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Study of the Great Assam Earthquake of August 1950 and its aftershocks

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ABSTRACT. Epicentre and origin time of the Great Assam earthquake of 15 August 1950 and 54 other earthquake shocks which occurred in the Assam region upto the end of April 1951 have been determined by the Least Square method. Magnitudes of these shocks have also been estimated from data of Indian stations. Using data of near stations at Tocklai, Tezpore, Shillong (specially opened for this study) and of Calcutta and Chatra, the velocities of seismic waves in Assam have been calculated within narrow limits of error and estimates of depths of crustal layers have been obtained. Travel times of seismic waves in Assam and neigbourhood have been compared with the travel time tables of Jeffreys and Bullen (1940).

1. Introduction

On 15 August 1950 a destructive earthquake took place near the northeastern border of the State of Assam. A number of papers describing the effects due to the earthquake and giving estimation of its epicentre etc, have been published. These include accounts by Sohoni (1950), Tandon (1950), Kingdon-Ward (1951), Malurkar (1950), Tillotson (1951), and Pramanik and Mukherjee (1951). Recently a full geological report of the damage done by the earthquake has been published by Poddar (1952). Estimation of the epicentre and magnitude as determined by the various organisations in the world are given below—

	Epicentre		Magnitude
	Lat. (°N)	Long. (°E)	
India Meteorological Department (Poona)	29·0	97·0	
U.S. Coast and Geodetic Survey (Washington)	28·5	97·0	8·6 (*Pasadena*) 8·25 (*Berkeley*) 8·5 (*Praha*)
B.C.I.S. (Strasbourg)	28·6	96·5	8·6
J.S.A. (St. Louis, U.S.A.)	28·2	97·2	

An isoseismal map drawn on the basis of the voluntary observers reports collected by the India Meteorological Department was also published by the author (Tandon 1950), and is reproduced in Fig. 1.

The earthquake was followed by a very large number of after shocks with epicentres scattered over a large area round about the epicentre of the main shock. At the time of occurrence of the earthquake the Seismological Observatories functioning in India were at Poona, Bombay, Calcutta, New Delhi, Kodaikanal, Hyderabad and Chatra. Of these only Chatra and Calcutta were within a distance of 10 degrees of arc from the epicentral region. Since the occurrence of after shocks provided a good opportunity for a regional seismological study of the Assam region, it was decided to open three more stations in upper Assam as close to the epicentral region as possible. The choice of the stations had to be limited to the availability of proper facilities. The stations finally selected were Tezpore, Shillong and Tocklai. These were equipped with Wood-Anderson type of Seismographs of the design given by the author (Tandon 1951). Since the selected places were very often visited by strong earthquakes it was decided to strengthen the suspensions a little and to reduce the magnifications of the instruments. A fine phosphor-bronze strip suspension and a copper mass (diameter = 4 mm, length = 3·8 cm) was used. This arrangement gave

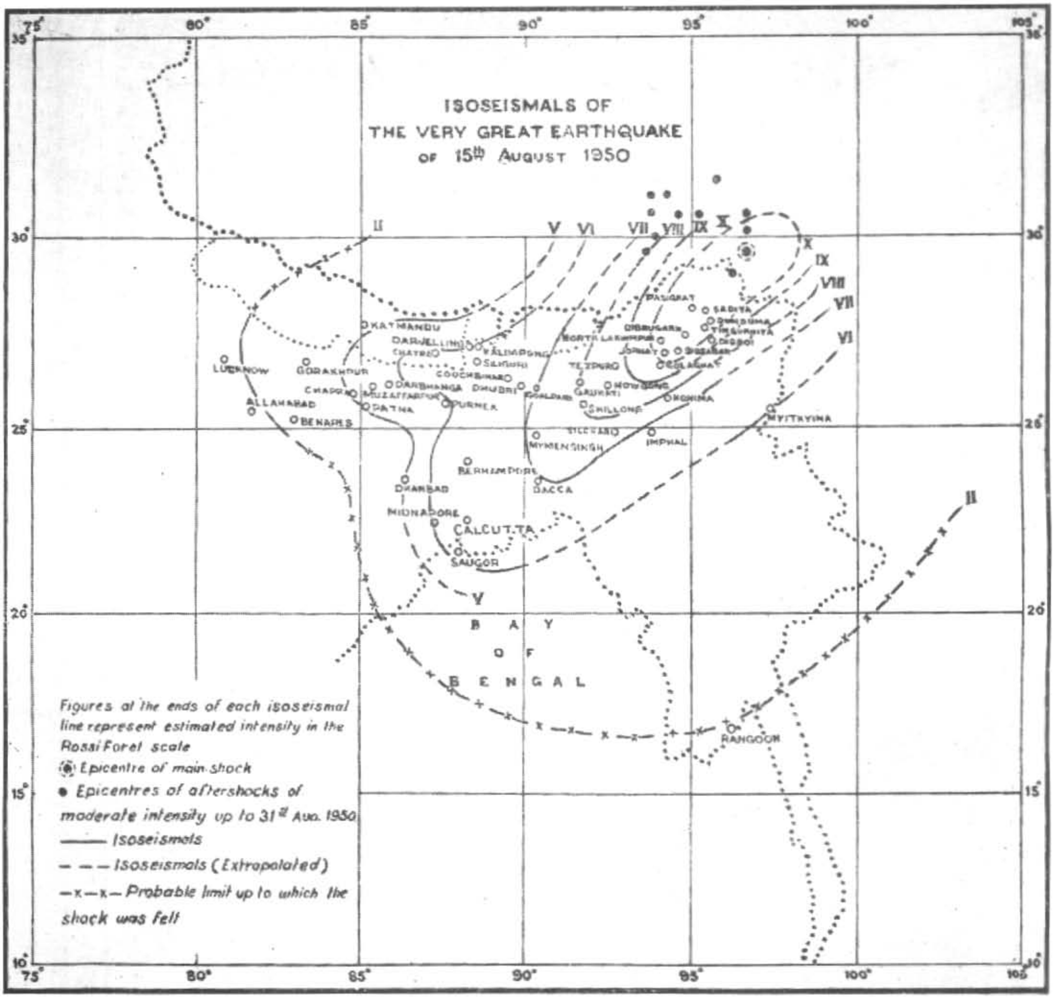


Fig. 1

a static magnification of about 700 when the recording drum was put up at a distance of nearly one metre from the mirror attached to the mass. All instruments were adjusted to a period of 1 sec and nearly critical damping. The location of Indian Observatories, including those at Tezpore, Shillong and Tocklai and their instrumental constants are given in Table 1 (p. 110). The new observatories started functioning from the middle of November 1950.

2. Data used

Preliminary determination of epicentres of most of the after shocks recorded at the Indian Seismological Observatories have already been published from time to time in the Monthly Seismological Bulletins of the India Meteorological Department. These determinations were mostly based on the data of only Indian stations and much accuracy, therefore, could not be claimed. Data used in the new determinations of the epicentres have been collected from the bulletins supplied by the Observatories or from the collective bulletins issued by B.C.I.S. (Strasbourg), U. S. Coast and Geodetic Survey, and the J.S.A. In the case of the main shock, copies of seismograms were made available to the author through the kindness of the Directors of a number of Seismological Observatories in the world. A fresh measurement could be made and the tabulations were thus checked.

In all, epicentres and origin times of the main shocks and 54 after shocks, which took place up to the end of April 1951, have been determined. Only those shocks were selected which were at least clearly recorded at all the Indian stations. A large number of them were well recorded at European stations as well, and in other parts of the world. Final epicentre, origin time etc of these shocks are listed in Table 2 (p. 111). Wherever possible the depth of focus below the surface and the magnitude of the shock is also given. In some cases the magnitude of the shock was determined by European stations like Strasbourg, Praha or Rome from their data, but in the majority of cases the magnitude has been determined with the help of Wood-Anderson Seismographs working at Poona, New Delhi and Chatra. The position of the epicentres is plotted in Fig. 2. Seismograms of Indian stations for a few shocks are reproduced in Figs. 4—7 (pp. 101—104).

3. Method of determining epicentres

In each case the arrival times of P and S waves at each recording station from which data were available were tabulated. Using S—P interval and Jeffreys and Bullen (1940) Travel Time Tables tentative distances from each observatory were found. With the help of a 30-inch globe a tentative epicentre could thus be found and an estimate for the origin time could also be determined. Distances from this tentative epicentre to the recording stations were calculated by the formulae

$$\cos\triangle = aA+bB+cC$$

or $$2(1-\cos\triangle) = (a-A)^2+(b-B)^2+(c-C)^2$$

where $\triangle$ is the epicentral distance, a, b, c are direction cosines of the observatory and A, B, C the direction cosines of the epicentre. These are related to the latitude ϕ and longitude λ of the station by the formulae—

$$a = \cos\phi\cos\lambda$$
$$b = \cos\phi\sin\lambda$$
$$c = \sin\phi$$

As customary only geocentric direction cosines have been used. For distances less than 10 degrees of arc 6-figure logarithms were used and for larger distances 4-figures were found to be sufficient. This procedure gave distances correct to the second decimal place at all distances.

After calculating the distances the travel time of P for these distances were found from the J. B. Tables (1940) and were tabulated against the observed travel times and the residuals (observed travel time—calculated travel time) for all these distances were tabulated. An inspection of the residuals in many cases indicated obvious shift of the epicentre or origin time or both and the entire process was repeated until a fairly good estimation of the epicentre and origin time was achieved. This position was considered to be the provisional epicentre in the determination of the final value by the least square method. At this stage the distances were recalculated. Let us assume that for a particular earthquake the correct epicentre is at Q and the origin time 0, and a tentative determination gives these values at x degrees east and y degrees north of this and τ as the origin time. If $\triangle$ be the true distance from the correct epicentre and σ from the tentative result and z the azimuth of the station from the epicentre, then

$$\triangle = \sigma + x\sin z + y\cos z$$

provided x and y are small. The corresponding travel times $T(\triangle)$ and $T(\sigma)$ as read from the tables for distances $\triangle$ and σ are related by

$$T(\triangle) = T(\sigma)+(x\sin z + y\cos z)\,t(\sigma)\,..(1)$$

where $t(\sigma)$ is the travel time for one degree at distance σ.

If we further assume that the J.B. Tables (1940) are correct, then

$$T(\triangle) - T(\sigma) - \tau - \varepsilon = \mu \quad .... \quad (2)$$

where ε is the observational error and μ the the residual worked out with the help of tentative epicentre and J. B. Tables (1940).

Combining equations (1) and (2), we get

$$(x \sin z + y \cos z)\, t(\sigma) - \tau - \mu = \varepsilon \quad (3)$$

which represents an equation of condition between x, y and τ.

The normal equations corresponding to n observing stations are—

$$x\Sigma p^2 + y\Sigma pq - \tau\Sigma p - \Sigma\mu p = 0 \quad .. (4)$$

$$x\Sigma pq + y\Sigma q^2 - \tau\Sigma q - \Sigma\mu q = 0 \quad .. (5)$$

$$x\Sigma p + y\Sigma q - n\tau - \Sigma\mu = 0 \quad .. (6)$$

where $p = \sin z.\, t(\sigma)$, $q = \cos z\ t(\sigma)$

Solution of (4), (5) and (6) gives the value of x, y and τ and substitution of these values in each equation of the type (3) gives the value of ε which is the final value of the residual. For small values of $\triangle$ epicentral distances and azimuth were recalculated and fresh residuals found. The value of z was calculated with the help of the formulae :

$$2+2 \sin \triangle \cos z = (a - G)^2 + (b - H)^2 + (c - K)^2$$

Where $G = \sin\phi \cos\lambda$

$H = \sin\phi \sin\lambda$

$K = -\cos\phi$

The method of least squares as enumerated above presumes that the observing stations are distributed in all azimuths round the epicentre and data are available at various distances. According to Jeffreys (1935) observations of P must be available from at least 3 stations at nearly the same epicentral distances, which are in widely distributed azimuths. In the case of the shocks studied in this paper this ideal might not have been achieved in some cases. While a good number of stations existed in direction between SW to NW, very few readings were available from east of the epicentres. In most cases the only readings available have been from College (Alaska) and Brisbane and in some cases from Japanese stations. In a few cases data were not available even from these stations and the epicentre has been determined with the help of the limited data at disposal. These cases have been marked with an asterisk in Table 2. In such cases a further check was made with S readings and the solution was not accepted unless both P and S readings at all the observing stations were suitably accounted for.

Table 3 (pp. 112—128) gives the tabulations of P and S arrival times at various observing stations for shocks listed in Table 2. The values of residuals for P and S times with reference to J. B. Tables (1940) are also given. The residuals for P are generally much smaller in comparison to S as the exact beginning of the latter is often not free from ambiguity.

