 1 | 3 | 2 | 2 | 2 | 0 | 1] | 0 | 0 | 0 |
| 54.1-57.0 | 0 | 0 | 0 | 0 | [1 | 1 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 1] | 0 | 0 |
| 57.1-60.0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | [1 | 1 | 1 | 1 | 1 | 2 | 1] | 0 | 0 | 0 | 0 | 0 | 0 |

| | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.1-65.0 | 0 | 0 | 0 | 0 | 0 | 0 | [2 | 4 | 8 | 5 | 4 | 5 | 0 | 2 | 1] | 3 | 0 | 1 | 0 | 1 | 0 |
| 65.1-70.0 | 0 | 0 | 3 | 1 | 0 | [2 | 3 | 3 | 6 | 9 | 10 | 5 | 2 | 1 | 2 | 1] | 0 | 3 | 0 | 0 | 0 |
| 70.1-75.0 | 1 | 1 | 1 | 0 | 5 | 0 | [5 | 4 | 8 | 4 | 7 | 4 | 5 | 1 | 3] | 1 | 1 | 2 | 0 | 0 | 1 |
| 75.1-80.0 | 1 | 2 | 1 | 0 | [3 | 9 | 8 | 13 | 21 | 11 | 13 | 5 | 2 | 5 | 3 | 2] | 1 | 1 | 1 | 0 | 0 |
| 80.1-85.0 | 0 | 2 | 0 | 8 | [2 | 8 | 12 | 10 | 17 | 20 | 20 | 12 | 13 | 5 | 2] | 5 | 1 | 2 | 2 | | |
| 85.1-90.0 | 0 | 0 | 3 | 1 | 0 | [6 | 8 | 8 | 13 | 15 | 12 | 13 | 6 | 1] | 7 | 4 | 7 | 1 | 4 | 0 | 0 |
| 90.1-95.0 | 0 | 0 | [3 | 4 | 5 | 4 | 5 | 3 | 8 | 4 | 1 | 3 | 0 | 3] | 0 | 3 | 0 | 1 | 0 | 1 | 0 |
| 95.1-100.0 | 0 | 0 | [3 | 2 | 1 | 1 | 3 | 2 | 5 | 1 | 0 | 1] | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| 100.1-105.0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 0 | 0 | 2] | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |

## TABLE VI

### MEANS OF $P_y$. JAPANESE SHOCKS

| Δ | Number | Mean | Japan–Europe and America | Δ | Number | Mean | Reduction | Japan–Europe and America |
|---|---|---|---|---|---|---|---|---|
| 0-3.0 | 7 | +0.3 | +0.2 | 19.1-20.0 | 4 | −2.2 | | −3.1 |
| 3.1-6.0 | 14 | +0.6 | +1.2 | 20.1-21.0 | | indet. | | |
| 6.1-9.0 | 22 | 0.0 | −0.3 | 21.1-22.0 | | indet. | | |
| 9.1-12.0 | 13 | 0.0 | +0.1 | 22.1-23.0 | | indet. | | |
| 12.1-15.0 | 13 | +0.6 | 0.0 | 23.1-24.0 | | indet. | | |
| 15.1-18.0 | 14 | +1.6 | +0.7 | 24.1-25.0 | | indet. | | |
| 18.1-19.0 | 7 | +1.8 | +0.4 | 25.1-26.0 | | indet. | | |

| Δ | Number | Mean | Japan–Europe and America | Δ | Number | Mean | Reduction | Japan–Europe and America |
|---|---|---|---|---|---|---|---|---|
| 26.1-27.0 | | indet. | | 54.1-57.0 | 12 | −1.2 | | −0.4 |
| 27.1-28.0 | | indet. | | 57.1-60.0 | 8 | −0.9 | | −1.1 |
| 28.1-30.0 | 4 | −5.5 | −0.1 | 60.1-65.0 | 31 | −0.8 | | −1.8 |
| 30.1-33.0 | 12 | −5.6 | 0.0 | 65.1-70.0 | 44 | −0.6 | | −2.3 |
| 33.1-36.0 | 6 | −7.0 | −1.4 | 70.1-75.0 | 32 | −0.7 | 1 | −1.4 |
| 36.1-39.0 | 7 | −4.6 | −0.1 | 75.1-80.0 | 83 | −1.6 | 1 | −1.6 |
| 39.1-42.0 | 6 | −5.8 | −2.5 | 80.1-85.0 | 99 | −1.0 | 2 | −0.8 |
| 42.1-45.0 | | indet. | | 85.1-90.0 | 73 | −1.2 | 1 | −0.4 |
| 45.1-48.0 | | indet. | | 90.1-95.0 | 32 | −3.4 | 1 | −1.4 |
| 48.1-51.0 | | indet. | | 95.1-100.0 | 19 | −4.1 | | −0.6 |
| 51.1-54.0 | 19 | −0.9 | +1.5 | 100.1-105.0 | 4 | −2.0 | | +1.3 |

3. 1. It was plain from the start that no progress could be made in the discussion of S without some means of removing misidentifications. As a preliminary table of SKS was available, the observations attributed to S beyond 82° or so were examined, and those that agreed reasonably with SKS were removed. But even at shorter distances the S residuals were so irregular in most cases that it seemed that the amount of variation at any distance was likely to exceed the corrections needed to the tables. Fortunately, however, it turned out that some of the earthquakes showed S residuals varying fairly smoothly over a long range of distance, and the presumption was that in these cases the majority of the observations did really refer to the same pulse, which was presumably S. These were

European shocks : 1926 Aug. 30, 1928 Mar. 31 ;

N. American shocks : 1925 Mar. 1, June 28, 1929 Feb. 22, Nov. 18.

Of these, the Saguenay River shock of 1925 Mar. 1 and the Newfoundland one of 1929 Nov. 18 were specially valuable, because they had the European stations in the range from 35° to 80°. A depth of focus of 0.01 R was inferred for the former in the I. S. S., but no confirmatory evidence was found, and the record from Toronto, a copy of which was kindly sent to us by Dr Hodgson, seemed a characteristic upper layer one. The Newfoundland shock had not been treated in the I. S. S., but Miss Bellamy sent us a copy of the reports from the stations, from which we were able to determine the epicentre and the distances. It was not included in the reduction for P, being strictly a North Atlantic shock. With these six shocks a preliminary curve for S was found. It appeared that the J. table was right within a few seconds up to 20°, but that there was then a bend in the curve similar to that found for P, and negative corrections were needed reaching — 8 s. about 30°. The correction then rose steadily, reaching + 5 s. about 65°, and from there on remained nearly constant. The resulting curve was not in any sense final, but was sufficient for identification. The next step was to determine $Y_S$ by successive approximation. The deviations of S from the approximate curve were grouped for each earthquake, and an approximate $Y_S$ found for the principal group. Sometimes it was found that there were two well marked concentrations of frequency ; then the earlier was taken as referring to S. Some earthquakes showed no marked concentration at all ; these were omitted from the determination. A second set of corrections was then found by a process analogous to that used for P, and the $Y_S$ redetermined. The next stage showed little change, and the final form of the S curve was known.

## TABLE VII

### Summaries for S. European shocks

1927 July 1 and 1928 Apr. 14 omitted. 1927 July 22 kept for $\Delta > 36°$.

| Δ | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.1-6.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.1-9.0 | 0 | 0 | [1 | 0 | 3 | 0 | 1 | 3 | 0 | 1 | 0 | 2 | 0 | 1] | 0 | 2 | 1 |
| 9.1-12.0 | 1 | 0 | [1 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 0 | 2 | 0 | 1] | 0 | 0 |
| 12.1-15.0 | 1 | 0 | 2 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 3 |
| 15.1-18.0 | 0 | 1 | 2 | 2 | 2 | 2 | [1 | 3 | 3 | 2 | 1 | 4 | 4] | 0 | 2 | 3 | 2 |
| 18.1-19.0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 2 | 0 | 0 | 2 | 1 | 1] | 0 | 0 |
| 19.1-20.0 | 0 | 0 | 0 | 1 | 0 | [2 | 0 | 2 | 1 | 0 | 2 | 2] | 0 | 0 | 0 | 1 | 0 |
| 20.1-21.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [2 | 1 | 2 | 3 | 1] | 0 | 4 | 2 |
| 21.1-22.0 | 0 | 0 | 0 | 0 | [3] | 0 | 0 | 0 | [1 | 1 | 1 | 0 | 2 | 0 | 2] | 0 | 0 |
| 22.1-23.0 | 0 | 0 | 0 | 0 | [1 | 0 | 0 | 1] | 0 | 0 | 0 | 0 | [1 | 1 | 1 | 1 | 1] |
| 23.1-24.0 | 0 | 0 | 0 | 0 | [1 | 0 | 2 | 1 | 0 | 1] | 0 | 0 | 0 | [1 | 1 | 0 | 1 |
| 24.1-25.0 | 0 | 0 | 0 | [5] | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | [1 |

| | −14 | −13 | −12 | −11 | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25.1-26.0 | 0 | 0 | 0 | [ 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1] | 0 | 0 | 0 | 0 | 4 |
| 26.1-27.0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | [1 | 1] | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 1 |
| 27.1-28.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28.1-30.0 | [1 | 0 | 1 | 0 | 2 | 1 | 0 | 3 | 0 | 2 | 1 | 0 | 1] | 0 | 0 | 0 | 0 |
| 30.1-33.0 | 0 | 0 | [1 | 0 | 2 | 0 | 1] | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 33.1-36.0 | 1 | 0 | 0 | 0 | 0 | 0 | [1 | 1 | 3 | 2] | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 36.1-39.0 | 0 | 0 | 0 | 0 | 0 | [1 | 1 | 0 | 2 | 2 | 1] | 0 | 0 | 0 | 1 | 1 | 0 |
| 39.1-42.0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | [3 | 1] | 0 | 2 | 1 | 1 | 0 | 1 | 0 |
| 42.1-45.0 | 1 | 0 | 0 | 0 | 0 | [1 | 3 | 1 | 0 | 1 | 2 | 2 | 1 | 1] | 0 | 0 | 1 |

| | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45.1-48.0 | 1 | 1 | 0 | [1 | 0 | 1 | 0 | 3 | 0 | 2 | 0 | 1] | 0 | 0 | 1 | 2 | 1 |
| 48.1-51.0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | [2] | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 51.1-54.0 | 1 | 1 | 0 | [1 | 0 | 2 | 0 | 0 | 1 | 2 | 1] | 0 | 0 | 0 | 1 | 1 | 2 |
| 54.1-57.0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 1 | 0 |
| 57.1-60.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 1 | 2 | 1 | 1 |

| | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.1-65.0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 3 | 0 | 0 | 1 | 2] | 0 | 0 | 0 | 0 | 0 |
| 65.1-70.0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | [2 | 0 | 1 | 2 | 1] | 0 | 1 | 0 |
| 70.1-75.0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | [2 | 5 | 2 | 2 | 1 | 1 | 0 | 1] | 0 | 1 |
| 75.1-80.0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | [1 | 0 | 1 | 0 | 3] | 0 | 0 | 0 | 3 | 0 |
| 80.1-85.0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | [1 | 2 | 1 | 1] | 0 | 0 | 0 | 0 | 1 |
| 85.1-90.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | [1 | 1] | 0 | 0 | 0 | 0 | 1 | 0 |
| 90.1-95.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 0 | 0 | 0 | 1] | 0 | 0 |
| 95.1-100.0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1] | 0 | 0 |
| 101.1-105.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## TABLE VIII

### Summaries for S. N. American shocks

### 1925 July 7, Dec. 10, 1928 Mar. 22, Aug. 4 omitted

| Δ | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.1-6.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 1] | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6.1-9.0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 0 | 1 | 1] | 0 | 0 | 0 | 0 | 0 | 1 |
| 9.1-12.0 | 1 | 0 | 0 | 0 | [1 | 1 | 0 | 0 | 1 | 0 | 1] | 0 | 0 | 0 | 0 | 0 | 0 |
| 12.1-15.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 1] | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.1-18.0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 1 | 0 | 1] | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.1-20.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.1-21.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1] | 0 | 0 | 0 | 0 | 1 |
| 21.1-22.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.1-23.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1] | 0 | 0 | 0 | 0 |
| 23.1-24.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [2] | 0 | 0 | 0 | 0 |
| 24.1-25.0 | 0 | 0 | 0 | [1 | 1 ] | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |

| | −16 | −15 | −14 | −13 | −12 | −11 | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3− | 2 | −1 | 0 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25.1-26.0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1] | 0 | 0 | 1 |
| 26.1-27.0 | 1 | 0 | 0 | 0 | [1 | 0 | 0 | 2 | 1 | 0 | 1 | 1 | 2] | 0 | 0 | 0 | 0 | 1 |
| 27.1-28.0 | [1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 2 | 2] | 0 | 0 | 0 | 0 | 0 | 0 |
| 28.1-30.0 | 0 | 3 | 2 | 0 | 0 | [1 | 0 | 3 | 1 | 1] | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 |
| 30.1-33.0 | 0 | 0 | [1 | 1 | 1 | 3 | 1 | 1 | 0 | 3 | 1 | 1 | 2] | 0 | 2 | 3 | 0 | 1 |
| 33.1-36.0 | 0 | [1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 3 | 5 | 3 | 1 | 2] | 0 | 1 | 1 |
| 36.1-39.0 | 1 | 0 | 0 | [1 | 0 | 1 | 1 | 3 | 5 | 3 | 3 | 0 | 0 | 3 | 2] | 0 | 2 | 0 |
| 39.1-42.0 | 0 | 0 | [1 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 2 | 3 | 2 | 1 | 1] | 0 | 0 | 0 |
| 42.1-45.0 | 0 | 1 | 0 | 0 | 0 | 0 | [2 | 0 | 2 | 4 | 1 | 0 | 4 | 3 | 3 | 2] | 0 | 1 |
| 45.1-48.0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | [1 | 1 | 1 | 1 | 3 | 4 | 2 | 3 | 4] | 0 | 0 |

| | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48.1-51.0 | [1 | 2 | 2 | 1 | 1 | 2 | 6 | 2 | 5 | 1 | 3 | 2 | 1] | 0 | 0 | 0 | 0 | 0 |
| 51.1-54.0 | 1 | 2 | 0 | 1 | 0 | [2 | 3 | 2 | 1 | 0 | 1 | 2 | 0 | 2] | 0 | 0 | 5 | 0 |
| 54.1-57.0 | 0 | 1 | 0 | 0 | 0 | [1 | 2 | 4 | 1 | 3 | 1] | 0 | 1 | 1 | 6 | 4 | 1 | 3 |
| 57.1-60.0 | 1 | 0 | 0 | 0 | 0 | 0 | [2 | 2 | 2 | 1 | 3 | 1 | 1] | 2 | 4 | 2 | 2 | 1 |
| 60.1-65.0 | 1 | 0 | 0 | [1 | 0 | 2 | 0 | 1 | 0 | 2 | 2 | 1] | 0 | 3 | 6 | 1 | 3 | 1 |
| 65.1-70.0 | 0 | 0 | 2 | 0 | 0 | [3 | 0 | 1 | 3 | 1 | 1 | 4 | 2 | 1 | 1] | 1 | 1 | 0 |
| 70.1-75.0 | 1 | 0 | 1 | 1 | 1 | 4 | 1 | 0 | [1 | 4 | 4 | 3 | 7 | 3 | 4 | 2 | 1] | 2 |
| 75.1-80.0 | 0 | 1 | 0 | 1 | 2 | 3 | 1 | 5 | [1 | 4 | 2 | 4 | 9 | 6 | 7 | 3 | 2 | 1] |
| 80.1-85.0 | 0 | 0 | 1 | 0 | 1 | 1 | 3 | [2 | 5 | 3 | 6 | 6 | 8 | 8 | 6 | 3 | 6 | 1] |
| 85.1-90.0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | [1 | 2 | 3 | 2 | 5 | 2 | 3 | 2 | 2 | 6 | 1] |
| 90.1-95.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | [1 | 1 | 1 | 2 | 1] | 0 |
| 95.1-100.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

## TABLE IX

### Means for S.

| | Europe | | N. America | | |
|---|---|---|---|---|---|
| | Number | Mean | Number | Mean | Final mean |
| 0-3.0 | 0 | | 0 | | ? |
| 3.1-6.0 | 0 | | 2 | −0.5 | −0.2 |
| 6.1-9.0 | 12 | −0.9 | 4 | −0.2 | −0.7 |
| 9.1-12.0 | 9 | +0.9 | 4 | −1.2 | +0.5 |
| 12.1-15.0 | ? | | 3 | +0.7 | +1.0 |
| 15.1-18.0 | 18 | +1.5 | 3 | +0.6 | +1.4 |
| 18.1-19.0 | 7 | +3.0 | 0 | | +3.0 |
| 19.1-20.0 | 9 | +0.2 | 0 | | +0.2 |
| 20.1-21.0 | 9 | +3.0 | 1 | +3.0 | +3.0 |
| 21.1-22.0 | 3 | −4.0 | 0 | | −4.0 |
| | 7 | +3.3 | | | +3.3 |
| 22.1-23.0 | 2 | −2.5 | | | −2.5 |
| | 5 | +6.0 | 1 | +4.0 | +5.7 |
| 23.1-24.0 | 5 | −1.6 | | | −1.6 |
| | 4 | +7.8 | 2 | +4.0 | +6.5 |
| 24.1-25.0 | 5 | −5.0 | 2 | −4.2 | −4.8 |
| | 2 | +9.5 | | | +9.5 |
| 25.1-26.0 | 3 | −7.0 | 5 | −6.2 | −6.3 |

| | Europe Number | Europe Mean | N. America Number | N. America Mean | Final mean |
|---|---|---|---|---|---|
| 26.1-27.0 | 2 | −6.5 | 8 | −7.1 | −6.7 |
| | 6 | +10.3 | | | +10.3 |
| 27.1-28.0 | 1 | −7.0 | 9 | −8.0 | −7.6 |
| | 3 | +15.3 | | | +15.3 |
| 28.1-30.0 | 12 | −7.7 | 6 | −8.6 | −8.1 |
| 30.1-33.0 | 4 | −10.0 | 15 | −8.7 | −8.7 |
| 33.1-36.0 | 7 | −6.1 | 26 | −7.1 | −6.7 |
| 36.1-39.0 | 7 | −6.1 | 23 | −7.5 | −7.0 |
| 39.1-42.0 | 4 | −5.8 | 15 | −6.8 | −6.4 |
| 42.1-45.0 | 12 | −5.2 | 21 | −5.3 | −5.0 |
| 45.1-48.0 | 8 | −2.7 | 20 | −3.8 | −3.3 |
| | 4 | +5.0 | | | +5.0 |
| 48.1-51.0 | 2 | −3.0 | 29 | −2.6 | −2.3 |
| | 2 | +5.5 | | | +5.5 |
| 51.1-54.0 | 7 | −3.0 | 8 | −2.7 | −2.7 |
| | 6 | +6.8 | | | +6.8 |
| 54.1-57.0 | 5 | +1.8 | 12 | −1.5 | −1.2 |
| | 3 | +6.7 | | | |
| 57.1-60.0 | 9 | +2.0? | 12 | −0.3 | 0.0 |
| 60.1-65.0 | 7 | +1.7 | 9 | −1.3 | +0.2 |
| 65.1-70.0 | | | 15 | +0.5 | +0.8 |
| 70.1-75.0 | 14 | +2.2 | 29 | +2.8 | +2.8 |
| 75.1-80.0 | 5 | +2.8 | 39 | +3.5 | +3.7 |
| 80.1-85.0 | 5 | +2.4 | 55 | +3.0 | +3.2 |
| 85.1-90.0 | 2 | +2.5 | 26 | +3.7 | +3.9 |
| 90.1-95.0 | 3 | +3.7 | 6 | +5.5 | +4.8 |
| 95.1-100.0 | 3 | +3.3 | 1 | +4.0 | +3.7 |
| 100.1-105.0 | 1 | 0.0 | | | 0.0 |

On comparing the European and North American means as for P it was found that the latter needed on increase of 0.3 s. to make the series comparable. This was applied, and then a weighted mean was taken for each range of distance.

The reduction is somewhat unsatisfactory, as the fraction of the observations of S that have survived in the final means is small. Wholesale rejection of observations is always objectionable, but it is clear from inspection of the summaries that without it no means of any sort could be obtained at many of the distances. The principles that have been followed are (1) that if the pulse under discussion is real its time curve must be continuous and curved downwards (2) there should be a maximum of frequency of the residuals near the value that corresponds to any real curve if is to be established at all. The method of weighting, and the method of the uniform reduction, are hardly applicable because in many cases the number of observations in the groups is too small. The method adopted was to arrange the whole of the $S_v$ in order of magnitude and notice by inspection the position of the maximum frequencies. The ordinary errors of S observations seem to run up to about 4 s., so that with possibly a series of nearly parallel curves about 7 seconds apart the maxima would not be clearly separated. The usual practice was to retain observations to about equal distances on both sides of the mode, but the range retained varied with the epicentral distance and was chosen in accordance with the actual distribution.

3. 3. At distances under 20° the North American observations, though rather few, nearly all seemed to correspond to a single curve. For European ones, on the other hand, they were scattered up to over + 20 s. with concentrations near a few values that tended to repeat themselves at different distances. They may be arranged as follows.

TABLE X

| Δ | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-6 | | | | | | | | | | 1 | | 1 | | | | | | |
| 6-9 | | 2 | 1 | | | | | | 1 | 1 | | 1 | | | | | | |
| 9-12 | | | | 2 | 2 | | | | | 1 | | | 1 | 1 | | | 1 | |
| 12-15 | | | 3 | 3 | 1 | | 1 | | 1 | | 2 | 1 | | | | 2 | 1 | |
| 15-18 | 2 | 3 | 2 | 1 | 1 | 1 | 3 | 4 | 3 | 2 | 2 | | | | 2 | | 2 | 1 |
| 18-19 | | | | 1 | 2 | 1 | 2 | 1 | | | | | | 1 | | | | |
| 19-20 | | 1 | | 2 | | 1 | | | | 1 | 1 | | | | | | | |
| 20-21 | | 4 | 2 | | | 1 | 1 | | 3 | | | 1 | | | | | | 1 |

There seems to be a strong tendency for S to be read about 8 s. late, and similar, but less marked, tendencies for it to be read about 14 s. and 22 s. late. This agrees with what was suspected in an earlier paper, and attributed to the existence of several swings of increasing size in the S phase; this agreed with Byerly's actual readings in the Montana earthquake. The effect is clearest in the range 12° to 15°, where it was found impossible to form a summary for the true S in

European shocks ; it may therefore be suspected that in this range the true S is unusually small.

3. 4. Beyond 20° the S readings seem to fall into two groups, one showing positive and the other negative residuals. There is a natural interpretation for this when we consider the physical explanation of a sharp bend in the time curve. The phenomenon is very analogous to that arising in the study of near earthquakes, where $P_g$ is the first movement on the record up to about 100 km., but $P_n$ overtakes it there and is the first movement at greater distances. Here we may expect that the bends at 19° are the result of a finite discontinuity in velocity at some depth, the indirect wave first overtaking the more direct one at 19° for both P and S. In these conditions we should expect the direct wave to be the larger, but since the indirect P begins the record it will in any case be read as P. But since the S movement does not start from rest in either case it is problematic whether the first or the second will be read, and apparently it is sometimes the one and sometimes the other. The later observations lie fairly near a smooth curve, which continues the S curve for shorter distances, and therefore probably represents the direct wave. In the final tables the direct P and S are found from 20° to 25° by extrapolation on the supposition of a constant second difference.

3. 5. From 51° to 65° there are a number of observations lying 4 to 7 seconds late, but clearly separated from the earlier group. In the earlier approximations the separation was not clear and the mean of the whole suggested that the table needed positive corrections up to 5 s. in this range. It appears now, however, that they are truly distinct. The earlier seems to join more smoothly on to the curve for shorter distances, and is taken to be S. The means still rise with distance, and suggest that the mode at + 3 s. beyond 70° is S. But there are some early readings outside the main group. A possible explanation of these is that when S enters the upper layers it may be partly transformed to P, and this movement

would arrive a few seconds earlier than the wave that has been S all the way. It will be smaller than S, but may be detected by the more sensitive instruments.

3. 6. Beyond 90° the number of S observations is rather small; but they can be supplemented from those given in the paper of I. Lehmann and G. Plett[1]. Their readings of S are incorporated with the I. S. S. ones in our tables for the Philippine earthquake of 1925 Nov. 13 and the South American one of 1928 July 18. The Marianne Islands shock discussed by them has not yet appeared in the I. S. S., but they give readings of S up to $\Delta = 105^\circ.6$. These are particularly welcome because the scarcity of S observations beyond 100° had left some doubt as to whether S is identifiable at these distances at all. It may be noticed that Gutenberg[2] stops the S curve at 96°. Lehmann and Plett give the slope of the S curve at 100° as 8.9 s. per degree. That of the J. curve is 8.8 s. /1°. Thus the correction to S at 105° is 0.5 s. more than that at 100°. This may be within the uncertainty of the determination, but at any rate it shows that the correction 0.0 s. at 102°.5 is not permissible.

The only South American shock that gave appreciable help was that of 1928 July 18. The means of $S_\gamma$ are

80°.1 to 85°.0, +3.7 ; 85°.1 to 90°.0, +4.1 ; 90°.1 to 95°.0, +5.6 ; 95°.1 to 100°.0, +3.1.

Again the means centred on 92°.5 and 97°.5 suggest a correction decreasing with distance, but the data are not enough to establish it.

The best procedure seems to be to use the data of Lehmann and Plett for the Marianne Is. shock. Forming $S_\mu$ we have the following means : 96°.2 to 100°.0 (Bergen omitted), —10.1 ; 100°.1 to 102°.3 (Chicago omitted), —10.4 ; 103°.0 to 105°.6 (Stonyhurst omitted), —10.7.

It appears therefore from their data that the correction

1. *Gerlands Beiträge*, 36, 1932, 38-77.
2. *Handbuch der Geophysik*, 4, 212.

decreases slightly with distance in this range. In forming $S_\omega$ the correction was taken as +5 s. beyond 97°, but +4 s might have been better. In the final smoothing of the S curve the correction was taken as +4 s. beyond 85°; this appears to be within the limits of error attainable at present.

3. 7. The summaries of $S_\gamma$ for the Japanese shocks were much less satisfactory. Up to 20° very few readings lay anywhere near the S curve; the tendency for S to be read late was even more marked than for Europe. It was only at distances over 51° that any summaries were possible; they are as follows.

TABLE XI

| Δ | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51°1-54°0 | 1 | 0 | 0 | 1 | 0 | 0 | [1] | 0 | 0 | 0 | [3 | 3] | 0 | 1 | 1 | 0 | 2 | 1 | 0 |
| 54°1-57°0 | 0 | 0 | 0 | 1 | 0 | [1 | 0 | 1 | 0 | 1 | 0 | 1] | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57°1-60°0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 1 | 2] | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 60°1-65°0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | [3 | 2 | 4 | 2] | 0 | 2 | 0 | 2 | 0 | 0 | 2 |
| 65°1-70°0 | 1 | 0 | 1 | 1 | 0 | 2 | 0 | [1 | 2 | 1 | 2 | 2 | 3 | 5 | 2 | 4 | 2] | 0 | 1 |
| 70°1-75°0 | 1 | 3 | 0 | 0 | 0 | [2 | 1 | 2 | 1 | 1 | 6 | 7 | 3 | 4 | 4 | 2 | 2 | 2] | 1 |
| 75°1-80°0 | 0 | 3 | 1 | 1 | 0 | 3 | 3 | 2 | 2 | [4 | 5 | 7 | 16 | 5 | 6] | 1 | 2 | 1 | 2 |
| 80°1-85°0 | 2 | 0 | 1 | 0 | 0 | 2 | 2 | [3 | 3 | 8 | 12 | 4 | 10 | 6 | 4 | 3 | 3] | 2 | 5 |
| 85°1-90°0 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | [2 | 3 | 2 | 3 | 6 | 4 | 1 | 3 | 2 | 2 | 2] | 0 |
| 90°1-95°0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 1 | 1 | 0 |
| 95°1-100°0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 |
| 100°1-100°5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Means : 51.1-54.0, —2, +2.5 ; 54.1-57.0, 0.0 ; 57.1-60.0, +0.5 ; 60.1-65.0, +1.5 ; 65.1-70.0, +4.3 ; 70.1-75.0, +3.7 (reduction 1 applied) ; 75.1-80.0, +3.8 (reduction 2 applied) ; 80.1-85.0, +3.1 (reduction 2 applied) ; 85.1-90.0, +3.4 (reduction 1 applied) ; 90.1 —95.0, +5.0.

From 70° onwards these means agree well with those already obtained. At shorter distances the Japanese values are a little late ; this is opposite to the phenomenon noticed for P, but the data are scanty. It appears that S in Japanese shocks tells us nothing that we have not already found from the European and American ones.

4. 1. We now proceed to the waves influenced by the core, and begin with the diffracted P at distances over 105° and

the compressional wave P′ or PKP through the core. Both waves are difficult to observe, and it is therefore necessary to limit ourselves to shocks well observed at European stations. Since these waves are observed only at distances over 105° only epicentres in the Southern hemisphere are relevant. Depth of focus and crustal structure near the focus will affect these waves by nearly the same amount as P between 70° and 105°. Hence if we determine a mean of $P_{\omega}$ at the latter range of distance and subtract it from the times of P ($\Delta > 105°$) and P′ we eliminate these effects and obtain times comparable with those of P. For the diffracted P only the four South American shocks were useful; the wave was well observed to 115°, but beyond that the observations were few, there being only 6 in all beyond 125°. Four of these were on 1928 Dec. 1. The curve proved to be a straight line, as was expected. The summaries of the final residuals are as follows.

TABLE XII

| Δ | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 105.1-110.0 | 0 | 0 | 0 | 1 | 1 | [2 | 3 | 2 | 3] | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| 110.1-115.0 | 1 | 3 | 0 | 0 | [1 | 1 | 0 | 2] | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 |
| 115.1-120.0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 120.1-125.0 | | | | | none | | | | | | | | | | | |
| 125.1-130.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 130.1-135.0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 135.1-140.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 140.1-145.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Means : 105.1-110.0, + 0.7 (reduction 1 applied) ; 110.1-115.0, —0.2 ; 115.1-120.0, +1.0 ; 125.1-130.0, +1 ; 130.1-135.0, —1 ; 135.1-140.0, 0 ; 140.1-145.0, 0.

The straight line is therefore well within the probable error of the determination. Its slope is 4.87 s. /1°. That of P, as corrected, is 4.60 s. /1°. It appears therefore that the diffracted wave does not merely continue the P curve, there being a finite change of the slope where diffraction begins. This might have been expected. The movement is small and therefore liable to be read late, especially as, to judge by various reproduced seismograms, the beginning of the diffracted movement is an *emersio* rising slowly to a maximum. Thus an observer, having to wait till the displacement is large enough to be perceptible, will read it later than the true beginning, and the delay will increase with distance both on account of the decrease in size and, probably, on account of the increasing time to the first maximum. This systematic error increases the slope as found by observation ; it is interesting that the empirical curve is still a straight line, since this means that the systematic error increases linearly with the distance.

$P'$ (= PKP) and $P_2'$.

5. 1. A rough preliminary table for $P'$ was first formed from the South American shocks ; corrections were obtained by using also some oceanic ones. The residuals given in the reductions for the individual earthquakes are with respect to this second approximation. Then the whole of the South American and Oceanic shocks were combined in one summary ; as for P ($\Delta > 105^o$), the mean of $P_\omega$ for $\Delta$ between $70^o$ and $105^o$ was subtracted from all the $P'$ residuals before summarizing, so as to make the resulting table correspond to that for P. The New Zealand shock of 1927 July 18 was reserved, because there were not many observations of P and it seemed that the probable error of the mean of $P_\omega$ might be large.

In most of the ranges of distance the residuals were very scattered and it was difficult to form satisfactory means. Late readings are to be expected frequently, since the movement is small except about $145^o$ ; but we have to do our best with the data. It is often noticed that horizontal component instruments record later than vertical ones ; this has been explained by previous writers as due to the smallness of the horizontal movement. The square brackets [ ] indicate the observations at first retained in forming the means.

# TABLE XIII

## Summary for P′

| Δ | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 105.1-110.0 | 0 | 0 | [(1 | 0 | 0 | 0) | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1] | 0 | 0 | 0 | 0 | 0 |
| 110.1-115.0 | 0 | [(1 | 1 | 0 | 0 | 1) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1] | 0 | 0 |
| 115.1-120.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 120.1-125.0 | 0 | 0 | 0 | 0 | 0 | [(1 | 1 | 1) | 0 | 0 | 0 | 1 | 1] | 0 | 0 | 0 | 0 | 0 | 0 |
| 125.1-130.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [(2) | 0 | 0 | 0 | 1 | 2] | 0 | 1 | 0 | 1 | 0 |
| 130.1-135.0 | 0 | 0 | 1 | 0 | (1 | 1 | 1 | [3 | 2 | 1) | 4 | 0 | 2 | 2] | 1 | 0 | 1 | 1 | 0 |
| 135.1-140.0 | 0 | 0 | 0 | [(3 | 0 | 1 | 1 | 1 | 0 | 1) | 0 | 5] | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 140.1-145.0 | [(2 | 1 | 1 | 1 | 3 | 1 | 1 | 1) | 1 | 1 | 4 | 0 | 1] | 0 | 0 | 0 | 2 | 1 | 0 |
| 145.1-150.0 | 0 | (1 | 0 | 0 | 1 | [3 | 3 | 2) | 2 | 5 | 4 | 5 | 3] | 1 | 1 | 2 | 2 | 2 | 1 |
| 150.1-155.0 | (1 | 0 | 0 | 0 | 1 | [5 | 3 | 2) | 0 | 1 | 1 | 1 | 0 | 3] | 1 | 0 | 2 | 1 | 1 |
| 155.1-160.0 | (1 | 0 | [2 | 0 | 2 | 1 | 2 | 2) | 0 | 3 | 1 | 0 | 2] | 0 | 1 | 3 | 0 | 1 | 0 |
| 160.1-165.0 | 0 | 0 | 0 | 0 | 0 | [(3 | 1 | 1 | 2) | 0 | 2 | 0 | 2] | 0 | 0 | 0 | 1 | 0 | 1 |
| 165.1-170.0 | 0 | (1 | 0 | [1 | 0 | 1 | 0 | 1 | 2 | 1) | 0 | 1 | 1] | 0 | 1 | 1 | 1 | 0 | 0 |
| 170.1-175.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| 175.1-180.0 | | | | | none | | | | | | | | | | | | | | |

# TABLE XIV

## P′ Means.

| Δ | I. S. S. | | Reduction | 1927 July 18 | | | Difference | Final mean |
|---|---|---|---|---|---|---|---|---|
| | Number | Mean | | Number | Mean | Weight | | |
| 105.1-110.0 | 4 | −0.7 | 0 | | | | | −0.7 |
| 110.1-115.0 | 5 | −1.8 | 0 | | | | | −1.8 |
| 115.1-120.0 | 1 | +6 | 0 | | | | | +6 |
| 120.1-125.0 | 5 | −0.8 | 0 | | | | | −0.8 |
| 125.1-130.0 | 5 | +1.8 | 0 | | | | | +1.8 |
| 130.1-135.0 | 8 | −0.6 | 1 | 1 | −11 | 0.9 | −10.4 | −0.8 |
| 135.1-140.0 | 12 | −1.4 | 0 | | | | | −1.4 |
| 140.1-145.0 | 18 | −3.2 | 0 | 2 | −9 | 1.8 | −5.8 | −2.7 |
| 145.1-150.0 | 19 | 0.0 | 1 | 4 | −5.2 | 3.3 | −5.2 | +0.4 |
| 150.1-155.0 | 9 | −1.8 | 1 | 1 | −13 | 0.9 | −11.2 | −2.0 |
| 155.1-160.0 | 7 | −2.0 | 1 | 3 | −9.3 | 2.1 | −7.3 | −1.9 |
| 160.1-165.0 | 11 | −1.0 | 0 | 8 | −9.7 | 4.7 | −8.7 | −1.5 |
| 165.1-170.0 | 8 | −1.1 | 0 | 2 | −7.5 | 1.6 | −6.4 | −0.9 |
| 170.1-175.0 | 3 | +3.7 | 0 | 5 | −5.6 | 1.9 | −9.3 | +2.6 |
| 175.1-180.0 | 0 | | | 2 | −4.0 | | | +3.6 |
| | | | | | | Mean | −7.6 | |

Some of the ranges may include abnormal observations affected by systematic error. This is the case that the method of the uniform reduction was designed to meet.

The shock of 1927 July 18 gave a fine series of observations of P′ to 175°.6. Most of the residuals were about —8 s. from Ekaterinburg (133°.2) to Algiers (175°.6) apart from some plainly abnormal observations. The difficulty about this shock was that P was observed at only four stations beyond 70°, namely Manila, Zi-ka-wei, Phu-Lien, and La Paz. Three of these would fit a mean for $P_\omega$ near 0, but then the whole of the P′ observations are about 8 s. earlier than we should infer from the shocks that provide more material to determine $P_\omega$. On the other hand $P_\omega$ at Zi-ka-wei is —7 s., which agrees well with the mean of the P′ observations. It seems probable therefore that Zi-ka-wei is nearly right and the other three stations late. The alternative would be to suppose that Zi-ka-wei observed a microseism as P and that P′ is systematically late in all the other shocks, which hardly seems reasonable. Accordingly this shock was combined with the others by the method already used in combining the observations of P in the European and North American shocks. The weighted mean of the differences between 1927 July 18 and the others was —7.6 s. ; this was subtracted from all the means for this earthquake and final weighted means were taken.

At distances over 120° the corrections vary smoothly, except perhaps beyond 170°. A shorter distances they are less satisfactory ; they are fairly smooth, but there is a good deal of arbitrariness as to which observations should be retained. The approximation used in forming the residuals was a smoothed one, and the observations with small residuals were such as to make the corrected curve smooth. It seems certain therefore that they are the real diffracted P′. There are also a number of negative residuals about —20 s. and —30 s. between 105° and 120°, but these cannot be made to lie near any smooth continuation of the P′ curve. Their interpretation cannot be undertaken at present ; they are a minute earlier than PP and three minutes later than P.

5. 2. Additional information can be obtained from the spe-

cial studies of Macelwane on the earthquake of 1924 June 26[1] and Lehmann on that of 1929 June 16[2]. Neither of these was included in the reductions for P, S and SKS, the former because the I. S. S. observations were scanty, and the latter because when the reductions were made the I. S. S. was available only to March 1929. But both give good series of observations of the waves at great distances, which have an advantage over those in the I. S. S. because the single observer examining the whole of the records is more likely to adopt a uniform criterion about the beginning of a phase.

Macelwane gives the epicentre 56°56′ ± 14′ S., 155°38′ ± 77′ E. ; $T_0$ = 1 h. 37 m. 25 s. We found that this left some systematic variation of the P residuals with azimuth, and the epicentre was accordingly moved to 55°56′ S., 156°44′ E., $T_0$ being increased by 12 s. The epicentre, even as it is, is not very reliable. To the north-east there are three stations, which are not very consistent ; but those to NW and SE agree, and it seems that the epicentre requires little change in this direction.

Miss Lehmann's epicentre required no change, and was indistinguishable from that used in the I. S. S. Her estimate of the time of the earthquake is 22 h. 47 m. 27 s. The I. S. S. gives 22 h. 47 m. 18 s. ; we adopt 22 h. 47 m. 31 s. The I. S. S. readings leave some doubt about the allowance for focal depth expressed in the $P_\omega$ at distant stations ; from Batavia (67°.7) to Hyderabad (104°.2) they show two maximum frequencies, one at —5 s. and —4 s., and one at 0 s. If we take a simple mean from —10 s. to + 5 s. we get —2.1 s. ±0.9 s. On the other hand Lehmann gives readings in this range at Honolulu, Batavia, Manila, Hong Kong, and Santiago and Zi-ka-wei, which yield the value —4.0 s. ±0.5 s. It seems therefore that the earlier group from the I. S. S. represent the true P, and the zero of time for the study of P′ and $P_2'$ was accordingly taken to be 47 m. 31 s. — 4 s. = 47 m. 27 s.

1. *Gerlands Beiträge*, 28, 1930, 165-227.
2. *Gerlands Beiträge*, 26, 1930, 402-412.

Horizontal components had been noticed to give later readings of P′ than vertical ones, and to avoid systematic error the discussion was restricted to the latter.

The uncertainty of the epicentre and the focal depth in Macelwane's earthquake combine, since most of the European stations are in azimuths near 260°; the consistent groups for P are towards Japan and China in azimuth 340°, and South America about 150°. The distant P therefore gives us no help in finding the allowance for focal depth. This earthquake while useful in fixing the forms of the curves for the core waves therefore leaves them with an indeterminate additive constant. Macelwane does not indicate which readings were made on vertical instruments; the whole were therefore grouped according to distance and means taken for the chief group. Comparing these two shocks with the results already found from the I. S. S., we have the following mean residuals.

TABLE XV

| | I. S. S. | | 1924 June 26 | | 1929 June 16 | |
|---|---|---|---|---|---|---|
| Δ | *n* | Mean | *n* | Mean | *n* | Mean |
| 110°-120° | 6 | −0.5 | 1 | −1? | 1 | +5 |
| 120°-130° | 10 | +0.5 | 1 | −1 | 1 | −4 |
| 130°-140° | 21 | −1.2 | 1 | 0? | 1 | −3 |
| 140°-150° | 43 | −1.1 | 8 | −6.1 | 1 | −6 |
| 150°-160° | 18 | −2.0 | 16 | −4.9 | 2 | −5.0 |
| 160°-170° | 29 | −1.3 | 8 | −5.3 | 7 | −3.6 |
| 170°-180° | 10 | +2.8 | | | 1 | 0 |

5. 3. Lehmann's readings are systematically earlier than those inferred from the I. S. S.; the weighted mean of the differences is —2.7 s. Now the mean of the distant $P_\omega$ from her observations has a standard error of about 0.5 s., and Europe is in nearly the same azimuth as Japan. It seems unlikely therefore that the systematic difference is due to wrong estimate of $P_\omega$ or the epicentre; and the agreement of the majority of Lehmann's residuals (even remembering that some observations have been rejected) suggests that the difference is unlikely to arise from inaccu-

racy in her readings. The utmost error liable to arise in the discussion of this shock seems unlikely to exceed 1.5 s. The more probable interpretation of the systematic difference seems to be that late readings have been still retained in the reduction of the I. S. S. data. This suggests then that our best plan is to use the 1929 June 16 residuals to indicate a different selection of the I. S. S. data. This is shown in table XIII by the brackets ( ). It will be noticed that in nearly all cases the selection indicated now is one that might have been chosen originally ; the respective dangers of rejecting and keeping too many observations are that in the one case we increase the probable accidental error, while in the other we risk introducing systematic error. The new means are as follows, omitting 1927 July 18.

TABLE XVI

| | I. S. S. | | 1929 June 16 | | Total | | 1927 July 18 | | 1924 June 26 | | Final | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ | *n* | Mean | *n* | Mean | *n* | Mean | *n* | Mean | *n* | Mean | *n* | Mean |
| 105-110 | 1 | −7 | 0 | | 1 | −7 | 0 | | 0 | | 1 | −7 |
| 110-115 | 3 | −6.3 | 0 | | 3 | −6.3 | 0 | | 1 | −10 | 4 | −6.9 |
| 115-120 | 0 | | 0 | | 0 | | 0 | | 1 | −1 | 1 | +0.4 |
| 120-125 | 3 | −3.0 | 1 | −4 | 4 | −3.2 | 0 | | 1 | −1 | 5 | −2.5 |
| 125-130 | 2 | −1.0 | 0 | | 2 | −1.0 | 0 | | 0 | | 2 | −1.0 |
| 130-135 | 9 | −2.2 | 1 | −3 | 10 | −2.3 | 1 | −11 | 1 | 0 | 12 | −2.3 |
| 135-140 | 7 | −3.9 | 0 | | 7 | −3.9 | 0 | | 2 | −13.5 | 9 | −5.7 |
| 140-145 | 11 | −5.7 | 0 | | 11 | −5.7 | 2 | −9.0 | 4 | −7.5 | 17 | −5.6 |
| 145-150 | 10 | −3.8 | 1 | −6 | 11 | −4.0 | 3 | −6.7 | 3 | −6.3 | 17 | −3.8 |
| 150-155 | 12 | −4.2 | 2 | −5.0 | 14 | −4.3 | 2 | −10.0 | 5 | −5.4 | 21 | −4.3 |
| 155-160 | 10 | −4.7 | 0 | | 10 | −4.7 | 3 | −9.3 | 10 | −4.1 | 23 | −3.8 |
| 160-165 | 7 | −2.6 | 4 | −5.0 | 11 | −3.5 | 8 | −9.7 | 5 | −7.2 | 24 | −4.1 |
| 165-170 | 7 | −3.1 | 3 | −1.7 | 10 | −2.7 | 2 | −7.5 | 4 | −4.0 | 16 | −2.7 |
| 170-175 | 0 | | 1 | 0±3 | 1 | 0±3 | 5 | −5.6 | 0 | | 6 | −0.7 |
| 175-180 | 0 | | 0 | | 0 | | 2 | −4.0 | 0 | | 2 | +0.8 |

There is no longer any systematic difference between the I. S. S. results and those derived from Lehmann's readings. The latter are accordingly combined with the former to give the columns headed 'total'. We now compare the readings for 1927 July 18 and 1924 June 26 with these. In taking means for these we can now be more severe then before in rejecting late readings. Determining weights as before we find that P′ in the 1927 shock is early by 4.8 s., instead of by 7.6 s. as we found previously. In the 1924 one it is early by 1.4 s. We now subtract these means and combine the results from these shocks with those in the column marked Total (mean). These are added to the trial times to distances 107°.5, 112°.5 and so on to give empirical times for P′, which are now ready for smoothing.

5. 4. The I. S. S. observations for $P'_2$ were few and unsuited for giving corrections. The trial curve adopted was a straight line, and the data used were taken from the papers of Macelwane and Lehmann. The mean residuals were as follows.

TABLE XVII

| | 1929 June 16 | | 1924 June 26 | | |
|---|---|---|---|---|---|
| Δ | *n* | Mean | *n* | Mean | Final mean |
| 150°-155° | 0 | | 1 | −1 | +5.3 |
| 155°-160° | 0 | | 8 | −9.0 | −2.7 |
| 160°-165° | 9 | 0.0 | 7 | −8.4 | −0.9 |
| 165°-170° | 12 | −1.9 | 3 | −4.3 | −1.2 |
| 170°-175° | 1 | −4 | | | −4 |
| 175°-180° | 1 | −1 | | | −1 |

Macelwane's readings are early by 6.3 s. on an average; allowing for this difference, part of which may be due to the position of the epicentre, and part to focal depth, we obtain the final means. We now combine our corrections with the trial times and obtain the following times for P′ and $P'_2$.

TABLE XVIII

| | P′ | | | | | $P_2'$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| Δ | Trial Time | | Correction | Corrected Time | | Trial Time | | Correction | Corrected Time | |
| | m | s | | m | s | m | s | | m | s |
| 107°.5 | 18 | 21.0 | −7.0 | 18 | 14.0 | | | | | |
| 112°.5 | | 31.5 | −6.9 | | 24.6 | | | | | |
| 117°.5 | | 42.0 | +0.4 | | 42.4 | | | | | |
| 122°.5 | | 53.0 | −2.5 | | 50.5 | | | | | |
| 127°.5 | 19 | 5.0 | −1.0 | 19 | 4.0 | | | | | |
| 132°.5 | | 13.0 | −2.3 | | 10.7 | | | | | |
| 137°.5 | | 21.5 | −5.7 | | 15.8 | | | | | |

| Δ | | P′ Trial Time | P′ Correction | P′ Corrected Time | | P₂′ Trial Time | | P₂′ Correction | P₂′ Corrected Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| | m | s | | m | s | m | s | | m | s |
| 142°.5 | 19 | 31.0 | −5.6 | 19 | 25.4 | | | | | |
| 147°.5 | | 42.0 | −3.8 | | 38.2 | | | | | |
| 152°.5 | | 49.0 | −4.3 | | 44.7 | 20 | 13.0 | +5.3 | 20 | 18.3 |
| 157°.5 | | 55.5 | −3.8 | | 51.7 | | 35.0 | −2.7 | | 32.3 |
| 162°.5 | | 59.5 | −4.4 | | 55.1 | | 57.0 | −0.9 | | 56.1 |
| 167°.5 | 20 | 4.5 | −2.7 | 20 | 1.8 | 21 | 19.0 | −1.2 | 21 | 17.8 |
| 172°.5 | | 8.0 | −0.7 | | 7.3 | | 41.0 | −4 | | 37.0 |
| 177°.5 | | 10.0 | +0.8 | | 10.8 | 22 | 3.0 | −1 | 22 | 2.0 |

5. 5. In attempting to improve the tables further we can be guided by some theoretical principles. The curves representing P′ and $P'_2$ are the lower and upper branches of a curve with a cusp near 143°. The mean of their times should be a curve of finite curvature in this neighbourhood ; and their difference should be proportional to $(\Delta-143°)^{\frac{3}{2}}$. The concavity of the P′ curve should be downwards everywhere, while, since the wave emerges normally at the anticentre, its time at great distances should be of the form $a-b(180°-\Delta)^2$. The concavity of the $P'_2$ curve should be everywhere upwards.

A wholly satisfactory solution has not been obtained. It is natural to use the difference of the times of P′ and $P'_2$, so as to evaluate the coefficient of the semi-cubical term directly ; but on investigation it was found that the only distances capable of determining this interval are 157°.5 and 162°.5, and at these the effects of higher terms are already appreciable.

The procedure adopted for P′ was to smooth between 147°.5 and 177°.5 by Comrie's method, namely to subtract 1/12 of the fourth difference. This left three smoothed values in the centre of the range, with first differences —5.4 and —5.3. Beyond this distance extrapolation was carried out on the supposition that the first difference is proportional to 180°—Δ. The method worked well because the groups, except the two last, which have to be replaced by extrapolation, are of nearly equal weight. No improvement could be made in the value at 142°.5, which is affected by the strong curvature near the cusp.

Before 142°.5 the second differences found from the larger groups were roughly constant. A parabola was therefore fitted to the observations. The solution is

$$T = 19\text{m. } 24.06\text{s.} - 0.978\ (142^\circ.5 - \Delta) - 0.0327\ (142^\circ.5 - \Delta)^2. \qquad (1)$$

For $P_2'$ the curvature was too small to be determined ; the solution adopted from the three main groups was

$$T = 20\text{m. } 55.4\text{s.} + 4.55\ (\Delta - 162^\circ.5). \qquad (2)$$

The tables can now be computed. It will be noticed that the gradient of P′ has a sharp discontinuity at 142°.5 ; this is presumably connected with the proximity of the cusp, but to interpret it would require more knowledge of the diffraction of pulses in the neighbourhood of caustics than is at present available. To fill in the time between 142°.5 and 147°.5 with any accuracy will also probably need further investigation ; in particular the distance of minimum deviation needs to be redetermined.

TABLE XIX

| | P′ | | | $P_2'$ | | |
|---|---|---|---|---|---|---|
| | T (calc.) | | O-C | T (calc.) | | O-C |
| Δ | m | s | | m | s | |
| 107.5 | 18 | 9.8 | +4.2 | | | |
| 112.5 | | 25.3 | −0.7 | | | |
| 117.5 | | 39.2 | +3.2 | | | |
| 122.5 | | 51.4 | −0.9 | | | |
| 127.5 | 19 | 2.0 | +2.0 | | | |
| 132.5 | | 11.0 | −0.3 | | | |
| 137.5 | | 18.3 | −2.5 | | | |
| 142.5 | | 24.1 | +1.3 | | | |
| 147.5 | | 38.2 | 0.0 | | | |
| 152.5 | | 45.0 | −0.3 | | | |
| 157.5 | | 50.8 | +0.9 | 20 | 32.7 | −0.4 |
| 162.5 | | 56.2 | −1.1 | | 55.4 | +0.7 |
| 167.5 | 20 | 1.5 | +0.3 | 21 | 18.1 | −0.3 |
| 172.5 | | 5.1 | +2.2 | | 40.9 | −3.9 |
| 177.5 | | 6.9 | +3.9 | 22 | 3.6 | −1.6 |

SKS.

6. 1. Some attention had to be given to this wave before S

could be investigated at the greater distances. On account of the closeness of the two pulses there had been much difficulty in tracing the true S in the I. S. S. work, and though lately attention has been given in the I. S. S. to their separation it appears that it is still far from complete, especially at the distances up to 87° or so. The observations of SKS are the more numerous, and as already explained, it was found necessary to identify them as well as possible before S could be determined. Later we returned to SKS to find its time-curve more accurately. It was found, like S, to be systematically early in some shocks and in others late. We had therefore to proceed in the same way as for S. Residuals were first found for each shock against a trial table ; these were inspected for a maximum frequency, and a mean taken for the group around that maximum. This mean was subtracted from the whole of the residuals, thus effectively allowing for the variation of $T_0$ (SKS) between different shocks. Three South American shocks (omitting 1927 Nov. 14) were then combined ; these were chosen because they gave observations over a great range of distance. Means of the residuals over 5° ranges were then found ; thus the times were determined except for an additive constant.

We see that variation in focal depth and in crustal structure near the epicentre will ordinarily be expected to affect S at distances over 70° and SKS by about the same amount. In different earthquakes with foci in the upper layers these effects will simply displace the S and SKS curves up or down equally, and the times will differ by the same amount at the same distance. If we choose the additive constant for SKS so that it fits the observations for an earthquake with $Z = 0$, the times of SKS in all other earthquakes with foci in the upper layers will be found by simply adding Z to the tabular times. In this way the standard S and SKS curves can be made to refer to the same focal depth. Further, even if the focus is in the lower layer, focal depth will affect SKS by the same amount as the *distant* observations of S, and we shall still have correspondence provided that Z is determined only from the distant observations. We have therefore to find what value of the mean SKS residual corresponds to Z = 0, and add it to the SKS trial times ; then the SKS curve will be comparable with the S one. This was done in the first place by merely taking the means for the North American earthquakes. It appeared after the correction was made that the two curves cross about $\Delta = 81^{o}.6$.

In this way we found a second approximation to the SKS curve. The residuals in the reductions correspond to this approximation. Finally the whole of the North and South American, Japanese, and Oceanic shocks were taken together and the process repeated. Several of the latter showed the influence of focal depth in either P or S, or both, but with the precaution that the mean SKS residual has to be found for each shock separately there is no difficulty. In the Japanese shocks Z had already been found, effectively, from the distant stations, since the S observations at near ones are few.

## TABLE XX

### Summary for SKS

| Δ | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 82°0-85°0 | 1 | 1 | 2 | 0 | 0 | 1 | [2 | 7 | 6 | 11 | 12 | 10 | 12 | 10 | 3] | 1 | 0 | 0 | 0 | 0 | 0 |
| 85°1-90°0 | 0 | 1 | 3 | 3 | 1 | [7 | 7 | 7 | 13 | 11 | 17 | 26 | 14 | 26 | 9 | 8] | 2 | 2 | 4 | 8 | 1 |
| 90°1-95°0 | 1 | 2 | [3 | 4 | 3 | 5 | 6 | 10 | 12 | 13 | 18 | 18 | 7 | 5 | 7 | 5] | 2 | 1 | 0 | 4 | 1 |
| 95°1-100°0 | 2 | 0 | 3 | 2 | 2 | [4 | 6 | 9 | 8 | 8 | 5 | 8 | 13 | 10 | 2 | 3] | 0 | 3 | 0 | 0 | 1 |
| 100°1-105°0 | 1 | 0 | 2 | 0 | [4 | 3 | 2 | 0 | 4 | 6 | 5 | 2 | 2 | 2 | 2 | 1 | 0 | 2] | 1 | 1 | 3 |
| 105°1-110°0 | 1 | 0 | 0 | 1 | [2 | 3 | 0 | 4 | 1 | 3 | 3 | 0 | 2 | 4] | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 110°1-115°0 | 0 | 1 | 0 | 0 | 1 | [2 | 1 | 2 | 0 | 3 | 2 | 3] | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 115°1-120°0 | 1 | 0 | 0 | 0 | 1 | 0 | [2 | 1 | 1 | 3 | 0 | 4] | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 1 | 0 |
| 120°1-125°0 | 0 | 1 | 0 | [1 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1] | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 125°1-130°0 | 0 | 0 | 0 | 0 | 0 | 0 | [2 | 0 | 0 | 0 | 0 | 1 | 0 | 1] | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 130°1-135°0 | 0 | 0 | 0 | 0 | 0 | 0 | [1 | 0 | 0 | 0 | 2] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 135°1-140°0 | | | −20 | | | | | | | | | | | | | | | | | | |
| 140°1-145°0 | | | | | | none | | | | | | | | | | | | | | | |
| 145°1-150°0 | | | −26, −26 | | | | | | −17 | | | | | | +25 | | +26 | +33 | | | |
| 150°1-155°0 | | | | | | | | | | | +2 | | | | | +18 | | | +43 | | |
| 155°1-160°0 | | | | | | | | | | | | | +13 | | | | | | | | |
| 160°1-165°0 | | | | | | | none | | | | | | | | | | | | | | |
| 165°1-170°0 | | | | | | | | −3 | | | | +12 | | | | +52 | | | | | |

MEANS

| Δ | Reduction | Number | Mean | Δ | Reduction | Number | Mean |
|---|---|---|---|---|---|---|---|
| 82°.0-85°.0 | 1 | 64 | +0.4 | 110°.1-115°.0 | 1 | 7 | −1.1 |
| 85°.1-90°.0 | 2 | 123 | +0.7 | 115°.1-120°.0 | 1 | 5 | −0.3 |
| 90°.1-95°.0 | 2 | 88 | −0.5 | 120°.1-125°.0 | 0 | 5 | −3.2 |
| 95°.1-100°.0 | 2 | 54 | −0.2 | 125°.1-130°.0 | 0 | 4 | −1.0 |
| 100°.1-105°.0 | 1 | 22 | −1.4 | 130°.1-135°.0 | 0 | 3 | −1.3 |
| 105°.1-110°.0 | 1 | 14 | −1.1 | Beyond 135° | indeterminate. | | |

It seems that some of the scattered observations beyond 135° may refer to PPP. According to our trial tables we have the following comparison.

| | SKS | | PPP | | SKS−PPP |
|---|---|---|---|---|---|
| Δ | m | s. | m. | s. | |
| 145 | 26 | 39 | 26 | 5 | +34 |
| 150 | 26 | 59 | 26 | 41 | +18 |
| 155 | 27 | 4 | 27 | 18 | −14 |
| 160 | 27 | 9 | 27 | 53 | −44 |

Thus somewhere about 153° these two curves theoretically cross, as is shown also in Gutenberg's diagram. It appears therefore that some of the negative residuals before 150° and some of the positive ones beyond that distance are really due to PPP. In any case we have here no observational evidence that SKS exists beyond 135°.

In the above discussion we omitted a number of shocks that we could not find mean residuals for. These were :

North America : 1925 Mar. 1, Dec. 10; 1928 Feb. 10; 1929 Feb. 2, Nov. 18.

South America : 1927 Nov. 14.

Oceania : 1926 Jan. 18 ; 1928 Mar. 9, Sept. 22.

Japan : 1924 Aug. 25 ; 1928 June 1.

6. 2. The corrections found to our second approximation are so slight, especially at the distances where observations are most numerous, that it was unnecessary to redetermine the mean residuals of SKS, and we proceed at once to compare them with Z. The results are as follows.

# TABLE XXI

| North America | | Z | SKS mean |
|---|---|---|---|
| 1924 | Mar. 4 | 0 | 0 |
| | May 1 | −1 | −3 |
| 1925 | June 29 | +8 | +8 |
| 1927 | Aug. 10 | −1 | 0 |
| | Nov. 4 | +3 | +2 |
| 1928 | Mar. 22 | +2 | +3 |
| | Apr. 13 | −2 | 0 |
| | Aug. 4 | −2 | −2 |
| | Oct. 9 | 0 | +2 |
| 1929 | Jan. 24 | +2 | 0 |
| | Feb. 10 | −3 | −4 |
| | Feb. 22 | 0 | −1 |
| | Mean | +0.5 | +0.4 |

| South America | | Z | SKS mean |
|---|---|---|---|
| 1928 | July 18 | +2 | +4 |
| | Nov. 20 | −2 | −5 |
| | Dec. 1 | −1 | +1 |
| | Mean | −0.3 | 0.0 |

| Oceania | | Z | SKS mean |
|---|---|---|---|
| 1925 | Nov. 13 | −9 | −12 |
| 1927 | July 18 | −10 | −13 |
| 1928 | Mar. 16 | −4 | −7 |
| | June 15 | −7 | −7 |
| | July 9 | 0 | −4 |
| | Mean | −6.0 | −8.6 |

| Japan | | Z | SKS mean |
|---|---|---|---|
| 1923 | July 13 | −3 | −2 |
| 1924 | Mar. 15 | −1 | 0 |
| | May 6 | +1 | +1 |
| | Aug. 14 | −2 | −4 |
| | Dec. 28 | −8 | −6 |
| 1925 | Jan. 18 | −10 | −11 |
| | Jan. 28 | −2 | −3 |
| | Feb. 20 | −5 | −5 |
| | Apr. 16 | −7 | −7 |
| | Aug. 3 | −1 | +1 |
| 1927 | Feb. 16 | −5 | −5 |
| 1928 | May 27 | −5 | −5 |
| | Mean | −4.0 | −3.8 |

| | Mean square variations Z | Mean square variations SKS mean | Correlation coefficient |
|---|---|---|---|
| N. America | 2.8 | 3.0 | +0.91 |
| Oceania | 3.6 | 3.4 | +0.93 |
| Japan | 3.1 | 3.4 | +0.89 |

It appears therefore that the variations of Z and the mean of the SKS residuals are nearly equal and closely correlated. This is in accordance with what was expected theoretically, but it is desirable to have it verified directly, since it affords a check on the whole of our work up to this point. The earthquakes used in this comparison include all that provided good determinations of both these quantities.

The difference between the means of Z and the mean SKS residual should be applied as a correction to the table for SKS to make the SKS and S curves correspond to the same conditions. In the North American, South American, and Japanese shocks it is a small fraction of a second and not always of the same sign. It appears to be within the possible error and we need make no allowance for it. But in the Oceanic shocks SKS seems to be about 2.6 s. early in comparison with the others. It seems to be significant, but we are not in a position to say whether the peculiarity is in S or in SKS. In any case 3 seconds in a time of transmission of 24 minutes is not a large variation.

The results were prepared for interpolation by first adding the corrections to the trial times, as follows.

TABLE XXII

| Δ | Trial Time | | Correc-tion | Corrected time | | Fourth difference | Final Time | |
|---|---|---|---|---|---|---|---|---|
| | m. | s. | | m. | s. | | m. | s. |
| 83.5 | 22 | 47.4 | +0.4 | 22 | 47.8 | | (22 | 47.8) |
| 87.5 | 23 | 16.0 | +0.7 | 23 | 16.7 | | (23 | 16.7) |
| 92.5 | | 47.8 | −0.5 | | 47.3 | +0.9 | | 47.2 |
| 97.5 | 24 | 13.8 | −0.2 | 24 | 13.6 | +1.6 | 24 | 13.5 |
| 102.5 | | 38.7 | −1.4 | | 37.3 | −5.9 | | 37.8 |
| 107.5 | 25 | 2.8 | −1.1 | 25 | 1.7 | +0.8 | 25 | 1.6 |
| 112.5 | | 25.3 | −1.1 | | 24.2 | +0.2 | | 24.2 |
| 117.5 | | 43.3 | −0.3 | | 43.0 | +10.0 | | 42.2 |
| 122.5 | | 59.7 | −3.2 | | 56.5 | −17.0 | | 57.9 |
| 127.5 | 26 | 14.1 | −1.0 | 26 | 13.1 | | (26 | 12.1) |
| 132.5 | | 24.5 | −1.3 | | 23.2 | | ( | 26.3) |

Smoothing was carried out by subtracting 1/12 of the fourth difference; in the first two lines the original values were retained, and the last two were found by extrapolation.

The final time is less than Gutenberg's by 14 s. at 82°, 5 s. at 100°, and 10 s. at 120°. Considering that his table is calculated to suit P′ alone, and that a constant difference is hardly significant, the agreement is very good.

SKKS.

7. 1. There are many observations of this pulse, but unfor-

tunately few good series ; the only shock that could give a determination of the curve, however rough, is the New Zealand one of 1927 July 18. For this shock we have already had difficulty with P, and there are few distant observations of S and SKS. It appears that we cannot proceed by successive approximation as for SKS, since we have hardly any means of separating the additive constant special to each earthquake from the error in the tables in the range of distance where we happen to have observations. On the other hand we shall expect the additive constant to be the same for SKKS as for SKS and for distant S. Accordingly we proceed directly to allow for the additive constant by subtracting it in each case from the whole of the SKKS residuals. We take either the mean of the distant $S_{\omega}$ or the mean SKS residual, whichever appears the better determined, as our value of the constant ; the whole of the differences for the shocks are then assembled, and the resulting corrections are suited to the same depth of focus as the standard S curve. 1927 July 18 is reserved for separate treatment. On account of the scantiness of the observations it was found necessary to group them at intervals of 15° instead of 5° ; but in any case the second differences are so small that this change of the range introduces little error. In the oceanic shocks the SKS mean was taken without reference to S, since whatever the nature of the anomaly found in SKS for them may be it is likely to occur also in SKKS. 1925 Dec. 10, 1927 Nov. 14, 1928 May 9, and 1928 Sept. 22 were omitted.

## TABLE XXIII

### SKKS Summary

| | Residuals. |
|---|---|
| 90°-95°.0 | −13 −12[−8 −6 −6 −3 −3 −2] +3 |
| 95°.1-110°.0 | −16 −14 −13 −11 −8 −3 −3 +2 +5 +7 +10 +13 +15 +18 |
| 110°.1-125°.0 | −17 −11 −11 [−3 −1 −1 −1 −1, 0 +1 + 2+ 3+3 +3 +4 +5 +7] +12 +13 +14 +18 +18 +19 +19 +24 +24 +28 |
| 125°.1-140°.0 | −38 −28 −23 −10 [−5 −1 +3 +5 +8 +10 +10] +14 +28 |

140°.1-155°.0 −21 −21 −20 −19 −16 −14 [−5 −3 +1 +2 +4 +6 +7 +7 +7 +8 +8 +8 +8 +8 +9 +10 +12 +13] +17 +19 +20 +25 +32
155°.1-170°.0 −23 −18 −16 −11 −11 −8 −7 [−1 −1, 0, 0 +1 +5 +5 +9] +12 +14 +16 +16 +17 +26
170°.1-180°.0 −12 −8 +4

| | | | 1927 July 18 | | | |
|---|---|---|---|---|---|---|
| | Number | Mean | Number | Mean | Difference | Weight |
| 90°-95°.0 | 6 | −4.7 | 0 | | | |
| 95°.1-110°.0 | | ? | 1 | −9 | | |
| 110°.1-125°.0 | 14 | +1.5 | 3 | −9 | −10.5 | 2.5 |
| 125°.1-140°.0 | 7 | +4.3 | 1 | −5 | −9.3 | 0.9 |
| 140°.1-155°.0 | 18 | +6.1 | 4 | −6.7 | −12.8 | 3.3 |
| 155°.1-170°.0 | 8 | +2.2 | 6 | −7.3 | −9.5 | 3.4 |
| 170°.1-180°.0 | 3 | −5.3? | 2 | −8?? | | |

The weighted mean of the differences is —10.4 s., which is in agreement with the SKS residuals at Victoria and Irkutsk and with those of S at Hong Kong and Zi-ka-wei. The determination may therefore be considered satisfactory. We now subtract this from the mean residuals for 1927 July 18 and take final weighted means. These are given and applied to the trial times in the following table.

## TABLE XXIV

| Δ | Number | Trial time m. s. | Correction | Corrected time m. s. | Calculated time (1) | O-C | Calculated time (2) | O-C |
|---|---|---|---|---|---|---|---|---|
| 92.5 | 6 | 24 12.2 | −4.7 | 24 7.5 | 24 7.5 | 0.0 | 23 54.9 | +12.6 |
| 102.5 | 1 | 25 15.5 | +1.4 | 25 16.9 | 25 16.2 | +0.7 | 25 12.1 | +4.8 |
| 117.5 | 17 | 26 57.8 | +1.5 | 26 59.3 | 26 59.4 | −0.1 | 26 59.3 | 0.0 |
| 132.5 | 8 | 28 31.5 | +4.4 | 28 35.9 | 28 37.2 | −1.3 | 28 37.6 | −1.7 |
| 147.5 | 22 | 30 2.8 | +5.7 | 30 8.5 | 30 8.0 | +0.5 | 30 7.9 | +0.6 |
| 162.5 | 14 | 31 29.3 | +2.6 | 31 31.9 | 31 31.9 | 0.0 | 31 31.9 | 0.0 |
| 175.0 | 3 | 32 45.0 | −2.2 | 32 42.8 | 32 36.5 | +6.3 | 32 37.8 | +5.0 |

The weakness of the groups centred on 102°.5 and 175°.0 made interpolation difficult. The method adopted was to assume that from 117°.5 to 162°.5 the time is of the form

$$T = a + bx + cx^2$$

where

$$15x = \Delta - 140°.$$

Direct comparison of the times at 117°.5 ($x = -1.5$) and 162°.5 ($x = +1.5$) determined $b$, and times were found to 132°.5 and 147°.5 on the assumption that the relation was linear. On account of the term in $cx^2$ the actual values were in excess; but by taking a weighted mean $c$ could be found and hence $a$. The result was

$$a = 29\text{m. } 23.5\text{s.}; \; b = +90.87; \; c = -3.51.$$

Values were then found from 120° to 180° from the formula; but it made the time to 92°.5 too short, and a linear formula was adopted at distances from 92°.5 to 120°, there being no data to determine the curvature. The final results are shown in the table. Inspection of the last line shows that too many late observations have probably been retained at distances over 170°.

$S_cS$.

8. 1. Attempts were made to trace this pulse and $P_cP$ in the readings, but they were too scattered to be of much use. The importance of these pulses reflected on the outside of the core is very great, because they should provide our best means of determining the size of the core. Dr Whipple, at a Geophysical discussion at the Royal Astronomical Society on 1933 February 24, when a preliminary account of this work was given, suggested a method of constructing the $S_cS$ times from those of SKS and SKKS. Consider a ray descending from the surface at a definite angle, sufficient to make it capable of entering the core. Then the core breaks it up into various portions, three of which are $S_cS$, SKS, and SKKS. All emerge at the same angle and therefore with the same value of $dT/d\Delta$. Suppose that the angle traversed in the shell is $\theta$; then $\theta$ is the epicentral distance of $S_cS$. If SKS travels an angular distance $\varphi$ in the core, it emerges at distance $\theta+\varphi$; while SKKS travels distance $2\varphi$ in the core and emerges at distance $\theta + 2\varphi$. Similarly if the time of travel of $S_cS$ is $T_1$, and if SKS takes a time $T_2$ for its journey in the core, the total time of SKS is $T_1 + T_2$; and that of SKKS is

$T_1 + 2T_2$. Both the times and the distances of the three waves are in arithmetic progression.

Hence if we have tables for SKS and SKKS, and can locate points on them where the gradients $dT/d\Delta$ are the same, we can find corresponding values for $S_cS$ by using the relations

$$\Delta (S_cS) = 2\Delta (SKS) - \Delta (SKKS) ;$$
$$T (S_cS) = 2T (SKS) - T (SKKS). \qquad (1)$$

The obvious difficulty of the method is that $d^2T/d\Delta^2$ for SKKS is small, and there may be difficulty in identifying accurately the distance corresponding to a given value of $dT/d\Delta$. But it can be shown that this does not lead to serious error. It merely gives errors in both T and $\Delta$ for $S_cS$, which by construction are in the ratio $dT/d\Delta$, and therefore, provided the value of $d^2T/d\Delta^2$ for $S_cS$ is small in the neighbourhood, the effect of the error is merely to give us the value of T corresponding to the value of $\Delta$ that we actually find.

To put the matter formally, suppose that the correct times of SKS and SKKS are given by the functions

$$T (SKS) = F (\Delta) ; T (SKKS) = G (\Delta) ; \qquad (2)$$

and that the times in our tables are affected by small errors $f(\Delta)$ and $g(\Delta)$ respectively. Then we definitely choose a value of $\Delta$ that gives an assigned value of $F'(\Delta) + f'(\Delta)$. The same gradient of T for SKKS would be found at a distance $\Delta + \varphi$, where

$$G'(\Delta + \varphi) = F'(\Delta) \qquad (3)$$

if the tables were accurate. Actually it will be found at a distance $\Delta + \varphi + \varphi'$, where

$$G'(\Delta + \varphi + \varphi') + g'(\Delta + \varphi + \varphi') = F'(\Delta) + f'(\Delta). \qquad (4)$$

Neglecting squares of the errors and using (3) we get

$$\varphi' G''(\Delta + \varphi) = f'(\Delta) - g'(\Delta + \varphi). \qquad (5)$$

We now try to calculate the time of $S_cS$ ; the estimated distance will be $\Delta - \varphi - \varphi'$ and the estimated time

$$2 F(\Delta) + 2 f(\Delta) - G(\Delta + \varphi + \varphi') - g(\Delta + \varphi + \varphi') \qquad (6)$$

The true time at distance $\Delta - \varphi$ is $2\,F(\Delta) - G(\Delta + \varphi)$, and the slope is $F'(\Delta)$. Hence the true time at distance $\Delta - \varphi - \varphi'$ is

$$2F(\Delta) - G(\Delta + \varphi) - \varphi' F'(\Delta) \qquad (7)$$

and the error of (6) is

$$2f(\Delta) - g(\Delta + \varphi) - \varphi' G'(\Delta + \varphi) + \varphi' F'(\Delta) \qquad (8)$$

In this the terms in $\varphi'$ cancel by (3) ; hence the errors in $S_cS$ at the computed distance are of the same order as those in the tables of SKS and SKKS used.

The calculation is exhibited in the following table.

TABLE XXV

| dT/dΔ | SKS | | | SKKS | | | ScS | | | Divided |
|---|---|---|---|---|---|---|---|---|---|---|
| (sec./1°) | Δ | T | | Δ | T | | Δ | T | | Differences |
| | | m. | s. | | m. | s. | | m. | s. | |
| 6.8 | 87.0 | 23 | 15.1 | 92.5 | 24 | 7.5 | 81.5 | 22 | 22.7 | |
| | | | | | | | | | | 6.68 |
| 6.6 | 88.0 | 23 | 20.0 | 121.0 | 27 | 22.7 | 55.0 | 19 | 17.3 | |
| | | | | | | | | | | 6.46 |
| 6.2 | 89.5 | 23 | 29.5 | 135.0 | 28 | 52.8 | 44.0 | 18 | 6.2 | |
| | | | | | | | | | | 6.10 |
| 6.0 | 90.5 | 23 | 35.6 | 142.0 | 29 | 35.5 | 39.0 | 17 | 35.7 | |
| | | | | | | | | | | 5.90 |
| 5.8 | 91.5 | 23 | 41.5 | 148.0 | 30 | 10.9 | 35.0 | 17 | 12.1 | |
| | | | | | | | | | | 5.70 |
| 5.6 | 92.5 | 23 | 47.2 | 155.0 | 30 | 50-8 | 30.0 | 16 | 43.6 | |
| | | | | | | | | | | 5.50 |
| 5.4 | 93.5 | 23 | 52.7 | 161.0 | 31 | 23.8 | 26.0 | 16 | 21.6 | |
| | | | | | | | | | | 5.35 |
| 5.2 | 95.5 | 24 | 3.3 | 167.0 | 31 | 55.7 | 24.0 | 16 | 10.9 | |
| | | | | | | | | | | 5.13 |
| 5.0 | 97.5 | 24 | 13.5 | 174.0 | 32 | 31.5 | 21.0 | 15 | 55.5 | |

8.2. The time of SKS to 81°.5 is 22 m. 32.2 s., and can hardly be altered by a second ; and that found for $S_cS$ is shorter than this by 10 s. This is impossible because SKS must necessarily arrive before $S_cS$ at the same distance. It appears therefore that our time for SKKS at 92°.5 is too great by at least 10 s. If we make such a subtraction we find that the time should be 23 m. 57.5 s. ; this exceeds that of SKS at the same distance by 10.3 s. It seems probable therefore that our trial intervals between SKS and SKKS at distances up to 95° or so are much too long, and that actually SKKS follows SKS so quickly as to be indistinguishable from it. There is additional evidence in support of this. Lehmann and Plett remark on p. 69 of their paper that they have sought SKKS without success except for one possible observation at 115°. It is unlikely that this is due to the pulse being small, seeing that it is clearly observed at much greater distances by ordinary observers ; it is much more likely that it is too near to SKS. According to Gutenberg's table it should overtake S et 88°, where it is already 24 s. later than SKS ; but his interval between SKS and SKKS is remarkably constant with changing distance, considering that it must disappear at the distance where SKS first emerges. Our calculated $S_cS$ at 81°5 is 8 s. before our S ; Gutenberg's value for this interval is 36 s. *later* than S (computed from the tables on pp. 185 and 215 of the *Handbuch*). Since $S_cS$ must necessarily be later than S our result is impossible. Again, we found it impossible to decide in Table XXIII which observations of SKKS should be retained in the range from 95° to 110° ; but there is a strong group of negative residuals, whereas our calculated time is 3.5 s. more than the trial time. On all these grounds it seems that our results for SKKS at distances up to 120° are unreliable, and need a substantial reduction.

8.3. We can however proceed further by using our new information. The time of SKKS at 92°.5 must be more than that of SKS, which is 23 m. 47.2 s. Our time inferred in Table XXIII is 24 m. 7.5 s., which we have seen must be reduced by at least 10 s., giving 23 m. 57.5 s. Within a range of 10 s. we have at present no definite evidence to guide us. Somewhat arbitrarily, then, we take the time to 92°.5 to be 23 m. 55 s. We now assume that for SKKS

$$T = a + bx + cx^2 + dx^3$$

where as before

$$15\,x = \Delta - 140^\circ$$

and repeat the previous calculation. The values of $a$, $b$, and $c$ found from the groups centred on 117°.5 to 162°.5 now involve *d*, which has to be found from the additional equation for 92°.5. We find

$$a = 29\text{m. } 23.6\text{s.} ;\ b = 90.40 ;\ c = -3.56 ;\ d = +\ 0.21.$$

Using these we find the values in Table XXIV under « calculated time (2) ». For 102°.5 we find a value 3.4 s. less than the trial time ; the original residuals included two of —3, which happens to be the only repeated value ; but little weight can be attached to this, and we can only say that our solution is not obviously wrong. At distances under 120° it can be used for identification, but not for theoretical inferences.

The times of $S_cS$ can now be recomputed, as follows.