3. Energy and magnitude of shocks

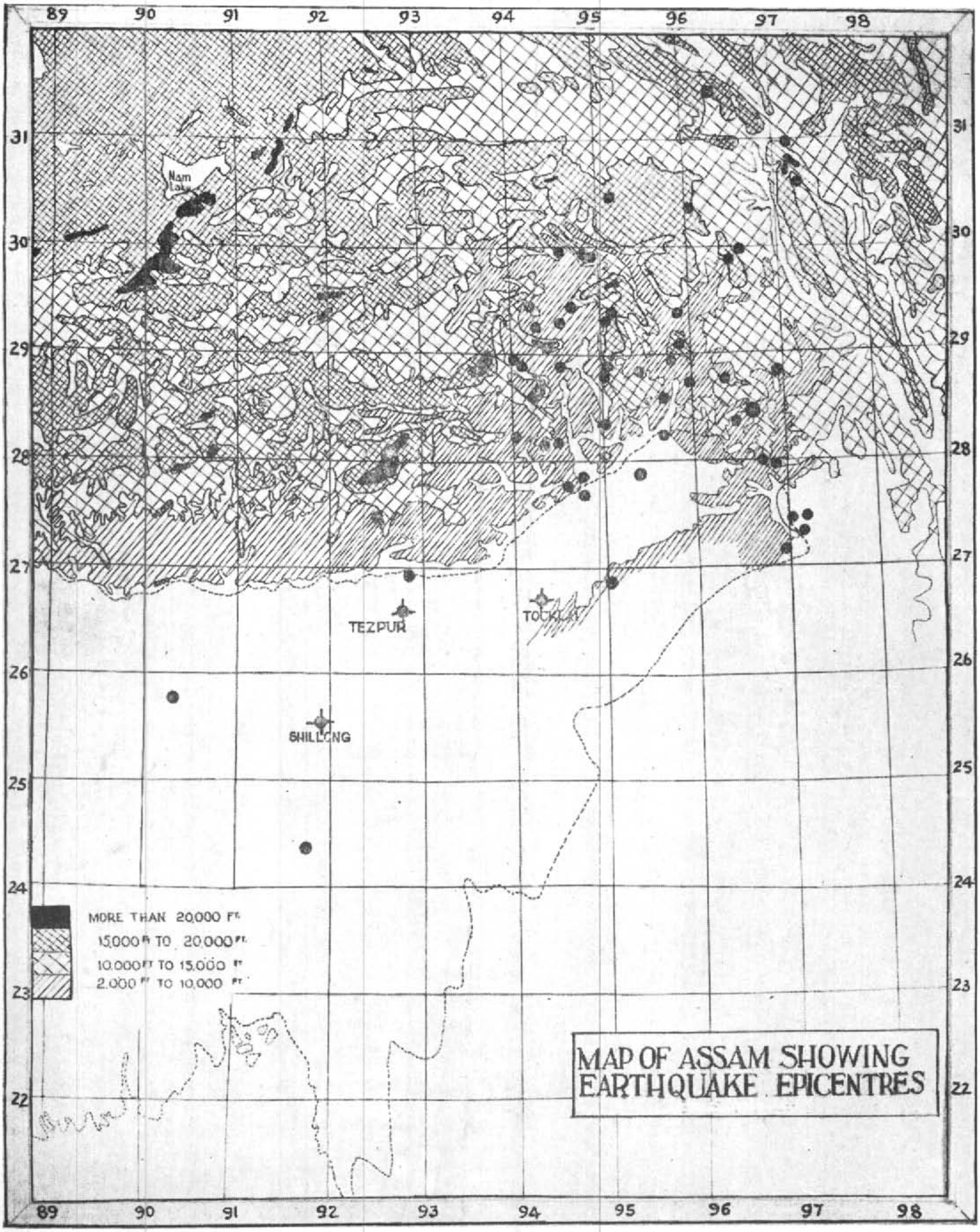
Richter (1935) has defined the magnitude of an earthquake as the logarithm (to base 10) of the maximum amplitude measured in microns (1 micron = ·001 mm) traced on a standard Wood-Anderson torsion seismograph having a period of 0·8 seconds, a static magnification of 2800 and a damping coefficient of 0·8 at a distance of 100 km from the epicentre. It is not always possible to get the data directly from standard seismographs at a distance of 100 km from the epicentre and the observed amplitudes have, therefore, to be reduced to expected amplitudes at $\triangle = 100$ km. For distances from 200 to 1500 km he found that the observed amplitudes are fairly well represented by the formula—

$$\log A = \log M + 3{\cdot}37 - 3 \log \triangle$$

where A is the seismograph amplitude in millimetres and M is the magnitude. If standard seismometers are not available the amplitude A can be calculated from the known earth-movement and earth wave period T by the relation

$$A = \frac{V}{1000\sqrt{(u^2-1)^2 + 4h^2u^2}}\, a \quad ..(7)$$

where $u = T/T_0$ and V is the static magnification and h the coefficient of damping. For distances over 25° the period of the


MAP OF ASSAM SHOWING
EARTHQUAKE EPICENTRES
MORE THAN 20,000 FT.
15,000 FT TO 20,000 FT.
10,000 FT TO 15,000 FT
2,000 FT TO 10,000 FT
TEZPUR
SHILLONG
Nam Lake
89
90
91
92
93
94
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98
31
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Fig 2

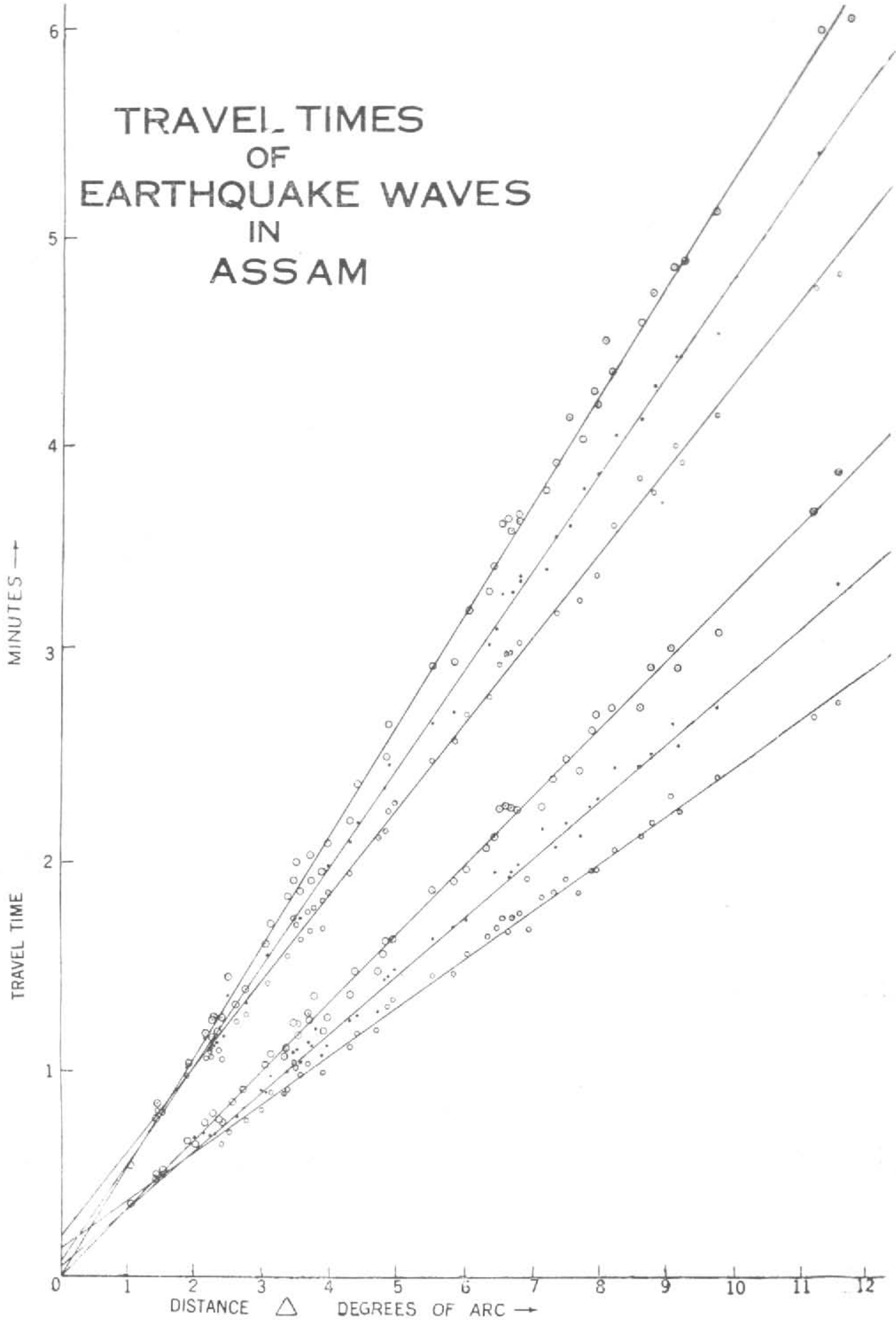
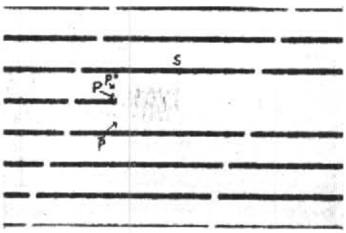

TRAVEL TIMES
OF
EARTHQUAKE WAVES
IN
ASSAM
TRAVEL TIME MINUTES →
DISTANCE △ DEGREES OF ARC →
0
1
2
3
4
5
6
7
8
9
10
11
12

Fig. 3

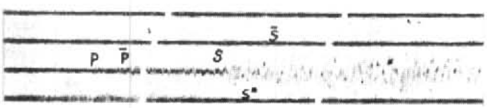
Earthquake shock No. 45 (8 February 1951)



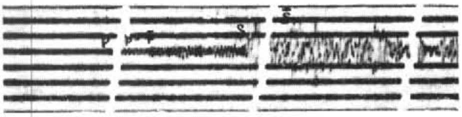
Tocklai

Shillong

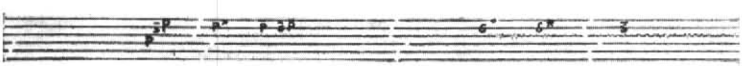
Earthquake shock No. 46 (15 February 1951)



Tocklai



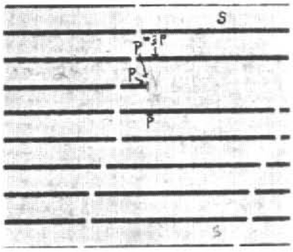
Tezpore



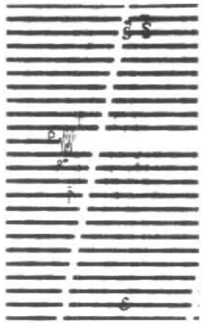
Chatra

Fig. 4

Earthquake shock No. 48 (6 March 1951)



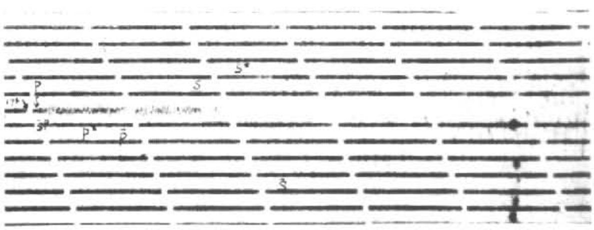
Tocklai



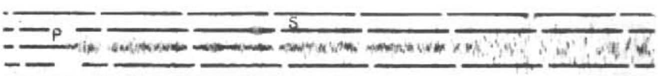
Tezpore

Shillong

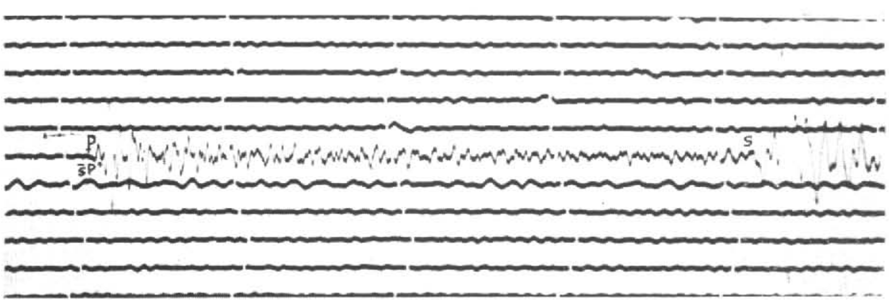
Chatra



Calcutta



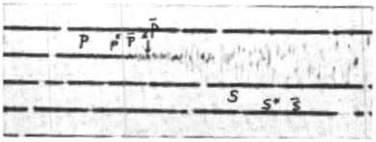
New Delhi



Poona

Fig. 5

Earthquake shock No. 50 (16 March 1951)

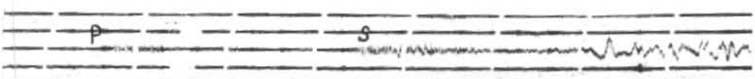


Tocklai

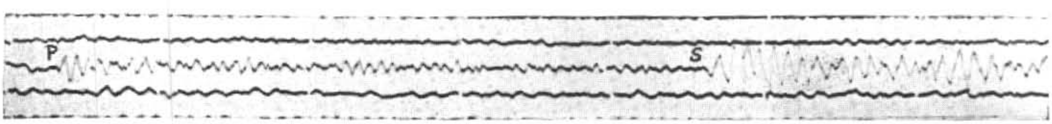
Tezpore

Chatra

Calcutta



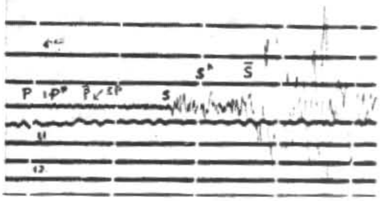
New Delhi



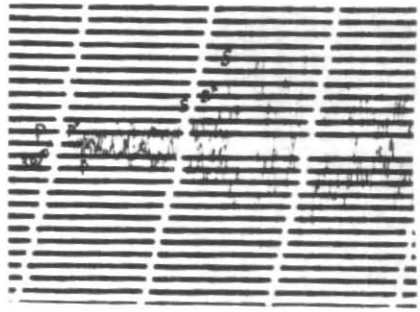
Poona

Fig. 6

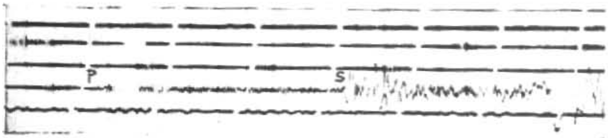
Earthquake shock No. 51 (17 March 1951)



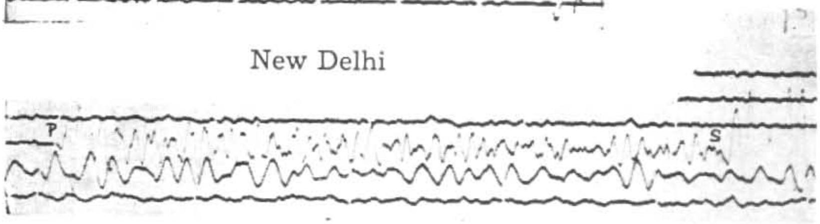
Chatra



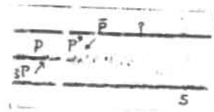
Tezpore



New Delhi

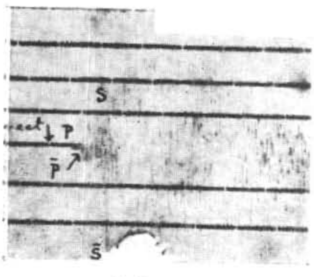


Poona

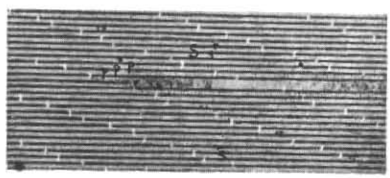


Tocklai

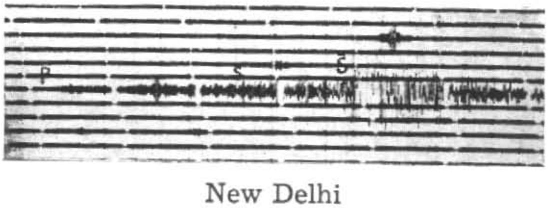
Earthquake shock No. 52 (7 April 1951)



Calcutta



Chatra



New Delhi

Fig. 7

earthwaves is generally much larger than that of the standard seismometer and so $u >> 1$ and $u^4 >> u^2 h^2$ and the relation (7) becomes

$$A = \frac{1 \cdot 8}{T^2} a$$

In general Richter found that the magnitude is given by the relation

$$M = \log A - \log A_0 \quad \ldots (8)$$

where A_0 is the amplitude recorded by a shock of magnitude 0 and can be represented by the empirical relation—

$$A_0 = -3 \cdot 7 - 2 \log \triangle$$

The above formulae have been used to calculate the magnitude of the aftershocks. Maximum amplitudes recorded by the Torsion Seismographs at Chatra, New Delhi and Poona have been used. Whenever there were two horizontal components the magnitude has been calculated with the help of both and an average taken. Finally an average of the various values determined by different stations has been taken and the result entered in Table 4 (p. 129). The magnitude of after shocks calculated in this was found to be higher by $0 \cdot 5$ to 1 unit than that calculated by European stations for some shocks. Magnitudes calculated from records of Milne-Shaw seismographs indicated smaller values. It seems that at distances below $\triangle = 25°$ the maximum earth movement corresponds to shorter periods. At larger distances these are filtered off and only larger periods predominate. The higher value obtained with Wood Anderson records seem more representative. For the main shock the recorded amplitudes at Indian stations were too large and in all cases the trace went out of record. An average value of $8 \cdot 5$ has been accepted which yields a total release of 4×10^{26} ergs of energy according to the relation—

$$\log E = \log_{10} E_0 + 1 \cdot 8 M$$

E_0 is generally taken to be 2×10^{11} ergs.

4. Depth of Focus

In nearly all the shocks given in Table 2 surface waves were recorded at all the Indian stations showing that the focal region was confined to the outer crust of the earth. The exact estimation of the depth has not been possible in many cases. Data from near stations were available for shocks No. 40 to 54 only and amongst these Scrase's phases $s\bar{P}$ could be identified in a few cases. Unless this phase could be traced at more than one station, the depth has not been calculated. In a number of records the wave $\bar{P}$ appears to be followed by a stronger phase. If it is assumed that the latter, designated hereafter as $s\bar{P}$ is due to a premitive $\bar{S}$ diffracted as $\bar{P}$ along the outer boundary of the earth near the epicentre, the depth of focus below the outer boundary can be calculated. The depth calculated in this way seems to be in general agreement with that calculated from $s\bar{P}$-P interval*. Assuming horizontal layering with 2 layers over the main rock, and no change in velocity with depth, it can be shown that for small epicentral distances the travel time of the wave $s\bar{P}$ is given by the formula

$$t_{s\bar{P}} = t_P + h \left\{ \frac{\sqrt{v^2_P - v^2_{\bar{s}}}}{v_P \times v_{\bar{s}}} + \frac{\sqrt{v^2_P - v^2_{\bar{P}}}}{v_P \times v_{\bar{P}}} \right\} \quad (9)$$

where v_P, $v_{\bar{P}}$ etc are the velocities for the waves P, $\bar{P}$ etc and h the depth of focus below the surface. The interval $(t_{s\bar{P}} - t_P)$ for epicentral distances upto $\triangle = 10°$ is, therefore, given by

$$t_{s\bar{P}} - t_P = h \left\{ \frac{\sqrt{v^2_P - v^2_{\bar{s}}}}{v_P \times v_{\bar{s}}} + \frac{\sqrt{v^2_P - v^2_{\bar{P}}}}{v_P \times v_{\bar{P}}} \right\} \quad (10)$$

Substituting the values of v_P, $v_{\bar{P}}$ and $v_{\bar{s}}$ for the region as given in Table 8 we get

$$t_{s\bar{P}} - t_P = 0 \cdot 39 \times h \quad \ldots \quad \ldots (11)$$

* It may be mentioned here that S. C. Roy (1939) determined the depth of the Bihar-Nepal earthquake of 1934 from the apparent delay of starting of $\bar{P}$ with respect to $\bar{S}$. He found a value of 14·[illegible] km for the depth

Even up to distances of $\triangle = 25°$ only very small change in the value of $t_{\bar{s}P} - t_P$ is to be expected. Data from all Indian stations has, therefore, been combined in the calculation of the depth h.

The difference in the travel times $t_{\overline{sP}}$ of the $\bar{s}$ wave diffracted as P along the upper boundary and the primitive P wave is given by the relation

$$t_{\overline{sP}} - t_{\overline{P}} = \frac{h \cos\theta}{v_{\bar{s}}} \qquad .. \quad (12)$$

where $\sin\theta = \dfrac{v_{\bar{s}}}{v_{\overline{P}}}$

Substituting the values of $v_{\bar{s}}$ and $v_{\overline{P}}$ as given in Table 8, we get

$$t_{\overline{sP}} - t_{\overline{P}} = 0\cdot23 \times h \qquad .. \quad (13)$$

The observed $\bar{s}P$—P and $\overline{sP}$—P intervals and the value of depths for some shocks calculated with the help of (11) and (13) are given in Table 5 (p. 130).

5. Velocities of longitudinal and transverse seismic waves in Upper Assam

It has already been mentioned above that for near earthquake studies three Seismological Observatories were opened at Shillong, Tocklai and Tezpore. Two observatories namely at Calcutta and Chatra which were within 10 degrees from the epicentral region were already functioning. Data for distances below 10 degrees were available for shocks Nos 38 to 54. In some cases, however, the records either were not good or the seismographs did not function and hence the records from all the five stations were not available. Seismograms from all these stations were examined and the times of arrivals of prominent phases were recorded. These are tabulated in Table 6 (pp. 130-134). The phases P, P^* and $\overline{P}$ in the longitudinal group and S, S^* and $\overline{S}$ in the transverse group have been tabulated in all cases when observed. Other well developed phases have also been tabulated. The phases P, $\overline{P}$, S and $\overline{S}$ are on the whole easily identifiable but P^* and S^* which are generally weak present difficulties. $\overline{P}$ appears to be the strongest phase in the P group and $\overline{S}$ in the S group. The actual maximum amplitude has not been measured but the clarity of the phases have been broadly classified as weak (W), strong (S) and very strong (V.S.). These have been entered after the arrival times. Where no remarks are given it may be inferred that the phase though not strong is easily identifiable.

Since the epicentres and origin times for these shocks were known with the help of other Indian and foreign stations the data given in Table 6 could be used for the calculation of seismic wave velocities in Assam. Following Jeffreys (1929) a three-layered structure has been assumed for the region and no change in the velocities with depth has been postulated. Knowing the observed travel times for various epicentral distances the data for each earthquake could be subjected to a least square analysis for determination of the velocities and the apparent delay of starting. This, however, was not possible as the maximum number of near stations for any one earthquake was only 5. Since the phases $\overline{P}$ and $\overline{S}$ were clearly recorded in nearly all the cases it could easily be inferred that the focus lay in the upper most layer, usually referred to as the Granitic layer, and the data for all the shocks could be combined for the purpose of a least square study. The travel time T for any ray from the focus to the observing station is given by the relation

$$T = \frac{\triangle}{v} + a$$

where a is apparent delay of starting and depends only on the focal depth h and distribution of velocity up to the lowest layer to which the ray penetrates.

Let us suppose that the position of the epicentres and the distance $\triangle$ of the epicentre from the observing station is correctly known, and there is only an uncertainty in the calculation of travel times. If τ is the uncertainty in the computation of the origin time, ε the error in observation of a particular phase (say P) at distance $\triangle$, then the computed travel time t is given by

$$t = T - \tau - \varepsilon$$

$$\text{and } (a_P - \tau) + \triangle v_P^{-1} - t = \varepsilon \quad .. \quad (14)$$

If we have n sets of $\triangle$ and t values, we can get n such equations of which the normal equations are

$$n\,(a_P - \tau) + (\Sigma\triangle) v_P^{-1} - \Sigma t = 0 \quad .. \quad (15)$$

$$(\Sigma\triangle)(a_P - \tau) + (\Sigma\triangle^2) v_P^{-1} - \Sigma\triangle t = 0 \quad .. \quad (16)$$

Solution of the above pair gives the values of v_P^{-1} and $(a_P - \tau)$. Substitution of these values in the n equations gives values of ε for each case. The square of the standard deviations for a_P and v_P^{-1} are

$$\sigma^2_{a_P} = \frac{(\Sigma\triangle)^2}{n(\Sigma\triangle^2)-(\Sigma\triangle)^2} \cdot \frac{\Sigma\varepsilon^2}{n-2} \quad .. \quad (17)$$

$$\sigma^2_{v_P^{-1}} = \frac{n}{n(\Sigma\triangle^2)-(\Sigma\triangle)^2} \cdot \frac{\Sigma\varepsilon^2}{n-2} \quad .. \quad (18)$$

from the value of the standard deviation for $\sigma_{v_P^{-1}}$ calculated thus, the value of the standard deviation for v_P, *i.e.*, σ_{v_P} can be calculated from the approximate relation

$$\sigma_{v_P} \simeq \frac{\sigma\, v_P^{-1}}{(v_P^{-1})^2}$$

Dividing the standard deviation by $\sqrt{n}$ the value of the standard error can be determined.