TABLE XXVI

| $dT/d\Delta$ | SKS | | | SKKS | | | $S_cS$ | | | T (Gutenberg) | | T-G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Δ | T | | Δ | T | | Δ | T | | | | |
| | | m. | s. | | m. | s. | | m. | s. | m. | s. | |
| 7.7 | 83.5 | 22 | 47.7 | 97.0 | 24 | 30.2 | 70.0 | 21 | 5.2 | 21 | 30 | –25 |
| 7.2 | 85.5 | 23 | 2.7 | 109.0 | 25 | 59.7 | 62.0 | 20 | 5.7 | 20 | 26 | –20 |
| 7.0 | 86.5 | 23 | 9.8 | 113.0 | 26 | 28.1 | 60.0 | 19 | 51.5 | 20 | 10 | –19 |
| 6.8 | 87.7 | 23 | 17.8 | 118.0 | 27 | 2.8 | 57.4 | 19 | 32.8 | 19 | 50 | –17 |
| 6.4 | 88.5 | 23 | 23.2 | 129.0 | 28 | 15.3 | 48.0 | 18 | 31.1 | 18 | 42 | –11 |
| 6.2 | 89.5 | 23 | 29.5 | 135.0 | 28 | 53.1 | 44.0 | 18 | 5.9 | 18 | 16 | –10 |
| 6.0 | 90.5 | 23 | 35.6 | 141.0 | 29 | 29.6 | 40.0 | 17 | 41.6 | 17 | 52 | –10 |
| 5.8 | 91.5 | 23 | 41.5 | 148.0 | 30 | 10.9 | 35.0 | 17 | 12.1 | 17 | 23 | –11 |
| 5.6 | 92.5 | 23 | 47.2 | 155.0 | 30 | 50.7 | 30.0 | 16 | 43.7 | 16 | 58 | –14 |
| 5.4 | 93.5 | 23 | 52.7 | 163.0 | 31 | 34.6 | 24.0 | 16 | 10.8 | 16 | 33 | –22 |
| 5.2 | 95.5 | 24 | 3.3 | 172.0 | 32 | 22.4 | 19.0 | 15 | 44.2 | 16 | 15 | –31 |
| 5.1 | 96.5 | 24 | 8.5 | 177.0 | 32 | 48.1 | 16.0 | 15 | 28.9 | 16 | 6 | –37 |

In the last column but one we give the times of $S_cS$ for the same distances interpolated from Gutenberg's table, and in the last the differences between our times and his. Our determination of the time of SKKS is reliable only from about 120° to 160°, and in the corresponding range our times of $S_cS$ are earlier than his by 11 s. on an average. At the greater distances the difference is greater, but our time for 70° is 68 s. later than S and at least is not obviously impossible. At the smaller distances the time of $S_cS$ should be of the form $a + b\Delta^2$ ; there is no sign of this in our results, but those for distances up to 24° depend on the extrapolated part of the

SKKS table and will require re-examination theoretically. We may remark that $S_cS$ emerging at the epicentre would correspond to SKS emerging at 180° and SKKS at 360°, so that it is far beyond the range of our determinations.

8. 4. Useful series of observations of $S_cS$ and $P_cP$ are given in the studies of deep-focus earthquakes by Scrase and Stechschulte, but are not ready for comparison since the allowance for focal depth is not yet known with accuracy. Our final table for $P_cP$ has been found by simply dividing the times of $S_cS$ by 1.825, the ratio of the times of P and S at 70° ; it is to be regarded only as a means of suggesting identifications.

PP, PS, and SS.

9. 1. Trial times for these waves were found from the J. tables. For PP and SS we used the formulae

$$PP(\Delta) = 2P(\tfrac{1}{2}\Delta)\,;\; SS(\Delta) = 2S(\tfrac{1}{2}\Delta) \qquad (1)$$

and for PS we took

$$PS(\Delta) = P(\Delta_1) + S(\Delta - \Delta_1) \qquad (2)$$

where $\Delta_1$ is chosen to make the sum stationary. The residuals given in the reductions are found by comparison with the resulting tables. There was an abundance of observations, which we hoped would settle a number of dubious points, such as the depth where these waves are reflected.

The actual time of transmission of any wave is not the time as given in the tables ; the true time of arrival of P at distance $\Delta$ is $T_0 + P(\Delta)$ and the actual time of the earthquake is $T_0 - a$, where $a$ is independent of $\Delta$. Hence the time of transmission is $a + P(\Delta)$. For a surface focus $a$ takes a special value A, say ; the time of transmission from a surface focus is $A + P(\Delta)$. Similarly for S the time of arrival is $T_0 + Z + S(\Delta)$, and the time of transmission is $a + Z + S(\Delta)$ For a surface focus this is $A + B + S(\Delta)$, where B is the value taken by Z for a surface focus.

For reflexion at the outer surface, the time of arrival of P at a place at distance $\frac{1}{2}\Delta$ is $T_0 + P(\frac{1}{2}\Delta)$; and the path from distance $\frac{1}{2}\Delta$ to $\Delta$ takes a time $A + P(\frac{1}{2}\Delta)$. Hence the time of arrival of PP is $T_0 + A + 2P(\frac{1}{2}\Delta)$. It appears further that A is practically the apparent delay in starting of P with reference to $P_g$ in near earthquakes, and this has usually been found to be about 6 or 7 seconds. We have therefore a determination of the times of PP. Since we have obtained a correction to the times of P, the correction required by PP should be double the correction to P at half the distance, together with a constant equal to about 7 s.

S arrives at distance $\frac{1}{2}\Delta$ at time $T_0 + Z + S(\frac{1}{2}\Delta)$; and the path from distance $\frac{1}{2}\Delta$ to $\Delta$ takes time $A + B + S(\frac{1}{2}\Delta)$. Thus the time of arrival of SS, measured from $T_0$, is $A + B + Z + 2S(\frac{1}{2}\Delta)$.

For PS, starting as P and reflected as S, the time of arrival at distance $\Delta_1$ is $T_0 + P(\Delta_1)$. The part of the path traversed as S takes time $A + B + S(\Delta - \Delta_1)$. Thus the time of arrival referred to $T_0$ is $A + B + P(\Delta_1) + S(\Delta - \Delta_1)$.

For SP, on the other hand, the arrival at distance $\Delta - \Delta_1$ is at $T_0 + Z + S(\Delta - \Delta_1)$; and the part of the path traversed as P takes time $A + P(\Delta_1)$. Thus the time of arrival of SP referred to $T_0$ is $A + Z + P(\Delta_1) + S(\Delta - \Delta_1)$. For a surface focus Z is equal to B, and PS and SP arrive together; but for other depths SP arrives first.

On the other hand, if PP is reflected at the top of the lower layer, it seems that at short distances its path is indistinguishable from that of P, and its time will be a linear function of $\Delta$ with the same constant term as for P. Hence when $T_0$ is taken as the origin of time, PP at distance $\Delta$ will be just $2P(\frac{1}{2}\Delta)$. At greater distances, however, this relation will be modified, since the delay in penetrating the upper layers varies with distance. The variation is not, however, more than 2 s. or so, so long as the focus is in the upper layers. It was previously shown to be probable that up to distance $35^\circ$ or so the PP wave reflected at the top of the lower layer would have the larger amplitude, whereas beyond that distance the larger would be the one reflected at the free surface[1]. Thus at the shorter distances we might expect PP to be read about 7 s. earlier than for reflexion at the surface.

We have seen also that there is a sharp bend in the P curve about distance 19°.5. Presumably the smooth curve traceable before this distance is continued a little further, but the more direct waves corresponding to this portion of the curve are later than the indirect ones and therefore not read as P. But they may nevertheless be the larger, and in that case their reflexions would be recorded as PP, between distances 39° and 50°, perhaps.

A further complication may arise if reflexion takes place under an ocean. The structure of the upper layers at the point of reflexion is then probably different from that below the continents, and the loss of time in traversing them may therefore be different. It is easy to see that for PP the delay would still have the same form, but the value of A to be taken would be that corresponding to oceanic and not to continental structure.

9. 2. The residuals of PP against the trial tables were first classified according to distance, in ranges of 5°. There were signs of concentration about particular values at some distances, but it was not sufficiently clear whether they should be regarded as two series with concentrations about different modes, or merely as a single distribution with a large scatter. But there is no reason to doubt the general theory of PP as a reflexion of P somewhere near the surface, and on this theory the time of PP should differ from $2P(\frac{1}{2}\Delta)$ by a quantity independent of the distance. We therefore revised the calculated times of PP to correspond to the revised times of P, by subtracting from all the residuals in the range from 80° to 85°, for instance, twice the correction to P at 41°.25. These revised residuals were then reclassified over 20° ranges of distance. The results were as follows.

1. *M. N. R. A. S. Geoph. Suppl.* 1, 1926, 345.

## TABLE XXVII

### European, North American, and Japanese Earthquakes

| | −20 to −15 | −14 to −10 | −9 to −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 to 15 | 16 ro 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0°-20° | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 1 |
| 20°-40° | 5 | 4 | 18 | 7 | 4 | 2 | 2 | 2 | 4 | 6 | 7 | 5 | 5 | 4 | 3 | 7 | 2 | 2 | 6 | 1 |
| 40°-60° | 1 | 6 | 6 | 2 | 1 | 0 | 0 | 1 | 4 | 0 | 2 | 0 | 6 | 7 | 4 | 4 | 3 | 3 | 17 | 5 |
| 60°-80° | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 3 | 3 | 2 | 5 | 6 | 4 | 6 | 5 | 9 | 20 | 12 |
| 80°-100° | 6 | 4 | 12 | 3 | 5 | 6 | 3 | 3 | 6 | 11 | 15 | 10 | 18 | 17 | 19 | 17 | 14 | 12 | 54 | 39 |
| 100°-120° | 4 | 3 | 2 | 0 | 1 | 4 | 1 | 3 | 3 | 6 | 3 | 7 | 7 | 5 | 4 | 3 | 7 | 6 | 20 | 2 |
| 120°-140° | 2 | 4 | 4 | 2 | 3 | 2 | 3 | 3 | 1 | 2 | 0 | 2 | 1 | 0 | 2 | 2 | 0 | 0 | 3 | 3 |
| 140°-160° | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0' | 0 | 1 | 3 |
| 160°-180° | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

### South American and Oceanic Earthquakes

| | −20 to −15 | −14 to −10 | −9 to −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 to 15 | 16 to 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0°-20° | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20°-40° | 0 | 2 | 1 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40°-60° | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60°-80° | 0 | 1 | 3 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 4 | 3 |
| 80°-100° | 3 | 3 | 6 | 1 | 7 | 3 | 2 | 1 | 1 | 6 | 4 | 2 | 3 | 9 | 9 | 4 | 3 | 3 | 13 | 15 |
| 100°-120° | 5 | 4 | 13 | 2 | 2 | 5 | 6 | 3 | 5 | 7 | 2 | 8 | 5 | 8 | 5 | 5 | 4 | 3 | 17 | 7 |
| 120°-140° | 1 | 3 | 8 | 5 | 4 | 6 | 6 | 3 | 3 | 5 | 7 | 3 | 7 | 5 | 4 | 1 | 2 | 2 | 7 | 2 |
| 140°-160° | 3 | 0 | 6 | 2 | 1 | 4 | 0 | 3 | 5 | 3 | 3 | 0 | 3 | 1 | 0 | 1 | 3 | 0 | 6 | 3 |
| 160°-180° | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 4 | 0 | 2 | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 4 | 3 |

The concentration of the residuals still leaves much to be desired. In most ranges, however, these is a mode about +5 to +7; there are often subsidiary maxima about −2 to 0 and also about +15. It is natural to interpret the chief maximum as due to the true PP; the early one can then be interpreted as PP reflected at the base of the upper layers, and the later one as due to a PP that has undergone one reflexion between the outer surface and the base of the upper layers before it has emerged. But, apparently owing to the standard error of an individual observation being in the neighbourhood of 3 s., the maxima are not clearly separated, and it seems better to use special studies to determine them. Good series of observations of PP are given by Lehmann and Plett in their paper for the Philippine and Marianne Islands shocks. The former is included in our reduction; the residuals of PP for it, against our corrected times, can be grouped as follows.

| | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80°-100° | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 3 | 5 | 3 | 2 | 1 | 0 |
| 100°-107° | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |

In the first place all the residuals were arranged in order, and the mean for the main group was +6.2 s. Then in cases where alternative readings were given only the one nearer to this mean was retained; Ravensburg, which gave +4 and +8, was omitted. The final mean was +6.1 s.

The P residuals in this earthquake show signs of focal depth. PP would be reflected at an average distance of 48°. It is possible that part of the positive residual at Manila is due to this cause. The mean for Amboina, Zi-ka-wei and Phu-lien is 0.0. At the great distances the average P residual, omitting Piatigorsk and Athens, which may be affected by clock errors, is —4 s. Interpolating for 48° by 1.6 (30) we find that at 48° the residual of P should be —3.1 s. This is supported by a number of stations about that distance, the mean from Irkutsk to Sydney being —3.4 s. ± 1.0. This gives an estimate of the effect of focal depth on PP at distance 96°; allowing for this we find that PP for a focus in the upper layers would be late by 9.5 s., with a standard error rather over 1 s.

For the Marianne Islands earthquake there is no sign of focal depth in P. PP is on an average late by 4.5 s. ± 0.6. If we subtract the mean residual for P at the distant stations the mean becomes +4.9 s., but still differs from that found for the Philippine earthquake by nearly 3 times the sum of the apparent standard errors. A simple mean gives +7.2 s., but in the circumstances we cannot expect it to be trustworthy within 2 s. or so. As it stands it agrees with what we expected from near earthquakes.

At the same time it is clear that the PP studied here is reflected at the outer surface or near it. But there are a few early readings, mostly associated with readings in the main group, and these may be due to PP reflected at some depth.

The I. S. S. observations at distances less than 40° show some concentration of the residuals at small values, and these may correspond to reflexion at some depth. Unfortunately we cannot test for the reflexion of the direct P beyond 20°, for this pulse reflected at the base of the crustal layers would arrive at about the same time as the indirect P reflected at the outer surface, and much more detailed work will be needed to separate them.

9. 3. The observations of PS and SS in the I. S. S. were classified, but led to no useful result. Lehmann and Plett give a series for SS in the Marianne Island shock, with mean residual +4.2 s. Unfortunately there is an acute doubt about Z for this shock, the mean residuals for S and SKS being respectively —16.3 s. and —8.9 s. This difference of 7.4 s. between the results of two excellent series of observations seems inexplicable. If we take SKS as correct, we find A + B = + 12.1 s. If A is + 7 s., this gives B = + 5 s. We have had values of Z up to + 8 s. The result cannot however be considered satisfactory without confirmation from normal earthquakes.

9.4. A difficulty was found in computing the times of PS. It was found that P arriving at distances up to 19° would be reflected as PS to distances from 46° to 87°; but then the sudden change in the slope of the P curve implies a discontinuity in the distance travelled as S, and the beginning of the indirect P corresponds to PS arriving at 100°. It can then be computed to 139°. The gap in the table for PS does not, however, mean that it does not exist in that range. The direct P beyond 19° will be reflected to distances beyond 87°, and the indirect P before 19° will be reflected to distances less than 100°, and it possible that the ranges where these reflexions emerge will overlap and the pulse will be duplicated or triplicated. The range from 87° to 100° includes most of Lehmann and Plett's observations, so that it is difficult to separate the systematic delay of PS in reflexion from the corrections to the form of the PS curve.

For the Philippine earthquake Lehmann and Plett have only three rather inconsistent observations beyond 100°, but there are several in the I. S. S. The series of negative residuals at the American stations, increasing with distance, may correspond to SKSP. We therefore corrected the PS residuals between 100° and 110°, including those of Lehmann and Plett for the difference between the trial and corrected PS times. They are as follows :

—6, —2, —1, 0, +1, +3, +6, +7.

The extreme residuals are at Cape Town, Paris, and Oxford. All are open to some suspicion, and if we omit them the mean of the rest is +0.2. The standard error as computed is 0.4, but this is probably an underestimate. SKS is rather more consistent than S, and if we determine Z from it as —10.6 we find that PS is late by 10.8 s.

In the Marianne Islands earthquake there are many observations of PS beyond 100° ; their mean is —5.7 s. Subtracting the mean S residual we get + 10.6 s. ; subtracting the mean SKS residual we get + 3.2 s. In this case therefore, unlike SS, SKS gives a less plausible result for the correction than S.

An attempt was made to use Miss Lehmann's earlier readings for the Mexican earthquake of 1928 March 22, but here again there is some abnormality. From the I. S. S. Z was determined for S as + 2 s. ; the mean SKS residual was + 3 s., and the agreement is good. But Miss Lehmann gives many more late readings for S, with residuals near +7 and + 15 s. For PS, the I. S. S. residuals against the corrected tables are

—10, —4, 0, +6, +10, +12, +13, +13, +15, +16, +20, +29.

Lehmann's readings give

0, +6, +8, +9, +13, +14, +14, +19, +19, +20, +20, +21, +28, +35.

There seems to be some suggestion that the group from +6 s. to + 16 s. represents the real PS, though we cannot be certain. The mean of all observations for this group is +12.3 s. ± 1.1. Subtracting the mean SKS residual we have + 9 s. Combining all results it seems that PS is late by about 10 s., an amount rather more than we inferred from PP, and much less reliable.

9. 5. The next step was to attempt to extend the table for PS into the gap. The mean residual for PS against the final tables, determined from distances outside the gap, was subtracted from the residuals against the trial tables within the gap. The three earthquakes just mentioned, including all the I. S. S. observations, were used. The resulting residuals, from which most of the abnormalities of the particular earthquakes have probably been eliminated, are as follows.

| | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 87°-90° | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 0 | 1 | 1 | 0 | 1 |
| 90°-95° | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 1 | 0 | 2 |
| 95°-100° | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 2 | 0 | 1 | 3 | 2 | 0 | 2 | 2 |

There are signs of a concentration near + 6 s., but it is not very clear. It agrees, however, with what we already know. Comparing the trial and revised times, we have

| Δ | 70° | 75° | 80° | 85° | 100° | 105° | 110° |
|---|---|---|---|---|---|---|---|
| Trial Time | 20 38.7 | 21 44.0 | 22 47.4 | 23 48.9 | 26 42.2 | 27 35.7 | 28 26.8 |
| Revised Time | 38.1 | 44.4 | 48.9 | 51.2 | 45.4 | 37.8 | 27.9 |
| Difference | −0.6 | +0.4 | +1.5 | +2.3 | +3.2 | +2.1 | +1.1 |

Thus the corrections we have made increase towards the gap on both sides, and we shall expect PS to need corrections of over 3 s. within it. What the observations show, and what might otherwise be in doubt, is that the gap is not real, PS occurring at all distances within it, and that we are therefore justified in trying to extrapolate from both sides into it. It appears that extrapolating from below will imply a correction of +3.1 at 90° and +3.9 at 95°; from above, +4.3 at 95°. The two latter agree. There is however a suggestion that the character of PS changes about 95°. We carry out an extrapolation; the two sides meet at 96°, the slope apparently changing suddenly from 11.7 s. per degree to 11.0 s. per degree. It remains possible that some of the PS readings at greater distances are derived from the direct P ; but it does not seem worth while to study them in greater detail until more information is available about the direct P itself.

SKSP.

10. 1. The theory of this wave is the same as for SP, and that of the companion wave PSKS the same as for PS. It appears that SKSP should arrive before SP at all the distances that we can compute times for by means of our results for P and SKS. Consequently it may be possible to trace it at shorter distances, and if so we should be able to use it to reconstruct part of the table for SKS at distances where it arrives after S ; thus we obtain information for higher levels in the core than is provided by any other observable wave.

A fair number of observations were found in the I. S. S. These were corrected for focal depth by subtracting in turn the mean residuals for P at distant stations and for SKS. There was little to choose between the results when they were classified ; but as SKSP would normally be expected to arrive before PSKS it was inferred that most of the observations would refer to SKSP, and accordingly the SKS residual was preferred. Gutenberg's table, however, was found to contain considerable errors. When the P and SKS tables were ready, however, a theoretical table was obtained for SKSP by the method used for PS ; this was possible from 127° to beyond 180°. This is given as the final SKSP table. The differences from Gutenberg's times were —38 s. at 130°, —21 s. at 140°, 0 at 160°, and —14 s. at 180°.

Accordingly the residuals of SKSP given in the reductions are in comparison with the final table. When corrected for focal depth they give the following results. Some observations between 115° and 127° that seemed too early for PS were reserved for further examination.

## TABLE XXVIII

| | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130°-140° | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 140°-150° | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 1 |
| 150°-160° | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 160°-170° | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Total | 1 | 0 | 1 | 1 | 1 | 0 | [1 | 1 | 1 | 2 | 2 | 1 | 4 | 4 | 4 | 1 | 1] | 0 | 1 | 1 | 4 | 1 | 1 |

Macelwane's readings for 1924 June 26 gave the following residuals.

## TABLE XXIX

| | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130°-140° | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 140°-150° | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150°-160° | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 160°-170° | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 |
| Total | 1 | 0 | 1 | 1 | 0 | [2 | 1 | 1 | 2 | 1 | 3 | 0 | 2] | 0 | 0 | 1 | 2 | 1 | 4 | 0 |

For 1929 June 16 Miss Lehmann kindly supplied us with a copy of her readings, which have not yet been published. In this case the mean SKS residual is —4.5 s., but it was thought better to postpone subtracting it till later. A few readings from the I. S. S. have been added.

## TABLE XXX

| | −11 | −10 | −9 | −8 | −7 | −6 | −5 | −4 | −3 | −2 | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 127°-130° | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 130°-140° | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 150°-160° | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 160°-170° | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 3 | 1 | 0 | 1 | 0 | 3 | 1 |
| Total | 1 | 0 | 0 | 1 | 1 | 2 | 0 | [1 | 1 | 1 | 1 | 1 | 1 | 4 | 0 | 3 | 1] | 0 | 1 | 1 | 3 | 1 |

There is in no case much sign of a variation with distance ; none is of course to be expected if the P and SKS tables are right and our theory of the nature of the pulse is also right. But there are signs that the residuals fall into groups. The means for the main groups are, for the I. S. S., $+ 2.7 \pm 0.6$ ; for Macelwane's data, $+3.5 \pm 0.7$ ; for 1929 June 16, $+1.1 \pm 0.8$. From the last we must subtract the SKS residual, giving $+5.6 \pm 0.8$. The delay is in all cases rather less than we should expect; to understand it, however, would require attention to be paid to the place of reflexion. Miss Lehmann's data are probably the most reliable, in spite of the apparently slightly greater standard error; the I. S. S. observations are few in any one earthquake, indicating a difficulty of reading which may introduce systematic error, and if the epicentre in Macelwane's earthquake is 0°.5 wrong it will affect the residuals by nearly 3 s.

10. 2. We next consider the observations before 127° that may refer to this pulse. After allowance has been made for the SKS residual they are as follows :

| Δ | T | Δ | T |
|---|---|---|---|
| 113.6 | 28 44 | 121.4 | 30 18 = PS +4 |
| 113.7 | 52 | 121.5 | 17 = PS +1 |
| 117.1 | 29 29 | 121.5 | 0 |
| 117.9 | 48 = PS + 3 | 122.1 | 9 |
| 118.0 | 6 = S | 122.4 | 2 |
| 118.9 | 50 = PS -2 | 122.8 | 24 |
| 118.9 | 56 = PS +4 | 122.9 | 32 = PS +4 |
| 119.0 | 30 4 = PS +11 | 123.7 | 36 = PS +1 |
| 119.0 | 1 = PS +8 | 125.1 | 48 = PS +0 |
| 119.1 | 29 59 = PS +5 | 126.6 | 48 |
| 119.7 | 30 3 = PS +4 | 126.8 | 31 7 = PS +4 |
| 121.4 | 15 = PS +1 | 127.0 | 30 49 +7 = 30 56 = PS -9 |

The tabulated value for 127° has been corrected roughly for the delay in reflexion by adding 7 s.

On comparing these readings with the corrected PS times we obtain the residuals indicated; the mean is +3.4 s. If then these observations are SKSP, this pulse must lie so near PS in this range that there is little possibility of separating it by observation. On the other hand they may be really PS. It is possible that this pulse passes partly through the upper layers as P, as we have already suspected for some observations of S, so that some early readings are to expected. (It must be recalled that the corrected PS table makes no allowance for the delay introduced on reflexion; the normal delay would be expected to be about 7 s.)

10. 3. The reading at 118°.0 may be S. If we extrapolate the S table linearly to this distance we get 29 m. 5 s., in good

agreement with the observation. The rarity of S observations beyond 95° is remarkable, since the S rays are theoretically less curved than the P ones, and therefore would be expected to reach a greater distance than P without striking the core. Lehmann and Plett give an observation at Toledo (115°.3) in the Marianne Islands shock at 27 m. 38 s. The calculated time without allowance for Z is 27 m. 40 s. ; but Z is large and negative, making the residual +14 s.

The other observations seem too early for PS, but are not consistent enough to determine a table for SKSP. It seems therefore that we cannot at present extend the SKSP table from observational material ; the final table has been extended linearly for some distance merely to assist identification.

PKS.

11. 1. In general features this pulse resembles P′, emerging with a large amplitude at minimum deviation about 131°, according to Gutenberg. About 150° its time is almost the same as for PP, from which it is there separable with difficulty. The mean residual of SKS was subtracted from all the I. S. S. residuals ; for 1927 Nov. 14 this was taken to be zero. No satisfactory observations were found at distances under 130° ; these would be analogous to P′ at distances under 143°. The results are shown in the following summary.

TABLE XXXI

| | |
|---|---|
| 130°-135° | [−21 −17 −13 −11 −10 −10 −8 −7 −6 −6 −6 −4 −4] −2 −2 +7 |
| 135°-140° | [−18 −17 −16 −15 −13 −12 −11 −5 −4] −1 +12 +23 |
| 140°-145° | [−17 −10] +2 +3 +22 |
| 145°-150° | +6 +10 |

| Δ | Mean | n | Trial Time | | Corrected Time | |
|---|---|---|---|---|---|---|
| | | | m. | s. | m. | s. |
| 132.5 | −9.3 | 13 | 22 | 52.5 | 22 | 45.0 |
| 137.5 | −12.3 | 9 | 23 | 11.5 | 23 | 0.3 |
| 142.5 | −13.5 | 2 | 23 | 26.0 | 23 | 12.5 |

It appears from the scatter of the observations that the slope cannot be determined from them with any accuracy comparable with that of Gutenberg's theoretical determination. It seems best therefore simply to take a weighted mean of the residuals, which is —10.8 s., and add it to the trial times without altering the slope. The trial times, however, were not very satisfactory, because they did not show the increase of $d^2T/d\Delta^2$ as the cusp is appoached. They were therefore smoothed in such a way as to introduce such an increase, though we cannot at present be sure of its amount.

*The standard focal depth and related problems.*

12. 1. We have adjusted our tables so that all of them refer to the same depth of focus, the standard depth being within the upper layers. Several methods appear to be capable of evaluating it, as follows.

(1.) We can compare our results for large earthquakes with those for near earthquakes, for which the depth can be estimated with an uncertainty of the order of 5 km. by methods given elsewhere by one of us [1]. Then Z could be found for near earthquakes of known depth and we have a standard of comparison. Unfortunately the methods applicable to near earthquakes do not give significant results for any earthquake considered here. The pulses $P_g$ and $S_g$, and probably $P^*$ and $S^*$, are recognizable in the Montana earthquake, but the epicentre depends on a single station (Victoria), and if this is not right we have no means of finding Z. Further, the near earthquakes studied are confined to Western and Central Europe, and we cannot assume that the velocities are the same in the regions considered here.

(2.) We can however determine the velocities of P and S at short distances from our present data. We have however a feature that does not arise in the study of near earthquakes. In the latter we practically confine ourselves to stations at distances under 8° or less, so that the cube terms in the times of transmission are negligible. Here we have few observations at short distances, and must use those up to 19° to evaluate and eliminate the cube terms. The solutions for P and S then contain constant terms, and the difference bet-

1. *M. N. R. A. S. Geoph. Suppl.* 3, 1933, 131-156.

ween them should provide a means of finding the focal depth without our needing to suppose the European velocities universal.

(3). If a focus is at a finite depth, even within the upper layers, there will be reflexion at the outer surface, giving Scrase's waves pP, sP, and sS. If there is no primitive P movement, the apparent P movement is really sP. The intervals between P and pP, and between S and sS, depend directly on the focal depth and should provide a means of determining it. Unfortunately however the intervals in these shallow focus earthquakes are short, and pP and sS cannot be distinguished from other pulses following P and S by a few seconds.

(4.) Some earthquakes show the effects of focal depth in the P residuals, showing that the focus is in the lower layer and that there is primitive P movement. From the variation of the P residuals with distance we should be able to estimate the depth of the focus below the top of the lower layer. We can then correct S for this depth and find Z for a focus at the top of the lower layer.

12. 2. The most promising method seems to be (2). We assume that the time at distance $\Delta$ is

$$T = a + b\Delta - c\Delta^3 \qquad (1)$$

Then each range of distance gives an equation of condition, weighted according to the number of observations. These equations can be solved for $a$, $b$, and $c$ by least squares. Alternatively we can adapt a method suggested by Eddington for determining a linear representation of a series of observations. If the independent variable is uniformly distributed over a range, the observations in the centre of the range have little weight in determining the slope, and if we simply find the slope by comparing the mean of the first third of the observations with the mean of the last third, the standard error is only slightly greater than that given by a complete least squares solution. Here we proceed as follows. We divide the observations now into three ranges, simply adding the equations of condition for each range, and then solve directly.

The standard errors of individual observations are found first by simply considering the $P_v$ and $S_v$ up to 18°.0 ; they are $\sigma_P = \pm 2.4$ s. ; $\sigma_S = \pm 2.7$ s.

For P our results are, for Europe and North America together, as follows.

TABLE XXXII

| Δ | T (trial) | Correction | T (obs.) | $n$ | T (calc) | O-C |
|---|---|---|---|---|---|---|
| 1.5 | 21.4 | +0.1 | 21.5 | 2 | 21.19 | +0.31 |
| 4.5 | 64.1 | −0.6 | 63.5 | 7 | 64.12 | −0.62 |
| 7.5 | 106.4 | +0.3 | 106.7 | 34 | 106.58 | +0.12 |
| 10.5 | 148.0 | −0.1 | 147.9 | 45 | 148.23 | −0.33 |
| 13.5 | 188.4 | +0.6 | 189.0 | 66 | 188.77 | +0.23 |
| 16.5 | 227.0 | +0.9 | 227.9 | 78 | 227.88 | +0.02 |
| 18.5 | 251.5 | +1.4 | 252.9 | 22 | 253.00 | −0.10 |

The equations of condition for the groups are formed and their averages found as indicated by the brackets, the weights being the numbers of observations. Standard errors are calculated from $\sigma_P$. We find

$$a + 6.733\,b - 348.6\,c = 95.70 \pm 0.37 \qquad (2)$$
$$a + 12.284\,b - 1932.2\,c = 172.34 \pm 0.23 \qquad (3)$$
$$a + 16.940\,b - 4896.8\,c = 233.40 \pm 0.24\,; \qquad (4)$$

whence

$$a = -0.36 \pm 0.86\,;\ b = 14.369 \pm 0.18\,;\ c = 0.00197 \pm 0.00033.$$

In the column T(calc.) we enter the values found for T with these values of $a$, $b$, and $c$.

For S we have similarly the following.

TABLE XXXIII

| | T (trial) | Correction | T (obs.) | $n$ | T (calc) | O-C |
|---|---|---|---|---|---|---|
| 4.5 | 115.2 | −0.2 | 115.0 | 2 | 113.8 | +1.2 |
| 7.5 | 191.2 | −0.7 | 190.5 | 16 | 190.7 | −0.2 |
| 10.5 | 265.7 | +0.5 | 266.2 | 13 | 266.0 | +0.2 |
| 13.5 | 338.3 | +1.0 | 339.3 | 3 | 339.4 | −0.1 |
| 16.5 | 408.5 | +1.4 | 409.9 | 21 | 410.1 | −0.2 |
| 18.5 | 453.5 | +3.0 | 456.5 | 7 | 455.6 | +0.9 |

Grouping the equations of condition in pairs as for P we get

$$a = -3.31 \pm 3.8 \,;\; b = 26.07 \pm 0.53 \,;\; c = 0.00369 \pm 0.00086.$$

Thus $c$ for S is uncertain by one part in 4 ; for P it is uncertain by one part in 6. But the P and S curves are very similar in form, the ratio of the slopes and curvatures being about 1.75. The ratio of the most probable values of $b$ found is 1.80 ; of those of $c$, 1.86. In the range from 40° to 50° the ratio of the mean slopes is 1.83. Thus the ratio of the values of $c$ is better known than either of them individually. Accordingly we take as equations of condition for $c$

$$c = 0.00197 \pm 0.00033 \qquad (5)$$
$$1.8\,c = 0.00369 \pm 0.00086 \qquad (6)$$

and combining these by the usual methods we get the improved values

$$c = 0.00200 \pm 0.00027 \qquad (7)$$
$$1.8\,c = 0.00360 \pm 0.00049 \qquad (8)$$

It appears that any permissible change in the ratio (say to 1.9) will not affect either of the $c$'s by a third of its surviving standard error. These values may therefore be taken as sufficiently definite. Then (2) and (4) give, the uncertainty being now taken to be wholly expressed in $c$ [1],

$$b = 14.382 \pm 0.120 \,;$$

and the whole of the P observations, suitably weighted, give for $a$

$$a = -0.48 \pm 0.82.$$

Applying the same methods to the S observations we get

$$b = 26.02 \pm 0.23$$
$$a = -2.97 \pm 1.55.$$

1. This is an approximation, based on the fact that the uncertainty in $a$ and $b$ does seem to arise mostly from that in $c$. Strictly we should take the equations of condition for $a$, $b$, $c$ for P, $a^1$, $b^1$, $c^1$ for S, with $c^1 = 1.8\,c$, and solve for five unknowns,

The values of $b$ correspond to surface velocities near the epicentre of 7.73 km/sec for P and 4.270 km/sec for S. The uncertainty in each case is about one per cent. The T(calc) values for S are derived from this final solution.

The value of $a$ for S is less than that for P by 2.5 s., and the standard error of this difference is about 1.7 s. It is therefore probably significant. If however there was primitive P movement the difference would be in the other sense, S being more delayed than P in passage through the upper layers.

12. 3. This difference can be calculated roughly from the data of a previous paper ; we simply adopt the delay-depth coefficients for the velocities of $P_x$ and $S_n$ there given. The delay of P, for a surface focus, is

$$2( .173\ H) + 2\ ( .131\ H_1) + 2\ ( .101\ H_2) + 2\ ( .093\ H_3)$$

where H, $H_1$, $H_2$, $H_3$ are the thicknesses of the sedimentary, granitic, and upper and lower intermediate layers respectively. Taking $H = 4$ km., $H_1 = H_2 = H_3 = 10$ km., we get for the delay 7.9 s. That for S is 1.79 times this, and the difference is $0.79 \times 7.9 = 6.2$ s. The constant term in the time of S should exceed that in P by 6.2 s. ; actually it is less by 2.5 s. Even if we assume a focus at the base of the lower intermediate layer, P and S still have to make the upward passage through the upper layers, and the constant term for S should still exceed that for P by 3.1 s.

It appears therefore that our standard earthquake, with $Z = 0$, cannot have primitive P movement, P being generated from S by reflexion at the free surface. On this hypothesis we recalculate the delays for various depths. For a surface focus there is no change. For one at the base of the sedimentary layer the calculated delay of S with reference to P is 1.9 s. ; for one at the base of the granitic layer it is —2.7 s. ; for one at the base of the upper intermediate layer, —6.7 s. ; at the base of the lower intermediate layer, —10.4 s. The numerical values will need some rediscussion, because it is not certain how far the European structure can be considered general, and even in Europe the depths are uncertain by a few kilometres. But it seems that with our present knowledge we can account for the data for an earthquake with Z equal to 0 by supposing that its focus is near the base of the granitic layer and that there is no primitive P movement; while for a surface focus Z would be + 8.9 s., and for a focus at the base of the lower intermediate layer without primitive P movement Z is —7.7 s., and for one at the same depth with primitive P movement it is +5.8 s. It appears that this range of variation covers that actually found.

12. 4. The fourth method suggested requires the use of earthquakes showing the effects of focal depth in the residuals for P. These are recognizable only in the Oceanic shocks, with two exceptions, one European and one Japanese. For the oceanic ones we have the following results.

| Date | Distant Pω | Distant Sω or SKS +3 |
|---|---|---|
| 1925 Nov. 13 | −4 | −9 |
| 1926 Jan. 18 | −8 | −11 |
| 1927 July 18 | −5 (from P′) | −10 |
| 1928 Mar. 9 | 0 | −6 |
| Mar. 16 | −1 | −4 |
| June 15 | −4 | −7 |
| July 9 | 0 | −4 |
| Sept. 22 | −3 | −5 |
| Dec. 12 | 0 | −3 |
| Mean | −2.8 | −6.6 |
| Standard deviation | 2.94 | 2.59 |

The correlation coefficient is +0.80. But we should have expected the variations of the times of arrival of P and S at distant stations to be in the ratio of the velocities; actually S varies less than P. If we try to estimate Z for a focus at the top of the lower layer we should expect it to be equal to

$$-6.6 + 1.8 \times 2.8 = -1.6;$$

and this is for an earthquake with primitive P movement. If this result is to be accepted we must therefore suppose that there is no surface layer below the oceans. This is possible, but hardly probable; even if there is no granitic layer there should be some basaltic material. On the other hand the P means seem to fall into two groups ; there are four of 0 or —1, and five from —3 to —8. For the former group there is no evidence of a focus in the lower layer. The means are for P, —0.2 ; for S, —4.2 ; and this is consistent with the absence of primitive P movement. For the other group the means are —4.8, —8.4, correlation coefficient +0.79 ; and

$$-8.4 + 1.8 \times 4.8 = + 0.2.$$

The suggestion is therefore that for a focus at the top of the lower layer with primitive P movement Z is +0.2. But there is a great deal of uncertainty in the determination, and the accuracy of the epicentres is insufficient to determine a quantity of this amount. The value of Z for a focus of this type in a continent is = +5.8, so that at least we have evidence that the crustal layers are thinner below the oceans or else less clearly distinguished from the lower one ; but a clearer understanding of the data must await a fuller examination of actual seismograms of oceanic earthquakes at the nearer stations.

The European earthquake showing a deep focus is that of 1926 June 26, not included in the present tabulations. It was destructive in Crete and Asia Minor ; the I. S. S. epicentre was 36°.0 N., 28°.0 E., in Rhodos. In the present discussion this was found to be too far east, and the revised epicentre was 36°.8 N., 27°.4 E., near Cos. But the P residuals diminished by about 10 s. with distance, giving a clear indication of focal depth, which is supported by the wide extent of the macroseismic area. Unfortunately, however, Helwan is the only station to the south, and those to the north-east are inconsistent. Hence it is difficult to determine the epicentre accurately when the new unknown, the focal depth, has also to be introduced.

The Japanese one is that of 1927 Aug. 5. Mizusawa and Irkutsk are both near azimuth 300°, so that the epicentre is fairly well determined locally. The P residuals diminish by

3.5 s., the mean of the best marked group of distant S is —5.6 s., while the distant SKS residuals are about —8 s., but rather irregular. Now

$$-5.6 + 1.8 \times 3.5 = +0.9.$$

But the P residuals at Mizusawa and Irkutsk are +4 s. and —2 s. respectively, and the uncertainty of the determination is therefore at least 3 s.

It appears therefore that this method, while possibly suggesting future lines of progress, is not suited for giving information of use at present.

12. 5. To test the third method we asked Mr Scrase to examine the Eskdalemuir and Kew records of all the earthquakes except the European ones for his near reflexions. He has been kind enough to do so, and has supplied us with readings that appeared as if they might refer to the pulses in question. His readings of P, S, and SKS in general agree with those given in the Summary. We need therefore consider only the differences pP-P, sS-S, sSKS —SKS.

*North America.*

| | pP-P | sS-S | sSKS-SKS | Z |
|---|---|---|---|---|
| 1927 Aug. 10 | 14 | | | −1 |
| Nov. 4 | 3 | 18 | | +3 |
| 1928 Feb. 10 | | 28 | | −6 |
| Aug. 4 | 13 | | | −2 |
| 1929 Jan. 24 | 11 | 27 | | +2 |

*N. Atlantic.*

| | pP-P | sS-S | sSKS-SKS | Z |
|---|---|---|---|---|
| 1929 Feb. 2 | 16 | 28 | | 0 |
| Feb. 22 | 5 | | | 0 |
| Nov. 18 | 20 | | | 0 |

*S. America.*

| | pP-P | sS-S | sSKS-SKS | Z |
|---|---|---|---|---|
| 1928 July 18 | 4,14 | | | +2 |
| Nov. 20 | | | 20 | −2 |
| Dec. 1 | 10,17 | 19 | 17 | +1 |

*Japan.*

| | pP-P | sS-S | sSKS-SKS | Z |
|---|---|---|---|---|
| 1924 Aug. 14 | 10 | | | –2 |
| 1925 Jan. 18 | 12 | | | –10 |
| Jan. 28 | 17 | 20 | | –2 |
| 1927 Aug. 5 | 18 | 28 | | –6 |
| 1928 May 27 | 12 | 21 | | –5 |
| June 1 | 10 | | | –3 |

*Oceania.*

| | | | | |
|---|---|---|---|---|
| 1926 Jan. 18 | | | 10 | –11? |
| 1927 July 18 | 9 | | | –10 |
| 1928 Mar. 9 | 8 | | | –6 |
| Mar. 16 | 6 | | | –4 |

In other cases no possible identifications of the near reflexions were made. These include several oceanic shocks where the effects of deep focus are traceable in the residuals of P. It appears therefore that in some cases where these waves must exist they are too vague to be recognizable. In the above list the correlation coefficient between pP —P and Z, excluding ambiguous cases, is only —0.08. It seems therefore that the pulse read as pP is something else, possibly not always the same. This entirely corresponds to the hesitation of Mr Scrase himself about the identifications. On the other hand the intervals recorded as pP-P and sS-S are correlated and in about the theoretical ratio 1.8. There is therefore a suggestion that the pulses following P, S, and SKS are internal reflexions ; but a definite interpretation hardly seems possible at present.

It may be mentioned that pP and sS are clearly traceable in the I. S. S. readings of the Turkestan earthquake of 1929 Feb. 1. A large number of stations read something about 50 s. after P and about 85 s. after S, these additional readings being presumably pP and sS. The corresponding depth of focus is about 220 km. This is a true deep focus shock and is recorded as such in the I. S. S. ; but a fuller discussion would be outside the scope of the present work.

In Lehmann and Plett's readings of the Marianne Islands earthquake there are a number about 22 s. later than S and

SKS ; these may be sS and sSKS, but again we cannot be sure.

## TRIAL TABLES

All residuals in the reductions for the individual earthquakes except Pω, Sω and SKSP are with respect to these tables.

| Δ | P | S | PP | PS | SS |
|---|---|---|---|---|---|
| 0 | 0.0 | 0.0 | | | |
| 1 | 14.3 | 25.7 | | | |
| 2 | 28.6 | 51.4 | | | |
| 3 | 42.8 | 1 17.0 | | | |
| 4 | 57.0 | 42.5 | | | |
| 5 | 1 11.2 | 2 7.9 | | | |
| 6 | 25.4 | 33.3 | | | 2 34.0 |
| 7 | 39.4 | 58.6 | 1 39.8 | | 59.4 |
| 8 | 53.4 | 3 23.7 | 1 54.0 | | 3 25.0 |
| 9 | 2 7.4 | 48.6 | 2 8.2 | | 50.4 |
| 10 | 21.2 | 4 13.4 | 2 22.4 | | 4 15.8 |
| 11 | 34.8 | 37.9 | 2 36.6 | | 41.2 |
| 12 | 48.4 | 5 2.2 | 50.8 | | 5 6.6 |
| 13 | 3 1.8 | 26.3 | 3 4.8 | | 31.8 |
| 14 | 15.0 | 50.2 | 18.8 | | 57.2 |
| 15 | 28.0 | 6 13.7 | 32.8 | | 6 22.4 |
| 16 | 40.7 | 37.0 | 46.8 | | 47.4 |
| 17 | 53.2 | 59.9 | 4 0.8 | | 7 12.4 |
| 18 | 4 5.5 | 7 22.4 | 14.8 | | 37.2 |
| 19 | 17.5 | 44.5 | 28.6 | | 8 2.0 |
| 20 | 29.2 | 8 6.1 | 42.4 | | 26.8 |
| 21 | 40.6 | 27.3 | 56.0 | | 51.4 |
| 22 | 51.7 | 47.9 | 5 9.6 | | 9 15.8 |
| 23 | 5 2.5 | 9 7.9 | 23.2 | | 40.2 |
| 24 | 13.0 | 27.4 | 36.8 | | 10 4.4 |
| 25 | 23.2 | 46.4 | 50.2 | | 28.6 |
| 26 | 33.1 | 10 4.8 | 6 3.6 | | 52.6 |
| 27 | 42.8 | 22.6 | 16.8 | | 11 16.6 |
| 28 | 52.3 | 39.8 | 30.0 | | 40.4 |
| 29 | 6 1.6 | 56.5 | 43.0 | | 12 4.0 |
| 30 | 10.8 | 11 12.7 | 56.0 | | 27.4 |
| 31 | 19.7 | 28.6 | 7 8.8 | | 50.8 |
| 32 | 28.5 | 44.1 | 21.4 | | 13 14.0 |
| 33 | 37.3 | 59.4 | 34.0 | | 37.0 |
| 34 | 45.9 | 12 14.5 | 46.4 | | 59.8 |
| 35 | 54.4 | 29.5 | 58.8 | | 14 22.4 |
| 36 | 7 2.8 | 44.3 | 8 11.0 | | 44.8 |
| 37 | 11.2 | 59.1 | 23.0 | | 15 7.0 |
| 38 | 19.6 | 13 13.8 | 35.0 | | 29.0 |
| 39 | 27.9 | 28.4 | 46.8 | | 50.8 |
| 40 | 36.1 | 43.0 | 58.4 | | 16 12.2 |
| 41 | 1 44.3 | 13 57.6 | 9 10.0 | | 16 33.6 |
| 42 | 52.4 | 14 12.0 | 21.2 | | 54.6 |
| 43 | 8 0.4 | 26.3 | 32.4 | 14 26.4 | 17 15.4 |
| 44 | 8.3 | 40.5 | 43.4 | 40.6 | 35.8 |
| 45 | 16.1 | 54.6 | 54.4 | 54.8 | 56.0 |
| 46 | 23.9 | 15 8.6 | 10 5.0 | 15 9.1 | 18 15.8 |
| 47 | 31.5 | 22.4 | 15.6 | 23.4 | 35.6 |
| 48 | 39.1 | 36.2 | 26.0 | 37.5 | 54.8 |
| 49 | 46.5 | 49.9 | 36.4 | 51.7 | 19 14.0 |
| 50 | 53.9 | 16 3.5 | 46.4 | 16 5.8 | 32.8 |
| 51 | 9 1.1 | 17.1 | 56.4 | 20.0 | 51.4 |
| 52 | 8.3 | 30.5 | 11 6.4 | 34.0 | 20 9.6 |
| 53 | 15.5 | 43.9 | 16.0 | 48.0 | 27.6 |
| 54 | 22.6 | 57.3 | 25.6 | 17 2.0 | 45.2 |
| 55 | 29.6 | 17 10.6 | 35.2 | 15.9 | 21 2.6 |
| 56 | 36.6 | 23.8 | 44.6 | 29.8 | 19.6 |
| 57 | 43.5 | 37.0 | 54.0 | 43.5 | 36.4 |
| 58 | 50.4 | 50.1 | 12 3.2 | 57.3 | 53.0 |
| 59 | 57.2 | 18 3.1 | 12.4 | 18 11.1 | 22 9.4 |
| 60 | 10 4.0 | 16.1 | 21.6 | 24.7 | 25.4 |
| 61 | 10.8 | 28.9 | 30.6 | 38.3 | 41.4 |
| 62 | 17.5 | 41.7 | 39.4 | 51.9 | 57.2 |
| 63 | 24.2 | 54.3 | 48.2 | 19 5.5 | 23 12.8 |
| 64 | 30.8 | 19 6.7 | 57.0 | 19.0 | 28.2 |
| 65 | 37.4 | 19.0 | 13 5.8 | 32.4 | 43.6 |
| 66 | 44.0 | 31.3 | 14.6 | 45.7 | 58.8 |
| 67 | 50.5 | 43.4 | 23.2 | 59.0 | 24 14.0 |
| 68 | 56.9 | 55.4 | 31.8 | 20 12.3 | 29.0 |
| 69 | 11 3.3 | 20 7.4 | 40.2 | 25.5 | 44.0 |
| 70 | 9.6 | 19.2 | 48.8 | 38.7 | 59.0 |
| 71 | 15.8 | 31.0 | 57.2 | 52.0 | 25 13.8 |
| 72 | 22.0 | 42.6 | 14 5.6 | 21 5.1 | 28.6 |
| 73 | 28.0 | 54.2 | 14.0 | 18.1 | 43.4 |
| 74 | 34.0 | 21 5.7 | 22.4 | 31.1 | 58.2 |
| 75 | 39.9 | 17.1 | 30.8 | 44.0 | 26 12.8 |
| 76 | 45.7 | 28.3 | 39.2 | 57.0 | 27.6 |
| 77 | 51.4 | 39.5 | 47.4 | 22 9.7 | 40.2 |
| 78 | 57.0 | 50.5 | 55.8 | 22.4 | 56.8 |
| 79 | 12 2.6 | 22 1.3 | 15 4.0 | 35.0 | 27 11.4 |
| 80 | 8.0 | 12.1 | 12.2 | 47.4 | 26.0 |

| Δ | P | S | PP | PS | SS | SKS | SKKS | P′ | $P_2$′ | PKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 81 | 12 13.4 | 22 22.7 | 15 20.4 | 22 59.9 | 27 40.6 | 22 29 | | | | |
| 82 | 18.6 | 33.1 | 28.6 | 23 12.3 | 55.2 | 36 | | | | |
| 83 | 23.8 | 43.4 | 36.6 | 24.5 | 28 9.6 | 44 | | | | |
| 84 | 29.0 | 53.6 | 44.8 | 36.7 | 24.0 | 51 | | | | |
| 85 | 34.0 | 23 3.6 | 52.8 | 48.9 | 38.4 | 58 | | | | |
| 86 | 39.0 | 13.5 | 16 0.8 | 24 0.9 | 52.6 | 23 6 | | | | |
| 87 | 44.0 | 23.3 | 8.8 | 12.9 | 29 6.8 | 13 | | | | |
| 88 | 49.0 | 32.9 | 16.6 | 24.8 | 21.0 | 19 | 23 39 | | | |
| 89 | 53.9 | 42.5 | 24.4 | 36.6 | 35.2 | 26 | 46 | | | |
| 90 | 58.8 | 52.0 | 32.2 | 48.4 | 49.2 | 33 | 53 | | | |
| 91 | 13 3.7 | 24 1.4 | 40.0 | 25 0.2 | 30 3.2 | 39 | 24 0 | | | |
| 92 | 8.5 | 10.7 | 47.8 | 11.8 | 17.2 | 45 | 7 | | | |
| 93 | 13.3 | 19.9 | 55.4 | 23.4 | 31.0 | 51 | 15 | | | |
| 94 | 18.1 | 29.1 | 17 3.0 | 34.9 | 44.8 | 56 | 22 | | | |
| 95 | 22.9 | 37.8 | 10.6 | 46.3 | 58.6 | 24 2 | 29 | | | |
| 96 | 27.7 | 47.1 | 18.2 | 57.7 | 32 12.4 | 7 | 37 | | | |
| 97 | 32.5 | 56.1 | 25.6 | 26 8.9 | 26.0 | 12 | 44 | | | |
| 98 | 37.3 | 25 4.9 | 33.0 | 20.1 | 39.8 | 17 | 51 | | | |
| 99 | 42.1 | 13.7 | 40.4 | 31.2 | 53.4 | 22 | 58 | | | |
| 100 | 46.9 | 22.5 | 47.8 | 42.2 | 32 7.0 | 27 | 25 5 | 18 6 | | |
| 101 | 51.7 | 31.3 | 55.0 | 53.2 | 20.6 | 31.5 | 12 | 8 | | |
| 102 | 56.5 | 40.1 | 18 2.2 | 27 4.0 | 34.2 | 36.3 | 19 | 10 | | |
| 103 | 14 1.3 | 48.8 | 9.4 | 14.7 | 47.6 | 41.1 | 25 | 12 | | |
| 104 | 6.1 | 57.6 | 16.6 | 25.2 | 33 1.0 | 46.0 | 32 | 14 | | |
| 105 | 10.9 | 26 6.4 | 23.8 | 35.7 | 14.4 | 50.9 | 38 | 16 | | |
| 106 | | 15.2 | 31.0 | 46.1 | 27.8 | 55.7 | 45 | 18 | | |
| 107 | | | 38.0 | 56.4 | 41.2 | 25 0.4 | 51 | 20 | | |
| 108 | | | 45.2 | 28 6.6 | 54.6 | 5.2 | 57 | 22 | | |
| 109 | | | 52.2 | 16.8 | 34 7.8 | 9.9 | 26 4 | 24 | | |
| 110 | | | 59.2 | 26.8 | 21.2 | 14.5 | 10 | 26 | | |
| 111 | | | 19 6.2 | 36.7 | 34.4 | 18.9 | 17 | 28 | | |
| 112 | | | 13.2 | 46.6 | 47.6 | 23.3 | 23 | 30 | | |
| 113 | | | 20.0 | 56.4 | 35 0.8 | 27.3 | 30 | 33 | | |
| 114 | | | 27.0 | 29 6.1 | 14.0 | 31.1 | 36 | 35 | | |
| 115 | | | 33.8 | 15.7 | 27.0 | 34.7 | 42 | 37 | | |
| 116 | | | 40.8 | 25.3 | 40.2 | 38.2 | 49 | 39 | | |
| 117 | | | 47.6 | 34.8 | 53.2 | 41.6 | 55 | 41 | | |
| 118 | | | 54.4 | 44.3 | 36 6.2 | 44.9 | 27 1 | 43 | | |
| 119 | | | 20 1.2 | 53.7 | 19.2 | 48.3 | 7 | 45 | | |
| 120 | | | 8.0 | 30 3.0 | 32.2 | 51.7 | 13 | 47 | | |
| 121 | | | 14.8 | 12.3 | 45.0 | 54.9 | 20 | 49 | | |
| 122 | | | 21.6 | 21.5 | 57.8 | 58.1 | 26 | 52 | | |
| 123 | | | 28.2 | 30.6 | 37 10.6 | 26 1.3 | 32 | 54 | | |
| 124 | | | 35.0 | 39.8 | 23.4 | 4.3 | 38 | 57 | | |
| 125 | | | 41.6 | 48.9 | 36.0 | 7.3 | 44 | 19 0 | | |
| 126 | | | 48.4 | 57.9 | 48.6 | 10.1 | 51 | 2 | | |
| 127 | | | 55.0 | 31 6.8 | 38 1.0 | 12.8 | 57 | 4 | | |
| 128 | | | 21 1.6 | 15.7 | 13.4 | 15.3 | 28 3 | 6 | | |
| 129 | | | 8.2 | 24.6 | 25.8 | 17.6 | 9 | 7 | | |
| 130 | | | 14.8 | 33.4 | 38.0 | 19.7 | 16 | 9 | | 22 45 |
| 131 | | | 21.4 | 42.2 | 50.7 | 21.7 | 22 | 11 | | 48 |
| 132 | | | 28.0 | 51.0 | 39 2.6 | 23.6 | 28 | 12 | | 51 |

| Δ | P | S | PP | PS | SS | SKS | SKKS | P′ | $P_2$′ | PKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 133 | | | 21 34.4 | 31 57.7 | 39 14.6 | 26 25.4 | 28 35 | 19 14 | | 22 54 |
| 134 | | | 41.0 | 32 8.5 | 26.8 | 27.1 | 41 | 15 | | 58 |
| 135 | | | 47.4 | 17.3 | 38.8 | 28.7 | 47 | 17 | | 23 2 |
| 136 | | | 53.8 | 26.1 | 50.8 | | 53 | 19 | | 23 6 |
| 137 | | | 22 0.2 | 34.9 | 40 2.8 | | 59 | 21 | | 10 |
| 138 | | | 6.6 | 43.7 | 14.8 | | 29 5 | 22 | | 13 |
| 139 | | | 12.8 | 52.5 | 26.6 | | 12 | 24 | | 16 |
| 140 | | | 19.2 | 33 1.3 | 38.4 | | 18 | 26 | | 20 |
| 141 | | | 25.4 | 10.1 | 50.2 | | 24 | 28 | | 23 |
| 142 | | | 31.6 | 18.9 | 41 2.0 | | 30 | 30 | | 25 |
| 143 | | | 37.8 | 27.7 | 13.6 | | 36 | 32 | | 27 |
| 144 | | | 44.0 | 36.5 | 25.2 | | 42 | 34 | 19 35 | 29 |
| 145 | | | 50.0 | | 36.8 | | 48 | 36 | 40 | 30 |
| 146 | | | 56.0 | | 48.4 | | 54 | 39 | 44 | 32 |
| 147 | | | 23 2.0 | | 59.8 | | 30 0 | 41 | 49 | 33 |
| 148 | | | 8.0 | | 42 11.4 | | 6 | 43 | 53 | 35 |
| 149 | | | 13.8 | | 22.8 | | 12 | 44 | 57 | 36 |
| 150 | | | 19.8 | | 34.2 | | 17 | 46 | 20 2 | 37 |
| 151 | | | 25.6 | | 45.5 | | 23 | 47 | 6 | 39 |
| 152 | | | 31.4 | | 56.6 | | 29 | 48 | 11 | 40 |
| 153 | | | 37.0 | | 43 7.8 | | 35 | 50 | 15 | 41 |
| 154 | | | 42.8 | | 19.0 | | 41 | 51 | 19 | 42 |
| 155 | | | 48.4 | | 30.0 | | 46 | 53 | 24 | 43 |
| 156 | | | 54.0 | | 41.0 | | 52 | 54 | 28 | 44 |
| 157 | | | 59.6 | | 51.8 | | 58 | 55 | 33 | 45 |
| 158 | | | 24 5.2 | | 44 2.6 | | 31 3 | 56 | 37 | 45 |
| 159 | | | 10.6 | | 13.4 | | 9 | 57 | 41 | 46 |
| 160 | | | 16.0 | | 14.2 | | 15 | 58 | 46 | 47 |
| 161 | | | 21.4 | | 34.8 | | 21 | 59 | 50 | 48 |
| 162 | | | 26.8 | | 45.4 | | 26 | 59 | 55 | 48 |
| 163 | | | 32.0 | | 55.8 | | 32 | 20 0 | 59 | 49 |
| 164 | | | 37.2 | | 45 6.2 | | 38 | 1 | 21 3 | 50 |
| 165 | | | 42.4 | | 16.6 | | 44 | 2 | 8 | 50 |
| 166 | | | 47.6 | | 26.8 | | 50 | 3 | 12 | 51 |
| 167 | | | 52.8 | | 37.0 | | 56 | 4 | 17 | 51 |
| 168 | | | 58.0 | | 47.2 | | 32 2 | 5 | 21 | 52 |
| 169 | | | 25 3.0 | | 57.2 | | 8 | 6 | 25 | 52 |
| 170 | | | 8.0 | | 46 7.2 | | 14 | 6 | 30 | 53 |
| 171 | | | 13.0 | | 17.0 | | 20 | 7 | 34 | 53 |
| 172 | | | 18.0 | | 27.0 | | 26 | 8 | 39 | 53 |
| 173 | | | 23.0 | | 36.8 | | 33 | 8 | 43 | 54 |
| 174 | | | 28.0 | | 46.6 | | 39 | 9 | 47 | 54 |
| 175 | | | 33.0 | | 56.2 | | 45 | 9 | 52 | 54 |
| 176 | | | 38.0 | | 47 5.8 | | 51 | 10 | 56 | 55 |
| 177 | | | 42.8 | | 15.4 | | 57 | 10 | 22 1 | 55 |
| 178 | | | 47.8 | | 25.0 | | 33 3 | 10 | 5 | 55 |
| 179 | | | 52.6 | | 34.6 | | 9 | 10 | 9 | 55 |
| 180 | | | 57.6 | | 44.0 | | 15 | 10 | 14 | 55 |

## FINAL TABLES

Italic figures denote very uncertain values, only given to suggest possible identifications.

| | P | S | PP | PS | SS | $P_cP$ | $S_cS$ | Pd | Sd |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 0.0 | 0 0.0 | | | | | | | |
| 1 | 14.3 | 25.7 | | | | | | | |
| 2 | 28.6 | 51.4 | | | | | | | |
| 3 | 42.8 | 1 17.0 | | | | | | | |
| 4 | 57.0 | 42.5 | | | | | | | |
| 5 | 1 11.2 | 2 7.9 | | | | | | | |
| 6 | 25.3 | 33.3 | | | | | | | |
| 7 | 39.4 | 58.6 | | | | | | | |
| 8 | 53.4 | 3 23.7 | | | | | | | |
| 9 | 2 7.3 | 48.6 | | | | | | | |
| 10 | 21.1 | 4 13.4 | 2 22.4 | | 4 15.8 | | | | |
| 11 | 34.8 | 38.1 | 36.5 | | 41.2 | | | | |
| 12 | 48.4 | 5 2.6 | 50.6 | | 5 6.6 | | | | |
| 13 | 3 1.9 | 26.9 | 3 4.7 | | 31.9 | | | | |
| 14 | 15.3 | 51.1 | 18.8 | | 57.2 | | | | |
| 15 | 28.5 | 6 14.9 | 32.8 | | 6 22.3 | | | | |
| 16 | 41.4 | 38.5 | 46.8 | | 47.4 | | | | |
| 17 | 54.1 | 7 1.7 | 4 0.7 | | 7 12.3 | | | | |
| 18 | 4 6.6 | 24.6 | 14.6 | | 37.2 | | | | |
| 19 | 18.8 | 47.1 | 28.4 | | 8 2.0 | | | | |
| 20 | 29.7 | 8 *6.8* | 42.2 | | 26.8 | *8 40.2* | *15 49.4* | 4 30.8 | 8 9.3 |
| 21 | 40.3 | *26.3* | 55.9 | | 51.5 | *43.0* | *54.8* | 42.6 | 31.1 |
| 22 | 50.6 | *45.9* | 5 9.6 | | 9 16.2 | *46.1* | *16 0.1* | 54.2 | 52.6 |
| 23 | 5 0.6 | 9 *4.7* | 23.2 | | 40.7 | *49.0* | *5.5* | 5 5.5 | 9 13.7 |
| 24 | 10.4 | *23.1* | 36.8 | | 10 5.2 | *51.9* | *10.8* | 16.6 | 34.5 |
| 25 | 19.9 | *41.0* | 50.3 | | 29.5 | *54.9* | 16.2 | 27.5 | 54.9 |
| 26 | 29.1 | 58.4 | 6 3.8 | | 53.8 | *57.9* | 21.7 | | |
| 27 | 38.2 | 10 15.4 | 17.2 | | 11 18.0 | *9 0.9* | 27.2 | | |
| 28 | 47.2 | 32.0 | 30.6 | | 42.2 | *3.9* | 32.7 | | |
| 29 | 56.1 | 48.2 | 43.8 | | 12 6.0 | *7.0* | 38.2 | | |
| 30 | 6 5.0 | 11 4.1 | 57.0 | | 29.8 | *10.0* | 43.7 | | |
| 31 | 13.9 | 19.8 | 7 9.9 | | 53.4 | *13.1* | 49.4 | | |
| 32 | 22.7 | 35.3 | 22.8 | | 13 17.0 | *16.2* | 55.1 | | |
| 33 | 31.5 | 50.7 | 35.5 | | 40.2 | *19.3* | 17 0.7 | | |
| 34 | 40.3 | 12 6.0 | 48.2 | | 14 3.4 | *22.4* | 6.4 | | |
| 35 | 49.1 | 21.2 | 8 0.6 | | 26.3 | *25.5* | 12.1 | | |
| 36 | 57.8 | 36.3 | 13.2 | | 49.2 | *28.8* | 17.9 | | |
| 37 | 7 6.4 | 51.4 | 25.4 | | 15 11.7 | *32.0* | 23.7 | | |
| 38 | 15.0 | 13 6.4 | 37.6 | | 34.2 | *35.2* | 29.6 | | |
| 39 | 23.5 | 21.4 | 48.5 | | 53.9 | *38.5* | 35.6 | | |
| 40 | 32.0 | 36.3 | 59.4 | | 16 13.6 | *41.7* | 41.6 | | |
| 41 | 40.4 | 51.2 | 9 10.0 | | 33.3 | *45.1* | 47.6 | | |
| 42 | 48.6 | 14 6.1 | 20.6 | | 53.0 | *48.4* | 53.6 | | |
| 43 | 56.7 | 20.9 | 30.9 | | 17 12.4 | *51.7* | 59.7 | | |
| 44 | 8 4.7 | 35.6 | 41.2 | | 31.8 | *55.1* | 18 5.9 | | |

| | P | S | PP | PS | SS | $P_cP$ | $S_cS$ | SKS | SKKS |
|---|---|---|---|---|---|---|---|---|---|
| 45 | 8 12.7 | 14 50.1 | 9 51.2 | | 17 50.6 | 9 58.4 | 18 12.1 | | |
| 46 | 20.7 | 15 4.4 | 10 1.2 | 15 4.4 | 18 9.4 | 10 2.0 | 18.4 | | |
| 47 | 28.5 | 18.6 | 11.0 | 18.7 | 27.8 | 5.5 | 24.7 | | |
| 48 | 36.2 | 32.8 | 20.8 | 32.9 | 46.2 | 9.0 | 31.1 | | |
| 49 | 43.8 | 46.9 | 30.3 | 47.4 | 19 4.1 | 12.6 | 37.5 | | |
| 50 | 51.4 | 16 0.9 | 39.8 | 16 1.4 | 22.0 | 16.2 | 43.9 | | |
| 51 | 58.9 | 14.7 | 49.0 | 15.6 | 39.4 | 19.8 | 50.4 | | |
| 52 | 9 6.4 | 28.4 | 58.2 | 29.8 | 56.8 | 23.5 | 57.1 | | |
| 53 | 13.9 | 42.1 | 11 7.3 | 43.9 | 20 13.8 | 27.1 | 19 3.8 | | |
| 54 | 21.3 | 55.7 | 16.4 | 58.1 | 30.8 | 30.7 | 10.6 | | |
| 55 | 28.6 | 17 9.3 | 25.4 | 17 12.2 | 47.4 | 34.4 | 17.4 | | |
| 56 | 35.9 | 22.8 | 34.4 | 26.3 | 21 4.0 | 38.1 | 24.2 | | |
| 57 | 43.1 | 36.2 | 43.3 | 40.4 | 20.2 | 41.9 | 31.0 | | |
| 58 | 50.3 | 49.5 | 52.2 | 54.3 | 36.4 | 45.8 | 37.9 | | |
| 59 | 57.4 | 18 2.8 | 12 1.1 | 18 8.2 | 52.3 | 49.5 | 44.9 | | |
| 60 | 10 4.5 | 16.0 | 10.0 | 22.0 | 22 8.2 | 53.3 | 51.9 | | |
| 61 | 11.5 | 29.1 | 18.9 | 35.8 | 23.9 | 57.3 | 59.0 | | |
| 62 | 18.4 | 42.0 | 27.8 | 49.5 | 39.6 | 11 1.2 | 20 6.2 | | |
| 63 | 25.2 | 54.8 | 36.6 | 19 3.2 | 55.1 | 5.1 | 13.5 | | |
| 64 | 32.0 | 19 7.4 | 45.4 | 16.8 | 23 10.6 | 9.0 | 20.8 | | |
| 65 | 38.7 | 19.9 | 54.2 | 30.5 | 26.0 | 12.9 | 28.1 | | |
| 66 | 45.3 | 32.4 | 13 3.0 | 44.1 | 41.4 | 17.0 | 35.4 | | |
| 67 | 51.8 | 44.7 | 11.8 | 57.7 | 56.7 | 21.0 | 42.8 | | |
| 68 | 58.2 | 56.9 | 20.6 | 20 11.3 | 24 12.0 | 25.2 | 50.2 | | |
| 69 | 11 4.5 | 20 9.1 | 29.4 | 24.7 | 27.2 | 29.2 | 57.7 | | |
| 70 | 10.7 | 21.1 | 38.2 | 38.1 | 42.4 | 33.3 | 21 5.2 | | |
| 71 | 16.8 | 33.1 | 46.9 | 51.5 | 57.5 | | | | |
| 72 | 22.9 | 44.9 | 55.6 | 21 4.7 | 25 12.6 | | | | |
| 73 | 28.8 | 56.7 | 14 4.2 | 17.9 | 27.7 | | | | |
| 74 | 34.6 | 21 8.5 | 12.8 | 31.2 | 42.8 | | | | |
| 75 | 40.3 | 20.1 | 21.4 | 44.4 | 57.8 | | | | |
| 76 | 46.0 | 31.5 | 30.0 | 57.6 | 26 12.8 | | | | |
| 77 | 51.6 | 42.8 | 38.5 | 22 10.6 | 27.8 | | | | |
| 78 | 57.1 | 53.9 | 47.0 | 23.4 | 42.8 | | | | |
| 79 | 12 2.5 | 22 4.8 | 55.5 | 36.2 | 57.7 | | | | |
| 80 | 7.9 | 15.7 | 15 4.0 | 48.9 | 27 12.6 | | | | |
| 81 | 13.1 | 26.4 | 12.8 | 23 1.5 | 27.5 | | | 22 28.2 | |
| 82 | 18.2 | 36.9 | 20.8 | 14.0 | 42.4 | | | 36.1 | |
| 83 | 23.3 | 47.2 | 29.0 | 26.5 | 57.3 | | | 43.9 | |
| 84 | 28.3 | 57.5 | 37.2 | 38.9 | 28 12.2 | | | 51.6 | |
| 85 | 33.3 | 23 7.6 | 45.3 | 51.2 | 27.0 | | | 59.1 | |
| 86 | 38.2 | 17.5 | 53.4 | 24 3.5 | 41.8 | | | 23 6.3 | |
| 87 | 43.1 | 27.3 | 16 1.4 | 15.7 | 56.5 | | | 13.3 | |
| 88 | 47.9 | 36.9 | 9.4 | 27.8 | 29 11.2 | | | 20.0 | |
| 89 | 52.7 | 46.5 | 17.4 | 39.7 | 25.7 | | | 26.4 | |
| 90 | 57.4 | 56.0 | 25.4 | 51.5 | 40.2 | | | 32.6 | 23 35.1 |
| 91 | 13 2.1 | 24 5.4 | 33.4 | 25 3.3 | 54.5 | | | 38.6 | 43.1 |
| 92 | 6.7 | 14.7 | 41.4 | 15.0 | 30 8.8 | | | 44.4 | 51.1 |
| 93 | 11.3 | 23.9 | 49.2 | 26.7 | 23.0 | | | 50.0 | 59.0 |
| 94 | 15.9 | 33.1 | 57.0 | 38.4 | 37.2 | | | 55.4 | 24 6.9 |
| 95 | 20.5 | 42.1 | 17 4.7 | 50.1 | 51.4 | | | 24 0.7 | 14.7 |
| 96 | 25.1 | 51.1 | 12.4 | 26 1.8 | 31 5.6 | | | 5.9 | 22.5 |

| | P | | S | | PP | | PS | | SS | | $P_cP$ | $S_cS$ | SKS | | SKKS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 97 | 13 | 29.7 | 25 | 0.1 | 17 | 20.0 | 26 | *12.8* | 31 | 19.7 | | | 24 | 11.0 | 24 | *30.2* |
| 98 | | 34.3 | | 8.9 | | 27.6 | | *23.8* | | 33.8 | | | | 16.0 | | *37.9* |
| 99 | | 38.9 | | 17.7 | | 35.2 | | *34.6* | | 47.8 | | | | 20.9 | | *45.5* |
| 100 | | 43.5 | | 26.5 | | 42.8 | | 45.4 | 32 | 1.8 | | | | 25.8 | | *53.2* |
| 101 | | 48.1 | | 35.3 | | 50.3 | | 56.1 | | 15.6 | | | | 30.6 | 25 | *0.7* |
| 102 | | 52.7 | | 44.1 | | 57.8 | 27 | 6.6 | | 29.4 | | | | 35.4 | | *8.3* |
| 103 | | 57.3 | | 52.8 | 18 | 5.3 | | 17.1 | | 43.1 | | | | 40.2 | | *15.8* |
| 104 | 14 | 1.9 | 26 | 1.6 | | 12.8 | | 27.5 | | 56.8 | | | | 45.0 | | *23.2* |
| 105 | | 6.5 | | 10.4 | | 20.3 | | 37.8 | 33 | 10.5 | | | | 49.8 | | *30.6* |

| | P | | P' | | PP | | PS | | SS | | SKS | | SKKS | | PKS | | SKSP | | $P_2$' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | 14 | 11 | 18 | 4.8 | 18 | 27.8 | 27 | 47.9 | 33 | 24.2 | 24 | 54.6 | *25* | *37.9* | | | | | |
| 107 | | 16 | | 8.2 | | 35.2 | | 58.1 | | 37.8 | | 59.3 | | *45.2* | | | | | |
| 108 | | 21 | | 11.4 | | 42.6 | 28 | 8.1 | | 51.4 | 25 | 4.0 | | *52.5* | | | | | |
| 109 | | 26 | | 14.6 | | 49.9 | | 18.0 | 34 | 5.0 | | 8.7 | | *59.7* | | | | | |
| 110 | | 31 | | 17.7 | | 57.2 | | 27.9 | | 18.6 | | 13.3 | *26* | *6.9* | | | | | |
| 111 | | 35 | | 20.8 | | 4.9 | | 37.7 | | 32.1 | | 17.7 | | *14.0* | | | | | |
| 112 | | 40 | | 23.8 | 19 | 11.8 | | 47.3 | | 45.6 | | 22.1 | | *21.1* | | | | | |
| 113 | | 45 | | 26.8 | | 19.0 | | 56.9 | | 59.0 | | 26.2 | | *28.1* | | | | | |
| 114 | | 50 | | 29.6 | | 26.2 | 29 | 6.5 | 35 | 12.4 | | 30.0 | | *35.2* | | | | | |
| 115 | | 55 | | 32.5 | | 33.4 | | 15.9 | | 25.7 | | 33.6 | | *42.1* | | | 29 | *15.4* | |
| 116 | 15 | 0 | | 35.2 | | 40.6 | | 25.3 | | 39.0 | | 37.2 | | 49.0 | | | | *23.2* | |
| 117 | | 5 | | 37.9 | | 47.7 | | 34.5 | | 52.3 | | 40.6 | | 55.9 | | | | *31.0* | |
| 118 | | 9 | | 40.5 | | 54.8 | | 43.7 | 36 | 5.6 | | 43.9 | 27 | 2.8 | | | | *38.8* | |
| 119 | | 14 | | 43.0 | 20 | 1.9 | | 53.0 | | 18.8 | | 47.1 | | 9.6 | | | | *46.6* | |
| 120 | | 19 | | 45.5 | | 9.0 | 30 | 2.2 | | 32.0 | | 50.3 | | 16.3 | | | | *54.4* | |
| 121 | | 24 | | 47.9 | | 16.0 | | 11.3 | | 45.1 | | 53.4 | | 23.0 | | | 30 | *2.2* | |
| 122 | | 29 | | 50.3 | | 23.0 | | 20.3 | | 58.2 | | 56.4 | | 29.7 | | | | *10.0* | |
| 123 | | 34 | | 52.5 | | 29.9 | | 29.2 | 37 | 11.1 | | 59.3 | | 36.3 | | | | *17.8* | |
| 124 | | 39 | | 54.7 | | 36.8 | | 38.2 | | 24.0 | 26 | 2.2 | | 42.9 | | | | *25.6* | |
| 125 | | 44 | | 56.9 | | 43.6 | | 47.1 | | 36.8 | | 5.1 | | 49.4 | | | | *33.4* | |
| 126 | | 49 | | 59.0 | | 50.4 | | 56.1 | | 49.6 | | 7.9 | | 55.9 | | | | *41.2* | |
| 127 | | 54 | 19 | 1.0 | | 57.2 | 31 | 5.1 | 38 | 2.2 | | 10.7 | 28 | 2.4 | | | | 49.0 | |
| 128 | | 59 | | 3.0 | 21 | 4.0 | | 13.9 | | 14.8 | | 13.5 | | 8.9 | | | | 56.8 | |
| 129 | 16 | 3 | | 4.9 | | 10.7 | | 22.8 | | 17.3 | | 16.4 | | 15.3 | | | 31 | 4.6 | |
| 130 | | 5 | | 6.7 | | 17.4 | | 31.6 | | 39.8 | | 19.2 | | 21.7 | 22 | 33.2 | | 12.4 | |
| 131 | | 13 | | 8.5 | | 24.0 | | 40.4 | | 52.3 | | 22.0 | | 28.0 | | 37.8 | | 20.2 | |
| 132 | | 18 | | 10.2 | | 30.6 | | 49.2 | 39 | 4.8 | | 24.9 | | 34.3 | | 42.1 | | 27.8 | |
| 133 | | 23 | | 11.8 | | 37.1 | | 58.0 | | 17.1 | | 27.7 | | 40.6 | | 46.2 | | 35.4 | |
| 134 | | 28 | | 13.4 | | 43.6 | 32 | 6.7 | | 29.4 | | 30.6 | | 46.9 | | 50.1 | | 43.0 | |
| 135 | | 33 | | 14.9 | | 50.0 | | 15.5 | | 41.6 | | 33.4 | | 53.1 | | 53.7 | | 50.5 | |
| 136 | | 38 | | 16.3 | | 56.4 | | 24.3 | | 53.8 | | | | 59.3 | | 57.1 | | 58.1 | |
| 137 | | 43 | | 17.6 | 22 | 2.7 | | 33.1 | 40 | 6.0 | | | 29 | 5.4 | 23 | 0.3 | 32 | 5.6 | |
| 138 | | 48 | | 18.9 | | 9.0 | | 41.9 | | 18.2 | | | | 11.5 | | 3.3 | | 13.1 | |
| 139 | | 52 | | 20.2 | | 15.2 | | 50.7 | | 30.2 | | | | 17.6 | | 6.2 | | 20.4 | |
| 140 | | 57 | | 21.4 | | 21.4 | | | | 42.2 | | | | 23.6 | | 8.8 | | 27.7 | |
| 141 | 17 | 2 | | 22.5 | | 27.5 | | | | 54.2 | | | | 29.6 | | *11.2* | | 35.0 | |
| 142 | | 7 | | 23.6 | | 33.6 | | | 41 | 6.2 | | | | 35.6 | | *13.5* | | 42.2 | |
| 143 | | 12 | | 27.5 | | 39.7 | | | | 18.0 | | | | 41.5 | | *15.7* | | 49.4 | |
| 144 | | 17 | | 31.3 | | 45.8 | | | | 29.8 | | | | 47.5 | | *17.7* | | 56.5 | |
| 145 | | 21 | | 33.7 | | 51.7 | | | | 41.6 | | | | 53.4 | | *19.5* | 33 | 3.7 | |
| 146 | | | | 35.6 | | 57.6 | | | | 53.4 | | | | 59.3 | | *21.2* | | 10.8 | |

| | P | P' | PP | PS | SS | SKS | SKKS | PKS | SKSP | $P_2'$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 147 | | 19 37.3 | 23 3.4 | | 42 5.2 | | 30 5.1 | *23 22.7* | 33 17.8 | |
| 148 | | 38.9 | 9.2 | | 17.0 | | 10.9 | *24.2* | 24.8 | |
| 149 | | 40.4 | 14.9 | | 28.6 | | 16.6 | *25.6* | 31.7 | |
| 150 | | 41.7 | 20.6 | | 40.2 | | 22.4 | *26.8* | 38.5 | 19 58.6 |
| 151 | | 43.1 | 26.3 | | 51.6 | | 28.1 | *28.0* | 45.3 | 20 3.2 |
| 152 | | 44.4 | 32.0 | | 43 3.0 | | 33.8 | *29.1* | 52.0 | 7.7 |
| 153 | | 45.6 | 37.6 | | 14.3 | | 39.5 | *30.2* | 58.6 | 12.2 |
| 154 | | 46.8 | 43.2 | | 25.6 | | 45.1 | *31.2* | 34 5.2 | 16.8 |
| 155 | | 48.0 | 48.7 | | 36.7 | | 50.7 | *32.1* | 11.7 | 21.3 |
| 156 | | 49.1 | 54.2 | | 47.8 | | 56.3 | *33.0* | 18.2 | 25.9 |
| 157 | | 50.3 | 59.6 | | 58.7 | | 31 1.8 | *33.9* | 24.6 | 30.4 |
| 158 | | 51.4 | 24 5.0 | | 44 9.6 | | 7.4 | *34.7* | 30.9 | 35.0 |
| 159 | | 52.4 | 10.4 | | 20.5 | | 12.9 | *35.5* | 37.1 | 39.5 |
| 160 | | 53.5 | 15.8 | | 31.4 | | 18.3 | *36.2* | 43.3 | 44.1 |
| 161 | | 54.6 | 21.0 | | 42.1 | | 23.8 | *36.9* | 49.4 | 48.6 |
| 162 | | 55.7 | 26.2 | | 52.8 | | 29.2 | *37.5* | 55.5 | 53.2 |
| 163 | | 56.8 | 31.3 | | 45 3.3 | | 34.6 | *38.1* | 35 1.5 | 57.7 |
| 164 | | 58.0 | 36.4 | | 13.8 | | *40.0* | *38.7* | 7.4 | 21 2.2 |
| 165 | | 59.1 | 41.5 | | 24.1 | | *45.4* | *39.3* | 13.2 | 6.8 |
| 166 | | 20 0.1 | 46.6 | | 34.4 | | *50.7* | *39.9* | 19.0 | 11.3 |
| 167 | | 1.0 | 51.6 | | 44.7 | | *56.0* | *40.4* | 24.7 | 15.9 |
| 168 | | 1.9 | 56.6 | | 55.0 | | *32 1.4* | *40.9* | 30.4 | 20.4 |
| 169 | | 2.8 | 25 1.6 | | 46 5.1 | | *6.7* | *41.4* | 36.0 | 25.0 |
| 170 | | 3.5 | 6.6 | | 15.2 | | *11.9* | *41.9* | 41.6 | 29.5 |
| 171 | | 4.2 | 11.5 | | 25.1 | | *17.1* | *42.3* | 47.1 | 34.1 |
| 172 | | 4.8 | 16.4 | | 35.0 | | *22.4* | *42.7* | 52.5 | 38.6 |
| 173 | | 5.4 | 21.3 | | 44.8 | | *27.6* | *43.0* | 57.9 | 43.1 |
| 174 | | 5.8 | 26.2 | | 54.6 | | *32.7* | *43.3* | 36 3.3 | 47.7 |
| 175 | | 6.2 | 31.0 | | 47 4.2 | | *37.9* | *43.5* | 8.6 | 52.2 |
| 176 | | 6.5 | 35.8 | | 13.8 | | *43.0* | *43.7* | 13.8 | 56.8 |
| 177 | | 6.8 | 40.6 | | 23.4 | | *48.1* | *43.8* | 19.0 | 22 1.3 |
| 178 | | 7.0 | 45.4 | | 33.0 | | *53.3* | *43.9* | 24.2 | 5.9 |
| 179 | | 7.1 | 50.1 | | 42.5 | | *58.3* | *44.0* | 29.3 | 10.4 |
| 180 | | 7.1 | 54.8 | | 52.0 | | *33 3.4* | *44.0* | 34.3 | 15.0 |

## Notes on the Final Tables

The tables are adapted to a single focal depth, which appears to correspond in continental conditions to a focus near the base of the granitic layer without primitive P movement. At most distances the times of P are probably correct for average structure within a fraction of a second. Those of S are less reliable, but the uncertainty is probably under 2 s. For foci within the upper layers the times of S may be later, with respect to P, by an amount Z which is independent of the distance and may apparently range from about +8 s. to

—10 s. For this reason the S—P interval should not be used to determine Δ if much accuracy is aimed at, though it is useful in a preliminary approximate determination of the epicentre.

At great distances a larger movement often seems to follow P after about 7 s., and is often read as P where the true P is too weak to be visible. P′ also is often read late, especially on the horizontal components. It appears probable that the true S is usually feeble between 10° and 20°, and that other pulses 7 s. or 15 s. later are often read for it. Special attention should lead to a considerable improvement in the determination of S in this range.

S is overtaken about 82° by SKS, which here, with normal depth, follows P by 10 m. 23 s. This interval increases to 10 m. 43 s. at 100°. If the apparent S —P interval is in this neighbourhood it may be suspected that the apparent S is really SKS, and search for the true S after it may lead to valuable results.

The times given for SKS are about as accurate as for S; the chief uncertainty in this wave is in the additive constant needed to adapt the times to the same focal depth as for S.

There are discontinuities in the values of $dT/d\Delta$ for both P and S at 19°. Special examination of seismograms between 19° and 30° for the direct P and S waves, which continue the curves applicable at shorter distances, is desirable; and the same applies to the search for possible places of large amplitude before and after 19° that would be expected if the change in the slope is due to a continuous transition. On the other hand if there is a true discontinuity it should give rise to reflexions, and if these can be traced they would lead to a more accurate determination of the depth than is likely to be possible otherwise. This applies especially to PP reflected on the inside of the discontinuity.

The times given for PP, PS, SS, and SKSP are calculated and make no allowance for a systematic delay that is probably introduced by reflexion, but may have different values according as the reflexion takes place below continents or oceans. The delay seems likely to be about 7s. for PP, Z + 7s. for SP and SKSP, Z + 12s. for SS. Reflexion seems also to occur sometimes at the base of the upper layers; when this occurs the delays are smaller.

SKKS, PKS, and $P_2'$ are less reliable than any of P, S, SKS, and P′; but the tables are certainly accurate enough to serve as a basis for identification, and may be used for theoretical work if they are found to be consistent with results obtained from the better recorded pulses.

There is need of special study to determine the behaviour of S, SKKS, and probably $PS_cS$ between 90° and 120°, where there is at present a curious lack of observations.

According to the cubic formulae derived for the times of P and S at short distances, the trial tables require small negative corrections at distances up to about 3° for P and 6° for S; but these seem to be within the possible uncertainty and have not been applied, pending a direct investigation of the times at these distances.

$P_cP$ is likely to be confused with S, $S_d$, SS, or the surface waves up to about 25°; near 47° it nearly coincides with PP. Up to about 34° $S_cS$ will probably be hidden by the long waves, and it is only from about 47° that it precedes SS.

In conclusion, we must express our indebtedness to the work of the International Summary, initiated by the late Professor Turner, to all the observatories that have contributed to it, and to Mr J. S. Hughes and Miss E. F. Bellamy, who have carried on the work since Prof. Turner's death. Without this the present investigation could never have been begun. We are also grateful to Mr Hughes and Miss Bellamy for information received in the course of the work, and in particular to Miss Bellamy for an advance copy of the readings for the Newfoundland earthquake, which was the starting-point of our solution for S. Much of the computation of distances was done under the supervision of Dr L. J. Comrie, the expenses being covered by a grant from the Department of Geodesy and Geophysics at Cambridge. We wish also to thank many colleagues for information given privately, which has enabled us to decide many points that would otherwise have remained in doubt. This refers particularly to Miss I. Lehmann for communicating her discovery of the late P and S beyond 20°, which decided whether the curves in this region are double or merely simple curves with strong curvature, and for her additional readings for 1929 June 16; Mr F. J. Scrase for his special search for pP and sS in many of our earthquakes; Prof. Byerly for information about the Montana and Santa Barbara earthquakes; and Dr E. A. Hodgson for information about the Saguenay River earthquake. We have also to thank the Seismological Committee of the British Association for making a grant of £ 60 in aid of the printing of the reductions for the individual earthquakes, and Mr C. W. Brannon, of the Isle of Wight County Press, for his great personal attention and ingenuity in devising a suitable arrangement of these tables.

# SUMMARIES
## FOR THE
# INDIVIDUAL
# EARTHQUAKES.

Isle of Wight:
The County Press,
Newport.
1934.

# NOTES ON THE REDUCTIONS OF THE INDIVIDUAL EARTHQUAKES.

A station often gives a number of readings a few seconds apart for a single phase. If there is little difference between them they probably arise from the phase not being equally clear on all components; but a difference of several seconds may mean a later pulse, such as a reflexion near the epicentre. The policy adopted has been to take only the earliest where the difference does not exceed 3s.; for greater differences all readings are given.

Originally many readings that might be either S or SKS were given in both the corresponding columns, and were included in both frequency distributions until a criterion was available for separating them. Consequently it will be found, if any reader is disposed to check our classification of the residuals, that those given in the text will be somewhat more numerous than in the final tables for the individual earthquakes. In general this will show chiefly in the larger residuals. In the final tables such readings have been compared with the final means of S and SKS, and each has been entered in the column where it gives the smallest residual.

A determination of the epicentre was not in general considered satisfactory unless there were at least two accordant P observations near each of three well separated azimuths. It was found occasionally that even the best stations might be in disagreement with the bulk of the others, possibly owing to microseisms; and in discussing an individual shock it seemed desirable not only to know that a station was usually reliable, but to have confirmation from another station that it was correct on the particular occasion. For this reason a considerable number of the shocks used in former papers have had to be omitted. A few that did not satisfy the criterion have, however, still been retained for special reasons, notably the Montana and Santa Barbara earthquakes.

Search was made in the I.S.S. for all readings that might be P, S, PP, PS, SS, PPP, SSS, SKS, SKKS, P′, $P'_2$, PKS, and SKSP. All of these are given here except PPP and SSS, which seemed too irregular to be likely to give useful results. As 13 sets of residuals had to be fitted, for purposes of printing, into 9 columns at most, some rearrangement has been needed; overlapping has been avoided in any column, but it has not been possible to keep a uniform arrangement throughout. All other readings were finally plotted to see if there was any sign of other phases traceable over a range of distance; but there were no convincing indications of any. There were a number of readings that might be $S_cS$, and others that might be S at distances over 105°; but they were not sufficiently numerous or consistent to enable tables to be made.

The names of the stations are given as in the I.S.S., except for the restoration of some accents and modification marks. In general it is probably more convenient to use the form of a place-name that is current in the place itself, rather than an Anglicized form, but we have thought it undesirable to adhere to this principle where reference to the I.S.S. has been habitual and may have to be made frequently again.

The geographical classification of the epicentres on the whole explains itself; but two epicentres in the Northern Hemisphere appear among the Pacific ones. These are in the Philippines; they are 3° south of and 2° and 6° respectively east of another Philippine epicentre, which has been included with the Japanese ones. It might have been more natural to include all Pacific earthquakes north of the equator with the Japanese ones, but the information given by these two approximates to the oceanic type, notably in the long series of distant SKS observations.

Epicentral distances were adopted from the I.S.S. when the epicentre was not shifted. When the epicentre was shifted the distances of the nearer stations were recalculated; in general greater distances were evaluated by applying a correction according to azimuth, except in the case of stations in unusual azimuths, which were recalculated. Those recalculated are indicated by retaining the second decimal. Dr. Comrie and his assistants recalculated the whole of the distances in the earthquakes submitted to them, but in some of these further corrections to the epicentre proved necessary. Errors of computation in the I.S.S. were so rare in the distances actually recalculated that it did not seem worth while to undertake complete recalculation in other cases. But as both the I.S.S. and Comrie's distances were rounded off to the nearest 0°·1, and the corrections also were rounded to 0°·1, it is to be expected that the final distances will occasionally be wrong by 0°·1. The resulting errors in the times for a given distance are comparable with those introduced by the normal sources of error and therefore will have affected the results only by a slight increase of the standard error.

The mark * indicates that a miscount of an exact number of minutes is suspected; the mark † that a clock error is suspected from the agreement of large residuals for two or more phases. In many cases stations whose observations all lie outside the range of residuals retained in the summaries have been omitted; also stations recording no identifiable phase among those considered here, but some in the shadow of the core have been kept so that the distances may be available for any re-examination of the records.

We give $T_0$ in the following way.

1925 Nov. 13d. 12h. 14m. 40s. +15s. =14m.55s.

Here the time first given is from the I.S.S.; +15s. is our correction; 14m.55s. is our corrected time together with an exact number of hours. Z is the difference between the values of $T_0$ that suit P and S. Where we cannot determine Z we write "Z taken = 0." The "first revised epicentre" is obtained using the J tables.

# EPICENTRES IN EUROPE, WITH THE MEDITERRANEAN AND WESTERN AND CENTRAL ASIA.

1926 Aug. 30d. 11h. 38m. 0s. +5s. =38m. 5s. Z = +1.

I.S.S. Epicentre 37°·5N. 23°·0E. First Revised Epicentre 36°·78N. 23°·23E.
Final Epicentre 36°·64N. 23°·05E.

A = +·7384, B = +·3141, C = +·5966.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Athens | 1·44 | +5 | +5 | | |
| Mostar | 7·81 | +4 | +4 | | |
| Naples | 8·04 | +17 | +17 | −23 | −23 |
| Sarajevo | 8·04 | +2 | +2 | −4+31 | −4+31 |
| Belgrade | 8·41 | +1 | +1 | | |
| Sebenico | 8·97 | −11 | −11 | −6 | −6 |
| Rocca di Papa | 9·37 | +2 | +2 | +1 | +1 |
| Helwan | 9·73 | 0 | 0 | −12 | −12 |
| Zagreb | 10·6 | 0 | 0 | 0 | 0 |
| Budapest | 11·24 | +3 | +3 | | |
| Laibach | 11·40 | −3 | −3 | −47 | −47 |
| Florence | 11·48 | +1 | +1 | +22 | +22 |
| Graz | 11·8 | −1 | −1 | −8 | −8 |
| Vienna | 12·6 | −4 | −4 | +8 | +8 |
| Lemberg | 13·28 | +1 | +1 | −4+20 | −5+19 |
| Innsbruck | 13·8 | −2 | −2 | −10 | −11 |
| Moncalieri | 14·3 | 0 | 0 | +17 | +16 |
| Ravensburg | 14·9 | +6 | +6 | +9 | +8 |
| Marseilles | 15·0 | +69 | +69 | +86 | +85 |
| Zürich | 15·2 | +1 | 0 | +4 | +3 |
| Cheb | 15·5 | −1 | −2 | −1 | −2 |
| Hohenheim | 15·76 | −3 | −4 | −5 | −7 |
| Neuchâtel | 15·80 | +2 | +1 | +8 | +7 |
| Makeyevka | 15·84 | +3 | +2 | +3 | +2 |
| Algiers | 16·02 | +3 | +2 | +3 | +2 |
| Strasbourg | 16·3 | −4 | −5 | +3 | +2 |
| Besançon | 16·5 | +1 | 0 | −4 | −5 |
| Barcelona | 16·88 | +2 | +1 | +7 | +5 |
| Piatigorsk | 16·94 | +17 | +16† | +24 | +22† |
| Tortosa | 18·0 | +4 | +3 | 0 | −2 |
| Bagnères | 18·54 | +2 | +1 | +4 | +2 |
| Alicante | 18·72 | −1 | −2 | +1 | −1 |
| Hamburg | 19·2 | +1 | 0 | −5 | −7 |
| Paris | 19·3 | +1 | 0 | −3 | −5 |
| Uccle | 19·4 | +2 | +1 | +3 | +1 |
| De Bilt | 19·9 | +1 | +1 | +3 | +2 |
| Almeria | 20·4 | +6 | +6 | +14 | +14 |
| Baku | 21·28 | +1 | +1 | | |
| Granada | 21·3 | −2 | −2 | +4 | 0(d) |
| Toledo | 21·4 | 0 | 0 | 0 | +1 |
| Malaga | 22·0 | −2 | −1 | −4 | −2 |
| Kew | 22·2 | 0 | +1 | −1 | +1 |
| Oxford | 22·9 | −11 | −9† | −14 | −11† |
| San Fernando | 23·4 | +2 | +4 | −2 | +1 |
| Pulkovo | 23·6 | −3 | −1 | −15 | −11 |
| Rio Tinto | 23·6 | −14 | −12 | | |
| Leningrad | 23·7 | −3 | −1 | −15 | −11 |
| West Bromwich | 23·7 | −3 | −1 | −85 | −81 |
| Stonyhurst | 24·6 | −6 | −3 | −15 | −10 |
| Bidston | 24·7 | −4 | −1 | −5 | 0 |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Lisbon | 25·5 | −7 | −3 | −18 | −12 |
| Edinburgh | 26·1 | −2 | +2 | −12 | −5 |
| Dyce | 26·5 | −7 | −3 | −59 | −52 |
| Ekaterinburg | 32·0 | −5 | +1 | −19 | −10 |
| Azores | 38·4 | +8 | +12 | | |
| Simla | 44·6 | −12 | −9 | −25 | −20 |
| Bombay | 46·9 | −3 | 0 | −9 | −5 |
| Hyderabad | 52·1 | −4 | −2 | −9 | −7 |
| Kodaikanal | 55·5 | | | −11 | −10 |
| Irkutsk | 56·9 | −2 | −2 | −7 | −6 |
| Calcutta | 57·4 | +50 +74 | | | |
| Colombo | 59·5 | +4 | +4 | +4 | +4 |
| Halifax | 63·1 | +1 | 0 | −10 | −11 |
| Harvard | 69·0 | +21 | +20 | −2 | −5 |
| Ottawa | 70·2 | +1 | 0 | −17 −1 | −19 −3 |
| Cape Town | 70·8 | | | +25 | +23 |
| Fordham | 71·5 | | | +5 | +3 |
| Ithaca | 72·3 | −1 | −2 | +3 | +1 |
| Toronto | 73·3 | −2 | −3 | −5 | −8 |
| Ann Arbor | 76·7 | +17 | +17 | −6 | −9 |
| Hong Kong | 77·7 | 0 | 0 | | |
| Zi-ka-wei | 77·9 | −3 | −3 | | |
| Chicago | 79·3 | −1 | −1 | −10 | −14 |
| Taihoku | 81·6 | +6 | +6 | | |
| Osaka | 85·0 | +11 | +12 | | |
| Mizusawa | 85·2 | −5 | −4 | | |
| Nagoya | 85·5 | −7 | −6 | | |
| Manila | 87·5 | −2 | −1 | | |
| Batavia | 88·7 | −3 | −2 | | |
| Victoria | 89·8 | −1 | 0 | | |
| Malabar | 90·3 | −1 | 0 | | |
| Tucson | 98·7 | 0 | +3 | −1 | −6 |
| Lick | 99·1 | | | +10 | +5 |
| Sucre | 100·0 | +6 | +10 | | |
| La Paz | 100·8 | −17 | −13 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Bagnères | 18·54 | | | | | | −4 |
| Alicante | 18·72 | | | | +2,10,18 | | |
| Toledo | 21·4 | | | | +3, 12, 27 | | +11 |
| Oxford | 22·9 | | | | +23 | | |
| Ekaterinburg | 32·0 | | | | −8 | | |
| Irkutsk | 56·9 | | | | +17 | | |
| Harvard | 69·0 | | | | | +6, 16 | −8 |
| Fordham | 71·5 | | | | | +16 | −21 |
| Toronto | 73·3 | | | | | +6 | |
| Ann Arbor | 76·7 | | | | +28 | | +5 |
| Chicago | 79·3 | | | | −16 | −10 | −16 |
| Batavia | 88·7 | | +1 | | | −19 | |
| Victoria | 89·8 | | −11 | | | | |
| Malabar | 90·3 | | +9 | | | | |
| Tucson | 98·7 | | | | +6 | | |
| Lick | 99·1 | | −11 | | +32 | | |
| Sucre | 100·0 | | −22+8 | | +20 | | |
| La Paz | 100·8 | | −11 | | −4 | | −13 |
| Honolulu | 122·1 | | | | | −11 | +2 |
| Riverview | 138·0 | | | | +2 | | |

Honolulu 30m.10s. may be SKSP.

NOTE.—According to *The Times*, 1926 Sept. 1, numbers of dwellings collapsed at Sparta, and important buildings were damaged at Athens and Phaleron. The epicentre is 70 km from Sparta and 160 km from Athens.

The P residuals are normal, but those of S are strongly negative from Pulkovo to the distant stations. The distribution suggests focal depth for S, but no depth would suit all the distances.

1927 July 1d. 8h. 18m. 54s. +6s. =19m. 0s.     Z = +5.

I.S.S. Epicentre 37°·5N., 23°·0E.  Revised epicentre 36°·7N. 22°·8E.

A = +·7392, B = +·3107, C = +·5976.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Pompeii | 7·6 | +4 | +4 | −52 | −52 |
| Naples | 7·8 | −1 | −1 | −54 | −54 |
| Belgrade | 8·3 | −2 | −2 | +3 | +3 |
| Rocca di Papa | 9·3 | 0 | 0 | 0 +41 | 0 +41 |
| Helwan | 9·9 | −1 | −1 | −17 | −17 |
| Zagreb | 10·5 | −28 | −28 | +10 | +10 |
| Ksara | 11·0 | +2 | +2 | −14 | −14 |
| Budapest | 11·1 | +4 | +4 | | |
| Laibach | 11·2 | 0 | 0 | | |
| Florence | 11·3 | +1 | +1 | +20 | +20 |
| Graz | 11·7 | −2 | −2 | −2 | −2 |
| Venice | 11·8 | +4 | +4 | 0 | 0 |
| Vienna | 12·5 | −2 | −2 | +3 | +3 |
| Lemberg | 13·2 | +4 | +4 | +16 | +15 |
| Moncalieri | 14·1 | 0 | 0 | +18 | +17 |
| Prague | 14·7 | 0 | 0 | −10 | −11 |
| Zürich | 15·0 | 0 | 0 | +2 | +1 |
| Cheb | 15·3 | 0 | −1 | +5 | +4 |
| Grenoble | 15·4 | +5 | +4 | −2 | −3 |
| Hohenheim | 15·6 | −1 | −2 | +1 | 0 |
| Algiers | 15·8 | +3 | +2 | −7 | −8 |
| Makeyevka | 15·9 | +4 | +3 | +4 | +3 |
| Strasbourg | 16·2 | +2 | +1 | +1 | 0 |
| Jena | 16·3 | +1 | 0 | −1 | −3 |
| Besançon | 16·3 | +2 | +1 | −15 | −17 |
| Barcelona | 16·7 | +1 | 0 | +2 | 0 |
| Feldberg | 17·0 | +1 | 0 | +9 | +7 |
| Potsdam | 17·1 | +3 | +2 | 0 | −2 |
| Puy de Dôme | 17·4 | 0 | −1 | +19 | +17 |
| Tiflis | 17·7 | +8 | +7 | +8 | +6 |
| Tortosa | 17·8 | +6 | +5 | −3 | −5 |
| Königsberg | 18·2 | +4 | +3 | −8 | −10 |
| Bagnères | 18·3 | +4 | +3 | +4 | +2 |
| Alicante | 18·5 | +4 | +3 | −5 | −7 |
| Hamburg | 19·1 | +1 | 0 | −1 | −3 |
| Paris | 19·1 | +1 | 0 | −2 | −4 |
| Uccle | 19·3 | +1 | 0 | 0 | −2 |
| De Bilt | 19·8 | +3 | +2 | 0 | −1 |
| Copenhagen | 20·2 | −1 | −1 | −3 | −3 |
| Almeria | 20·2 | 0 | 0 | −5 | −5 |
| Granada | 21·0 | 0 | 0 | +1 | +2 |
| Toledo | 21·2 | 0 | 0 | −4 | −3 |
| Baku | 21·4 | +3 | +3 | +2 | +3 |
| Kucino | 21·7 | −2 | −1 | −9 | −7 |
| Malaga | 21·7 | 0 | +1 | −4 | −2 |
| Kew | 22·1 | −1 | 0 | −3 | −1 |
| Oxford | 22·7 | −2 | 0 | −7 | −4 |
| San Fernando | 23·2 | 0 | +2 | −12 | −9 |
| Upsala | 23·4 | −3 | −1 | −11 | −8 |
| Helsingfors | 23·5 | +1 | +3 | −2 | +2 |
| Pulkovo | 23·6 | −1 | +1 | −12 | −8 |
| Stonyhurst | 24·4 | +2 | +4 | −10 | −6 |
| Edinburgh | 26·0 | −3 | +1 | −17 | −10 |
| Dyce | 26·4 | −5 | −1 | −20 | −14 |
| Ekaterinburg | 32·1 | −17 | −11 | −34 | −25 |
| Tashkent | 36·0 | −5 | 0 | −22 | −14 |
| Simla | 44·9 | −3 | 0 | −10 | −6 |
| Bombay | 47·1 | −1 | +2 | −8 | −4 |
| Hyderabad | 52·4 | −4 | −2 | −14 | −12 |
| Irkutsk | 57·0 | −2 | −2 | −10 | −9 |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Ottawa | 70·0 | +1 | 0 | −6 | −8 |
| Cape Town | 70·7 | | | +20 | +18 |
| Fordham | 71·3 | +16 | +15 | −8 | −10 |
| Ithaca | 72·1 | −8 | −9 | −23 | −21 |
| Phu-Lien | 73·0 | −1 | −2 | −14 | −17 |
| Ann Arbor | 76·5 | | | −15 | −18 |
| Hong Kong | 77·9 | | | −11 | −14 |
| Zi-ka-wei | 78·1 | 0 | 0 | −19 | −22 |
| Chicago | 79·1 | −3 | −3 | −29 | −32 |
| Osaka | 85·1 | +4 | +4 | −1 | −5 |
| Mizusawa | 85·3 | 0 | +1 | | |
| Manila | 87·7 | −3 | −2 | | |
| Batavia | 88·9 | −32 | −31 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Königsberg | 18·2 | | | | +9 | | |
| Uccle | 19·3 | | | | +10 | | |
| Granada | 21·0 | | | | −3+13 | | |
| Toledo | 21·2 | | | | +15 | | |
| Baku | 21·4 | | | | +30 | | |
| Kucino | 21·7 | | | | +4 | | |
| Ekaterinburg | 32·1 | | | | −17 | | |
| Tashkent | 36·0 | | | | +6 | | |
| Irkutsk | 57·0 | | | | −19 | | −13 |
| Ottawa | 70·0 | | | | | | +17 |
| Fordham | 71·3 | | | | | +3 | −16 |
| Ann Arbor | 76·5 | | | | | −9, 3 | |
| Chicago | 79·1 | | | | +11 | | −43 |
| Mizusawa | 85·3 | | −9 | | | −25 | |
| Manila | 87·7 | | −12 | | | | |
| Batavia | 88·9 | | −24+11 | | | | |
| Victoria | 89·7 | | −7 | | | | |
| La Paz | 100·5 | | +20 | | +5 | | |

NOTE.—The P residuals are normal, but those of S indicate focal depth. This earthquake was not used in forming the S curve.

1927 July 11d. 13h. 3m. 55s. +18s. =4m.13s. Z = −3.

I.S.S. epicentre 32°·0N. 35°·5. Revised epicentre 31°·9N. 35°·3E.

A = +·6929, B = +·4906, C = ·5284.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Ksara | 2·0 | +1 | +1 | | |
| Helwan | 3·9 | +1 | +1 | +17 | +17 |
| Tiflis | 12·4 | 0 | 0 | +16 | +16 |
| Baku | 14·5 | 0 | 0 | +14 | +14 |
| Makeyevka | 16·3 | −3 | −4 | +4 | +3 |
| Belgrade | 17·4 | −1 | −2 | +13 | +11 |
| Pompeii | 18·9 | +11 | +10 | +21 | +19 |
| Naples | 19·1 | +5 | +4 | +70 | +68* |
| Lemberg | 19·8 | +4 | +3 | +11 | +10 |
| Budapest | 19·9 | +1 | +1 | +16 | +16 |
| Zagreb | 20·4 | +3 | +3 | +23 | +23 |
| Rocca di Papa | 20·5 | +1 | +1 | +14 | +14 |
| Laibach | 21·4 | 0 | 0 | | |
| Graz | 21·5 | −2 | −1 | +10 | +11 |
| Vienna | 21·7 | −2 | −1 | +9 | +11 |
| Florence | 22·3 | +3 | +4 | +19 | +21 |
| Venice | 22·3 | +6 | +7 | | |
| Innsbruck | 23·8 | 0 | +2 | +16 | +20 |
| Prague | 23·9 | −2 | +1 | −1 | +3 |
| Cheb | 24·9 | −2 | +1 | +2 | +7 |

*Continued on next page.*

| | Δ | $P_\nu$ | $P_\omega$ | $S_\nu$ | $S_\omega$ |
|---|---|---|---|---|---|
| | ° | | | | |
| Moncalieri | 25·1 | −4 | −1 | +64 | +69* |
| Ravensburg | 25·1 | −7 | −4 | +14 | +19 |
| Königsberg | 25·2 | −2 | +1 | +2 | +7 |
| Zürich | 25·5 | −3 | +1 | +27 | +32 |
| Hohenheim | 25·8 | −4 | 0 | +17 | +24 |
| Jena | 25·8 | −5 | −1 | +3 +17 | +10 +24 |
| Potsdam | 26·1 | −5 | −1 | +13 | +20 |
| Grenoble | 26·5 | −10 | −6 | +12 | +19 |
| Strasbourg | 26·6 | −6 | −2 | +2 | +9 |
| Feldberg | 27·0 | −2 | +2 | +9 | +16 |
| Algiers | 27·0 | −5 | −1 | +11 | +18 |
| Besançon | 27·1 | −5 | −1 | −7 | 0 |
| Barcelona | 28·0 | −9 | −4 | +17 | +24 |
| Pulkovo | 28·1 | −8 | −3 | −10 | −2 |
| Hamburg | 28·2 | −6 | −1 | +18 | +26 |
| Puy de Dôme | 28·5 | −10 | −5 | | |
| Tashkent | 28·6 | −9 | −4 | −7 | +1 |
| Copenhagen | 28·7 | −7 | −2 | −14 | −6 |
| Helsingfors | 29·1 | −6 | 0 | −10 | −2 |
| Tortosa | 29·2 | −2 | +4 | −2 | +6 |
| Uccle | 29·6 | −7 | −1 | −9 | −1 |
| De Bilt | 29·8 | −7 | −1 | −7 | +1 |
| Paris | 29·8 | −7 | −1 | −4 | +4 |
| Alicante | 29·8 | +5 | +11 | +20 | +28 |
| Upsala | 30·3 | −8 | −2 | −10 | −1 |
| Ekaterinburg | 30·4 | −10 | −4 | −10 | −1 |
| Almeria | 31·4 | −4 | +2 | +11 | +20 |
| Granada | 32·3 | −5 | +1 | +3 | +12 |
| Kew | 32·5 | −7 | −1 | +6 | +15 |
| Toledo | 32·6 | −5 | +1 | −8 | +1 |
| Malaga | 32·9 | −2 | +4 | −1 | +7 |
| Oxford | 33·2 | −7 | −1 | −6 | +2 |
| San Fernando | 34·4 | +4 | +9 | −8 | −1 |
| Stonyhurst | 34·6 | −9 | −4 | −5 | +3 |
| Bidston | 34·8 | −66 | −61* | −69 | −61* |
| Simla | 35·5 | | | −53 −5 | −45 +3 |
| Edinburgh | 35·9 | −9 | −4 | −14 | −6 |
| Dyce | 36·0 | −7 | −2 | −7 | +1 |
| Bombay | 36·1 | −6 | −2 | −5 | +3 |
| Hyderabad | 41·5 | | | +1 | +7 |
| Kodaikanal | 44·5 | | | −8 | −3 |
| Irkutsk | 52·8 | −4 | −2 | 0 | +2 |
| Phu-Lien | 63·8 | −3 | −4 | −1 | −2 |
| Cape Town | 67·7 | | | +5 | +3 |
| Hong Kong | 69·4 | | | −2 | −4 |
| Zi-ka-wei | 71·2 | −6 | −7 | 0 | −2 |
| Manila | 78·8 | +1 | +1 | −33 | −37 |
| Ottawa | 80·7 | | | +3 | −1 |
| Toronto | 83·8 | | | +12 | +8 |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Innsbruck | 23·8 | | | | | | −10 |
| Moncalieri | 25·1 | | | | | | +11 |
| Königsberg | 25·2 | | | | +4 | | −6 |
| Jena | 25·8 | | | | +11 | | −21, 8 |
| Strasbourg | 26·6 | | | | | | +6 |
| Pulkovo | 28·1 | | | | +10 | | |
| Tashkent | 28·6 | | | | | | −38 |
| Upsala | 30·3 | | | | +10 | | |
| Ekaterinburg | 30·4 | | | | +10 | | |
| Almeria | 31·4 | | | | +5 | | −29 |
| Granada | 32·3 | | | | +7 | | |
| Irkutsk | 52·8 | | | | +10 | | +22 |
| Victoria | 97·5 | | 0 | | | | |
| La Paz | 109·8 | | | | +5 | | |

NOTE.—Up to 27° Makeyevka and Prague seem to be the only stations recording the true S, 1927 July 22d. 3h. 54m. 54s. +23s. =55m.17s. Z = +4.

I.S.S. epicentre 34°·7N. 54°·0E. Retained.

A = +·483, B = +·665, C = +·569.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Baku | 6·5 | +5 | +5 | +18 | +18 |
| Tiflis | 10·0 | +2 | +2 | | |
| Tashkent | 13·7 | −2 | −2 | +8 | +7 |
| Ksara | 15·0 | +1 | +1 | +22 | +21 |
| Makeyevka | 17·9 | +3 | +2 | +16 | +15 |
| Simla | 19·7 | −13 −1 | −14 −2 | −3 +3 | −5 +1 |
| Helwan | 19·7 | −6 | −7 | +10 | +8 |
| Dehra Dun | 20·6 | +11 | +11 | +6 | +6 |
| Ekaterinburg | 22·6 | −2 | 0 | −18 | −15 |
| Bombay | 23·0 | 0 | +2 | +64 | +67* |
| Kucino | 23·8 | 0 | +2 | +15 | +19 |
| Lemberg | 26·5 | +1 | +5 | +3 | +10 |
| Belgrade | 27·5 | −26 | −21 | +5 | +12 |
| Hyderabad | 27·8 | +2 | +7 | +11 | +19 |
| Budapest | 28·9 | −1 | +4 | +40 | +48 |
| Pulkovo | 29·4 | −5 | +1 | −6 | +2 |
| Königsberg | 30·6 | −3 | +3 | −13 | −4 |
| Zagreb | 30·7 | −6 | 0 | +38 | +47 |
| Vienna | 30·9 | −9 | −3 | −12 | −3 |
| Graz | 31·2 | −6 | 0 | −9 | 0 |
| Helsingfors | 31·6 | −12 | −6 | −25 | −16 |
| Naples | 31·7 | −8 | −2 | +24 | +33 |
| Laibach | 31·8 | −6 | 0 | +4 | +13 |
| Calcutta | 32·3 | | | +8 | +17 |
| Prague | 32·5 | −3 | +3 | +22 | +31 |
| Rocca di Papa | 32·9 | −6 | 0 | −19 | −10 |
| Venice | 33·2 | −4 | +2 | −5 | +4 |
| Cheb | 33·8 | −8 | −2 | +4 | +13 |
| Potsdam | 33·9 | −5 | +1 | −2 | +7 |
| Florence | 33·9 | −6 | 0 | −14 | −5 |
| Innsbruck | 34·0 | +11 | +17 | −18 | −9 |
| Jena | 34·4 | −1 | +4 | +19 | +28 |
| Upsala | 34·5 | −9 | −4 | −12 | −4 |
| Copenhagen | 35·2 | −4 | +1 | −16 | −8 |
| Ravensburg | 35·3 | −9 | −4 | | |
| Hohenheim | 35·6 | −6 | −1 | | |
| Hamburg | 36·0 | −5 | 0 | −6 | +2 |
| Zürich | 36·0 | −7 | −2 | | |
| Feldberg | 36·3 | −2 | +3 | −6 | +2 |
| Moncalieri | 36·5 | −8 | −3 | −9 +7 | −1 +15 |
| Strasbourg | 36·6 | −8 | −3 | 0 | +8 |
| Besançon | 37·7 | −6 | −1 | +7 | +15 |
| De Bilt | 38·6 | −5 | −1 | −5 | +2 |
| Uccle | 39·0 | −5 | −1 | −6 | +1 |
| Irkutsk | 39·5 | −4 | 0 | −6 | +1 |
| Paris | 40·0 | −5 | −1 | −6 | +1 |
| Barcelona | 40·8 | +27 | +31 | | |
| Algiers | 40·9 | −15 | −11 | −11 | −5 |
| Kew | 41·9 | −3 | +1 | −2 | +4 |
| Oxford | 42·6 | −5 | −1 | −8 | −2 |
| Tortosa | 43·2 | −14 | −10 | −30 | −25 |
| Alicante | 43·3 | +10 | +14 | +41 | +46 |
| Stonyhurst | 43·3 | −3 | +1 | −4 | +1 |
| Dyce | 43·4 | +12 | +16 | −3 | +2 |
| Bidston | 43·7 | +9 | +13 | −2 | +3 |
| Edinburgh | 43·8 | −5 | −1 | +7 | +12 |
| Almeria | 45·1 | −5 | −2 | +9 | +14 |
| Toledo | 45·7 | −5 | −2 | −7 | −3 |
| Granada | 46·0 | −7 | −4 | +6 | +10 |

*Continued on next page.*

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Malaga | 46·7 | −3 | 0 | +19 | +23 |
| Phu-Lien | 48·0 | −3 | 0 | −10 | −7 |
| Zi-ka-wei | 55·6 | +4 | +5 | 0 | +1 |
| Manila | 62·9 | +20 | +19 | 0 | 0 |
| Sumoto | 64·6 | | | 0 | −1 |
| Cape Town | 76·2 | | | +4 | +1 |
| Ottawa | 87·9 | 0 | +1 | | |
| Perth | 88·4 | | | +2 | −2 |

Other readings :

| | △ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Ekaterinburg | 22·6 | | | | +2 | | |
| Helsingfors | 31·6 | | | | | | −34 |
| Calcutta | 32·3 | | | | −3 | | |
| Hohenheim | 35·6 | | | | +11 | | |
| Feldberg | 36·3 | | | | −22 | | |
| De Bilt | 38·6 | | | | +8 | | |
| Uccle | 39·0 | | | | | | +3 |
| Almeria | 45·1 | | | | | | −67 |
| Granada | 46·0 | | | | | | −77 |
| Phu-Lien | 48·0 | | | | | | +19 |
| Batavia | 64·3 | | | | −10 | | |
| Sumoto | 64·6 | | | | | −7 | |
| Ottawa | 87·9 | | −6 | | | | |
| Toronto | 90·9 | | −9 | | | | |
| Chicago | 95·9 | | −15, 8 | | | | |
| Victoria | 96·9 | | +2 | | | | −42 |
| Melbourne | 111·1 | | | | | −25 | |
| Riverview | 113·8 | +18 | | | | | |
| Sucre | 124·4 | | | | +2 | | |
| La Paz | 125·5 | −1 | | | +39 | | |

NOTE.—Pulkovo or possibly Dehra Dun is the nearest station to record S. Stations from 36° on were used in forming the S table.

1927 Sept. 11d. 22h. 15m. 40s. +11s. =15m. 51s. Z = −4.

I.S.S. epicentre 44°·5N. 34°·5E. Revised epicentre 44°·4N. 34°·3E.

A = +·5902, B = +·4026, C = +·6997.

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Makeyevka | 4·44 | +1 | +1 | | |
| Tiflis | 8·11 | −2 | −2 | −4 | −4 |
| Lemberg | 8·85 | 0 +8 | 0 +8 | +1 +7 | +1 +7 |
| Belgrade | 9·85 | −2 | −2 | +9 | +9 |
| Ksara | 10·67 | 0 | 0 | 0 | 0 |
| Budapest | 11·00 | −1 | −1 | +19 | +19 |
| Kucino | 11·6 | +1 | +1 | +6 | +6 |
| Baku | 12·1 | +6 | +6 | +22 | +22 |
| Vienna | 12·9 | 0 | 0 | +30 | +30 |
| Zagreb | 13·0 | 0 | 0 | +21 +60 | +20 +59 |
| Graz | 13·4 | +1 | +1 | +31 | +30 |
| Königsberg | 13·7 | −1 | −1 | −2 | −3 |
| Laibach | 14·0 | −1 | −1 | +27 | +26 |
| Prague | 14·6 | −2 | −2 | +24 | +23 |
| Helwan | 14·7 | +5 | +5 | 0 | −1 |
| Pompeii | 15·0 | +6 | +6 | +27 | +26 |
| Venice | 15·5 | +15 | +14 | +20 | +19 |
| Pulkovo | 15·6 | −6 | −7 | −9 | −10 |
| Cheb | 15·8 | +4 | +3 | +23 | +22 |
| Rocca di Papa | 16·0 | +2 | +1 | +16 | +15 |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Potsdam | 16·2 | +23 | +22 | −4 | −6 |
| Jena | 16·5 | +2 | +1 | +4 +22 | +2 +20 |
| Florence | 16·5 | 0 | −1 | +25 | +23 |
| Ravensburg | 17·4 | 0 | −1 | +20 | +18 |
| Chur | 17·5 | 0 | −1 | +11 | +9 |
| Hohenheim | 17·7 | +3 | +2 | +13 +43 | +11 +41 |
| Copenhagen | 17·9 | −4 | −5 | −16 | −18 |
| Zürich | 18·1 | −2 | −3 | +19 | +17 |
| Upsala | 18·4 | −6 | −7 | −8 | −10 |
| Strasbourg | 18·7 | −1 | −2 | +10 | +8 |
| Moncalieri | 18·8 | 0 | −1 | +5 +10 | +3 +8 |
| Besançon | 19·8 | 0 | 0 | +9 | +8 |
| Grenoble | 20·2 | +5 | +5 | +8 | +5(d) |
| Ekaterinburg | 20·6 | −2 | −2 | +1 | +1 |
| De Bilt | 20·8 | 0 | 0 | +11 | +11 |
| Marseilles | 20·8 | +5 | +5 | +14 | +14 |
| Uccle | 21·0 | 0 | 0 | +17 | +18 |
| Paris | 22·1 | +2 | +3 | +6 | +1(d) |
| Puy de Dôme | 22·1 | +3 | +4 | +16 | +11(d) |
| Bergen | 23·5 | −9 | −7 | +15 | +8(d) |
| Barcelona | 23·6 | −1 | +1 | +8 | 0(d) |
| Kew | 23·9 | −1 | +1 | +5 | −3(d) |
| Bagnères | 24·5 | −1 | +2 | −9 | −4 |
| Oxford | 24·7 | +12 | +15 | +8 | −1(d) |
| Algiers | 24·8 | −4 | −1 | −2 | +3 |
| Tortosa | 25·0 | −5 | −2 | +4 +25 | −5(d) +16(d) |
| Stonyhurst | 25·5 | +6 | +10† | +3 | +9† |
| Tashkent | 25·6 | +12 | +16† | +15 | +21† |
| Bidston | 25·9 | −9 | −5 | −14 | − 8 |
| Dyce | 25·9 | +7 | +11 | +2 | +8 |
| Edinburgh | 26·2 | +2 | +6 | +8 | −2(d) |
| Plymouth | 26·5 | +19 | +23 | +21 | +10(d) |
| Alicante | 26·6 | +9 | +13 | +21 | +10(d) |
| Almeria | 28·6 | −3 | +2 | −5 | +3 |
| Toledo | 28·6 | −7 | −2 | +4 | +13 |
| Granada | 29·3 | −5 | +1 | −7 | +1 |
| Malaga | 30·1 | −9 | −3 | +1 | +10 |
| San Fernando | 31·6 | −1 | +5 | 0 | +9 |
| Simla | 35·9 | −23 −5 | −18,0 | −6,0 | +2 +8 |
| Bombay | 41·0 | −1 | +3 | −6 | 0 |
| Hyderabad | 45·7 | −6 | −3 | −15 | −11 |
| Calcutta | 49·0 | −6 | −3 | +11 +15 | +14 +18 |
| Kodaikanal | 50·3 | +31 | +33 | | |
| Colombo | 54·4 | −2 | −1 | +1 | +3 |
| Phu-Lien | 63·1 | +3 | +2 | +4 | +3 |
| Zi-ka-wei | 66·8 | −2 | −3 | +6 | +5 |
| Hong Kong | 67·5 | +6 | +5 | +5 | +4 |
| Ootomari | 69·2 | | | +2 | 0 |
| Harvard | 70·7 | +43 | +42† | +44 | +42† |
| Hukuoka | 71·0 | | | −36 | −38 |
| Ottawa | 71·0 | +1 | 0 | +7 +12 | +5 +10 |
| Sumoto | 73·3 | | | −26 | −29 |
| Osaka | 73·4 | −29 | −30 | −42 | −45 |
| Ithaca | 73·5 | 0 | −1 | +3 | 0 |
| Toronto | 74·0 | −3 | −2 | +2 | −1 |
| Ann Arbor | 77·2 | −2 | −2 | +13 | +10 |
| Manila | 77·5 | +12 | +12 | 0 | −3 |
| Sitka | 78·2 | | | −45 | −48 |
| Chicago | 79·4 | +4 | +4 | −3 +12 | −6 +9 |
| Cape Town | 79·7 | | | −4 | −7 |
| Batavia | 82·1 | +17 | +17 | −5 | −8 |
| St. Louis | 83·1 | +18 | +19 | −8 +2 | |
| Victoria | 85·2 | +4 +10 | +5 +11 | +13 | +9 |
| Berkeley | 95·1 | +5 | +7 | | |
| Amboina | 95·4 | −35 | −33 | | |
| Tucson | 97·0 | +11 | +14 | | |

*Continued on next page.*

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Jena | 16·5 | | | | −1+5 | | |
| Grenoble | 20·2 | | | | −5+2 | | |
| Puy de Dôme | 22·1 | | | | −4 | | |
| Granada | 29·3 | | | | +22 | | |
| Zi-ka-wei | 66·8 | | | | +14 | | |
| Hong Kong | 67·5 | | | | −1 | | −3 |
| Ottawa | 71·0 | | | | | | +9 |
| St. Louis | 83·1 | | −12, 2 | | | | |
| Victoria | 85·2 | | +7 | | | | |
| Berkeley | 95·1 | | | | +6 | +32 | |
| Rio de Janeiro | 97·5 | | +3 | | +2 | | |
| La Paz | 110·3 | −30 | −2 | | −3 | +15 | −42 |
| Honolulu T.H. | 113·3 | | | | | | +10 |
| Pilar | 117·0 | | | | −9 | | |
| Adelaide | 123·1 | | −7 | | | +14 | |
| Riverview | 131·1 | | | | −25 | | +33 |

1928 Mar. 31d. 0h. 29m. 42s. +10s. =29m.52s. Z=0.

I.S.S. Epicentre 38°·5N. 28°·0E. First Revised Epicentre 38°·3N. 27°·9E.
Final Epicentre 38°·1N. 27°·7E.

A = +·6967, B = +·3658, C = +·6170.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Ksara | 7·86 | +1 | +1 | +7 | +7 |
| Yalta | 8·02 | +2 | +2 | −2 | −2 |
| Belgrade | 8·63 | +57 | +57* | +82 | +82 |
| Helwan | 8·79 | −3 | −3 | −4 | −4 |
| Theodosia | 8·98 | +3 | +3 | +3 | +3 |
| Mostar | 9·13 | +22 | +22† | +32 | +32† |
| Pompeii | 10·58 | 0 | 0 | +31 | +31 |
| Naples | 10·8 | −2 | −2 | −3 | −3 |
| Budapest | 11·1 | +1 | +1 | | |
| Zagreb | 11·67 | −1 | −1 | | |
| Lemberg | 12·07 | −11 −5 | −11 −5 | +3 +21 | +3 +21 |
| Rocca di Papa | 12·1 | −1 | −1 | +4 | +4 |
| Makeyevka | 12·48 | +7 | +7 | +28 | +28 |
| Laibach | 12·5 | +2 | +2 | −1 | −1 |
| Graz | 12·7 | +11 | +11† | +16 | +16† |
| Vienna | 13·0 | −3 | −3 | −6 | −6 |
| Venice | 13·6 | 0 | 0 | | |
| Florence | 13·7 | −1 | −1 | −3 | −4 |
| Innsbruck | 15·0 | −8 | −8 | −12 | −13 |
| Chur | 15·9 | +3 | +2 | +17 | +16 |
| Ravensburg | 16·3 | +7 | +6 | +16 | +15 |
| Moncalieri | 16·4 | +1 | 0 | −1 +64 | −3 +62 |
| Zürich | 16·7 | 0 | −1 | +12 | +10 |
| Hohenheim | 17·0 | +5 | +4 | +7 | +5 |
| Jena | 17·1 | +4 | +3 | +13 | +11 |
| Baku | 17·30 | +8 | +7 | +25 | +23 |
| Königsberg | 17·5 | −3 | −4 | −3 | −5 |
| Potsdam | 17·56 | +3 | +2 | +12 | +10 |
| Neuchâtel | 17·6 | 0 | −1 | −5 | −7 |
| Marseilles | 17·7 | +29 | +28 | +46 | +44 |
| Strasbourg | 17·8 | −1 | −2 | +6 | +4 |
| Grenoble | 17·9 | −8 | −9 | −6 | −8 |
| Feldberg | 18·2 | +2 | +1 | +11 | +9 |
| Besançon | 18·3 | 0 | −1 | +6 | +4 |
| Kucino | 19·0 | −9 | −10 | 0 | −2 |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Algiers | 19·58 | −2 | −3 | +2 | 0 |
| Hamburg | 19·68 | −1 | −2 | +2 | 0 |
| Puy de Dôme | 19·9 | +1 | +1 | +15 | +14 |
| Barcelona | 20·0 | −5 | −5 | −3 | −3 |
| Lund | 20·1 | −1 | −1 | +1 | +1 |
| Copenhagen | 20·33 | −1 | −1 | +2 | −1(d) |
| Uccle | 20·8 | −1 | −1 | +4 | 0(d) |
| De Bilt | 21·0 | +2 | +2 | +7 | +3(d) |
| Paris | 21·0 | +2 | +2 | +8 | +4(d) |
| Tortosa | 21·2 | −5 | −5 | +2 | −2(d) |
| Bagnères | 21·4 | +1 | +1 | +1 | −3(d) |
| Pulkovo | 21·73 | −3 | −2 | −4 | −2 |
| Helsingfors | 22·1 | +3 | +4 | +8 | +3(d) |
| Alicante | 22·1 | −23 | −22† | −20 | −25† |
| Upsala | 22·8 | −1 | +1 | −4 | −1 |
| Kew | 23·7 | 0 | +2 | +1 | +5 |
| Almeria | 23·89 | −2 | +1 | −4 | 0 |
| Oxford | 24·4 | −1 | +2 | −5 | 0 |
| Toledo | 24·7 | −5 | −2 | −5 | 0 |
| Granada | 24·8 | −2 | +1 | −5 | 0 |
| Malaga | 25·4 | −2 | +1 | +2 | +8 |
| Bidston | 26·0 | | | −13 | −6 |
| Bergen | 26·4 | −29 | −25 | −4 | +3 |
| San Fernando | 26·9 | −4 | 0 | −6 | +1 |
| Edinburgh | 27·1 | −1 | +4 | +15 | +2(d) |
| Dyce | 27·4 | | | +14 | 0(d) |
| Ekaterinburg | 28·6 | −3 | +2 | −5 | +3 |
| Tashkent | 31·8 | −3 | +3 | −12 | −3 |
| Entebbe | 38·2 | −9 | −5 | −18 | −11 |
| Scoresby Sund | 41·3 | 0 | +4 | −3 | +3 |
| Bombay | 43·4 | −2 | +2 | +3 | +8 |
| Irkutsk | 53·17 | +1 | +3 | +9 | +11 |
| Tananarive | 59·9 | | | +5 | +5 |
| Phu-Lien | 68·9 | +1 | 0 | +2 | 0 |
| Ottawa | 71·9 | | | +1 | −1 |
| Zi-ka-wei | 74·0 | +1 | 0 | | |
| Ithaca | 74·1 | | | +1 | −2 |
| Toronto | 75·0 | | | +2 | −1 |
| Georgetown | 76·6 | +6 | +6 | +8 | +5 |
| Chicago | 80·7 | | | +4 +13 | 0 +9 |
| Cincinnati | 80·8 | | | +1 | −3 |
| St. Louis | 84·4 | +2 | +3 | 0 | −4 |
| Victoria | 89·8 | | | +8 | +4 |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Jena | 17·1 | | | | +2 | | |
| Königsberg | 17·5 | | | | +9, 16 | | |
| Feldberg | 18·2 | | | | +6 | | |
| Barcelona | 20·0 | | | | | | +10 |
| Kew | 23·7 | | | | | | +32 |
| Oxford | 24·4 | | | | −5 | | |
| Dyce | 27·4 | | | | +7 | | |
| Scoresby Sund | 41·3 | | | | +7 | | +14 |
| Georgetown | 76·6 | | | | −5 | | |
| St. Louis | 84·4 | | +1 | | | | +13 |
| Sucre | 103·9 | | | | −18 | | |

1928 April 14d. 8h. 59m. 43s., +18s. =9h.0m.1s. Z taken =0.

I.S.S. Epicentre 41°·7N. 26°·3E. Revised Epicentre 42°·2N. 25°·7E.

A = + ·6674, B = + ·3213, C = + ·6717.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Belgrade | 4·6 | −7 | −7 | +9 | +9 |
| Sarajevo | 5·6 | −4 | −4 | −47 | −47 |
| Yalta | 6·4 | 0 | 0 | +6 | +6 |
| Budapest | 7·0 | +7 | +7 | | |
| Sebenico | 7·3 | +7 | +7 | +18 | +18 |
| Theodosia | 7·4 | +4 | +4 | +9 | +9 |
| Lemberg | 7·7 | +10 | +10 | +19 | +19 |
| Zagreb | 7·8 | +1 | +1 | −34 | −34 |
| Pompeii | 8·4 | +6 | +6 | +6 | +6 |
| Naples | 8·6 | +8 | +8 | −17 | −17 |
| Graz | 8·7 | −2 | −2 | +12 | +12 |
| Vienna | 8·9 | −2 | −2 | −12 | −12 |
| Laibach | 9·0 | +1 | +1 | +32 | +32 |
| Rocca di Papa | 9·7 | 0 | 0 | −36 | −36 |
| Florence | 10·6 | +5 | +5 | +18 | +18 |
| Innsbruck | 11·4 | −7 | −7 | +17 | +17 |
| Ksara | 11·5 | +3 | +3 | +48 | +48 |
| Chur | 12·3 | +3 | +3 | +82 | +82 |
| Ravensburg | 12·6 | +2 | +2 | −54 | −54 |
| Jena | 12·8 | 0 | 0 | +5 | +4 |
| Helwan | 13·1 | +1 | +1 | +25 | +24 |
| Königsberg | 13·1 | 0 | 0 | +8 | +7 |
| Zürich | 13·2 | 0 | 0 | +11 | +10 |
| Potsdam | 13·2 | +2 | +2 | +8 | +7 |
| Hohenheim | 13·3 | 0 | 0 | −37 | −38 |
| Moncalieri | 13·3 | −2 | −2 | +33 | +32 |
| Neuchâtel | 14·2 | −1 | −1 | +15 | +14 |
| Strasbourg | 14·2 | −3 | −3 | +15 | +14 |
| Grenoble | 14·7 | +4 | +4 | +16 | +15 |
| Besançon | 14·9 | −1 | −1 | +13 | +12 |
| Marseilles | 15·0 | +3 | +2 | +28 | +27 |
| Hamburg | 15·4 | +2 | +1 | +19 | +18 |
| Kucino | 15·7 | −7 | −8 | +8 | +7 |
| Lund | 15·9 | −3 | −4 | | |
| Copenhagen | 16·1 | −2 | −3 | −1 | −3 |
| Puy de Dôme | 16·7 | −4 | −5 | +8 | +6 |
| Uccle | 17·0 | +1 | 0 | +11 | +9 |
| De Bilt | 17·1 | +1 | 0 | +14 | +12 |
| Barcelona | 17·5 | +1 | 0 | +16 | +14 |
| Paris | 17·5 | +1 | 0 | +8 | +6 |
| Pulkovo | 17·7 | +1 | 0 | +3 | +1 |
| Helsingfors | 18·0 | −1 | −2 | +25 | +23 |
| Baku | 18·2 | +6 | +5 | +17 | +15 |
| Algiers | 18·2 | +2 | +1 | +3 | +1 |
| Upsala | 18·3 | 0 | −1 | +3 | +1 |
| Bagnères | 18·7 | +2 | +1 | +2 | −1 |
| Tortosa | 18·8 | +3 | +2 | +9 | +7 |
| Kew | 19·9 | +3 | +3 | +15 | +14 |
| Alicante | 20·2 | +5 | +5 | +14 | +14 |
| Oxford | 20·7 | −1 | −1 | +7 | +3(d) |
| Stonyhurst | 21·9 | −10 | −9 | +8 | +3(d) |
| Almeria | 22·1 | +8 | +9 | +16 | +11(d) |
| Bergen | 22·1 | +8 | +9 | | |
| Bidston | 22·2 | +3 | +4 | +5 | 0(d) |
| Toledo | 22·4 | 0 | +1 | +9 | +3(d) |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Edinburgh | 22·7 | +6 | +8 | +15 | +9(d) |
| Granada | 22·9 | +2 | +4 | +10 | +3(d) |
| Malaga | 23·8 | −3 | 0 | +8 | 0(d) |
| San Fernando | 25·1 | −5 | −2 | −29 | −24 |
| Ekaterinburg | 26·5 | −1 | +3 | −10 | −3 |
| Tashkent | 32·1 | −1 | +5 | +27 | +36 |
| Reykjavik | 34·8 | | | +4 | +12 |
| Scoresby Sund | 36·8 | 0 | +5 | +9 | +17 |
| Entebbe | 42·4 | +3 | +6 | −24 | −18 |
| Bombay | 45·9 | +2 | +5 | +5 | +9 |
| Irkutsk | 51·6 | +1 | +3 | 0 | +2 |
| Calcutta | 54·9 | −16 | −15 | | |
| Kodaikanal | 55·2 | | | +10 | +11 |
| Colombo | 59·2 | 0 | 0 | −7 | −7 |
| Tananarive | 64·3 | +3 | +2 | −1 +5 | −2 +4 |
| Harvard | 67·1 | +21 | +20† | +14 | +13† |
| Ottawa | 68·1 | +1 | 0 | +6 | +4 |
| Johannesburg | 68·2 | | | +1 | −1 |
| Phu-Lien | 69·5 | +3 | +2 | +7 | +5 |
| Ithaca | 70·2 | +3 | +2 | +9 | +7 |
| Toronto | 71·2 | +1 | 0 | +1 | −1 |
| Georgetown | 72·8 | −6 | −7 | −39 | −42 |
| Zi-ka-wei | 73·5 | +2 | +1 | +13 | +10 |
| Hong Kong | 74·0 | +5 | +4 | | |
| Charlottesville | 74·6 | +1 | 0 | +34 | +31 |
| Ootomari | 74·9 | | | +8 | +5 |
| Cape Town | 75·1 | | | −34 | −37 |
| Chicago | 76·7 | +1 | +1 | +4 | +1 |
| Cincinnati | 76·9 | +2 | +2 | −25 | −28 |
| Hukuoka | 77·6 | | | −6 | −9 |
| Toyooka | 78·8 | +5 | +5 | +18 | +15 |
| Sumoto | 79·4 | −66 | −66* | | |
| Osaka | 79·8 | +14 | +14 | +36 | +33 |
| St. Louis | 80·4 | +2 | +2 | +5 | +1 |
| Manila | 84·0 | +6 | +7 | | |
| Spokane | 84·5 | +1 | +2 | +7 | +3 |
| Victoria | 85·4 | +1 | +2 | +11 | +7 |
| Batavia | 87·6 | −9 | −8 | +11 | +7 |
| Tucson | 95·5 | 0 | +2 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Toledo | 22·4 | | | | +5 | | +25 |
| Scoresby Sund | 36·8 | | | | +4 | | |
| Tananarive | 64·3 | | | | +16 | +1 | |
| Chicago | 76·7 | | | | −21 | | |
| Cincinnati | 76·9 | | | | | +3 | |
| Osaka | 79·8 | | | | | +1 | |
| St. Louis | 80·4 | | | | | | +6, 12 |
| Manila | 84·0 | | −1 | | | +8 | |
| Spokane | 84·5 | | | | +19 | | |
| Victoria | 85·4 | | +5 | | | | |
| Batavia | 87·6 | | +4 | | | −16 | |
| Rio de Janeiro | 90·8 | | −7+1 | | | | +9 |
| Lick | 95·0 | | | | −12 | | |
| Tucson | 95·5 | | −7 | | −10 | | |
| Sucre | 103·2 | | | | +9 | | |
| La Paz | 103·9 | | | | +5 | | |
| Adelaide | 128·4 | | | | −27 | | +14 |

Also 134°·3 (Melbourne) PKS−12.

1928 April 18d. 19h. 22m. 37s. +19s. =22m.56s. Z = +1.

I.S.S. Epicentre 41°·7N. 26°·3E., revised later to 41°·8N. 25°·0E.
First Revised Epicentre 42°·4N. 24°·9E. Final Epicentre 42°·2N. 25°·2E.

A = +·6704, B = +·3154, C = +·6717.

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Belgrade | 4·3 | −1 | −1 | +15 | +15 |
| Sarajevo | 5·2 | +13 | +13 | −23 | −23 |
| Budapest | 6·8 | +4 | +4 | | |
| Sebenico | 6·9 | +2 | +2 | +31 | +31 |
| Yalta | 7·0 | −2 | −2 | −1 | −1 |
| Zagreb | 7·5 | 0 | 0 | −1 | −1 |
| Lemberg | 7·7 | −3 | −3 | | |
| Theodosia | 7·9 | +1 | +1 | +3 | +3 |
| Pompeii | 8·2 | +7 | +7 | +8 | +8 |
| Naples | 8·4 | −1 | −1 | −21 | −21 |
| Graz | 8·4 | −2 | −2 | +15 | +15 |
| Laibach | 8·5 | 0 | 0 | | |
| Vienna | 8·6 | −3 | −3 | | |
| Rocca di Papa | 9·3 | −2 | −2 | | |
| Venice | 9·8 | +2 | +2 | | |
| Florence | 10·3 | 0 | 0 | +18 | +18 |
| Makeyevka | 10·8 | −3 | −3 | +4 | +4 |
| Innsbruck | 10·9 | −2 | −2 | +15 | +15 |
| Ksara | 12·0 | 0 | 0 | +37 | +37 |
| Chur | 12·0 | 0 | 0 | | |
| Ravensburg | 12·2 | +4 | +4 | −32 | −32 |
| Jena | 12·7 | −4 +2 | −4 +2 | −8 −4 | −8 −4 |
| Zürich | 12·8 | 0 | 0 | +8 | +8 |
| Hohenheim | 12·8 | +5 | +5 | −19 | −19 |
| Moncalieri | 12·9 | −1 | −1 | | |
| Königsberg | 13·0 | −2 | −2 | | |
| Potsdam | 13·0 | +2 | +2 | | |
| Helwan | 13·4 | −3 | −3 | +5 | +4 |
| Neuchâtel | 13·7 | −1 | −1 | +8 | +7 |
| Strasbourg | 13·7 | −1 | −1 | +12 | +11 |
| Feldberg | 14·0 | 0 | 0 | +12 | +11 |
| Grenoble | 14·3 | −14 | −14 | −6 | −7 |
| Besançon | 14·4 | −1 | −1 | +9 | +8 |
| Marseilles | 14·5 | +6 | +6 | +10 | +9 |
| Hamburg | 15·1 | +1 | 0 | +14 | +13 |
| Lund | 15·5 | −1 | −2 | 0 | −1 |
| Copenhagen | 15·8 | −3 | −4 | +1 | 0 |
| Kucino | 15·9 | −2 | −3 | +22 | +21 |
| Puy de Dôme | 16·3 | −6 | −7 | +10 | +8 |
| Uccle | 16·5 | +5 | +4 | | |
| De Bilt | 16·6 | +4 | +3 | +14 | +12 |
| Paris | 17·0 | +2 | +1 | +13 | +11 |
| Barcelona | 17·1 | 0 | −1 | +15 | +13 |
| Pulkovo | 17·9 | −4 | −5 | −10 | −12 |
| Algiers | 17·9 | +1 | 0 | +4 | +2 |
| Helsingfors | 18·0 | −14 | −15 | −3 | −5 |
| Upsala | 18·2 | −2 | −3 | +1 | −1 |
| Bagnères | 18·2 | +3 | +2 | +12 | +10 |
| Tortosa | 18·4 | 0 | −1 | +9 | +7 |
| Baku | 18·6 | +5 | +4 | | |
| Kew | 19·5 | +2 | +1 | +9 | +8 |
| Alicante | 19·9 | +4 | +4 | +7 | +6 |
| Oxford | 20·2 | +3 | +3 | +4 | +1(d) |
| Stonyhurst | 21·5 | 0 | +1 | +4 | 0(d) |
| Bidston | 21·7 | +3 | +4 | +6 | +1(d) |
| Bergen | 21·8 | −21 | −20† | −16 | −21(d)† |
| Almeria | 21·9 | +7 | +8 | +10 | +5(d) |
| Toledo | 22·0 | −1 | 0 | +5 | 0(d) |
| Edinburgh | 22·7 | +1 | +2 | +4 | −2(d) |
| Malaga | 23·4 | −4 | −2 | +6 | −1(d) |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| San Fernando | 24·8 | −8 | −5 | −11 | −6 |
| Ekaterinburg | 26·8 | −1 | +3 | −7 | 0 |
| Tashkent | 32·6 | −72 | −66* | −68 | −59* |
| Scoresby Sund | 36·7 | −1 | +4 | +1 | +9 |
| Entebbe | 42·7 | −9 | −5 | −14 | −9 |
| Bombay | 46·4 | +9 | +12 | +21 | +25 |
| Hyderabad | 51·4 | 0 | +2 | −2 | 0 |
| Irkutsk | 52·0 | −1 | +1 | −7 | −5 |
| Calcutta | 55·6 | −4 | −3 | +8 | +9 |
| Tananarive | 64·8 | −1 | −2 | 0 | −1 |
| Harvard | 66·8 | | | +14 | +13 |
| Ottawa | 67·6 | +1 | 0 | +4 | +2 |
| Ithaca | 69·9 | +5 | +4 | +8 | +6 |
| Phu-Lien | 70·1 | +4 | +3 | +1 | −1 |
| Toronto | 70·7 | +3 | +2 | 0 | −2 |
| Georgetown | 72·5 | +4 | +3 | | |
| Zi-ka-wei | 73·8 | +6 | +5 | +12 | +9 |
| Charlottesville | 73·9 | +6 | +5 | +4 | +1 |
| Hong Kong | 74·6 | +3 | +2 | +10 | +7 |
| Ootomari | 75·3 | +6 | +6 | +2 | −1 |
| Cape Town | 76·4 | +11 | +11 | −7 | −10 |
| Chicago | 76·4 | +6 | +6 | +4 | +1 |
| Cincinnati | 76·6 | +1 | +1 | +8 | +5 |
| Hukuoka | 78·0 | +1 | +1 | | |
| Nagasaki | 78·2 | +12 | +12 | +8 | +5 |
| Toyooka | 79·2 | +9 | +9 | +13 | +10 |
| Kobe | 80·0 | +7 | +7 | | |
| Sumoto | 80·1 | +1 | +1 | | |
| Mizusawa | 80·1 | +5 | +5 | +10 | +6 |
| St. Louis | 80·1 | +1 | +1 | +2 | −2 |
| Osaka | 80·3 | +13 | +13 | +9 | +5 |
| Spokane | 84·2 | +5 | +6 | +4 | 0 |
| Manila | 84·5 | +5 | +6 | | |
| Victoria | 85·2 | +3 | +4 | | |
| Batavia | 88·1 | −5 | −4 | +2 | −2 |
| Malabar | 89·3 | +5 | +6 | −1 | −5 |
| Rio de Janeiro | 90·6 | −3 | −1 | +1 | −3 |
| Berkeley | 94·3 | +4 | +6 | +7 | +2 |
| Lick | 94·8 | +7 | +9 | +3 | −2 |
| Tucson | 95·2 | +9 | +11 | +7 | +2 |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Scoresby Sund | 36·7 | | | | +4 | | −9 |
| Ottawa | 67·6 | | | | | | +23 |
| Georgetown | 72·5 | | | | +4 | +29 | |
| Charlottesville | 73·9 | | | | | | +7 |
| Cincinnati | 76·6 | | | | | +6 | +19 |
| St. Louis | 80·1 | | | | | −11, 6 | +17 |
| Spokane | 84·2 | | +2 | | +6 | | |
| Victoria | 85·2 | | +3 | | | | |
| Denver | 86·4 | | −4 | | | | −54 |
| Batavia | 88·1 | | +5 | | | +2 | |
| Tucson | 95·2 | | −3 | | +9 | +15 | +19 |
| Sucre | 102·9 | | | | | | −2 |
| Perth | 111·3 | | | | | | +16 |
| Honolulu T.H. | 116·0 | | | | | +13 | +14 |
| Adelaide | 128·8 | | | | | | −4 |
| Riverview | 137·4 | | | | | | +57 |

Also 137°·4 (Riverview) PKS−1.

Note.—The epicentre is only 0°·5 from the last, but direct comparison of the residuals shows that the difference is real.

1928 May 2d. 21h. 54m. 21s. +14s. =54m. 35s. Z =0.

I.S.S. Epicentre 39°·7N. 29°·3E. Revised Epicentre 39°·60N., 29°·1E.

A = + ·6733, B = + ·3747, C = + ·6374.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Yalta | 6·18 | −5 | −5 | −1 | −1 |
| Theodosia | 7·14 | −1 | −1 | +5 | +5 |
| Ksara | 7·92 | +1 | +1 | +14 | +14 |
| Belgrade | 8·24 | −5 | −5 | +17 +22 | +17 +22 |
| Mostar | 9·24 | +62 | +62* | | |
| Helwan | 9·92 | −3 | −3 | −6 | −6 |
| Makeyevka | 10·55 | 0 | 0 | +9 | +9 |
| Budapest | 10·73 | +10 | +10 | +10 | +10 |
| Lemberg | 10·87 | −8 −2 | −8 −2 | | |
| Pompeii | 11·2 | −1 | −1 | +4 | +4 |
| Zagreb | 11·4 | 0 | 0 | +2 | +2 |
| Naples | 11·5 | 0 | 0 | +10 | +10 |
| Graz | 12·3 | +2 | +2 | −44 | −44 |
| Vienna | 12·6 | −12 | −12 | +6 | +6 |
| Rocca di Papa | 12·7 | −3 | −3 | +25 | +25 |
| Venice | 13·6 | +3 | +3 | +9 | +8 |
| Florence | 14·0 | −1 | −1 | | |
| Innsbruck | 14·9 | +4 | +4 | +50 | +49 |
| Baku | 15·8 | +7 | +6 | +33 | +32 |
| Chur | 15·9 | 0 | −1 | +14 | +13 |
| Ravensburg | 16·2 | +2 | +1 | +15 | +13 |
| Königsburg | 16·3 | 0 | −1 | +3 | +1 |
| Moncalieri | 16·7 | −1 | −2 | +11 | +9 |
| Zürich | 16·7 | +6 | +5 | +12 | +10 |
| Jena | 16·8 | +58 | +57* | +2 +6 | 0 +4 |
| Hohenheim | 16·8 | −1 | −2 | +7 | +5 |
| Potsdam | 16·9 | 0 | −1 | −6,0 | −8 −2 |
| Kucino | 17·1 | −11 | −12 | −1 | −3 |
| Strasbourg | 17·7 | −2 | −3 | +9 | +7 |
| Feldberg | 18·0 | −2 | −3 | +1 +8 | −1 +6 |
| Grenoble | 18·1 | +5 | +4 | +12 | +10 |
| Besançon | 18·3 | +1 | 0 | +13 | +11 |
| Hamburg | 19·2 | 0 | −1 | −1 | −3 |
| Lund | 19·2 | +1 | 0 | −1 | −3 |
| Copenhagen | 19·5 | +1 | 0 | 0 | −1 |
| Pulkovo | 20·2 | −3 | −3 | +3 | −1(d) |
| Barcelona | 20·5 | +3 | +3 | +3 | −1(d) |
| Uccle | 20·5 | −1 | −1 | +7 | +3(d) |
| Helsingfors | 20·7 | +2 | +2 | +7 | +3(d) |
| Algiers | 20·7 | −4 | −4 | +7 | +3(d) |
| De Bilt | 20·8 | −3 | −3 | +5 | +1(d) |
| Paris | 21·0 | 0 | 0 | +4 | 0(d) |
| Upsala | 21·6 | −3 | −2 | −4 | −2 |
| Bagnères | 21·8 | +35 | +36 | +10 | +5(d) |
| Tortosa | 21·8 | −1 +3 | 0 +4 | +6 | +1(d) |
| Alicante | 23·0 | +2 | +4 | +7 | 0(d) |
| Kew | 23·5 | −3 | −1 | −2 +10 | +2, +3(d) |
| Oxford | 24·2 | −6 | −3 | −5 | −1 |
| Almeria | 24·8 | −4 | −1 | −18 | −13 |
| Toledo | 25·4 | −5 | −1 | −7 | −1 |
| Bergen | 25·6 | −1 | +3 | +27 | +33 |
| Stonyhurst | 25·6 | +12 | +16 | +2 | +8 |
| Granada | 25·7 | −4 | 0 | −3 | +3 |
| Bidston | 25·8 | −3 | +1 | −11 | −5 |
| Malaga | 26·4 | −28 | −24† | −35 | −28† |
| Ekaterinburg | 26·7 | −2 | +2 | −2 | +5 |
| Edinburgh | 26·8 | −4 | 0 | +9 | −2(d) |
| San Fernando | 27·9 | −16 | −11 | −33 | −25 |
| Scoresby Sund | 40·4 | −3 | +1 | −1 | +5 |
| Bombay | 42·8 | −2 | +2 | −1 | +4 |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Hyderabad | 47·9 | +1 | +4 | +4 | +7 |
| Irkutsk | 51·3 | +1 | +3 | +4 | +6 |
| Kodaikanal | 51·9 | | | +20 | +22 |
| Phu-Lien | 67·5 | −2 | −3 | −1 | −2 |
| Ottawa | 71·7 | | | +1 | −1 |
| Zi-ka-wei | 72·3 | +1 | 0 | +9 | +7 |
| Toronto | 74·8 | | | +1 | −2 |
| Georgetown | 76·5 | +1 | +1 | +4 | +1 |
| St. Louis | 84·0 | −7 | −6 | | |
| Victoria | 88·8 | | | +3 | −1 |

Other readings

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Scoresby Sund | 40·4 | | | | +8 | | |
| Toronto | 74·8 | | | | | | −22 |
| St. Louis | 84·0 | | +2 | | | +23 | +5 |
| La Paz | 106·0 | | | | +32 | | |

1928 Oct. 15d. 14h. 19m. 32s. +14s. =19m. 46s. Z = +1.

I.S.S. Epicentre 28°·5N. 66°·3E. Revised Epicentre 28°·6N. 67°·2E.

A = + ·3402, B = + ·8094, C = + ·4787.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Dehra Dun | 9·6 | −15 | −15 | −58 | −58* |
| Bombay | 10·86 | −5 | −5 | +52 | +52* |
| Tashkent | 12·82 | −1 | −1 | | |
| Hyderabad | 15·22 | 0 | −1 | −7 | −8 |
| Frunse | 15·6 | −2 | −3 | −2 | −3 |
| Almata | 16·7 | −35 | −36 | | |
| Baku | 18·45 | +2 | +1 | +4 | +2 |
| Calcutta | 20·05 | 0 | 0 | −11 +12 | −11 +12 |
| Kodaikanal | 20·73 | +25 | +25 | | |
| Colombo | 24·8 | −6 | −3 | +11 | +2(d) |
| Ksara | 27·20 | −1 | +4 | −1 | +6 |
| Ekaterinburg | 28·62 | −4 | +1 | −12 | −4 |
| Theodosia | 29·99 | −7 | −1 | +72 | +80 |
| Yalta | 30·64 | −3 | +3 | | |
| Simferopol | 30·81 | −5 | +1 | | |
| Sebastopol | 31·1 | −10 | −4 | | |
| Helwan | 31·22 | −5 | +1 | −3 | +6 |
| Kucino | 34·23 | −5 | 0 | −15 | −6 |
| Irkutsk | 36·20 | −4 | +1 | −4 | +4 |
| Phu-Lien | 36·50 | −3 | +2 | −8 | 0 |
| Lemberg | 38·8 | +12 | +16 | | |
| Pulkovo | 39·90 | −3 | +1 | −5 | +2 |
| Belgrade | 40·18 | −14 | −10 | −3 | +3 |
| Budapest | 41·5 | 0 | +4 | +3 | +9 |
| Königsberg | 42·4 | −4 | 0 | −5 | +1 |
| Helsingfors | 42·4 | −3 | +1 | +2 | +8 |
| Hong Kong | 42·7 | | | −9 | −3 |
| Vienna | 43·4 | −5 | −1 | −3 | +2 |
| Zagreb | 43·5 | −3 | +1 | −8 | −3 |
| Entebbe | 43·77 | −3 | +1 | −4 | +1 |
| Graz | 43·8 | +9 | +13 | | |
| Pompeii | 44·3 | +3 | +6 | −32 | −27 |
| Naples | 44·5 | +2 | +5 | −7 | −2 |
| Upsala | 45·6 | −11 | −8 | −5 | −1 |
| Rocca di Papa | 45·7 | −5 | −2 | −3 | +1 |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Venice | 45·9 | −1 | +1 | | |
| Potsdam | 46·1 | −2 | +1 | +5 | +9 |
| Innsbruck | 46·6 | −9 | −6 | −34 | −30 |
| Zi-ka-wei | 46·6 | −2 | +1 | −1 +5 | +3 +9 |
| Florence | 46·7 | −15 | −12† | −20 | −16† |
| Jena | 46·7 | 0 | +3 | +1 | +5 |
| Lund | 46·7 | −3 | 0 | −1 | +3 |
| Copenhagen | 47·1 | −4 | −1 | −3 | +1 |
| Chur | 47·9 | −9 | −6 | −3 | 0 |
| Ravensburg | 47·9 | −2 | +1 | −42 | −39 |
| Hamburg | 48·1 | −3 | 0 | −3 | 0 |
| Hohenheim | 48·2 | −4 | −1 | −46 | −43 |
| Zürich | 48·7 | −4 | −1 | −7 | −4 |
| Feldberg | 48·7 | +1 | +4 | +8 | +11 |
| Moncalieri | 49·2 | −6 | −3 | −59 | −56* |
| Strasbourg | 49·2 | −4 | −1 | −3 | 0 |
| Besançon | 50·3 | −3 | −1 | −9 | −6 |
| De Bilt | 50·9 | 0 | +2 | +3 | +5 |
| Tananarive | 51·17 | −7 | −5 | −10 −5 | −8 −3 |
| Uccle | 51·3 | −1 | +1 | +5 | +7 |
| Bergen | 51·6 | +2 | +4 | +11 | +13 |
| Manila | 51·5 | +18 | +20 | +6 | +8 |
| Batavia | 51·6 | −12 | −10 | | |
| Paris | 52·6 | 0 | +2 | −1 | +1 |
| Nagasaki | 53·3 | | | +6 | +8 |
| Barcelona | 53·5 | −3 | −1 | −1 | +1 |
| Algiers | 53·7 | −4 | −3 | −5 | −3 |
| Kew | 54·2 | 0 | +1 | +3 | +5 |
| Tortosa | 54·8 | −3 | −2 | +2 | +3 |
| Dyce | 55·2 | +14 | +15 | +6 | +7 |
| Stonyhurst | 55·4 | +2 | +3 | +3 | +4 |
| Bidston | 55·8 | +2 | +3 | +5 | +6 |
| Edinburgh | 55·8 | +7 | +8 | +2 | +3 |
| Alicante | 56·1 | +2 | +3 | +3 | +4 |
| Sumoto | 57·0 | 0 | 0 | +7 | +8 |
| Kobe | 57·1 | +2 | +2 | +6 | +7 |
| Osaka | 57·4 | +2 | +2 | +10 | +11 |
| Almeria | 57·9 | −2 | −2 | −1 | 0 |
| Toledo | 58·4 | −1 | −1 | +3 | +3 |
| Nagoya | 58·4 | −22 | −22 | +4 | +4 |
| Granada | 58·8 | −3 | −3 | +1 | +1 |
| Malaga | 59·5 | −22 | −22 | −3 | −3 |
| Ootomari | 60·2 | | | −5 | −5 |
| Mizusawa | 60·6 | +4 | +3 | +4 | +4 |
| San Fernando | 61·0 | 0 | −1 | +3 | +3 |
| Scoresby Sund | 62·91 | +3 | +2 | +15 | +15 |
| Perth | 76·1 | | | +25 | +22 |
| Ottawa | 98·6 | | | +4 | 0 |
| Toronto | 101·5 | | | 0 | −4 |
| Georgetown | 104·6 | −2 | +2 | | |
| Cincinnati | 107·4 | | −4 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Ksara | 27·20 | | | | −2 | | |
| Theodosia | 29·99 | | | | | | +1 |
| Belgrade | 40·18 | | | | −35 | | |
| Königsberg | 42·4 | | | | +6 | | +23 |
| Hong Kong | 42·7 | | | | | | +17 |
| Vienna | 43·4 | | | | −12 | | −59 |
| Zagreb | 43·5 | | | | +10 | | +24 |
| Upsala | 45·6 | | | | +1 | | +16 |
| Zi-ka-wei | 46·6 | | | | +12 | | +35 |
| Florence | 46·7 | | | | | | +41 |

*Continued on next page.*

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Jena | 46·7 | | | | | | +14 |
| Lund | 46·7 | | | | +8 | | −42+18 |
| Copenhagen | 47·1 | | | | +5 | | |
| Ravensburg | 47·9 | | | | −9+27 | | |
| Hamburg | 48·1 | | | | | | +17 |
| Hohenheim | 48·2 | | | | −14+18 | | −64 |
| Feldberg | 48·7 | | | | | | +38 |
| Strasbourg | 49·2 | | | | +3 | | |
| De Bilt | 50·9 | | | | | | +7 |
| Tananarive | 51·17 | | | | | | +7 |
| Uccle | 51·3 | | | | | | +16 |
| Bergen | 51·6 | | | | +20 | | |
| Kew | 54·2 | | | | | | +47 |
| Granada | 58·8 | | | | +1 | | |
| Ootomari | 60·2 | | | | | | +57 |
| Mizusawa | 60·6 | | | | | −8 | |
| Scoresby Sund | 62·91 | | | | −9 | | |
| Adelaide | 92·2 | | −7 | | | | |
| Melbourne | 98·3 | | −6 | | | +3 | −46 |
| Ottawa | 98·6 | | −4 | | | | +8 |
| Sydney | 101·0 | | −47 | | | | |
| Toronto | 101·5 | | −5 | | | | |
| Victoria | 102·8 | | 0 | | −26 | | |
| Ann Arbor | 104·2 | | −3 | | | +11 | +4 |
| Georgetown | 104·6 | | | | +4 | +11 | |
| Chicago | 105·9 | | −76 | | | | |
| Charlottesville | 106·0 | | −6 | | | | |
| Cincinnati | 107·4 | | | | +1 | +6 | |
| Florissant | 109·4 | | −4 | | 0 | +9 | |
| Rio de Janeiro | 117·8 | | | | | +20 | |
| Tucson | 119·2 | | | | −53* | −50* | |
| Sucre | 135·7 | +6 | | | | | 0 |
| La Paz | 137·2 | +2 | | | | | |

Also 135°·7, PKS−21 ; 137°·2, PKS−14.