Observed values of $\triangle$ and t and the calculated values of the residual ε for each case are given in Table 7 (pp 135-136) for the waves P, P^*, $\bar{P}$, S, S^* and $\bar{S}$. Fig.3 represents the travel times of these waves for the Assam region. Velocities corresponding to these phases and the calculated values of the apparent delay of starting $(a_P - \tau)$ along with the calculated standard deviations and limits of error rounded to second place of decimal are given in Table 8 (p. 136). Values of the velocities determined by other investigators in other parts of the world are given in Table 9 (p. 136).

6. Thickness of crustal layers

In the case of horizontal layering if the focus is at a depth h below the outer surface of the earth and H_1 and H_2 are the thicknesses of the upper and intermediate layers (often designated as the Granitic and Basaltic Layers) it can be shown that the apparent delays of starting a for the waves P^* and P are given by (provided the effect due to the topmost sedimentary layers is neglected)—

$$a_{P^*} = 2H_1\left(\frac{1}{v^2_{\bar{P}}} - \frac{1}{v^2_{P^*}}\right)^{\frac{1}{2}} - h\left(\frac{1}{v^2_{\bar{P}}} - \frac{1}{v^2_{P^*}}\right)^{\frac{1}{2}} \quad .. \quad (19)$$

$$a_P = 2H_1\left(\frac{1}{v^2_{\bar{P}}} - \frac{1}{v^2_P}\right)^{\frac{1}{2}} + 2H_2\left(\frac{1}{v^2_{P^*}} - \frac{1}{v^2_P}\right)^{\frac{1}{2}} - h\left(\frac{1}{v^2_{\bar{P}}} - \frac{1}{v^2_P}\right)^{\frac{1}{2}} \quad .. \quad (20)$$

and similarly of S^* and S. There is no delay of starting for $\bar{P}$ and $\bar{S}$. Knowing $v_{\bar{P}}$, v_P, a_{P^*} and a_P the values of H_1 and H_2 can be calculated, provided h is known. As we have already seen the standard deviations for the velocities are quite small but for a_{P^*} and a_P their magnitude is much larger. There is also a considerable amount of uncertainty in the determination of h. Consequently great accuracy cannot be claimed for the results obtained for H_1 and H_2. If a large number of reporting stations were available it should have been preferable to calculate the values of H_1 and H_2 from records of individual earthquake, but in the present study this has not been possible. With a small number of reporting stations calculations from data of a single earthquake may lead to erroneous results. In the present case all the available data from shocks No. 40 to 56 have been combined for the determination of values of a and the velocities. The earthquakes selected have apparently different depths ranging from about 5 km to about 20 km. A mean value of 13 km has been chosen for h. Substituting the values of a_{p*}, a_p and the velocities as given in Table 8, in equations (19) and (20) we get

$$H_1 = 25\cdot8 \text{ km}$$
$$H_2 = 20\cdot5 \text{ km},$$

from data of S group of waves the corresponding results are

$$H_1 = 23\cdot8 \text{ km}$$
$$H_2 = 22\cdot5 \text{ km}.$$

These results give a mean depth of 24·8 km for the Granitic, and 21·5 km for the Basaltic or Intermediate layer and the depth of the Mohorovicic discontinuity as 46·3 km below the surface. The result obtained by Jeffreys (1939) for Japanese earthquakes gave $H_1 = 15 \pm 3$ km and $H_2 = 18 \pm 4$ km. Gutenberg (1951) has estimated the depth of Mohorovicic discontinuity in southern California to be 35 km in Coastal regions but deeper under the mountain regions. Byerly (1939) found the thickness of crustal layers as 32 km in the Central Californian region. An estimate of about 50 km for the depth of the Mohorovicic discontinuity for Central India was arrived at by Mukherjee (1942). From a study of the Bihar-Nepal earthquake of 1934. Roy (1939) calculated the thicknesses of the Granitic and Basaltic layers as 14·8 km and 25·4 km respectively.

7. Frequency analysis of P and S residuals

Residuals of P and S as given in Table 3 have been rounded up to the nearest second, and their frequencies of occurrence in ranges of 3 degrees have been given in Tables 10 and 11 (p.137). In the last column of the table the mean value of the residual for the particular range has been given. Values of residuals larger than 10 seconds have not been taken into account while calculating the mean. A perusal of the tables shows that for P residuals the distribution is fairly normal, but the S residuals show a large scatter. This is to be expected as the errors in the estimation of S times are larger than those for P. The table for P residuals shows the following noticeable departures from the J. B. Tables.

(1) Travel times within the sub-range 4° to 7° seem to be about 2 seconds larger but if an average value for distances below $\Delta=10°$ is taken, the times are nearly 1 second larger.

(2) Travel times from 10° to 19° are smaller on an average by about 2 seconds.

(3) No significant departures from $\Delta=52°$ to $\Delta=88°$.

The number of observations in the other sub-ranges are too small to draw any conclusion but it seems probable that the travel times of P from the region investigated are larger by 1 to 2 seconds than those in J. B. Tables (1940) for $\Delta=20°$ to $\Delta=52°$ and for $\Delta=90°$ to $\Delta=103°$.

Tables for S residuals also show that the travel times within the sub-range 4 to 7 degrees are higher by about 2 seconds and for $\Delta=10°$ to 16° smaller by about 4 seconds. After $\Delta=16°$, there is a tendency for the travel times to increase again, and the mean of the S residuals show positive values ranging from 1 to 5 seconds up to $\Delta=52°$, beyond which there does not seem to be any significant departure up to $\Delta=75°$.

A mean value of +4·2 for the sub-range $\Delta=76°$ to $\Delta=78\cdot9°$ is based only on 5 observations and can be ignored. Slightly larger travel times of P and S for distances up to $\Delta=10°$ are perhaps due to the greater depth of the crustal layers in the region, the total depth being about 45 km as compared to 33 km found by Jeffreys for the European continent. The effect due to the sedimentary layers has also been neglected which too would contribute to larger travel time. For distances between $\Delta=10°$ to $\Delta=20°$ the effect due to greater depth of the crustal layer is perhaps more than compensated by the larger velocity of the P_n waves, being 7.91 km sec^{-1}

as against 7·76 km sec^{-1} found by Jeffreys for Europe. For still larger distances the regional effects become less important and there are no significant differences in travel times with respect to those given in J. B. Tables (1940), the latter being an average for shocks in different regions of the globe.

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TABLE 1

Serial No.	Station	Latitude (°N)	Longitude (°E)	Instrument	Comp.	Period of Inst. T_0 (sec)	Speed of paper mm/min	Damping ratio	V
1	Bombay	18°54′	72°49′	Milne Shaw	N	12	8·0	20 : 1	250
				Milne Shaw	E	12	8·0	20 : 1	350
2	Calcutta	22°32′	88°22′	Milne Shaw	E	12	8·0	20 : 1	250
				Wood Anderson	N	2	30·0	nearly critical	870
3	Chatra	26°50′	87°10′	Milne Shaw		10	16·0	20 : 1	150
				Wood Anderson	E	1	60·0	30 : 1	1000
				Wood Anderson	N	1	60·0	30 : 0	1000
				Benioff	Z	$T_0=0\cdot8$ $Tg=0\cdot45$	60·0	critical	—
4	Hyderabad	17°26′	78°27′	Milne Shaw	N	12	8·0	20 : 1	268
				Milne Shaw	E	12	8·0	20 : 1	242
5	Kodaikanal	10°14′	77°28′	Milne Shaw	E	10	8·0	20 : 1	250
6	New Delhi	28°35′	77°12′	Milne Shaw	N	12	8·0	20 : 1	299
				Wood Anderson	N	4	16·0	20 : 1	1000
				Wood Anderson	E	2	60·0	30 : 1	1700
7	Poona	18°32′	73°51′	Milne Shaw	N	12	8·0	20 : 1	250
				Wood Anderson	E	4	16·0	20 : 1	1000
				Sprengnether	E	$T_0=Tg=7\cdot2$	30·0	critical	—
				Benioff	Z	$T_0=1$ $Tg=0\cdot25$	60·0	critical	—
8	Shillong	25°34′	91°53′	Wood Anderson	N	1	24·0	nearly critical	700
				Wood Anderson	E	1	60·0	,,	700
9	Tezpore	26°37′	92°47′	Wood Anderson	N	1	24·0	,,	600
10	Tocklai	26°45′	94°46′	Wood Anderson	E	1	30·0	,,	700
				Wood Anderson	N	1	30·0	,,	700

TABLE 2

Serial number of shock	Date	Origin Time (GMT)			Epicentre Lat. (°N)	Epicentre Long. (°E)	Magnitude
Main Shock	15-8-1950	14	09	28·5	28·46	96·66	8·5
1	,,	16	29	19·5	27·34	97·13	
2	,,	18	38	42·1	28·71	95·99	
3	,,	21	42	22·9	26·94	92·85	
4	,,	23	44	40·6	28·74	95·08	
5*	16-8-1950	05	33	06·0	28·82	96·99	6·6
6	,,	06	41	59·5	28·57	95·66	7·0, 6·25 (Pr)
7	,,	15	29	26·2	29·42	94·70	6·6, 5·75 (Pr)
8	,,	17	51	30·8	27·48	92·54	6·7, 5·75 (Pr)
9	,,	19	25	35·2	29·07	95·82	6·4, 5·5 (Pr)
10	17-8-1950	01	54	14·0	28·86	94·52	6·5, 5·75—6·0 (Pr)
11	,,	05	29	13·6	29·92	94·83	6·2, 5·5 (Pr)
12	18-8-1950	01	07	51·2	29·35	95·83	6·5, 6·5 (Pr), 7·0 (Pas)
13	,,	16	58	48·9	29·89	96·43	6·6, 5·75 (Pr)
14	20-8-1950	09	03	37·0	29·90	94·92	6·4
15	21-8-1950	05	51	29·8	27·49	97·01	6·1
16	,,	08	29	34·8	32·68	92·98	6·4, 5·75—6 (Pr)
17*	,,	18	43	53·1	29·43	94·21	6·1
18*	,,	22	55	31·3	28·81	95·40	6·2
19	22-8-1950	02	22	37·1	30·44	95·18	6·0, 5·5 (Pr)
20	,,	06	43	10·8	29·29	94·52	6·3, 5·5—5·75 (Pr), 5·75 (St)
21	,,	13	22	20·1	27·49	97·16	6·3
22	23-8-1950	03	09	19·0	29·28	95·07	6·3, 5·75 (St and Ro)
23*	,,	15	33	56·8	27·19	96·94	5·9
24	,,	18	46	58·7	28·79	96·39	6·7, 6·0 (St and Pr)
25	24-8-1950	01	27	45·6	28·34	96·42	6·3
26	26-8-1950	06	33	06·4	26·84	95·06	7·0, 6·0 (St), 6·1 (Pr)
27	27-8-1950	11	00	02·0	29·96	94·56	6·2
28	31-8-1950	19	52	31·4	28·22	95·68	6·1
29*	2-9-1950	16	14	39·2	29·94	96·56	6·5
30*	13-9-1950	11	07	34·1	27·84	95·33	7·0
31	30-9-1950	70	28	53·7	28·66	94·32	6·7
32	3-10-1950	23	01	58·0	28·00	96·72	6·3
33	8-10-1950	04	50	14·2	28·89	94·11	6·6
34*	16-10-1950	15	42	32·6	28·34	95·02	6·2
35*	29-10-1950	06	02	30·6	27·82	94·72	6·4
36*	30-10-1950	09	04	51·3	27·97	96·89	6·0
37*	2-11-1950	20	17	28·7	30·55	97·26	6·3
38*	12-11-1950	21	30	27·3	27·68	94·77	6·4
39*	18-11-1950	00	44	10·0	27·73	94·59	6·7
40	21-11-1950	07	10	02·9	28·93	95·76	
41	3-12-1950	06	26	56·1	29·34	95·14	6·6
42	29-12-1950	22	35	20·1	24·39	91·74	6·3
43	3-1-1951	21	14	12·5	29·03	94·40	6·6
44	4-1-1951	23	13	25·3	28·60	94·21	5·6
45	8-2-1951	21	14	27·6	28·15	94·42	5·8
46	15-2-1951	08	23	37·9	30·31	96·02	5·3
47	21-2-1951	02	24	14·7	28·91	94·02	5·8
48	6-3-1951	18	58	13·8	28·84	95·09	6·4
49	12-3-1951	14	52	17·2	28·19	94·49	6·5, 6·0 (Pr), 5·5—5·75 (Ro) 6·5 (St)
50	16-3-1951	13	56	57·5	31·20	96·20	6·0
51	17-3-1951	04	27	30·8	30·94	97·16	6·5
52	7-4-1951	20	29	12·4	25·77	90·35	6·8
53	14-4-1951	23	40	49·4	28·22	94·05	6·4
54	22-4-1951	03	37	40·7	29·21	94·30	6·5