# EPICENTRES IN NORTH AND CENTRAL AMERICA, WITH THE NORTH ATLANTIC.

1924 Mar. 4d. 10h. 7m. 36s. +17s. =7m.53s. Z=0.

I.S.S. Epicentre 9°·5N. 84°·0W. First Revised Epicentre 9°·8N. 84°·3W.
Final Epicentre 9°·9N. 83°·9W.

A = +·1047, B = −·9795, C = +·1719.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Balboa Heights | 4·4 | −16 −6 | −16 −6 | −4 | −4 |
| Port au Prince | 14·2 | 0 | 0 | +36 | +35 |
| Tacubaya | 17·6 | −7 | −8 | +6 | +4 |
| Porto Rico | 19·7 | +11 | +10† | +19 | +16(d)† |
| St. Louis | 29·3 | −2 +3 | +4 +9 | | |
| Cheltenham | 29·5 | +5 +16 | +11 +22 | −9 | −1 |
| Georgetown | 29·6 | −11 | −5 | −9 −1 | −1 +7 |
| Washington | 29·6 | −8 | −2 | −3 | +5 |
| La Paz | 30·7 | −1 | +5 | −1 | +8 |
| Chicago | 32·1 | +2 | +8 | −9 | 0 |
| Ann Arbor | 32·4 | −7 | −1 | −7 | +2 |
| Ithaca | 33·2 | −6 | 0 | −5 | +4 |
| Tucson | 33·5 | −9 | −3 | −10 | −1 |
| Toronto | 34·0 | −19 −9 | −13 −3 | −8 | 0 |
| Northfield | 35·6 | −2 | +3 | −3 | +5 |
| Ottawa | 36·2 | −6 | −1 | −8 | 0 |
| Halifax | 38·8 | −2 | +4 | +8 | +15 |
| Lick | 43·6 | −4 | 0 | −22 −18 | −17 −13 |
| Berkeley | 44·3 | −8 | −5 | −3 +3 +10 | +2 +8 +15 |
| Victoria | 50·7 | −6 −2 | −4,0 | +14 +29 | +17 +32 |
| La Plata | 51·1 | −4 | −2 | −4 +4 | −2 +6 |
| Rio de Janeiro | 51·6 | −4 | −2 | −3 | −1 |
| Honolulu | 71·6 | +27 | +26 | −1 +33 | −3 +31 |
| Lisbon | 72·0 | | | +6 | +4 |
| San Fernando | 74·4 | +1 | 0 | +9 | +6 |
| Granada | 76·4 | +2 | +2 | +7 | +4 |
| Eskdalemuir | 76·6 | −2 | −2 | | |
| Bidston | 76·6 | −79 | −79 | −4 | −7 |
| Edinburgh | 76·6 | +3 | +3 | −1 | −4 |
| Stonyhurst | 77·0 | | | +8 | +5 |
| West Bromwich | 77·3 | −6 | −6 | +4 | +1 |
| Oxford | 77·7 | −4 | −4 | +3 | 0 |
| Tortosa | 79·6 | 0 | 0 | +6 | +2 |
| Paris | 80·2 | +1 | +1 | +3 | −1 |
| Barcelona | 80·6 | +11 | +11 | +4 | 0 |
| Uccle | 81·3 | −3 | −3 | 0 | −4 |
| Algiers | 81·7 | 0 | 0 | +1 | −3 |
| De Bilt | 81·7 | 0 | 0 | +4 | 0 |
| Strasbourg | 83·7 | −5 | −4 | 0 | −4 |
| Moncalieri | 84·2 | −11 | −10† | −9 | −13 |
| Hamburg | 84·3 | −4 | −3 | −1 | −5 |
| Zürich | 84·4 | −4 | −3 | −1 | −5 |
| Innsbruck | 86·3 | +5 | +6 | +11 | +7 |
| Florence | 86·9 | +3 | +4 | | |
| Upsala | 87·1 | −6 | −5 | +5 | +1 |
| Venice | 87·3 | −7 | −6 | +3 | −1 |
| Rocca di Papa | 88·3 | +2 +19 | +3 +20 | +7 | +3 |
| Vienna | 89·4 | −1 | 0 | +7 | +3 |
| Pompeii | 89·9 | −34 | −33 | | |
| Belgrade | 93·0 | +59 | +61* | | |
| Pulkovo | 93·2 | −1 | +1 | +22 | +18 |
| Athens | 97·5 | −35 | −32† | | |
| Ekaterinburg | 107·2 | | +61* | | |

*Continued on next page.*

Other readings :

| | △ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| La Paz | 30·7 | | | | −14+10 | | +3 |
| Lick | 43·6 | | | | | | −28 |
| Rio de Janeiro | 51·6 | | | | | | +5 |
| Honolulu | 71·6 | | | | | | −38 |
| Bidston | 76·6 | | | | −14 | | |
| Edinburgh | 76·6 | | | | | | +30 |
| Stonyhurst | 77·0 | | | | | | +30 |
| Paris | 80·2 | | | | | | −21 |
| Uccle | 81·3 | | | | | | +14 |
| Strasbourg | 83·7 | | | | +7 | | +17 |
| Hamburg | 84·3 | | +3 | | | | +10 |
| Zürich | 84·4 | | +3 | | | | |
| Florence | 86·9 | | | | | −5 | |
| Vienna | 89·4 | | +1 | | | | +21 |
| Belgrade | 93·0 | | +4 | | | | |
| Pulkovo | 93·2 | | −1 | | −2 | | −29 |
| Athens | 97·5 | | −14 | | | | |
| Kucino | 98·7 | | | | | −21 | |
| Wellington | 104·9 | | −25 | | +26 | +25 | +32 |
| Cape Town | 105·8 | | −6 | | | | +12 |
| Helwan | 106·3 | −33 | −3 | | | +8 | |
| Ekaterinburg | 107·2 | | | +7 | +2 | +10 | |
| Baku | 114·0 | | +1 | | +46 | | |
| Riverview | 124·3 | | | | +50 | +15 | +30 |
| Zi-ka-wei | 132·4 | −8 | | | | | |
| Bombay | 143·2 | −5 | | | | | |
| Hong Kong | 143·3 | +57 | | | | | |
| Manila | 145·2 | −1 | | | | | |
| Calcutta | 146·7 | +10, 30 | | | | | |
| Hyderabad | 147·6 | −12 | | | | | |
| Perth | 151·3 | +71 | | | | | +10 |
| Batavia | 168·7 | +47 | | | | | +21 |

Also 133°·9 (Adelaide), PKS−9; 147°·6, SKSP+13.

Mean P residual (△ >70°), 0 ; S, 0 ; SKS, 0.

1924 May 1d. 19h. 54m. 15s. +14s. =54m. 29s. Z = −1.

I.S.S. Epicentre 14°·0N. 89°·0W. Revised epicentre 12°·7N. 88°·15W.

A = + ·0316, B = − ·9750, C = + ·2198.

| | △ | Pγ | Pω | Sγ | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Vera Cruz | 7·7 | | | +16 | +16 |
| Balboa Heights | 9·0 | +16 | +16 | | |
| Tacubaya | 12·6 | −14 | −14 | −8 | −9 |
| Port au Prince | 16·3 | +5 | +4 | +40 | +39 |
| Mobile | 18·0 | −44 | −45 | −30 | −32 |
| Mazatlan | 20·3 | −14 | −14 | −5 | −5 |
| Porto Rico | 22·7 | −2 | 0 | +12 | +6(d) |
| St. Louis | 26·0 | −2 | +2 | −4 | +2 |
| Cheltenham | 27·9 | −6 | −1 | −16 | −8 |
| Georgetown | 28·0 | −11 −7 | −6 −2 | −6 +4 | +2 +12 |
| Washington | 28·0 | +17 | +22† | +21 | +29† |
| Tucson | 28·6 | −9 | −4 | +47 | +55 |
| Chicago | 29·1 | −8 | −2 | −14 | −6 |
| Ann Arbor | 29·9 | −9 | −3 | −15 | −7 |
| Denver | 30·8 | −17 | −13 | | |
| Ithaca | 31·4 | −5 | +1 | +25 | +34 |
| Toronto | 31·9 | −7 | −1 | −11 | −2 |
| Northfield | 34·2 | −3 | +2 | −6 | +2 |
| Ottawa | 34·4 | −3 | +2 | −4 | +4 |
| La Paz | 35·3 | −7 −3 | −2 +2 | −2 | +6 |

*Continued on next page.*

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Halifax | 38·2 | 0 | +4 | 0 | +7 |
| Berkeley | 39·4 | −15 | −11 | −17 | −10 |
| Victoria | 46·1 | −7 | −4 | −7 | −3 |
| La Plata | 55·6 | −8 | −7 | −12 −4 | −11 −3 |
| Rio de Janeiro | 56·6 | −2 | −1 | 0 | +1 |
| Sitka | 57·0 | 0 | 0 | +8 | +9 |
| Honolulu | 66·7 | −51 | −52 | −83 | −84 |
| Lisbon | 73·6 | | | +2 | −1 |
| San Fernando | 76·1 | +5 | +5 | +11 | +8 |
| Edinburgh | 76·7 | +7 | +7 | +23 | +20 |
| Dyce | 77·2 | −3 | −3 | −3 | −6 |
| Stonyhurst | 77·2 | −2 | −2 | 0 | −3 |
| Toledo | 77·4 | −10 | −10† | −11 | −14† |
| Oxford | 78·1 | +1 | +1 | −5 | −8 |
| Granada | 78·1 | +1 | +1 | +5 | +2 |
| Tortosa | 80·7 | −1 | −1 | +2 +9 | −2 +5 |
| Paris | 80·9 | +1 | +1 | +7 | +3 |
| Uccle | 81·8 | −4 +1 | −4 +1 | −2 +7 | −6 +3 |
| Barcelona | 81·8 | 0 | 0 | +4 | 0 |
| De Bilt | 82·0 | +1 | +1 | +2 | −2 |
| Algiers | 83·4 | +1 | +2 | | |
| Besançon | 83·5 | +3 | +4 | | |
| Strasbourg | 84·4 | −3 +2 | −2 +3 | | |
| Hamburg | 84·5 | −2 | −1 | | |
| Moncalieri | 85·1 | +17 | +18 | +2 | −2 |
| Zürich | 85·2 | +2 | +3 | +1 | −3 |
| Upsala | 86·7 | −4 | −3 | | |
| Innsbruck | 87·0 | −1 | 0 | | |
| Florence | 87·9 | −3 | −2 | | |
| Rocca di Papa | 89·5 | +2 | +3 | | |
| Vienna | 89·9 | −2 +30 | −1 +31 | | |
| Königsberg | 90·0 | −1 | 0 | | |
| Pulkovo | 92·5 | −5 | −3 | | |
| Kucino | 98·1 | −3 | 0 | | |
| Ekaterinburg | 105·8 | −12 | −7 | | |
| Helwan | 107·9 | | +25 | | |
| Irkutsk | 114·1 | | −12 | | |
| Baku | 114·3 | | −4 | | |
| Melbourne | 126·7 | | −21 | | |

Other readings :

| | △ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| St. Louis | 26·0 | | | | | | +12 |
| Toronto | 31·9 | | | | | | +49 |
| Ottawa | 34·4 | | | | −14+4 | | |
| La Plata | 55·6 | | | | −4 | | −15−8 |
| Oxford | 78·1 | | | | +4 | | |
| Granada | 78·1 | | | | | −4 | |
| Paris | 80·9 | | | | | −26 | |
| Uccle | 81·8 | | | | 0 | | +2 |
| Barcelona | 81·8 | | −1 | | +19 | | +46 |
| De Bilt | 82·0 | | −2 | | | | +28 |
| Algiers | 83·4 | | 0 | | | | |
| Besançon | 83·5 | | −1 | | | | |
| Strasbourg | 84·4 | | −8 | | +9 | | +24 |
| Hamburg | 84·5 | | +1 | | | | |
| Upsala | 86·7 | | −3 | | +3 | | |
| Innsbruck | 87·0 | | 0 | | | | |
| Florence | 87·9 | | | | | −17 | |
| Rocca di Papa | 89·5 | | −2 | | | | |
| Vienna | 89·9 | | −2 | | | −21+42 | |
| Königsberg | 90·0 | | −5 | | +7+23 | | |

*Continued on next page.*

| | Δ | P′ | SKS | SKRS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Pulkovo | 92·5 | | −7 | | 0 | | −41 |
| Lemberg | 94·0 | | −8 | | +40 | | |
| Kucino | 98·1 | | −5 | | | | |
| Athens | 98·7 | | −5 | | +17 | | |
| Wellington | 103·6 | | −13 | | +17 | | |
| Ekaterinburg | 105·8 | −63 | −13 | | −5 | +5 | |
| Helwan | 107·9 | | −4 | | | | |
| Cape Town | 110·7 | | | | +8 | +23 | |
| Irkutsk | 114·1 | −66−46 | | −4 | | +6 | +8 |
| Baku | 114·3 | | −3+5 | +16 | +8 | +21 | +63 |
| Hong Kong | 138·7 | −4 | | | | | |
| Manila | 140·3 | −3 | | | | | |
| Bombay | 143·3 | −9 | | | | | |
| Perth | 150·8 | | | | +16 | | |
| Batavia | 163·9 | +24 | | | | | |

Also 143°·3, PKS−18.

Mean SKS residual −3.

Note.—The P, S, and PP residuals at Uccle, as obtained from the I.S.S., were unusually large and negative, and Prof. Somville was consulted about the possibility of a clock error. He has very kindly read the reccords again, and his readings are given above. The movement at P−4 may be the true P: in that event the larger one at P+1 and those read at most of the other stations are sP, as for shocks without primitive P movement. It is possible that the second and larger S movement is the true S, and the earlier one a P wave generated when S entered the upper layers.

1925 Mar. 1d. 2h. 19m. 12s., +9s. =19m.21s. Z = −1.

I.S.S. Epicentre 48°·2N. 70°·8W. Retained.

A = +·219, B = −·629, C = +·745.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Ottawa | 4·4 | +2 | +2 | +6 | +6 |
| Harvard | 5·8 | −8 | −8 | +11 | +11 |
| Halifax | 6·1 | 0 | 0 | −3 | −3 |
| Ithaca | 7·0 | −13 | −13† | −17 | −17† |
| Toronto | 7·5 | 0 | 0 | −1 | −1 |
| Fordham | 7·6 | −6 | −6 | −14 | −14 |
| Georgetown | 10·3 | 0 | 0 | −3 | −3 |
| Cheltenham | 10·5 | 0 | 0 | −4 | −4 |
| Ann Arbor | 10·8 | +13 | +13† | +16 | +16† |
| Chicago | 13·5 | +2 | +2 | +2 | +1 |
| St. Louis | 17·0 | +4 | +3 | −1 | −3 |
| Mobile | 22·0 | +9 | +10 | +12 | +7(d) |
| Saskatoon | 22·4 | +14 | +15† | +29 | +23(d)† |
| Loyola | 23·5 | +61 | +63* | +67 | +60(d)* |
| Denver | 25·8 | +8 | +12 | −71 | −65* |
| Victoria | 34·2 | −1 | +4 | +10 | +18 |
| Vera Cruz | 35·5 | +12 | +17 | −63 | −55 |
| Tacubaya | 36·8 | −2+2 | +3+7 | −3+1 | +5+9 |
| Berkeley | 38·3 | −1+4 | +3+7 | +5+10 | +12+17 |
| Edinburgh | 40·6 | −4 | 0 | −6 | 0 |
| Eskdalemuir | 40·7 | −8 | −4 | −21 | −15 |
| Bidston | 41·5 | −6 | −2 | −14 | −8 |
| Stonyhurst | 41·7 | −5 | −1 | −2 | +4 |
| West Bromwich | 42·4 | −14 | −10 | +8 | +14 |
| Bergen | 43·4 | −25 | −21 | | |
| De Bilt | 46·5 | −3 | 0 | −9 | −5 |
| Paris | 46·6 | −4 | −1 | −2 | +2 |
| Uccle | 46·7 | −4 | −1 | −4 | 0 |
| Toledo | 47·2 | −7 | −4 | −12 | −8 |
| San Fernando | 47·7 | −33 | −30 | −8 | −4 |

*Continued on next page.*

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Hamburg | 48·4 | −1 | +2 | −5 | −2 |
| Malaga | 48·7 | −6 | −3 | −3 | 0 |
| Granada | 49·0 | −2 | +1 | +2 | +5 |
| Upsala | 49·2 | −3 | 0 | −1 | +2 |
| Besançon | 49·4 | −4 | −1 | −3 | 0 |
| Tortosa | 49·5 | −2 | 0 | −3 | 0 |
| Strasbourg | 49·7 | −2 | 0 | +1 | +4 |
| Almeria | 49·9 | −7 | −5 | −8 | −5 |
| Barcelona | 50·2 | −20 | −18 | −7 | −4 |
| Alicante | 50·3 | −9 | −7 | 0 | +3 |
| Hohenheim | 50·5 | −5 | −3 | −3 | 0 |
| Zürich | 50·8 | −3 | −1 | +1 | +4 |
| Ravensburg | 51·1 | −4 | −2 | −11 | −8 |
| Moncalieri | 51·6 | +31 | +33 | +17 | +19 |
| Innsbruck | 52·5 | −6 | −4 | | |
| Königsberg | 53·1 | 0 | +2 | +1 | +3 |
| Algiers | 53·5 | −8 | −6 | −8 | −6 |
| Venice | 54·0 | −2 | −1 | −17 | −15 |
| Florence | 54·4 | −4 | −3 | +7 | +9 |
| Pulkovo | 54·6 | 0 | +1 | +5 | +7 |
| Vienna | 54·7 | −4 | −3 | −3 | −1 |
| Zagreb | 55·9 | +3 | +4 | +3 | +4 |
| Rocca di Papa | 56·4 | −2 | −1 | −10 | −9 |
| Budapest | 56·6 | −2 | −1 | +8 | +9 |
| Belgrade | 59·0 | +57 | +57* | | |
| Kucino | 60·3 | +58 | +57* | +62 | +62* |
| La Paz | 64·7 | −7 | −8 | −17 | −18 |
| Ekaterinburg | 67·4 | +4 | +3 | +10 | +9 |
| Piatigorsk | 71·0 | +9 | +8 | +15 | +13 |
| Honolulu | 72·4 | | | | |
| Rio de Janeiro | 75·3 | −7 | −7 | −10 | −13 |
| Helwan | 75·5 | −2 | −2 | 0 | −3 |
| Baku | 77·1 | −2 | −2 | +10 | +7 |
| La Plata | 83·8 | 0 | +1 | −12 | −16 |

Other readings :

| | △ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Berkeley | 38·3 | | | | −36 | | |
| Bidston | 41·5 | | | | −7 | | −16+18 |
| Stonyhurst | 41·7 | | | | +7 | | +23 |
| Uccle | 46·7 | | | | | | +19 |
| Hamburg | 48·4 | | | | +9 | | |
| Granada | 49·0 | | | | | | −21 |
| Upsala | 49·2 | | | | 0 | | −42 |
| Strasbourg | 49·7 | | | | +6 | | +30 |
| Zürich | 50·8 | | | | −3 | | |
| Pulkovo | 54·6 | | | | | | +7 |
| Vienna | 54·7 | | | | | | +15 |
| Zagreb | 55·9 | | | | +23 | | +34 |
| La Paz | 64·7 | | | | −15 | | |
| Honolulu | 72·4 | | | | | +29 | |
| La Plata | 83·8 | | −1 | | | | |
| Zi-ka-wei | 99·9 | | | | +1 | | |
| Bombay | 105·5 | −47 | | | | +12 | |
| Hyderabad | 106·8 | | | | +9 | +32 | |
| Hong Kong | 109·3 | | | | | +9 | |
| Manila | 116·4 | | | | −5 | | |
| Colombo | 119·2 | | | | | +13 | |
| Riverview | 145·8 | +1 | | | 0 | | |
| Perth | 162·9 | −18 | | | | | |

Also 134°·4 (Wellington) PKS−16.

The Saguenay River earthquake ; see Hodgson, Trans. Roy. Soc. Canada, 21, 1927, 145-152.

1925 June 28d. 1h. 20m. 59s. +15s. =21m. 14s. Z = +1.

I.S.S. Epicentre 46°·4N. 111°·2W. Revised Epicentre 46°·5N. 111°·6W.

A = −·2534, B = −·6400, C = +·7254.

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Victoria | 8·1 | −1 | −1 | +1 | +1 |
| Berkeley | 11·7 | −2 | −2 | 0 | 0 |
| Lick | 11·8 | −2 | −2 | +2 | +2 |
| Santa Clara | 11·9 | −1 | −1 | | |
| Tucson | 14·3 | +13 | +13 | −1 | −2 |
| St. Louis | 17·5 | −1 | −2 | | |
| Chicago | 17·9 | −7,0 | −8 −1 | +2 | 0 |
| Sitka | 17·9 | +10 | +9 | +25 | +23 |
| Ann Arbor | 20·3 | −5 | −5 | +8 | +4(d) |
| Toronto | 22·8 | −1 | +1 | +4 +9 +21 | −2(d) +3(d) +15(d) |
| Ottawa | 24·8 | −2 | +1 | −5 | 0 |
| Ithaca | 25·2 | +1 | +4 | +9 | +5(d) |
| Georgetown | 26·2 | −2 | +2 | −9 | −2 |
| Cheltenham | 26·5 | −4 +2 | 0 +6 | −12 −8 | −5 −1 |
| Fordham | 27·6 | −4 | +1 | −8 | 0 |
| Harvard | 28·9 | −3 | +2 | +5 | +13 |
| Tacubaya | 28·9 | −5 | 0 | +35 | +43 |
| Halifax | 33·1 | −8 | −2 | −4 | +4 |
| Port au Prince | 42·7 | −6 | −2 | | |
| Honolulu | 45·1 | −5 | −2 | −1 | +3 |
| Dyce | 61·0 | +2 | +1 | +1 | +1 |
| Edinburgh | 61·4 | 0 | −1 | +2 | +2 |
| Bergen | 61·6 | −29 | −30 | −52 | −52 |
| Eskdalemuir | 61·7 | +1 | 0 | −1 | −1 |
| Stonyhurst | 63·1 | +2 | +1 | +2 | +1 |
| West Bromwich | 64·2 | +1 | 0 | 0 | −1 |
| Oxford | 65·0 | +3 | +2 | +5 | +4 |
| Upsala | 65·9 | +2 | +1 | +2 | +1 |
| Ootomari | 66·4 | +5 | +4 | | |
| De Bilt | 67·5 | +3 | +2 | −1 | −2 |
| Uccle | 68·2 | 0 | −1 | +3 | +1 |
| Hamburg | 68·4 | +1 | 0 | +6 | +4 |
| Paris | 68·9 | +1 | 0 | −2 | −4 |
| Pulkovo | 69·3 | +2 | +1 | | |
| Lisbon | 70·2 | −15 | −16† | −17 | −19† |
| Königsberg | 70·9 | +4 | +3 | +5 | +3 |
| Strasbourg | 71·3 | −1 | −2 | +6 | +4 |
| Besançon | 71·6 | 0 | −1 | +5 | +3 |
| Toledo | 72·0 | +1 | 0 | +10 | +8 |
| Zürich | 72·6 | 0 | −1 | +4 | +2 |
| San Fernando | 73·6 | −3 | −4 | +2 | −1 |
| Tortosa | 73·9 | −1 | −2 | +3 | 0 |
| Moncalieri | 74·0 | −1 | −2 | +3 | 0 |
| Barcelona | 74·1 | −2 | −3 | +3 | 0 |
| La Paz | 74·2 | −7 | −8 | −4 | −7 |
| Malaga | 74·3 | −1 | −2 | +1 | −2 |
| Granada | 74·4 | −3 | −4 | +1 | −2 |
| Kucino | 74·6 | +1 | 0 | +5 | +2 |
| Vienna | 75·1 | −1 +6 | −1 +6 | +5 | +2 |
| Alicante | 75·2 | −11 | −11† | −8 | −11† |
| Almeria | 75·3 | +2 | +2 | +3 | 0 |
| Venice | 75·7 | +4 | +4 | +16 | +13 |
| Laibach | 76·1 | 0 | 0 | +2 | −1 |
| Ekaterinburg | 76·5 | +2 | +2 | +5 | +2 |
| Florence | 76·6 | −3 +2 | −3 +2 | +10 | +7 |

*Continued on next page.*

| | Δ | $P_p$ | $P_\omega$ | $S_p$ | $S_\omega$ |
|---|---|---|---|---|---|
| | ° | | | | |
| Budapest | 76·7 | +1 | +1 | +5 | +2 |
| Zagreb | 76·9 | 0 +7 | 0 +7 | +5 | +2 |
| Algiers | 78·2 | −1 | −1 | 0 | −3 |
| Rocca di Papa | 78·8 | +1 +6 | +1 +6 | −13 +3 | −16,0 |
| Belgrade | 79·4 | −69 | −69 | +5 | +2 |
| Naples | 80·2 | +8 | +8 | +22 | +18 |
| Piatigorsk | 86·7 | −63 | −62* | | |
| Zi-ka-wei | 88·7 | +11 | +12 | +19 | +15 |
| Baku | 91·6 | +2 | +4 | | |
| Helwan | 96·6 | +2 | +5 | | |
| Manila | 102·8 | +24 | +28 | | |
| Wellington | 109·5 | | +24 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Georgetown | 26·2 | | | | +5 | | |
| Cheltenham | 26·5 | | | | −4 | | +13 |
| Fordham | 27·6 | | | | −12 | | |
| Tacubaya | 28·9 | | | | +23 | | |
| Honolulu | 45·1 | | | | +6+13 | | +25 |
| Eskdalemuir | 61·7 | | | | −9 | | −6 |
| Oxford | 65·0 | | | | +5 | | +42 |
| De Bilt | 67·5 | | | | +1 | | +28 |
| Uccle | 68·2 | | | | | | +21 |
| Hamburg | 68·4 | | | | +11 | | |
| Pulkovo | 69·3 | | | | −2 | | +68 |
| Königsberg | 70·9 | | | | | +37 | |
| Strasbourg | 71·3 | | | | +1 | | +43 |
| Toledo | 72·0 | | | | +32 | | +18 |
| La Paz | 74·2 | | | | | +34 | +62 |
| Granada | 74·4 | | | | +2 | +23 | +33 |
| Kucino | 74·6 | | | | −12 | +10 | +15 |
| Vienna | 75·1 | | | | −1 | +14 | −6 |
| Zagreb | 76·9 | | | | +1 | | |
| Belgrade | 79·4 | | | | 0 | | |
| Piatigorsk | 86·7 | | −74* | | −60* | | |
| Baku | 91·6 | | +2 | | | | |
| Helwan | 96·6 | | −4 | | | | |
| Hong Kong | 99·7 | | | | −3 | | |
| Phu-Lien | 104·4 | | | | | +27 | |
| Wellington | 109·5 | | | | | +3 | |
| Riverview | 118·5 | | | | | −45 | |
| Sydney | 118·5 | | | | | −21 | |

Also 140°·6 (Cape Town) PKS−20.

Mean SKS residual −1.

This is the Montana earthquake, studied by Byerly. There is unfortunately some doubt about the epicentre. Byerly's determination was adopted in the I.S.S., but depended on the tables of A. Mohorovicic. With the present tables a displacement of 0°·3 to the west is needed to fit Victoria. On the other hand Byerly's epicentre lay on a known fault. On this ground Prof. Byerly was asked whether the field data would forbid a displacement of the epicentre, and he informs us that there is no evidence of movement on the fault in question during the earthquake. It appears therefore that the field data are indecisive. This earthquake is of special importance because it is one of the few large earthquakes known from the existence of $P_g$ and $S_g$ to have had foci in the granitic layer.

1925 June 29d. 14h. 42m. 10s. +16   42m.26s.   Z = +8.

I.S.S. Epicentre 34°·0N. 119°·0W.   Revised Epicentre 34°·4N. 119°·8W

A = − ·4101, B = − ·7160, C = + ·5650.

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Lick | 3·3 | −1 | −1 | | |
| Santa Clara | 3·5 | −18 | −18 | | |
| Berkeley | 4·0 | −3 | −3 | 0 +10 | 0 +10 |
| Tucson | 7·8 | +21 | +21 | +2 | +2 |
| Victoria | 14·2 | +3 | +3 | +26 | +25 |
| Tacubaya | 23·6 | +2 | +4 | +10 | +3(d) |
| St. Louis | 24·0 | +6 | +9 | +13 | +5(d) |
| Chicago | 26·2 | +39 | +43 | −5 | +2 |
| Toronto | 32·4 | −4 | +2 | −10 | −1 |
| Georgetown | 34·3 | −2 | +3 | +1 | +9 |
| Cheltenham | 34·4 | +6 | +11 | −15 | −7 |
| Ithaca | 34·5 | −2 | +3 | −5 | +3 |
| Ottawa | 35·1 | −6 | −1 | −9 | −1 |
| Honolulu | 35·8 | −22 | −17 | −2 | +6 |
| Fordham | 36·5 | +7 | +12 | −8 | 0 |
| Harvard | 38·4 | −3 | +1 | +3 | +11 |
| La Paz | 70·7 | +9 | +8 | −6 | −8 |
| Dyce | 74·5 | +2 | +1 | +3 | 0 |
| Edinburgh | 74·9 | +9 | +9 | 0 | −3 |
| Eskdalemuir | 75·3 | −4 | −4 | −4 | −7 |
| Stonyhurst | 76·5 | 0 | 0 | | |
| Oxford | 78·5 | +4 | +4 | | |
| Upsala | 79·4 | −3 | −3 | +2 | −1 |
| Uccle | 81·7 | −1 | −1 | +6 | +2 |
| Hamburg | 81·9 | 0 | 0 | 0 | −4 |
| Paris | 82·2 | 0 | 0 | +3 | −1 |
| Pulkovo | 82·7 | +1 | +1 | −2 | −6 |
| Strasbourg | 84·8 | −1 | 0 | | |
| Toledo | 85·0 | 0 | +1 | | |
| Besançon | 85·0 | +6 | +7 | | |
| Irkutsk | 85·2 | 0 +8 +12 | +1 +9 +13 | | |
| San Fernando | 86·0 | +4 | +5 | +10 | +6 |
| Malaga | 86·9 | −3 | −2 | +1 | −3 |
| Tortosa | 86·9 | −10 +3 | −9 +4 | +9 | +5 |
| Granada | 87·1 | −2 | −1 | | |
| Barcelona | 87·3 | | | −2 | −6 |
| Innsbruck | 87·4 | 0 | +1 | | |
| Kucino | 87·9 | −3 | −2 | +4 | 0 |
| Almeria | 88·0 | −20 | −19 | | |
| Vienna | 88·6 | −2 | −1 | | |
| Ekaterinburg | 88·8 | −2 | −1 | | |
| Venice | 89·2 | +10 | +11 | | |
| Laibach | 89·6 | +8 | +9 | | |
| Zagreb | 90·4 | +5 | +6 | | |
| Algiers | 91·1 | −10 | −8 | | |
| Rocca di Papa | 92·3 | −3 | −1 | | |
| Zi-ka-wei | 92·7 | +15 | +17 | | |
| Belgrade | 93·0 | +1 | +3 | | |
| Baku | 104·6 | +2 | +7 | | |

Other readings :

| | △ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| St. Louis | 24·0 | | | | | | −6+38 |
| Chicago | 26·2 | | | | +8 | | |
| Ottawa | 35·1 | | | | +2 | | −1+37 |
| Honolulu | 35·8 | | | | +25 | | +7+38 |
| Fordham | 36·5 | | | | | | +10 |

*Continued on next page.*

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Honolulu | 48·1 | −2 | +1 | −6 | −3 |
| La Paz | 52·2 | −4 | −2 | −4 | −2 |
| Rio de Janeiro | 75·1 | | | −9 | −12 |
| Edinburgh | 81·0 | −9 | −9 | +13 | +9 |
| Dyce | 81·1 | +17 | +17 | −1 | −5 |
| Eskdalemuir | 81·2 | +5 | +5 | 0 | −4 |
| Oxford | 83·7 | 0 | +1 | | |
| San Fernando | 86·4 | +21 | +22 | +2 | −2 |
| Toledo | 86·7 | −3 | −2 | +3 | −1 |
| De Bilt | 87·1 | −1 | 0 | −3 | −7 |
| Paris | 87·1 | +3 | +4 | +3 | −1 |
| Uccle | 87·2 | −4 | −3 | +7 | +3 |
| Malaga | 87·6 | −1 | 0 | +2 | −2 |
| Granada | 88·0 | −6 | −5 | +19 | +15 |
| Hamburg | 88·9 | | | +6 | +2 |
| Almeria | 89·0 | −1 | 0 | +19 | +15 |
| Tortosa | 89·4 | +50 | +51* | | |
| Alicante | 89·7 | +2 | +3 | | |
| Besançon | 89·9 | | | +5 | +1 |
| Strasbourg | 90·3 | +1 +5 | +2 +6 | | |
| Moncalieri | 92·1 | +26 | +28 | | |
| Innsbruck | 93·0 | −4 | −2 | | |
| Algiers | 93·0 | +6 | +8 | | |
| Pulkovo | 93·2 | −6 | −4 | | |
| Vienna | 95·2 | +66 | +68* | | |
| Rocca di Papa | 96·9 | −30 | −27 | | |
| Pompeii | 98·5 | −43 | −40 | | |
| Ekaterinburg | 102·8 | −10 | −6 | | |
| Irkutsk | 103·2 | −6 | −2 | | |
| Batavia | 144·9 | | +67 | | |

Other readings :

| | △ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Lick | 22·1 | | | | | | −6+2 |
| St. Louis | 23·7 | | | | | | −9 |
| Chicago | 27·3 | | | | | | +1+33 |
| Ann Arbor | 29·8 | | | | | | −17 |
| Fordham | 35·0 | | | | +1 | | |
| Ottawa | 36·2 | | | | +8 | | +8+26 |
| Harvard | 37·5 | | | | +1 | | +22 |
| Honolulu | 48·1 | | | | 0 | | −23+20 |
| Oxford | 83·7 | | −2 | | | | |
| De Bilt | 87·1 | | | | −5 | | +5 |
| Uccle | 87·2 | | | | | | +7 |
| Granada | 88·0 | | −64* | | | | |
| Upsala | 88·6 | | −5 | | | | |
| Hamburg | 88·9 | | | | +3 | | |
| Alicante | 89·7 | | 0 | | | | |
| Barcelona | 90·2 | | | | −1 | | |
| Strasbourg | 90·3 | | −2 | | +2 | | |
| Moncalieri | 92·1 | | | | | −9 | |
| Innsbruck | 93·0 | | | | | +34 | |
| Königsberg | 93·0 | | −6 | | | +13 | |
| Pulkovo | 93·2 | | +24 | | −12 | | |
| Vienna | 95·2 | | | | | +15 | |
| Budapest | 97·1 | | | | −29 | | |
| Pompeii | 98·5 | | −32 | | | | |
| Ekaterinburg | 102·8 | | | | 0 | | +15 |
| Baku | 116·1 | | | | +15 | | |

Mean P residual ( $\Delta > 70°$), −1 ; S, −3 (?) ; SKS, −3.

| | Δ | P′ | SKS | SKKS | PP | PS | |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Harvard | 38·4 | | | | +11 | | +23+ |
| Dyce | 74·5 | | | | | | +9 |
| Eskdalemuir | 75·3 | | | | | | −16 |
| Uccle | 81·7 | | | | 0 | | +21 |
| Hamburg | 81·9 | | | | | | +3 |
| Pulkovo | 82·7 | | | | 0 | | −19 |
| Strasbourg | 84·8 | | +10 | | | | |
| Irkutsk | 85·2 | | +7 | | +3 | | +12 |
| Tortosa | 86·9 | | +11 | | | | |
| Granada | 87·1 | | +8 | | +1 | | −52 |
| Kucino | 87·9 | | | | −11 | | +44 |
| Almeria | 88·0 | | −20 | | | | |
| Vienna | 88·6 | | | | −51 | | |
| Ekaterinburg | 88·8 | | +7 | | −13 | | +17 |
| Venice | 89·2 | | −53 | | | | |
| Laibach | 89·6 | | −21 | | | | |
| Florence | 90·0 | | | | | −1 | |
| Budapest | 90·2 | | | | −30 | | |
| Rocca di Papa | 92·3 | | −60−30 | | | +48 | |
| Zi-ka-wei | 92·7 | | | | +7 | +28 | |
| Belgrade | 93·0 | | +17 | | | | |
| Manila | 104·3 | | | | −45 | | |
| Baku | 104·6 | | | | +9 | +11 | |
| Colombo | 134·7 | | | | | +109 | |

Mean SKS residual +8.

This earthquake was destructive at Santa Barbara, California. With the I.S.S. epicentre it would have been equally destructive at Los Angeles. The near stations are not very consistent, but suggested an epicentre in the San Rafael Mountains, north of Santa Barbara. Prof. Byerly, when consulted, reported that this also did not agree with the field evidence, and gave from field data the epicentre adopted here.

1925 July 7d. 14h. 12m. 12s. +21s. = 12m. 33s. Z = +3.

I.S.S. Epicentre 19°·6N. 106°·5W. Retained.

A = −·268, B = −·903, C = +·336.

| | Δ | Pγ | Pω | Sγ | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Manzanillo | 2·1 | +86 | +86 | | |
| Guadalajara | 3·0 | +14 | +14 | | |
| Tacubaya | 6·9 | −5 | −5 | | |
| Oaxaca | 9·6 | −21 | −21 | −4 | −4 |
| Vera Cruz | 9·8 | −6 | −6 | +4 | +4 |
| Tucson | 13·2 | +14 +23 | +14 +23† | +21 | +20† |
| Lick | 22·1 | 0 | +1 | +17 | +12(d) |
| Berkeley | 22·8 | −4 +1 | −2 +3 | +17 | +11(d) |
| St. Louis | 23·7 | −1 | +1 | +2 | +6 |
| Chicago | 27·3 | +1 | +6 | +2 +24 | +9 +31 |
| Ann Arbor | 29·8 | −6 | 0 | −16 | −8 |
| Victoria | 31·8 | −5 | +1 | −12 | −3 |
| Georgetown | 31·9 | −7 | −1 | −3 | +6 |
| Cheltenham | 31·9 | | | −1 | +8 |
| Toronto | 33·0 | −8 | −2 | −3 | +6 |
| Ithaca | 34·0 | +26 | +32 | −26 | −17 |
| Fordham | 35·0 | −9 | −4 | −5 | +3 |
| Ottawa | 36·2 | −9 | −4 | −3 | +5 |
| Harvard | 37·5 | −6 | −1 | 0 +24 | +7 +31 |
| Sitka | 43·0 | | | +8 | +13 |

*Continued on next page.*

1925 Dec. 10d. 14h. 14m. 42s. +16s. =14m.58s. Z dubious, taken =0.

I.S.S. Epicentre 15°·5N. 92°·5W. Retained.

A = −·042, B = −·963, C = +·267.

| | Δ | $P_\nu$ | $P_\omega$ | $S_\nu$ | $S_\omega$ |
|---|---|---|---|---|---|
| | ° | | | | |
| Oaxaca | 4·4 | −43 | −43 | | |
| Vera Cruz | 5·1 | +33 | +33 | | |
| Merida | 6·1 | +45 | +45 | | |
| Tacubaya | 7·5 | −8 | −8 | −17 | −17 |
| Guadalajara | 11·7 | +39 | +39 | +36 | +36 |
| Balboa Heights | 14·2 | +22 | +22 | | |
| Mazatlan | 15·2 | −40 | −41 | −20 | −21 |
| Port au Prince | 19·5 | +11 | +10 | +57 | +56* |
| St. Louis | 23·2 | −2 | 0 | +10 | +4(d) |
| Tucson | 23·7 | +6 | +8 | +20 | +13(d) |
| Chicago | 26·6 | −7 | −3 | −14 +28 | −7 +35 |
| Cheltenham | 27·0 | +34 | +38 | −9 +14 | −2 +21 |
| Georgetown | 27·1 | −1 | +4 | +19 | +26 |
| Ann Arbor | 27·9 | | | | |
| Fordham | 30·1 | +5 | +11 | +4 | +12 |
| Ithaca | 30·2 | +10 | +16 | +24 | +32 |
| Toronto | 30·3 | −7 +1 | −1 +7 | 0 | +8 |
| Harvard | 32·6 | +1 | +7 | +2 | +11 |
| Ottawa | 33·1 | −6 | 0 | −1 | +8 |
| Berkeley | 34·5 | −8 | −3 | −3 | +5 |
| La Paz | 40·0 | −3 | +1 | | |
| Victoria | 41·5 | −3 | +1 | +5 | +11 |
| Sitka | 52·5 | | | +13 | +15 |
| La Plata | 60·1 | −4 | −5 | −19 | −19 |
| Rio de Janeiro | 61·7 | +2 | +1 | −13 | −13 |
| Honolulu | 62·1 | +2 | +1 | −1 | −1 |
| Edinburgh | 76·9 | +1 | +1 | +29 | +26 |
| Bidston | 77·3 | | | +8 | +5 |
| Stonyhurst | 77·6 | +13 | +13 | +4 | +1 |
| San Fernando | 78·0 | +14 | +14 | +59 | +56* |
| Oxford | 78·7 | +2 | +2 | +8 | +5 |
| Toledo | 79·0 | −4 | −4 | −1 | −4 |
| Malaga | 79·3 | −3 | −3 | −4 | −7 |
| Granada | 79·9 | −1 | −1 | +1 | −2 |
| Almeria | 80·9 | −5 | −5 | −9 | −13 |
| Paris | 81·7 | +1 | +1 | −4 | −8 |
| Alicante | 82·0 | −14 | −14† | −12 | −16† |
| Tortosa | 82·2 | | | −63 | −67* |
| Uccle | 82·3 | +1 | +1 | −1 | −5 |
| De Bilt | 82·4 | +2 | +2 | +4 | 0 |
| Apia | 83·7 | | | +11 | +7 |
| Hamburg | 84·8 | +3 | +4 | | |
| Strasbourg | 85·0 | +1 | +2 | +13 | +9 |
| Algiers | 85·2 | −2 | −1 | +5 | +1 |
| Zürich | 86·0 | −2 | −1 | | |
| Moncalieri | 86·1 | −25 | −24 | | |
| Upsala | 86·3 | −1 | 0 | | |
| Cheb | 87·4 | +32 | +33 | | |
| Florence | 88·9 | +4 | +5 | | |
| Königsberg | 90·0 | +13 | +14 | +7 | +3 |
| Laibach | 90·2 | +36 | +37 | | |
| Graz | 80·4 | | | +3 | −1 |
| Vienna | 90·5 | +13 | +15 | | |
| Rocca di Papa | 90·6 | −20 | −18 | +22 | +18 |
| Leningrad | 91·7 | 0 | +2 | | |

*Continued on next page.*

| | Δ | $P_{\nu}$ | $P_{\omega}$ | $S_{\nu}$ | $S_{\omega}$ |
|---|---|---|---|---|---|
| | ° | | | | |
| Pulkovo | 91·8 | −3 | −1 | +3 | −1 |
| Naples | 92·0 | −7 | −5 | | |
| Pompeii | 92·3 | −52 | −50* | | |
| Belgrade | 94·5 | +29 | +31 | | |
| Kucino | 97·5 | −3 | 0 | | |
| Athens | 99·9 | −24 | −20 | | |
| Ekaterinburg | 104·3 | −2 | +3 | | |
| Helwan | 109·4 | | +6 | | |
| Irkutsk | 110·7 | | −6 | | |
| Baku | 114·1 | | +10 | | |
| Riverview | 120·2 | | +42 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Tucson | 23·7 | | | | −11 | | −2 |
| Chicago | 26·6 | | | | +9 | | |
| Georgetown | 27·1 | | | | | | −9 |
| Ann Arbor | 27·9 | | | | +3 | | |
| Harvard | 32·6 | | | | | | −8+18 |
| Ottawa | 33·1 | | | | | | +33 |
| Berkeley | 34·5 | | | | | | +24 |
| La Plata | 60·1 | | | | −4 | | |
| Rio de Janeiro | 61·7 | | | | −5 | | −26 |
| Toledo | 79·0 | | | | | | +35 |
| Granada | 79·9 | | | | | +49 | +40 |
| Uccle | 82·3 | | | | | | +27 |
| De Bilt | 82·4 | | | | | | +23 |
| Besançon | 84·4 | | −5 | | | | |
| Hamburg | 84·8 | | +4 | | | | |
| Zürich | 86·0 | | 0 | | | | |
| Moncalieri | 86·1 | | −1 | | | | |
| Upsala | 86·3 | | +3 | | | | −6 |
| Cheb | 87·4 | | | | | | −3 |
| Königsberg | 90·0 | | | | | +14+47 | |
| Vienna | 90·5 | | −1 | | +3 | +49 | +33 |
| Rocca di Papa | 90·6 | | | | −14 | +15 | |
| Leningrad | 91·7 | | +17 | | +6 | | |
| Pulkovo | 91·8 | | −1+28 | | +7 | | +12 |
| Naples | 92·0 | | −13 | | | | |
| Belgrade | 94·5 | | | | | +60 | |
| Kucino | 97·5 | | | | +5 | +15 | |
| Athens | 99·9 | | −11 | | | | |
| Wellington | 102·1 | | −14 | | | | |
| Ekaterinburg | 104·3 | | −39−12 | | +8 | +17 | |
| Helwan | 109·4 | | | | | +6 | |
| Irkutsk | 110·7 | | | | −3 | −16 | −64 |
| Baku | 114·1 | | | | +8 | +11 | +77 |
| Cape Town | 115·8 | | | | +4 | | |
| Riverview | 120·2 | | | | | | +63 |
| Sydney | 120·2 | +43 | | | | | |
| Melbourne | 125·0 | +45 | | | | | +26 |
| Adelaide | 130·5 | | | −17 | | | |
| Bombay | 142·7 | −21 | | | | | |
| Hyderabad | 145·9 | −2 | | | | | |
| Colombo | 156·4 | +26 | | | +6 | | |

Also 130°·5, PKS−19 ; 132°·3 (Simla), PKS−2 ; 142°·7, SKSP+3.

Mean P residual (Δ >70°), 0 ; S, −1 ; SKS dubious.

1927 Aug. 10d. 1h. 35m. 22s. +9s. =35m.31s. Z = −1.

I.S.S. Epicentre 8°·0N. 81°·5W. First revised epicentre 6°·8N. 83°·2W. Final epicentre 6°·9N. 82°·6W.

A = +·1279, B = −·9845, C = +·1201.

| | △ | Pv | Pω | Sv | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Balboa Heights | 3·7 | −24 | −24† | −25 | −25† |
| Port au Prince | 15·4 | +7 +14 | +6 +13 | | |
| San Juan | 19·8 | 0 | −1 | | |
| Tacubaya | 20·4 | +3 | +3 | +19 | +16(d) |
| La Paz | 27·4 | −1 | +4 | +5 +19 | +12 +26 |
| Mazatlan | 28·1 | +2 | +7 | +40 | +48 |
| Sucre | 31·0 | +1 | +7 | −2 | +7 |
| Cheltenham | 32·3 | | | −55 | −46 |
| St. Louis | 32·5 | −3 | +3 | −13 | −4 |
| Fordham | 34·9 | −9 | −4 | 0 | +8 |
| Chicago | 35·1 | −14 | −9 | −20 −5 | −12 +3 |
| Ithaca | 35·9 | −4 | +1 | −7 | +1 |
| Tucson | 36·5 | −4 | +1 | −10 | −2 |
| Harvard | 36·9 | +1 +15 | +6 +20 | −2 +15 | +6 +23 |
| Toronto | 36·9 | −7 −12 | −2 −7 | −16 | −8 |
| Ottawa | 39·0 | −8 | −4 | −9 | −2 |
| Halifax | 41·2 | +2 | +6 | +5 | +11 |
| Pilar | 42·4 | −9 −3 | −5 +1 | | |
| Berkeley | 47·4 | −4 | −1 | +2 | +6 |
| La Plata | 47·7 | +7 | +10† | +5 | +8† |
| Rio de Janeiro | 48·7 | −15 −5 | −12 −1 | −6 −1 | −3 +2 |
| Victoria | 54·0 | −5 −2 | −4 −1 | +2 | +4 |
| Honolulu T.H. | 73·8 | +12 | +11 | +8 | +5 |
| Rio Tinto | 74·7 | −69 | −70 | −44 | −47 |
| San Fernando | 75·0 | +11 | +11 | +7 | +4 |
| Malaga | 76·8 | +2 | +2 | +26 | +23 |
| Toledo | 76·8 | 0 | 0 | +4 +9 | +1 +6 |
| Granada | 77·1 | +2 | +2 | +6 | +3 |
| Almeria | 78·0 | +1 | +1 | +4 | +1 |
| Edinburgh | 78·4 | +12 | +12 | −2 | −5 |
| Dyce | 79·0 | +12 | +12 | 0 | −3 |
| Oxford | 79·3 | +16 | +16 | −5 | −8 |
| Alicante | 79·6 | +13 | +13 | +14 | +11 |
| Kew | 79·9 | −3 | −3 | −2 | −5 |
| Tortosa | 80·3 | +5 | +5 | +5 | +1 |
| Barcelona | 81·5 | +8 | +8 | −1 | −5 |
| Paris | 81·6 | −2 | −2 | −3 | −7 |
| Algiers | 82·4 | +1 | +1 | −2 | −6 |
| Uccle | 82·7 | −1 | −1 | +1 | −3 |
| De Bilt | 83·1 | +1 | +2 | +1 | −3 |
| Besançon | 84·0 | −3 | −2 | | |
| Strasbourg | 85·0 | +3 | +4 | +8 | +4 |
| Feldberg | 85·3 | −5 | −4 | | |
| Moncalieri | 85·3 | +1 | +2 | | |
| Zürich | 85·7 | −1 | 0 | | |
| Hamburg | 86·0 | −1 | 0 | | |
| Hohenheim | 86·0 | −1 | 0 | | |
| Copenhagen | 87·2 | 0 | +1 | +1 | −3 |
| Jena | 87·2 | 0 +14 | +1 +15 | | |
| Innsbruck | 87·6 | −1 | 0 | | |
| Cheb | 87·9 | −17 | −16 | | |
| Potsdam | 87·9 | +6 +18 | +7 +19 | | |
| Florence | 88·0 | +10 | +11 | | |
| Upsala | 89·1 | −13 | −12 | −3 | −7 |
| Prague | 89·2 | −4 | −3 | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Rocca di Papa | 89·4 | +4 +15 | +5 +16 | | |
| Naples | 90·6 | −8 | −6 | | |
| Vienna | 90·7 | −2 +14 | 0 +16 | | |
| Pompeii | 90·8 | +26 | +28 | | |
| Zagreb | 81·0 | −4,0 +15 | −2 +2 +17 | | |
| Königsberg | 91·8 | +19 +27 | +21 +29 | | |
| Budapest | 92·7 | +17 | +19 | | |
| Pulkovo | 95·3 | −5,0 | −3 +2 | | |
| Kucino | 100·7 | +1 +10 | +5 +14 | | |
| Makeyevka | 104·4 | −1 | +4 | | |
| Ekaterinburg | 109·5 | | 0 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| La Paz | 27·4 | | | | −4 | | +8 |
| Sucre | 31·0 | | | | −4 | | 0 |
| St. Louis | 32·5 | | | | +4 | | +8 |
| Fordham | 34·9 | | | | | | −6 |
| Chicago | 35·1 | | | | | | −14+40 |
| Ithaca | 35·9 | | | | −11 | | |
| Tucson | 36·5 | | | | −2 | | |
| Harvard | 36·9 | | | | +3 | | |
| Toronto | 36·9 | | | | +7 | | |
| Ottawa | 39·0 | | | | 0 | | +15 |
| Almeria | 78·0 | | | | +10 | | |
| Dyce | 79·0 | | | | −13 | | |
| Oxford | 79·3 | | | | | | +19 |
| Kew | 79·9 | | | | | +13 | |
| Uccle | 82·7 | | −1 | | | | +10 |
| De Bilt | 83·1 | | 0 | | 0 | | +15 |
| Besançon | 84·0 | | −2 | | | | |
| Strasbourg | 85·0 | | +3 | | +9 | +8 | |
| Feldberg | 85·3 | | +7 | | | | −2 |
| Moncalieri | 85·3 | | +3 | | | | |
| Zürich | 85·7 | | +5 | | | | |
| Hamburg | 86·0 | | +2 | | −5 | | |
| Hohenheim | 86·0 | | +1 | | −2 | | |
| Copenhagen | 87·2 | | −3 | | −5 | +8 | +44 |
| Innsbruck | 87·6 | | −17 | | | | |
| Cheb | 87·9 | | −10 | | | | |
| Prague | 89·2 | | −8 | | | | |
| Rocca di Papa | 89·4 | | +3 | | | | |
| Vienna | 90·7 | | −2 | | +7 | | +12 |
| Pompeii | 90·8 | | −9 | | | | |
| Zagreb | 91·0 | | −5−2 | | +15 | | |
| Königsberg | 91·8 | | | | +13 | +14 | |
| Pulkovo | 95·3 | | | | −6 | +11 | −8 |
| Kucino | 100·7 | | −4 | | 0 | 0 | +12 |
| Cape Town | 103·1 | | −1 | | | | |
| Wellington | 104·0 | | +10 | | | +5 | |
| Makeyevka | 104·4 | | | | +6 | −7 | |
| Ksara | 109·1 | −59 | −19 | | | | |
| Ekaterinburg | 109·5 | | +2 | | +6 | −13 | |
| Tiflis | 111·7 | −27 | −1 | | +3 | +7 | |
| Baku | 115·7 | +9 | +1 | | −6, 0 | | |
| Irkutsk | 120·5 | | | | | +39 | −22 |
| Tashkent | 125·4 | +41 | | +5 | +10 | | +12 |
| Riverview | 125·7 | | | | | | +26 |
| Melbourne | 127·1 | | | +28 | | | |
| Zi-ka-wei | 135·6 | | | | −2 | | |
| Bombay | 144·6 | +7 | | +7 | | | |
| Hong Kong | 146·6 | 0 | | | | | |

Also 151°·0 (Phu-Lien), $P_2'$−3 ; 170°·6 (Batavia), $P_2'$−3.

Mean P residual (Δ >70°), +1 ; S, 0 ; SKS, 0.

1927 Nov. 4d. 13h. 50m. 51s. +15s. =51m. 6s. Z = +3.

I.S.S. Epicentre 34°·9N. 121°·0W. Revised Epicentre 34°·9N. 120°·7W.

A = −·4187, B = −·7053, C = +·5721.

| | △ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Lick | 2·5 | −1 +3 +11 | −1 +3 +11 | +17 | +17 |
| Berkeley | 3·2 | −4 +1 +9 | −4 +1 +9 | −1 +22 | −1 +22 |
| Tucson | 8·6 | 0 +13 | 0 +13 | +8 | +8 |
| Denver | 13·4 | +9 | +9 | +1 +21 | 0 +20 |
| Victoria | 13·6 | +2 | +2 | | |
| Mazatlan | 17·1 | +2 | +1 | +8 | +6 |
| Saskatoon | 20·0 | −16 | −16† | −12 | −15(d)† |
| Sitka | 24·2 | +3 | +6 | +10 | +2(d) |
| Tacubaya | 24·5 | −17 | −14 | +3 | +8 |
| St. Louis | 24·6 | 0 | +4 | +1 | +6 |
| Chicago | 26·7 | −3 | +1 | −9 | −2 |
| Vera Cruz | 26·8 | −36 | −32 | −19 | −12 |
| Cincinnati | 29·0 | −9 | −3 | +8 | +16 |
| Ann Arbor | 29·6 | −7 | −1 | −9 | −1 |
| Merida | 30·6 | +6 | +12 | 0 | +8 |
| Toronto | 32·8 | −7 | −1 | −14 | −5 |
| Ithaca | 34·9 | | | −6 | +2 |
| Honolulu T.H. | 35·4 | −6 | −1 | −5 | +3 |
| Ottawa | 35·4 | −6 | −1 | −4 | +4 |
| Fordham | 37·0 | +4 | +9 | −7 | +1 |
| San Juan | 50·8 | +122 | +124* | +87 | +89 |
| Apia | 68·7 | −1 | −2 | +2 | 0 |
| Ootomari | 69·4 | +1 | 0 | +2 | 0 |
| La Paz | 71·6 | −3 | −4 | −9 −4 | −11 −6 |
| Mizusawa | 74·3 | 0 | −1 | 0 +10 | −2 +8 |
| Dyce | 74·4 | +3 | +2 | +1 | −2 |
| Edinburgh | 74·9 | −6 | −6 | +3 | 0 |
| Bergen | 75·0 | −4 | −4 | | |
| Sucre | 75·3 | −4 | −4 | +3 | 0 |
| Stonyhurst | 76·5 | −3 | −3 | −11 | −14 |
| Bidston | 76·5 | | | +4 | +1 |
| Suva | 78·4 | −11 +7 | −11 +7 | −40 | −42 |
| Oxford | 78·5 | +2 | +2 | +3 | +1 |
| Upsala | 79·2 | −6 | −6 | −2 | −4 |
| Kew | 79·3 | 0 | 0 | +3 | +1 |
| Toyooka | 80·4 | +2 | +2 | +4 | 0 |
| Osaka | 80·6 | +1 | +1 | −20 | −24 |
| Kobe | 80·7 | 0 | 0 | −4 | −8 |
| Helsingfors | 80·8 | +2 | +2 | +4 | 0 |
| Copenhagen | 80·9 | +4 | +4 | +5 | +1 |
| De Bilt | 81·0 | +2 | +2 | +7 | +3 |
| Sumoto | 81·1 | | | +42 | +38 |
| Uccle | 81·6 | +2 | +2 | +3 | −1 |
| Hamburg | 81·7 | −2 | −2 | +9 +13 | +5 +9 |
| Pulkovo | 82·3 | +3 | +3 | +5 | +1 |
| Feldberg | 83·5 | +126 | +127* | +11 | +7 |
| Königsberg | 84·2 | | | +9 | +5 |
| Paris | 84·3 | −7 | −6 | | |
| Irkutsk | 84·4 | −3 | −2 | | |
| Hukuoka | 84·5 | +4 | +5 | | |
| Jena | 84·5 | −2 +4 +8 | −1 +5 +9 | | |
| Strasbourg | 84·8 | 0 | +1 | +1 | −3 |
| Besançon | 85·0 | +2 | +3 | −1 | −5 |
| Rio Tinto | 85·1 | +19 | +20 | | |
| Toledo | 85·1 | −12 −8 | −11 −7 | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω |
|---|---|---|---|---|---|
| | ° | | | | |
| Bagnères | 85·4 | 0 | +1 | | |
| Cheb | 85·4 | +5 | +6 | 0 | −4 |
| Neuchâtel | 85·6 | 0 | +1 | | |
| Zürich | 86·0 | +1 | +2 | | |
| Ravensburg | 86·1 | +12 | +13 | +2 | −2 |
| Prague | 86·3 | 0 | +1 | | |
| San Fernando | 86·3 | −7 | −6 | | |
| Grenoble | 86·4 | | | | |
| Tortosa | 87·0 | +3 | +4 | −1 | −5 |
| Malaga | 87·0 | −3 | −2 | | |
| Granada | 87·2 | +3 | +4 | +13 | +9 |
| Barcelona | 87·4 | +12 | +13 | +2 | −2 |
| Moncalieri | 87·5 | −8 | −7 | | |
| Kucino | 87·6 | −3 | −2 | | |
| Marseilles | 87·7 | −3 | −2 | +8 | +4 |
| Alicante | 88·1 | −17 | −16 | | |
| Almeria | 88·1 | +2 | +3 | +2 | −2 |
| Ekaterinburg | 88·2 | −3 +40 | −2 +41 | 0 | −4 |
| Vienna | 88·5 | 0 | +1 | +7 | +3 |
| Graz | 89·1 | +1 | +2 | +4 | 0 |
| Venice | 89·1 | +60 | +61* | | |
| Laibach | 89·5 | −17 | −16 | | |
| Florence | 90·0 | −5 | −4 | −1 | −5 |
| Budapest | 90·1 | −65 | −64* | | |
| Zagreb | 90·3 | +3 | +4 | +6 | +2 |
| La Plata | 91·1 | −4 | −2 | | |
| Algiers | 91·3 | −7 | −5 | | |
| Zi-ka-wei | 91·9 | 0 | +2 | | |
| Rocca di Papa | 92·3 | 0 | +2 | | |
| Belgrade | 92·9 | +1 | +3 | −2 | −6 |
| Makeyevka | 94·9 | +1 | +3 | | |
| Wellington | 96·5 | | | +4 +12 | 0 +8 |
| Tiflis | 102·3 | −4 +6 | 0 +10 | | |
| Hong Kong | 102·7 | −1 | +3 | | |
| Tashkent | 103·2 | −5 | 0 | | |

Other readings :

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| St. Louis | 24·6 | | | | −3 | | +7 |
| Ann Arbor | 29·6 | | | | −3 | | +12 |
| Toronto | 32·8 | | | | −1 | | |
| Honolulu T.H. | 35·4 | | | | −3 | | |
| Ottawa | 35·4 | | | | | | −10 |
| Fordham | 37·0 | | | | −3 | | +20 |
| Apia | 68·7 | | | | | −4 | |
| La Paz | 71·6 | | | | 0 | +22 | +36 |
| Dyce | 74·4 | | | | | | +10 |
| Edinburgh | 74·9 | | | | | | +3 |
| Sucre | 75·3 | | | | +28 | −12+7 | −11 |
| Stonyhurst | 76·5 | | | | +1 | +28 | −11 |
| Oxford | 78·5 | | | | | | +6+18 |
| Upsala | 79·2 | | | | | | +2 |
| Kew | 79·3 | | | | −3 | +17 | +28 |
| Helsingfors | 80·8 | | | | +9 | | +16 |
| Copenhagen | 80·9 | | | | −2 | | −21 |
| De Bilt | 81·0 | | | | +2 | | +4 |
| Uccle | 81·6 | | | | +3 | | |
| Hamburg | 81·7 | | | | +3 | | |
| Pulkovo | 82·3 | | | | +8 | | −36 |
| Feldberg | 83·5 | | | | | | −8 |
| Irkutsk | 84·4 | | | | +27 | −5 | +38 |
| Strasbourg | 84·8 | | | | +3 | | |
| Toledo | 85·1 | | +5 | | | | |

*Continued on next page.*

| | Δ | P′ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Bagnères | 85·4 | | +6 | | | | |
| Neuchâtel | 85·6 | | +7 | | | | |
| Zürich | 86·0 | | +5 | | | | |
| Prague | 86·3 | | +3 | | +1 | | |
| San Fernando | 86·3 | | +5 | | | | |
| Grenoble | 86·4 | | +5 | | | | |
| Tortosa | 87·0 | | +3 | | | | |
| Malaga | 87·0 | | +3 | | | | |
| Granada | 87·2 | | −2 | | +37 | +31 | |
| Moncalieri | 87·5 | | −11 | | | | |
| Kucino | 87·6 | | −13 | | +3 | | |
| Alicante | 88·1 | | −6 | | | | |
| Almeria | 88·1 | | | | +29 | | |
| Ekaterinburg | 88·2 | | −1 | | | +16 | |
| Vienna | 88·5 | | −3 | | +6 | +19 | +28 |
| Venice | 89·1 | | −3 | | | | |
| Laibach | 89·5 | | −14 | | | | |
| Zagreb | 90·3 | | 0 | | | | |
| Algiers | 91·3 | | +2 | | | | |
| Zi-ka-wei | 91·9 | | | | +4 | −13 | |
| Rocca di Papa | 92·3 | | +1 | | | | |
| Makeyevka | 94·9 | | +1 | | 0 | +13 | +13 |
| Wellington | 96·5 | | | | −5 | | −20+20 |
| Tiflis | 102·3 | | −2 | | 0 | −20+17 | −6 |
| Tashkent | 103·2 | | −5 | | | +25 | |
| Baku | 104·3 | | −6 | | | | |
| Sydney | 107·2 | −4 | | | −21 | +8 | +23 |
| Riverview | 107·2 | | | | +6 | −4 | −32 |
| Ksara | 107·8 | −29 | | | | +17 | |
| Phu-Lien | 108·5 | | | | +4 | −1 | −7 |
| Helwan | 110·1 | | | | +4 | +8 | |
| Simla | 111·8 | | | +9 | | +21 | |
| Melbourne | 113·6 | +7 | | | | −14 | +15 |
| Adelaide | 117·1 | −65 | | | | −5 | |
| Hyderabad | 124·6 | | | | +34 | | |
| Bombay | 124·7 | −27 | | | | 0 | |
| Batavia | 127·8 | | | | −42 | | |
| Colombo | 133·9 | −1 | | | | | |
| Cape Town | 147·0 | −2 | | | | | |

Also 133°·3 (Perth), PKS−9. Melbourne 28m.46s. and Adelaide 29m.31s. may be SKSP.

Mean P residual (Δ >70°), 0 ; S, 0 ; SKS, +2.

1928 Feb. 10d. 4h. 38m. 20s.+13s.=38m.33s. Z=−6.

I.S.S. Epicentre 18°·2N. 97°·5W. Revised Epicentre 18°·4N. 97°·9W.

A=−·1304, B=−·9399, C=+·3156.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Puebla | 0·7 | −17 | −17 | +3 | +3 | | | | |
| Tacubaya | 1·6 | +7 | +7 | | | | | | |
| Oaxaca | 1·8 | +13 | +13 | | | | | | |
| Vera Cruz | 1·9 | −20 | −20 | −14 | −14 | | | | |
| Guadalajara | 5·7 | −18 | −18 | −1 | −1 | | | | |
| Manzanillo | 6·1 | −31 | −31 | −18 | −18 | | | | |
| Chihuahua | 12·7 | +29 | +29 | +41 | +41 | | | | |
| Tucson | 18·1 | +4 | +3 | +18 | +16 | | | | |
| Denver | 22·1 | −32 | −31 | +20 | +22 | | | | |
| Cincinnati | 23·8 | −2 | 0 | +4 | −3d | | +3 | | +3+14 |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Chicago | 25·0 | −8 | −5 | −4 | +1 | | −12 | | |
| Charlottesville | 25·9 | +18 | +22 | +1 | +7 | | | | |
| Georgetown | 27·3 | −3 | +2 | +40 | +47 | | −14 | | |
| Lick | 28·1 | −1 | +4 | | | | | | |
| Berkeley | 28·8 | −8 | −3 | | | | | | |
| Toronto | 29·7 | +4 | +10 | −15 | −7 | | | | |
| Ithaca | 30·1 | −4 | +2 | | | | −3 | | |
| Ottawa | 32·7 | −6 | 0 | −6 | +3 | | | | −61 |
| Victoria | 37·1 | −10 | −5 | −13 | −5 | | | | |
| La Paz | 45·6 | −1 | +2 | −2+3 | +2+7 | | | | −46+69 |
| Sucre | 49·3 | −4 | −1 | +2 | +5 | | | | |
| La Plata | 65·4 | −5 | −6 | −4 | −5 | | | | |
| Oxford | 79·6 | | | +5 | +2 | | | | |
| Kew | 80·3 | −1 | −1 | +4 | 0 | | | | |
| San Fernando | 80·5 | −1 | −1 | +3 | −1 | | | | |
| Toledo | 81·2 | 0 | 0 | +3 | −1 | | | | |
| Malaga | 81·8 | +1 | +1 | +2 | −2 | | | | |
| Granada | 82·3 | −1 | −1 | +7 | +3 | | | −5 | |
| Paris | 82·8 | 0 | 0 | +3 | −1 | | | | |
| Almeria | 83·3 | −2 | −1 | +2 | −2 | | | | |
| De Bilt | 83·3 | 0 | +1 | +7 | +3 | | | | |
| Uccle | 83·3 | −1 | 0 | +4 | 0 | | | | −18 |
| Tortosa | 84·2 | −4 | −3 | | | | | | |
| Alicante | 84·3 | −2 | −1 | | | −6 | | | |
| Hamburg | 85·4 | −1 | 0 | | | | | | |
| Besançon | 85·6 | −3 | −2 | | | +5 | | | |
| Copenhagen | 85·7 | −3 | −2 | +12 | +8 | | | +39 | |
| Feldberg | 85·9 | | | −18+33 | −22+29 | +2 | | −20+48 | +6 |
| Strasbourg | 86·1 | −2 | −1 | +7 | +3 | | | | |
| Lund | 86·1 | | | +7 | +3 | | | | |
| Upsala | 86·1 | −3 | −2 | +14 | +10 | | | | |
| Zürich | 87·1 | −2 | −1 | +6 | +2 | | | | |
| Algiers | 87·4 | −2 | −1 | | | −3 | | | |
| Jena | 87·4 | −3 | −2 | | | | | −23 | |
| Moncalieri | 87·6 | +4 | +5 | | | +1 | | | |
| Rocca di Papa | 92·2 | 0 | +2 | +7 | +3 | | | | |
| Zagreb | 92·4 | −1 | +1 | | | −14 | | | |
| Wellington | 100·1 | −59 | −55* | | | −14 | | | |
| Makeyevka | 102·8 | | | P′ | | +24 | | | +42 |
| Irkutsk | 106·7 | | | −6 | | | −20 | | |
| Baku | 114·0 | | | | | +23 | | | |
| Tashkent | 119·1 | | | +7 | | +19 | | PKS | |
| Bombay | 141·6 | | | −1 | | | | −21 | |

Mean P residual (Δ>70°), −1 ; S, +1 ; SKS, 0?

1928 Mar. 22d. 4h. 16m.50s.+15s.=17m.5s. Z=+2.

I.S.S. Epicentre 16°·0N. 96°·0W. Retained.

A=−·100, B=−·956, C=+·276.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Oaxaca | 1·2 | −16 | −16† | −19 | −19† | | | | |
| Vera Cruz | 3·2 | +14 | +14 | | | | | | |
| Puebla | 3·7 | −14 | −14† | −8 | −8† | | | | |
| Tacubaya | 4·6 | +12 | +12 | −6 | −6 | | | | |
| Guadalajara | 8·5 | −5 | −5 | −11 | −11 | | | | |
| Manzanillo | 8·5 | −15 | −15† | −14 | −14† | | | | |
| Mazatlan | 12·2 | +9 | +9 | +1 | +1 | | | | |
| Chihuahua | 15·7 | −15 | −16† | −10 | −11† | | | | |
| Balboa Heights | 17·5 | +16 | +15 | +42 | +40 | | | | |
| Tucson | 21·0 | −5 | −5 | +21 | +17d | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Port au Prince | 22·7 | +4 | +6 | −25 | −22 | | +30 | | |
| St. Louis | 23·2 | −2 | 0 | +3 | −3d | | | | |
| Cincinnati | 25·2 | −2+3 | +1+6 | −4 | +1 | | +19 | | |
| Chicago | 26·7 | −3 | +1 | −7 | 0 | | −8 | | |
| Charlottesville | 26·8 | −9 | −5 | −2 | +5 | | | | |
| Georgetown | 28·2 | −3 | +2 | −5 | +3 | | −3 | | −14 |
| Toronto | 31·0 | −11 | −5 | −5 | +4 | | −2+12 | | −56 |
| Lick | 31·1 | −2+2 | +4+8 | +41 | +50 | | | | |
| Berkeley | 31·8 | −5 | +1 | −3 | +6 | | | | |
| Ottawa | 33·9 | −6 | 0 | −13 | −4 | | −24 | | |
| Harvard | 33·9 | −5 | +1 | +1 | +10 | | −7 | | +6 |
| Spokane | 36·3 | −2+3 | +3+8 | −2 | +6 | | | | |
| Saskatoon | 37·1 | −13 | −8 | −16 | −8 | | | | |
| Victoria | 39·4 | −7 | −3 | −2 | +5 | | | | |
| Halifax | 39·5 | −4 | 0 | −11 | −4 | | | | +27 |
| La Paz | 42·6 | −3 | +1 | −9−3 | −3+3 | | −14 | | +13 |
| Sucre | 46·3 | −9−4 | −6−1 | −7 | −3 | | | | −18 |
| Sitka | 50·5 | +5 | +6 | +15 | +18 | | | | |
| Santiago | 55·0 | +16 | +17† | +9 | +10† | | | | |
| Honolulu T.H. | 58·7 | −4 | −4 | −6+4 | −6+4 | | +9 | | −10+6 |
| La Plata | 62·5 | −1 | −2 | −11 | −11 | | | | |
| Reykjavik | 68·7 | +5 | +4 | +11+37 | +9+35 | | | −5 | |
| Scoresby Sund | 69·6 | +2+7 | +1+6 | +2 | 0 | | +16 | | +8 |
| Edinburgh | 78·4 | +2 | +2 | +8 | +5 | | | +11 | |
| Dyce | 78·6 | +4 | +4 | 0+15 | −3+12 | | | | +34 |
| Bidston | 78·9 | −7 | −7 | −7 | −10 | | | | |
| Stonyhurst | 79·2 | +10 | +10 | +10 | +7 | | +2 | +7 | |
| Rio Tinto | 79·8 | −12 | −12 | | | | | | |
| San Fernando | 80·3 | +6 | +6 | +9 | +5 | | | | |
| Oxford | 80·4 | −6 | −6 | +7 | +3 | | +10 | | |
| Apia | 80·6 | +3 | +3 | 0 | −4 | | | | +3 |
| Kew | 81·0 | −1 | −1 | +7 | +3 | | −16 | +22 | −28 |
| Toledo | 81·3 | −2 | −2 | −1 | −5 | | −16 | | |
| Malaga | 81·7 | 0 | 0 | +13 | +9 | | | | |
| Granada | 82·2 | +10 | +10 | +13 | +9 | | | −8+31 | +39 |
| Le Mans | 82·2 | −15 | −15 | +3 | −1 | +2 | | | |
| Almeria | 83·3 | +3 | +4 | | | +2 | | | |
| Paris | 83·5 | −1 | 0 | | | +2 | | | |
| Bagnères | 83·6 | 0+5 | +1+6 | +2 | −2 | +2 | | +15 | |
| De Bilt | 84·0 | −1 | 0 | +9 | +5 | +4 | −8 | | |
| Uccle | 84·0 | −1+5 | 0+6 | | | +6 | +4 | | |
| Alicante | 84·3 | −1 | 0 | | | +3 | | | |
| Tortosa | 84·4 | −11−7 | −10−6 | | | +4 | | | |
| Barcelona | 85·4 | +6 | +7 | +7 | +3 | | | +18 | |
| Besançon | 86·2 | −3+5 | −2+6 | | | +4 | +2 | | |
| Hamburg | 86·3 | −2 | −1 | | | +4 | 0 | | |
| Feldberg | 86·6 | +7 | +8 | +7 | +3 | | −11 | +15 | |
| Copenhagen | 86·7 | −1 | 0 | −3+18 | −7+14 | −20 | −6+1 | +16 | −14 |
| Grenoble | 86·7 | +7 | +8 | | | +4 | | | |
| Strasbourg | 86·8 | −3 | −2 | | | −1 | −5 | −15 | |
| Neuchâtel | 86·8 | −2+5 | −1+6 | | | +5 | | | |
| Lund | 87·2 | +1 | +2 | +2+17 | −2+13 | | | | |
| Upsala | 87·4 | −3 | −2 | −2 | −6 | | 0 | | |
| Algiers | 87·5 | +4 | +5 | −1 | −5 | | | | |
| Hohenheim | 87·7 | +4 | +5 | +3 | −1 | | +23 | | |
| Zürich | 87·8 | 0 | +1 | | | −20 | | | |
| Moncalieri | 88·1 | −2 | −1 | +1 | −3 | −1 | | | |
| Ravensburg | 88·2 | +4 | +5 | | | +6 | +9 | | |
| Jena | 88·2 | 0+5 | +1+6 | +12 | +8 | +4 | −3+1 | +14 | |
| Potsdam | 88·4 | +4 | +5 | +13 | +9 | | | | |
| Chur | 88·5 | +6 | +7 | | | +5 | | | |
| Innsbruck | 89·5 | +3 | +4 | | | | | | |
| Florence | 90·8 | −7+3 | −6+4 | +17 | +13 | −11 | −5 | −24 | −25 |
| Venice | 90·8 | +5 | +6 | | | −9 | | | |
| Suva | 91·0 | +9 | +11 | | | −12 | | | −8 |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Königsberg | 91·3 | +4 | +6 | | | +12 | +6 | +12+37 | |
| Laibach | 92·0 | +4 | +6 | | | +4 | −2 | | |
| Graz | 92·2 | +4 | +6 | | | +12 | +5 | +19 | |
| Vienna | 92·2 | −5+3 | −3+5 | +4+9 | 0+5 | +2+7 | +5 | +20+26 | −57−48 |
| Rocca di Papa | 92·6 | −7+1 | −5+3 | +13 | +9 | −9+1 | | +12 | |
| Pulkovo | 92·8 | −3 | −1 | | | −5 | | | |
| Zagreb | 93·0 | +5 | +7 | +15 | +11 | −6 | 0 | +12 | −56 |
| Budapest | 94·1 | +6 | +8 | | | +2 | −5 | | |
| Pompeii | 94·3 | +15 | +17 | | | −38 | | | |
| Lemberg | 95·7 | −25+5 | −22+8 | | | −34+2 | | | |
| Belgrade | 96·2 | 0 | +3 | +18 | +14 | | | | |
| Kucino | 98·4 | −2 | +1 | | | −12+36 | −5 | | |
| Wellington | 99·9 | +13 | +16 | | | −31+7 | +8+14 | | −71 |
| Christchurch | 101·9 | | | | | +12 | | | |
| Makeyevka | 104·0 | 0 | +5 | | | +1 | | | |
| Yalta | 104·4 | | | | | | +32 | | |
| Ekaterinburg | 104·6 | −4 | +1 | | | −3 | −37 | | |
| Irkutsk | 109·4 | | −2 | | | −32 | −2 | | |
| Sumoto | 110·2 | | | | | | | +14 | |
| Helwan | 111·6 | | −2 | | | | | −2 | |
| Ksara | 112·3 | | | | | −3 | +1 | | +70 |
| Hukuoka | 113·6 | | | | | | | +4 | |
| Nagasaki | 114·5 | | | | | | | −45 | |
| Baku | 115·3 | | +5 | | SKKS | +9 | +4 | | |
| Riverview | 117·6 | | | | +2 | +2 | +9 | +8+23 | +29+51 |
| Sydney | 117·6 | | | | | −31 | | | |
| Cape Town | 118·9 | | −79 | | | | −2 | | |
| Zi-ka-wei | 120·7 | | −1 | P′ | | | +1 | | |
| Tashkent | 121·1 | | −2 | +7 | | | −8 | +42 | |
| Melbourne | 122·6 | | | | +2 | | +7 | | |
| Entebbe | 126·7 | | | | | | +4 | | |
| Hong Kong | 131·6 | | | | | | +4 | PKS | |
| Manila | 132·4 | | | +7 | | | | +1 | −11 |
| Phu-Lien | 137·0 | | | −15 | | | | | |
| Calcutta | 141·2 | | | | | SKSP | +20 | | |
| Bombay | 143·4 | | | −13 | | +4 | | | |
| Tananarive | 145·1 | | | +4 | | +20 | | | +4+28 |
| Hyderabad | 146·1 | | | −3 | | | | | |
| Perth | 147·0 | | | +8 | | | | | |
| Batavia | 155·4 | | | −14+6 | | | | | |
| Colombo | 156·7 | | | +3 | | | | | |

Mean P residual (Δ>70°), +1 ; S, 0 ; SKS, +3. This earthquake is the subject of a study by I. Lehmann, *Gerlands Beiträge* 28, 1930, 151−164.

Vienna also SKS −10.

1928 April 13d. 23h. 15m. 57s.+16s.=16m.13s. Z=−2.

I.S.S. Epicentre 15°·5N. 96°·4W. Revised Epicentre 15°·1N. 96°·5W.

A=−·1093, B=−·9593, C=+·2605.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Tacubaya | 5·0 | +14 | +14 | | | | | | |
| Merida | 8·8 | +3 | +3 | +2 | +2 | | | | |
| Tucson | 21·6 | +6 | +7 | +18 | +13d | | | | +62 |
| St. Louis | 24·2 | −4 | −1 | +6 | −2d | | | | +55 |
| Denver | 25·7 | −1 | +3 | +2+6 | −8d−4d | | | | |
| Cincinnati | 26·3 | −7 | −3 | −6 | 0 | | | | |
| Chicago | 27·9 | −13 | −8 | −6 | +2 | | | | |
| Charlottesville | 27·9 | −4 | +1 | −5+3 | +3+11 | | | | |
| Georgetown | 29·3 | −6 | 0 | +8 | +16 | | | | |
| Berkeley | 32·1 | −7, 0 | −1+6 | −7−1 | +2+8 | | | | |

*Continued on next page.*

| | Δ | $P_v$ | $P_\omega$ | $S_v$ | $S_\omega$ | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Toronto | 32·2 | −5 | +1 | −11 | −2 | | | | |
| Ithaca | 32·4 | −17 | −11 | −7 | +2 | | | | |
| Harvard | 34·9 | −1 | +4 | +2 | +10 | | | | |
| Ottawa | 35·1 | −10 | −5 | −8 | 0 | | | | |
| Spokane | 36·9 | +10 | +15† | +14 | +22† | | +8 | | |
| Victoria | 39·9 | +2 | +2 | +3 | +10 | | | | |
| La Paz | 42·2 | −3 | +1 | +8+15 | +14+21 | | | | |
| Sucre | 45·9 | −3 | 0 | +6 | +10 | | | | |
| Rio de Janeiro | 64·5 | | | +12 | +11 | | | | |
| Scoresby Sund | 70·7 | −2+15 | −3+14 | +4 | +2 | | | | +74 |
| Edinburgh | 79·4 | | | +3 | 0 | | | | |
| San Fernando | 81·3 | +2 | +2 | −7 | −11 | | | | |
| Oxford | 81·4 | | | +2 | −2 | | | | |
| Kew | 82·0 | +1 | +1 | +1 | −3 | −3 | | | |
| Toledo | 82·3 | 0 | 0 | +1 | −3 | −3 | | | |
| Granada | 83·2 | +2 | +3 | +11 | +7 | | −5 | +21 | |
| Almeria | 84·2 | −1 | 0 | +4 | 0 | | | −1 | |
| Paris | 84·5 | −1 | 0 | +2 | −2 | | | | |
| Uccle | 85·0 | +1 | +2 | | | +1 | | | |
| De Bilt | 85·1 | −1 | 0 | +2 | −2 | | | | |
| Alicante | 85·3 | | | | | −7 | | | |
| Tortosa | 85·4 | −37 | −36 | | | +3 | | | |
| Hamburg | 87·3 | −59 | −58* | | | −1 | | | |
| Feldberg | 87·7 | +3 | +4 | | | +7 | −20 | | −1 |
| Copenhagen | 87·8 | 0 | +1 | | | +3 | −2 | +9+69 | +11 |
| Strasbourg | 87·8 | −1 | 0 | | | −2 | | | |
| Lund | 88·2 | | | | | +2 | −1 | | |
| Algiers | 88·4 | +9 | +10 | +3 | −1 | | −10 | | |
| Upsala | 88·5 | | | +11 | +7 | | | | |
| Moncalieri | 89·1 | +2 | +3 | | | −12+2 | | | |
| Helsingfors | 90·7 | | | | | | +3 | | |
| Rocca di Papa | 93·7 | −29 | −28 | +18 | +44 | | | | |
| Pulkovo | 93·9 | −2 | 0 | | | −1 | −4 | | |
| Zagreb | 94·1 | +9 | +11 | | | +1 | | | |
| Kucino | 99·6 | −10 | −6 | | | −8 | | | |
| Makeyevka | 105·1 | | | | | 0 | −2 | | |
| Ekaterinburg | 105·6 | −4 | +1 | | | −2 | | +1 | |
| Irkutsk | 110·3 | | | P′ | | −4 | +5 | | |
| Ksara | 113·3 | | | −43 | | | | | |
| Baku | 115·6 | | | | | | +12 | +15 | |
| Zi-ka-wei | 121·1 | | | | | | +6 | | |
| Tashkent | 121·4 | | | | | | +6 | | |
| Bombay | 144·3 | | | +10 | | | | | |

Mean P residual (△>70°), 0 ; S, −2 ; SKS, 0.

1928 Aug. 4d. 18h. 26m. 6s.+16s.=26m.22s. Z=+1.

I.S.S. Epicentre 16°·2N. 97°·2W. Revised Epicentre 16°·6N. 97°·8W.

A=−·1300, B=−·9494, C=+·2847.

| | Δ | $P_v$ | $P_\omega$ | $S_v$ | $S_\omega$ | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Puebla | 2·5 | +32 | +32 | | | | | | |
| Vera Cruz | 2·9 | −25 | −25 | −15 | −15 | | | | |
| Tacubaya | 3·2 | +6 | +6 | +11 | +11 | | | | |
| Manzanillo | 6·7 | +33 | +33 | | | | | | |
| Merida | 8·9 | +2 | +2 | −18 | −18 | | | | |
| Mazatlan | 10·5 | −24 | −24† | −17 | −17† | | | | |
| Chihuahua | 14·4 | −21 | −21† | −17 | −18† | | | | |
| Balboa Heights | 19·2 | +6 | +5 | +12 | +9d | | | | |
| Tucson | 19·65 | +4 | +3 | +17 | +14d | | | | |
| Denver | 23·93 | −4 | −1 | −8 | −4 | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Port au Prince | 24·34 | +11 | +14 | −5 | −1 | | | | |
| Chicago | 26·68 | −38 | −34† | −35 | −28† | | | | |
| Charlottesville | 27·34 | −3 | +2 | −8 | 0 | | −3 | | |
| Ann Arbor | 28·38 | +6 | +11 | +26 | +34 | | | | |
| Georgetown | 28·7 | −4 | +1 | +8 | +16 | | +3 | | |
| Lick | 29·5 | −4 | +2 | +6 | +14 | | | | |
| San Juan | 30·2 | −2 | +4 | −31 | −22 | | | | |
| Toronto | 31·3 | −10 | −4 | −2+2 | +7+11 | | −5 | | |
| Ithaca | 31·6 | +21 | +27 | +21 | +30 | | | | |
| Harvard | 34·2 | −6 | −1 | −5 | +3 | | | | |
| Ottawa | 34·3 | −6 | −1 | −3+3 | +5+11 | | +8 | | |
| Saskatoon | 36·2 | −7 | −2 | −5 | +3 | | −5 | | |
| Victoria | 38·1 | −5 | 0 | −3 | +4 | | | | |
| La Paz | 44·17 | 0 | +4 | −8 | −3 | | +2 | | +16 |
| Sucre | 47·9 | −4+1 | −1+5 | −8 | −5 | | −15+19 | | −26 |
| Sitka | 49·3 | −4 | −1 | +3 | +6 | | +7 | | −14 |
| Santiago | 56·3 | +13 | +14† | +23 | +24† | | | | |
| Honolulu T.H. | 56·63 | −3+4 | −2+5 | −5 | −4 | | | | |
| La Plata | 63·92 | −3 | −4 | −10 | −11 | | | | |
| Azores | 65·95 | −11 | −12 | | | | | | |
| Rio de Janeiro | 66·3 | −8 | −9 | −8 | −9 | | | | |
| Reykjavik | 69·0 | +5 | +4 | +14 | +13 | | +3 | | |
| Edinburgh | 78·9 | 0 | 0 | −7 | −10 | | −3 | | |
| Dyce | 79·1 | +2 | +2 | +9 | +6 | | | | −18 |
| Bidston | 79·5 | +1 | +1 | +15 | +12 | | | | |
| Stonyhurst | 79·9 | −2 | −2 | +9 | +6 | | −1 | | |
| Oxford | 81·0 | −1 | −1 | +1 | −3 | | +35 | | +22 |
| San Fernando | 81·47 | +2 | +2 | +5 | +1 | | +22 | −9 | |
| Kew | 81·7 | −2 | −2 | +12 | +8 | | 0 | | −32 |
| Bergen | 82·0 | +7 | +7 | +17 | +13 | | +9 | | |
| Toledo | 82·3 | −3 | −3 | +10 | +6 | | | | |
| Malaga | 82·8 | −3 | −3 | +4 | 0 | | | | |
| Granada | 83·4 | −3 | −2 | +5 | +1 | | +9 | +1 | |
| Paris | 84·2 | +5 | +6 | +1 | −3 | | +8 | | |
| Almeria | 84·4 | −2 | −1 | 0 | −4 | | −3 | | |
| Bagnères | 84·6 | +3 | +4 | +2 | −2 | | +7 | +17 | |
| De Bilt | 84·7 | −2 | −1 | +4 | 0 | | −2 | | +6 |
| Uccle | 84·7 | −4 | −3 | +9 | +5 | | −4 | | +11 |
| Alicante | 85·3 | +2 | +2 | +2 | −2 | | | | |
| Tortosa | 85·4 | −3 | −2 | +7 | +3 | | | | |
| Barcelona | 86·3 | +1 | +2 | −1 | −5 | | | +21 | |
| Hamburg | 86·8 | −4 | −3 | 0 | −4 | | −1 | +10 | +11 |
| Besançon | 86·9 | −1 | 0 | +3 | −1 | | −3 | +19 | |
| Copenhagen | 87·2 | −3 | −2 | +1 | −3 | −18 | 0 | +21 | −17+17 |
| Feldberg | 87·3 | −58 | −57* | −43 | −47* | −31−42 | | | 0 |
| Grenoble | 87·4 | +6 | +7 | +15 | +11 | | | +25 | +26 |
| Neuchâtel | 87·5 | −3 | −2 | | | | | | |
| Strasbourg | 87·5 | −3 | −2 | +1 | −3 | | −5 | +12 | +12 |
| Lund | 87·6 | −2 | −1 | | | −17 | | | |
| Upsala | 87·8 | −3 | −2 | | | −5 | −2 | | |
| Hohenheim | 88·4 | +1 | +2 | 0 | −4 | | −2 | | +12 |
| Algiers | 88·5 | −2 | −1 | | | +3 | | | |
| Zürich | 88·5 | −4 | −3 | | | +3 | | | |
| Moncalieri | 88·8 | −4 | −3 | | | +7 | | | |
| Jena | 88·9 | −3+2 | −2+3 | | | +2+13 | −7 | +3 | |
| Ravensburg | 88·9 | +2 | +3 | | | +6 | +7 | | |
| Potsdam | 89·1 | +3 | +4 | | | +9 | −5 | | |
| Chur | 89·3 | +2 | +3 | | | −17 | | | |
| Suva | 89·5 | +12 | +13 | | | +9 | | | +26 |
| Helsingfors | 90·6 | +56 | +58* | | | | | | |
| Florence | 91·6 | −5 | −3 | | | −6 | | | |
| Venice | 91·7 | −4 | −2 | | | −5 | | | |
| Königsberg | 91·7 | −11−4 | −9−2 | | | −5 | −6+8 | +3+13 | |
| Laibach | 92·7 | +2 | +4 | | | −1 | −1 | | |
| Vienna | 92·8 | +2 | +4 | | | −1 | −3 | −25+16 | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Graz | 92·9 | −39 | −37 | | | −18 | −2 | +3+19 | |
| Pulkovo | 92·9 | −5 | −3 | | | −13 | 0 | +17 | |
| Rocca di Papa | 93·4 | −5, 0 | −3+2 | +11+33 | +7+29 | +11 | | −32 | |
| Zagreb | 93·7 | −4+2 | −2+4 | +33 | +29 | +1 | 0 | −33+25 | +11 |
| Budapest | 94·8 | +2 | +4 | | | −3 | | | |
| Pompeii | 95·1 | +5 | +8 | | | −14 | | | |
| Lemberg | 96·2 | −15−9 | −12−6 | | | | | | |
| Ootomari | 96·7 | | | | | | | | +7 |
| Belgrade | 96·9 | −1 | +2 | | | −13 | −58* | | |
| Kucino | 98·4 | −25 | −22 | | | +14 | −28 | −16 | |
| Wellington | 99·0 | −34−20 | −31−17 | | | −13−8 | +4 | | +19 |
| Christchurch | 101·0 | | | | | | | | |
| Makeyevka | 104·3 | −7 | −3 | | | +1 | | +5 | |
| Ekaterinburg | 104·3 | −8 | −4 | | | | +3 | +4 | |
| Sebastopol | 104·5 | | | | | | +8 | | |
| Simferopol | 104·6 | | | | | | +7 | | |
| Yalta | 104·9 | | | | | | −2 | | |
| Theodosia | 105·1 | | | | | | 0 | | |
| Irkutsk | 108·4 | | −5 | | | | −3 | +6 | +9 |
| Helwan | 112·5 | | 0 | | SKKS | | −1 | +6 | |
| | | P′ | | | | | | | |
| Nagasaki | 112·9 | −19 | | | | | −26 | +10 | |
| Ksara | 113·1 | −20 | | | +17 | −11 | +2 | +5 | 0 |
| Riverview | 116·3 | | | | | −1 | +8 | | |
| Zi-ka-wei | 119·0 | | | | | | −1 | +44 | |
| Cape Town | 120·7 | | | | | | +4 | +4 | |
| Tashkent | 120·7 | | −7 | | | | +1 | +5 | |
| Melbourne | 121·4 | | | | | −11 | +13 | −3 | |
| Adelaide | 126·6 | | | | | | | −17 | −10 |
| Entebbe | 128·2 | | | | | | −5 | | |
| Hong Kong | 130·0 | | | | | | −1 | | |
| Manila | 130·6 | | | | | | −7 | | |
| Phu-Lien | 135·7 | | SKSP | | | | −5 | | |
| Bombay | 143·2 | −6 | +2 | | | | | | |
| Hyderabad | 145·7 | +17 | | | | | | | |
| Tananarive | 146·9 | −2 | +17 | | +6 | −28 | +6 | | +6+41 |
| Kodaikanal | 152·7 | | | | | | −15 | | |
| Batavia | 153·7 | −36 | | | −22 | | | | |
| Colombo | 156·3 | +3 | | | | | | | |

Mean P residual ( Δ>70°), −2; S,−3; SKS,−2.

1928 Oct. 9d. 3h. 1m. 0s.+13s.=1m.13s. Z=0.

I.S.S. Epicentre 16°·2N. 97°·2W. Revised Epicentre 16°·2N. 97°·5W.

A=−·1253, B=−·9520, C=+·2790.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Puebla | 2·9 | −2 | −2 | −5 | −5 | | | | |
| Vera Cruz | 3·3 | +4 | +4 | | | | | | |
| Tacubaya | 3·7 | −3 | −3 | 0 | 0 | | | | |
| Manzanillo | 7·1 | −12 | −12† | −13 | −13† | | | | |
| Guadalajara | 7·3 | +24 | +24† | +24 | +24† | | | | |
| Merida | 8·8 | −33 | −33 | −14 | −14 | | | | |
| Chihuahua | 14·7 | −17 | −17† | −13 | −15† | | | | |
| Balboa Heights | 18·8 | −1 | −2 | +16 | +13 | | | | |
| Tucson | 20·12 | +4 | +4 | +10 | +6d | | +8 | | |
| Florissant | 23·47 | −5 | −3 | | | | −19 | | |
| Port au Prince | 24·13 | −6 | −3 | +5 | −3d | | | | |
| Cincinnati | 25·60 | −2 | +2 | +8 | −2 | | +1 | | +16 |
| Chicago | 27·0 | −57 | −53* | −61 | −54* | | +3 | | |
| Charlottesville | 27·49 | −8 | −3 | −8 | 0 | | | | |
| Ann Arbor | 28·6 | −5 | 0 | +15 | +23 | | | | |

*Continued on next page.*

| | △ ° | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| Georgetown | 28·9 | −4 | +1 | −11 | −3 | | −1+10 | | +1+[illegible] |
| Lick | 30·0 | −4+4 | +2+10 | −3 | +5 | | | | |
| Berkeley | 30·8 | −3 | +3 | −4 | +4 | | | | +53 |
| Toronto | 31·4 | −10 | −4 | −12 | −3 | | | | |
| Harvard | 34·4 | −33 | −28† | −32 | −24† | | | | −15 |
| Ottawa | 34·4 | −4 | +1 | −5 | +3 | | −2 | | −17+[illegible] |
| Spokane | 35·5 | | | −15−10 | −7−2 | | | | |
| Saskatoon | 36·7 | −4 | +1 | −7 | +1 | | +9 | | −13+44 |
| Victoria | 38·6 | −8 | −4 | −3 | +4 | | | | |
| Halifax | 40·3 | −11 | −7 | −9 | −2 | | 0 | | +29 |
| La Paz | 43·68 | −2 | +2 | −2+3 | +3+8 | | +4 | | +23 |
| Sucre | 47·4 | −2 | +1 | −1 | +3 | | +4 | | −12 |
| Sitka | 49·8 | +2 | +3 | +9 | +12 | | +10 | | +41 |
| Santiago | 55·8 | 0 | +1 | +6 | +7 | | | | |
| Honolulu T.H. | 57·0 | +4 | +4 | +8 | +9 | | | | −14 |
| La Plata | 63·4 | −3 | −4 | −6 | −7 | | | | |
| Rio de Janeiro | 65·9 | +4 | +3 | +3 | +2 | | | | |
| Reykjavik | 69·1 | +3 | +2 | +28 | +27 | | | −6 | |
| Scoresby Sund | 70·0 | −3 | −4 | 0 | −2 | | −2 | | |
| Edinburgh | 79·1 | −3 | −3 | −4 | −7 | | 0 | | |
| Dyce | 79·3 | −1 | −1 | +26 | +23 | | +7 | −7 | |
| Apia | 79·4 | +28 | +28† | +53 | +50† | | | +20 | +42 |
| Bidston | 79·6 | −1 | −1 | −1 | −2 | | | | |
| Stonyhurst | 80·0 | −3 | −3 | +3 | 0 | | −2 | | +8 |
| Oxford | 81·1 | 0 | 0 | +3 | −1 | | +12+46 | | |
| San Fernando | 81·4 | +4 | +4 | +19 | +15 | | | | |
| Kew | 81·8 | −2 | −2 | +6+13 | +2+9 | | −3 | +13 | −32 |
| Toledo | 82·19 | −3 | −3 | +7 | +3 | | | | |
| Bergen | 82·2 | +7 | +7 | +7 | +3 | | +17 | | |
| Malaga | 82·7 | +18 | +18† | +26 | +22† | | | | |
| Le Mans | 83·0 | −37 | −37† | −16 | −20† | | | | |
| Granada | 83·30 | −1 | 0 | | | | +4 | +32 | |
| Paris | 84·24 | −1 | 0 | +5 | +1 | | +6 | | |
| Almeria | 84·3 | −4 | −3 | | | +1 | | | |
| Bagnères | 84·6 | +3 | +4 | +26 | +22 | | −9 | | |
| De Bilt | 84·79 | −1 | 0 | +4 | 0 | | | | |
| Uccle | 84·8 | −1 | 0 | +5 | +1 | | −4 | | |
| Alicante | 85·3 | +6 | +7 | +7 | +3 | | | | |
| Tortosa | 85·4 | −2 | −1 | 0 | −4 | | | | |
| Barcelona | 86·3 | −1 | 0 | | | +5 | +1 | +22 | |
| Besançon | 87·0 | +4 | +5 | | | −2 | −1 | +10 | |
| Hamburg | 87·0 | −1 | 0 | | | +7 | −6 | +18 | −4 |
| Feldberg | 87·4 | 0 | +1 | 0 | −4 | | −15−1 | +19 | |
| Copenhagen | 87·4 | −1 | 0 | −2 | −6 | | −6 | −15+19 | −8 |
| Grenoble | 87·5 | 0 | +1 | | | −71 | +6 | | |
| Neuchâtel | 87·6 | +1 | +2 | | | −7 | | | |
| Strasbourg | 87·6 | −1 | 0 | | | +11 | −1 | +12 | +23 |
| Lund | 87·8 | +1 | +2 | +17 | +13 | +11 | | −34+19 | −7 |
| Upsala | 87·9 | −7 | −6 | | | −3 | −5 | | |
| Marseilles | 88·0 | +19 | +20† | +23 | +19† | | +39† | +32 | |
| Algiers | 88·5 | −2 | −1 | | | +3 | | | |
| Hohenheim | 88·5 | 0 | +1 | | | +6 | +2 | | |
| Zürich | 88·6 | 0 | +1 | | | +10 | | | |
| Moncalieri | 88·9 | +1 | 0 | | | −25 | | | |
| Jena | 89·0 | −7−1 | −6, 0 | +4 | 0 | 0 | −6, 0 | +17 | −30+42 |
| Ravensburg | 89·0 | −3 | −2 | | | +3 | −1 | +3 | +33 |
| Potsdam | 89·2 | +3 | +4 | | | −3 | +21 | −25−17 | |
| Chur | 89·4 | −2 | −1 | | | +5 | | | |
| Suva | 89·6 | +20 | +21† | | | | +24† | | +33 |
| Innsbruck | 90·4 | −2 | −1 | +6 | +2 | 0 | 0 | −6+24 | |
| Helsingfors | 90·8 | −3 | −1 | | | +6 | | | |
| Florence | 91·7 | −5 | −3 | | | +4 | | | |
| Venice | 91·8 | 0 | +2 | | | 0 | | | |
| Königsberg | 91·9 | +2 | +4 | +23 | +19 | +5 | −2 | +14+40 | +7 |
| Laibach | 92·8 | −6 | −4 | | | | +2 | +19 | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | SKKS | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Vienna | 92·9 | −4 | −2 | | | −8+7 | −1 | −35+29 | +41 |
| Graz | 93·0 | +8 | +10 | | −10 | +18 | | −20+31 | |
| Pulkovo | 93·1 | −2 | 0 | | | −5 | −25 | | |
| Rocca di Papa | 93·5 | −11−2 | −9, 0 | | | +1 | +15 | | |
| Zagreb | 93·8 | +1 | +3 | | | −3+12 | −1 | +2+24 | −1 |
| Budapest | 94·9 | +3 | +5 | | | +9 | +8 | +14 | |
| Naples | 94·9 | −13 | −11 | | | +3 | | | |
| Pompeii | 95·2 | −7 | −5 | | | +4 | | | |
| Belgrade | 97·0 | −9 | −6 | | | +5 | | | |
| Ootomari | 97·1 | | | | | | | | −8 |
| Kucino | 98·6 | +13 | +16 | | | +9 | +10 | +26 | |
| Wellington | 99·0 | −34 | −31 | | | −14 | +7 | | |
| Christchurch | 101·0 | | | | | +9 | | | |
| Sebastopol | 104·7 | | | | | +3 | | | |
| Ekaterinburg | 104·7 | −2 | +3 | | | −18 | +6 | | |
| Simferopol | 104·8 | | | | | 0 | | | |
| Yalta | 105·1 | | | | | −48 | | | |
| Theodosia | 105·3 | P′ | +11 | | | +1 | | | |
| Kobe | 108·7 | +4 | | | | | | | |
| Irkutsk | 108·9 | | | | | −16 | −6 | −1 | |
| Hukuoka | 112·4 | | | | | | +3 | | |
| Helwan | 112·5 | | 0 | | | | | +11 | |
| Ksara | 113·1 | | | | −15 | −1 | −1 | | |
| Nagasaki | 113·4 | | | | | | +6 | | |
| Baku | 115·8 | | −10 | | | | +6 | +14 | |
| Riverview | 116·4 | −2 | | | +5 | +1 | +12 | | +54 |
| Sydney | 116·4 | | | | | −11 | −15 | | |
| Zi-ka-wei | 119·5 | +1 | | | | | | | |
| Cape Town | 120·3 | | | | | | −6 | | |
| Almata | 120·3 | +25 | | | | | | | |
| Frunse | 120·4 | +11 | | | | | | | |
| Tashkent | 121·1 | +2 | +3 | | | −2 | −12 | | |
| Melbourne | 121·5 | | | | | −1 | −2 | | +26 |
| Adelaide | 126·7 | +34 | SKSP | | | | | | +11 |
| Entebbe | 128·0 | −1 | +20 | | | | 0 | | |
| Hong Kong | 130·5 | +9 | | | | | −1 | | +12 |
| Manila | 131·1 | +1 | | | | | | | |
| Dehra Dun | 133·2 | +8+17 | | | −8 | | +11 | | |
| Amboina | 133·4 | | +3 | | | | | | |
| Calcutta | 140·9 | +28 | | | | | | | |
| Bombay | 143·6 | −1 | +4 | | | | | | |
| Perth | 146·0 | −7+3 | | | | | | | +26 |
| Hyderabad | 146·1 | +1 | | PKS | | | | | |
| Tananarive | 146·6 | −1+41 | +13 | −13 | −1 | −15+3 | −10 | | +20 |
| Kodaikanal | 153·1 | +45 | | | | | | | |
| Malabar | 153·9 | 0 | | | | | | | |
| Batavia | 154·1 | −3+3 | | | | | | | |

Mean P residual (Δ>90°), 0; S, 0; **SKS**, +2.

Melbourne 30m.2s. may be SKSP.

1929 Jan. 24d. 20h. 36m. 28s.+18s.=36m.46s. Z=+2.

I.S.S. Epicentre 12°·8N. 91°·0W. Revised Epicentre 13°·3N. 90°·7W.

A=−·0122, B=−·9731, C=+·2300.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Merida | 7·8 | −13 | −13 | +4 | +4 | | | | |
| Vera Cruz | 8·0 | −28 | −28† | −21 | −21† | | | | |
| Puebla | 9·2 | −29 | −29† | −18 | −18† | | | | |
| Tacubaya | 10·17 | +2 | +2 | +12 | +12 | | | | |
| Balboa Heights | 11·8 | −11 | −11† | −8 | −8† | | | | |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Manzanillo | 14·2 | −16 | −16† | −11 | −12† | | | | |
| Mazatlan | 17·8 | −20 | −21† | −9 | −11† | | | | |
| Port au Prince | 18·43 | +9 | +8 | +6 | +4 | | | | |
| Chihuahua | 21·0 | −18 | −18 | −5 | −4 | | | | |
| St. Louis | 25·35 | −5 | −1 | −6 | 0 | | +6 | | |
| Florissant | 25·6 | −7 | −3 | −11 | −5 | | | | |
| Cincinnati | 26·42 | 0 | +4 | −4 | +3 | | | | |
| Tucson | 26·44 | −2 | +2 | −4+1 | +3+8 | | | | |
| Charlottesville | 27·02 | −27−3 | −22+2 | −11−7 | −4, 0 | | +25 | | |
| Georgetown | 28·4 | −3+7 | +2+12 | −26−22 | −18−14 | | −8 | | |
| Chicago | 28·6 | −4+9 | +1+14 | −1+12 | +7+19 | | | | |
| Denver | 29·3 | −64 | −58* | −69 | −61* | | | | |
| Ann Arbor | 29·7 | 0 | +6 | +16 | +24 | | +4 | | |
| Fordham | 31·3 | 0 | +6 | +1 | +10 | | | | |
| Toronto | 31·9 | −9−6 | −3, 0 | −11 | −2 | | | | |
| Harvard | 33·7 | −5 | +1 | −6 | +3 | | | | |
| Ottawa | 34·5 | −6 | −1 | −8 | 0 | | | | |
| Lick | 36·57 | −4 | +1 | −3 | +5 | | +4 | | |
| La Paz | 37·23 | −3 | +2 | −9 | −1 | | | | |
| Berkeley | 37·4 | −2 | +3 | −2 | +6 | | | | |
| Sucre | 40·9 | −3 | +1 | +3 | +9 | | +12 | | |
| Victoria | 44·26 | −2 | +1 | | | | | | |
| Sitka | 55·3 | | | +17 | +21 | | | | |
| La Plata | 57·3 | +12 | +12 | −11 | −7 | | | | |
| Rio de Janeiro | 59·0 | −1 | −1 | −9−2 | −6+1 | | | | |
| Honolulu T.H. | 64·12 | | | +1 | 0 | | | | |
| Scoresby Sund | 70·5 | −1 | −2 | −19 | −21 | | | +4 | |
| Edinburgh | 77·5 | +2 | +2 | +21 | +18 | | | −8 | |
| San Fernando | 77·8 | +18 | +18 | +4 | +1 | | | | |
| Bidston | 78·0 | +71 | +71 | +36 | +33 | | | +6 | |
| Stonyhurst | 78·3 | −1 | −1 | +11 | +8 | | | | |
| Dyce | 78·5 | +28 | +28 | −8 | −11 | | | | |
| Toledo | 79·0 | −2 | −2 | +5 | +2 | | | | |
| Malaga | 79·2 | −28 | −28 | +6 | +3 | | | | |
| Oxford | 79·3 | −6 | −6 | +1 | −2 | | | −1 | +23 |
| Granada | 79·7 | −6 | −6 | +16 | +13 | | | | |
| Kew | 79·9 | −4 | −4 | −2 | −6 | | +5 | | −37+3 |
| Almeria | 80·8 | −8 | −8 | +11 | +7 | | | | |
| Bergen | 81·5 | +81 | +81† | +77 | +73† | | | | |
| Alicante | 81·9 | −11 | −11 | −23 | −27 | | | | |
| Paris | 82·2 | 0 | 0 | +13 | +9 | | | | |
| Tortosa | 82·3 | | | −12+12 | −16+8 | | | | |
| Uccle | 82·9 | −3 | −3 | +5 | +1 | | +2 | | |
| De Bilt | 83·1 | −1 | 0 | +3 | −1 | −1 | −1 | | +11 |
| Barcelona | 83·4 | −49 | −48 | −29 | −33 | | | | |
| Algiers | 85·1 | +1 | +2 | | | +4 | | +24 | |
| Neuchâtel | 85·5 | −3 | −2 | | | +1 | +1 | | |
| Strasbourg | 85·6 | −2 | −1 | +6 | +2 | | −6 | +20 | +27 |
| Feldberg | 85·6 | +31 | +32 | | | | | | |
| Hamburg | 85·6 | −1 | 0 | | | +3 | | | +4 |
| Göttingen | 86·2 | −5+2 | −4+3 | | | +5 | +18 | | |
| Copenhagen | 86·3 | −2 | −1 | | | −1 | −19 | +22 | +17 |
| Moncalieri | 86·5 | −58 | −57* | | | +2 | | | |
| Zürich | 86·5 | −19 | −18 | | | +2 | | | |
| Lund | 86·7 | +1 | +2 | | | | | +28 | |
| Ravensburg | 86·9 | −6 | −5 | | | +2 | | | |
| Chur | 87·2 | +2 | +3 | | | +2 | | | |
| Jena | 87·3 | −32−3 | −31−2 | | | −1 | | +27 | +3 |
| Upsala | 87·5 | −4 | −3 | | | −2 | | | |
| Florence | 89·3 | −2 | −1 | | | −14 | | | |
| Venice | 89·4 | −42 | −41 | | | | | | |
| Helsingfors | 90·7 | −3 | −1 | +5 | +1 | 0 | +3 | | |
| Graz | 91·0 | +6 | +8 | | | +1 | | | |
| Vienna | 91·2 | −15 | −13 | | | | +11 | | |
| Zagreb | 91·8 | +1 | +3 | | | −3+11 | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Naples | 92·3 | | | −1 | −5 | | | | |
| Pulkovo | 93·1 | −4 | −2 | | | −3+11 | +2 | | |
| Kucino | 98·7 | −1 | +2 | | | −5 | +2 | +1 | +3 |
| Wellington | 102·0 | | | | | −2 | | | |
| Sebastopol | 103·3 | | | | | 0 | | | |
| | | | | P′ | | | | | |
| Theodosia | 104·1 | | | −35 | | | | | |
| Ekaterinburg | 106·0 | | −1 | | | −3 | −4 | −29 | |
| Helwan | 109·5 | | | | | +2 | | | |
| Ksara | 110·7 | | | | | | | +14 | |
| Irkutsk | 113·3 | | −2 | −18 | | +1 | | +10 | +21 |
| Riverview | 120·6 | | −68 | | | | +38 | +2+16 | +1 |
| Frunse | 122·2 | | | −9 | | | | | |
| Tashkent | 122·4 | | −16 | −1 | | | −1 | −23 | −35 |
| Samarkand | 123·2 | | | +17 | | | | | |
| Melbourne | 125·1 | | | | | −4 | +2 | −2 | −8 |
| | | PKS | SKSP | | | | | | |
| Adelaide | 130·7 | −8 | | | | | | | |
| Hong Kong | 136·8 | −3 | +20? | | | | +23 | −9? | |
| Manila | 138·0 | | | −11 | | | | | |
| Tananarive | 139·60 | | | | | | +1 | +15 | +17 |
| Phu-Lien | 141·9 | | | −18 | | | | | +25 |
| Bombay | 144·0 | | −6 | −3 | | | | | |
| Calcutta | 144·2 | | | −9 | | | | +11 | |
| Hyderabad | 147·5 | | | −3 | | | | | |
| Perth | 149·3 | | | +28 | | | | | |
| Kodaikanal | 153·7 | | | | | | +33 | | |
| Colombo | 157·8 | | | −22 | | | | | |
| Batavia | 161·3 | | | −1 | | | | | |

Mean P residual (Δ>70°), 0; S, 0; SKS, 0.

Tashkent 30m.2s., Melbourne 30m.48s. may be SKSP.

1929 Feb. 2d. 0h. 0m. 14s.+11s.=0m.25s. Z=0.

I.S.S. Epicentre 1°·5S. 21°·8W. Retained.

A=+·928, B=−·371, C=−·026.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Rio de Janeiro | 29·8 | −6 | 0 | −14−8 | −6, 0 | | | | |
| San Fernando | 40·6 | −4 | 0 | −65 | −59* | | | | |
| Malaga | 41·5 | −3 | +1 | +18 | +24 | | | | |
| Granada | 42·2 | −3 | +1 | | | | | | |
| Almeria | 42·4 | +163 | +167† | +115 | +121† | | | | |
| Alicante | 44·4 | −16 | −13† | −39 | −34† | | | | |
| Toledo | 44·4 | −12 | −9† | −23 | −18† | | | | |
| Algiers | 44·7 | −5 | −2 | +10 | +14 | | 0 | | +19 |
| Sucre | 46·0 | 0 | +3 | +20 | +24 | | −14 | | |
| Tortosa | 46·9 | −4 | −1 | −15 | −11 | | | | |
| La Plata | 47·4 | −5 | −2 | −4 | 0 | | | | |
| La Paz | 48·0 | −7 | −4 | +13 | +16 | | −5 | | |
| Barcelona | 48·1 | −4 | −1 | −16 | −13 | | | | |
| Bagnères | 48·8 | −3 | 0 | | | | | | −7 |
| Cape Town | 49·6 | +10 | +13 | +9 | +12 | | | | |
| Grenoble | 52·7 | +4 | +6 | +7 | +9 | | | | |
| Moncalieri | 53·3 | −3 | −1 | −9 | −7 | | | | |
| Naples | 53·5 | +12 | +11 | −12 | −10 | | | | |
| Florence | 54·1 | −5 | −4 | −8 | −6 | | +22 | | |
| Entebbe | 54·3 | +8 | +9 | | | | | | |
| Besançon | 54·4 | −1 | 0 | 0 | +1 | | | | |
| Chur | 55·5 | −9 | −8 | | | | | | |
| Zürich | 55·6 | −1 | 0 | −2 | −1 | | | | |
| Paris | 55·7 | −11 | −10 | −21 | −20 | | | | |
| Santiago | 55·7 | −6 | −5 | +9 | +10 | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Venice | 55·8 | 0 | +1 | +5 | +6 | | | | |
| Kew | 56·0 | −3 | −2 | −2 | −1 | | | | |
| Oxford | 56·0 | +6 | +7 | +1 | +2 | | | | |
| Strasbourg | 56·2 | −1 | 0 | 0 | +1 | | +20 | +21 | |
| West Bromwich | 56·5 | −3 | −2 | | | | | | |
| Innsbruck | 56·7 | −10 | −9 | −2 | −1 | | | +19 | |
| Uccle | 56·8 | −1 | 0 | −1 | 0 | | | | |
| Bidston | 57·1 | +6 | +6 | −3 | −2 | | | | |
| Laibach | 57·3 | −1 | −1 | +18 | +19 | | | | |
| Stonyhurst | 57·7 | −6 | −6 | −2 | −1 | | | | |
| Feldberg | 57·8 | 0 | 0 | 0 | +1 | | | | |
| Zagreb | 57·8 | 0 | 0 | −16−3 | −15−2 | | 0 | +20 | −21 |
| De Bilt | 58·2 | −1 | −1 | +1 | +1 | | | | |
| Balboa Heights | 58·5 | −15 | −15 | −22−18 | −22−18 | | | | |
| Graz | 58·5 | 0 | 0 | +7 | +7 | | | | |
| Halifax | 59·2 | +2 | +2 | +2 | +2 | | | | |
| Edinburgh | 59·3 | | | +4 | +4 | | | | −29 |
| Göttingen | 59·4 | −3+1 | −3+1 | +3+11 | +3+11 | | | | |
| Helwan | 59·5 | +4 | +4 | +4 | +4 | | | | |
| Belgrade | 59·6 | 0 | 0 | +1 | +1 | | | | |
| Jena | 59·6 | +1 | +1 | +55+70 | +55+70 | | | | |
| Vienna | 59·7 | −2 | −2 | +6 | +6 | | −9 | +39 | |
| Budapest | 60·5 | +1 | 0 | +16 | +16 | | | | −18 |
| Dyce | 60·8 | 0 | −1 | −4 | −4 | | | | |
| Hamburg | 61·1 | −1 | −2 | +5 | +5 | | | | |
| Harvard | 62·4 | +14 | +13 | −4 | −4 | | | | |
| Copenhgen | 63·6 | 0 | −1 | 0 | 0 | | | | |
| Lund | 63·9 | +1 | 0 | +8 | +7 | | | | |
| Georgetown | 64·7 | +3 | +2 | +5 | +4 | | | +27 | |
| Charlottesville | 65·4 | −5 | −6 | −1 | −2 | | | | −33 |
| Ithaca | 65·9 | −6 | −7 | −7 | −8 | | | | |
| Königsberg | 66·1 | 0 | −1 | +5 | +4 | | −10 | +12 | 0 |
| Ottawa | 66·8 | +1 | 0 | −4 | −5 | | | | +34 |
| Sebastopol | 67·2 | 0 | −1 | | | | | | |
| Yalta | 67·6 | +1 | 0 | | | | | | |
| Simferopol | 67·8 | +1 | 0 | | | | | | |
| Toronto | 68·3 | −14 | −15 | +1 | 0 | | | −5 | |
| Theodosia | 68·6 | +2 | +1 | | | | | | |
| Upsala | 68·6 | −1 | −2 | −7 | −9 | | | | |
| Merida | 70·0 | −35 | −36† | −23 | −25† | | | | |
| Tananarive | 70·0 | +18 | +17 | −66 | −68 | | | +42 | |
| Cincinnati | 70·2 | −2 | −3 | −7 | −9 | | +11 | +4 | +3 |
| Ann Arbor | 70·7 | −3 | −4 | −10 | −12 | | −20 | +17 | |
| Helsingfors | 71·4 | +1 | 0 | +1 | −1 | | +24 | +10 | |
| Scoresby Sund | 72·0 | +16 | +15 | +25 | +23 | | | | |
| Chicago | 73·2 | −4 | −5 | −5 | −8 | | | | −35 |
| Pulkovo | 73·3 | −1 | −2 | −4 | −7 | | | | |
| St. Louis | 74·2 | +5 | +4 | 0 | −3 | | | | |
| Florissant | 74·4 | +2 | +1 | 0 | −3 | | | +7 | |
| Kucino | 74·8 | +8 | +7 | −4 | −7 | | | | |
| Vera Cruz | 76·4 | −1 | −1 | | | | | | |
| Baku | 77·2 | +3 | +3 | | | | | +14 | |
| Tacubaya | 78·6 | +12 | +12† | +14 | +11† | | | | |
| Ekaterinburg | 87·1 | +2 | +3 | −3 | −7 | | | | |
| Tucson | 90·0 | +6 | +7 | 0 | −4 | | | | |
| Tashkent | 91·8 | −15 | −14 | | | | | | |
| Bombay | 94·9 | +57 | +59* | −58 | −62* | +30 | | | |
| Frunse | 95·7 | −2 | +1 | | | | | | |
| Victoria | 98·7 | +36 | +39 | | | | | −30 | |
| Lick | 98·7 | +5 | +8 | | | | +19 | | |
| Berkeley | 99·2 | | | −6 | −10 | | −11 | | +11 |
| Colombo | 101·7 | +2 | +6 | | | | | | |
| Sitka | 103·9 | | | +21 | +17 | | | | +21 |

*Continued on next page.*

| | Δ | PKS | P′ | PP | SS |
|---|---|---|---|---|---|
| | ° | | | | |
| Batavia | 128·1 | | −17 | | |
| Hong Kong | 132·4 | −25 | | | |
| Honolulu T.H. | 132·8 | | | | −6+23 |
| Christchurch | 133·2 | | | −7 | −8 |
| Wellington | 134·6 | +18 | | +15 | +44 |
| Melbourne | 138·8 | +5 | | | +46 |
| Adelaide | 139·2 | −14 | | | |
| Manila | 141·0 | +5 | | | |
| Riverview | 144·1 | | +9 | +22 | +51 |
| Sydney | 144·1 | | | | −15 |
| Suva | 152·1 | | −15 | | |

Mean P residual (Δ>70°), 0? ; S, −6.

1929 Feb. 10d. 15h. 39m. 4s.+13s.=39m.17s.  Z=−3.

I.S.S. Epicentre 13°·9N. 91·2W. Revised Epicentre 13°·3N. 90°·7W.

A=−·0122, B=−·9731, C=+·2300.

| | Δ | $P_v$ | $P_\omega$ | $S_v$ | $S_\omega$ | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Oaxaca | 6·2 | +27 | +27 | | | | | | |
| Merida | 7·8 | −25 | −25 | −23 | −23 | | | | |
| Vera Cruz | 8·0 | +15 | +15 | −2 | −2 | | | | |
| Puebla | 9·2 | +1 | +1 | −14 | −14 | | | | |
| Tacubaya | 10·17 | +4 | +4 | −4 | −4 | | | | |
| Balboa Heights | 11·8 | +9 | +9 | +33 | +33 | | | | |
| Manzanillo | 14·2 | −14 | −14 | −57 | −58 | | | | |
| Port au Prince | 18·43 | +7 | +6 | +66 | +64 | | | | |
| St. Louis | 25·35 | −5 | −1 | +2 | +8 | | | | |
| Florissant | 25·6 | −7 | −3 | −2 | +4 | | +8 | | +10 |
| Cincinnati | 26·42 | −9 | −5 | +12 | +1d | | | | |
| Tucson | 26·44 | −4 | 0 | | | | | | |
| Charlottesville | 27·02 | −2 | +3 | −5 | +2 | | | | |
| Georgetown | 28·4 | −6+2 | −1+7 | +21 | +29 | | | | |
| Chicago | 28·6 | −5+2 | 0+7 | −15−7 | −7+1 | | +5 | | |
| Ann Arbor | 29·7 | −7 | −1 | +8 | +16 | | +9 | | |
| Fordham | 31·3 | +37 | +43 | +52 | +61 | | | | |
| Ithaca | 31·8 | −11 | −5 | −5 | +4 | | | | |
| Toronto | 31·9 | −7 | −1 | −19−4 | −10+5 | | | | −12 |
| Harvard | 33·7 | −7 | −1 | −14 | −5 | | | | |
| Ottawa | 34·5 | −5 | 0 | −12 | −3 | | | | +10 |
| Lick | 36·57 | −5 | 0 | −6 | +2 | | | | |
| La Paz | 37·23 | −1 | +4 | +13 | +21 | | | | |
| Berkeley | 37·4 | −12−6 | −7−1 | −8 | 0 | | | | |
| Sucre | 40·9 | +14 | +18 | +13 | +19 | | +12 | | +14 |
| Victoria | 44·26 | −6 | −3 | −2 | +3 | | | | |
| Rio de Janeiro | 59·0 | +2 | +2 | +5 | +5 | | | | |
| Honolulu T.H. | 64·12 | | | +5 | +4 | | | | |
| Scoresby Sund | 70·5 | 0 | −1 | −3 | −5 | | −4 | | −11 |
| San Fernando | 77·8 | −5 | −5 | +30 | +27 | | | −5 | |
| Stonyhurst | 78·3 | +6 | +6 | | | | | +23 | |
| Toledo | 79·0 | 0 | 0 | +4 | +1 | | | | |
| Malaga | 79·2 | +3 | +3 | +2 | −2 | | | | |
| Granada | 79·7 | +2 | +2 | +7 | +3 | | | | |
| Kew | 79·9 | −1 | −1 | | | | | −3 | |
| Alicante | 81·9 | −21 | −21 | −40 | −44 | | | | |
| Uccle | 82·9 | −4 | −4 | −5 | −9 | | | | |
| De Bilt | 83·1 | +1 | +2 | +10 | +6 | | | | +9 |
| Algiers | 85·1 | 0 | +1 | | | 0 | | | |
| Hamburg | 85·6 | +16 | +17 | | | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SKKS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Strasbourg | 85·6 | −1 | 0 | +2 | −2 | | −3 | | |
| Göttingen | 86·2 | | | | | −18 | | | |
| Copenhagen | 86·3 | −11 | −10 | +2 | −2 | | −7 | | |
| Zürich | 86·5 | −2 | −1 | | | −2 | | | |
| Moncalieri | 86·5 | | | | | −2 | | | |
| Lund | 86·7 | | | +14 | +10 | | | | |
| Chur | 87·2 | −2 | −1 | | | | | | |
| Upsala | 87·5 | | | | | −11 | | | |
| Graz | 91·0 | | | | | −4 | | | |
| Vienna | 91·2 | −4 | −2 | | | | | +29 | |
| Zagreb | 91·8 | 0 | +2 | | | −5 | +26 | | −10 |
| Pulkovo | 93·1 | −1 | +1 | +3 | −1 | −5 | 0 | +14 | SS |
| Kucino | 98·7 | | | | | −9 | +3 | +10 | +22 |
| Wellington | 102·0 | | | | | +4 | | | +26 |
| Ekaterinburg | 106·0 | | 0 | | | −4 | 0 | +4 | +24 |
| Helwan | 109·5 | | +50 | | | | | +4 | |
| Cape Town | 113·2 | | | | | | +10 | +16 | |
| Irkutsk | 113·3 | | −14 | | | | 0 | −9 | −17 |
| Baku | 115·1 | | | P′ | | | +6 | | |
| Tashkent | 122·4 | | | +2 | | −2 | +2 | | +34 |
| Samarkand | 123·2 | | | +8 | | | | | |
| Melbourne | 125·1 | PKS | | | | +2 | | +7 | +44 |
| Hong Kong | 136·8 | −11 | | | | | | | |
| Manila | 138·0 | | | | | | −24 | | |
| Tananarive | 139·60 | −5 | SKSP | | | | | | |
| Bombay | 144·0 | | +4 | 0 | | | | −36 | |
| Calcutta | 144·2 | | | −20−2 | | | | | |

Mean P residual (Δ>70°), 0; S, −2; SKS, −4.

The I.S.S. epicentres for this earthquake and that of 1929 Jan. 24 differ by 1°·1, but on revision the epicentres were found to agree within their uncertainty. The mean of the revised positions was therefore adopted for both.

1929 Feb. 22d. 20h. 41m. 39s.+13s.=41m.52s. Z=0.

I.S.S. Epicentre 10°·6N. 42°·5W. Revised Epicentre 10°·7N. 41°·6W.

A=+·7348, B=−·6523, C=+·1857.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Fort de France | 19·4 | −3 | −4 | | | | | | |
| Azores | 30·5 | +31 | +37 | | | | | | |
| Port au Prince | 30·7 | +5 | +11 | −1 | +8 | | +14 | | |
| Rio de Janeiro | 33·6 | −3+1 | +2+6 | −11 | −2 | | | | |
| Balboa Heights | 37·5 | −5 | 0 | −8 | 0 | | | | |
| La Paz | 37·8 | −5 | 0 | −8 | −1 | | 0,+5 | | −14+23 |
| Sucre | 37·8 | −6 | −1 | −9 | −2 | | | | −20+17 |
| Halifax | 38·8 | −1 | +3 | −6 | +1 | | +9 | | |
| Harvard | 40·7 | −3 | +1 | −5 | +1 | | | | |
| San Fernando | 41·0 | −1 | +3 | −5 | +1 | | | | |
| Fordham | 41·4 | +37 | +41† | +25 | +31† | | | | |
| Georgetown | 42·3 | −3 | +1 | −1 | +5 | | +5 | | |
| Malaga | 42·4 | −1 | +3 | −1 | +5 | | | | |
| Charlottesville | 42·8 | −5 | −1 | −10 | −5 | | +13 | | −8+9 |
| Granada | 43·2 | −2 | +2 | +2 | +7 | | | | |
| Ithaca | 43·9 | −5 | −1 | −8 | −3 | | | | +15 |
| Almeria | 43·9 | +18 | +22 | +10 | +15 | | | | |
| Toledo | 44·2 | −5 | −2 | +2 | +7 | | +2 | | +12 |
| Ottawa | 45·2 | −2 | +1 | −4 | 0 | | | | −6 |
| Alicante | 45·9 | +5 | +8 | +5 | +9 | | | | |
| Toronto | 46·3 | −5 | −2 | −5 | −1 | | +5 | | +12 |
| Cincinnati | 47·6 | +1 | +4 | −21 | −17 | | +4 | | −17+15 |
| Tortosa | 47·7 | 0 | +3 | +5 | +9 | | | | |
| Algiers | 47·8 | −3 | 0 | +4 | +7 | | +6 | | |
| La Plata | 48·2 | −8 | −5 | −11 | −8 | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ann Arbor | 48·4 | −4 | −1 | −4 | −1 | | +2 | | −1 |
| Bagnères | 48·6 | +1 | +4 | −1 | +2 | | | | |
| Barcelona | 49·1 | +2 | +5 | +1 | +4 | | | | |
| Chicago | 50·7 | −4 | −2 | −9−2 | −6+1 | | | | −53 |
| St. Louis | 51·4 | −2 | 0 | −1 | +1 | | | | −16−1 |
| Florissant | 51·6 | −5 | −3 | −2 | 0 | | | | |
| Santiago | 52·1 | −13 | −11 | −4 | −2 | | | | |
| Oxford | 52·5 | +2 | +4 | −2 | 0 | | | | |
| Bidston | 52·6 | −2 | 0 | −65 | −63* | | | | |
| Kew | 52·8 | −2+3 | 0+5 | +2+7 | +4+9 | | | | −13 |
| Paris | 52·8 | −2 | 0 | +4 | +6 | | | | |
| Grenoble | 53·0 | −7 | −5 | +7 | +9 | | | | |
| Stonyhurst | 53·2 | 0 | +2 | +7 | +9 | | | | |
| Besançon | 54·0 | +4 | +5 | +7 | +9 | | | | |
| Edinburgh | 54·1 | +5 | +6 | +5 | +7 | | | | |
| Moncalieri | 54·2 | +3 | +4 | +9 | +11 | | | | |
| Neuchâtel | 54·5 | 0 | +1 | +6 | +7 | | | | |
| Uccle | 54·8 | −2 | −1 | +4 | +5 | | | | |
| Dyce | 55·5 | +2 | +3 | +5 | +6 | | | | |
| Zürich | 55·7 | −1 | 0 | −2 | −1 | | | | |
| Strasbourg | 55·8 | 0 | +1 | +5 | +6 | | | | |
| De Bilt | 55·9 | +4 | +5 | +6 | +7 | | | | |
| Tacubaya | 56·1 | −7 | −6 | −4 | −3 | | | | |
| Florence | 56·2 | −2 | −1 | +17 | +18 | | | | |
| Karlsruhe | 56·4 | +7 | +8 | +8 | +9 | | +14 | | |
| Hohenheim | 56·8 | −2 | −2 | +6 | +7 | | | | |
| Feldberg | 56·9 | +3 | +3 | +5 | +6 | | | | |
| Naples | 57·4 | −13 | −13 | −14 | −13 | | | | |
| Venice | 57·4 | 0 | 0 | +6 | +7 | | | | |
| Pompeii | 57·6 | +15 | +15 | +13 | +14 | | | | |
| Göttingen | 58·3 | +3 | +3 | +18 | +19 | | −4 | −2+2 | |
| Jena | 59·0 | +1 | +1 | +5 | +5 | | −4 | | −9 |
| Laibach | 59·0 | 0 | 0 | +5 | +5 | | | | |
| Hamburg | 59·2 | −2 | −2 | −1+5 | −1+5 | | | | |
| Graz | 60·0 | −4 | −4 | +1 | +1 | | | | |
| Zagreb | 60·0 | +3 | +3 | −1 | −1 | | +8 | −1+6 | |
| Bergen | 60·5 | −8 | −9 | +7 | +7 | | | | |
| Vienna | 60·9 | −1 | −2 | +5 | +5 | | −4 | | +10 |
| Scoresby Sund | 61·1 | +4 | +3 | −2 | −2 | | +33 | | |
| Copenhagen | 61·3 | −1 | −2 | +7 | +7 | | | | |
| Lund | 61·8 | +1 | 0 | +7 | +7 | | | | |
| Budapest | 62·4 | +8 | +7 | +11 | +11 | | −11 | +23 | |
| Chihuahua | 62·5 | −7 | −8 | −9 | −9 | | | | |
| Belgrade | 62·8 | −1 | −2 | +4 | +4 | | | | |
| Denver | 62·8 | −9 | −8 | −5 | −5 | | +1 | | |
| Upsala | 64·8 | +4 | +3 | +10 | +9 | | | | |
| Königsberg | 65·4 | 0,+4 | −1+3 | +2 | +1 | | +17 | | +24 |
| Lemberg | 66·2 | +5 | +4 | +4 | +3 | | | +14 | |
| Tucson | 66·8 | 0+6 | −1+5 | +2 | +1 | | | +34 | −12 |
| Helsingfors | 69·2 | +3 | +2 | −1 | −3 | | | +40 | |
| Helwan | 70·0 | +3 | +2 | +7 | +5 | | | | |
| Pulkovo | 71·7 | −1 | −2 | +4 | +2 | | | | |
| Sebastopol | 71·9 | +5 | +4 | | | | | | |
| Simferopol | 72·4 | +3 | +2 | | | | | | |
| Yalta | 72·4 | −16 | −17 | | | | | | |
| Cape Town | 72·5 | +11 | +10 | +2 | 0 | | | | |
| Theodosia | 73·3 | +5 | +4 | +3 | 0 | | | | |
| Ksara | 73·7 | +3 | +2 | +8 | +5 | | +26 | | |
| Entebbe | 74·3 | +4 | +3 | +5 | +2 | | | | |
| Kucino | 75·3 | +6 | +6 | +10 | +7 | | | | |
| Lick | 75·6 | −3 | −3 | −6 | −9 | | | | |
| Berkeley | 76·2 | −4 | −4 | +2 | −1 | | | | |
| Victoria | 76·5 | −1+6 | −1+6 | −2+3 | −5, 0 | | | | |
| Baku | 84·3 | +6 | +6 | +12 | +8 | | | | |
| Ekaterinburg | 87·6 | −1 | −1 | | | −5 | −9 | | |

*Continued on next page.*

| | Δ | Pv | Pω | PKS | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Tananarive | 92·6 | +4 | +6 | | | 0 | | −23+25 | +2 |
| Samarkand | 97·0 | −1 | +2 | | | −1 | | | |
| Tashkent | 98·0 | −64 | −61* | | | −15 | −26 | 0 | |
| Andijan | 100·6 | +6 | +10 | | | +1 | | | |
| Frunse | 100·9 | −4 | 0 | | | | | | |
| Bombay | 109·0 | | +1 | | | +2 | | | |
| Honolulu T.H. | 109·8 | | | | | −12 | | +5 | +1 |
| Irkutsk | 110·5 | P′ | | | | | | | |
| Colombo | 119·1 | +41 | | | | | | −2 | |
| Calcutta | 120·7 | | | | | | −18 | | |
| Kobe | 134·6 | | | | | | +21 | | |
| Zi-ka-wei | 135·0 | +3 | | −2 | | | | | +21 |
| Phu-Lien | 135·6 | | | | | | +10 | | |
| Wellington | 135·8 | | | | | | | | +48 |
| Hong Kong | 139·3 | | | | | | +10 | | |
| Batavia | 148·4 | +7 | | | | | | | |
| Manila | 149·3 | +8 | | | | | +9+16 | | |
| Perth | 150·4 | +21 | | | | | | | |
| Melbourne | 152·3 | +40 | | | | | | | +27 |
| Riverview | 154·1 | +28 | | | | | | | |
| Adelaide | 155·7 | +33 | | | | | | | |
| Amboina | 167·6 | +8+19 | | | | | | | |

Mean P residual (Δ>70°),+1 ; S, 0 ; SKS,−1.

There is a long series of positive S residuals from Kew (52°·8) 8, Upsala (64°·8) ; but within this range normal residuals occur at Zürich, Tacubaya, Hamburg, Graz, Zagreb, and Scoresby Sund. It seems probable that the latter refer to the time S and the others to a strong successor.

1929 Nov. 18d. 20h. 32m. 5s. Z=0.

Epicentre 44°·55N. 55°·95W.

A=+·3990, B=−·5905, C=+·7015.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Harvard | 11·2 | −11 | −11 | −8 | −8 | | | | |
| Fordham | 13·7 | −7 | −7 | −20 | −21 | | | | |
| Ottawa | 14·0 | −6 | −6 | −12 | −13 | | | | |
| Georgetown | 16·7 | 0 | −1 | +6 | +4 | | | | |
| Toronto | 16·8 | −5 | −6 | −8, 0 | −10−2 | | | | |
| Ann Arbor | 20·2 | 0 | 0 | +3 | +3 | | | | |
| Chicago | 23·2 | −1 | +1 | +4 | −3d | | | | +13 |
| St. Louis | 26·2 | −6 | −2 | −22 | −15 | | −4+4 | | −8 |
| Florissant | 26·2 | −6 | −2 | −16 | −9 | | −4+4 | | −8 |
| Port au Prince | 29·4 | 0 | +6 | +8 | +16 | | | | |
| Scoresby Sund | 30·8 | +1 | +7 | −2 | +7 | | | | |
| Edinburgh | 34·6 | +15 | +20 | −13 | −5 | | | | |
| Stonyhurst | 35·2 | −5 | 0 | −8 | 0 | | | | +18 |
| Saskatoon | 35·5 | −5 | 0 | −18 | −10 | | | | −16 |
| Denver | 36·2 | −21 | −16 | +230 | +238* | | | | |
| Oxford | 36·3 | −3 | +2 | −11 | −3 | | | | |
| Merida | 36·4 | −14 | −9 | −16 | −8 | | | | |
| Kew | 36·9 | −5 | 0 | −10 | −2 | | | | |
| Toledo | 38·0 | −6 | −1 | −7 | 0 | | | | −24 |
| San Fernando | 38·1 | 0 | +4 | 0 | +7 | | | | |
| Paris | 38·8 | 0 | +4 | −3 | +4 | | | | |
| Bergen | 38·8 | −5 | −1 | −6 | +1 | | | | |
| Malaga | 39·2 | −3 | +1 | −3 | +4 | | | | |
| Granada | 39·6 | −5 | −1 | −6 | +1 | | +18 | | −25 |
| Uccle | 40·0 | −5 | −1 | −13 | −6 | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| De Bilt | 40·1 | −4 | 0 | −9 | −2 | | | | |
| Almeria | 40·5 | −5 | −1 | −5 | −1 | | +5 | | |
| Puy de Dôme | 40·6 | −13 | −9 | −4 | +2 | | | | |
| Tortosa | 40·8 | −1 | +3 | −8 | −2 | | | | |
| Alicante | 41·3 | −1 | +3 | −4 | +2 | | | | |
| Barcelona | 41·7 | −9 | −5 | −9 | −3 | | +7 | | |
| Besançon | 42·1 | −5 | −1 | −8 | −2 | | | | |
| Hamburg | 42·5 | −4 | 0 | −4 | +2 | | | | +16 |
| Grenoble | 42·6 | +6 | +10 | −3 | +3 | | | | |
| Chihuahua | 42·6 | −95 | −91† | −128 | −122† | | | | |
| Neuchâtel | 42·7 | −3 | +1 | −4 | +1 | | | | |
| Strasbourg | 42·7 | −3 | +1 | −7 | −2 | | −4 | | |
| Feldberg | 42·9 | −5 | −1 | +9 | +14 | | | | +23 |
| Karlsruhe | 43·0 | +4 | +8 | +2 | +7 | | | | |
| Göttingen | 43·1 | −5 | −1 | −6 | −1 | | | | |
| Marseilles | 43·1 | −19 | −15 | | | | | | |
| Copenhagen | 43·3 | −5 | −1 | −7 | −2 | | | | +15 |
| Hohenheim | 43·6 | −4 | 0 | −7 | −2 | | −8 | | +20 |
| Zürich | 43·65 | −3 | +1 | −3 | +2 | | | | |
| Tacubaya | 43·7 | −3 | +1 | −35 | −30 | | | | |
| Tucson | 43·9 | −5 | −1 | −2 | +3 | | | | +23 |
| Moncalieri | 44·0 | −8 | −4 | −15 | −10 | | | | |
| Ravensburg | 44·15 | −1 | +2 | −4 | +1 | | 0 | | +16 |
| Jena | 44·3 | −3 | 0 | −10 | −5 | | | | |
| Algiers | 44·4 | −3 | 0 | −4 | +1 | | | | +11 |
| Upsala | 44·9 | −5 | −2 | −7 | −2 | | | | +11 |
| Cheb | 45·0 | +1 | +4 | +1 | +6 | | | | +11 |
| Piacenza | 45·2 | −3 | 0 | −2 | +2 | | | | |
| Innsbruck | 45·5 | −2 | +1 | −5 | −1 | | | | +16 |
| Livorno | 46·3 | −483 | −480* | | | | | | |
| Padova | 46·5 | −8 | −5 | −1 | +3 | | | | |
| Treviso | 46·6 | −3 | 0 | −3 | +1 | | | | |
| Florence | 46·8 | −7 | −4 | −4 | 0 | | | | |
| Laibach | 47·9 | −4 | −1 | −5 | −2 | | +24 | | +24 |
| Graz | 48·0 | −5 | −2 | | | | +20 | | +15 |
| Königsberg | 48·0 | −3 | 0 | −3 | 0 | | +2 | +11 | −27+6 |
| Vienna | 48·1 | −6 | −3 | −1 | +2 | | +2 | | +19 |
| Helsingfors | 48·4 | −4 | −1 | −7 | −4 | | | | |
| Rome | 48·4 | −1 | +2 | −2 | +1 | | | | |
| Rocca di Papa | 48·7 | −5 | −2 | −6 | −3 | | | | +22 |
| Lick | 48·8 | −3 | 0 | +3 | +6 | | +6 | | +8 |
| Zagreb | 48·9 | 0 | +3 | −3 | 0 | | −13 | | |
| Berkeley | 49·0 | −3 | 0 | −1 | +2 | | +2+6 | | +2 |
| Casamicciola | 49·9 | −5 | −3 | −8 | −5 | | | | |
| Naples | 50·1 | −3 | −1 | −3 | 0 | | | | |
| Budapest | 50·1 | −2 | 0 | −1 | +2 | | | | |
| Pulkovo | 51·0 | −1 | +1 | −4 | −2 | | | | |
| Bari | 51·7 | +3 | +5 | −6 | −4 | | | | |
| Belgrade | 52·2 | −2 | 0 | −3 | −1 | | | | |
| Trenta | 52·25 | +8 | +10 | −3 | −1 | | | | |
| Taranto | 52·3 | +4 | +6 | | | | | | |
| Catania | 52·35 | −1 | +1 | +1 | +3 | | | | |
| Kucino | 56·7 | −1 | 0 | −3 | −2 | | | | |
| Sebastopol | 60·2 | +2 | +1 | +5 | +5 | | | | |
| Simferopol | 60·3 | +1 | 0 | +4 | +4 | | | | |
| Yalta | 60·6 | +1 | 0 | +4 | +4 | | | | |
| Theodosia | 61·0 | +3 | +2 | +6 | +6 | | | | |
| Sucre | 64·2 | −8 | −9 | −10 | −11 | | +9 | | |
| Ekaterinburg | 65·6 | −1 | −2 | | | | | | |
| Helwan | 67·8 | 0 | −1 | −4 | −5 | | | | |
| Ksara | 68·2 | +1 | 0 | +4 | +2 | | | | |
| Rio de Janeiro | 68·4 | +6 | +5 | −12 | −14 | | | | |
| Baku | 72·2 | +1 | 0 | +3 | +1 | | | | |
| La Plata | 79·4 | −6 | −6 | −10 | −14 | | | | |
| Tashkent | 81·1 | −19 | −19† | −29 | −33† | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SKKS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Samarkand | 81·4 | 0 | 0 | +1 | −3 | | | | |
| Irkutsk | 81·7 | 0 | 0 | −3 | −7 | | | | |
| Almata | 82·7 | +2 | +2 | +6 | +2 | | | | |
| Honolulu T.H. | 83·2 | 0+6 | +1+7 | −1 | −5 | | | | |
| Andijan | 83·3 | −1 | 0 | +2 | −2 | | | | |
| Entebbe | 88·8 | −2 | −1 | +5 | +1 | | | | |
| Dehra Dun | 94·2 | +6 | +8 | +4 | 0 | | | | |
| Agra | 96·9 | −28 | −25 | −17 | −21 | | | | |
| Kobe | 99·8 | | | | | −6 | +12 | | |
| Bombay | 101·3 | −3 | +1 | | | | | | −11 |
| Hukuoka | 101·4 | +55 | +59* | +100 | +96 | | | +17 | |
| Hyderabad | 105·4 | | | | | | | +3 | |
| Hong Kong | 112·5 | | | | | | +7 | | SS |
| Tananarive | 112·6 | | | | | | +20 | +4+8 | +23 |
| Phu-Lien | 112·7 | | | | | | +4 | +3 | −6 |
| | | P′ | | | | | | | |
| Colombo | 115·3 | +5 | | | | | | | −7 |
| Manila | 120·8 | +15 | | PKS | | | +16 | +6 | |
| Batavia | 138·8 | +17 | | −14 | | | | | |
| Christchurch | 145·6 | −6 | SKSP | | | | | | SKKS |
| Riverview | 156·5 | 0, +5 | −2 | | | | | | −8 |
| Melbourne | 162·9 | −16 | +7 | | | | +31 | | |
| Adelaide | 165·3 | +29 | | | | | +25 | | |
| Perth | 165·9 | +2 | | | | | −7 | | +14 |

Mean P residual (Δ>70°), 0; S, −3; SKS, −6??

This is the shock that broke the Atlantic cables off Grand Banks, Newfoundland. The European and North American Stations are nearly in opposite azimuths; those to the north and south of the epicentre (Scoresby Sund, Port au Prince, Sucre, and La Plata) cannot be brought into agreement, and the latitude is practically determined to suit Samarkand, Irkutsk, Almata, and Andijan. Scoresby Sund comments on the difficulty of reading. The uncertainty of the epicentre in a NNW direction of course hardly affects the European and North American distances or inferences from them. La Paz gives a number of readings that cannot refer to this shock. The near stations, Harvard, Fordham, Ottawa, and Toronto show curious negative residuals. There may have been a small foreshock about 6s. earlier; or there may have been some primitive P movement which was noticeable at these near stations and not at others.

# EPICENTRES IN SOUTH AMERICA.

1927 Nov. 14d. 7h. 19m. 20s.+6s.=19m.26s.  Z=0.

I.S.S. Epicentre 30°·2S. 71°·0W. Revised Epicentre 30°·6S. 70°·9W.

A=+·2816, B=−·8133, C=−·5090.

| | Δ | Pv | Pω | Sv | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Santiago | 2·9 | +2 | +2 | −22 | −22 | | | | | |
| Pilar | 6·2 | −6 | −6 | −40 | −40 | | | | | |
| La Plata | 11·7 | +4 | +4 | −1 | −1 | | | | | |
| Sucre | 12·7 | +2+20 | +2+20 | +8 | +8 | | | | | |
| La Paz | 14·3 | +10+29 | +10+29 | +24+59 | +23+58 | | | | | |
| Rio de Janeiro | 25·8 | +3 | +7 | −4 | +2 | | | | | |
| Balboa Heights | 40·4 | −33 | −29 | | | | | | | |
| Tacubaya | 56·9 | −13 | −13† | −12 | −11† | | | | | |
| Chihuahua | 68·1 | −24 | −25† | −23 | −25† | | | | | |
| Cincinnati | 70·9 | 0+9 | −1+8 | +18 | +16 | | | | | |
| St. Louis | 71·5 | +1+15 | 0+14 | −3 | −5 | | | | −2+19 | |
| Cape Town | 73·0 | +4 | +3 | +5 | +2 | | | | | |
| Ithaca | 73·2 | +9 | +8† | +10 | +7† | | | | | |
| Tucson | 73·4 | +2 | +1 | 0 | −3 | | | +2 | | −7 |
| Ann Arbor | 73·8 | +1 | 0 | −5 | −8 | | | | | −22 |
| Chicago | 74·0 | | | −7 | −10 | | | | | |
| Toronto | 74·7 | −10 | −10† | −16 | −19† | | | +14 | | |
| Ottawa | 76·1 | −2 | −2 | −4 | −7 | | | +22 | | +17 |
| Berkeley | 83·6 | −2 | −2 | −5+8 | −9+4 | −4+9 | | | | |
| Wellington | 86·0 | −2 | −1 | | | −8 | | +23 | | −7+8 |
| San Fernando | 90·4 | 0 | +1 | +1 | −3 | | | | | |
| Rio Tinto | 90·9 | +27 | +28 | | | | | | | |
| Malaga | 91·7 | −3 | −1 | | −12 | | *−10* | −1 | | |
| Victoria | 91·8 | −4 | −2 | | | −10−6 | | | | |
| Apia | 92·1 | +30 | +32 | +18 | +13 | −27 | | | | |
| Granada | 92·5 | +2 | +4 | +13 | +8 | | | | | |
| Almeria | 93·0 | −6 | −4 | | −16 | | *−11* | −1 | | |
| Toledo | 93·8 | −4 | −2 | | | +13 | *−13* | 0 | | |
| Alicante | 95·1 | −6 | −4 | | | +20 | *−11* | | | |
| Algiers | 96·6 | 0 | +2 | | | +12 | *−16* | +1 | | |
| Honolulu | 98·2 | | | +2 | −3 | | | | | −21 |
| Oxford | 102·4 | | | +9 | +4 | +14 | *−26* | +14 | | |
| Kew | 102·7 | −5 | −1 | +9 | +4 | +15 | *−27* | −4 | +9 | +34 |
| Paris | 102·8 | −3 | +1 | +9 | +4 | +16 | | | | |
| Stonyhurst | 103·0 | −13 | −9 | +1 | −3 | +9 | | | | |
| Edinburgh | 103·8 | | | | | +16 | | | | |
| Moncalieri | 103·9 | +4 | +8 | | | +10 | | | | |
| Besançon | 104·0 | −8 | −4 | | | | | +7 | | |
| Riverview | 104·3 | | | | | −10 | | | +6 | +9 |
| Sydney | 104·3 | | | | | −19 | | | | |
| Neuchâtel | 104·4 | −5 | 0 | | | +16 | | | | |
| Uccle | 104·8 | −7 | −2 | | | +17 | | −22 | | |
| Dyce | 105·0 | | | | | +18 | | | | |
| Florence | 105·5 | | | | | | | | | |
| Rocca di Papa | 105·5 | | +1 | | | | | | | |
| Zürich | 105·6 | | 0 | | | −16 | | | | |
| Strasbourg | 105·7 | | −1 | | | | −7 | +5 | | |
| De Bilt | 105·9 | | 0 | | | +17 | | +2 | | |
| Pompeii | 106·3 | | | | | | | −3 | | |
| Hohenheim | 106·6 | | | | | +11 | | +39 | | |
| Feldberg | 106·8 | | | | | | | −33 | | |
| Venice | 106·9 | | | | | | | | | |
| Adelaide | 108·8 | | | | | −15 | −8 | | | |
| Jena | 108·9 | | | | | | | −6, 0 | −12 | −32 |
| Cheb | 109·0 | | | | | | | +8 | +11 | |

*Continued on next page.*

| | Δ | P′ | Pω | PKS | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Hamburg | 109·2 | −27 | −2 | | | | | +3 | +9 | |
| Graz | 109·6 | | | | | | | | +37 | |
| Prague | 110·2 | | | | | | | −4 | −5 | +35 |
| Vienna | 110·6 | | | | | | | −3 | −10 | |
| Copenhagen | 111·4 | | −3 | | | −47 | +2+16 | −16+1 | +3+33 | −6 |
| Budapest | 112·0 | | | | | | | −9 | | |
| Helwan | 114·3 | | | | | | | +5 | +6 | |
| Upsala | 115·4 | | | | | | | +1 | +6 | |
| Helsingfors | 119·0 | −26 | | | | −22 | | +1+5 | +4 | |
| Ksara | 119·3 | | | | | +14 | | +7 | +37 | |
| Pulkovo | 121·6 | −4 | | | | +1 | | −2 | 0 | |
| Makeyevka | 124·4 | −6, 0 | SKSP | | | −7 | 0 | +1 | | +5 |
| Tiflis | 128·1 | +2+9 | +16 | | | | | | −3 | +5 |
| Baku | 131·7 | +1 | | −6 | | −44 | | +6 | | |
| Ekaterinburg | 137·6 | 0+4 | +12 | −11 | | | | +1 | | +10 |
| Batavia | 143·1 | +8+12 | | | | | | | | |
| Colombo | 143·8 | −4 | | | | | | | | |
| Kodaikanal | 144·2 | | | | | | | | | |
| Bombay | 145·2 | −2 | | | | | | | | |
| Tashkent | 146·4 | −2 | | | | | | | | +17 |
| Hyderabad | 149·2 | +6 | +5 | | | | | | | |
| Mizusawa | 152·5 | +9 | | | | | | | | |
| Simla | 152·7 | | | | | | +23 | | | |
| Osaka | 157·4 | | | | | | | | | |
| Irkutsk | 158·0 | −4 | −19 | | | +19 | | +5 | | +4 |
| Manila | 160·6 | −3 | | | | | | | | |
| Zi-ka-wei | 169·4 | 0 | +22 | | | | | | | |
| Phu-Lien | 169·9 | +1 | | | | | | −1 | | |
| Hong Kong | 170·5 | +3 | | | | | | | | |

Mean P residual ( Δ>70°), −2 ; S, −3? ; SKS, −10 or +11.

Note.—There are signs of focal depth in both P and S, though hardly conclusive in either case. This shock was used in determining the corrections to P ; Y was then chosen to fit the stations from 70° to 86°, since the focal depth effect is nearly constant at these great distances and is thus eliminated. SKS is usually late by about 11s., but a few stations show negative residuals, notably Wellington, Victoria, and Zürich, whose time is indicated as correct by P, and also Makeyevka. It is possible that the late readings are sSKS, and the earlier the true SKS. S is early at the distant stations as far as Berkeley, but on this interpretation none of them are late enough to be sS. In some cases SKKS may be alternatively interpreted as S ; these cases are shown by italics.

Ekaterinburg also P′−8.

1928 July 18d. 19h. 4m. 52s.+16s.=5m.8s. Z=+2.

I.S.S. Epicentre 5°·0S. 79°·5W. Revised Epicentre 5°·2S. 78°·7W.