NOTE: Pr—Praha; Pas—Pasadena; St—Strasbourg; Ro—Rome

TABLE 3

S. No. of shock	Station	Degrees of arc	Azimuth Degrees from North	Observed travel time for *P*		Obs.—Cal.	Observed travel time for *S*		Obs.—Cal.
		△	z	(min)	(sec)	(sec)	(min)	(sec)	(sec)
Main shock	Chatra	8·68	262	2	7·9	—1·9			
	Calcutta	9·57	234	2	21·5	—0·6			
	Delhi	17·19	275	3	59·5	—3·6			
	Hyderabad	20·01	241	4	35·5	—1·6			
	Poona	23·10	250	5	7·4	—1·0	9	14·5	—1·6
	Colombo	26·68	220	5	46·5	+4·0	10	21·5	+4·3
	Kochi	31·89	71	6	29·5	+0·3	11	29·5	—10·4
	Siomisaki	33·81	71	6	44·5	—1·3			
	Nagano	35·73	66	7	3·5	+1·3	12	44·5	+5·0
	Djakarta	35·80	162	7	2·5	—1·2			
	Tokyo	37·00	68	7	13·5	+0·5	12	59·8	+0·3
	Sendai	37·92	63	7	21·5	+0·8			
	Sapporo	38·62	55	7	23·5	—3·1	13	27·5	+3·8
	Ksara	51·64	292	9	10·5	0	16	32·6	+1·4
	Istambul	55·66	302	9	40·5	+0·4	16	24·5	—1·1
	Helwyn	56·33	289	9	45·1	+0·1			
	Athens	60·35	300	10	13·7	+0·6	18	24·0	—3·1
	Uppsala	60·44	325	10	11·5	—2·2	18	25·5	—2·7
	Beograd	61·13	308	10	18·5	+0·1	18	41·5	+4·4
	Vienna	63·14	312	10	33·2	+1·3			
	Copenhagen	63·83	321	10	37·5	+1·1	19	7·5	—4·5
	Praha	63·94	315	10	38·0	+0·9	19	10·5	—1·9
	Zagreb	63·98	310	10	36·5	—0·8	19	14·5	+1·5
	Leipzig	64·88	316	10	41·0	—2·3	22	17·5	—6·5
	Cheb	65·22	315	10	46·5	+1·1			
	Trieste	65·53	310	10	48·0	+0·7	19—	32·0	—0·5
	Jena	65·48	318	10	47·5	+0·5	19—	33·5	+2·1
	Adak	66·22	42	10	49·5	—2·4			
	Gottingen	66·28	317	10	53·5	+1·2	19	43·5	+2·3
	Tannarive	66·86	231	10	55·5	—0·4	19	41·5	—6·7
	Rome	67·53	307	10	58·0	—2·1	19	55·5	—0·8
	Stuttgart	67·58	319	11	0·5	+0·1	20	0·5	+3·9
	Chur	67·96	312	11	3·0	+0·2	20	1·2	—0·2
	Zurich	68·42	313	11	5·7	0	20	6·5	—0·4
	Strasbourg	68·54	314	11	7·5	+1·1	20	8·5	+0·2
	De Bilt	68·95	319	11	8·5	—0·5	20	13·5	—0·8
	Kew	72·36	319	11	30·5	+0·9			
	College	74·55	24	11	41·5	—0·9			
	Rathfarnham	74·87	323	11	44·9	+0·6	21	21·7	+0·6
	Ebro	76·30	309	11	53·0	+0·6	21	45·0	+8·1
	Brisbane	77·55	131	11	57·5	—1·9			
	Alicante	78·06	307	12	4·5	+2·4			
	Cartuja	80·79	307	12	14·5	—2·4	22	29·5	+4·8
	Riverview	80·62	137	12	18·5	+2·5			
	Malaga	81·58	307	12	24·5	+3·5	22	32·5	—0·4
	Sitka	84·22	26	12	36·5	+1·9			
	Pretoria	85·03	234	12	38·5	—0·2			
	Pietermaritzberg	85·66	233	12	43·5	+1·7			
	Ivigtut	86·19	344	12	40·5	—3·9			
	Seattle	96·52	25	13	35·0	+2·4			
	Apia	97·81	101	13	40·5	+2·1			
	Hungry Horse	98·74	20	13	43·5	+0·8			
	Wellington	100·06	121	13	52·5	+3·8			
	Shasta	102·23	29	13	59·5	+1·1	25	34·5	—4·5
	Berkeley	104·60	31	14	10·5	+1·6			
	Ottawa	106·17	354	14	17·5	+1·7			
	Harward	108·56	351	14	28·5	+2·2			
	Buffalo	108·84	357	14	29·5	+2·0			
	Pasadena	109·53	29	14	31·5	+1·0			
	Palisades	110·34	352	14	35·3	+1·2			
	Washington	112·74	355	14	45·5	+0·8			

TABLE 3—(*contd*)

S. No. of shock	Station	Degrees of arc	Azimuth Degrees from North	Observed travel time for P		Obs.—Cal.	Observed travel time for S		Obs.—Cal.
		Δ	z	(min)	(sec)	(sec)	(min)	(sec)	(sec)
1	Beograd	62·19	308	10	24·5	— 1·0			
	Praha	65·05	315	10	44·5	+ 0·2	19	27·5	+ 1·4
	Trieste	66·60	311	10	53·5	— 0·8			
	Stuttgart	68·70	315	11	6·5	— 0·9			
	Prato	68·92	309	11	7·5	— 1·3			
	Strasbourg	69·66	312	11	13·5	+ 0·2			
	Besancon	71·20	314	11	21·5	— 1·2			
	Paris	72·84	316	11	33·5	+ 1·1			
	College	75·40	23	11	48·5	+ 1·3			
	Tammanrasset	81·22	291	12	21·5	+ 2·3			
	Cartuja	81·81	307	12	26·5	+ 4·3			
	Pietermaritzberg	84·82	233	12	42·5	+ 2·3			
	Hungry Horse	99·63	19	13	48·5	+ 1·9			
2	New Delhi	16·50	270	3	41·9	—12·4	6	35·9	—18·0
	Hyderabad	19·61	239	4	31·9	— 0·7	8	1·9	— 6·5
	Poona	22·65	248	5	2·9	— 0·9	9	2·9	— 5·1
	Bombay	23·30	250	5	11·9	+ 1·6	9	18·9	— 0·7
	Kodaikanal	25·29	227	5	31·9	+ 2·4	9	59·9	+ 6·2
	Colombo	26·51	218	5	41·9	+ 1·0	10	2·9	—11·1
	Tokyo	37·44	68	7	37·4	+20·7	13	5·5	— 0·2
	Helsinki	56·18	325	9	43·9	0	17	44·9	+12·3
	Praha	63·36	314	10	32·9	— 0·3	19	7·9	+ 2·7
	Trieste	64·93	310	10	41·9	— 1·6	19	23·9	— 0·7
	Stuttgart	66·99	314	10	54·9	— 1·8			
	Strasbourg	67·96	314	11	2·9	— 0·9	20	0·9	— 1·0
	De Bilt	68·38	318	11	8·9	+ 3·4	20	13·9	+ 7·5
	Paris	71·16	316	11	21·9	— 0·5			
	Kew	71·80	319	11	25·9	— 0·4			
	College	74·54	23	11	42·9	+ 0·6			
	Tortosa	75·69	309	11	49·9	+ 1·0	21	29·9	— 0·3
	Brisbane	78·15	130	12	2·9	+ 0·3			
	Tammanrasset	79·8	290	12	11·9	+ 0·3			
	Cartuja	80·18	307	12	16·9	+ 3·2	22	15·9	— 2·5
	Pretoria	84·79	237	12	35·9	— 1·1			
	Pietermaritzberg	85·36	232	12	35·9	— 4·4			
3	New Delhi	13·94	280	3	18·1	— 3·1	5	50·1	— 7·7
	Poona	19·40	249	3	30·1	+ 0·1			
	Fukuoka	32·98	69	6	36·7	— 2·1			
	Nagoya	38·43	66	7	23·8	— 1·3	13	22·6	+ 1·8
	Helsinki	56·06	326	9	41·1	— 2·0	17	36·1	+ 5·0
	Beograd	59·42	308	10	8·1	+ 1·4	18	21·0	+ 3·9
	Praha	62·61	315	10	29·1	+ 0·9	19	2·1	+ 6·3
	Rome	65·71	306	10	55·4	— 3·1	19	34·2	+13·4
	Stuttgart	66·22	314	10	51·8	0	19	40·4	+ 5·6
	Strasbourg	67·19	314	10	58·1	+ 0·1	19	52·2	+ 4·9
	De Bilt	67·84	318	11	1·1	— 1·0	20	0	+25·1
	Paris	70·49	315	11	18·6	+ 0·2	20	31·3	+ 2·8
	Kew	71·29	319	11	24·1	+ 0·9	20	40·7	+ 4·4
	Alger Univ	74·27	303	11	47·1	+ 6·4			
	Tortosa	74·61	308	11	42·1	— 0·6	21	18·2	+11·9
	College	77·25	22	11	58·1	+ 0·4	21	47·2	+ 4·9
	Brisbane	79·19	128	12	8·1	— 0·2			
	Grahamstown	86·87	230	12	38·1	— 9·7			
	Sitka	87·01	24	12	51·1	+ 2·7	23	26·7	—11·6
	Hungry Horse	101·28	18	13	54·1	— 0·1			

TABLE 3—*(contd)*

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for *P* (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for *S* (min)	(sec)	Obs.—Cal. (sec)
4	Hyderabad	18·85	240	4	25·4	+1·7	8	1·4	+ 9·9
	Poona	21·85	249	4	55·4	—0·6	8	59·4	+ 6·0
	Bombay	22·48	252	4	59·4	—2·8	9	6·4	+ 1·5
	Kodaikanal	24·64	228	5	25·4	+2·1	9	59·4	+16·6
	Ksara	50·18	293	9	1·4	0	16	22·4	+11·1
	Praha	62·71	315	10	27·9	—1·1	19	1·4	+ 4·4
	Trieste	63·23	310	10	38·4	+5·8	19	16·4	+12·8
	Stuttgart	66·34	314	10	52·4	—0·3	19	42·4	+ 0·5
	Prato	66·56	309	10	52·6	—1·4	19	50·8	+ 6.2
	Paris	70·52	316	11	18·9	+0·1			
	Kew	71·21	319	11	22·4	—0·4			
	Alger Univ	74·85	304	11	42·4	+0·3			
	College	74·87	23	11	43·4	—0·8			
	Toledo	78·50	309	12	4·4	—0·2			
	Tammanrasset	78·94	290	12	7·4	+0·4			
	Pretoria	83·95	237	12	33·4	+0·1			
	Pietermaritzberg	84·68	233	12	38·4	+1·5			
5	Chatra	8·88	262	2	10·0	+0·2	3	47·0	+ 5·9
	Hyderabad	20·24	241	4	38·0	—1·7	8	27·0	+ 5·0
	Poona	23·27	250	5	9·0	—0·7	9	17·0	— 2·1
	Bombay	23·95	252	5	18·0	+1·4	9—	31·0	0
	Kodaikanal	25·83	229	5	34·0	—0·2	10	2·2	— 0·8
	Praha	63·72	315	10	35·0	—0·7	19	12·0	+ 2·3
	Stuttgart	67·37	314	10	59·0	—0·2	19	56·0	+ 1·7
	Strasbourg	68·34	314	11	6·0	+0·7	20	0·8	+ 2·1
	De Bilt	68·72	319	11	9·0	+1·5	20	13·0	+ 2·5
	Paris	71·52	316	11	25·0	+0·4	20	46·0	+ 2·7
	Kew	72·12	319	11	29·0	+0·8	20	50·0	— 0·2
	Dublin	74·63	323	11	43·0	+0·1	21	16·0	— 2·5
	Tammanrasset	80·35	290	12	16·0	+1·5			
	Pretoria	85·28	237	12	40·0	0			
6	Chatra	7·74	260	1	58·5	+1·7	3	27·5	+ 1·4
	Hyderabad	19·30	239	4	25·5	—3·5	8	7·5	+ 5·9
	Poona	22·31	248	4	59·5	—0·4	9	0·5	— 1·3
	Bombay	23·00	250	5	7·5	+0·1			
	Colombo	26·23	218	5	40·5	+2·2	10	15·5	+ 6·1
	Fukuoka	30·11	71	6	11·4	—2·0			
	Tokyo	37·77	68	7	21·2	+1·7	13	10·6	+ 0·8
	Ksara	50·78	292	9	3·5	—0·5	16	25·5	+ 6·1
	Helsinki	56·12	325	9	44·5	+1·0	17	34·5	+16·1
	Praha	63·26	314	10	33·1	+0·6	19	6·5	+ 2·6
	Rome	66·65	306	10	54·2	—1·0	19	48·5	+ 2·8
	Stuttgart	66·88	314	10	56·5	+0·5	19	54·5	+ 6·1
	Strasbourg	67·84	314	11	1·5	—0·6	19	57·5	— 2·4
	De Bilt	68·28	318	11	4·5	—0·4	20	4·5	— 0·7
	Paris	71·05	316	11	21·5	—0·3	20	43·5	+ 6·1
	Kew	71·70	319	11	26·5	+0·8	20	50·5	+ 5·2
	Alger Univ	75·44	304	11	45·5	—2·0			
	Tortosa	75·55	309	11	48·5	+0·4	21	35·5	+ 6·9
	Pretoria	84·36	237	12	35·5	+0·2			
	Grahamstown	89·82	231	13	2·5	+0·6			
7	Chatra	7·09	250	1—	50·8	+3·2	3	13·8	+ 4·0
	Hyderabad	19·05	235	4	26·8	+0·7	7	59·8	+ 3·8
	Poona	21·87	245	4	53·8	—2·4	8—	53·8	0
	Bombay	22·51	247	5	3·8	+1·3	9	7·8	+ 2·3
	Kodaikanal	24·98	224	5	21·8	—4·8	9	47·8	— 1·1
	Upsala	58·65	325	10	3·8	+2·3	18	5·8	+ 0·7
	Praha	62·06	314	10	24·8	+0·1	18	48·8	— 0·1
	Trieste	63·60	309	10	33·8	—1·1			