A=+·1951, B=−·9766, C=−·0906.

| | Δ | $P_v$ | Pω | $S_v$ | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Balboa Heights | 14·2 | +12 | +12 | +20 | +19 | | | | | |
| La Paz | 15·32 | +2 | +2 | +33+61 | +32+60* | | | | | |
| Sucre | 19·07 | 0 | −1 | +21 | +19 | | | | | |
| Port au Prince | 24·56 | −11 | −8 | +16 | +8d | | | −8 | | |
| San Juan | 26·66 | −1 | +3 | +4 | +11 | | | | | |
| Merida | 28·3 | +9 | +14 | +9 | +17 | | | | | |
| Oaxaca | 28·5 | +32 | +37† | +33 | +31† | | | | | |
| Santiago | 29·20 | −13 | −8 | +3 | +11 | | | | | |
| Vera Cruz | 29·8 | −3 | +2 | −2 | +6 | | | | | |
| Tacubaya | 31·8 | +7 | +12 | +14 | +23 | | | | | |
| La Plata | 35·37 | −8 | −3 | −18 | −10 | | | | | |
| Rio de Janeiro | 38·52 | −6 | −1 | −6 | +1 | | | | | |
| Chihuahua | 42·9 | +10 | +13† | +15 | +20† | | | | | |
| Charlottesville | 43·24 | +12 | +15† | +8 | +13† | | | | | |
| Georgetown | 44·12 | −2 | +2 | +16 | +21 | | | +12 | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Cincinnati | 44·7 | −1 | +3 | +2 | +7 | | | | | +23 |
| St. Louis | 45·12 | −6 | −3 | −8 | −4 | | | −25 | | +16 |
| Ithaca | 47·6 | −44 | −41 | | | | | | | |
| Chicago | 47·7 | −23 | −20† | −22−8 | −19†−5 | | | | | −1 |
| Ann Arbor | 47·72 | −3 | 0 | 0 | +3 | | | +10 | | +20 |
| Harvard | 48·1 | −6 | −3 | −2 | +1 | | | | | +14 |
| Tucson | 48·33 | −3 | 0 | −7 | −4 | | | −17 | | |
| Toronto | 48·88 | −16−9 | −13−6 | −5 | −2 | | | | | +4 |
| Ottawa | 50·67 | −4 | −2 | −6 | −3 | | | +10 | | +5 |
| Lick | 58·3 | +1 | +1 | −6+18 | −6+18 | | | −55* | | |
| Berkeley | 59·1 | −5 | −5 | +8 | +8 | | | | | |
| Saskatoon | 62·0 | −15 | −16† | −14 | −14† | | | | | |
| Spokane | 62·8 | +12 | +11† | +17 | +17† | | | | | |
| Azores | 65·2 | −5 | −6 | +100 | +99 | | | | | |
| Victoria | 66·2 | +4 | +3 | +8 | +7 | | | | | |
| San Fernando | 79·2 | +8 | +8 | +6 | +5 | | | | +51 | |
| Malaga | 80·7 | −1 | −1 | +5 | +4 | | | | | |
| Granada | 81·4 | +1 | +1 | +6 | +5 | | | +8 | −22 | |
| Toledo | 81·73 | −1 | −1 | +3+7 | −1+3 | | | +15 | | +3 |
| Honolulu T.H. | 81·8 | +4 | +4 | +3+12 | −1+8 | | | | +10 | −11 |
| Almeria | 82·3 | −4 | −4 | −9 | −13 | +2 | | 0 | | |
| Alicante | 84·0 | +6 | +7 | +3 | −1 | | | | | |
| Scoresby Sund | 84·6 | −2 | −1 | +2 ! | −2 | +1 | | | +13 | |
| Tortosa | 85·3 | −2 | −1 | +3 ! | −1 | +6 | | | | |
| Bagnères | 85·6 | 0 | +1 | | | | | | | |
| Bidston | 85·7 | +2 | +3 | +4 ! | 0 | +1 | | | | |
| Stonyhurst | 86·2 | −2 | −1 | +7 ! | +3 | +6 | | | | |
| Edinburgh | 86·3 | +1 | +2 | +7 ! | +3 | +3 | | | | |
| Oxford | 86·4 | −1 | 0 | +4 ! | 0 | +4 | | +10 | | |
| Barcelona | 86·6 | −2 | −1 | | | +4 | | | | |
| Algiers | 86·6 | −2 | −1 | +2 ! | −2 | +4 | | | | |
| Kew | 86·9 | −1 | 0 | +4 | 0 | +3 | | −9 | −4+14 | +7 |
| Dyce | 87·3 | −1 | 0 | +1 ! | −3 | −1 | | +17 | | |
| Paris | 88·14 | −1 | 0 | +5 ! | +1 | +2 | | | | |
| Marseilles | 89·2 | +1 | +2 | | | | | | | |
| Uccle | 89·6 | −2 | −1 | +3+8 ! | −1+4 | +3 | | | | |
| De Bilt | 90·3 | 0 | +2 | +3 | −1 | +5 | | | | |
| Neuchâtel | 90·7 | −1 | +1 | +7 ! | +2 | +4 | | | | |
| Moncalieri | 91·1 | +1 | +3 | | | −8 | | | | |
| Strasbourg | 91·5 | −3 | −1 | +9 | +4 | +4 | | −1 | | |
| Bergen | 91·7 | −15 | −13 | | | | | | | |
| Zürich | 91·8 | −1 | +1 | +5 ! | 0 | +4 | | | | |
| Feldberg | 92·0 | +6 | +8 | +4 | −1 | +4 | | | +15 | |
| Hohenheim | 92·3 | +6 | +8 | | | +5 | | −7 | | |
| Chur | 92·5 | −2 | 0 | +4 ! | −1 | +3 | | | | |
| Ravensburg | 92·6 | +3 | +5 | +9 ! | +4 | +4 | | −8 | | |
| Cape Town | 93·1 | +3 | +5 | | | +6 | | | | |
| Hamburg | 93·3 | −1 | +1 | +5 ! | 0 | +6 | | −20 | | |
| Florence | 93·5 | −2 | 0 | | | +5 | | | | |
| Innsbruck | 93·7 | +5 | +7 | | | +1 | | | | |
| Jena | 94·21 | −3+3 | −1+5 | +9 ! | +4 | +4 | | −17 | +3 | −8 |
| Rocca di Papa | 94·4 | −4 | −2 | | | +4 | | | | |
| Copenhagen | 94·9 | −2 | 0 | +7+12 | +2+7 | +9 | | −1+3 | +3+10 | +6 |
| Potsdam | 95·1 | +7 | +10 | +4 | −1 | +6 | | | | |
| Lund | 95·3 | −2 | +1 | +4 | −1 | +2 | | | | |
| Naples | 95·5 | −9 | −6 | | | | | | | |
| Pompeii | 95·8 | −15 | −12 | | | −4 | | | | |
| Graz | 96·5 | −4 | −1 | +9 ! | +4 | +1 | | | | |
| Zagreb | 96·9 | −5 | −2 | +3 ! | −1 | −3+5 | | −10+11 | +3 | +4 |
| Vienna | 97·1 | −6 | −3 | −1 | −6 | +3 | | −5 | +11 | +20 |
| Upsala | 97·6 | −1 | +2 | −1 | −6 | −1 | | | | +5 |
| Wellington | 98·8 | +5 | +8 | 0+15 | −5+10 | | | | | |
| Budapest | 98·9 | +5 | +8 | +6 ! | +1 | +7 | | | | |
| Königsberg | 99·5 | +5 | +8 | +4 | −1 | +5 | | −16+7 | +20 | −21 |
| Belgrade | 100·0 | +8 | +12 | +12 | +7 | | | −3 | | |

*Continued on next page.*

| | Δ | Pν | Pω | P′ | $P_2'$ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Suva | 100·5 | −15 | −11 | | | +22 | | | | |
| Helsingfors | 102·3 | | | | | +8 | | +9 | +9 | |
| Pulkovo | 103·9 | −7 | −3 | | | −1 | | −9 | | |
| Kucino | 108·9 | | −1 | | | | | +2 | +6 | |
| Simferopol | 109·6 | | | | | | | | | |
| Yalta | 109·7 | | | −21 | | | | | | |
| Theodosia | 110·5 | | | | | | | | +19 | |
| Entebbe | 111·1 | | | | | −1 | | −16 | +3 | |
| Makeyevka | 111·4 | | +1 | | | | | +4 | +8 | |
| Ksara | 113·2 | | | +19 | | | | −2 | +24 | |
| Riverview | 118·9 | | | | | +11 | −8 | −4 | +9 | +30 |
| Sydney | 118·9 | | | | | +22 | | +21 | | |
| Ekaterinburg | 119·3 | | +4 | +13 | | +10 | +17 | +2 | | |
| Melbourne | 121·1 | | | | | +17 | | | | +10 |
| Tananarive | 121·8 | | | | | +13 | +8 | | +32 | +15 |
| Baku | 122·0 | | +60* | +3 | | | | +25 | | |
| Adelaide | 126·7 | | | | | | | | PKS | |
| Mizusawa | 130·5 | | | +1 | | | | | −6 | |
| Irkutsk | 132·8 | | | −4 | | 0 | | +4 | | |
| Tashkent | 133·9 | | | 0 | | | −35 | +13 | | |
| Osaka | 136·7 | | | +17 | | | | | | |
| Kobe | 136·9 | | | +2 | | | | | | +60 |
| Sumoto | 137·3 | | | +10 | | | | | −11 | |
| Nagasaki | 141·6 | | | | | | | | | |
| Dehra Dun | 146·4 | | | +19 | | | +28 | | | |
| Zi-ka-wei | 147·8 | | | −3+3 | | −13 | | +10 | | |
| Bombay | 149·0 | | | +9 | | | +22 | | | |
| Taihoku | 152·1 | | | | | | | | | |
| Kodaikanal | 155·8 | | | | | | | | | |
| Manila | 158·5 | | | +6 | | | | | | |
| Colombo | 158·7 | | | +3 | | | | | | |
| Hong Kong | 158·8 | | | +3 | | | | | | |
| Phu-Lien | 163·6 | | | +9 | | | | | | |
| Batavia | 167·9 | | | −1+5 | +7 | | | | | |

Mean P residual of P (Δ>70°), 0 ; S, −1 ; SKS, +4.

Note.—This earthquake is discussed by I. Lehmann and G. Plett (*Gerlands Beiträge* 36, 38−77, 1932). They take the epicentre as 5°·0S, 79°·0W. In view of the scarcity of readings of S at great distances, theirs are incorporated in the above table and indicated by the mark ! Where S is recorded in the I.S.S., the I.S.S. reading is taken ; the agreement is in nearly all cases within a second. The means of Sν are, 80°·1−85°·0, +3·7 ; 85°·1−90°·0, +3·6 ; 90°·1−95°·0, +5·0 (three readings of +9·0 omitted) ; 95°·1−100°·0, +5·0. The first two agree with the corrections already derived ; the others are incorporated in the final curve and smoothed.

1928 Nov. 20d. 20h. 35m. 5s.−2s.=35m.3s. Z=−2.

I.S.S. Epicentre 22°·5S. 70°·5W. Revised Epicentre 23°·7S. 70°·9W.

A=+·2996, B=−·8652, C=−·4019.

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Sucre | 7·01 | −2 | −2 | −2 | −2 | | | | | |
| La Paz | 7·64 | −1 | −1 | 0 | 0 | | | | | |
| Santiago | 9·77 | +31 | +31† | +23 | +23† | | | | | |
| La Plata | 15·92 | +5 | +5 | +10 | +9 | | | | | |
| Rio de Janeiro | 25·39 | −8 | −4 | −19−11 | −13−5 | | | | | |
| Tacubaya | 51·2 | +6 | +8† | +6 | +8† | | | | | |
| Charlottesville | 62·1 | −1 | −2 | −4 | −4 | | | | | |
| Georgetown | 62·9 | +1 | 0 | +3 | +2 | | | +29 | +9 | |
| Cincinnati | 64·2 | −2 | −3 | −6 | −7 | | | | +5+24 | −40 |
| Florissant | 65·2 | −3 | −4 | −7 | −8 | | | −7 | | −18 |
| Ithaca | 66·3 | +3 | +2 | −2 | −3 | | | | | |
| Ann Arbor | 67·2 | +5 | +4 | −3 | −4 | | | | | −2 |
| Chicago | 67·4 | −1 | −2 | −20 | −21 | | | | | |
| Tucson | 67·7 | +7 | +6 | +3+8 | +2+7 | | | −33−27 | | +22 |
| Toronto | 67·9 | +4+16 | +3+15 | −8−3 | −9−4 | | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Ottawa | 69·3 | −2 | −3 | −7 | −9 | | | | | |
| Cape Town | 76·5 | +3 | +3 | +11 | +8 | | | | | |
| Lick | 77·5 | +7 | +7 | +4 | +1 | | | | | +8 |
| Berkeley | 78·2 | 0 | 0 | +5 | +2 | | | | | +8 |
| San Fernando | 85·6 | +2 | +3 | | | −3 | | | | |
| Victoria | 86·0 | +4 | +5 | | | −5 | | | | |
| Malaga | 86·9 | −11 | −10 | −1 | −5 | | | | | |
| Johannesburg | 87·1 | | | | | | | | | |
| Granada | 87·7 | +1 | +2 | | +2 | | | | +30 | |
| Almeria | 88·4 | −1 | 0 | +5 | +1 | | | | | |
| Toledo | 88·9 | −1 | 0 | | | −1 | | | | |
| Alicante | 90·4 | 0 | +2 | | | 0 | | | | |
| Wellington | 91·1 | +22 | +22 | | | +9 | | | | |
| Algiers | 92·2 | −1 | +1 | −8 | −13 | −7 | | | | |
| Tortosa | 92·4 | −3 | −1 | | | −4 | | | | |
| Barcelona | 93·7 | | | +22 | +17 | −11 | | | | |
| Apia | 94·1 | | | | | +10 | | | | |
| Honolulu T.H. | 95·7 | | | | | +7 | | | | |
| Puy de Dôme | 96·2 | | | | | | | +27 | | |
| Oxford | 96·8 | +14 | +17 | | | −9 | | | | |
| Kew | 97·2 | −3 | 0 | +14 | +9 | −8 | | −2+9 | +1+17 | −11 |
| Stonyhurst | 97·3 | | | | | −3 | | | | |
| Paris | 97·6 | 0 | +3 | | | −4 | | −6 | | |
| Grenoble | 97·8 | +5 | +8 | | | | | | | |
| Edinburgh | 98·0 | | | | | −4 | | | −1 | |
| Besançon | 98·8 | | | | | −6 | | −4 | | |
| Moncalieri | 99·0 | −8 | −5 | | | −5 | | | | |
| Dyce | 99·1 | | | | | −9 | | +6 | | −2 |
| Neuchâtel | 99·3 | −4 | −1 | | | | | | | |
| Uccle | 99·5 | −5 | −2 | | | −7 | | −5 | +2 | |
| Scoresby Sund | 100·2 | −1 | +4 | +18 | +13 | −7 | | | | |
| De Bilt | 100·5 | 0 | +3 | | | −2 | | −2 | −3 | |
| Strasbourg | 100·5 | −4 | 0 | | | | | −4 | +14 | |
| Florence | 100·7 | | | | | | | −5 | | |
| Chur | 100·9 | −2 | +2 | | | −5 | | | | |
| Rocca di Papa | 101·0 | −1 | +3 | | | −1 | | | | |
| Ravensburg | 101·3 | | | | | | | | | 0 |
| Pompeii | 101·9 | +1 | +5 | | | | | −4 | | |
| Venice | 102·1 | 0 | +4 | | | | | | | |
| Innsbruck | 102·2 | −16 | −12 | | | −10 | | | | |
| Entebbe | 102·2 | +4 | +8 | | | 0 | | +5 | | |
| Hamburg | 103·8 | −5 | −1 | | | −5 | | −6 | +3+14 | |
| Laibach | 103·8 | | | | | | | +1 | | |
| Jena | 103·9 | −4 | 0 | | | +5 | | −19 | +1 | +9 |
| Zagreb | 104·6 | −1 | +3 | | | | | −3 | | −27 |
| Graz | 104·7 | | | | +12 | | | −5 | | |
| Potsdam | 105·0 | P′ | | | | −13+20 | | | | |
| Vienna | 105·7 | −7 | 0 | | | −10 | | | +5 | +12 |
| Copenhagen | 105·8 | | +5 | | | −2 | +14 | −2 | +2+14 | +10 |
| Lund | 106·2 | | | | | −12 | | 0 | +2 | −3 |
| Tananarive | 106·4 | | | | | | −18 | +7 | +45 | +17 |
| Budapest | 107·1 | | | | | | | −5 | −13 | |
| Belgrade | 107·3 | | | | | +9 | | | | |
| Upsala | 109·6 | | +49 | | | | +11 | −1 | −6 | |
| Riverview | 109·9 | | +38 | | | | +9 | −12+34 | +20 | +24 |
| Lemberg | 110·0 | | | | | +1 | | −2+10 | | |
| Melbourne | 110·0 | | | | | +3 | +8 | +33 | 0+45 | +21 |
| Helwan | 111·6 | | | | | | | −8 | +15 | |
| Helsingfors | 113·3 | | | | | | | −2 | −1 | |
| Adelaide | 115·0 | | | | | −6 | | +28 | −9 | +38 |
| Pulkovo | 115·9 | | −2 | | | −11 | | −1 | 0 | −30 |
| Ksara | 116·4 | | | | | | | −3 | +4 | +1 |
| Theodosia | 117·7 | | | | | | | | | |
| Kucino | 119·8 | +6 | | | | −9 | | −5 | | −23 |
| Perth | 124·0 | | | | | | | +27 | | |

*Continued on next page,*

| | Δ | P′ | Pω | SKSP | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Baku | 128·2 | +12 | +2 | | | | | 0 | +10 | |
| Ekaterinburg | 132·0 | +5 | −2 | −2 | | | −27 | −7 | | 0 |
| Tashkent | 142·5 | −9 | −53 | | | | | 0 | | −11 |
| Frunse | 145·7 | +3 | | | | | | | | |
| Bombay | 146·0 | +12 | | +15 | | | | | | |
| Amboina | 146·9 | +13 | | | | | | | | |
| Kodaikanal | 147·0 | −15 | | | | | | | | |
| Almata | 147·2 | +7 | | | | | | | | |
| Colombo | 147·3 | +7 | | | | | | | | |
| Mizusawa | 148·9 | | | | | | | | | |
| Batavia | 150·0 | +13 | | | | | | | | |
| Hyderabad | 150·7 | +10 | | | | | | | | |
| Irkutsk | 151·2 | −2 | | | | −3 | −20 | −1 | | |
| Dehra Dun | 151·6 | +9 | $P_2'$ | | | | | | | |
| Nagoya | 153·4 | +15 | −10 | | | | | | | |
| Calcutta | 161·0 | +20 | −15 | | | | | | | |
| Manila | 165·5 | | | | | | | −36 | | |
| Zi-ka-wei | 166·8 | +6 | | | | | −15 | +19 | | |
| Taihoku | 168·7 | | | | | +7 | | | | |
| Hong Kong | 175·1 | | | | | | −16 | +21 | | |
| Phu-Lien | 176·5 | | | | | | −12 | +17 | | −14 |

Mean P residual (Δ>70°), 0 ; S, dubious ; SKS, −5.

Note.—Most of the SKS residuals are near −7s., but there are a number about +10s. Algiers and Kew, with possibly Potsdam, give readings that fit both series. It is possible again that the early series is the true SKS and the later sSKS. S is early at Toronto, Ottawa, Malaga, and Algiers ; late at Cape Town, Barcelona, Kew, and Scoresby Sund.

1928 Dec. 1d. 4h. 6m. 8s.−3s.=6m.5s. Z=−1.

I.S.S. Epicentre 34°·0S. 73°·0W. Revised Epicentre 35°·7S. 73°·0W.

A=+·2375 B=−·7766, C=−·5835.

| | Δ | Pv | Pω | Sv | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Santiago | 2·94 | −7 | −7 | | | | | | | |
| La Plata | 12·27 | −1 | −1 | +2 | +2 | | | | | |
| Sucre | 17·98 | −1 | −1 | +1 | 0 | | | +6 | | |
| La Paz | 19·70 | 0 | 0 | +2+7 | +1+6 | | | −2 | | |
| Rio de Janeiro | 28·79 | −5 | 0 | +23 | +31 | | | | | |
| Balboa Heights | 45·1 | −1+11 | +2+14 | −5+1 | 0+6 | | | | | |
| Port au Prince | 54·25 | +2 | +3 | −16 | −14 | | | | | |
| Merida | 58·9 | −20 | −20† | −33 | −33† | | | | | |
| Vera Cruz | 59·1 | −31 | −31† | −29 | −29† | | | | | |
| Tacubaya | 60·4 | +9 | +8† | +9 | +9† | | | | | |
| Guadalajara | 63·4 | −11 | −12 | −38 | −39 | | | | | |
| Mazatlan | 66·9 | +9 | +8† | +9 | +8† | | | | | |
| Chihuahua | 71·5 | +14 | +13† | +10 | +8† | | | | | |
| Cape Town | 72·0 | +5 | +4 | +25 | +23 | | | | | |
| Charlottesville | 73·9 | +9 | +8 | −9+59 | −12+56 | | | | | −30+42 |
| Georgetown | 74·7 | +4 | +4 | +3 | 0 | | | +28 | +16 | |
| Cincinnati | 75·6 | +5 | +5 | −5, +1 | −8−2 | | | +11+16 | −14+8 | −24 |
| St. Louis | 76·0 | −3 | −3 | −10 | −13 | | | | | |
| Florissant | 76·2 | −5 | −5 | −18−12 | −21−15 | | | | | −5 |
| Tucson | 76·7 | +7 | +7 | −4+2 | −7−1 | | | +8 | | −7 |
| Harvard | 78·1 | 0 | 0 | −5 | −8 | | | | | |
| Ithaca | 78·2 | +32 | +32 | +15 | +12 | | | | | |
| Chicago | 78·6 | +2 | +2 | −9, 0 | −12−3 | | | −22 | | −46 |
| Ann Arbor | 78·6 | +7 | +7 | −1 | −4 | | | +12 | | +49 |
| Toronto | 79·4 | −4+3 | −4+3 | −12−7 | −15−10 | | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Christchurch | 80·6 | +30 | +30† | +38 | +35† | | | +38† | | |
| Denver | 81·0 | +7 | +7 | +3 | −1 | | | | +5 | −2+8 |
| Wellington | 81·0 | +14 | +14† | +11+16 | +7+12† | | | | | +26 |
| Ottawa | 81·1 | −1 | −1 | −2 | −6 | | | +12 | | |
| Johannesburg | 83·1 | −38 | −38 | | | | | | | |
| Lick | 85·8 | +4+9 | +5+10 | +16 | +12 | −13 | | | −10+49 | +17 |
| Berkeley | 86·5 | +5+14 | +6+15 | +6+26 | +2+22 | +10 | | | +2 | +11 |
| Apia | 88·9 | +34 | +35 | +18 | +14 | | | −24 | | |
| Saskatoon | 92·6 | +6 | +8 | | | −2+16 | *−12* | | | −19 |
| Suva | 93·7 | −40 | −38† | | | −38† | | −36† | | |
| San Fernando | 95·1 | +7 | +9 | | | −57* | | | | |
| Victoria | 95·3 | +14 | +16 | | | +11 | | | | |
| Malaga | 96·3 | +1 | +3 | | | +2 | | | | |
| Granada | 97·2 | −1 | +2 | | | | | +12 | +45 | |
| Almeria | 97·8 | 0 | +3 | | | −21 | | | | |
| Honolulu T.H. | 98·4 | | | | | +1 | | | | −20 |
| Melbourne | 98·6 | +15 | +18 | | | +15 | | −14+25 | | +29 |
| Toledo | 98·7 | −2+7 | +1+10 | | | −7+21 | *−15* | −2 | | |
| Riverview | 99·1 | +25 | +28 | +29 | +24 | +6 | | | | −44 |
| Sydney | 99·1 | | | | | +3 | | | | +30 |
| Alicante | 99·8 | +1 | +4 | | | +8 | | | | |
| Algiers | 101·1 | 0 | +3 | −1 | −6 | | | +6 | | |
| Tananarive | 101·7 | +17 | +21 | | | | | +9 | | +33 |
| Tortosa | 102·0 | +5 | +9 | +20 | +15 | | | | | |
| Entebbe | 102·6 | −1 | +3 | | | +16 | | +24 | | |
| Bagnères | 103·2 | +10 | +14 | | | +19 | | +13 | | |
| Barcelona | 103·4 | +33 | +37 | | | +13 | | +18 | +15 | |
| Adelaide | 103·5 | | | | | +3 | | −8 | | +51 |
| Marseilles | 106·4 | | +2 | | | | | +20 | +23 | |
| Sitka | 106·6 | | | | | +16 | | | +27 | +37 |
| Puy de Dôme | 106·6 | | +13 | | | −4 | | 0 | −1+4 | |
| Reykjavik | 107·6 | | | | | | | | +17 | −20+15 |
| Bidston | 107·6 | | +13 | | | | | +4 | | |
| Paris | 107·8 | P′ | 0 | | | +10 | | +5 | | |
| Kew | 107·9 | −23 | −1+10 | | | −2 | | +8 | +8 | +7 |
| Stonyhurst | 108·2 | | +9 | | | +1 | | +5 | +6 | +37 |
| Moncalieri | 108·7 | | +4 | | | | −2 | | | |
| Edinburgh | 109·0 | | +7 | | | +15 | | | +4 | |
| Neuchâtel | 109·4 | −16 | −2 | | | +15 | | +18 | | |
| Uccle | 109·9 | | −3 | | | +4 | | +2 | +7 | |
| Rocca di Papa | 110·0 | | −26+1 | | | | | +10 | −10+8 | |
| Dyce | 110·2 | | +7 | | | +12 | | +9 | | |
| Florence | 110·2 | −13 | −5 | | | | | +9 | −4 | +1 |
| Zürich | 110·5 | −16 | | | | | | | +6 | |
| Strasbourg | 110·6 | +7 | −5 | | | +19 | | | +6 | |
| Chur | 110·8 | | −5 | | | | | +20 | | |
| Naples | 110·8 | +34 | | | | | | | | |
| Pompeii | 110·8 | | +21 | | | | | | +30 | |
| De Bilt | 111·0 | | −2 | | | | | | +8 | |
| Ravensburg | 111·4 | −25 | −6 | | | +2 | | +22 | +6 | +35 |
| Hohenheim | 111·6 | | +6 | | | +1 | | +13 | +4 | −7 |
| Venice | 111·7 | | +6 | | | | | | | |
| Feldberg | 111·9 | −19−12 | +20 | | | | | +37 | +3+29 | |
| Perth | 111·9 | | | | | | | +20 | +28 | |
| Innsbruck | 112·1 | −7 | | | | −11 | | +23 | +1 | 0 |
| Scoresby Sund | 112·3 | | +13 | | | | | +15 | +9 | |
| Jena | 113·9 | −29 | +41 | | | +9 | | −7−1+9 | −2+2 | +42 |
| Hamburg | 114·2 | −22 | +1 | | | −2 | | +6 | +7 | −4 |
| Zagreb | 114·2 | −69* | −9 | | | +14 | | +3 | +8 | |
| Graz | 114·5 | −33 | | | | | | | +3 | +38 |
| Bergen | 115·2 | | | | | | | +15 | | |
| Potsdam | 115·4 | | | | | +12 | | +6+20 | +9 | |
| Vienna | 115·5 | +28 | | | | +16 | | +8 | +7 | +22 |
| Belgrade | 116·5 | | −36 | | | | | +20 | +57 | |
| Lund | 116·8 | +13 | | | | +2 | | +9 | +10 | +4 |

*Continued on next page.*

| | Δ ° | P′ | Pω | SKSP | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| Budapest | 116·8 | −17 | | | | | | | −4 | |
| Königsberg | 120·4 | | | | | −49 | | +7 | +3 | |
| Upsala | 120·6 | | | | | | | +9 | +2 | +20 |
| Lemberg | 120·7 | +29 | | | | | | +6 | +21+25 | |
| Ksara | 122·9 | +28 | | | | | | | | +42 |
| Helsingfors | 124·3 | | | | | +10 | | +7 | | |
| Sebastopol | 125·0 | +34 | | | | | | | | |
| Yalta | 125·4 | +27 | | | | | | | | |
| Simferopol | 125·5 | +11 | | | | | | | | |
| Theodosia | 126·4 | +16 | | | | | | | | +7 |
| Pulkovo | 126·7 | +4 | 0 | | | +2 | | +7 | | |
| Kucino | 130·3 | +4 | 0 | +16? | | | | +3 | −5? | |
| Baku | 135·5 | +2 | 0 | | | | | +17 | | |
| Malabar | 137·1 | +10 | | | | | | +26 | PKS | |
| Batavia | 138·1 | +8 | | | | | | −5 | −35 | +43 |
| Colombo | 142·0 | +1 | | | | | | | | +9 |
| Ekaterinburg | 142·7 | −5 | 0 | +12 | | | | −1 | | |
| Kodaikanal | 143·1 | +27 | | | | | | | | |
| Bombay | 145·8 | +2 | | +18 | | | | | | |
| Hyderabad | 148·9 | −22 | | −16 | | −25+34 | −18 | | | |
| Tashkent | 150·0 | | +44 | | | | | +24 | | +21 |
| Ootomari | 151·3 | +14 | | −4 | | | | | | |
| Mizuaswa | 152·9 | +19 | | | | | | | | |
| Frunse | 154·1 | +14 | | | | | | | | |
| Dehra Dun | 155·3 | +16 | | | | | | | | |
| Manila | 155·4 | +10 | | +5 | | | +6+18 | +40 | | |
| Almata | 155·7 | +15 | $P_2'$ | | | | | | | |
| Nagoya | 155·7 | | +7 | | | | | | | |
| Osaka | 156·8 | | | | | | | | | |
| Kobe | 157·1 | +5+15 | | | | | | | | |
| Sumoto | 157·3 | +14 | | | | | +17 | | | |
| Toyooka | 157·4 | | | | | | | | | |
| Calcutta | 159·1 | +8+22 | | +12 | | | | | | |
| Hukuoka | 160·7 | +19 | | | | | | | | |
| Nagasaki | 161·0 | +11 | | | | | +2 | | | |
| Hong Kong | 161·3 | +18 | | | | | | | | |
| Irkutsk | 163·3 | +3 | | +6 | | | | 0 | | |
| Taihoku | 163·7 | | | | | | | | | |
| Phu-Lien | 165·1 | −2 | | | | | | | | +13 |
| Zi-ka-wei | 167·8 | +7+17 | +2 | +26 | | −2 | +18+24 | +22 | | |

**Mean P residual (Δ>70°) 0 ; S, dubious ; SKS, +1.**

# EPICENTRES IN JAPAN AND NEIGHBOURING REGIONS.

1923 July 13d. 11h. 13m. 33s.+7s.=13m.40s.   Z=−3.

I.S.S. Epicentre 31°·5N. 130°·0E.  First revised Epicentre 30°·7N. 130°·9E.  Final Epicentre 30°·9N. 131°·0E.

A=−·5629, B=+·6476, C=+·5135.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Nagasaki | 2·1 | −3 | −3 | | | | | | |
| Kobe | 5·2 | −2 | −2 | +15 | +15 | | | | |
| Osaka | 5·3 | +3 | +3 | | | | | | |
| Nagoya | 6·6 | −3 | −3 | +3 | +3 | | | | |
| Zi-ka-wei | 8·2 | 0 | 0 | +2 | +2 | | | | |
| Taihoku | 10·2 | +3 | +3 | +21 | +21 | | | | |
| Mizusawa | 11·7 | +1 | +1 | | | | | | |
| Hokoto | 12·5 | +25 | +25 | +25 | +25 | | | | |
| Hakodate | 13·4 | +8 | +8 | | | | | | |
| Sapporo | 14·7 | +5 | +5 | +21 | +20 | | | | |
| Hong Kong | 17·2 | −8 | −9 | | | | | | |
| Ootomari | 18·2 | +20 | +19 | +33 | +31 | | | | |
| Manila | 18·7 | +2 | +1 | −24 | −26 | | | | |
| Calcutta | 38·7 | +5 | +9 | +73 | +80 | | | | |
| Batavia | 43·7 | −7 | −3 | −4 | +1 | | | | |
| Dehra Dun | 45·2 | −21 | −18 | −35 | −31 | | | | |
| Simla | 45·7 | −1 | +2 | | | | | | |
| Colombo | 53·4 | +26 | +28 | +10 | +12 | | | | |
| Bombay | 53·6 | −1 | 0 | +21 | +23 | | | | |
| Kodaikanal | 53·6 | −42 | −41 | | | | | | |
| Ekaterinburg | 54·0 | +5 | +6 | +7 | +9 | | | | |
| Honolulu | 63·6 | +7 | +6 | +5 | +4 | | | | |
| Adelaide | 66·2 | | | +49 | +55 | | | | |
| Sitka | 66·4 | −8 | −9 | −13+2 | −14+1 | | | −2 | |
| Tiflis | 67·4 | +45 | +44 | +5 | +4 | | | +6 | |
| Riverview | 67·5 | −1 | −2 | −10−6 | −11−7 | | | | |
| Sydney | 67·5 | | | −14 | −15 | | | | |
| Pulkovo | 68·7 | −1 | −2 | +7 | +5 | | +6 | +28 | +17 |
| Upsala | 74·2 | +3 | +2 | +3 | 0 | | | | |
| Lemberg | 76·7 | −6 | −6 | +35 | +32 | | | +2 | |
| Victoria | 76·7 | −10 | −10 | +3 | 0 | | | | |
| Bergen | 78·6 | | | +26 | +23 | | | | |
| Hamburg | 81·4 | 0 | 0 | +25 | +21 | | | | |
| Belgrade | 81·5 | −1 | −1 | −12 | −16 | | | | |
| Vienna | 81·7 | 0 | 0 | +18 | +14 | | +8 | −16 | |
| Helwan | 82·4 | −1 | −1 | +4 | 0 | | | | |
| Wellington | 82·8 | +3 | +3 | | | −10 | +39 | | +2 |
| Berkeley | 83·1 | | | +4+13 | 0+9 | | | | |
| Athens | 83·4 | | | −60 | −64* | | | | |
| Zagreb | 83·4 | −1 | 0 | +3 | −1 | | | | |
| De Bilt | 84·5 | −2 | −1 | | | 0 | −4 | | +25 |
| Innsbruck | 84·9 | 0 | +1 | +1 | −3 | | | | |
| Edinburgh | 84·9 | 0 | +1 | +2 | −2 | | −2 | | +31 |
| Eskdalemuir | 85·4 | 0 | +1 | | | −1 | +1 | | |
| Uccle | 85·8 | −3 | −2 | | | −2 | −3 | | |
| Strasbourg | 85·8 | +1 | +2 | +13 | +9 | −31 | 0 | | |
| Zürich | 86·2 | +1 | +2 | | | −3 | | | |
| Stonyhurst | 86·2 | −2 | −1 | | | +1 | | | |
| West Bromwich | 87·1 | 0 | +1 | | | −2 | | | |
| Florence | 87·2 | | | +8 | +4 | | | | |
| Pompeii | 87·4 | +15 | +16 | | | +1 | | | |
| Oxford | 87·4 | −1 | 0 | | | −4 | | | |
| Besançon | 87·6 | | | −2 | −6 | +7 | | | |
| Rocca di Papa | 87·8 | 0+8 | +1+9 | +22 | +18 | | | +14 | |
| Paris | 88·0 | +1 | +2 | | | −2 | +3 | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Moncalieri | 88·3 | −1 | 0 | | | −10 | | | |
| Puy de Dôme | 90·1 | −2 | −1 | | | | | | |
| Marseilles | 90·7 | +13 | +15 | | | −17 | | | |
| Tortosa | 95·0 | | | | | | −4+2 | +21 | |
| Algiers | 96·6 | | | | | | 0 | | |
| Toledo | 97·9 | −8 | −5 | | | +15 | +1 | +24+36 | |
| Chicago | 99·1 | | | | | −12 | −21 | | |
| Coimbra | 99·6 | −4+27 | −1+30 | | | −5+15 | | +14 | |
| Granada | 99·8 | | | +23 | +19 | | +23 | | |
| Ottawa | 99·9 | −2 | +1 | | | −6 | −2 | | |
| | | | | | | | | SKKS | |
| Ann Arbor | 100·2 | | | | | | +1 | −15 | |
| Toronto | 100·3 | 0+6 | +3+9 | | | −8−2 | +3 | | |
| San Fernando | 101·6 | +5 | +9 | | | −3 | +11 | | |
| Washington | 105·5 | | | P′ | SKSP | | +3 | | |
| La Paz | 157·5 | | | +2 | −19 | | | | |

Mean P residual ( Δ>70°), 0 ; mean SKS residual (readings −6 to +1 retained), −2.

1923 Sept. 1d. 2h. 58m. 28s.+8s.=58m.36s. Z dubious, taken 0.

I.S.S. Epicentre 35°0N. 139°·5E. Retained.

A=−·6229, B=+·5320, C=+·5736.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Nagoya | 2·1 | −1 | −1 | −15 | −15 | | | | |
| Osaka | 3·4 | 0 | 0 | +12 | +12 | | | | |
| Kobe | 3·6 | 0 | 0 | | | | | | |
| Mizusawa | 4·3 | +1 | +1 | | | | | | |
| Hakodate | 6·8 | 0 | 0 | | | | | | |
| Nagasaki | 8·4 | −4 | −4 | | | | | | |
| Ootomari | 11·9 | −3 | −3 | | | | | | |
| Zi-ka-wei | 15·6 | +3 | +2 | +13 | +12 | | | | |
| Taihoku | 18·4 | +6 | +5 | +14 | +12 | | | | |
| Hokoto | 20·8 | +17 | +17 | | | | | | |
| Hong Kong | 25·5 | −2 | +2 | −12 | −6 | | | | |
| Manila | 26·4 | −2 | +2 | | | | | | |
| Calcutta | 46·0 | −11 | −8 | −12+4 | −8+8 | | | | |
| Batavia | 51·4 | −3 | −1 | 0 | +2 | | | | |
| Simla | 51·5 | −5 | −3 | −12+6 | −10+8 | | | | |
| Malabar | 51·9 | −3 | −1 | | | | | | |
| Ekaterinburg | 55·5 | −4 | −3 | −6 | −5 | | −28 | | |
| Honolulu | 55·8 | +6+11 | +7+12 | +11+25 | +12+26 | | | | |
| Sitka | 58·7 | −6 | −6 | +18 | +18 | | | | |
| Bombay | 60·5 | +1 | 0 | −1 | −1 | | | | |
| Colombo | 61·3 | −1 | −2 | | | | | | |
| Pulkovo | 68·9 | −3 | −4 | −3 | −5 | | −4 | +31 | −13 |
| Victoria | 68·9 | +1 | 0 | +1+13 | −1+11 | | | | |
| Riverview | 69·7 | +3 | +2 | −1 | −3 | | +12 | | |
| Sydney | 69·7 | +4 | +3 | −11 | −13 | | | | |
| Adelaide | 70·0 | +14 | +13 | −25 | −27 | | | | |
| Perth | 70·6 | +6 | +5 | −6 | −8 | | | | |
| Tiflis | 70·7 | −8+4 | −9+3 | +3 | +1 | | | 0 | −21 |
| Melbourne | 73·0 | −10 | −11 | −48 | −51 | | | | −49 |
| Upsala | 73·9 | −9 | −10 | +1 | −2 | | | | |
| Berkeley | 74·9 | 0 | 0 | +7 | +4 | | +14+25 | | +33 |
| Lick | 75·7 | −3+1 | −3+1 | +16 | +13 | | +6 | | +16 |
| Saskatoon | 76·1 | +3 | +3 | +4 | +1 | | | | |
| Bergen | 77·5 | +7 | +7 | +5 | +2 | | | | |
| Lemberg | 77·8 | +1 | +1 | +8 | +5 | | | | |
| Hamburg | 81·3 | −4 | −4 | +9 | +5 | | | | |
| Budapest | 81·9 | −68 | −68* | −59 | −63* | | | | |
| Vienna | 82·6 | −4 | −4 | +9 | +5 | | +14 | +23 | +10 |
| Wellington | 82·9 | +7 | +7 | −6 | −10 | | | | |
| Belgrade | 83·0 | 0 | 0 | +8 | +4 | | +26 | +28 | |

*Continued on next page.*

| | △ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Edinburgh | 83·7 | +5 | +6 | +7 | +3 | | +12 | | |
| Christchurch | 84·2 | −12 | −11 | −14 | −18 | | +14 | | |
| De Bilt | 84·2 | −4 | −3 | | | 0 | | | |
| Sarajevo | 84·7 | −4 | −3 | | | −14+1 | | | |
| Stonyhurst | 85·3 | +6 | +7 | | | −19 | | | |
| Mostar | 85·3 | +2 | +3 | +51 | +47 | −6 | −15 | +5 | |
| Innsbruck | 85·5 | +1 | +2 | | | −6 | +6 | | +15 |
| Uccle | 85·5 | −4 | −3 | | | +5 | −15 | | |
| Travnik | 85·5 | | | | | | | −3 | |
| Sinj | 85·7 | +34 | +35 | 0 | −4 | | | | |
| Bidston | 85·8 | +4 | +5 | | | | | | |
| Tucson | 85·8 | +8+15 | +9+16 | +14+21 | +10+17 | | | | |
| Strasbourg | 86·1 | −3 | −2 | | | +4 | | | +5 |
| West Bromwich | 86·3 | +1 | +2 | | | −26 | | | |
| Helwan | 86·4 | −4 | −3 | | | −4 | | | |
| Venice | 86·5 | +5 | +6 | | | +2 | | | |
| Zürich | 86·7 | −5 | −4 | | | 0 | | | |
| Oxford | 87·0 | +2 | +3 | | | −7 | +15 | | |
| Besançon | 87·9 | +4 | +5 | | | +5 | | | |
| Paris | 87·9 | −2 | −1 | | | +6 | | | |
| Florence | 88·2 | +5 | +6 | | | | | | |
| Pompeii | 88·9 | +19 | +20 | | | −22 | | | |
| Rocca di Papa | 89·1 | −2 | −1 | | | +11 | | | |
| Puy de Dôme | 90·3 | −6 | −5 | | | +6 | +11 | | |
| Marseilles | 91·2 | −6 | −4 | | | −6 | | | |
| Chicago | 91·9 | −2 | 0 | | | −4 | | | |
| Ann Arbor | 93·2 | −2 | 0 | | | +2 | −3 | | −10 |
| Ottawa | 93·6 | −13 | −11 | | | +6 | | SKKS | |
| Toronto | 93·7 | −5 | −3 | | | | | −6 | |
| Barcelona | 94·1 | +16 | +18 | | | 0 | +13 | | |
| Tortosa | 95·3 | +5 | +7 | | | +1+12 | | | |
| Northfield | 95·6 | +1 | +4 | | | +5 | | | |
| Ithaca | 95·8 | −4 | −1 | | | +2 | −13 | | |
| Algiers | 97·5 | −3 | 0 | | | −26 | +7 | | |
| Halifax | 97·6 | −5 | −2 | | | +9 | −16 | | |
| Toledo | 97·9 | −8 | −5 | | | 0 | +14 | | −26−13 |
| Georgetown | 98·7 | −44−33 | −41−30 | | | +4 | | | |
| Washington | 98·7 | +4 | +7 | | | +5 | +9 | | |
| Cheltenham | 98·9 | +25 | +28 | −4+10 | −8+6 | +5+12 | +4 | | |
| Coimbra | 99·2 | −7 | −4 | | | +4 | −2 | | |
| Granada | 100·1 | 0 | +3 | +27 | +23 | | +5 | | |
| Lisbon | 100·8 | +5 | +9 | +35 | +31 | | | | |
| San Fernando | 107·7 | −3 | +1 | P′ | | +2 | +16 | | |
| Johannesburg | 121·5 | | | +2 | | | | | |
| Porto Rico | 121·8 | | | | | | +24 | | +17 |
| | | PKS | SKSP | | $P_2'$ | | | | |
| Cape Town | 132·1 | −2 | | | | | | | |
| La Paz | 149·2 | | +23 | +3 | | | | +34 | +11 |
| La Plata | 165·7 | | | | +17 | | −20+19 | +18 | +30 |
| Rio de Janeiro | 167·7 | | | +12 | | | −24−2 | +28 | |

Mean P residual (△>70°), −3? ;  S residual, △>70°, +3 ;  SKS residual, +2.

This is the earthquake that destroyed Tokyo and Yokohama. P is well read at near and distant stations. The residuals for the former are in good agreement with the I.S.S. epicentre ; those for distant stations tend to be negative. The actual distribution of these distant stations would be consistent with any of three interpretations : the actual epicentre may be slightly west of the I.S.S. one ; there may be a slight focal depth ; or there may be a systematic difference between the times of transmission in American and Japanese earthquakes.

The earthquake is exceptional among Japanese ones, in that there are near stations about azimuth 270° and the epicentre is probably more accurately determinable from near stations than usual ; though there is no station near azimuth 315°. It was found on trial that a shift of the epicentre sufficient to remove the negative tendency of distant residuals would result in spoiling the agreement of the near stations.

The choice is therefore between a focal depth of order 25km. below the top of the lower layer and a small systematic difference in the times of transmission below Asia and the Atlantic.

A somewhat similar set of circumstances appears in the earthquake of 1924 Jan. 1d., which has nearly the same epicentre. In this case the readings of the near stations are less consistent than here, and for this and other reasons the latter earthquake was not discussed.

E

1924 Mar. 15d. 10h. 31m. 12s.+12s.=31m.24s.    Z=−1.

I.S.S. Epicentre 49°·0N. 144°·0E.   First revised Epicentre 49°·1N. 143°·1E.   Final Epicentre 49°·1N. 142°·9E.

A=−·4559, B=+·6029, C=+·6547.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ootomari | 2·4 | +2 | +2 | | | | | | |
| Sapporo | 6·1 | +6 | +6 | −30 | −30 | | | | |
| Mizusawa | 10·1 | +1 | +1 | +53 | +53 | | | | |
| Osaka | 15·4 | +5 | +4 | | | | | | |
| Kobe | 15·5 | +2 | +1 | +51 | +50 | | | | |
| Nagasaki | 19·0 | −1 | −2 | +27 | +25 | | | | |
| Zi-ka-wei | 24·0 | −1 | +2 | −18 | −14 | | | | −19 |
| Taihoku | 29·3 | +4 | +10 | +16 | +24 | | | | |
| Hong Kong | 35·0 | −3 | +2 | −3 | +5 | | +7 | | |
| Manila | 38·9 | −3 | +1 | −1 | +6 | | | | |
| Sitka | 46·7 | +2 | +5 | +27 | +31 | | | | −22 |
| Ekaterinburg | 47·0 | 0 | +3 | −1 | +3 | | −18 | | −21 |
| Calcutta | 50·1 | +7 | +9 | | | | | | |
| Honolulu | 54·2 | +4 | +5 | +21+37 | +23+39 | | | +13 | |
| Victoria | 57·6 | −1 | −1 | +7+17 | +8+18 | | | | |
| Pulkovo | 58·1 | +1 | +1 | +6 | +7 | | | | |
| Hyderabad | 60·2 | −1 | −2 | 0 | 0 | | | | |
| Upsala | 62·3 | +4 | +3 | +3 | +3 | | | | |
| Baku | 62·3 | +3 | +2 | +10 | +10 | | | | |
| Bombay | 62·8 | −2 | −3 | +2 | +2 | | | | |
| Batavia | 63·6 | 0 | −1 | +1 | 0 | | | | |
| Berkeley | 65·2 | −11 | −12 | +10 | +9 | | | | |
| Bergen | 65·2 | | | +35 | +34 | | | | |
| Lick | 65·9 | +7 | +6 | +14 | +13 | | | | |
| Colombo | 67·3 | −4 | −5 | +2 | +1 | | | | |
| Lemberg | 67·9 | | | +7 | +6 | | | +3 | |
| Dyce | 69·8 | | | +7 | +5 | | | | |
| Hamburg | 69·9 | +1 | 0 | +4 | +2 | | | +41 | |
| Edinburgh | 71·2 | | | +4 | +2 | | | | |
| Vienna | 72·2 | 0 | −1 | +9 | +7 | | −11 | +19 | |
| De Bilt | 72·6 | 0 | −1 | +1 | −1 | | | | |
| Stonyhurst | 72·9 | | | +16 | +13 | | | | |
| Bidston | 73·5 | 0 | −1 | −23 | −26 | | | | |
| Belgrade | 73·4 | +7 | +6 | +5 | +2 | | | | |
| Uccle | 74·0 | −1 | −2 | −2 | −5 | | | | −10 |
| Oxford | 74·6 | −3 | −4 | −1 | −4 | | | | |
| Innsbruck | 74·7 | +1 | 0 | +5 | +2 | | | | |
| Ksara | 74·8 | −27 | −27† | −28 | −31† | | | | |
| Strasbourg | 74·9 | 0 | 0 | +4 | +1 | | | | +8 |
| Zürich | 75·5 | +3 | +3 | +2 | −1 | | | | |
| Venice | 76·0 | −2 | −2 | −51 | −54* | | | | |
| Paris | 76·3 | −1 | −1 | −7 | −10 | | | | |
| Athens | 77·6 | 0 | 0 | +4 | +1 | | | | |
| Florence | 77·8 | −5 | −5 | −1 | −4 | | | | |
| Moncalieri | 78·0 | +34 | +34† | +32 | +29† | | | | |
| Chicago | 78·9 | | | −15 | −18 | | | | |
| Rocca di Papa | 79·0 | −15 | −15 | +6 | +3 | | | | |
| Ottawa | 79·7 | | | −1 | −5 | | | | |
| Ann Arbor | 79·9 | | | +14 | +10 | | | | +27 |
| Toronto | 80·1 | −7 | −7 | −3+1 | −7−3 | | | | |
| Helwan | 80·3 | +1 | +1 | −1 | −5 | | | | |
| Riverview | 83·2 | −1 | 0 | | | 0 | | | |
| Sydney | 83·3 | | | | | −4 | | | |
| Tortosa | 84·1 | −7 | −6 | | | −1 | | | |
| Perth | 84·5 | +2 | +3 | +1 | −3 | | | | |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Georgetown | 85·2 | +6 | +7 | 0 | −4 | +3 | | | |
| Washington | 85·2 | | | | | +1 | | | |
| Toledo | 86·3 | −1 | 0 | | | −2 | | | |
| Algiers | 86·9 | −2 | −1 | −71 | −75 | | | | |
| Lisbon | 88·7 | | | | | 0 | | | |
| Granada | 88·7 | −17 | −16 | | | +10 | | | |
| San Fernando | 90·0 | | | +4 | 0 | | | | |
| Wellington | 94·7 | −7 | −5 | +9 | +5 | P′ | −5 | | PKS |
| La Paz | 138·0 | | | | | +9 | | +33 | −8 |

Mean SKS residual omitting Granada, 0.

1924 May 6d. 16h. 9m. 20s.+11s.=9m.31s. Z=+1.

I.S.S. Epicentre 16°·0N. 119°·0E. Retained.

A=−·4660, B=+·8407, C=+·2756.

| | Δ | Pω | Pv | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Manila | 2·4 | +1 | +1 | | | | | | |
| Hokoto | 7·5 | | | −2 | −2 | | | | |
| Hong Kong | 7·8 | −2 | −2 | +26 | +26 | | | | |
| Taihoku | 9·3 | +15 | +15 | | | | | | |
| Zi-ka-wei | 15·3 | 0 | −1 | 0 | −1 | | | | |
| Nagasaki | 19·4 | +1 | 0 | +9 | +6 | | | | |
| Osaka | 23·8 | +1 | +3 | +10 | +3d | | | | |
| Nagoya | 25·0 | −16 | −13 | +3 | −6d | | | | |
| Calcutta | 29·6 | +7 | +13 | +7 | +15 | | | | |
| Mizusawa | 30·2 | −8 | −2 | −15 | −6 | | | | |
| Irkutsk | 38·1 | −4 | 0 | −4 | +3 | | | | |
| Hyderabad | 38·8 | −2 | +2 | +3 | +10 | | | | |
| Colombo | 39·4 | −26 | −22 | −6 | +1 | | +18 | | |
| Kodaikanal | 40·8 | +11 | +15 | +45 | +51 | | | | |
| Bombay | 44·0 | +12 | +15 | −32 | −37 | | | | |
| Perth | 48·1 | +11 | +14 | −7 | −4 | | +16 | | |
| Riverview | 58·6 | +13 | +13 | −15 | −15 | | | | |
| Sydney | 58·6 | −20 | −20 | | | | | | |
| Melbourne | 59·1 | | | −24 | −24 | | | | |
| Ksara | 75·3 | +6 | +6 | +15 | +12 | | | −12 | |
| Pulkovo | 75·6 | −2 | −2 | +3 | 0 | | | | −11 |
| Wellington | 77·1 | −5 | −5 | −7 | −10 | | | | |
| Honolulu | 77·9 | | | +9 | +6 | | | | |
| Helwan | 80·2 | 0 | 0 | −3 | −7 | | | | |
| Lemberg | 80·9 | −5 | −5 | −7−1 | −11−5 | | | | |
| Upsala | 81·8 | −7 | −7 | −1 | −5 | | | | |
| Athens | 84·3 | +8 | +9 | | | +1 | | | |
| Belgrade | 84·7 | +6 | +7 | | | +1 | | | |
| Vienna | 86·2 | +1 | +2 | +5 | +1 | | +36 | −26 | |
| Hamburg | 87·9 | −20 | −19 | | | +4 | | | |
| Innsbruck | 89·7 | −4 | −3 | | | −1 | | | |
| Rocca di Papa | 91·0 | +5 | +7 | | | | | | |
| De Bilt | 91·2 | +5 | +7 | | | +4 | | | +10 |
| Florence | 91·2 | | | | | | | | +22 |
| Zürich | 91·4 | −1 | +1 | | | −6 | | | |
| Strasbourg | 91·4 | +3 | +5 | | | +11 | | | |
| Uccle | 92·2 | −3 | −1 | | | −6 | | | +8 |
| Dyce | 92·2 | +1 | +3 | | | +5 | +29 | | |
| Moncalieri | 93·0 | +16 | +18 | | | −10 | | | |
| Besançon | 93·1 | +14 | +16 | | | −3 | | | |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Edinburgh | 93·3 | | | +8 | +4 | | −28 | | |
| Eskdalemuir | 93·7 | +17 | +19 | | | +1 | −2 | | |
| Paris | 93·8 | +1 | +3 | | | +1 | −6 | | |
| Stonyhurst | 94·2 | +38 | +40 | | | +2 | | | |
| Oxford | 94·7 | | | +28 | +24 | | +23 | | |
| Bidston | 94·7 | | | | | −11 | −3 | | |
| Victoria | 95·1 | +8 | +10 | | | +3+8 | | | |
| Barcelona | 98·2 | | | | | −4 | +8 | | |
| Tortosa | 99·5 | | | | | | +9 | | |
| Toledo | 103·0 | −12 | −8 | | | 0 | | | |
| Granada | 104·2 | −13 | −9 | | | +17 | | −23 | |
| Ottawa | 117·2 | | | P′ | | | +6 | +7 | −29 |
| Chicago | 117·2 | | | +24 | | | | | |
| Toronto | 118·0 | | | +45 | | | −25+16 | −37+6 | +8 |
| Ann Arbor | 118·0 | | | | | | +11 | | |
| Ithaca | 119·8 | | | | | | +12 | | −1 |
| Washington | 123·0 | | | | | | −14 | | |
| Rio de Janeiro | 162·0 | | | +37 | | | | | |
| La Paz | 173·1 | | | +7 | | | | | |

Mean SKS residual +1. The epicentre is fixed by near observations. Toronto 29m.7s. may be SKSP.

1924 Aug. 14d. 23h. 27m. 24s.+7s.=27m.31s. Z=−2.

I.S.S. Epicentre 36°·0N. 142°·0E. Retained.

A=−·6375, B=+·4981, C=+·5878.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Mizusawa | 3·2 | 0 | 0 | 0 | 0 | | | | |
| Nagoya | 4·2 | +1 | +1 | | | | | | |
| Osaka | 5·5 | +5 | +5 | | | | | | |
| Kobe | 5·8 | −1 | −1 | +16 | +16 | | | | |
| Sapporo | 7·1 | +10 | +10 | +3 | +3 | | | | |
| Nagasaki | 10·6 | −2 | −2 | | | | | | |
| Ootomari | 10·7 | +2 | +2 | −6 | −6 | | | | |
| Taihoku | 20·7 | +9 | +9 | +26 | +26 | | | | |
| Hong Kong | 27·9 | −11 | −6 | +16 | +24 | | | | |
| Manila | 28·5 | +7 | +12 | | | | | | |
| Irkutsk | 31·1 | −8 | −2 | −12 | −3 | | | | |
| Calcutta | 48·1 | −23 | −20 | | | | | | |
| Simla | 53·3 | +2+8 | +4+10 | −2+4 | 0+6 | | | | |
| Batavia | 53·6 | 0 | +1 | −5 | −3 | | | | |
| Honolulu | 53·7 | +12 | +13 | +33 | +35 | | | | |
| Sitka | 56·6 | | | +12 | +13 | | | | |
| Hyderabad | 58·7 | −3 | −3 | +26 | +26 | | | | |
| Bombay | 62·5 | −2 | −3 | +7 | +7 | | | | |
| Victoria | 66·7 | 0 | −1 | −1 | −2 | | | | |
| Baku | 69·1 | 0 | −1 | +18 | +16 | | | +28 | +23 |
| Pulkovo | 69·1 | −2 | −3 | −3 | −5 | | | | |
| Riverview | 70·4 | | | +2 | 0 | | | | |
| Adelaide | 71·1 | | | +8 | +6 | | | | |
| Perth | 72·3 | −44 | −45 | −22+19 | −24+17 | | | | +19 |
| Berkeley | 72·7 | +12 | +11 | +8 | +6 | | | | |
| Lick | 73·4 | +10 | +9 | +6 | +3 | | | +14 | +8 |
| Upsala | 73·9 | −6 | −7 | −7 | −10 | | | | |
| Königsberg | 76·3 | 0 | 0 | −16+1 | −19−2 | | | −13+27 | |
| Bergen | 77·3 | −23 | −23 | +4 | +1 | | | | |
| Lemberg | 78·2 | −14 | −14 | −13 | −16 | | | | |
| Hamburg | 81·3 | −2 | −2 | +4 | 0 | | | | |
| Dyce | 82·0 | −1 | −1 | +2 | −2 | | | | |
| Ksara | 82·0 | +1 | +1 | −2 | −6 | | | | |
| Budapest | 82·2 | +8 | +8 | +13 | +9 | | | −3 | |
| Vienna | 82·9 | −1 | −1 | −31+14 | −35+10 | | −20 | | |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Wellington | 83·0 | | | | | −6 | | | −7 |
| Belgrade | 83·5 | 0 | +1 | | | | +9 | | |
| Eskdalemuir | 84·0 | −5 | −4 | | | −6 | +9 | | +26 |
| De Bilt | 84·2 | −1 | 0 | +13 | +9 | −3 | | | |
| Stonyhurst | 85·0 | +14 | +15 | +18 | +14 | | | | |
| Uccle | 85·6 | −3 | −2 | +4 | 0 | | +8 | | +19 |
| Bidston | 85·6 | +8 | +9 | +11 | +7 | | | | |
| Innsbruck | 85·8 | −2 | −1 | +19 | +15 | | | | |
| Strasbourg | 86·2 | +9 | +10 | +9 | +5 | | | | |
| Oxford | 86·6 | −1 | 0 | +1 | −3 | | | | |
| Venice | 86·7 | −23 | −22 | | | | | | |
| Zürich | 86·9 | −4 | −3 | | | 0 | | | |
| Helwan | 87·4 | −5 | −4 | +15 | +11 | | 0 | | |
| Paris | 87·9 | −1 | 0 | | | +7 | | | |
| Besançon | 88·0 | −2 | −1 | +12 | +8 | | | | |
| Florence | 88·6 | −13 | −12 | | | −3 | | | |
| Pompeii | 89·4 | −11 | −10 | +6 | +2 | | | | |
| Rocca di Papa | 89·5 | +8 | +9 | +3+17 | −1+13 | | −2 | | |
| Chicago | 89·9 | −36 | −35 | −60 | −64 | | | | |
| Ann Arbor | 91·3 | +21 | +23 | +6 | +2 | | +20 | SKKS | +19 |
| Ottawa | 91·8 | −7 | −5 | −2 | −6 | | +10 | −6 | +16 |
| Toronto | 91·9 | +22 | +24 | | | | | −7 | |
| Mazatlan | 92·3 | −22 | −20 | | | −2 | | | |
| Ithaca | 94·0 | | | | | −11 | | | +11 |
| Tortosa | 95·5 | −12 | −9 | | | −2 | | | |
| Harvard | 96·0 | −65* | −62* | | | −7 | | | +3 |
| Georgetown | 96·8 | −46 | −43 | +7 | +3 | | | | +20 |
| Algiers | 97·8 | +13 | +16 | | | +11 | | | |
| Toledo | 98·0 | −2 | −5 | | | +16 | | | |
| Tacubaya | 99·9 | +9 | +12 | | | +21 | | −7 | |
| Granada | 100·2 | −1 | +2 | +1 | −3 | | −2 | | |
| Malaga | 100·9 | −23 | −19 | | | +13 | | | |
| San Fernando | 101·8 | +4 | +8 | PKS | | +10 | +19 | | +48 |
| Cape Town | 134·5 | P′ | | +2 | | | | | |
| La Paz | 146·9 | +5 | | | | | | | |
| La Plata | 163·8 | −29 | | | | | | −15 | |

Mean P residual (Δ>70°), −1 ; S, −2 ; SKS, −4.

1924 Aug. 25d. 14h. 30m. 48s.+7s.=30m.55s. Z dubious, taken 0.

I.S.S. Epicentre 36°·0N. 142°·0E. Revised Epicentre 35°·9N. 142°·9E.

A=−·6461, B=+·4886, C=+·5864.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Mizusawa | 3·5 | −5 | −5 | 0 | 0 | | | | |
| Nagoya | 5·1 | +2 | +2 | | | | | | |
| Osaka | 6·4 | +1 | +1 | | | | | | |
| Kobe | 6·7 | −3 | −3 | | | | | | |
| Ootomari | 10·7 | +3 | +3 | −9 | −9 | | | | |
| Nagasaki | 11·5 | −41 | −41 | | | | | | |
| Zi-ka-wei | 18·7 | −7 | −8 | −10 | −12 | | | | |
| Taihoku | 21·5 | −6 | −7 | +46 | +47 | | | | |
| Hong Kong | 28·7 | −4 | +1 | +5 | +13 | | | | |
| Manila | 29·1 | +1 | +7 | | | | | | |
| Irkutsk | 31·8 | −11 | −5 | −21 | −12 | | | | |
| Honolulu | 52·8 | +63 | +65* | +24 | +26 | | | | |
| Simla | 54·2 | | | −1 | +1 | | | | |
| Batavia | 54·2 | +1 | +2 | −1 | +1 | | | | |
| Ekaterinburg | 56·7 | −2 | −2 | −5 | −4 | | −5 | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Hyderabad | 59·6 | −6 | −6 | −8 | −8 | | | | |
| Bombay | 63·4 | −1 | −2 | +5 | +4 | | | | |
| Victoria | 66·1 | +7 | +6 | +13 | +12 | | | | |
| Pulkovo | 69·6 | −2 | −3 | −6 | −8 | | | | −6 |
| Baku | 69·9 | −1 | −2 | −2 | −4 | | | | |
| Riverview | 70·2 | | | +10 | +8 | | | | |
| Lick | 72·7 | +7 | +6 | | | | −13 | | |
| Upsala | 74·4 | −4 | −5 | −6 | −9 | | | | |
| Königsberg | 76·8 | +1 | +1 | −3 | −6 | | | | |
| Lemberg | 78·8 | | | 0 | −3 | | | | |
| Hamburg | 81·8 | 0 | 0 | −6 | −10 | | | | |
| Dyce | 82·3 | −1 | −1 | | | −5 | | | |
| Ksara | 82·8 | +2 | +2 | | | −7 | −11 | | |
| Budapest | 82·8 | −1 | −1 | | | −3 | | | |
| Vienna | 83·4 | 0 | +1 | | | −8 | | +21 | |
| Edinburgh | 83·8 | +1 | +2 | | | | | | |
| Belgrade | 84·1 | −10 | −9 | | | −14 | | | |
| Eskdalemuir | 84·3 | +1 | +2 | | | +2 | | | |
| De Bilt | 84·6 | 0 | +1 | | | +3 | | | |
| Stonyhurst | 85·4 | −1 | 0 | +4 | 0 | | | | |
| Uccle | 86·0 | −2 | −1 | | | 0 | | | 0 |
| Bidston | 86·0 | +6 | +7 | +4 | 0 | | | | |
| Innsbruck | 86·3 | +1 | +2 | | | | | | |
| Strasbourg | 86·7 | +4 | +5 | +3 | −1 | | | | |
| Oxford | 87·0 | +4 | +5 | −3 | −7 | | | | |
| Zürich | 87·3 | −1 | 0 | | | −3 | | | |
| Paris | 88·3 | 0 | +1 | | | +8 | | | |
| Besançon | 88·5 | | | | | +4 | | | |
| Florence | 89·1 | +11 | +12 | | | +7 | | | |
| Ann Arbor | 89·9 | −23 | −22 | +2 | −2 | | | | |
| Pompeii | 90·0 | −26 | −25 | | | | | | |
| Rocca di Papa | 90·1 | +3 | +4 | −5 | −9 | | +8+13 | | |
| Ottawa | 91·5 | −1 | +1 | | | −7 | +2 | | +13 |
| Toronto | 91·5 | +5 | +7 | | | −10−1 | | | |
| Georgetown | 96·4 | −16 | −13 | | | −64 | | | |
| | | | | | | | | PKS | |
| Cape Town | 135·1 | | | P′ | | | | +5 | |
| La Paz | 146·2 | | | +11 | | | | | |

Mean P residual ( Δ>70°), +1 ; S, −5? ; SKS, −5?

1924 Dec. 28d. 22h. 54m. 52s.+12s.=55m.4s. Z=−8.

I.S.S. Epicentre 43°·2N. 147°·2E. Retained.

A=−·6128, B=+·3949, C=−·6845.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Sapporo | 4·3 | +1 | +1 | −7 | −7 | | | | |
| Ootomari | 4·7 | −1 | −1 | −13 | −13 | | | | |
| Mizusawa | 6·2 | +1 | +1 | +1 | +1 | | | | |
| Nagoya | 11·3 | −14 | −14 | +13 | +13 | | | | |
| Osaka | 12·5 | −5 | −5 | −2 | −2 | | | | |
| Kobe | 12·7 | −1 | −1 | +78 | +77 | | | | |
| Nagasaki | 17·2 | 0 | −1 | | | | | | |
| Zi-ka-wei | 23·6 | +7 | +9 | +17 | +10d | | | | +16 |
| Taihoku | 27·8 | +2 | +7 | +18 | +6d | | | | |
| Irkutsk | 29·8 | −11 | +5 | −1 | +7 | | | | |
| Hong Kong | 34·4 | −6 | −1 | +6 | +14 | | | | |
| Manila | 36·4 | −2 | +3 | −24 | −16 | | | | |
| Sitka | 48·6 | +2 | +5 | +24+35 | +27+38 | | +13 | | |
| Honolulu | 50·1 | | | +16 | +19 | | | | |
| Calcutta | 52·4 | −5+6 | −3+8 | +2 | +4 | | | | |

*Continued on next page.*

| | Δ | $P_v$ | $P_\omega$ | $S_v$ | $S_\omega$ | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ekaterinburg | 53·3 | +8 | +10 | +2 | +4 | | | | +25 |
| Simla | 55·5 | −7−1 | −6, 0 | +11 | +12 | | | | |
| Victoria | 58·9 | | | −48+20 | −48+20 | | | +14 | |
| Batavia | 61·4 | −2 | −3 | −3 | −3 | | | | |
| Hyderabad | 62·8 | −2 | −3 | +7 | +7 | | | | |
| Pulkovo | 64·8 | +1 | 0 | +1 | 0 | | | | |
| Berkeley | 65·5 | −2 | −3 | +13 | +12 | | +21 | | |
| Bombay | 66·0 | −5 | −6 | +5 | +4 | | | | |
| Baku | 68·1 | 0 | −1 | +8 | +6 | | | | |
| Kodaikanal | 68·3 | | | +17 | +15 | | | | |
| Upsala | 69·0 | −4 | −5 | −8 | −10 | | | | |
| Königsberg | 72·0 | −2 | −3 | +15 | +13 | | | | |
| Lemberg | 74·6 | −6 | −7 | −3 | −6 | | | | |
| Tucson | 76·2 | | | +19 | +16 | | | | |
| Breslau | 76·4 | +8 | +8 | +32 | +29 | | | −6 | |
| Hamburg | 76·5 | −2 | −2 | +5 | +2 | | | | |
| Riverview | 77·2 | +10 | +10 | +4 | +1 | | | | +28 |
| Sydney | 77·2 | | | +4 | +1 | | | | |
| Budapest | 78·5 | −4 | −4 | +8 | +5 | | | | |
| Adelaide | 78·6 | | | −3 | −6 | | | | |
| Vienna | 78·9 | −4 | −4 | +20 | +17 | | | +17 | −17 |
| De Bilt | 79·2 | +3 | +3 | +19 | +15 | | | | |
| Belgrade | 80·1 | −1 | −1 | +27 | +23 | | | | |
| Perth | 80·5 | −6 | −6 | +2 | −2 | | | | |
| Uccle | 80·6 | −3 | −3 | +8 | +4 | | | | |
| Ksara | 80·8 | −2 | −2 | +5 | +1 | | | | |
| Melbourne | 81·1 | | | −2 | −6 | | | | |
| Innsbruck | 81·5 | −2 | −2 | +2 | −2 | | | | |
| Strasbourg | 81·6 | −4 | −4 | | | | | | |
| Zürich | 82·4 | −5 | −5 | +1 | −3 | | | | |
| Paris | 82·9 | 0 | 0 | +4 | 0 | | | | |
| St. Louis | 83·1 | +5 | +6 | +2+7 | −2+3 | | +11 | +7+16 | −6 |
| Ann Arbor | 83·1 | −4 | −3 | +25 | +21 | | +25 | | |
| Besançon | 83·4 | +5 | +6 | | | | | | |
| Ottawa | 83·6 | −9 | −8 | | | −7 | | | |
| Toronto | 83·7 | −19 | −18 | +15 | +11 | −6 | | | |
| Athens | 84·2 | −82 | −81 | −22 | −26 | | | | |
| Florence | 84·6 | −26 | −25 | +9 | +5 | | | | |
| Moncalieri | 84·8 | +25 | +26 | +43 | +39 | | | | |
| Rocca di Papa | 85·8 | −2 | −1 | +16 | +12 | | | | |
| Pompeii | 85·8 | +18 | +19 | +23 | +19 | | | | |
| Helwan | 86·3 | −5 | −4 | +18 | +14 | | | | |
| Harvard | 87·8 | | | +17 | +13 | −2 | | | |
| Wellington | 88·1 | −1 | 0 | +11 | +9 | | +6 | | +14 |
| Fordham | 88·1 | +1 | +2 | | | −5 | | | |
| Georgetown | 88·6 | −56 | −55 | +3 | −1 | | | | |
| Cheltenham | 88·9 | | | 0+21 | −4+17 | | | | |
| Barcelona | 89·7 | +10 | +11 | +2 | −2 | | | | |
| Tortosa | 90·7 | | | +5 | −1 | | | | |
| Tacubaya | 92·7 | | | +4+13 | 0+9 | | | | |
| Toledo | 93·0 | −4 | −2 | 0 | −4 | | | | |
| Algiers | 93·6 | −7 | −5 | | | +9 | | | |
| Almeria | 95·2 | −30 | −28 | | | −24 | | | |
| Granada | 95·3 | −2 | 0 | +25 | +21 | | | | |
| Rio Tinto | 95·6 | | | | | | | 0 | |
| Malaga | 96·0 | −64 | −61* | | | −1 | | | |
| San Fernando | 96·7 | | | | | +16 | | +21 | PKS |
| Cape Town | 139·5 | | | P′ | | | | | −16 |
| La Paz | 139·8 | | | +3 | | | | +35 | +22 |
| Rio de Janeiro | 157·9 | | | +7 | | | | | |
| La Plata | 158·9 | | | +8 | | | | | |

Mean P residual (Δ>70°), −3; S, −2?; SKS, −6. The epicentre is determined by near stations. We have the same phenomenon as in the Tokyo earthquake; but here the large negative value of Z needed to fit many of the stations seems to imply absence of primitive P movement. In that event the effect of focal depth would not show in P; and the negative residuals of P at distant stations will have to be attributed to a difference in the times of transmission.

1925 Jan. 18d. 12h. 5m. 52s.+7s.=5m.59s.    Z=−10.

I.S.S. Epicentre 48°·8N. 153°·5E.  First revised Epicentre 48°·0N. 153°·5E.  Final Epicentre 47°·9N. 153°·1E.

A=−·5979, B=+·3033, C=+·7420.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ootomari | 7·1 | +11 | +11 | +30 | +30 | | | | |
| Mizusawa | 12·3 | 0 | 0 | 0 | 0 | | | | |
| Tokyo | 15·7 | +2 | +1 | +14 | +13 | | | | |
| Nagoya | 17·4 | −6 | −7 | +7 | +5 | | | | |
| Osaka | 18·6 | +11 | +10 | +33 | +31 | | | | |
| Kobe | 18·8 | +4 | +3 | +23 | +21 | | | | |
| Sumoto | 19·2 | +61 | +60* | +3 | +1 | | | | |
| Nagasaki | 23·1 | 0 | +2 | +18 | +11d | | | | |
| Zi-ka-wei | 29·2 | 0 | +6 | +6 | +14 | | | | |
| Irkutsk | 31·1 | −7 | −1 | +2 | +11 | | | | |
| Taihoku | 33·7 | −10 | −4 | −17 | −8 | | | | |
| Hong Kong | 40·2 | −10 | −6 | −4 | +3 | | | | |
| Sitka | 42·4 | +9 | +13 | +5 | +11 | | | | −16 |
| Manila | 42·5 | −15 | −11 | | | | | | |
| Phu-Lien | 46·1 | −4 | −1 | | | | | | |
| Honolulu | 47·3 | −15 | −12 | +7+17 | +11+21 | | −9 | | +10+17 |
| Victoria | 52·7 | −7 | −5 | +2 | +4 | | | | |
| Amboina | 56·1 | −12 | −11 | +82 | +83 | | | | |
| Calcutta | 56·8 | +11 | +11 | +17+58 | +18+59 | | | | |
| Dehra Dun | 58·4 | −7 | −7 | +1 | +2 | | | | |
| Simla | 58·5 | +1 | +1 | +2+14 | +3+15 | | | | |
| Berkeley | 59·7 | −4 | −4 | +12 | +12 | | | +12 | |
| Lick | 60·4 | −4 | −5 | −5, 0 | −5, 0 | | +25 | +5 | |
| Pulkovo | 62·7 | −3 | −4 | +5 | +5 | | | | |
| Kucino | 63·2 | −3 | −4 | | | | | | |
| Upsala | 66·4 | −3 | −4 | +1 | 0 | | | | |
| Hyderabad | 67·0 | −4 | −5 | 0 | −1 | | +9 | | −1 |
| Batavia | 67·6 | −1 | −2 | +4 | +2 | | +23 | | |
| Malabar | 68·1 | +1 | 0 | +4 | +2 | | | | |
| Bergen | 68·6 | +17 | +16† | +16 | +12† | | | | |
| Baku | 68·7 | 0 | −1 | +13 | +11 | | | | |
| Apia | 69·0 | +12 | +11 | +6 | +4 | | | | |
| Bombay | 69·7 | −5 | −6 | +5 | +3 | | | | |
| Königsberg | 69·9 | 0 | −1 | +7 | +5 | | +33 | +27 | +26 |
| Tucson | 70·4 | +2 | +1 | +6 | +4 | | | | |
| Dyce | 72·9 | +4 | +3 | +3 | +1 | | −5 | | +28 |
| Kodaikanal | 72·9 | −14 | −15† | −24 | −22† | | | | |
| Lemberg | 73·0 | | | −1 | −4 | | | | |
| Hamburg | 73·8 | −1 | 0 | +7 | +4 | | 0 | | |
| Colombo | 73·8 | −2 | −3 | +38 | +35 | | | | |
| Edinburgh | 74·3 | | | +6 | +3 | | | | |
| Eskdalemuir | 74·8 | −2 | −2 | +5 | +2 | | | | |
| Chicago | 75·5 | +3 | +3 | | | | | | |
| Stonyhurst | 76·1 | +1 | +1 | +27 | +24 | | +1 | | −3 |
| De Bilt | 76·3 | −2 | −2 | +7 | +4 | | | | |
| Cheb | 76·5 | +45 | +45† | +51 | +48† | | | | |
| Bidston | 76·7 | +53 | +53† | +73 | +70† | | | | |
| Budapest | 76·7 | −4 | −4 | −3 | −6 | | −29 | +21 | |
| Ann Arbor | 76·8 | +5 | +5 | +4 | +1 | | | | +8 |
| St. Louis | 76·8 | +2 | +2 | +5 | +2 | | | −8 | +15 |
| Vienna | 76·9 | −4 | −4 | +6 | +3 | | | | |
| West Bromwich | 77·3 | 0 | 0 | +8 | +5 | | | | |
| Ottawa | 77·4 | −3 | −3 | −3 | −6 | | | | |
| Toronto | 77·4 | 0 | 0 | +1 | −2 | | | | |
| Uccle | 77·7 | −3 | −3 | +4 | +1 | | −1 | | +9 |
| Oxford | 77·9 | −2 | −2 | +5 | +2 | | | −9 | |
| Hohenheim | 78·5 | −1 | −1 | +5 | +2 | | | | |
| Belgrade | 78·6 | 0 | 0 | +4 | +1 | | | | |
| Strasbourg | 79·0 | −2 | −2 | +4 | +1 | | +3 | −38 | |
| Innsbruck | 79·3 | −6 | −6 | +2 | −2 | | | | |

*Continued on next page.*

| | △ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ravensburg | 79·3 | −2 | −2 | +4 | 0 | | | −24 | |
| Ithaca | 79·6 | +31 | +31† | +19 | +15† | | | | |
| Mazatlan | 79·7 | +25 | +25† | +38 | +34† | | | | |
| Zürich | 79·9 | −4 | −4 | +4 | 0 | | | | |
| Paris | 80·0 | −5 | −5 | +2 | −2 | | | | |
| Sarajevo | 80·1 | 0 | 0 | +9 | +5 | | | | |
| Besançon | 80·6 | +2 | +2 | +7 | +3 | | | | |
| Venice | 80·7 | −5 | −5 | −9 | −13 | | | | |
| Mostar | 80·8 | −1 | −1 | +4 | 0 | | | | |
| Harvard | 81·6 | +4 | +4 | +7 | +3 | | | −18 | −6 |
| Riverview | 81·8 | −7 | −7 | −7 | −10 | | +19 | | |
| Sydney | 81·8 | +13 | +13 | −8 | −12 | | | | |
| Fordham | 81·9 | −1 | −1 | +4 | 0 | | | | −7 |
| Moncalieri | 82·3 | −3 | −3 | +4 | 0 | | | | |
| Georgetown | 82·4 | −3 | −3 | +1 | −3 | | | | |
| Florence | 82·5 | −2 | −2 | +2+8 | −2+6 | | | | |
| Cheltenham | 82·6 | −2 | −2 | +2 | −2 | | +3 | −6 | +12 |
| Athens | 83·2 | −3 | −2 | 0 | −4 | | | | |
| Loyola | 83·3 | +3 | +4 | +8 | +4 | | | | |
| Rocca di Papa | 83·9 | −3 | −2 | −22 | −26 | | | | |
| Adelaide | 83·9 | | | | | −19 | | | |
| Mobile | 84·1 | −2 | −1 | | | −8 | | | |
| Pompeii | 84·2 | +11 | +12 | +15 | +11 | | | | |
| Helwan | 86·6 | 0 | +1 | | | −11 | | | |
| Perth | 86·6 | +8 | +9 | +5 | +1 | −10 | +16 | −23 | |
| Tacubaya | 86·8 | −13 | −12 | | | −10 | | | |
| Barcelona | 87·1 | 0 | +1 | +9 | +5 | −5 | | | |
| Tortosa | 88·0 | −1 | 0 | | | −11 | | | |
| Toledo | 89·9 | −7 | −6 | | | −10 | −28 | | −20 |
| Alicante | 90·6 | −2 | 0 | | | −14 | | | |
| Algiers | 91·2 | −4 | −2 | | | −16 | | | |
| Wellington | 91·2 | −13 | −11 | | | +3 | +9 | | |
| Lisbon | 91·9 | −14 | −12 | | | −24 | | | |
| Granada | 92·4 | −17 | −15 | | | −26 | | | |
| Almeria | 92·5 | −2 | 0 | | | −16 | | | |
| Malaga | 93·0 | −5 | −3 | | | −14 | | | |
| San Fernando | 93·6 | +3 | +5 | P′ | SKKS | −9 | | PKS | |
| La Paz | 133·9 | | | +18 | −16 | | | −21−1 | +7 |
| Cape Town | 143·5 | | | −4 | | | | | |
| La Plata | 153·8 | | | | −16 | | −18−11 | | |

Mean P residual (△>70°), −1 ; S, +1? ; SKS, −11.

1925 Jan. 28d. 4h. 5m. 25s.+13s.=5m.38s. Z dubious, taken 0.

I.S.S. Epicentre 43°·2N. 147°·2E. Revised Epicentre 43°·7N. 147°·2E.

A=−·6078, B=+·3916, C=+·6909.

| | △ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ootomari | 4·3 | +8 | +8 | | | | | | |
| Mizusawa | 6·4 | 0 | 0 | −3 | −3 | | | | |
| Tokyo | 9·8 | −1 | −1 | −13 | −13 | | | | |
| Nagoya | 11·6 | +16 | +16 | +3 | +3 | | | | |
| Osaka | 12·8 | +9 | +9 | | | | | | |
| Kobe | 12·9 | +2 | +2 | +5 | +4 | | | | |
| Sumoto | 13·4 | +4 | +4 | −81 | −82 | | | | |
| Nagasaki | 17·4 | −2 | −3 | +41 | +39 | | | | |
| Zi-ka-wei | 23·8 | +2 | +4 | +1 | +5 | | | | |
| Taihoku | 28·0 | +15 | +20 | −12+10 | −4+18 | | | | |
| Irkutsk | 29·5 | +68 | +74 | +1 | +9 | | | | |
| Hong Kong | 34·6 | −8 | −3 | −10 | −2 | | | | |
| Manila | 36·7 | −2 | +3 | | | | | | |
| Phu-Lien | 40·7 | −3 | +1 | −10 | −4 | | | | |
| Honolulu | 50·4 | | | −5 | −2 | | | | +5 |

*Continued on next page.*

| | Δ | $P_\nu$ | $P_\omega$ | $S_\nu$ | $S_\omega$ | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Calcutta | 52·4 | +3 | +5 | +12 | +14 | | | | |
| Ekaterinburg | 53·0 | −2 | 0 | −7 | −5 | | | | |
| Simla | 55·4 | | | +6 | +7 | | | | |
| Victoria | 58·6 | +2 | +2 | −6 | −5 | | | | |
| Batavia | 61·8 | +1 | 0 | −6 | −6 | | | | |
| Hyderabad | 62·8 | −1 | −2 | −3 | −3 | | | | |
| Kucino | 64·1 | −3 | −4 | −5 | −6 | | | | −2 |
| Pulkovo | 64·4 | −1 | −2 | −7 | −8 | | | | +5 |
| Berkeley | 65·2 | | | −10 | −11 | | −3+11 | | |
| Bombay | 65·9 | +2 | +1 | +6 | +5 | | | | |
| Baku | 67·8 | +4 | +3 | +10 | +8 | | | +10 | |
| Upsala | 68·5 | −3 | −4 | −4 | −6 | | | | |
| Colombo | 69·0 | +7 | +6 | +15 | +13 | | | | |
| Königsberg | 71·6 | +1 | 0 | +2 | 0 | | | | |
| Lemberg | 74·2 | | | −16 | −15 | | | | |
| Dyce | 75·9 | −2 | −2 | +1 | −2 | | +20 | | |
| Hamburg | 76·1 | −1 | −1 | +4 | +1 | | | | |
| Edinburgh | 77·3 | −1 | −1 | +12 | +9 | | | | |
| Riverview | 77·6 | −11 | −11 | −13 | −16 | | | | |
| Eskdalemuir | 77·9 | −3 | −3 | −1 | −4 | | | | |
| Budapest | 78·0 | +25 | +25 | +9 | +6 | | | | |
| Cheb | 78·3 | +59 | +59* | +58 | +55* | | | | |
| Vienna | 78·4 | 0 | 0 | +5 | +2 | | | −10+13 | |
| De Bilt | 78·7 | −1 | −1 | +2 | −1 | | +1 | | |
| Stonyhurst | 79·1 | +6 | +6 | −6 | −9 | | | | |
| Belgrade | 79·6 | −41 | −41 | +13 | +9 | | | | |
| Bidston | 79·6 | −1 | −1 | −1 | −5 | | | | |
| Uccle | 80·1 | −2 | −2 | +2 | −2 | | | | |
| West Bromwich | 80·2 | +2 | +2 | 0 | −4 | | | | |
| Hohenheim | 80·5 | −5 | −5 | +5 | +1 | | | | |
| Oxford | 80·7 | +1 | +1 | −1 | −5 | | | | |
| Perth | 80·9 | | | −10 | −14 | | | | |
| Innsbruck | 81·0 | +7 | +7 | −7 | −11 | | | | |
| Strasbourg | 81·1 | +1 | +1 | +5 | +1 | | | | |
| Ravensburg | 81·2 | −5 | −5 | 0 | −4 | | | | |
| Chicago | 81·4 | 0 | 0 | +1 | −3 | | | | |
| Melbourne | 81·6 | | | −13 | −17 | | | | |
| Zürich | 81·9 | −18 | −18 | | | −3 | | | |
| Venice | 82·3 | −3 | −3 | +7 | +3 | | | | |
| Paris | 82·5 | +2 | +2 | | | −3 | | | |
| Ann Arbor | 82·7 | +12 | +12 | +12 | +8 | | +38 | | +42 |
| Besançon | 82·8 | +1 | +1 | | | −1 | | | |
| Ottawa | 83·1 | −2 | −1 | | | −5 | −7 | | +11 |
| Toronto | 83·2 | −2 | −1 | | | −4 | | | |
| Athens | 83·7 | +17 | +18 | | | 0 | | | |
| Florence | 84·1 | +2 | +3 | | | −30 | | | |
| Moncalieri | 84·3 | 0 | +1 | | | −9 | | | |
| Rocca di Papa | 85·3 | −2 | −1 | +3 | −1 | 0 | | | |
| Pompeii | 85·5 | −15 | −14 | +16 | +12 | | | | |
| Helwan | 86·0 | −2 | −1 | | | −2 | | | |
| Harvard | 87·3 | | | −4 | −8 | −4 | | −12+10 | |
| Georgetown | 88·2 | −1 | 0 | | | 0 | | | |
| Wellington | 88·5 | −12 | −11 | | | +9 | | | |
| Barcelona | 89·3 | | | | | +8 | | | |
| Tortosa | 90·3 | −5 | −4 | | | −3 | | | |
| Toledo | 92·5 | −5 | −3 | | | −4 | | | |
| Algiers | 93·2 | −3 | −1 | | | −11 | | | |
| Granada | 95·0 | −8 | −6 | | | | −4 | +17 | +11 |
| Malaga | 95·5 | −14 | −11 | | | | | +26 | |
| San Fernando | 96·3 | | | | | −4 | | | |
| | | | | P′ | PKS | | | | |
| La Paz | 139·6 | | | +14 | −16 | | | | |
| La Plata | 158·8 | | | | | | +20 | | −15 |

Mean P residual (Δ>70°), −1 ; S, −2? ; SKS, −3.

1925 Feb. 20d. 1h. 2m. 20s.+12s.=2m.32s.  Z=−5.

I.S.S. Epicentre 46°·0N. 149°·0E. Retained.

A=−·5954, B=+·3578, C=+·7193.

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ootomari | 4·4 | +17 | +17 | −1 | −1 | | | | |
| Mizusawa | 8·9 | −3 | −3 | −2 | −2 | | | | |
| Nagoya | 14·1 | −5 | −5 | +18 | +17 | | | | |
| Osaka | 15·3 | 0 | −1 | +22 | +21 | | | | |
| Kobe | 15·4 | +1 | 0 | +24 | +22 | | | | |
| Hukuoka | 18·8 | +3 | +2 | +30 | +28 | | | | |
| Zi-ka-wei | 25·9 | −7 | −3 | −2 | +4 | | | | |
| Irkutsk | 29·5 | +4 | +10 | +12 | +20 | | | | |
| Hong Kong | 36·8 | −10 | −5 | −26 | −18 | | | | |
| Manila | 39·2 | −8 | −4 | | | | | | |
| Phu-Lien | 42·7 | −8 | −4 | −1 | +4 | | | | |
| Honolulu | 49·3 | | | −13 | −10 | | | | +15 |
| Ekaterinburg | 52·2 | −2 | 0 | +5 | +7 | | +5 | | |
| Amboina | 53·0 | −23 | −21 | +9 | +11 | | | | |
| Calcutta | 53·8 | −1 | 0 | +6 | +8 | | | | |
| Victoria | 56·2 | −10 | −9 | −5 | −4 | | | | |
| Simla | 56·2 | +2 | +3 | +1 | +2 | | | | |
| Kucino | 63·1 | −2 | −3 | +10 | +9 | | | | +27 |
| Pulkovo | 63·1 | −1 | −2 | +2 | +1 | | | | +32 |
| Hyderabad | 64·1 | −4 | −5 | 0 | −1 | | | | |
| Batavia | 64·2 | −2 | −3 | −3 | −4 | | | | |
| Upsala | 67·0 | −3 | −4 | −3 | −4 | | | | +4 |
| Bombay | 67·0 | +22 | +21 | | | | | | |
| Baku | 67·6 | +3 | +2 | +11 | +10 | | +36 | | |
| Piatigorsk | 68·7 | −2 | −3 | +11 | +9 | | | +35 | |
| Kodaikanal | 69·9 | | | +3 | +1 | | | | |
| Königsberg | 70·2 | +2 | +1 | +9 | +7 | | | +30 | |
| Lemberg | 73·0 | −6 | −7 | +3 | 0 | | | | |
| Dyce | 74·1 | | | −8 | −11 | | | | |
| Hamburg | 74·5 | −4 | −5 | +3 | 0 | | | | |
| Edinburgh | 75·5 | | | +25 | +22 | | | −7 | |
| Eskdalemuir | 76·0 | −3 | −3 | +6 | +3 | | +4 | | +30 |
| Budapest | 76·8 | −8 | −8 | +10 | +7 | | | | |
| De Bilt | 77·2 | −2 | −2 | +3 | 0 | | +20 | | |
| Vienna | 77·2 | −3 | −3 | +10 | +7 | | +35 | +28 | |
| Stonyhurst | 77·3 | −4 | −4 | +27 | +24 | | | −8 | |
| Bidston | 77·8 | +2 | +2 | −55 | −58* | | | | |
| Uccle | 78·5 | −4 | −4 | +2 | −1 | | | | |
| Belgrade | 78·5 | +3 | +3 | +6 | +3 | | | | |
| Chicago | 78·8 | | | −7 | −10 | | −12−7 | | |
| Oxford | 79·0 | −38 | −38 | +6 | +3 | | | | |
| Hohenheim | 79·1 | −3 | −3 | +4 | 0 | | | | |
| Innsbruck | 79·6 | +2 | +2 | | | | | | |
| Strasbourg | 79·7 | −3 | −3 | +3 | −1 | | +21 | | |
| Riverview | 79·8 | +20 | +20 | −5 | −8 | | | | +8 |
| Ravensburg | 79·8 | −1 | −1 | +3 | −1 | | | | |
| Ann Arbor | 80·0 | −4 | −4 | −9 | −13 | | −2 | | +14 |
| Zürich | 80·5 | −1 | −1 | +10 | +6 | | | | |
| Ottawa | 80·5 | −11 | −11 | +10 | +6 | | | | +7 |
| Toronto | 80·6 | −6 | −6 | −8 | −12 | | | | +18 |
| Paris | 80·8 | −1 | −1 | +2 | −2 | | | | |
| Venice | 80·9 | +1 | +1 | | | | | −1 | |
| Besançon | 81·4 | 0 | 0 | +5 | +1 | | | | |
| Adelaide | 81·5 | −18 | −18† | −19 | −23† | | | | |
| Florence | 82·8 | −5 | −5 | −8 | −12 | | | | |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Moncalieri | 82·9 | +3 | +3 | +5 | +1 | | | | |
| Rocca di Papa | 84·1 | 0 | +1 | | | −3 | | | |
| Pompeii | 84·2 | −2 | −2 | | | −15 | | | |
| Harvard | 84·8 | | | | | −17−11 | | | |
| Georgetown | 85·6 | −1 | 0 | −7 | −11 | −18−5 | | | |
| Helwan | 85·6 | −1 | 0 | | | −8 | | | |
| Barcelona | 87·7 | −16 | −15 | +6 | +2 | −4 | +6 | | |
| Tortosa | 88·8 | 0 | +1 | | | −7 | | | |
| Wellington | 90·2 | | | | | −5 | | | −44 |
| Toledo | 90·8 | −9 | −7 | | | −9 | 0 | | |
| Alicante | 91·4 | | | | | −17 | | | |
| Algiers | 91·8 | −3 | −1 | | | −3 | | | |
| Almeria | 93·3 | −33 | −31 | | | −41 | | | |
| Granada | 93·3 | −10 | −12 | | | 0 | −9 | +23 | |
| Malaga | 93·9 | −30 | −28 | | | −8 | | | |
| San Fernando | 94·6 | −16 | −14 | −7 | −11 | | | | |
| | | | | P′ | | | | | |
| La Paz | 137·3 | | | +3 | | | | +14 | −5 |
| Rio de Janeiro | 154·9 | | | −11 | | | | | |

| Other readings : | Δ | SKKS |
|---|---|---|
| Toledo | 90·8 | −11 |
| San Fernando | 94·6 | −8 |

Mean P residual (Δ>70°), −1 ; S, 0 ; SKS, −5.

1925 April 16d. 19h. 52m. 30s.+13s.=52m.43s. Z=−7.

I.S.S. Epicentre 22°·0N. 120°·5E. First revised Epicentre 21°·8N. 120°·7E. Final Epicentre 21°·7N. 121°·1E.

A=−·4799, B=+·7956, C=+·3698.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Hokoto | 2·3 | −11 | −11 | | | | | | |
| Taihoku | 3·3 | +4 | +4 | | | | | | |
| Hong Kong | 6·4 | −4 | −4 | +64 | +64 | | | | |
| Manila | 7·1 | 0 | 0 | | | | | | |
| Zi-ka-wei | 9·5 | −4 | −4 | +5 | +5 | | | | |
| Phu-Lien | 13·4 | +3 | +3 | +27 | +26 | | | | |
| Nagasaki | 13·7 | −7 | −7 | | | | | | |
| Hukuoka | 14·7 | −8 | −8 | | | | | | |
| Sumoto | 17·8 | −11 | −12 | +8 | +6 | | | | −5 |
| Kobe | 18·2 | 0 | −1 | +15 | +13 | | | | |
| Osaka | 18·4 | 0 | −1 | +15 | +13 | | | | |
| Nagoya | 19·6 | −24 | −25† | −30 | −31† | | | | |
| Mizusawa | 24·7 | −7 | −4 | −5 | 0 | | | | |
| Calcutta | 30·2 | −15 | −9 | +2 | +11 | | | | |
| Ootomari | 30·8 | −6 | 0 | +5 | +14 | | | | |
| Batavia | 31·0 | −3 | +3 | +8 | +17 | | | | |
| Malabar | 31·6 | −1 | +5 | −3 | +6 | | | | |
| Irkutsk | 33·1 | −8 | −3 | −5 | +4 | | | | |
| Simla | 40·1 | +4+10 | +8+14 | +3+9 | +10+16 | | | | |
| Hyderabad | 40·1 | −4 | 0 | +13 | +20 | | | | |
| Kodaikanal | 43·2 | +3 | +7 | | | | | | |
| Bombay | 45·0 | 0 | +3 | +6 | +11 | | | | |
| Perth | 53·9 | −5 | −4 | +3 | +5 | | +15 | | |
| Ekaterinburg | 55·8 | −60 | −59* | −53 | −52* | | | | |
| Adelaide | 59·1 | | | +2 | +2 | | | | |
| Baku | 62·0 | +3 | +2 | +15 | +15 | | | | |
| Riverview | 62·5 | +9 | +8 | −4 | −4 | | | +17 | |
| Sydney | 62·6 | | | +11 | +11 | | | | |
| Piatigorsk | 66·6 | −7 | −8 | +2 | +1 | | +12 | | +9 |
| Pulkovo | 71·5 | −2 | −3 | +2 | 0 | | +7 | +23 | +49 |

*Continued an next page.*

| | Δ | $P_\nu$ | $P_\omega$ | $S_\nu$ | $S_\omega$ | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Honolulu | 74·7 | −1 | −2 | +3 | 0 | | | −34−21 | −28 |
| Upsala | 77·8 | −3 | −3 | 0 | −3 | | | | |
| Lemberg | 77·8 | −9 | −9 | 0 | −3 | | | | |
| Königsberg | 78·1 | 0 | 0 | +4 | +1 | | +8 | −13 | +22 |
| Helwan | 79·1 | −1 | −1 | +3 | 0 | | | | |
| Budapest | 81·7 | +6 | +6 | 0 | −4 | | | | |
| Belgrade | 81·9 | +2 | +2 | +1 | −3 | | −27 | | |
| Bergen | 82·9 | −6 | −6 | +7 | +3 | | +11 | | +9 |
| Vienna | 83·1 | 0 | +1 | +8 | +4 | | +8 | +22 | +42 |
| Hamburg | 84·2 | +1 | +2 | +1 | −3 | | | | |
| Zagreb | 84·3 | −11 | −10 | +10 | +6 | | +20 | | |
| Cheb | 84·5 | | | | | −3 | | | |
| Innsbruck | 86·5 | +1 | +2 | | | +2 | | | −7 |
| Venice | 86·8 | −26 | −25 | | | | | | |
| De Bilt | 87·5 | +3 | +4 | | | −3 | +4 | | |
| Pompeii | 87·6 | −60 | −59* | +25 | +21 | | | | |
| Naples | 87·7 | −69 | −68* | +1 | −3 | | | | |
| Strasbourg | 88·0 | 0 | +1 | +6 | +2 | | | | |
| Zürich | 88·1 | 0 | +1 | +2 | −2 | | | | |
| Florence | 88·3 | 0 | +1 | +7 | +3 | | | | |
| Rocca di Papa | 88·3 | −1 | 0 | | | | | −20 | |
| Uccle | 88·6 | −1 | 0 | +3 | −1 | −6 | −1 | | |
| Edinburgh | 89·1 | | | +4 | 0 | | | | |
| Eskdalemuir | 89·5 | | | +3 | −1 | | | | |
| Besançon | 89·7 | −8 | −7 | +12 | +8 | | | | |
| Victoria | 89·7 | +6 | +7 | | | −12 | | | |
| Moncalieri | 89·8 | −20 | −21 | | | −9 | | | |
| Stonyhurst | 90·1 | −6 | −5 | | | +6 | | | 0 |
| Bidston | 90·6 | +7 | +9 | | | +8 | +12 | | |
| Paris | 90·7 | | | | | −7 | +11 | | |
| Oxford | 90·8 | | | | | −4 | −2 | | |
| Grenoble | 91·0 | −51 | −49 | | | −41 | | +4 | |
| Marseilles | 92·2 | −29 | −27 | | | −9 | | | |
| Puy de Dôme | 92·2 | +1 | +3 | | | | | | |
| Barcelona | 95·2 | | | | | | +9 | | +2 |
| Berkeley | 96·1 | | | | | −22 | | | |
| Tortosa | 96·6 | | | | | −56 | +7 | | |
| Algiers | 97·2 | −6 | −3 | | | −7 | +3 | | |
| Alicante | 98·6 | | | | | −10 | +8 | | |
| Toledo | 99·9 | | | | | −10 | | | |
| Almeria | 100·8 | | | | | −13 | +22 | | |
| Granada | 101·3 | −5 | −1 | | | 0 | +4 | | |
| Malaga | 102·1 | | | | | | −1 | | |
| San Fernando | 103·4 | | | | | | −17 | | |
| Ottawa | 111·0 | | | | | | +15 | +60 | |
| Chicago | 111·2 | | | | | | +9 | −25−10 | |
| Toronto | 112·0 | | | | | | +14 | +12+56 | |
| Ann Arbor | 112·1 | | | | | | +45 | +23 | +64 |
| Harvard | 114·8 | | | P′ | $P_2'$ | | | | |
| Fordham | 115·8 | | | +2 | | | | +3 | |
| Georgetown | 117·0 | | | | | | +2 | −1 | |
| Rio de Janeiro | 165·3 | | | | | | +36 | | |
| La Plata | 166·8 | | | | +22 | | +37 | | |
| La Paz | 170·3 | | | +32 | | | +71 | | |

Mean P residual (Δ>70°), 0 ; S, 0 ; SKS, −7. Epicentre determined from near stations ; but here, unlike 1923 Sept. 1d. and 1924 Dec. 28d., there is no concentration of negative P residuals at the greater distances.

1926 Aug. 3d. 3h. 41m. 30s.+7s.=41m.37s.  Z=−1.

I.S.S. Epicentre 22°·0N. 121°·0E. **Retained.**

A=−·4775, B=+·7948, C=+·3746.

| | △ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Taihoku | 3·5 | +68 | +68* | +75 | +75* | | | | |
| Manila | 7·0 | −1 | −1 | +25 | +25 | | | | |
| Hong Kong | 7·1 | −1 | −1 | | | | | | |
| Zi-ka-wei | 9·7 | −4 | −4 | +9 | +9 | | | | |
| Nagasaki | 13·4 | −1 | −1 | | | | | | |
| Phu-Lien | 14·1 | +3 | +3 | +32 | +31 | | | | |
| Hukuoka | 14·3 | +2 | +2 | | | | | | |
| Sumoto | 17·3 | 0 | −1 | +19 | +17 | | | | |
| Osaka | 17·9 | +1 | 0 | +36 | +34 | | | | |
| Nagoya | 19·1 | −2 | −3 | | | | | | |
| Mizusawa | 24·2 | −2 | +1 | −7 | −2 | | | | |
| Amboina | 26·0 | +1 | +5 | +26 | +16d | | −4 | | |
| Ootomari | 30·4 | +1 | +7 | −23 | −14 | | | | |
| Calcutta | 30·8 | −3+12 | +3+18 | | | | | | |
| Batavia | 31·3 | −16 | −10 | | | | | | |
| Malabar | 31·9 | −4 | +2 | | | | | | |
| Irkutsk | 33·6 | −7 | −1 | +7 | +16 | | | | |
| Simla | 40·8 | −8 | −4 | −1 | +5 | | | | |
| Hyderabad | 40·9 | +2 | +6 | −22 | −16 | | | | |
| Colombo | 43·0 | +23 | +27 | +68 | +73 | | | | |
| Bombay | 45·8 | +68 | +71 | 0 | +4 | | | | |
| Ekaterinburg | 56·4 | +4 | +5 | +3 | +4 | | | | |
| Baku | 62·7 | +5 | +4 | +11 | +11 | | | | |
| Piatigorsk | 67·3 | −17 | −18† | −21 | −22† | | | −4 | |
| Makeyevka | 70·1 | 0 | −1 | +2 | 0 | | | +35 | |
| Pulkovo | 72·2 | +1 | 0 | +2 | 0 | | | +26 | +16 |
| Leningrad | 72·2 | +2 | +1 | +3 | +1 | | | +28 | |
| Honolulu | 73·9 | +14 | +13† | +17 | +14† | | | | +27 |
| Upsala | 78·3 | −4 | −4 | −2 | −5 | | | | |
| Budapest | 82·4 | 0 | 0 | +10 | +6 | | | | |
| Athens | 82·9 | +2 | +2 | −6 | −10 | −8 | | | |
| Vienna | 83·7 | 0 | +1 | +11 | +7 | | | | |
| Graz | 84·8 | +11 | +12 | | | +2 | | | |
| Hamburg | 84·8 | 0 | +1 | | | +3 | | | |
| Zagreb | 85·0 | +2 | +3 | | | +3 | +10 | | |
| Venice | 87·4 | +14 | +15 | | | −8+1 | | | |
| Hohenheim | 87·7 | −19 | −18 | +8 | +4 | | | | |
| De Bilt | 88·1 | +10 | +11 | | | +2 | | | |
| Pompeii | 88·2 | +7 | +8 | | | +6 | | | |
| Dyce | 88·4 | +6 | +7 | −4 | −8 | | | | |
| Strasbourg | 88·6 | −1 | 0 | +3 | −1 | | +8 | +8 | |
| Zürich | 88·7 | −5 | −4 | | | −7 | | | |
| Florence | 88·9 | 0 | +1 | +2 | −2 | | | | |
| Rocca di Papa | 88·9 | +2 | +3 | −53 | −57* | | | | |
| Uccle | 89·2 | +2 | +3 | −14 | −18 | | +3 | | |
| Edinburgh | 89·7 | | | +11 | +7 | | | | |
| Moncalieri | 90·5 | −11 | −9 | | | +10 | | | |
| Stonyhurst | 90·7 | +39 | +41 | +5 | +1 | | | | |
| Kew | 91·2 | −1 | +1 | | | +2 | +1 | | |
| Bidston | 91·3 | +28 | +30 | | | | +11 | | |
| Paris | 91·3 | +9 | +11 | | | +2 | | | |
| Barcelona | 95·8 | | | | | −3 | +19 | | |
| Tortosa | 97·2 | | | | | −3 | | | |
| Algiers | 97·9 | +10 | +13 | | | −3 | +6 | | |
| Toledo | 100·5 | | | | | | −21 | | |
| Granada | 101·9 | | | | | | +6 | +3 | |
| San Fernando | 104·0 | | | | | +11 | | | |
| Ann Arbor | 112·0 | | | P′ | | | | −10 | |
| La Paz | 169·4 | | | +13 | | | SKKS | | |
| Sucre | 173·0 | | | +18 | | | +5 | | |

Mean P residual (△>70°), +1 ; S, 0 ; SKS, +1. Epicentre determined from near stations.

1927 Feb. 16d. 1h. 35m. 12s.+16s.=35m.28s. Z dubious, taken 0.

I.S.S. Epicentre 46°·0N. 154°·0E. Revised Epicentre 46°·4N. 153°·4E.

A=−·6166, B=+·3087, C=+·7242.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Ootomari | 7·3 | +2 | +2 | +11 | +11 | | | | |
| Mizusawa | 11·5 | −2 | −2 | −6 | −6 | | | | |
| Nagoya | 16·7 | +4 | +3 | +30 | +28 | | | | |
| Toyooka | 17·6 | +2 | +1 | | | | | | |
| Osaka | 17·9 | −1 | −2 | | | | | | |
| Kobe | 18·0 | +3 | +2 | +15 | +13 | | | | |
| Sumoto | 18·4 | +2 | +1 | | | | | | |
| Hukuoka | 21·6 | 0 | +1 | +17 | +12d | | | | |
| Nagasaki | 22·5 | +2 | +3 | +19 | +13d | | | | |
| Zi-ka-wei | 28·8 | 0 | +5 | 0 | +8 | | | | |
| Irkutsk | 31·8 | −7 | −1 | −7 | +2 | | | | |
| Taihoku | 33·1 | +3 | +9 | | | | | | −31−25 |
| Hong Kong | 39·6 | −4 | 0 | | | | | | |
| Manila | 41·6 | +2 | +6 | | | | | | |
| Sitka | 43·2 | +3+13 | +7+17 | −3 | +2 | | +12 | | |
| Honolulu T.H. | 45·0 | +14 | +17† | +6+20 | +11+25† | | | +29 | +18 |
| Phu-Lien | 45·6 | −2 | +1 | +6 | +10 | | +7 | | +5 |
| Victoria | 53·0 | +2 | +4 | +4 | +6 | | | | |
| Ekaterinburg | 53·9 | −3 | −2 | −5 | −3 | | −20 | +3 | 0 |
| Amboina | 54·6 | −13 | −12† | −15 | −14† | | | | |
| Calcutta | 56·9 | +12 | +12 | +8 | +9 | | | | |
| Tashkent | 58·0 | 0 | 0 | +7 | +8 | | +1 | +29 | +39 |
| Simla | 59·0 | −7 | −7 | +5+11 | +5+11 | | | | |
| Berkeley | 60·1 | +1 | 0 | +3 | +3 | | | −1 | |
| Saskatoon | 60·1 | −2 | −3 | 0 | 0 | | | | |
| Leningrad | 63·9 | 0 | −1 | +11 | +10 | | 0 | −24 | +45 |
| Pulkovo | 64·1 | −3 | −4 | +6 | +5 | | −5 | −27 | +45 |
| Kucino | 64·5 | −62 | −63* | −61 | −62* | | +26 | −28+5 | |
| Helsingfors | 65·4 | −13 | −14 | +22 | +21 | | −29 | | +31 |
| Batavia | 66·8 | −2 | −3 | +17 | +16 | | | | |
| Upsala | 67·8 | −8 | −9 | −7 | −8 | | | | |
| Baku | 69·7 | 0 | −1 | +16 | +14 | | +3 | | |
| Bombay | 69·8 | −1 | −2 | −2 | −4 | | | | |
| Makeyevka | 70·0 | −1 | −2 | +13 | +11 | | −1 | +24 | |
| Bergen | 70·1 | −8 | −9 | +9 | +7 | | | | |
| Tucson | 70·7 | +2 | +1 | +5 | +3 | | | | −1 |
| Königsberg | 71·3 | −2 | −3 | −7+10 | −9+8 | | | +8+38 | |
| Tiflis | 71·6 | −4 | −5 | +6 | +4 | | +29 | +29 | +62 |
| Kodaikanal | 72·9 | +5 | +4 | | | | | +40 | |
| Hamburg | 75·3 | −3 | −3 | +3 | 0 | | −1 | +11+22 | +15 |
| Potsdam | 75·6 | +1 | +1 | −8 | −11 | | | | |
| Edinburgh | 75·8 | −6 | −6 | +4 | +1 | | | | |
| Chicago | 76·5 | +4 | +4 | +2+9 | −1+8 | | | | |
| Stonyhurst | 77·1 | −4 | −4 | +11 | +8 | | +10 | | |
| Prague | 77·3 | −5 | −5 | −6 | −9 | | | | |
| St. Louis | 77·6 | −10 | −10 | −4 | −7 | | | +1 | |
| Cheb | 77·8 | −2 | −2 | −3 | −6 | | | | |
| De Bilt | 77·8 | −2 | −2 | +3 | 0 | | | | +25 |
| Ann Arbor | 77·9 | +16 | +16 | −1 | −4 | | | | +37 |
| Budapest | 78·0 | −3 | −3 | | | | | | |
| Bidston | 78·2 | −5 | −5 | −2 | −5 | | | | |
| Vienna | 78·3 | −5 | −5 | +13 | +10 | | +4 | | |
| Toronto | 78·5 | −2 | −2 | −6+1 | −9−2 | | | | |
| Ottawa | 78·6 | −9 | −9 | −6 | −9 | | | | |
| St. Anne | 78·8 | 0 | 0 | −3 | −6 | | | | |

*Continued on next page.*

| | △ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Feldberg | 78·8 | −3 | −3 | −1 | −4 | | | | |
| Uccle | 79·2 | −5 | −5 | +1 | −3 | | −6 | | +4 |
| Graz | 79·5 | −3 | −3 | +2 | −2 | | | +20 | |
| Oxford | 79·5 | −2 | −2 | −4 | −8 | | +2 | | |
| Kew | 79·6 | −3 | −3 | −3 | −7 | | −7 | | +33 |
| Hohenheim | 79·8 | −3 | −3 | +2 | −2 | | | +27 | |
| Riverview | 80·3 | | | −5 | −9 | | | | |
| Sydney | 80·3 | | | −1 | −5 | | | | |
| Strasbourg | 80·5 | −4 | −4 | −3 | −7 | | −3 | +6 | |
| Zagreb | 80·5 | −3 | −3 | −5 | −9 | | | | |
| Innsbruck | 80·6 | +4 | +4 | −6 | −10 | | | | |
| Ravensburg | 80·6 | −7+3 | −7+3 | +3 | −1 | | | | |
| Ithaca | 80·7 | | | +2 | −2 | | | | |
| Zürich | 81·3 | −4 | −4 | −1 | −5 | | | | |
| Plymouth | 81·3 | +19 | +19 | | | | | −3+5 | |
| Paris | 81·5 | −1 | −1 | −2 | −6 | | | | |
| Chur | 81·6 | −2 | −2 | 0 | −4 | | | | |
| Ksara | 82·1 | 0 | 0 | −1 | −5 | | | | |
| Besançon | 82·2 | −4 | −4 | | | −8 | | | |
| Adelaide | 82·5 | −5 | −5 | −66 | −70* | | | | |
| Harvard | 82·9 | | | +1 | −3 | −6 | | | |
| Fordham | 83·1 | −1 | 0 | +2 | −2 | | | +2 | +26+40 |
| Cheltenham | 83·8 | | | | | −5 | | | |
| Florence | 83·8 | +2 | +3 | −77 | −81* | | | | |
| Moncalieri | 83·8 | −4 | −3 | | | −5 | | | |
| Melbourne | 84·3 | | | | | −13 | | | |
| Puy de Dôme | 84·3 | −7 | −6 | +4 | 0 | | | | |
| Athens | 84·5 | +2 | +3 | | | −3 | | | |
| Loyola | 84·6 | +5 | +6 | | | | | | |
| Rocca di Papa | 85·2 | +1 | +2 | −3 | −7 | −8 | | | |
| Perth | 85·3 | | | −5 | −9 | | | | |
| Pompeii | 85·5 | +26 | +27 | | | | | | |
| Naples | 85·5 | −5 | −4 | +23 | +19 | | | | |
| Bagnères | 87·4 | +6 | +7 | | | +4 | | | |
| Tacubaya | 87·5 | 0 | +1 | | | −2 | | | |
| Helwan | 87·6 | −2 | −1 | | | −5 | | | |
| Barcelona | 88·5 | +2 | +3 | +1 | −3 | | | | |
| Tortosa | 89·5 | −8 | −7 | | | −2 | | | |
| Wellington | 89·7 | +15 | +16 | | | −10 | | | −11 |
| Toledo | 91·4 | −3 | −1 | | | 0 | | | |
| Alicante | 92·1 | −13 | −11 | | | 0 | | | |
| Algiers | 92·7 | −8 | −6 | | | −7 | | | |
| Rio Tinto | 93·9 | | | | | | | −2 | |
| Granada | 94·0 | −12 | −10 | | | +16 | +2 | +13 | |
| Almeria | 94·0 | −4 | −2 | | | −6 | | | |
| Malaga | 94·5 | −2 | 0 | −7 | −11 | | | | |
| San Fernando | 95·1 | −3 | −1 | −16 | −20 | −3 | | | |
| Entebbe | 110·6 | PKS | | P′ | | −10 | +1 | | |
| La Paz | 134·5 | −2 | | +5 | | | | +56 | |
| Sucre | 138·2 | +18 | | +10 | | | | | |
| Pilar | 148·1 | | | +9 | | | | | |
| Rio de Janeiro | 153·1 | | | | | | | | |
| La Plata | 154·0 | | | | | | | | |

Malaga S−11 =SKKS−2.

Mean P residual (△>70°), −3; S,−3; SKS,−5. There are indications of slight focal depth.

1927 Aug. 5d. 21h. 12m. 50s.+11s.=13m.1s.    Z taken=0.

I.S.S. Epicentre 38°·5N. 142°·5E. Revised Epicentre 37°·9N. 142°·3E.

A=−·6243, B=+·4825, C=+·6143.

| | △ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Mizusawa | 1·5 | +4 | +4 | +10 | +10 | | | | |
| Nagoya | 5·1 | +5 | +5 | +15 | +15 | | | | |
| Osaka | 6·4 | 0 | 0 | +18 | +18 | | | | |
| Toyooka | 6·4 | 0 | 0 | 0 | 0 | | | | |
| Kobe | 6·6 | −2 | −2 | +15 | +15 | | | | |
| Sumoto | 7·0 | 0 | 0 | −20 | −20 | | | | |
| Matuyama | 8·7 | +11 | +11 | −22 | −22 | | | | |
| Ootomari | 8·8 | −1 | −1 | | | | | | |
| Hukuoka | 10·6 | −4 | −4 | | | | | | |
| Nagasaki | 11·4 | −3 | −3 | 0 | 0 | | | | |
| Zi-ka-wei | 18·4 | −2 | −3 | −3 | −5 | | | | |
| Taihoku | 21·8 | +1 | +2 | −5 | −3 | | | | |
| Hong Kong | 28·7 | −5 | 0 | −13 | −5 | | | | |
| Irkutsk | 30·0 | −8 | −2 | −12 | −3 | | | | |
| Manila | 30·0 | −6 | 0 | −22 | −13 | | | | |
| Phu-Lien | 35·2 | −10 | −5 | −19 | −11 | | | | |
| Amboina | 43·6 | −6 | −2 | −18 | −13 | | | | |
| Calcutta | 48·3 | −12 | −9 | −15 | −12 | | | | |
| Dehra Dun | 52·7 | −11 | −9 | −38 | −36 | | | | |
| Simla | 53·0 | −4 | −3 | −9 | −7 | | | | |
| Honolulu T.H. | 53·7 | −4 | −3 | −2 | 0 | | | | |
| Tashkent | 54·6 | −3 | −2 | −4 | −3 | | | +13 | |
| Ekaterinburg | 54·8 | −5 | −4 | −5 | −4 | | −3 | | |
| Sitka | 55·1 | −30 | −29 | +6 | +7 | | | | −18−10 |
| Batavia | 55·1 | −5 | −4 | +4 | +5 | | | | |
| Hyderabad | 59·0 | −4 | −4 | −8 | −8 | | | | |
| Bombay | 62·6 | −9 | −10 | −7 | −7 | | | | |
| Kodaikanal | 64·0 | +4 | +3 | | | | | | |
| Victoria | 65·2 | +3 | +2 | −3 | −4 | | | | |
| Apia | 67·3 | −26 | −27 | −1 | −2 | | | +9 | |
| Pulkovo | 67·5 | −4 | −5 | −3 | −4 | | −6 | | |
| Baku | 68·1 | −3 | −4 | −3 | −5 | | +34 | | |
| Tiflis | 70·6 | −2 | −3 | −5 | −7 | | −14 | | +51 |
| Makeyevka | 71·0 | −5 | −6 | +3 | +1 | | −7 | +24 | +3 |
| Berkeley | 71·5 | −3 | −4 | −2 | −4 | | | | |
| Upsala | 72·2 | −5 | −6 | −4 | −6 | | | | |
| Riverview | 72·2 | −8 | −9 | −13 | −15 | | | −2+24 | −16 |
| Sydney | 72·2 | | | −28 | −30 | | | | |
| Adelaide | 72·9 | −10 | −11 | −5 | −7 | | | | |
| Königsberg | 74·8 | −3 | −4 | −2 | −5 | | −12+24 | −2+6 | |
| Bergen | 75·6 | −8 | −8 | −7 | −10 | | | | |
| Melbourne | 75·8 | | | +21 | +18 | | | | +35 |
| Lemberg | 76·8 | −15 | −15† | −14−2 | −17†−5 | | | | |
| Copenhagen | 77·2 | −5 | −5 | −4 | −7 | | −4 | | +10 |
| Potsdam | 79·5 | 0 | 0 | +14 | +11 | | | | |
| Hamburg | 79·7 | −4 | −4 | +1 | −2 | | | | |
| Dyce | 80·3 | −3 | −3 | −3 | −7 | | −20 | | |
| Budapest | 80·8 | +17 | +17† | +14 | +10† | | | | |
| Prague | 80·8 | −3 | −3 | −2 | −6 | | 0 | | |
| Ksara | 81·0 | −3 | −3 | +9 | +5 | | +8 | +27 | +8 |
| Jena | 81·2 | −1 | −1 | +16 | +12 | | −5 | | |
| Vienna | 81·4 | −6 | −6 | 0 | −4 | | | | −19 |
| Cheb | 81·6 | −1 | −1 | 0 | −4 | | | | |
| Edinburgh | 81·7 | −3 | −3 | +20 | +16 | | | | |
| Belgrade | 82·1 | −1+11 | −1+11 | −1 | −5 | | | | +16 |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Tucson | 82·3 | +1 | +1 | −4 | −8 | | −17 | | −18−4 |
| De Bilt | 82·6 | −4 | −4 | | | −8 | −3 | | |
| Feldberg | 83·0 | −1 | −1 | +8 | +4 | | | | |
| Stonyhurst | 83·4 | +1 | +2 | | | −4 | −10 | | −2 |
| Zagreb | 83·4 | −6 | −5 | | | −8 | −1 | | |
| Bidston | 83·9 | +4 | +5 | −4 | −8 | | | | |
| Uccle | 83·9 | −5 | −4 | | | −6 | −3 | | |
| Hohenheim | 83·9 | +1 | +2 | −3 | −7 | | | | |
| Laibach | 83·9 | −3 | −2 | | | −9 | −12 | | |
| Innsbruck | 84·2 | −5 | −4 | | | | | | |
| Ravensburg | 84·5 | +4 | +5 | | | −19 | +4 | | |
| Wellington | 84·5 | | | | | −19 | | | +4 |
| Strasbourg | 84·6 | −5 | −4 | | | −7 | +2 | | +22 |
| Kew | 84·8 | −3 | −2 | | | −8 | −2 | | +12 |
| Oxford | 84·8 | −5 | −4 | | | −9 | | | −24 |
| Zürich | 85·3 | −5 | −4 | | | −2 | | | |
| Venice | 85·3 | +23 | +24 | | | | | | |
| Paris | 86·2 | −3 | −2 | | | −9 | −1 | | |
| Besançon | 86·3 | 0 | +1 | −12 | −16 | | | | |
| Helwan | 86·5 | −5 | −4 | | | −13 | −4 | | |
| Florence | 87·1 | −8 | −7 | | | −14 | | | |
| Moncalieri | 87·6 | −11 | −10 | | | −15 | | | |
| Pompeii | 88·0 | −40 | −39 | +6 | +2 | | | | |
| Rocca di Papa | 88·0 | −3 | −2 | | | −11 | | | |
| Naples | 88·1 | −5 | −4 | +5 | +1 | | | | |
| Chicago | 88·3 | −7 | −6 | −14 | −18 | +*1* | −2 | | −8 |
| Puy de Dôme | 88·7 | −7 | −6 | +5 | +1 | | | | |
| St. Louis | 89·5 | | | −5 | −9 | | | | |
| Ann Arbor | 89·5 | +3 | +4 | 0 | −4 | | +25 | | +11 |
| Ottawa | 89·9 | −5 | −4 | −11−5 | −15−9 | −15−9 | −12 | | |
| Toronto | 90·1 | −2 | 0 | −7 | −11 | −9 | −4 | | |
| Bagnères | 92·0 | −2 | 0 | | | −13 | | | |
| Ithaca | 92·3 | −2 | 0 | −12 | −16 | | −14 | | |
| Barcelona | 92·8 | +9 | +11 | | | −13 | | | |
| Tortosa | 93·9 | −8 | −6 | | | −12 | | | |
| Fordham | 94·6 | −7 | −5 | +16 | +12 | −19 | −4 | −9 | −41 |
| Toledo | 96·3 | −6 | −3 | | | −13 | 0 | | |
| Algiers | 96·4 | −6 | −3 | | | | 0 | | |
| Alicante | 96·4 | −6 | −3 | | | −6 | | | |
| Almeria | 98·5 | −18 | −15 | | | −27 | −7 | 0 | |
| Granada | 98·6 | −7 | −4 | | | +1 | 0 | +30 | |
| Malaga | 99·3 | +11 | +14 | | | −16 | −1 | | |
| San Fernando | 100·1 | +11 | +14 | | | −14 | | | |
| Azores | 103·6 | | | +17 | +13 | | | | |
| Cape Town | 135·0 | | | | | | 0 | | |
| | | | P′ | | PKS | | | | |
| La Paz | 145·8 | | −3 | | | | | | |
| Sucre | 149·5 | | −1 | | −6 | | | | |
| La Plata | 163·5 | | −40 | | | | | | |

Mean P residual (Δ>70°), −3·5 ; S, −5·6 ; SKS, −8·5? Focal depth is indicated.

| Other readings : | Δ | SKKS |
|---|---|---|
| St. Louis | 89·5 | −*14* |
| Ann Arbor | 89·5 | −*9* |
| Ottawa | 89·9 | −*12* |
| Ithaca | 92·3 | −*13* |
| Barcelona | 92·7 | −8 |
| Algiers | 96·4 | −15 |

1928 May 27d. 9h. 50m. 18s.+12s.=50m.30s.     Z=−5.

I.S.S. Epicentre 40°·0N. 142°·5E. Retained.

A=−·6077, B=+·4663, C=+·6428.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Mizusawa | 1·4 | +2 | +2 | | | | | | |
| Nagoya | 6·6 | +1 | +1 | −10 | −10 | | | | |
| Ootomari | 6·6 | −1 | −1 | | | | | | |
| Toyooka | 7·5 | +3 | +3 | +11 | +11 | | | | |
| Osaka | 7·8 | 0 | 0 | +22 | +22 | | | | |
| Kobe | 7·9 | 0 | 0 | +9 | +9 | | | | |
| Sumoto | 8·3 | 0 | 0 | −28 | −28 | | | | |
| Sikka | 9·2 | +1 | +1 | +12 | +12 | | | | |
| Matuyama | 9·9 | −15 | −15 | −58 | −58 | | | | |
| Hukuoka | 11·6 | +3 | +3 | | | | | | |
| Nagasaki | 12·5 | −1+5 | −1+5 | +10 | +10 | | | | |
| Zi-ka-wei | 19·2 | −3+20 | −4+19 | +25 | +23 | | | | |
| Irkutsk | 28·8 | −7 | −2 | −2 | +6 | | | | |
| Hong Kong | 29·8 | −6, 0 | 0+6 | +5 | +13 | | | | |
| Manila | 31·7 | −4 | +2 | +92 | +101 | | | | 0 |
| Phu-Lien | 36·1 | −7 | −2 | −8 | 0 | | | | |
| Amboina | 45·6 | −1 | +2 | −11 | −7 | | | | +2 |
| Sitka | 53·4 | | | | | | | | −15 |
| Honolulu T.H. | 53·6 | 0 | +1 | −8+3 | −6+5 | | | | |
| Tashkent | 53·9 | +1 | +2 | +3 | +5 | | | | |
| Batavia | 56·7 | −5 | −4 | −1 | 0 | | | | |
| Hyderabad | 59·2 | −6 | 0 | −1 | −1 | | | | |
| Bombay | 62·6 | −4 | −5 | −11 | −12 | | | | |
| Victoria | 63·6 | +5 | +4 | +3 | +2 | | | | |
| Colombo | 64·8 | −2 | −3 | +2 | +1 | | | | |
| Kucino | 65·0 | +5 | +4 | +28 | +27 | | 0 | +10 | |
| Pulkovo | 65·9 | +1 | 0 | +5 | +4 | | | | |
| Baku | 67·1 | +2 | +1 | +22 | +21 | | | | |
| Spokane | 67·3 | −2 | −3 | 0 | −1 | | | | −12 |
| Helsingfors | 67·6 | −1 | −2 | +5 | +4 | | | | |
| Apia | 68·6 | | | −5 | −7 | | +22 | | |
| Scoresby Sund | 69·0 | −1 | −2 | +8 | +6 | | −1 | +17 | +4 |
| Makeyevka | 69·5 | 0 | −1 | +11 | +9 | | | | |
| Berkeley | 70·1 | +4 | +3 | +4 | +2 | | | | |
| Upsala | 70·4 | −3 | −4 | +2 | 0 | | | | |
| Lick | 70·8 | −3 | −4 | +2 | 0 | | | | |
| Theodosia | 72·8 | 0 | −1 | +10 | +8 | | | | |
| Königsberg | 73·0 | +2 | +1 | +29 | +26 | | +4+10 | 0 | +11 |
| Simferopol | 73·6 | −3 | −4 | +3 | 0 | | | | |
| Bergen | 73·7 | −16 | −17 | | | | | | |
| Yalta | 73·8 | −6 | −5 | | | | | | |
| Riverview | 74·3 | −1 | −2 | −7 | −10 | | | −12, 0 | −6 |
| Adelaide | 75·0 | −6 | −6 | −7 | −10 | | | | |
| Lund | 75·1 | −2 | −2 | +4 | +1 | | −5 | −4 | |
| Lemberg | 75·2 | −5 | −5 | −2 | −5 | | | | |
| Copenhagen | 75·3 | −3 | −3 | +6 | +3 | | −1 | −1 | +25 |
| Hamburg | 77·8 | −1 | −1 | +5 | +2 | | −1 | | +14 |
| Potsdam | 77·8 | −2 | −2 | +22 | +19 | | | | |
| Melbourne | 77·9 | | | | | | | | −20 |
| Dyce | 78·4 | −2 | −2 | +26 | +23 | | 0 | | |
| Budapest | 79·2 | 0 | 0 | +24 | +21 | | | −8 | |
| Jena | 79·5 | −5 | −5 | −2 | −5 | | | +19 | |
| Vienna | 79·8 | −4 | −4 | | | | | −17+34 | |
| Edinburgh | 79·8 | −2 | −2 | +4 | 0 | | | | +10 |
| Ksara | 79·8 | 0 | 0 | +18 | +15 | | +6 | | +33 |

*Continued on next page.*

| | △ | $P_\nu$ | $P_\omega$ | $S_\nu$ | $S_\omega$ | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Belgrade | 80·6 | −1 | −1 | +3 | 0 | | | | |
| De Bilt | 80·7 | −1 | −1 | +6 | +3 | | +1 | | +11 |
| Tucson | 80·9 | −3 | −3 | −6 | −9 | | | | −30 |
| Graz | 81·0 | −2 | −2 | +29 | +25 | | | −13 | |
| Feldberg | 81·2 | −12−1 | −12−1 | +4 | 0 | | −5 | | −12 |
| Stonyhurst | 81·4 | −2 | −2 | +3 | −1 | | +7 | | +18 |
| Zagreb | 81·8 | −13 | −13 | +4 | 0 | | −6 | | +9 |
| Bidston | 82·0 | −1 | −1 | +2 | −2 | | | | |
| Uccle | 82·1 | −2 | −2 | +6 | +2 | | 0 | | |
| Hohenheim | 82·2 | −2 | −2 | 0 | −4 | | +10 | +15 | |
| Ravensburg | 82·8 | −3 | −3 | +10 | +6 | | | | |
| Strasbourg | 82·8 | −7 | −7 | +4 | 0 | | | −12 | |
| Kew | 82·9 | −1 | −1 | +5 | +1 | | +1 | −7+29 | +12 |
| Oxford | 83·0 | −1 | −1 | +2 | −2 | | 0 | | +11+35 |
| Zürich | 83·5 | −1 | 0 | +2 | −2 | | | | |
| Chur | 83·6 | −2 | −1 | +2 | −2 | | | | |
| Venice | 83·6 | +3 | +4 | +1 | −3 | | | | |
| Paris | 84·4 | −1 | 0 | | | 0 | | | |
| Neuchâtel | 84·4 | −2 | −1 | | | −2 | | | |
| Besançon | 84·6 | 0 | +1 | | | −3 | | | |
| Helwan | 85·4 | −3 | −2 | | | −4 | | | |
| Florence | 85·4 | −3 | −2 | +8 | +4 | | +4 | +17 | +29 |
| Moncalieri | 85·8 | −3 | −2 | | | −6 | | | |
| Chicago | 86·4 | −4 | −3 | | | −7 | +11 | | −18, 0 |
| Wellington | 86·4 | +12 | +13 | | | −16 | | | −21−17 |
| Grenoble | 86·4 | +1 | +2 | −1 | −5 | | | | |
| Rocca di Papa | 86·4 | −4 | −3 | | | −13−4 | +3 | | |
| Pompeii | 86·4 | +9 | +10 | | | | | +14 | |
| Naples | 86·5 | +5 | +6 | +14 | +10 | | | | |
| St. Louis | 87·8 | −4 | −3 | −1 | −5 | −8+7 | | | −1 |
| Ottawa | 88·0 | −4 | −3 | −4 | −8 | −5 | +11 | | +5 |
| Toronto | 88·2 | −8 | −7 | | | −9+9 | | | +6 |
| Marseilles | 88·2 | +24 | +25 | +4 | 0 | | | | |
| Cincinnati | 89·9 | −41 | −40 | +3 | −1 | −4 | | | −8−3 |
| Bagnères | 90·2 | 0 | +1 | | | −26 | | | |
| Ithaca | 90·3 | | | | | −7 | | | |
| Barcelona | 91·0 | −14 | −12 | | | −4 | | | |
| Tortosa | 92·1 | −6 | −4 | | | −2 | | | |
| Harvard | 92·2 | | | 0 | −4 | | | | |
| Georgetown | 93·2 | −2 | 0 | −12 | −16 | | | | −8 |
| Charlottesville | 93·4 | | | −13 | −17 | −5 | | | −25 |
| Toledo | 94·5 | −6 | −4 | | | −7 | +4 | | |
| Algiers | 94·6 | −4 | −2 | | | +7 | | | |
| Alicante | 94·7 | −18 | −16 | | | −17 | | | |
| Almeria | 96·6 | −12 | −9 | | | −12 | −1 | | |
| Granada | 96·8 | −4 | −1 | +8 | +4 | | +6 | | +36 |
| Malaga | 97·5 | −19 | −16 | | | −18 | | | |
| San Fernando | 98·3 | −8 | −5 | | | −7 | −27 | | |
| Entebbe | 105·2 | −12 | −8 | | | −11 | −2 | | |
| Tananarive | 105·7 | | | | | −8−3 | +10 | +20 | +10 |
| | | PKS | | P′ | SKSP | | | | |
| Cape Town | 135·6 | | | | −1 | | | −29 | |
| La Paz | 144·5 | +19 | | +2 | | | | | +17 |
| Sucre | 148·2 | | | 0+4 | | | | | |
| Rio de Janeiro | 162·2 | | | −1+5 | | | | | |

| Other readings : | △ | SKKS |
|---|---|---|
| Cincinnati | 89·9 | −10 |
| La Paz | 144·5 | −3 |

Mean P residual (△>70°), −2; S, 0; SKS, −5.

1928 June 1d. 13h. 12m. 13s.+11s.=12m.24s. Z=−3.

I.S.S. Epicentre 40°·0N. 143°·5E. Revised Epicentre 39°·7N. 142°·8E.

A=−·6129, B=+·4652, C=+·6388.

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Mizusawa | 1·8 | 0 | 0 | +4 | +4 | | | | |
| Nagoya | 6·6 | 0 | 0 | +14 | +14 | | | | |
| Ootomari | 7·0 | +1 | +1 | +55 | +55 | | | | |
| Toyooka | 7·8 | 0 | 0 | +11 | +11 | | | | |
| Osaka | 7·9 | −3 | −3 | +27 | +27 | | | | |
| Kobe | 8·2 | 0 | 0 | +15 | +15 | | | | |
| Sumoto | 8·4 | 0 | 0 | +17 | +17 | | | | |
| Matuyama | 10·2 | −32 | −32 | +29 | +29 | | | | |
| Hukuoka | 11·9 | +3 | +3 | +42 | +42 | | | | |
| Nagasaki | 12·7 | 0 | 0 | +31 | +30 | | | | |
| Zi-ka-wei | 19·6 | −5 | −6 | +17 | +15 | | | | |
| Taihoku | 23·4 | −7 | −5 | −2 | +2 | | | | |
| Irkutsk | 29·4 | −5 | +1 | +1 | +9 | | | | |
| Hong Kong | 31·1 | −4 | +2 | −2 | +7 | | | | |
| Manila | 31·6 | +7 | +13 | | | | | | |
| Phu-Lien | 36·5 | −7 | −2 | −13 | −5 | | | | |
| Amboina | 45·3 | +4 | +7 | −18 | −14 | | | | |
| Calcutta | 49·2 | −12−4 | −9−1 | +5+13 | +8+16 | | | | |
| Honolulu T.H. | 52·9 | | | +8 | +10 | | | | |
| Dehra Dun | 53·1 | +25 | +27† | +27 | +29† | | | | |
| Ekaterinburg | 54·0 | +3 | +4 | +8 | +10 | | | | |
| Tashkent | 54·5 | −4 | −3 | −11 | −10 | | | | |
| Batavia | 56·7 | −4 | −3 | −3 | −2 | | | | |
| Hyderabad | 59·8 | −2 | −2 | +19 | +19 | | | | |
| Bombay | 63·3 | −2 | −3 | +2 | +1 | | | | |
| Victoria | 63·5 | | | +5 | +4 | | | | |
| Colombo | 65·2 | | | −6 | −7 | | | | |
| Pulkovo | 66·5 | −2 | −3 | +5 | +4 | | | | |
| Kucino | 66·6 | +47 | +46 | +6 | +5 | | | | |
| Helsingfors | 68·2 | 0 | −1 | +2 | 0 | | | | |
| Scoresby Sund | 69·4 | 0 | −1 | +7 | +5 | | −2 | | +10 |
| Berkeley | 70·0 | +1 | 0 | +3 | +1 | | | −19 | |
| Makeyevka | 70·3 | +1 | 0 | +6 | +4 | | | | |
| Upsala | 71·0 | −4 | −5 | 0 | −2 | | −7 | | |
| Theodosia | 73·6 | +2 | +1 | +5 | +2 | | | | |
| Königsberg | 73·7 | −2 | −3 | +7 | +4 | | +4 | | |
| Riverview | 73·8 | −43 | −44 | −3 | −6 | | +8 | −1 | |
| Sydney | 73·8 | | | −12 | −15 | | | | |
| Bergen | 74·2 | +13 | +12 | | | | | | |
| Simferopol | 74·3 | −2 | −3 | +3 | 0 | | | | |
| Yalta | 74·6 | −4 | −5 | | | | | | |
| Lund | 75·7 | −1 | −1 | +3 | 0 | | | −6 | |
| Lemberg | 75·9 | −9+3 | −9+3 | +1+7 | −2+4 | | | | |
| Copenhagen | 76·0 | −3 | −3 | +2 | −1 | | −4 | −9 | +8 |
| Melbourne | 77·5 | | | −6 | −9 | | | | |
| Dyce | 77·8 | | | +27 | +24 | | | | |
| Potsdam | 78·4 | +2 | +2 | +1 | −2 | | −3 | | |
| Hamburg | 78·5 | 0 | 0 | +4 | +1 | | | | |
| Edinburgh | 78·7 | | | +23 | +19 | | | | |
| Budapest | 79·8 | 0 | 0 | +4 | 0 | | | | |
| Jena | 80·0 | −2 | −2 | +3 | −1 | | | | |
| Vienna | 80·3 | −4 | −4 | +5 | +1 | | | +9 | |
| Ksara | 80·6 | −1 | −1 | +1 | −3 | | | | |
| Tucson | 80·8 | +1 | +1 | +3 | −1 | | | | |
| Belgrade | 81·2 | −1 | −1 | +1 | −3 | | | | |
| De Bilt | 81·3 | 0 | 0 | +3 | −1 | | 0 | | |
| Graz | 81·7 | −1 | −1 | +2 | −2 | | | | |
| Bidston | 82·5 | −11 | −11 | +6 | +2 | | | | |
| Zagreb | 82·5 | −5 | −5 | +1 | −3 | | −10 | | +13 |
| Uccle | 82·7 | −2 | −2 | 0 | −4 | | | | |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Laibach | 82·9 | −7 | −7 | +1 | −3 | | | | |
| Ravensburg | 83·4 | 0 | +1 | +5 | +1 | | +7 | +19 | +12 |
| Strasbourg | 83·4 | −1 | 0 | +4 | 0 | | −4 | | |
| Kew | 83·5 | +1 | +2 | +4 | 0 | | 0 | | −2 |
| Oxford | 83·5 | +3 | +4 | +6 | +2 | | | | |
| Zürich | 84·2 | −2 | −1 | | | −3 | | | |
| Paris | 85·0 | −1 | 0 | | | +2 | | | |
| Neuchâtel | 85·1 | −2 | −1 | | | −2 | | | |
| Besançon | 85·2 | 0 | +1 | | | | | | |
| Florence | 86·1 | −3 | −2 | | | +4 | | | |
| Moncalieri | 86·5 | +5 | +6 | | | −1 | | | |
| Rocca di Papa | 87·1 | −3 | −2 | | | −5 | −4+8 | | |
| Naples | 87·2 | +4 | +5 | +7 | +3 | | | | |
| Pompeii | 87·2 | −24 | −23 | | | −19 | | | |
| St. Louis | 87·7 | −5 | −4 | 0 | −4 | −9 | | | +1 |
| Ann Arbor | 87·8 | | | −4 | −8 | +6 | | | +7 |
| Ottawa | 88·1 | | | −3 | −7 | +8 | | | |
| Toronto | 88·3 | −14 | −13 | −5 | −9 | +7 | | | |
| Bagnères | 90·8 | | | | | −6 | | | |
| Barcelona | 91·4 | −4 | −3 | | | | +3 | +30 | |
| Tortosa | 92·7 | −2 | −1 | | | −5 | | | |
| Georgetown | 93·3 | −8 | −7 | | | +1 | | | |
| Toledo | 95·1 | −2 | 0 | | | | | | |
| Algiers | 95·3 | | | | | −10 | −23 | | |
| Alicante | 95·3 | −34 | −32† | | | −37† | | | |
| Almeria | 97·3 | −7 | −4 | −2 | −6 | | +3 | | |
| Granada | 97·4 | −2 | +1 | +7 | +3 | | | | |
| Malaga | 98·1 | | | −18 | −22 | | | | |
| San Fernando | 98·9 | | | | | +3 | | | |
| Tananarive | 106·2 | | | | | −6 | +5 | +36 | |
| | | | | P′ | | | | | |
| La Paz | 142·8 | | | +3 | | | | | |
| Sucre | 148·1 | | | +4 | | | | | |

Mean P residual, △>70°, −1 ; S, −1 ; SKS, −5? Readings at Ann Arbor, Ottawa, and Toronto are given under both S and SKS, but may refer to an intermediate pulse.

1930 Oct. 24d. 20h. 15m. 11s.+1s.=15m.12s. Z taken=0.

Lehmann and Plett's Epicentre 18°·4N. 146°·8E. Revised Epicentre 18°·4N. 147°·0E.

All readings are from Lehmann and Plett.

| | Δ | Pω | Sω | SKS | PP | PSω | SS | PSv |
|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | |
| Koti | 19·3 | 0 | | | | | | |
| Nagasaki | 20·9 | −2 | | | | | | |
| Mizusawa | 21·3 | +1 | | | | | | |
| Taihoku | 24·5 | +3 | | | | | | |
| Manila | 25·2 | +2 | | | | | | |
| Phu-Lien | 38·0 | +1 | | | | | | |
| Batavia | 46·5 | −1 | | | | | | |
| Irkutsk | 47·4 | 0 | | | | | | |
| Honolulu T.H. | 51·5 | +2 | | | | | | |
| Riverview | 52·3 | +2 | | | | | | |
| Perth | 58·4 | −5 | | | | | | |
| Tashkent | 68·8 | +1 | | | | | | |
| Ekaterinburg | 72·7 | 0 | | | | | | |
| Bergen | 95·4 | −5 | −11 | −11 | +1 | | +10 | +6 |
| Lund | 96·3 | +7 | −18−13 | −9 | +4 | | −6 | 0 |
| Copenhagen | 96·6 | −3 | −18 | −9 | +5 | | −6 | −1 |
| Potsdam | 98·7 | +16 | −16 | −7 | +6 | | +1+6 | −8 |
| Hamburg | 99·1 | −2 | | | +4 | | | −3 |
| Budapest | 99·3 | +7 | −15 | −10 | +11 | | | −5 |
| Ivigtut | 99·6 | | −21 | −9 | +2 | | +10 | +4 |

*Continued on next page.*

| | Δ | Pω | Sω | SKS | PP | PSω | SS | PSν |
|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | |
| Leipzig | 99·8 | −1 | −18 | −9 | +1+7? | | −5+2 | −3 |
| Vienna | 100·1 | 0+4 | −12 | −7 | +6 | | | |
| Dyce | 100·1 | | −17 | −10 | +12 | +2 | +3 | |
| Belgrade | 100·2 | +8 | −17 | −5 | +15+22 | | | |
| Jena | 100·4 | +2 | −18 | −10 | +1+5 | −2 | −1+5 | |
| Göttingen | 100·7 | | −19 | −9 | +5 | −8 | +5 | |
| Graz | 101·4 | | −15 | −10 | −2+13? | −3 | | |
| Chicago | 101·4 | +4 | −5+11 | −7 | +13? | +10 | +25 | |
| Zagreb | 102·0 | +2 | −16 | −10 | +3+15 | | | |
| De Bilt | 102·1 | | −16 | −7 | +6+16 | −3 | +1 | |
| Feldberg | 102·3 | +6 | −14 | −8 | +5 | −5 | +4 | |
| München | 102·4 | | −16 | −9 | +4 | −8, 0 | +6 | |
| Hohenheim | 103·1 | | −18 | −10 | +2+4 | −5 | +4 | |
| Stuttgart | 103·1 | 0 | −16 | −10 | +3 | −7 | +6 | |
| Stonyhurst | 103·1 | | −17 | −9 | +6 | −1 | +3 | |
| Innsbruck | 103·2 | | | −11 | | −7 | +4 | |
| Uccle | 103·4 | +2 | −15 | −7 | +5 | −5 | +5 | |
| Ravensburg | 103·6 | | | −10 | | | +3 | |
| Bidston | 103·7 | | −17 | −12 | +3 | −5 | +14 | |
| Strasbourg | 103·8 | +1 | −14 | −9 | +3 | −5 | −4 | |
| Chur | 104·4 | −3 | | −12 | +4 | −7 | +5 | |
| Zürich | 104·4 | −3 | −17 | −13 | +7+19 | −9 | +6 | |
| Kew | 104·5 | | −17 | −9 | +5 | −8 | +1+5 | |
| Oxford | 104·6 | | −20−14 | −6 | +5 | −2 | +1 | |
| Toronto | 104·7 | +13 | −14 | −9 | | +12 | −18 | |
| Ottawa | 105·3 | +19 | −14 | −6 | +7 | +2 | +14 | |
| Neuchâtel | 105·4 | −2 | −17 | −10 | +3 | −10 | +7 | |
| Paris | 105·7 | | −18 | −9 | −8 | −9 | +10 | |
| Florence | 105·8 | | | −12 | | | | |
| Toledo | 115·3 | | | | −23 | +3 | | |

The residuals PSν are against the trial tables; all others are against the final tables. Mean P residual, $\Delta > 70°$, −0·4; S, −16·3; SKS, −8·9; PP, +4·5; PS($\Delta > 100°$), −5·7; SS, +4·2.

# EPICENTRES IN THE PACIFIC AND INDIAN OCEANS.

1925 Nov. 13d. 12h. 14m. 40s.+15s.=14m.55s.  Z taken=0.

I.S.S Epicentre 13°·0N. 124°·7E.  First revised Epicentre 12°·5N. 124°·7E.  Final Epicentre 12°·8N 124°·8E.

A=−·5565, B=+·8007, C=+·2215.

| | △ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Manila | 4·1 | +8 | +8 | | | | | | | |
| Taihoku | 12·6 | +15 | +15† | +14 | +14† | | | | | |
| Hong Kong | 13·9 | −5 | −5 | −6 | −7 | | | | | |
| Amboina | 16·8 | +3 | +2 | −2 | −4 | | | | | |
| Zi-ka-wei | 18·7 | −1 | −2 | −2 | −4 | | | | | |
| Phu-Lien | 19·1 | +1 | 0 | +29 | +27 | | | | | |
| Nagasaki | 20·5 | +2 | +2 | +7 | +3d | | | | | |
| Hukuoka | 21·4 | +5 | +6 | +2 | +3 | | | | | |
| Sumoto | 23·4 | +3 | +5 | −2 | +2 | | | 0 | | |
| Kobe | 23·8 | −10 | −7 | +2 | +6 | | | | | |
| Osaka | 24·0 | −4 | −1 | −8 | −4 | | | | | |
| Batavia | 26·1 | −6 | −2 | +9 | −1d | | | | | |
| Malabar | 26·3 | −6 | −2 | +6 | −4d | | | | | −16 |
| Mizusawa | 30·1 | −10 | −4 | −63 | −54* | | | | | |
| Calcutta | 35·9 | −5 | 0 | +10 | +18 | | | | | |
| Ootomari | 37·1 | +3 | +8 | +13 | +21 | | | | | |
| Irkutsk | 42·8 | −11 | −7 | −10 | −5 | | | | | |
| Colombo | 44·6 | −3 | 0 | −4 | +1 | | | | | |
| Perth | 45·5 | −7 | −4 | −15 | −11 | | | | | |
| Kodaikanal | 46·4 | −4 | −1 | | | | | | | |
| Dehra Dun | 46·5 | −4 | −1 | −26 | −22 | | | | | |
| Simla | 47·4 | −6 | −3 | +7 | +10 | | | | | |
| Adelaide | 49·5 | −10 | −7 | −17 | −14 | | | +4 | | −20 |
| Bombay | 50·2 | −2 | 0 | −1 | +2 | | | | | |
| Riverview | 53·0 | −6 | −4 | −15 | −13 | | | | | −4 |
| Sydney | 53·0 | −10 | −8 | −9 | −7 | | | | | |
| Melbourne | 54·0 | +30 | +31† | +32 | +34† | | | | | |
| Ekaterinburg | 65·3 | −4 | −5 | −3 | −4 | | | −2 | | |
| Apia | 68·3 | +1 | 0 | −3 | −5 | | | | | −8 |
| Wellington | 71·1 | −10 | −11 | −33−16 | −35−18 | | | | | −11 |
| Honolulu | 73·6 | −4+6 | −5+5 | −1 | −4 | | | −11 | | |
| Piatigorsk | 75·2 | −10 | −10 | −10 | −13 | | | | | |
| Kucino | 77·7 | −4 | −4 | +4 | +1 | | | −3 | | |
| Makeyevka | 78·4 | −19 | −19 | | | | | | | |
| Pulkovo | 81·2 | −7 | −7 | −8 | −12 | | | | | |
| Leningrad | 81·2 | −7 | −7 | −6 | −10 | | | −2 | −4 | |
| Sitka | 84·5 | −2 | −2 | −4 | −8 | | | +22 | | −28+11 |
| Helwan | 86·5 | −5 | −4 | −43 | −47 | | | | | |
| Lemberg | 87·0 | −15 | −14† | −18 | −22† | | | | | |
| Upsala | 87·3 | −2 | −1 | −8 ! | −12 ! | | | | −2! | |
| Königsberg | 87·5 | +1 | +2 | −9 !+1 | −13 !−3 | | | | +5 ! | |
| Athens | 90·6 | −11 | −10 | | | −18 | | −10 | | −9 |
| Belgrade | 90·9 | +3 | +5 | | | −6 ! 0 ! | | | | |
| Budapest | 90·9 | +62 | +64* | | | | | | | |
| Vienna | 92·3 | −11 | −9 | +20 ! | +16 ! | −13 | | −10 | +10 ! | |
| Bergen | 92·5 | −6 | −4 | −10 | −14 | | | | | |
| Graz | 93·3 | −1 | +1 | −5 ! | −9 ! | −14 | | −4 | +17 ! | |
| Zagreb | 93·4 | −61 | −59 | −4!+20! | −8!+16! | −11 ! | | | −2 ! | |
| Leipzig | 93·4 | | | | | −8 ! | | | −4 ! | |
| Hamburg | 93·7 | −7 | −5 | −2 | −6 | −16−8 ! | | 0 | −1 ! | |
| Cheb | 93·9 | −4 | −2 | | | −6 | | | | |
| Victoria | 94·2 | 0+12 | +2+14 | | | −11 | | | | |
| Laibach | 94·3 | −53 | −51 | | | −11 | | | | |
| Göttingen | 94·6 | | | | 0 ! | −14 ! | | | +22 ! | |
| München | 95·2 | | | | −10!−11 | −11 ! | | | +12 ! | |

*Continued on next page.*

| | Δ | Pν | Pω | PKS | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Nördlingen | 95·6 | | | | | −13! | | | | |
| Innsbruck | 95·7 | −5 | −2 | | | −15+3 | | | | |
| Venice | 96·0 | −23 | −20 | +3 | −1 | | | | | |
| Hohenheim | 96·4 | | | | −14! | −13! | | | +6! | |
| Pompeii | 96·4 | +65 | +68 | −6 | −10 | | | | | |
| Naples | 96·6 | +2 | +5 | | | −35 | | | | |
| Ravensburg | 96·6 | | | | −4! | −11! | | | | |
| De Bilt | 97·0 | −7 | −4 | | −5! | −9! | | −1 | −7+10! | |
| Rocca di Papa | 97·2 | −8 | −5 | | | −14−8 | | −1 | | |
| Strasbourg | 97·3 | −7 | −4 | +30 | +26 | −13! | | 0 | +9! | |
| Florence | 97·3 | +1 | +4 | −4 | −8 | −10! | | | +17! | |
| Zürich | 97·4 | −7 | −4 | −10! | −14! | −13 | | | | |
| Dyce | 97·5 | | | | −18! | −7 | | 0 | +7! | |
| Uccle | 98·0 | −6 | −3 | | −3! | −10 | | +1 | +9!+21! | |
| Edinburgh | 98·8 | −6 | −3 | | −3! | −12! | | | +6 | |
| Moncalieri | 99·0 | −3 | 0 | | −14! | −10! | | | +7! | |
| Besançon | 99·0 | | | | | −9 | | +25 | | |
| Berkeley | 99·2 | | | | | −11 | | | −1 | |
| Stonyhurst | 99·7 | +32 | +35 | | −3! | −6! | | | +1! | |
| Lick | 99·9 | | | | | −10 | | | | |
| Paris | 100·1 | −7 | −4 | | −2! | −11 | | 0 | +9! | |
| Grenoble | 100·2 | +6 | +10 | −13 | −17 | | +6 | | | |
| Bidston | 100·3 | −3 | +1 | | | −3 | | | | |
| Oxford | 100·4 | | | | −4! | −8 | | | −3! | |
| Marseilles | 101·3 | +12 | +16 | | | 0 | | | | |
| Puy de Dôme | 101·4 | | | | | | | +9 | | |
| Johannesburg | 101·6 | | | | | −17 | | | | |
| Barcelona | 104·3 | | P′ | | | | | −7 | +3 | |
| Tortosa | 105·7 | | −4 | | | | | −3 | +2 | |
| Algiers | 106·1 | | | | | −13 | | 0 | | |
| Alicante | 107·8 | | | | | | | −9 | | |
| Toledo | 109·1 | | | | | | | +1 | | |
| Almeria | 109·8 | | −4 | | | | | | +4 | |
| Tucson | 110·1 | | | | | | | +26 | 0 | +36 |
| Granada | 110·4 | | | | | | | | | |
| Cape Town | 110·6 | | | | | | | +28 | +8 | |
| Malaga | 111·2 | | −1 | | | | | | −8 | |
| Rio Tinto | 112·0 | | | | | | | −8 | | |
| San Fernando | 112·5 | | −8 | | | | | | +17 | |
| Lisbon | 112·9 | | | | | | | −15 | | |
| Chicago | 117·8 | | | | | | | +9 | +3 | −57 |
| Ottawa | 118·9 | | | | | | −8 | −11 | −8 | +3 |
| Ann Arbor | 119·0 | | +25 | | | | | | −1 | −14 |
| St. Louis | 119·0 | | | | | | | | −4 | +6 |
| Toronto | 119·7 | | | | | | | −6 | −8 | −6 |
| Ithaca | 121·4 | | | | | | −15 | +10 | −9 | −3 |
| Harvard | 122·9 | | | | | | | +2 | −9 | −13+2 |
| Fordham | 123·7 | | | | | | | −28 | −12 | +37 |
| Georgetown | 124·4 | | | | | | | −33 | +13 | |
| Cheltenham | 124·6 | | | | | | | | | +3 |
| La Plata | 157·8 | | +2 | | | | −12 | | | −32+29 |
| Rio de Janeiro | 164·7 | | +3 | | | | −12+3 | +2 | | |
| La Paz | 167·2 | | +1+5 | | | | | +14 | | +62 |

Mean P residual ($\Delta > 70°$), −4; S, −9; SKS, −12.

This earthquake is discussed by Lehmann and Plett, who give the epicentre as 13°·0N. 124°·7E, agreeing with the I.S.S. Their readings are indicated by the mark ! if not given in the I.S.S. The P residuals are negative at the greater distances, implying some depth of focus and primitive P movement. The S readings given by their readings fall into two groups, mean −12·3 and −3·2. Those for SKS give −10·6. St. Louis 29m.50s., Ithaca 30m.7s., Harvard 30m.21s., Fordham 30m.25s., may be SKSP.

1926 Jan. 18d. 21h. 7m. 18s.+18s.=7m.36s. Z taken=0.

I.S.S. Epicentre 1°·5S. 88°·5E. Revised Epicentre 1°·7S. 88°·9E.

A=+·0192, B=+·9994, C=−·0297.