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for *P* (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for *S* (min)	(sec)	Obs.—Cal. (sec)
7 (*contd*)									
	Stuttgart	65·70	314	10	47·8	—0·7	19	35·8	+ 1·7
	Strasbourg	66·64	314	10	54·8	+0·2			
	Paris	69·86	315	11	14·8	+0·2	20	24·8	+ 0·9
	College	74·35	23	11	38·8	—2·5			
	Tammanrasset	78·46	290	12	4·8	+0·5			
	Brisbane	79·50	130	12	13·8	+3·8			
	Pretoria	84·11	236	12	33·8	—0·3			
	Hungry Horse	98·41	22	13	40·8	—0·3			
8	Chatra	4·87	268	1	21·2	+5·0	2	21·2	+ 7·1
	New Delhi	13·60	278	3	17·2	+0·6	5	40·2	— 9·7
	Hyderabad	16·41	235	3	55·2	+2·0	7	15·2	+19·3
	Poona	19·35	246	4	22·2	—7·3	7	54·2	— 8·5
	Bombay	20·04	249	4	29·2	—8·3	8	30·2	+13·0
	Kodaikanal	22·29	223	5	1·2	+0·8	9	11·2	+ 9 7
	Colombo	23·73	212	5	19·2	+4·7	9	44·2	+17·0
	Ksara	48·64	292	8	50·2	+2·7	16	6·2	+16·8
	Praha	62·04	315	10	24·7	+0·1	18	48·2	0
	Trieste	63·38	310	10	32·2	—1·2	19	4·2	— 1·2
	Stuttgart	65·66	314	10	47·2	—1·0	19	32·2	— 1·4
	Strasbourg	66·63	314	10	54·2	—0·2			
	Paris	69·89	315	10	14·7	0			
	Clermont	70·51	312	11	19·2	+0·7			
	Kew	70·72	319	11	20·2	+0·4	20	33·2	— 0·8
	College	76·87	22	11	54·2	—1·3			
	Cartuja	78·45	306	11	55·2	—9·1	22	2·2	+ 1·1
	Tammanrasset	77·33	289	11	59·2	+1·0			
	Brisbane	79·74	128	12	12·2	+0·9			
	Pretoria	81·46	235	12	22·2	+1·8			
	Hungry Horse	100·84	18	13	53·2	+1·0			
9	Chatra	7·94	257	1	56·8	—2·7	3	29·8	— 1·3
	New Delhi	16·29	271	3	46·8	—4·8	6	34·8	—19·3
	Hyderabad	19·68	238	4	34·8	+1·5	8	4·8	— 5·2
	Poona	22·61	248	5	4·8	+1·2	9	6·8	— 0·5
	Bombay	23·28	250	5	9·8	—0·3	9	20·8	— 0·5
	Ksara	50·69	292	9	5·8	+2·6	16	25·8	+ 7·7
	Praha	62·97	315	10	30·8	0	19	1·8	+ 1·5
	Trieste	64·62	310	10	39·8	—1·7			
	Stuttgart	66·55	314	10	53·8	—0·1			
	Strasbourg	67·57	314	11	0·8	+0·4			
	Paris	70·75	316	11	20·3	+0·3			
	Kew	71·39	319	11	24·8	+0·9			
	College	74·28	23	11	39·8	—1·0			
	Alger Univ	75·25	304	11	43·8	—2·6			
	Tammanrasset	79·49	290	12	10·8	+0·9			
	Pretoria	84·72	237	12	36·8	—0·3			
	Hungry Horse	98·44	21	13	41·8	+0·5			
10	New Delhi	15·12	273	3	37·0	+0·4	6	25·0	— 0·7
	Hyderabad	18·57	237	4	17·0	—2·9	7	57·0	+11·8
	Poona	21·46	247	4	56·0	+3·9	8	50·0	+ 4·0
	Bombay	22·10	249	5	2·0	+2·4	9	2·0	+ 4·0
	Kodaikanal	24·43	225	5	17·0	—4·3	9	43·0	+ 3·8
	Colombo	25·85	213	5	37·0	+2·2	10	7·0	+ 2·8
	Ksara	49·71	276	8	57·0	+1·2	16	18·0	+14·6
	Upsala	58·99	325	10	5·0	+1·3	18	10·0	+ 0·6
	Praha	62·29	314	10	27·0	+0·7	18	57·0	+ 5·4
	Trieste	63·81	310	10	36·0	—0·2	19	15·0	+ 4·3
	Rome	65·75	306	10	47·7	—0·1	19	36·0	+ 1·1
	Stuttgart	65·92	315	10	50·5	+0·5	19	42·0	+ 5·3

TABLE 3 *(contd)*

S. No. of shock	Station	Degrees of arc Δ	Azimuth Degrees from North z	Observed travel time for P (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for S (min)	(sec)	Obs.—Cal. (sec)
10	*(contd)*								
	Strasbourg	66·89	314	10	57·0	+0·8	19	54·0	+ 5·6
	Paris	70·12	315	11	12·0	—4·2	20	31·0	+ 4·1
	Kew	70·79	319	11	22·0	+1·7	20	40·0	+ 5·3
	Alger Univ	74·43	304	11	40·5	—1·3			
	Tammanrasset	78·48	290	12	5·0	+0·5			
	Pretoria	83·66	236	12	29·0	—2·8			
	Hungry Horse	98·99	19	13	44·0	+0·2			
11	Chatra	7·33	251	1	52·4	+1·4	3	16·4	+ 0·6
	New Delhi	15·39	271	3	37·4	—2·7	6	26·4	— 5·7
	Hyderabad	19·40	236	4	27·4	—2·7	8	9·4	+ 5·8
	Poona	22·14	245	5	2·4	+3·5	9	4·4	+ 5·7
	Bombay	22·77	248	5	5·4	+0·3	9	12·4	+ 2·2
	Ksara	49·57	291	8	59·4	+4·7	16	21·4	+18·8
	Helsinki	55·57	325	9	33·4	+1·1	17	10·4	—13·2
	Upsala	58·27	325	9	59·4	+0·7	18	1·4	+ 1·3
	Praha	62·74	314	10	21·4	—1·2	18	46·4	—11·0
	Rome	65·30	306	10	42·4	—3·5	19	27·4	— 1·8
	Stuttgart	65·39	314	10	46·9	+0·4			
	Strasbourg	66·34	314	10	52·4	—0·2			
	Besancon	67·91	313	11	1·4	—1·1			
	Paris	69·54	315	11	12·4	—0·6			
	Kew	70·16	319	11	17·4	+0·9	20	33·4	+ 5·9
	College	73·86	23	11	37·4	—1·0			
	Tammanrasset	78·28	290	12	3·4	+0·1			
	Cartuja	78·58	306	12	6·4	+1·4	22	2·4	+ 0·9
	Pretoria	84·45	236	12	33·4	—2·4			
	Hungry Horse	97·93	19	13	40·4	+1·4			
12	New Delhi	16·30	271	3	48·8	—3·0	6	41·8	—11·5
	Hyderabad	19·84	237	4	34·8	—0·4	8	14·8	+ 1·3
	Poona	22·73	247	5	5·8	+1·0	9	8·8	— 0·7
	Bombay	23·40	248	5	12·8	+1·5	9	32·8	+11·4
	Kodaikanal	25·62	225	5	31·8	—0·8	9	59·8	+ 0·6
	Fukuoka	29·70	73	6	8·1	—1·7	11	9·8	+ 4·4
	Osaka	33·92	71	6	47·2	+0·5	12	36·7	+25·2
	Tokyo	37·33	69	7	23·8	+8·1	13	12·0	+ 8·0
	Ksara	50·65	291	9	2·8	+1·3	16	22·8	+ 5·2
	Helsinki	55·57	325	9	39·8	+0·3	17	23·8	— 0·6
	Praha	62·80	314	10	29·3	—0·3	18	55·8	— 2·4
	Trieste	64·41	309	10	39·8	—0·4	19	19·8	+ 1·6
	Rome	66·43	306	10	52·1	—1·0	19	40·1	— 2·9
	Stuttgart	66·45	314	10	53·3	0	19	44·8	+ 1·6
	Strasbourg	67·40	314	10	58·8	—0·6	19	55·8	+ 1·1
	De Bilt	67·81	318	11	2·8	+0·9	20	2·8	+ 3·2
	Paris	70·59	315	11	19·8	+0·7	20	31·8	— 0·7
	Kew	71·21	319	11	22·8	0	20	40·8	+ 1·1
	Alger Univ	75·12	304	11	45·8	+0·1			
	Brisbane	78·69	130	12	5·8	+0·2			
	Toledo	79·26	309	12	6·8	—1·9	22	4·8	— 3·9
	Tammanrasset	79·45	290	12	11·8	+1·1	22	8·8	— 1·9
	Riverview	81·79	137	12	29·8	+7·7	22	35·8	+ 0·8
13	Chatra	8·69	251	2	11·1	+1·1	3	54·1	+ 4·3
	Calcutta	10·32	226	2	30·1	—2·4	4	27·1	— 2·9
	New Delhi	16·81	269	3	57·1	—1·2	7	0·1	— 4·0
	Hyderabad	20·58	237	4	43·1	+0·1	8	33·1	+ 4·2
	Poona	23·43	246	5	11·1	—0·5	9	31·1	+ 9·2
	Bombay	24·06	248	5	19·1	+1·4	9	36·1	+ 3·2
	Colombo	27·64	205	5	51·1	—0·1	10	31·1	— 1·3
	Ksara	50·94	291	9	7·1	+2·0	16	35·1	+13·5