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Colombo | 12·47 | +1 | +1 | | | | | | | |
| Kodaikanal | 16·6 | −36 | −37† | −15 | −17† | | | | | |
| Batavia | 18·43 | −2 | −3 | +9 | +7 | | | | | |
| Malabar | 19·45 | −1 | −2 | +3 | 0d | | | | | |
| Hyderabad | 21·73 | −2 | −1 | +3 | −2d | | | | | |
| Calcutta | 24·24 | −2+2 | +1+5 | +9+21 | +1d+13d | | | | | |
| Bombay | 25·8 | −6 | −2 | −3 | +3 | | | | | |
| Phu-Lien | 28·4 | +1 | +6 | +6 | +14 | | | | | |
| Dehra Dun | 33·7 | +71 | +77† | +64 | +73† | | | | | |
| Hong Kong | 34·43 | −5 | 0 | +4 | +12 | | | | | |
| Simla | 34·6 | +3 | +8 | +1 | +9 | | | | | |
| Manila | 35·65 | 0 | +5 | | | | | | | |
| Amboina | 39·3 | +42 | +46 | | | | | | | |
| Perth | 39·5 | −4 | 0 | −12 | −5 | | | | | |
| Taihoku | 41·3 | +8 | +12 | +20 | +26 | | | | | |
| Zi-ka-wei | 45·1 | −3 | 0 | +2 | +6 | | | | | |
| Baku | 55·1 | −4 | −3 | +4 | +5 | | | | | |
| Irkutsk | 55·5 | −5 | −4 | +3 | +4 | | | | | −13 |
| Osaka | 56·7 | +8 | +9 | +8 | +9 | | | | | |
| Adelaide | 56·8 | | | −12 | −11 | | | | | +9 |
| Piatigorsk | 61·3 | −10 | −11 | −5 | −5 | | | +9 | | +33 |
| Ekaterinburg | 62·8 | −5 | −6 | −3 | −3 | | | −5 | | −17 |
| Helwan | 63·3 | −10 | −11 | | | | | | | +2 |
| Riverview | 66·2 | | | −10 | −11 | | | | −12 | |
| Sydney | 66·2 | | | −29 | −30 | | | | | |
| Makeyevka | 66·4 | −7 | −8 | −3 | −4 | | | | +23 | +28 |
| Kucino | 70·7 | −7 | −8 | −7 | −9 | | | +1 | | −15 |
| Athens | 71·9 | −11 | −12 | −13 | −15 | | | | | |
| Cape Town | 72·9 | | | −9 | −11 | | | | | |
| Belgrade | 76·1 | −8 | −8 | −10−2 | −13−5 | | | −18 | | |
| Pulkovo | 76·2 | −5 | −5 | −6 | −9 | | | −8 | | −12 |
| Leningrad | 76·4 | −7 | −7 | −8 | −11 | | | −5 | | |
| Budapest | 77·8 | −2 | −2 | −7 | −10 | | | | | |
| Königsberg | 79·1 | −7 | −7 | −7 | −10 | | | | −10 | −7 |
| Vienna | 79·7 | −8 | −8 | −9 | −12 | | | | −5 | −2 |
| Graz | 80·0 | −12 | −12 | −15 | −18 | | | | | |
| Rocca di Papa | 81·0 | −9 | −9 | −13 | −17 | | | | | |
| Upsala | 82·1 | −10 | −10 | −2 | −6 | | | +7 | | −1 |
| Florence | 82·4 | −7 | −7 | −3 | −7 | | | | | |
| Cheb | 82·7 | −6 | −6 | −4 | −8 | | | | | |
| Innsbruck | 82·8 | −8 | −8 | | | | | | | |
| Christchurch | 84·2 | | | +16 | +12 | | | | −27 | +9 |
| Hohenheim | 84·5 | −6 | −5 | −11 | −15 | | | | | |
| Zürich | 84·7 | −9 | −8 | | | −23 | | | | |
| Hamburg | 84·8 | −8 | −7 | −4 | −8 | *+1* | | +10 | | +6 |
| Moncalieri | 85·0 | −5 | −4 | −6 | −10 | *0* | | | | |
| Strasbourg | 85·4 | −9 | −8 | −7 | −11 | *0* | | +3 | | |
| Wellington | 85·7 | | | | | −15 | | | | |
| De Bilt | 87·5 | −8 | −7 | −9 | −13 | *+3* | | +1 | +11 | +10 |
| Algiers | 87·7 | −10 | −9 | −11 | −15 | *+2* | | −6 | | |
| Uccle | 87·8 | −8 | −7 | −12 | −16 | *+1* | | −11 | +14 | +11 |
| Barcelona | 88·7 | −2 | −1 | −13 | −17 | *+3* | | | | |
| Paris | 88·9 | −7 | −6 | −7 | −11 | *+6* | | | | |
| Tortosa | 89·9 | −11 | −10 | | | +7 | | | | |
| Alicante | 90·6 | −6 | −4 | +11 | +7 | | | | | |
| Kew | 90·8 | | | | | −1 | | | | |
| Dyce | 92·0 | 0 | +2 | −7 | −11 | | | | | +25 |
| Almeria | 92·1 | −11 | −9 | −2 | −6 | | | | | |
| Stonyhurst | 92·2 | −10 | −8 | +7 | +3 | | | | | |
| Edinburgh | 92·6 | | | | | 0 | | +4 | +11 | +3 |

*Continued on next page.*

| | Δ | $P_v$ | $P_\omega$ | $S_v$ | $S_\omega$ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Bidston | 92·6 | | | −7 | −11 | | | | | |
| Granada | 93·1 | −22 | −20 | | | +1 | | +3 | | |
| Toledo | 93·4 | −12 | −10 | −13 | −17 | | | | | −8 |
| Malaga | 93·7 | −30 | −18 | | | −8 | | | | |
| San Fernando | 95·2 | −4 | −2 | | | +9 | | | | |
| | | | P′ | PKS | SKSP | | | | | |
| Ottawa | 134·3 | | | | +11 | | +16 | −2 | | |
| Toronto | 136·8 | | | | | | | 0 | | |
| Ann Arbor | 138·9 | | | −16 | | | | | | |
| Chicago | 139·9 | | +6 | | | | | +6 | −2 | |
| Sucre | 147·3 | | −2 | | +7 | | | | | |
| La Paz | 151·0 | | −4 | +36 | −12 | | | | | |

Mean P residual, Δ>70°, −8 ; S, −11. The SKS residuals fall into two groups, one early, the other averaging +2. The latter may be sSKS.

1927 July 18d. 11h. 19m. 40s.+15s.=19m.55s. Z taken=0.

I.S.S. Epicentre 32°·0S. 179°·0W. Revised Epicentre 32°·8S. 179°·2W.

A=−·8405, B=−·0118, C=−·5417.

| | Δ | $P_v$ | $P_\omega$ | $S_v$ | $S_\omega$ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Wellington | 9·7 | +2 | +2 | −32 | −32 | | | | | |
| Christchurch | 12·5 | −2 | −2 | +39 | +39 | | | | | |
| Suva | 14·8 | −8 | −8 | | | | | | | |
| Riverview | 24·7 | −12 | −9 | +3 | −7d | | | −9 | | −17 |
| Sydney | 24·7 | −115 | −112* | −12 | −7 | | | | | |
| Melbourne | 29·5 | −127 | −121* | +30 | +38 | | | | | |
| Adelaide | 34·9 | +17 | +22 | −13 | −5 | | | | | |
| Perth | 54·0 | | | −7 | −5 | | | | | |
| Honolulu | 57·8 | +1 | +1 | +8 | +9 | | | | | |
| Batavia | 73·2 | +17−63 | +16−64 | −46−13 | −49−16 | | | | | |
| Manila | 74·2 | +2 | +1 | | | | | | | |
| Osaka | 79·1 | +15 | +15† | +15 | +12† | | | | | |
| Hong Kong | 84·1 | | | −4 | −8 | | | | | |
| Zi-ka-wei | 85·1 | −8 | −7 | −6 | −10 | | | | | |
| Phu-Lien | 88·7 | −2 | −1 | 0 | −4 | | | | | |
| Victoria | 95·3 | | | | | −10 | | 0 | | |
| La Paz | 98·0 | −4 | −1 | | | −19 | | | | |
| Irkutsk | 108·0 | | | | | −10 | −9 | | +9 | |
| Chicago | 112·2 | | | | | | −14 | −5 | −4 | |
| Toronto | 118·5 | | | | | | −7 | +7 | | |
| Fordham | 121·5 | | | | | | −6 | −6 | −10 | −42 |
| Ottawa | 121·6 | P′ | | PKS | SKSP | | | −2 | | +12 |
| Ekaterinburg | 133·2 | −11 | | −20 | −17 | | −5 | | | +9 |
| Baku | 140·4 | −10 | | −20 | | | −10 | +39 | | |
| Tiflis | 144·3 | −8 | | | | | | | | |
| Kucino | 145·6 | −6 | | | +32 | | +3 | +14 | | |
| Pulkovo | 146·8 | −10 | | | −7 | | −13 | +3 | | +6 |
| Makeyevka | 148·3 | −4 | | | +20 | | −4 | | | |
| Helsingfors | 148·4 | −1 | | | | | −2 | −7−3 | | +7 |
| Upsala | 150·8 | −7 | | | | | | | | |
| Ksara | 150·8 | −13 | $P_2'$ | | | | | | | |
| Königsberg | 154·0 | +1 | | | | | | −4 | | |
| Dyce | 155·5 | | +6 | | −5 | | −8 | +1 | | |
| Copenhagen | 155·7 | −11 | +2 | | −5 | 0 | −8 | 0 | | −44 |
| Hamburg | 158·2 | −11 | | | | | | +5 | | |
| Budapest | 159·8 | −6 | | | | | | | | |
| Prague | 160·0 | | −8 | | | | | | | |
| De Bilt | 160·4 | −9 | −11 | | | | −4 | +3 | | |
| Vienna | 160·6 | −10 | | | | | −4 | | | |
| Oxford | 161·0 | +6 | | | | | | +20 | | |

*Continued on next page.*

| | Δ | P′ | $P_2$′ | PKS | SKSP | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Kew | 161·3 | −9 | | | | | | −1 | | |
| Uccle | 161·7 | −10 | | | | | | +3 | | |
| Zagreb | 162·5 | −7 | | | +33 | | −10 | | | |
| Strasbourg | 163·4 | −12 | | | | | | 0 | | |
| Paris | 163·9 | −10 | | | | | | | | |
| Zürich | 164·3 | −11 | | | | | | | | |
| Venice | 164·5 | +8 | | | | | −26 | | | |
| Florence | 166·3 | +2 | | | | | −10 | | | |
| Pompeii | 166·4 | +7 | | | | | | | | |
| Naples | 166·6 | +9 | | | | | | | | |
| Moncalieri | 166·7 | −6 | | | | +39 | | | | |
| Rocca di Papa | 166·9 | −9−3 | | | | | | +5 | | |
| Toledo | 171·9 | −8 | | | | | | | | |
| Tortosa | 172·0 | −6 | | | | | −17 | | | |
| San Fernando | 173·2 | −2 | | | | | +1 | | | |
| Malaga | 174·2 | −7 | | | | | | | | |
| Granada | 174·2 | −5 | +3 | | | | | +4 | | |
| Almeria | 175·2 | 0 | | | | | | +8 | | |
| Algiers | 175·6 | −8 | | | | | −32 | +11 | | |

See the text under P′ and SKKS for discussion of the P, S, and SKS residuals. Fordham 30m.7s.. may be SKSP.

1928 Mar. 9d. 18h. 5m. 20s.+8s.=5m.28s. Z taken=0.

I.S.S. Epicentre 2°·3S. 88°·5E. Revised Epicentre 2°·8S. 88°·5E.

A=+·0262, B=+·9985, C=−·0488.

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Colombo | 13·00 | 0 | 0 | | | | | | | |
| Kodaikanal | 17·1 | +26 | +25 | | | | | | | |
| Batavia | 18·56 | −1 | −2 | +1 | −1 | | | | | |
| Malabar | 19·54 | −4 | −5 | +4 | +1d | | | | | |
| Hyderabad | 22·53 | +3 | +5 | +8 | +2d | | | | | |
| Bombay | 26·6 | +1 | +5 | +4 | +11 | | | | | |
| Phu-Lien | 29·54 | −6 | 0 | −7 | +1 | | | | | |
| Dehra Dun | 34·6 | +25 | +30† | +13 | +21† | | | | | |
| Hong Kong | 35·5 | −6 | −1 | −9 | −1 | | | | | |
| Manila | 36·6 | −1 | +4 | +27 | +35 | | | | | |
| Perth | 38·9 | 0 | +4 | 0 | +7 | | | | | −32 |
| Amboina | 39·5 | +2 | +6 | | | | | | | |
| Taihoku | 42·4 | +2 | +6 | 0 | +6 | | | | | |
| Tananarive | 43·2 | +3 | +7 | 0 | +5 | | | +14 | | +14 |
| Zi-ka-wei | 46·2 | −1 | +2 | 0 | +4 | | | +22 | | |
| Tashkent | 47·45 | 0 | +3 | −35 | −32 | | | | | |
| Nagasaki | 52·8 | +11 | +12† | +11 | +13† | | | +16 | | |
| Hukuoka | 53·6 | +1 | +2 | +15 | +17 | | | | | |
| Entebbe | 55·8 | +1 | +2 | +7 | +8 | | | | | |
| Adelaide | 56·4 | +8 | +9 | +17 | +18 | | | | | |
| Irkutsk | 56·6 | +1 | +2 | −10 | −9 | | | | | |
| Sumoto | 57·2 | +2 | +2 | −1 | 0 | | | | | −17 |
| Kobe | 57·6 | +3 | +3 | +5 | +6 | | | | | |
| Osaka | 57·8 | +3 | +3 | +6 | +7 | | | | | |
| Toyooka | 57·9 | +3 | +3 | +8 | +9 | | | | | |
| Nagoya | 59·1 | −2 | −2 | 0 | 0 | | | | | |
| Ksara | 61·4 | +1 | 0 | +2 | +2 | | | +12 | | +6 |
| Melbourne | 62·2 | +1 | 0 | +3 | +3 | | | | | |
| Ekaterinburg | 63·6 | +2 | +1 | −1 | −2 | | | | | |
| Helwan | 63·6 | +1 | 0 | +1 | 0 | | | | | |
| Mizusawa | 63·9 | 0+8 | −1+7 | −5+3 | −6+2 | | | | | |
| Riverview | 65·9 | −1 | −2 | +4 | +3 | | | +12 | −4 | |
| Sydney | 65·9 | +1 | 0 | −10 | −11 | | | | | |
| Makeyevka | 67·1 | +1 | 0 | | | | | | | |
| Ootomari | 68·5 | +20 | +19† | +13 | +12† | | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Kucino | 71·5 | +3 | +2 | −12 | −14 | | | | | |
| Cape Town | 71·9 | +5 | +4 | +15 | +13 | | | | | |
| Lemberg | 76·1 | +4 | +4 | −3+9 | −6+6 | | | | | |
| Belgrade | 76·7 | 0 | 0 | −19 | −22 | | | | | |
| Pulkovo | 77·1 | +1 | +1 | −3 | −6 | | | | | |
| Budapest | 78·4 | +7 | +7 | +2 | −1 | | | | | |
| Helsingfors | 79·7 | −3 | −3 | −8 | −11 | | | | | |
| Pompeii | 79·8 | +2 | +2 | −6 | −9 | | | | | |
| Königsberg | 79·9 | −1+3 | −1+3 | 0+4 | −3+1 | | | +25 | +21 | +15 |
| Zagreb | 80·0 | +5 | +5 | −4 | −8 | | | −16+20 | | |
| Naples | 80·1 | +10 | +10 | | | | | | | |
| Vienna | 80·4 | −1 | −1 | −1 | −5 | | | +2 | −26 | +12 |
| Graz | 80·7 | 0 | 0* | +3 | −1 | | | +5 | | +40 |
| Laibach | 81·0 | +10 | +10 | +3 | −1 | | | +8 | | |
| Rocca di Papa | 81·4 | −1 | −1 | −5 | −9−3 | | | | | |
| Venice | 82·4 | +4 | +4 | +10 | +6 | | | | | |
| Florence | 82·8 | −1 | −1 | +1 | −3 | | | +7 | +10 | −5 |
| Upsala | 83·0 | −1 | −1 | +4 | 0 | | | +5 | | +9 |
| Innsbruck | 83·4 | 0 | +1 | −3 | −7 | | | | | |
| Potsdam | 83·4 | +17 | +18 | +8 | +4 | | | | | |
| Christchurch | 83·8 | +24 | +25 | −41 | −45 | | | +15 | | |
| Jena | 84·0 | +3+11 | +4+12 | +6 | +2 | −1 | | −18+14 | +22 | −4+28 |
| Lund | 84·1 | +3 | +4 | | | −2 | | | | −8 |
| Copenhagen | 84·5 | 0 | +1 | +3 | −1 | −8 | | +1 | +7 | −11 |
| Chur | 84·6 | +1 | +2 | | | −1 | | | | |
| Ravensburg | 84·7 | −1 | 0 | | | 0 | | +12 | | |
| Hohenheim | 85·1 | +3 | +4 | +1 | −3 | | | +14 | | |
| Wellington | 85·3 | +4 | +5 | | | −17−6 | | +4 | | −3 |
| Hamburg | 85·5 | +1 | +2 | +5 | +1 | −4 | | +14 | | +14 |
| Moncalieri | 85·5 | +1 | +2 | | | −4 | | | | |
| Feldberg | 85·8 | +4 | +4 | +8 | +4 | +2 | | −10 | +15 | 0 |
| Strasbourg | 86·0 | −2 | −1 | | | +1 | | +13 | +1 | |
| Neuchâtel | 86·3 | 0 | +1 | | | 0 | | | | |
| Grenoble | 86·9 | +3 | +4 | +4 | 0 | +8 | | | | |
| Marseilles | 86·9 | +2 | +3 | | −2 | +4 | | | +11 | −25 |
| Besançon | 87·0 | +2 | +3 | +2 | −2 | | | +11 | | |
| De Bilt | 88·1 | +3 | +4 | | | −6 | | | +14 | +18 |
| Algiers | 88·1 | +4 | +5 | −3 | −7 | | | +11 | | |
| Uccle | 88·5 | +2 | +3 | +1 | −3 | −8 | | +2 | | +15 |
| Puy de Dôme | 88·9 | −13 | −12 | | | −5 | | −11 | −11 | −31 |
| Suva | 89·0 | −40 | −39† | | | −30† | | −24† | | −63† |
| Bergen | 89·1 | −2 | −1 | | | +4 | | −23 | | |
| Barcelona | 89·2 | +5 | +6 | | −9 | +8 | | | | +4 |
| Paris | 89·5 | 0 | +1 | | | +8 | | | | 0 |
| Tortosa | 90·3 | +3 | +4 | −4 | −8 | +5 | | | | |
| Bagnères | 90·6 | +9 | +11 | | | +8 | | +10 | +16 | +9 |
| Alicante | 91·0 | +1 | +3 | | | +6 | | +4 | | |
| Kew | 91·5 | +1 | +3 | −6 | −10 | −4 | | −5+4 | +12 | −3+1 |
| Oxford | 92·0 | +8 | +10 | | | −13 | | +16 | | −5 |
| Almeria | 92·5 | +9 | +11 | +14 | +10 | | | 0 | | |
| Dyce | 92·7 | +12 | +14 | +2 | −2 | | | −5 | | +28 |
| Stonyhurst | 92·8 | +9 | +11 | +17 | +13 | | | −9 | | +17 |
| Bidston | 93·2 | | | | | | | | | +18 |
| Edinburgh | 93·3 | +12 | +14 | +14 | +10 | +10 | | | +24 | +26 |
| Granada | 93·5 | +9 | +11 | +12 | +8 | | | +7 | +22 | +37 |
| Toledo | 93·8 | +70 | +72 | −4 | −8 | | | 0 | | +1 |
| Malaga | 94·0 | +3 | +5 | +12 | +8 | | | | | |
| San Fernando | 95·5 | +11 | +13 | −4 | −8 | | | +12 | | |
| Scoresby Sund | 99·4 | +9 | +12 | +19 | +15 | +12 | | −10 | +21 | +21 |
| Reykjavik | 101·3 | | | | | +17 | | | +18 | +28 |
| Honolulu T.H. | 113·0 | | | | | | | | +9 | −48−15 |
| Sitka | 115·6 | | | | | | | | +15 | |
| Rio de Janeiro | 126·4 | P′ | | | | | | +1+11 | | |
| Victoria | 126·8 | +22 | | | | | | | −11−4 | |
| Spokane | 129·8 | +33 | | | | | | +8 | +44 | +29 |

*Continued on next page.*

| | △ | P′ | SKSP | PKS | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| La Plata | 131·3 | +7 | | | | | | | |
| Berkeley | 134·9 | +4+12 | | +1 | +14 | | +9+15 | | +29 |
| Ottawa | 135·1 | +23 | +18? | | | | +15 | −8? | +38 |
| Lick | 135·6 | | | +17 | | | +16 | | +22+31 |
| Harvard | 136·4 | | | | | +8 | +10 | | −18+20 |
| Toronto | 137·6 | +17 | +18? | | | | +13 | −11? | +25 |
| Ithaca | 138·1 | | | | | | +5 | | |
| Santiago | 138·8 | | | | | | | +53 | |
| Chicago | 140·7 | +28 | | | | | | | +8 |
| Denver | 141·1 | −14 | | | −9 | | | | |
| Georgetown | 141·5 | +1 | | | | | +2 | | |
| Charlottesville | 142·8 | | | | | | | +16 | +63 |
| Cincinnati | 143·0 | +7 | +6 | | | | +22 | −33 | +4 |
| St. Louis | 144·0 | 0+11 | | | | −10 | +15 | +27 | −7 |
| Tucson | 145·4 | | | | | | +4 | | −4 |
| Sucre | 146·2 | 0 | +12 | | +6 | +8 | +16 | | −10 |
| La Paz | 149·9 | +6 | +12 | | | +14 | −36 | | |

Mean P residual (△>70°), 0 ; S,−6 ; SKS, dubious. Victoria 31m.1s. may be SKSP.

Note.—The epicentres of 1926 Jan. 18d., 1928 Feb. 7d., and 1928 Mar. 9d. are within about a degree of one another. The two latter may be identical, but on Feb. 7th the Indian stations were rather inconsistent. P in the 1926 shock shows focal depth clearly ; that of 1928 is not decisive, but there is a curious concentration of small positive residuals in all azimuths from △=36° to 58°. It is possible that the epicentre should be taken a little further east to fit Batavia and Malabar ; this would improve Hyderabad and Bombay at the expense of Colombo, Manila, and Zi-ka-wei. The change would hardly affect $T_0$, and the times at the distant stations are very consistent and do not indicate focal depth. There seems to be a real difference between 1926 Jan. 18d. and 1928 Mar. 9d. in this respect.

1928 Mar. 16d. 5h. 0m. 57s.+10s.=1m.7s. Z taken=0.

I.S.S. Epicentre 22°·8S. 170°·5E. Revised Epicentre 22°·5S. 170°·4E.

A=−·9110, B=+·1541, C=−·3827.

| | △ | $P_\nu$ | $P_\omega$ | $S_\nu$ | $S_\omega$ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Suva | 8·7 | −13 | −13† | −24 | −24† | | | | | |
| Apia | 19·0 | +2 | +1 | +8 | +5d | | | | | |
| Wellington | 19·1 | +3 | +2 | +18 | +15d | | | | | |
| Riverview | 20·3 | +1 | +1 | +13 | +9d | | | −2 | | +11 |
| Christchurch | 21·1 | +4 | +4 | −31 | −30 | | | | | |
| Melbourne | 26·6 | −4 | 0 | +14 | +2d | | | | | |
| Adelaide | 30·4 | −6 | 0 | −17 | −8 | | | | | |
| Amboina | 45·0 | −4 | −1 | −9 | −5 | | | | | |
| Perth | 48·9 | +1 | +4 | +8 | +11 | | | | | |
| Honolulu T.H. | 53·6 | −3 | −2 | −19+1 | −16+4 | | | −7 | | −10+11 |
| Manila | 61·0 | +3 | +2 | +2 | +2 | | | +11 | | |
| Malabar | 62·1 | −59 | −60* | +1 | +1 | | | | | |
| Batavia | 63·2 | −15 | −16† | −14 | −15† | | | | | |
| Nagoya | 65·8 | −1 | −2 | | | | | | | |
| Osaka | 66·0 | +6 | +5 | −6 | −7 | | | | | |
| Sumoto | 66·1 | −1 | −2 | | | | | | +23 | |
| Kobe | 66·2 | −1 | −2 | −4 | −5 | | | +2 | | |
| Taihoku | 67·1 | −7 | −8 | 0 | −1 | | | | | |
| Toyooka | 67·1 | +3 | +2 | −2 | −3 | | | | | |
| Nagasaki | 67·4 | +2 | +1 | −1 | −4 | | | | | |
| Mizusawa | 67·4 | 0 | −1 | −5 | −6 | | | | | |
| Hukuoka | 67·8 | +1 | 0 | −2 | −3 | | | | | |
| Hong Kong | 70·7 | 0 | −1 | 0 | −2 | | | | | |
| Zi-ka-wei | 71·3 | 0 | −1 | −2 | −4 | | | | | |
| Ootomari | 73·5 | −16 | −17 | −2 | −5 | | | | | |
| Phu-Lien | 75·8 | −1 | −1 | −1 | −4 | | | | | |
| Berkeley | 87·4 | −2 | −1 | | | −8 | | +4 | | |
| Calcutta | 91·6 | +6 | +8 | +21 | +17 | | | | | |
| Victoria | 92·3 | +4 | +6 | | | −3 | | | | |
| Tucson | 93·0 | +5 | +7 | | | −5 | | −15 | | |

*Continued on next page.*

| | Δ | $P_\nu$ | $P_\omega$ | $S_\nu$ | $S_\omega$ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Irkutsk | 94·2 | −2 | 0 | +15 | +11 | −11 | | | | |
| Chihuahua | 95·3 | +32 | +34 | −3 | −7 | | | | | |
| Spokane | 95·3 | +21 | +23 | +8 | +4 | −9 | | +10 | −1 | |
| Kodaikanal | 96·6 | +16 | +19 | | | | | | | −13 |
| Tacubaya | 97·7 | −12 | −9 | | | +8 | | | | |
| Hyderabad | 98·3 | −6 | −3 | | | −4 | | | | |
| Denver | 100·3 | | | | | | | | −31 | |
| Dehra Dun | 103·0 | −37 | −33 | | | −23 | | | | |
| Bombay | 103·8 | −3 | +2 | | | −13 | | | | |
| Tananarive | 110·4 | | | | | 0 | | +3 | +29 | +20 |
| La Paz | 110·7 | | +35 | | | | −4 | −2+13 | +26 | −13+23 |
| St. Louis | 110·9 | | | | | | −30+20 | −6 | +2 | −9 |
| Sucre | 111·6 | P′ | +23 | | | | | +22 | +23 | +20 |
| Tashkent | 112·7 | +13 | −5 | | | +4 | | | | |
| Chicago | 113·5 | | | | | | −6 | +1 | +3 | +7 |
| Cincinnati | 115·4 | | | | | −17 | −4 | 0 | −2 | −2 |
| Cape Town | 117·6 | | | | | | | +7 | +6 | |
| Johannesburg | 119·2 | | | | | | | +32 | | |
| Toronto | 119·7 | | | | | | −7 | +3 | −28 | |
| Charlottesville | 119·8 | | | | | +29 | | +41 | +40 | |
| Georgetown | 121·1 | +2 | | | | | +17 | | | |
| Ithaca | 121·7 | | +5 | | | | | | −26 | −1 |
| Ottawa | 122·3 | +12 | −9 | | | | | +29 | −4 | |
| Rio de Janeiro | 124·0 | | | | | | | +4 | | |
| Baku | 127·2 | +19 | | PKS | | | | | | |
| Scoresby Sund | 131·5 | +1+5 | | −12 | | −7 | −4 | +2 | −4, 0 | −3 |
| Kucino | 131·8 | +8 | | | | | +3 | | | |
| Entebbe | 133·3 | | | −9 | | | | | | |
| Pulkovo | 133·4 | −2 | +7 | | | | +1 | | | |
| Makeyevka | 134·5 | −7 | | | | | | +14 | | |
| Helsingfors | 135·3 | +13 | | | | | | | | |
| Upsala | 138·0 | +17 | | | | | | +3 | | |
| Ksara | 138·7 | −4 | | −19 | | −27 | −8 | | | |
| Königsberg | 140·6 | | | −5 | | | +1 | | +20 | |
| Bergen | 140·7 | | | | | | | | +45 | |
| Lemberg | 142·1 | +3+9 | SKSP | | | | | | | |
| Helwan | 142·7 | −11 | −4 | | | | | | | |
| Lund | 142·8 | +7 | | | | | | | | |
| Copenhagen | 143·0 | −5+7 | +4 | −4 | | | +5 | +3+17 | +1 | −9 |
| Dyce | 144·9 | −4 | +7 | +15 | | | +2 | | | |
| Potsdam | 145·4 | +1 | | | | | | | | |
| Hamburg | 145·6 | −2 | | | | | | | | |
| Budapest | 146·1 | +3 | | | | | | | | |
| Edinburgh | 146·3 | +2 | | | | | | | | |
| Belgrade | 146·8 | −5+8 | | | | | | | | |
| Vienna | 147·0 | −8−2 | | | | | | +10+22 | | −15−3 |
| Jena | 147·2 | 0+7 | | | | +18 | | +20 | +19 | |
| Graz | 148·2 | −3+15 | | | | | | | +9 | |
| Stonyhurst | 148·2 | +5 | | | | | | | | |
| De Bilt | 148·3 | −4+2 | +28 | | | | | | +11 | |
| Bidston | 148·7 | +8 | −2 | | | | | | | |
| Zagreb | 148·8 | −4+4 | | +3 | | +19 | | | | −8 |
| Feldberg | 148·9 | +2+6 | | | | | +6 | −29 | | |
| Laibach | 149·4 | 0 | | | | | +13 | | +3 | |
| Uccle | 149·7 | −3 | | | | | | | | |
| Hohenheim | 149·8 | +11+15 | | | | | | +10 | | |
| Innsbruck | 150·0 | +2+7 | | | | | | | | |
| Oxford | 150·0 | +4+8 | | | | | | +9 | | |
| Kew | 150·1 | −3+3 | +2 | | | +11 | −3 | −15+13 | +11 | |
| Ravensburg | 150·4 | | | | | | +10 | | | |
| Strasbourg | 150·5 | −4 | −9 | | | | | | | |
| Venice | 150·9 | +5 | | | | | | | | |
| Zürich | 151·2 | −2 | | | | | | | | |
| Chur | 151·2 | +7 | | | | | | | | |
| Paris | 152·0 | −3 | | | | | +1 | | | |

*Continued on next page.*

| | Δ | P′ | SKSP | SKKS | PP | PS |
|---|---|---|---|---|---|---|
| | ° | | | | | |
| Neuchâtel | 152·1 | +4 | | +1 | | |
| Besançon | 152·3 | +2 | | | | |
| Florence | 152·6 | −4 | | | | |
| Pompeii | 152·7 | +15 | | | | |
| Naples | 152·8 | | | −6 | | |
| Rocca di Papa | 153·2 | −3+7 | | | | |
| Moncalieri | 153·4 | +1 | | | | |
| Grenoble | 154·1 | +11+23 | | | | +2 |
| Puy de Dôme | 154·6 | +13 | | | | +27 |
| Marseilles | 155·8 | 0 | | | | |
| Bagnères | 157·8 | +10 | | | | +3 |
| Barcelona | 158·7 | +16 | | | | +9 |
| Tortosa | 159·8 | 0+5 | | | | |
| Algiers | 162·0 | +1 | −2 | | +17 | |
| Toledo | 162·0 | −4 | | | −3 | |
| Alicante | 162·3 | +1 | | +2 | | |
| Almeria | 164·4 | −1 | | | +15 | |
| Granada | 164·4 | +3+16 | −17 | −8 | −34+43 | |
| Malaga | 165·1 | −8 | +11 | | | |
| San Fernando | 165·8 | −16 | | −23 | | |

Mean P residual (Δ>70°), −1 ; S (Δ>60°), −2 ; SKS, −2 ?

1928 June 15d. 6h. 12m. 30s.+15s.=12m.45s. Z taken=0.

I.S.S. Epicentre 12°·3N. 121°·0E. Revised Epicentre 12°·9N. 121°·0E.

A=−·5020, B=+·8356, C=+·2233.

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Manila | 1·7 | +3 | +3 | +5 | +5 | | | | | |
| Hong Kong | 11·4 | 0 | 0 | +2 | +2 | | | | | |
| Phu-Lien | 15·9 | +1 | 0 | +12 | +11 | | | | | |
| Amboina | 18·1 | 0 | −1 | | | | | | | |
| Zi-ka-wei | 18·3 | −2 | −3 | +6 | +4 | | | | | |
| Nagasaki | 21·4 | 0 | 0 | +14 | +9d | | | −10 | | |
| Hukuoka | 22·4 | 0 | +1 | +7 | +1d | | | | | |
| Batavia | 23·7 | −6 | −4 | +3 | −4d | | | | | |
| Malabar | 24·1 | −3 | 0 | −50 | −58d* | | | | | |
| Sumoto | 24·9 | −4 | −1 | −2 | +3 | | | | | |
| Kobe | 25·3 | −8 | −5 | +10 | +1d | | | | | |
| Osaka | 25·4 | −23 | −19 | 0 | +6 | | | | | |
| Toyooka | 25·8 | −4 | 0 | +15 | +5d | | | | | |
| Nagoya | 26·5 | −2 | +2 | +9 | −2d | | | | | |
| Mizusawa | 31·7 | −10 | −4 | | | | | | | |
| Calcutta | 32·4 | +1+11 | +7+18 | −4+11 | +5+20 | | | | | |
| Ootomari | 38·4 | −8 | −4 | +11 | +18 | | | | | |
| Colombo | 40·9 | −10 | −6 | −3 | +3 | | | | | |
| Hyderabad | 41·2 | +1 | +5 | −2 | +4 | | | | | |
| Irkutsk | 41·6 | −10 | −6 | −30 | −24 | | | | | |
| Perth | 45·1 | −12 | −9 | −9 | −5 | | | | | +7 |
| Bombay | 46·6 | −3 | 0 | −13 | −9 | | | | | |
| Adelaide | 50·7 | −9 | −7 | −12 | −9 | | | −14 | | |
| Tashkent | 53·0 | 0 | +2 | +10 | +12 | | | | | |
| Riverview | 54·9 | −8 | −7 | −6 | −5 | | | −3 | −9 | |
| Sydney | 54·9 | −86 | −85 | −24 | −23 | | | | | |
| Melbourne | 55·5 | −8 | −7 | −7 | −6 | | | | | |
| Suva | 64·6 | +4 | +3 | | | | | | | |
| Baku | 67·3 | +1 | 0 | +6 | +5 | | | | | |
| Wellington | 73·4 | −10 | −11† | −17 | −20† | | | | | |
| Kucino | 75·5 | −10 | −10† | −14 | −17† | | | | | |
| Makeyevka | 75·8 | −2 | −2 | +1 | −2 | | | | | |
| Honolulu T.H. | 77·3 | −3 | −3 | −10 | −13 | | | −15+5 | | |
| Theodosia | 77·8 | −2 | −2 | −5 | −8 | | | | | |
| Simferopol | 78·7 | −6 | −6 | −5 | −8 | | | | | |

*Continued on next page.*

| | Δ | Pv | Pω | Sv | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Yalta | 78·8 | −4 | −4 | | | | | | | |
| Ksara | 78·9 | −1 | −1 | +4 | +1 | | | | | |
| Tananarive | 79·0 | −4 | −4 | +1 | −2 | | | +16 | | +18 |
| Pulkovo | 79·2 | −7 | −7 | −9 | −12 | | | | | |
| Helsingfors | 81·8 | −4 | −4 | −11 | −14 | | | | | |
| Helwan | 83·3 | −4 | −3 | −3 | −6 | | | | | |
| Lemberg | 84·6 | −5 | −4 | | | −10−4 | | | | |
| Upsala | 85·4 | −8 | −7 | | | −1 | | | | |
| Belgrade | 88·2 | −27 | −26 | −8 | −12 | | | | | |
| Budapest | 88·4 | −3 | −2 | −8 | −12 | | | | | |
| Entebbe | 88·6 | +23 | +24† | +36 | +32† | | | | | |
| Lund | 89·1 | −6 | −5 | | | | | | | |
| Copenhagen | 89·4 | −7 | −6 | 0 | −4 | | | 0 | +16 | |
| Vienna | 89·9 | −6 | −5 | | | +5 | | +3 | −6 | −19 |
| Graz | 90·3 | +7 | +8 | +4 | 0 | | | | | |
| Potsdam | 90·4 | | | | | +6 | | | | |
| Zagreb | 90·9 | −5 | −3 | | | −1 | | −10 | | |
| Hamburg | 91·6 | −4 | −2 | −10 | −14 | | | | | |
| Laibach | 91·8 | +58 | +60* | −11 | −15 | | | | | |
| Jena | 91·8 | −5 | −3 | −6−1 | −10−5 | | | | | |
| Scoresby Sund | 92·8 | −3 | −1 | | | −7 | | +2 | −6 | |
| Venice | 93·4 | −7 | −5 | +10 | +6 | | | | | |
| Pompeii | 93·7 | +14 | +16 | +45 | +41 | | | | −21 | |
| Feldberg | 93·9 | | | 0 | −4 | | | | | −28+14 |
| Hohenheim | 94·0 | | | | | | | | | −30 |
| Rocca di Papa | 94·5 | −9 | −7 | +4 | 0 | | | 0 | −20 | |
| Chur | 94·7 | −6 | −4 | | | | | | | |
| Florence | 94·8 | −7 | −5 | +9 | +5 | | | +11 | +1 | |
| De Bilt | 94·8 | −3 | −1 | | | −9 | | −1 | | |
| Strasbourg | 94·9 | −19 | −17 | +3 | −1 | −23 | | −2 | −3 | |
| Zürich | 95·0 | −5 | −3 | +2 | −2 | | | | | |
| Dyce | 95·8 | | | | | −10 | | | | |
| Uccle | 95·9 | −9 | −6 | | | −6 | −2 | −1 | | |
| Neuchâtel | 96·2 | −4 | −1 | | | −3 | | −4 | | |
| Victoria | 96·5 | −6 | −3 | | | −5 | | | | |
| Moncalieri | 96·6 | −33 | −30 | | | −22 | | | | |
| Besançon | 96·6 | | | +9 | +5 | | | | | |
| Edinburgh | 97·0 | | | | | | | −11 | +6 | |
| Stonyhurst | 97·9 | −6 | −3 | | | −31 | | −5 | | +7 |
| Paris | 97·9 | −7 | −4 | | | | | 0 | −17 | |
| Kew | 98·1 | −5 | −2 | +10 | +6 | −5 | | +1 | | +16 |
| Oxford | 98·4 | +48 | +51 | | | −21 | | −3 | | |
| Bidston | 98·4 | | | | | −4 | | | | |
| Puy de Dôme | 99·2 | | | 0 | −4 | | | | | |
| Spokane | 100·3 | | | | | −13 | | | | |
| Berkeley | 102·1 | | | | | −8 | | | | −19 |
| Algiers | 103·4 | +4 | +9 | −4 | −8 | | | +15 | | |
| Alicante | 105·1 | | | | | | | +27 | +38 | |
| Toledo | 106·6 | | | | | | | | +19 | |
| Almeria | 107·2 | | +37 | | | | −15 | +31 | | |
| | | P′ | | | | | | | | |
| Cape Town | 107·5 | −22 | | | | +7 | | | | |
| Granada | 107·8 | | −4 | | | | | +5 | −30 | |
| Malaga | 108·6 | | | | | | | | +21 | |
| San Fernando | 110·0 | −25 | | | | | | | | |
| Tucson | 113·0 | | | | | | −5 | −3 | | +16 |
| Chicago | 119·3 | | | | | | −18 | −17 | −21 | −44−5 |
| Ottawa | 119·8 | | | | | −4 | | −3 | +10 | +9 |
| Ann Arbor | 120·3 | | | | | | | +5 | +9 | −57 |
| Toronto | 120·4 | | | | | −11 | | +4 | −8 | −1 |
| St. Louis | 120·8 | | | | | −14 | | +3 | +3 | +4 |
| Ithaca | 122·4 | | | | | | | −4 | −3 | |
| Cincinnati | 122·8 | | | | | | | 0 | | −13 |
| Georgetown | 125·5 | −5 | | | | | | | | |
| Charlottesville | 125·9 | | | | | −4 | | −2 | −5 | |

*Continued on next page.*

| | Δ | P′ | SKSP | PP | SS |
|---|---|---|---|---|---|
| | ° | | | | |
| La Plata | 158·0 | −4 | | | |
| Rio de Janeiro | 162·0 | −34−16 | | | |
| La Paz | 170·5 | −1 | +31 | | +9 |
| Sucre | 171·4 | +2 | +9 | +1 | −25 |

Mean P residual (Δ>70°), −4 ; S, −7 ; SKS, −7.

1928 July 9d. 21h. 23m. 22s.+11s.=23m.33s. Z taken=0.

I.S.S. Epicentre 9°·5S. 160°·8E. Retained.

A=−·931, B=+·324, C=−·165.

| | Δ | $P_r$ | $P\omega$ | $S_r$ | $S\omega$ | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Suva | 19·1 | +32 | +31† | +124 | +122† | | | | | |
| Riverview | 25·9 | −6 | −2 | −14 | −8 | | | 0 | | −17+17 |
| Sydney | 25·9 | −17 | −13 | −12 | −6 | | | | | |
| Apia | 27·2 | +32 | +37 | | | | | | | |
| Melbourne | 31·7 | −65 | −59* | −71 | −62* | | | | | |
| Adelaide | 32·5 | −6 | 0 | −18 | −9 | | | | | |
| Amboina | 32·9 | −49 | −43† | | | | | −42† | | |
| Wellington | 34·1 | +23 | +28 | +94 | +102 | | | | | |
| Manila | 46·3 | −6 | −3 | | | | | | | |
| Perth | 47·2 | +9 | +12 | 0 | +4 | | | | | |
| Sumoto | 49·9 | +3 | +5 | +8 | +11 | | | | | |
| Osaka | 50·3 | −4 | −2 | +4 | +6 | | | | | |
| Kobe | 50·4 | 0 | +2 | | | | | | | |
| Honolulu T.H. | 51·0 | +7 | +9 | +10 | +12 | | | | | |
| Toyooka | 51·3 | −7 | −5 | −3 | −1 | | | | −2 | |
| Taihoku | 51·5 | 0 | +2 | | | | | | | |
| Nagasaki | 51·5 | 0 | +2 | −3 | −1 | | | | | |
| Hukuoka | 51·8 | +2 | +4 | | | | | | | |
| Mizusawa | 51·9 | +2 | +4 | −8+3 | −6+5 | | | | | |
| Batavia | 53·5 | −1 | 0 | −2 | 0 | | | | | |
| Zi-ka-wei | 55·5 | +3 | +4 | +3 | +4 | | | −4 | +19 | |
| Hong Kong | 55·7 | 0 | +1 | | | | | | | |
| Ootomari | 58·4 | −2 | −2 | −2 | −1 | | | | | |
| Phu-Lien | 61·3 | +1 | 0 | −1 | −1 | | | | | |
| Irkutsk | 78·3 | +1 | +1 | | | | | | +7 | |
| Colombo | 82·2 | −7 | −7 | +1 | −3 | | | | | |
| Berkeley | 85·6 | 0+5 | +1+6 | +4+11 | 0+7 | | | | | |
| Lick | 86·0 | −2 | −1 | +4 | 0 | | | | | |
| Victoria | 87·9 | +4 | +5 | | | +4 | | | | |
| Bombay | 91·2 | +23 | +25 | | | 0 | | | | |
| Tucson | 93·7 | +8 | +10 | +18 | +14 | +12 | | | | |
| Tashkent | 97·4 | −2 | +1 | | | −5 | | | | |
| Denver | 99·4 | | | | | | | −16 | −14 | +28 |
| Tananarive | 108·4 | | +65* | P′ | | | | | +1 | +16 |
| St. Louis | 110·7 | | | −8 | | | | +17 | +21 | |
| Baku | 112·0 | | 0 | | | | | +11 | +8 | |
| Chicago | 112·4 | | | | | | | | −12 | −9 |
| Ann Arbor | 115·2 | | | | | −8 | | | +21 | −33 |
| Kucino | 116·0 | | | | | +15 | | +22 | +20 | |
| Toronto | 117·0 | | | | | | | +16 | | |
| Pulkovo | 117·7 | | | | | −6 | | +5 | | |
| Makeyevka | 118·7 | | | | | −5 | | +8 | | −10 |
| Scoresby Sund | 119·0 | | | | | −3 | +9 | +38 | −3 | |
| Helsingfors | 119·7 | | | | | | | +9 | | 0 |
| Ottawa | 120·0 | | | | | −7 | | +1 | | −41 |
| Georgetown | 120·8 | | | | | | | +9 | +11 | |
| Theodosia | 121·4 | | | | | | | +9 | | |
| Upsala | 122·7 | | | | | | | +1 | | |
| Ksara | 124·1 | | | | | −16 | | +11 | | |
| Königsberg | 124·9 | | | | | | −5 | +13 | | |

*Continued on next page.*

| | △ | Pν | Pω | P′ | PKS | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| La Paz | 125·0 | | | +28 | | | | | | |
| Sucre | 126·4 | | | +19 | | | | | | |
| Lund | 127·3 | | | | | | | +6 | | |
| Copenhagen | 127·6 | | | −1 | | −21 | | +7 | | |
| Potsdam | 129·7 | | | | | | | +7 | | |
| Hamburg | 130·1 | | | +1 | | | | +6 | | |
| Budapest | 130·2 | | | +8 | | | | | | |
| Belgrade | 130·9 | | | −46 | | | | +15 | | |
| Vienna | 131·0 | | | −1 | −8 | | | +9 | | |
| Zagreb | 132·9 | | | −2 | −17 | | | | | |
| De Bilt | 133·0 | | | +3 | −6 | | | +9 | | |
| Feldberg | 133·4 | | | | | | | +6 | | |
| Stonyhurst | 133·6 | | | | | −19 | | | | |
| Uccle | 134·4 | | | −2 | −8 | | | +7 | | +9 |
| Ravensburg | 134·7 | | | | | | | | | |
| Strasbourg | 134·9 | | | +1 | −10 | | | | | |
| Kew | 135·3 | | | | −5 | | | +9 | | +23 |
| Oxford | 135·5 | | | | | | | | | +20 |
| Zürich | 135·5 | | | +34 | | | | −1 | | |
| Chur | 136·5 | | | +2 | | | | | | |
| Neuchâtel | 136·5 | | | −2 | | | | | | |
| Paris | 136·7 | | | 0 | | | | | | |
| Florence | 136·7 | | | −3 | | | | | | −32 |
| Pompeii | 136·8 | | | +5 | | | | | | |
| Naples | 137·0 | | | +25 | | | | | | |
| Rocca di Papa | 137·3 | | | +2+7 | +8 | | | | | |
| Moncalieri | 137·6 | | | −6 | | | +6 | | | |
| Rio de Janeiro | 140·0 | | | | | | | +8 | | |
| Tortosa | 144·1 | | | −3 | | | +2 | | | |
| Algiers | 146·1 | | | +12 | | | | | | |
| Alicante | 146·7 | | | −2 | | | +3 | | | |
| Toledo | 146·8 | | +9 | +1 | | | +4 | | | |
| Almeria | 148·7 | | | −1 | | | −25 | | | |
| Granada | 148·9 | | | −4 | | | | −5 | | |
| Malaga | 149·7 | | | +1 | | | −25 | | | |
| San Fernando | 150·6 | | | −4 | | | +3 | | | |

Mean P residual (△>70°), 0; S, −1; SKS, −4.

1928 Sept. 22d. 7h. 31m. 22s.+11s.=31m. 33s. Z taken=0.

I.S.S. Epicentre 13°·0S. 165°·5E. Revised Epicentre 12°·7S. 165°·9E.

A=−·9461, B=+·2376, C=−·2198.

| | △ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Apia | 21·75 | 0 | +1 | +6 | +1d | | | | | |
| Riverview | 25·04 | −2 | +1 | −3 | +2 | | | | | |
| Sydney | 25·0 | −2 | +1 | +13 | +4d | | | +2 | | +4 |
| Wellington | 29·61 | −13−5 | −7+1 | −22 | −14 | | | | | |
| Melbourne | 31·33 | −8 | −2 | +52 | +61* | | | | | |
| Honolulu T.H. | 49·3 | −15 | −12 | −10−1 | −7+2 | | | −6 | | |
| Perth | 49·5 | +22 | +24 | −6 | −3 | | | | | |
| Manila | 52·2 | −6 | −4 | −6 | −4 | | | −5 | | +16 |
| Nagoya | 55·15 | −4 | −3 | 0 | +1 | | | | | |
| Osaka | 55·43 | −1 | 0 | +1 | +2 | | | | | |
| Sumoto | 55·5 | −4 | −3 | −8 | −7 | | | | | |
| Kobe | 55·63 | −1 | 0 | −5 | −4 | | | | | |
| Mizusawa | 56·8 | +1 | +1 | −8 | −7 | | | | | |
| Nagasaki | 57·0 | 0 | 0 | +3 | +4 | | | | | |
| Hukuoka | 57·3 | +2 | +2 | 0 | +1 | | | | | |

*Continued on next page.*

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Taihoku | 57·4 | | | +3 | +4 | | | | | |
| Malabar | 57·57 | +2 | +2 | +4 | +5 | | | | | |
| Batavia | 58·5 | +1 | +1 | | | | | | | |
| Zi-ka-wei | 61·2 | −24−10 | −25−11 | −3 | −3 | | | −56* | | |
| Hong Kong | 61·6 | −1 | −2 | −1 | −1 | | | | | |
| Ootomari | 62·9 | 0 | −1 | −8 | −8 | | | | | |
| Phu-Lien | 67·2 | +1 | 0 | −2 | −3 | | | | | |
| Irkutsk | 83·4 | −6 | −5 | −7 | −11 | | | | +11 | +12 |
| Berkeley | 84·0 | −17 | −16 | +10 | +6 | | | −10 | | +4 |
| Lick | 84·4 | +17 | +18 | +37 | +33 | | | −14 | | |
| Sitka | 84·8 | | | | | | | | +23 | |
| Victoria | 87·3 | −9−1 | −8, 0 | +1 | −3 | | | | | |
| Colombo | 87·6 | −3 | −2 | | | −3 | | | | |
| Hyderabad | 90·9 | −5 | −3 | | | −12 | | | | |
| Tucson | 91·3 | | | | | | | | +3 | +12 |
| Bombay | 96·9 | +2 | +5 | | | | −7 | | | |
| Tashkent | 103·3 | −13 | −8 | | | −10 | | −2 | +60 | |
| Florissant | 108·7 | | −16 | | | | | −17−11 | −10−7 | −29+7 |
| Ekaterinburg | 109·0 | P′ | −6 | | | | −20 | −9 | −4 | |
| Chicago | 110·8 | −1 | | | | | | | −36 | +21 |
| Tananarive | 111·5 | | | | | −27 | −1 | | 0+12 | +28+40 |
| Ann Arbor | 113·7 | | | | | | | | −18 | |
| Toronto | 116·7 | | | | | | | −15 | | |
| Baku | 117·9 | | | | | | | +6 | −2 | +28 |
| Ithaca | 118·9 | | | | | | | | | +9 |
| Ottawa | 118·9 | | −23 | | | | | −5 | −10 | +9 |
| La Paz | 119·1 | | | | | | | | −23 | |
| Georgetown | 119·1 | | | | | | | −6 | −3 | +35 |
| Sucre | 120·4 | | | | | | | | | |
| Kucino | 121·3 | | | | | | +14 | +19 | +12 | |
| Scoresby Sund | 122·1 | | | | | | | −1 | 0 | |
| Pulkovo | 122·8 | −8 | −13 | | | | −14 | −20 | | |
| Helsingfors | 124·6 | | | | | | | −12 | −29 | |
| Theodosia | 127·1 | +3 | | | | | | | | |
| Upsala | 127·4 | | | | | | | | | |
| Simferopol | 128·0 | +1 | | | | | | | | |
| Yalta | 128·1 | +9 | | | | | | | | |
| Sebastopol | 128·5 | | | PKS | | | | +22 | | |
| Königsberg | 130·0 | | | −24 | | | | +1 | | |
| Ksara | 130·1 | +7 | | | | | +25 | +15 | +21 | |
| Entebbe | 132·1 | | | | | | | | | |
| Lund | 132·1 | | | −28 | | | | +6 | | |
| Copenhagen | 132·4 | −10 | | −14−1 | | | | 0 | | +19 |
| Dyce | 133·8 | | | | | | | +5 | | |
| Rio de Janeiro | 134·5 | | | | | | | +1 | | |
| Potsdam | 134·8 | | | | | | | | | |
| Hamburg | 134·9 | −6 | | −18 | | | | +4 | | −35 |
| Budapest | 135·6 | | | | | | | −24 | | |
| Edinburgh | 136·0 | +7 | | | | | | | | |
| Belgrade | 136·5 | | | | | | | | | |
| Vienna | 136·5 | −3 | | −11 | | | | −3 | | |
| Jena | 136·5 | −29 | | | | | | +1+6 | | |
| Graz | 137·6 | | | | | | | +29 | | +23 |
| De Bilt | 137·8 | −17 | | | | | | −2 | | |
| Zagreb | 138·3 | +2+14 | | −24 | | +30 | | −4 | | −21 |
| | | | | | SKSP | | | | | |
| Feldberg | 138·3 | | | | −4 | | −19 | +1 | | |
| Bidston | 138·4 | | | | | | | +3 | | |
| Hohenheim | 139·1 | | | | | | | +6 | | |
| Uccle | 139·1 | −25 | | | | | | +2 | | |
| Oxford | 139·7 | −26 | | −23 | | | | 0 | | |
| Kew | 139·8 | −17 | | −20 | | | | −17 | | |
| Strasbourg | 139·9 | −19 | | | | | | −11 | | |
| Venice | 140·4 | −16 | | | | | | | | |
| Zürich | 140·5 | −4 | | | | | | | | |
| Chur | 140·6 | +3 | | | | | | +13 | | |

*Continued on next page.*

| | Δ | P′ | $P_2$′ | SKSP | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | |
| Paris | 141·4 | −14 | | | | | −2 | | |
| Neuchâtel | 141·5 | −12 | | | | | −3 | | |
| Besançon | 141·6 | | | | | | −3 | | |
| Florence | 142·1 | +5 | | | | | | | |
| Pompeii | 142·4 | +6 | | | | | | −3 | |
| Rocca di Papa | 142·8 | −4+13 | | | | | | | −42 |
| Moncalieri | 142·8 | −7 | | | | | | | |
| Algiers | 151·5 | +2 | | −10 | | | | | |
| Toledo | 151·5 | −5 | | | | | | | |
| Alicante | 151·7 | −16 | | | | | | | |
| Almeria | 153·7 | −14 | −10 | | | | | | |
| Granada | 153·9 | −16−11 | | | +4 | −6 | −16 | | −5 |
| Malaga | 154·5 | −31 | | | | | | | |

Mean P residual (Δ>70°),−5 ; S,−7? ; SKS,−7?. Ann Arbor 28m.45s., Baku 29m.41s., Ottawa 29m.43s., Georgetown 29m.52s., may be SKSP.

1928 Dec. 12d. 20h. 19m. 40s.+10s.=19m.50s. Z taken=0.

I.S.S Epicentre 27°·5S. 176°·8W. Retained.

A=−·886, B=−·050, C=−·462.

| | Δ | Pν | Pω | Sν | Sω | SKS | SKKS | PP | PS | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Suva | 10·4 | +25 | +25† | +83 | +83† | | | | | |
| Apia | 14·4 | −1 | −1 | +12 | +11 | | | | | |
| Wellington | 15·4 | +2 | +1 | +35+40 | +34+39 | | | | | |
| Riverview | 28·2 | −4 | +1 | +7 | +15 | | | | | |
| Sydney | 28·2 | +4 | +9 | +27 | +35 | | | | | |
| Melbourne | 33·6 | −6 | 0 | +13 | +22 | | | | | |
| Adelaide | 38·6 | −6 | −2 | +12 | +19 | | | | | |
| Honolulu T.H. | 52·1 | +25 | +27 | +6 | +8 | | | | | |
| Perth | 57·8 | | | | | | | | | |
| Manila | 73·6 | +1 | 0 | | | | | | +7 | |
| Sumoto | 76·9 | +1 | +1 | +14 | +11 | | | | | |
| Kobe | 77·1 | −1 | −1 | | | | | | +7 | |
| Mizusawa | 77·4 | −4, 0 | −4, 0 | −20+4 | −23+1 | | | | | |
| Berkeley | 82·9 | −2 | −2 | +5 | +1 | | | | | |
| Lick | 83·0 | +6 | +6 | +7 | +3 | | | | | |
| Taihoku | 84·7 | −51 | −50† | −39 | −43† | | | | | |
| Hong Kong | 85·0 | −13 | −12 | −15 | −19 | | | | | |
| Tucson | 86·6 | +3 | +4 | | | +2 | | | | |
| Phu-Lien | 88·4 | +1 | +2 | | | −6 | | | | |
| Denver | 94·6 | | | | | | | −13 | +7 | |
| La Paz | 98·1 | +6 | +9 | +4 | 0 | −2 | | −4 | +7 | |
| Sucre | 99·0 | −2 | +1 | | | −5 | | | +3 | |
| Florissant | 104·2 | | | −1 | −5 | −7 | −4 | +8 | | |
| St. Louis | 104·3 | | | +6 | +2 | −7+2 | +2 | | | |
| Calcutta | 104·3 | | | | | | | +5 | | |
| Colombo | 105·0 | | | | | | | +2 | | |
| Irkutsk | 105·1 | | | | | −6 | | +1 | −25 | |
| Chicago | 107·3 | | | | | −11 | | | | |
| Cincinnati | 108·5 | | | | | | | | | |
| Ann Arbor | 110·2 | | | | | | | | −31 | +28 |
| | | P′ | | | | | | | | |
| Hyderabad | 110·7 | −30 | | | | | | | +16 | |
| Rio de Janeiro | 112·6 | | | | | −7 | | | | +4 |
| Toronto | 113·6 | | | | | | | | | |
| Georgetown | 114·0 | | | | | | | +10 | +4 | |
| Dehra Dun | 115·7 | | +46 | | | | +22 | | | |
| Bombay | 116·2 | −11 | | | | | | | | |
| Ottawa | 116·6 | | | | | | | | −1 | +30 |
| Tananarive | 116·8 | | | | | +3 | +12 | | +14 | |
| Almata | 119·8 | +28 | | | | | | | | |
| Tashkent | 125·1 | +3 | −16 | | | −10 | | +4 | | |

*Continued on next page.*

| | Δ | P′ | $P_2$′ | SKSP | PKS | SKS | SKKS | PP | SP | SS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Ekaterinburg | 130·4 | −3 | | +28 | | −6 | | −1 | +7 | −21 |
| Scoresby Sund | 134·7 | | | | −14 | | | +8 | | |
| Baku | 139·7 | −6 | | | −24 | | −34 | | | |
| Kucino | 142·4 | −6 | | −6 | | | −20 | +2 | | +9 |
| Pulkovo | 142·8 | −8 | | | −23 | | | +3 | | +11 |
| Helsingfors | 144·2 | −5 | | | | | | | | |
| Upsala | 146·2 | −4 | | | | | | +3 | | |
| Bergen | 147·1 | +13 | | | | | | | | |
| Theodosia | 149·1 | +3 | | | | | | | | |
| Königsberg | 149·9 | +2 | | | 0 | | | −3 | | |
| Simferopol | 149·9 | −1 | | | | | | | | |
| Yalta | 150·0 | +1 | | | | | | | | |
| Lund | 150·9 | +4 | | | | | | +3 | | |
| Copenhagen | 151·0 | −4 | | 0 | | +37 | +4+22 | +2 | | +19 |
| Edinburgh | 151·2 | | | | | | | −17 | | |
| Ksara | 151·3 | −4 | | | | | | | | |
| Stonyhurst | 153·3 | +8 | | | | | | +21 | | −1 |
| Bidston | 153·3 | +18 | | | | | | | | |
| Hamburg | 153·4 | −5 | | | | | | | | |
| Potsdam | 154·1 | +11 | | | | | | | | |
| De Bilt | 155·4 | −7 | | | | | | −[illegible]+1 | | +17 |
| Oxford | 155·5 | +1 | | | | | | | | |
| Jena | 155·8 | −5 | | | −34 | | | +6 | | |
| Kew | 155·9 | −3 | | | | | | +3 | | +8 |
| Budapest | 156·5 | +6 | | | | | | | | |
| Uccle | 156·7 | −4 | | −6 | | | | | | |
| Vienna | 156·8 | −5 | | | | | | +5 | | |
| Belgrade | 157·9 | −18+22 | | | | | | | | |
| Graz | 158·2 | −7 | | | | | | | | |
| Strasbourg | 158·6 | −3 | | +10 | | | | +3 | | |
| Paris | 158·7 | −2 | | | | | +6 | +1 | | |
| Zagreb | 159·1 | −9 | | | | | | | | |
| Innsbruck | 159·2 | −18 | | | | | | −2 | | |
| Zürich | 159·7 | | | | | | | −2 | | |
| Chur | 160·1 | −3 | | | | | | 0 | | |
| Besançon | 160·2 | | | | | | | +30 | | |
| Neuchâtel | 160·3 | −4 | | | | | | −6 | | |
| Moncalieri | 162·2 | −31 | | | | | | | | |
| Florence | 162·5 | −2 | −2 | | | | | +11 | | |
| Rocca di Papa | 163·8 | −4 | −9+21 | | | | | +5 | | |
| Toledo | 166·3 | −1 | | | | | −1 | | | |
| Tortosa | 166·5 | | +12 | | | | | | | |
| San Fernando | 169·0 | | | | | | −24 | | | |
| Alicante | 168·7 | −6 | | | | | −29 | | | |
| Granada | 168·7 | 0 | | | | | −13 | +6 | | |
| Malaga | 168·7 | −18 | | | | | −7 | | | |
| Almeria | 169·5 | −4 | | | | | | | | |

Mean P residual (Δ>70), 0?; S, 0?; SKS, −6.

1924 June 26d. 1h. 37m. 20s.+17s.=37m.37s.

I.S.S. Epicentre 57°·0S. 159°·0E. Macelwane's Epicentre 56°·9±0·2S. 155°·6 ±1·2E. Adopted Epicentre 55°56′S. 156°44′E.

| | Δ | Pω | Sω | SKS | SKKS | PP | PS | SS | SKSP | PKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Wellington | 18·4 | 0 | +14 | | | | | | | |
| Melbourne | 19·9 | −41 | +25 | | | | | | | |
| Riverview | 22·6 | +5 | +6 | | | | | | | |
| Sydney | 22·6 | +2 | +7 | | | | | | | |
| Adelaide | 24·8 | −12 | +39 | | | | | | | |
| Perth | 37·7 | +8 | +24 | | | | | +26 | | |
| Apia | 48·4 | +5 | +9 | | | +21 | +24 | | | |
| Malabar | 62·5 | +1 | +20 | | | | | | | |
| Batavia | 63·9 | 0 | +20 | | | +10 | +30 | +12 | | |
| Manila | 77·0 | +1 | +9 | | | +3 | +10 | +16 | | |

*Continued on next page.*

| | Δ | Pω | Sω | SKS | SKKS | PP | PS | SS | SKSP | PKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Santiago | 81·9 | +2 | −9 | | | +48 | +20 | +11 | | |
| Cape Town | 83·3 | −2 | +3 | | | | | | | |
| La Plata | 83·9 | −1 | −6 | | | −25 | | −10 | | |
| Honolulu | 85·8 | −5 | +4 | | | −15 | +13 | +12 | | |
| Hong Kong | 86·4 | −3 | −1 | | | | | +27 | | |
| Taihoku | 86·7 | +17 | −27 | | | −37 | | | | |
| Johannesburg | 87·7 | +19 | −11 | | | | | | | |
| Colombo | 88·9 | −11 | −22 | | | | | | | |
| Nagasaki | 92·0 | −3 | | | | | | +12 | | |
| Kodaikanal | 92·0 | +4 | −32 | −4 | | | | | | |
| Zi-ka-wei | 92·5 | −5 | +8 | −11 | +4 | −15 | +19 | +25 | | |
| Osaka | 92·6 | −4 | +11 | | | | | +30 | | |
| Mizusawa | 96·0 | +4 | | −11 | | | | | | |
| Calcutta | 97·6 | +7 | | +10 | | | | | | |
| La Paz | 98·0 | +2 | | −2 | | −14 | −18 | | | |
| Hyderabad | 99·0 | +22 | +28 | −8 | | +34 | +38 | | | |
| Rio de Janeiro | 99·2 | −11 | −10 | −23 | −27 | +8 | +5 | +6 | | |
| Bombay | 102·9 | −5 | | +1 | | | | | | |
| | | P′ | | | | | | | | |
| Dehra Dun | 109·1 | −37 | | +30 | | | | | | |
| Simla | 110·1 | | | +2 | | | +9 | | | |
| Oaxaca | 112·3 | | | | | | | | | |
| Vera Cruz | 114·5 | +15 | | −14 | | | | | | |
| Pasadena | 114·8 | −10 | | | +4 | −6 | −3 | −16 | | |
| Lick | 115·5 | | | | | +15 | +9 | +21 | | |
| Berkeley | 115·6 | −1 | | −11 | +15 | 0 | −2 | +28 | | |
| Balboa Heights | 115·8 | +7 | | | | | +8 | +34 | | |
| Victoria | 123·3 | −1 | | −2 | −13 | −5 | −3 | +6 | | |
| Sitka | 125·2 | | | +4 | +15 | +33 | +25 | +29 | | |
| St. Louis | 133·3 | | | −21 | −14 | +1 | +21 | +34 | +6 | −17 |
| Helwan | 134·4 | 0 | | | | | | | | |
| Ekaterinburg | 136·8 | −18 | | | | | | | | |
| Chicago | 136·9 | −9 | | | | | | | +6 | −25 |
| Georgetown | 140·5 | −7 | | | | | | | | |
| Washington | 140·5 | −9 | | | | | | | | −23 |
| Cheltenham | 140·5 | +7 | | | | | | | | |
| Ithaca | 142·2 | −4 | | | | | | | | |
| Toronto | 142·3 | −10 | | | −7 | | | | 0 | −20 |
| Athens | 144·4 | 0 | $P_2'$ | | | | | | | |
| Ottawa | 145·4 | −10 | +6 | | −4 | | | | | |
| Northfield | 146·4 | −6 | +3 | | +6 | | | | +12 | |
| Kucino | 147·4 | −24 | | | | | | | | |
| Trente | 149·5 | −3 | | | | | | | | |
| Belgrade | 151·2 | +4 | | | | | | | −23 | |
| Mostar | 151·5 | +5 | | | | | | | | |
| Halifax | 151·6 | | +12 | | | | | | | |
| Ischia | 151·8 | −3 | | | | | | | −9 | |
| Lemberg | 152·0 | 0 | | | | | | | | |
| Pulkovo | 152·6 | −6 | | | | | | | −7 | |
| Rocca di Papa | 153·4 | −8 | −1 | | −18 | | | | | |
| Budapest | 153·7 | −7 | +5 | | | | | | +3 | |
| Algiers | 154·4 | −3 | | | | | | | | |
| Florence | 155·6 | −6 | −3 | | | | | | −4 | |
| Vienna | 155·6 | −8 | −10 | −12 | | | | | −10 | −19 |
| Venice | 156·2 | −16 | −6 | | | | | | | |
| Moncalieri | 156·4 | +8 | | | | | | | | |
| Barcelona | 156·5 | −3 | | | | | | | | |
| Piacenza | 157·2 | −4 | | | | | | | | |
| Granada | 157·3 | +1 | −14 | −18 | | | | | +4 | |
| Innsbruck | 157·7 | −3 | +3 | | | | | | | |
| San Fernando | 157·8 | +2 | | | | | | | | |
| Munich | 158·2 | −4 | −15 | −46 | | | | | −3 | |
| Tortosa | 158·8 | −2 | −4 | +10 | | | | | −2 | |
| Upsala | 158·9 | −12 | | | | | | | | |
| Zürich | 159·3 | −5 | −9 | −7 | | | | | 0 | −16 |
| Potsdam | 159·6 | −2 | +2 | −4 | | | | | −6 | |

*Continued on next page.*

| | Δ | P′ | $P_2'$ | SKS | SKKS | SKSP | PKS |
|---|---|---|---|---|---|---|---|
| | ° | | | | | | |
| Toledo | 159·9 | −4 | −11 | −4 | | +5 | |
| Strasbourg | 160·4 | −10 | −9 | −15 | −33 | −7 | −16 |
| Lisbon | 160·6 | −16 | −14 | | | −5 | −22 |
| Besançon | 160·7 | +1 | | | | +6 | |
| Feldberg | 161·0 | +2 | +6 | −1 | −41 | | |
| Hamburg | 161·4 | −6 | −9 | | | +6 | |
| Coimbra | 161·8 | −5 | −2 | −27 | −47 | +4 | −29 |
| Paris | 163·4 | +7 | −6 | −15 | −32 | −4 | −21 |
| Uccle | 163·4 | −8 | −12 | | | −2 | |
| De Bilt | 163·5 | −7 | −7 | | | −14 | |
| Kew | 166·6 | +19 | | | | | |
| Oxford | 167·0 | +1 | −3 | −11 | | −2 | |
| West Bromwich | 167·8 | −3 | | | | | |
| Stonyhurst | 168·5 | −5 | −3 | −23 | | | |
| Eskdalemuir | 169·3 | −7 | −5 | | −29 | | −10 |
| Edinburgh | 169·9 | −1 | | | | | |

Note.—The readings are Macelwane's throughout. Hyderabad : Macelwane's PPS taken as PS, his PS as S. The near stations suggest that $T_0$ might be increased by 2s. Mean P residual (Δ>70°), −3? ; S, −3? ; SKS, −7.

1929 June 16d. 22h. 47m. 18s.+13s.=47m.31s. Z taken=0.

I.S.S. Epicentre 41°·8S. 172°·2E. Retained.

A=−·7386, B=+·1012, C=−·6665.

| | Δ | Pω | Sω | SKS | SKKS | PP | PS | SS | SKSP | PKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Christchurch | 1·8 | +3 | +3 | | | | | | | |
| Wellington | 2·0 | −2 | | | | | | | | |
| Riverview | 18·4 | +2 | +32 | | | +16 | | +41 | | |
| Sydney | 18·4 | +11 | +26 | | | | | | | |
| Melbourne | 21·2 | +60* | | | | | | | | |
| Suva | 24·3 | +20 | | | | | | | | |
| Adelaide | 27·0 | +2 | +14 | | | | | +17 | | |
| Apia | 31·2 | +4 | +19 | | | | | −40 | | |
| Perth | 45·4 | +13 | +24 | | | +5 | | | | |
| Amboina | 54·7 | +1 | +25 | | | | | +18 | | |
| Batavia | 67·7 | −4 | | | | | | | | |
| Honolulu T.H. | 68·9 | −3 | −9 | | | | | −55 | | |
| Manila | 73·6 | −41 | +9 | | | −19 | +23 | +25 | | |
| Isagakiyima | 79·7 | +3 | +10 | | | | | | | |
| Taihoku | 81·6 | +17 | +4 | | | | | | | |
| Muroto | 82·8 | +8 | | | | | +24 | | | |
| Tokyo | 83·0 | 0 | | | | | +27 | | | |
| Koti | 83·3 | −4 | +7 | | | | +11 | −3 | | |
| Nagoya | 83·5 | −5 | | | | | +29 | | | |
| Sumoto | 83·5 | −10 | +5 | | | | | | | |
| Osaka | 83·6 | 0 | +1 | | | | | | | |
| Hong Kong | 83·6 | −2 | +6 | | | −4 | +27 | +30 | | |
| Kobe | 83·7 | −5 | +7 | | | | +12 | −9 | | |
| Nagasaki | 84·2 | −5 | | | | −22 | +15 | | | |
| Hukuoka | 84·6 | +7 | +6 | | | | | | | |
| Toyooka | 84·6 | +3 | +5 | +7 | | | | | | |
| Santiago | 85·2 | +5 | | | | | | | | |
| Mizusawa | 85·7 | −1 | | +1 | | +8 | | | | |
| Zi-ka-wei | 86·7 | −6 | | +12 | | −4 | +27 | −60 | | |
| Phu-Lien | 87·1 | −4 | | +9 | | −5 | | +8 | | |
| Akita | 87·4 | +6 | | | | | | | | |
| La Plata | 90·6 | 0 | | +3 | | | | | | |
| Ootomari | 92·3 | 0 | +4 | | | | | | | |
| Sucre | 99·3 | −24 | | −31 | −5 | −17 | −6 | −54 | | |
| La Paz | 99·4 | −28 | | −9 | | −20 | +21 | −36 | | |

*Continued on next page.*

| | Δ | Pω | Sω | SKS | SKKS | PP | PS | SS | SKSP | PKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | | | |
| Lick | 99·4 | −30 | | | | +15 | +14 | −24 | | |
| Berkeley | 99·5 | | | +18 | +9 | | +10 | | | |
| Kodaikanal | 100·3 | −4 | | | | +33 | | | | |
| Calcutta | 100·4 | | | | | −13 | +23 | | | |
| Cape Town | 100·5 | | | | | +13 | +37 | | | |
| Tananarive | 100·6 | +12 | +6 | | −5 | +6 | +18 | +7 | | |
| Tacubaya | 101·7 | | P′ | | | −1 | +13 | | | |
| Tucson | 102·3 | +9 | −42 ! | | | +5 | | −12 | | |
| Chihuahua | 103·0 | | | | +14 | | | | | |
| Hyderabad | 104·2 | +4 | | −2 | | | | | | |
| Victoria | 106·5 | | | | | 0 | +11 | | | |
| Rio de Janeiro | 107·5 | +10 | −40 ! | | | | | | | |
| Sitka | 108·2 | | | | | +10 | −6 | +19 | | |
| Bombay | 109·3 | | | +5 | | | | | | |
| Agra | 110·6 | | | | | +11 | +21 | | | |
| Denver | 110·7 | | | | +3 | +10 | +4 | | | |
| Irkutsk | 110·9 | −6 | −44 ! ! | −7 | | −10 | +19 | +14 | | |
| Dehra Dun | 112·6 | | | | | −18 | −24 | | | |
| Florissant | 119·5 | | +1 ! ! | −10−3 | | +11 | 0 | +10 | | |
| Andijan | 121·9 | | | | | | | | | |
| Chicago | 122·8 | | | −4 | +10 | +10 | −9+9 | −64−28 | | |
| Tashkent | 124·4 | −6 | −8 ! ! | | 0 | +2 | +5 | | | |
| Entebbe | 124·7 | | | | | −31 | | | | |
| Samarkand | 125·1 | | +1 | | | | | | | |
| Ann Arbor | 125·6 | | | | | +14 | +11 | +28 | | |
| Charlottesville | 127·2 | | | | | +3 | −40+4 | 0+12 | | |
| Georgetown | 128·6 | | −2 | −5 | | | +77 | −2 | | +6 |
| Toronto | 129·1 | | | | | +4 | −18 | | +2 | |
| Fordham | 131·7 | | 0 | | +5 | +8+15 | | +32 | | +20 |
| Ottawa | 132·1 | | −11 ! | | | +4 | +7 | +10 | | |
| Harvard | 134·1 | | | | | +21 | | +13 | | |
| Ekaterinburg | 135·0 | −3 ! | −17 ! ! | | +1 | 0 | −19 | | +8 | |
| Baku | 137·3 | −7 | −71 ! | | | +9 | | | | |
| Ksara | 145·0 | | −2 | −13 | | | | −27−16 | | |
| Theodosia | 148·9 | | −31 ! | | | | | | | |
| Simferopol | 149·7 | | 0 | | | | | | | |
| Abisko ! | 149·9 | −10 | −10 ! ! | | | | | | | |
| Sebastopol | 150·1 | $P_2'$ | −2 | | | | | | | |
| Scoresby Sund | 150·4 | −2 | −9 ! ! | | | +2 | | +8 | | |
| Pulkovo | 150·6 | | −9 ! ! | −3 | | | | | | −19 |
| Helsingfors | 152·9 | | +21 ! | | | +20 | | −8 | +2 ! | −14 |
| Reykjavik | 156·2 | | | | | | | | | |
| Upsala | 156·2 | | +11 ! | | | +3 | | | −6 ! | |
| Lemberg | 156·6 | | | | | | | | | |
| Königsberg | 157·3 | +8 | +9 | | | +11 | | +11 | | +3 |
| Belgrade | 159·3 | | −1 | | | +12 | | | | |
| Lund ! | 160·5 | −2 ! | +19 ! | | | | | | +1 ! | |
| Copenhagen | 160·9 | −4 ! | −11 ! ! | | | +12 | | | 0 ! | |
| Vienna | 161·8 | −8 ! | −6 ! | | +35 | +15 | | | +7 ! | |
| Potsdam ! | 162·4 | −1 ! | 0 ! | | | | | | | |
| Zagreb | 162·4 | −6 ! | +12 ! | | +19 | 0 | | | −3 ! | +6 |
| Graz | 162·6 | −5 ! | +10 ! | | −30 | +15+31 | | −42 | +9 ! | |
| Leipzig ! | 163·2 | −6 ! | −7 ! | | | | | | +9 ! | |
| Pompeii | 163·2 | | | | | | | | | |
| Hamburg | 163·3 | +6 ! | −11 ! ! | | | +21 | | | −4 ! | |
| Laibach | 163·4 | | +5 | | −30 | +12 | | +8 | +9 | |
| Naples | 163·5 | | +17 | | | | | | | |
| Cheb | 163·8 | | +8 | | | +13 | | +29 | −7 | |
| Jena | 163·9 | −4 ! | −8 ! ! | | | −8 | | | −11 ! | |
| Dyce | 164·1 | −1 | +1 | | | | | | | |
| Göttingen | 164·5 | 0 ! | −2 ! ! | | −34 | +14 | | | −14 ! | |
| Venice | 165·0 | | +8 | | | | | | | |
| Innsbruck | 165·3 | +4 | −21 | | | −5 | | | | |
| Nördlingen | 165·4 | | | | | | | | +2 ! | |
| Edinburgh | 165·6 | −8 ! | +8 ! | | | +11 | | +8 | | |

*Continued on next page.*

| | Δ | $P_2'$ | P′ | SKKS | PP | SS | SKSP | PKS |
|---|---|---|---|---|---|---|---|---|
| | ° | | | | | | | |
| Azores | 165·7 | | | | +19 | | | |
| Florence | 165·9 | | 0 | | | | | |
| Feldberg | 166·0 | −8 ! | +2 ! | | | | | |
| Hohenheim | 166·2 | −5 ! | +8 ! | −39−17 | −8+13 | +10 | +5 ! | −40 |
| De Bilt | 166·5 | −4 ! | −7 ! ! | | +6 | | +2 ! | |
| Karlsruhe | 166·6 | −2 ! | +1 ! | | | | | |
| Chur | 166·7 | −3 ! | −6 ! ! | | | | −6 ! | |
| Zürich | 167·1 | −6 ! | +7 ! ! | | | | +4 ! | |
| Strasbourg | 167·2 | −11 ! | −5 ! ! | −26 | +10 | | +4 !+10 ! | |
| Stonyhurst | 167·4 | | −5 ! | −1 | +5 | | +10 ! | |
| Uccle | 167·7 | −5 ! | −3 ! ! | −17 | +7 | | −8 !+14 ! | |
| Bidston | 168·0 | | +10 | | | | | |
| Moncalieri | 168·3 | | −1 | | +4 | | | |
| Neuchâtel | 168·3 | | −8 | | | | | |
| Besançon | 168·9 | +4 | | | +12 | | | |
| Kew | 169·1 | −5 ! | −2 ! ! | | +4+10 | +35 | −1 ! | |
| Oxford | 169·1 | −6 ! | +8 ! | | +62 | | −2 ! | |
| Paris | 169·9 | −4 ! | +16 ! | +11 | | | +4 ! | |
| Algiers | 170·2 | −8 ! | +7 ! | +18 | +9 | | +14 ! | |
| Marseilles | 170·2 | +29 | | +20 | | +16 | | |
| Barcelona | 172·6 | | +15 ! | −16 | | | | |
| Alicante | 173·5 | | +10 | −22 | | | | |
| Almeria | 173·6 | | −6 | | −21+21 | | | |
| Tortosa | 173·7 | | +2 ! | | | | | |
| Bagnères | 173·9 | | | −29 | | | | |
| Malaga | 174·3 | | −41 | | | | | |
| Granada | 174·4 | −22 | −4 ! ! | −24 | +24 | | | −24 |
| San Fernando | 174·5 | | +6 ! | | | | | |
| Toledo | 176·6 | −5 ! | +8 ! | | −2 | | | |

Note.—Lehmann's readings indicated by ! Her readings of P′ on the vertical component by ! ! Mean P residual (Δ>70°),−4; S,+6; SKS,+4·5. ? Chicago 30m.20s. may be SKSP.