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc	Azimuth Degrees from North	Observed travel time for *P*		Obs.—Cal.	Observed travel time for *S*		Obs.—Cal.
		Δ	z	(min)	(sec)	(sec)	(min)	(sec)	(sec)
13 (*contd*)									
	Upsala	59·13	325	10	2·1	—3·8	18	11·1	— 0·3
	Praha	62·80	314	10	29·1	—0·4	18	56·1	— 2·1
	Jena	64·33	316	10	40·1	+0·5	19	21·9	+ 4·6
	Trieste	64·47	309	10	40·1	—0·5	19	19·1	+ 0·1
	Stuttgart	66·45	314	10	52·1	—1·1	19	38·1	— 5·1
	Rome	66·52	306	10	51·7	—2·1	19	41·9	— 3·2
	Strasbourg	67·42	314	11	0·1	+0·7	19	57·1	+ 2·2
	Paris	70·58	316	11	19·1	+0·2	20	32·1	— 0·3
	Kew	71·15	320	11	23·1	+0·7	20	41·1	+ 2·1
	Tortosa	73·24	309	11	47·1	+0·7			
	College	73·31	24	11	33·1	—2·1	21	8·1	+ 4·4
	Brisbane	78·63	131	12	5·1	—0·2			
	Tammanrasset	79·65	290	12	13·1	+2·3	22	19·1	+ 6·3
	Cartuja	79·66	307	12	14·1	+3·2	22	4·1	— 8·8
	Riverview	81·80	137	12	23·1	+0·9			
	Pretoria	85·64	237	12—	41·1	—0·6			
	Hungry Horse	97·48	20	13	37·1	+0·4			
	Shasta	101·10	29	13	54·1	+0·7			
14	Chatra	7·50	249	1—	53·0	—0·3	3	18·0	— 2·1
	Calcutta	9·39	220	2	22·0	+2·2	4	3·0	+ 0·7
	New Delhi	15·50	270	3	40·0	—1·4	6	29·0	— 5·6
	Hyderabad	19·50	234	4	29·0	—2·3	8	5·0	— 1·0
	Poona	22·26	244	5	0	—0·1	9	1·0	+ 0·1
	Bombay	22·89	247	5	8·0	+1·7	9	13·0	+ 0·8
	Kodaikanal	25·46	223	5	31·0	—0·2	10	2·0	+ 5·4
	Ksara	49·70	291	8	58·0	+2·3	16	17·0	+ 6·7
	Upsala	58·36	325	10	0	+0·7	18	4·0	+ 2·7
	Praha	61·84	314	10	24·0	+0·8			
	Stuttgart	65·49	314	10	47·0	—0·1	19	28·0	— 3·5
	Strasbourg	66·44	314	10	53·0	—0·2	19	43·0	— 0·1
	De Bilt	67·49	318	10	57·0	—2·9	19	53·0	— 2·8
	Paris	69·64	315	11	18·0	+1·2	20	30·0	+ 1·6
	Kew	70·24	319	11	18·0	+1·2	20	30·0	+ 1·6
	College	73·82	23	11	38·0	—0·1			
	Alger Univ	74·16	303	11	39·0	—1·2			
	Tammanrasset	78·50	290	12	4·0	—0·6			
	Brisbane	79·57	130	12	10·0	—0·4			
	Hungry Horse	97·90	19	13	39·0	+0·2			
15	Chatra	8·78	269	2	10·2	—1·0	3	49·2	— 2·9
	Calcutta	9·24	241	2	21·2	+3·7	4	7·2	+ 3·8
	New Delhi	17·48	273	4	4·2	—2·5	7	9·2	—11·2
	Hyderabad	19·81	244	4	35·2	+0·4	8	9·2	— 3·7
	Poona	23·02	253	5	6·2	—1·4	9	6·2	— 8·5
	Bombay	23·76	255	5	15·2	+0·4	9	28·2	+ 1·5
	Kodaikanal	25·14	231				10	57·2	+ 6·0
	Ksara	52·28	293	9	15·2	—0·1	16	54·2	+14·2
	Praha	64·83	315	10	44·2	+1·3			
	Stuttgart	68·48	315	11	3·7	—2·3	20	9·2	+ 1·6
	Strasbourg	69·43	312	11	10·2	—1·7			
	Paris	72·63	316	11	31·2	0			
	Kew	73·28	325	11	39·2	+4·1	21	13·2	+ 9·9
	College	75·32	23	11	45·2	—1·7			
	Dublin	75·83	323	11	53·2	+2·4	20	26·2	— 5·5
	Brisbane	76·70	131	11	53·2	—1·4			
	Tammanrasset	81·03	291	12	16·7	—1·5			
	Pretoria	84·76	238	12	35·2	—2·1			
	Hungry Horse	99·54	19	13	48·2	+1·9			

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc	Azimuth Degrees from North	Observed travel time for *P*		Obs.—Cal.	Observed travel time for *S*		Obs.—Cal.
		△	z	(min)	(sec)	(sec)	(min)	(sec)	(sec)
16	Calcutta	10·90	204	2	33·2	—7·2			
	New Delhi	14·18	258	3	18·2	—6·1	5	56·2	— 7·3
	Hyderabad	20·06	225	4	38·2	+0·5	8	22·2	+ 3·9
	Poona	22·21	236	4	58·2	—1·4	9	0·2	+ 3·6
	Bombay	22·70	238	5	5·2	+0·8			
	Ksara	47·30	288	8	37·2	+0·2	15	35·2	+ 4·5
	Praha	58·75	312	10	3·2	+1·1	17	58·2	— 8·2
	Stuttgart	62·40	312	10	25·2	—1·7	18	50·2	— 5·7
	Strasbourg	63·35	312	10	23·2	—10·0	19	0·2	— 4·9
	De Bilt	63·71	317	10	8·2	—27·4	19	3·2	— 6·4
	Paris	66·50	318	10	53·2	—0·5			
	Toledo	74·69	307	11	42·2	—1·1			
	Cartuja	75·75	305	11	52·2	+2·9	21	25·2	— 5·6
	Tammanrasset	76·02	288	11	50·2	—0·7			
17	Chatra	6·71	250	1	43·9	+1·7	2	57·9	— 2·4
	New Delhi	14·88	271	3	31·9	—1·5	6	13·9	— 6·2
	Poona	21·48	244	4	51·9	—0·3	8	42·9	— 3·5
	Bombay	22·10	247	4	47·9	—10·6	9	2·9	+ 4·9
	Kodaikanal	24·66	223	5	22·9	—0·6	9	46·9	+ 3·8
	Ksara	49·27	291	8	55·9	+3·5			
	Praha	61·73	314	10	21·9	—0·6	18	40·9	— 3·8
	Stuttgart	65·37	314	10	45·9	—0·6	19	39·9	+ 9·8
	Strasbourg	66·32	314	10	53·9	+1·5			
	Besancon	67·88	313	11	1·9	—0·5			
	Paris	69·53	315	11	12·9	+0·4			
	Kew	70·22	318	11	22·9	+6·1			
	Alger Univ	73·91	303	11	36·9	—1·8			
	Tammanrasset	78·06	289	12	0·9	—1·2			
18	Chatra	7·57	256	1	53·7	—0·6	3	5·7	—16·1
	New Delhi	15·98	274	3	36·7	—0·7	6	18·7	—27·2
	Hyderabad	19·26	237	4	20·7	—7·7	7	50·9	— 9·8
	Poona	22·20	247	5	1·7	+2·2	8	58·7	— 1·1
	Bombay	22·89	249	5	6·7	+0·4	9	6·7	— 5·7
	Kodaikanal	24·98	225	5	24·7	—1·9	9	49·7	+ 1·1
	Ksara	50·49	291	9	1·7	0	16	23·7	+ 8·3
	Praha	62·91	314	10	29·7	—0·6			
	Stuttgart	66·55	314	10	53·7	—0·2	19	33·7	—10·8
	Strasbourg	67·51	315	10	59·7	—0·3			
	Paris	70·71	315	11	19·7	0			
	Kew	71·25	319	11	24·7	+1·7	20	39·7	— 0·5
	Alger Univ	75·13	304	11	44·7	—1·1			
	Tammanrasset	79·27	290	12	8·7	—0·1			
19	Calcutta	9·97	221	2	29·9	+2·3			
	New Delhi	15·73	269	3	39·9	—4·6	6	28·9	—11·2
	Hyderabad	19·96	238	4	36·9	+0·3	8	16·9	+ 0·7
	Poona	22·68	245	5	2·9	—1·3	9	6·9	— 1·7
	Bombay	23·29	246	5	8·9	—1·3	9	17·9	— 1·6
	Kodaikanal	25·99	224	5	36·9	+0·8	10	3·9	— 1·3
	Ksara	49·71	290	8	57·9	+1·8	16	17·9	+13·6
	Trieste	63·27	310	9	28·9	—3·7			
	Upsala	58·04	325	10	4·9	+7·9	18	2·9	+ 5·8
	Praha	61·63	314	10	26·9	+5·1	18	48·9	+ 5·4
	Stuttgart	65·28	314	10	45·9	+0·1	19	27·9	— 1·0
	Strasbourg	66·23	314	10	51·9	0	19	48·9	+ 8·3
	De Bilt	66·61	318	10	53·9	—0·3			
	Paris	69·39	315	11	11·9	+0·3	20	19·5	+ 1·5
	Kew	70·01	319	11	16·9	+1·5	20	30·9	+ 5·2
	College	73·25	23	11	33·9	—0·9			
	Alger Univ	74·05	304	11	36·9	—2·6			

TABLE 3 *(contd)*

S. No. of shock	Station	Degrees of arc Δ	Azimuth Degrees from North z	Observed travel time for *P* (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for *S* (min)	(sec)	Obs.—Cal. (sec)
19 *(contd)*	Toledo	77·54	309	11	58·9	— 0·3			
	Tammanrasset	78·51	290	12	4·9	+ 0·3			
	Brisbane	79·83	130	12	11·9	+ 0·1			
	Shasta	101·14	28	14	0·9	+ 7·4			
20	Chatra	6·97	251	1	48·2	+ 2·4	3	5·2	— 1·6
	Calcutta	8·71	222	2	9·2	— 0·9	3	42·2	+16·8
	New Delhi	15·15	271	3	33·2	— 3·8	6	12·2	—14·2
	Hyderabad	18·84	234	4	19·2	— 4·4	7	49·2	— 2·1
	Poona	21·69	244	4	53·2	— 1·6	8	48·8	— 1·6
	Bombay	22·32	247	5	4·2	+ 3·5	8	59·2	— 2·8
	Kodaikanal	24·79	223	5	34·2	+ 9·4	9	55·2	+ 9·9
	Ksara	49·59	291	8	56·2	+ 1·3			
	Budapest	59·57	310	10	9·2	+ 1·5			
	Upsala	58·67	325	10	11·2	+ 9·7	18	9·2	+ 3·8
	Praha	62·02	314	10	24·2	— 0·2	18	51·2	+ 2·8
	Trieste	63·57	309	10	33·2	— 1·4	19	6·2	— 1·6
	Stuttgart	65·67	314	10	48·7	+ 0·4	19	30·2	— 3·5
	Strasbourg	66·62	314	10	54·2	— 0·1	20	0·2	+14·9
	De Bilt	67·09	318	10	58·2	+ 0·9			
	Paris	69·84	315	11	15·2	+ 0·8	20	25·2	+ 1·5
	Kew	70·50	318	11	19·2	— 0·2	20	42·2	+10·8
	Alger Univ	74·22	303	11	39·2	— 1·3			
	College	74·52	23	11	41·2	— 1·1	21	12·2	— 5·0
	Tammanrasset	78·37	289	12	4·2	+ 0·4			
	Pretoria	83·93	236	12	38·2	+ 5·0			
	Shasta	102·42	28	13	58·2	— 1·0			
21	Chatra	8·91	269	2	11·9	— 1·1	3	51·9	— 3·4
	Calcutta	9·40	241	2	22·9	+ 3·2	4	16·9	+ 9·5
	Hyderabad	19·94	244	4	34·9	— 1·5	8	13·9	— 1·9
	Poona	23·18	253	5	8·9	— 0·2	9	20·9	+ 3·4
	Bombay	23·90	255	5	15·9	— 0·2	9	32·9	+ 2·8
	Ksara	52·39	293	9	18·9	+ 2·7	16	48·9	+ 7·4
	Upsala	61·44	326	10	20·9	+ 0·4	18	43·9	+ 2·9
	Praha	64·92	315	10	42·9	— 0·5	19	0·9	—23·6
	Trieste	66·48	311	10	52·9	— 0·5	19	39·9	— 3·7
	Stuttgart	68·55	315	11	6·4	— 0·1	20	14·9	+ 6·5
	Strasbourg	69·52	312	11	12·9	+ 0·4	20	21·9	+ 2·0
	Paris	72·72	316	11	32·9	+ 1·1	21	3·9	+ 6·9
	Kew	73·39	320	11	35·9	+ 0·3	21	4·9	+ 0·3
	College	75·26	23	11	45·9	— 0·6	21	28·9	+ 3·4
	Tammanrasset	81·09	291	12	17·9	— 0·6			
	Pretoria	84·87	238	12	35·9	— 2·0			
	Hungry Horse	99·48	19	13	47·9	+ 1·9			
22	Calcutta	9·03	225	2	7·0	— 7·1	3	47·0	—11·2
	New Delhi	15·62	274	3	41·0	— 2·2	6	34·0	— 3·5
	Hyderabad	19·23	237	4	26·0	— 2·1	8	6·0	+ 6·0
	Poona	22·08	247	4	59·0	+ 0·7	9	1·0	+ 3·7
	Bombay	22·71	249	5	8·0	+ 3·4	9	13·0	+ 3·9
	Kodaikanal	25·09	225	5	26·0	— 1·6	9	58·0	+ 7·6
	Colombo	26·45	216	5	51·0	+10·7	10	16·0	+ 3·0
	Ksara	50·04	291	9	8·0	+ 9·8			
	Upsala	58·92	325	10	3·0	— 0·3	18	6·0	— 2·7
	Praha	62·36	314	10	26·5	— 0·2	18	51·0	— 1·6
	Trieste	63·93	310	10	35·0	— 2·0	19	10·0	— 2·3
	Stuttgart	65·99	314	10	51·0	+ 0·7	19	35·0	— 2·7
	Strasbourg	66·96	314	10	57·0	+ 0·5	19	49·0	— 0·4
	De Bilt	67·41	318	10	59·0	— 0·4	19	55·0	+ 0·2
	Paris	70·16	315	11	17·0	+ 0·7			
	Kew	70·81	319	11	20·0	— 0·3	20	50·0	+14·9

TABLE 3 *(contd)*

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for *P* (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for *S* (min)	(sec)	Obs.—Cal. (sec)
22 (*contd*)	College	74·55	23	11	40·0	— 2·4	21	13·0	—4·6
	Alger Univ	74·59	304	11	41·0	— 1·6			
	Brisbane	79·16	130	12	8·0	— 0·2			
	Tammanrasset	78·80	290	12	8·0	+ 1·9			
	Pretoria	84·30	233	12	36·0	+ 1·0			
	Hungry Horse	98·46	19	13	42·0	+ 0·6			
23	Chatra	8·74	269	2	12·2	+ 1·6	3	55·2	+ 4·1
	Calcutta	9·07	241				3	55·2	— 4·0
	New Delhi	17·49	273	4	4·2	— 2·6	7	18·2	— 2·5
	Hyderabad	19·65	244	4	32·2	— 1·3	8	14·2	+ 4·9
	Poona	22·92	253	5	8·2	— 0·1	9	18·2	+ 5·3
	Bombay	23·64	255	5	15·2	+ 1·5	9	30·2	+ 4·6
	Kodaikanal	24·92	231	5	32·2	+ 6·2	10	1·2	+13·7
	Ksara	52·34	293	9	17·2	+ 1·4	16	49·2	+ 8·4
	Praha	65·00	315	10	45·2	+ 1·2			
	Stuttgart	68·63	315	11	6·2	— 0·9			
	Strasbourg	69·60	312	11	12·2	— 0·8			
	De Bilt	70·05	319	11	24·2	+ 8·5			
	Besancon	71·15	314	11	21·2	— 1·2			
	Paris	72·80	316	11	32·2	— 0·1			
	Tammanrasset	81·08	291	12	19·2	+ 0·7			
24	Chatra	8·32	262	2	4·3	— 0·5	3	30·3	—10·3
	Calcutta	9·51	234	2	22·3	+ 1·0	4	8·3	— 1·8
	New Delhi	16·78	275	3	54·3	— 3·6	6	56·3	— 8·1
	Hyderabad	19·93	241	4	30·3	— 6·0	8	15·3	— 0·2
	Bombay	23·63	252	5	15·3	+ 1·7	9	26·3	+ 0·9
	Kodaikanal	25·55	229	5	32·3	+ 0·3	10	2·3	+ 4·2
	Colombo	26·76	220	5	41·3	— 1·9			
	Ksara	51·27	292	9	8·3	+ 0·7	16	29·3	+ 3·2
	Helsinki	56·29	325	9	45·3	+ 0·6	17	34·3	— 0·7
	Upsala	59·99	325	10	10·3	— 0·3	18	23·3	+ 0·8
	Praha	63·52	315	10	33·8	— 0·5	19	9·3	+ 2·1
	Trieste	65·12	310	10	45·3	+ 0·5	19	27·3	+ 0·3
	Stuttgart	67·17	314	10	57·8	0	19	52·3	+ 0·4
	Strasbourg	68·12	314	11	3·3	— 0·5	20	3·3	0
	De Bilt	68·54	319	11	6·3	— 0·1	20	11·3	+ 3·0
	Paris	71·32	316	11	24·3	+ 0·9	20	42·3	+ 1·3
	Kew	71·94	319	11	28·3	+ 1·2	20	50·3	+ 2·2
	College	74·34	24	11	42·3	+ 1·1	21	15·3	+ 0·1
	Alger Univ	75·52	304	11	49·3	— 0·4			
	Brisbane	77·97	131	11	58·3	— 3·3			
	Cartuja	80·37	307	12	13·3	— 1·3	22	31·3	+11·0
	Tammanrasset	80·06	290	12	13·3	+ 0·3	22	14·3	— 2·8
	Riverview	81·05	137	12	24·3	+ 6·0	22	27·3	— 0·1
	Pretoria	85·00	237	12	37·3	— 1·1			
	Hungry Horse	98·52	20	14	42·3	+ 0·7			
25	Chatra	8·34	262	2	4·4	— 0·7			
	Calcutta	9·32	234	2	30·4	+11·8	4	11·4	+ 6·0
	New Delhi	16·88	275	3	53·4	— 5·7	6	50·4	—16·3
	Hyderabad	19·75	241	4	42·4	+ 8·3	8	23·4	+11·9
	Poona	22·86	250	5	10·4	+ 4·4	9	16·4	+ 4·5
	Bombay	23·54	252	5	22·4	+ 9·8	9	29·4	+ 5·6
	Kodaikanal	25·31	229	5	33·4	+ 3·8	9	47·8	— 6·3
	Colombo	26·44	220				10	19·4	+ 6·5
	Ksara	51·47	292	9	13·4	+ 4·2	16	28·4	— 0·5
	Praha	64·86	315	10	36·4	— 0·2			
	Trieste	65·45	310	10	46·4	— 0·4			
	Stuttgart	67·51	314	11	0·4	+ 0·2	20	0·4	+ 4·4

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for *P* (min)	(sec)	Obs. —Cal. (sec)	Observed travel time for *S* (min)	(sec)	Obs.—Cal. (sec)
25 (*contd*)	Strasbourg	68·47	314	11	3·4	— 2·6			
	Paris	71·56	316	11	26·4	+ 0·9			
	College	74·73	24	11	42·4	— 1·0			
	Kew	72·31	319	11	43·4	+14·1	21	1·4	+9·1
	Alger Univ	76·12	304	11	51·4	0			
	Brisbane	77·63	131	11	57·4	— 2·3			
	Tammanrasset	80·26	290	12	15·4	+ 1·4			
	Pretoria	84·79	237	12	32·4	— 5·1			
	Hungry Horse	98·92	20	13	46·4	+ 3·0			
26	Chatra	7·04	272	1	48·6	+ 1·9	3	13·6	+ 5·0
	Calcutta	7·47	236	2	4·6	+11·7	3	44·6	+25·3
	New Delhi	15·88	280	3	42·6	— 3·9	6	32·6	—11·0
	Hyderabad	17·99	242	4	8·6	— 4·5	7	9·6	—22·5
	Poona	21·24	252	4	49·6	— 0·2	8	47·6	+ 5·7
	Bombay	21·95	253	4	55·6	— 2·4	8	55·6	+ 0·3
	Kodaikanal	23·42	228	5	17·6	+ 6·1			
	Colombo	24·54	219	5	23·6	+ 1·3			
	Nagoya	36·65	66	7	12·6	+ 2·6			
	Sapporo	40·70	54	8	27·6	—16·2			
	Ksara	50·97	293	9	10·6	+ 5·2	16	31·6	+ 9·6
	Jena	65·67	316	10	49·6	+ 1·3	19	26·6	— 7·1
	Strasbourg	68·67	315	11	6·6	— 0·6	20	3·6	— 6·3
	Paris	71·91	316	11	29·6	+ 2·6	20	41·6	— 6·2
	Alger Univ	75·98	304	11	49·6	— 1·0			
	Tammanrasset	79·66	290	12	10·6	— 0·2			
	Toledo	79·75	309	12	9·6	— 1·7			
	Pretoria	82·97	237	12	29·6	+ 1·3			
27	Chatra	7·18	244	1	52·0	+ 3·2	3	12·0	— 0·1
	New Delhi	15·24	268	3	37·0	— 1·1	6	22·0	— 6·5
	Hyderabad	19·27	232	4	26·0	— 2·6	7	51·0	— 9·9
	Poona	22·02	243	4	58·0	+ 0·3	8	56·0	— 0·6
	Kodaikanal	25·29	222	5	31·0	+ 1·4	9	55·0	+ 1·3
	Ksara	49·43	290	8	55·0	+ 1·4	16	19·0	— 0·9
	Praha	61·63	314	10	22·0	+ 0·3			
	Trieste	63·19	309	10	32·0	— 0·1			
	Stuttgart	65·26	313	10	46·7	+ 1·0	19	28·0	— 0·7
	Strasbourg	66·21	313	10	52·0	+ 0·3			
	Paris	70·02	315	11	14·0	— 1·5			
	Alger Univ	73·90	303	11	38·0	— 0·6			
	College	73·87	23	11	40·0	+ 1·6			
	Tammanrasset	78·22	289	12	2·0	— 1·0			
	Pretoria	84·34	236	12	34·0	— 1·3			
28	New Delhi	16·26	270	3	44·6	— 6·7	6	39·6	—12·8
	Hyderabad	19·15	239	4	24·6	— 2·6	8	4·6	+ 6·4
	Poona	22·22	248	5	0·6	+ 1·0	9	4·6	+ 4·4
	Bombay	22·92	250	5	8·6	+ 2·0	9	16·6	+ 3·7
	Ksara	50·93	292	9	7·6	+ 2·5	16	27·6	+ 6·2
	Praha	63·51	314	10	36·1	+ 1·9			
	Stuttgart	67·14	314	10	54·6	— 3·1	19	44·6	— 7·0
	Rome	66·99	306	10	54·6	— 2·1			
	Strasbourg	68·11	314	11	5·6	+ 1·8			
	Paris	71·31	316	11	18·6	— 4·8			
	Kew	71·98	319	11	30·6	+ 3·2			
	Tammanrasset	79·70	290	12	9·6	— 1·4			
	Pretoria	84·19	237	12	35·6	+ 1·2			
	Hungry Horse	99·02	20	13	44·6	+ 0·7			

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for *P* (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for *S* (min)	(sec)	Obs.—Cal. (sec)
29	Chatra	8·81	255	2	11·8	+ 0·2	3	51·3	— 1·5
	Calcutta	10·58	206	2	34·8	— 1·1	4	28·8	— 7·6
	New Delhi	16·88	271	3	57·8	— 1·4	6	57·8	— 8·9
	Poona	23·54	247	5	11·8	— 0·8	9	27·8	+ 4·0
	Bombay	24·15	250	5	19·8	+ 1·2	9	37·8	+ 3·4
	Kodaikanal	26·46	227	5	43·8	+ 3·4	10	13·8	+ 0·6
	Colombo	27·75	219	5	50·8	— 1·5	10	38·8	+ 4·6
	Ksara	50·98	291	9	7·8	+ 2·5	16	35·8	+13·7
	Istanbul	54·78	301	9	33·8	0	17	4·8	— 9·1
	Helwyn	55·75	288	9	40·8	0	17	29·8	+ 3·0
	Beograd	60·15	308	10	11·8	+ 0·1			
	Praha	62·82	314	10	29·8	+ 0 2	19	0·8	+ 2·4
	Trieste	64·49	310	10	38·8	— 1·3	19	21·8	+ 2·6
	Zurich	67·32	313	10	57·0	— 1·8			
	De Bilt	67·77	318	11	2·8	+ 1·1	20	0·8	+ 1·7
	Kew	71·15	319	11	22·8	+ 0·4	20	40·8	+ 1·8
30	Chatra	7·30	267	1	50·4	— 0·1	3	10·4	— 4·7
	Calcutta	8·20	235	2	3·9	+ 0·8	3	30·9	— 6·5
	New Delhi	16·06	278	3	37·9	—10·9	6	28·9	—18·9
	Poona	21·75	250	4	52·9	— 2·1	8	46·9	— 4·6
	Bombay	22·46	252	5	2·9	+ 0·9	9	4·9	+ 0·3
	Kodaikanal	24·27	228				9	30·9	— 5·6
	Ksara	50·76	293	9	4·9	+ 1·1	16	22·9	+ 3·8
	Istanbul	55·00	302	9	34·9	— 0·5	16	14·9	— 1·9
31	Chatra	6·56	257	1	44·1	+ 4·1	3	2·6	+ 6·0
	Calcutta	8·14	224	2	10·3	+ 8·0	3	38·3	+ 2·2
	New Delhi	14·99	274	3	30·3	— 4·5	6	13·3	— 8·4
	Hyderabad	18·34	236	4	15·3	— 2·1	7	49·3	+ 9·3
	Poona	21·37	247	4	51·3	+ 0·2	8	39·3	— 5·1
	Bombay	21·91	249	4	57·3	+ 0·8	8	57·3	+ 2·8
	Kodaikanal	24·19	224	5	28·3	+ 9·3	9	46·3	+11·2
	Colombo	25·59	215	5	39·3	+ 7·0	10	5·3	+ 6·5
	Manila	28·39	114				10	37·3	— 7·2
	Fukuoka	31·04	71	6	21·3	— 0·4			
	Tokyo	38·83	67	7	29·3	+ 0·9	13	12·6	—14·2
	Ksara	49·65	292	8	59·3	+ 4·0	16	9·3	+ 5·6
	Helwyn	54·30	288	9	30·3	0	17	6·3	— 1·1
	Beograd	59·39	307	10	6·3	— 0·2	18	17·2	+ 2·5
	Praha	62·33	314	10	26·3	— 0·2	18	47·3	— 5·0
	Trieste	63·84	310	10	36·3	— 0·1	19	8·3	— 2·9
	Rome	65·74	306	10	47·3	— 1·5	19	29·3	— 5·3
	Stuttgart	65·96	314	10	50·3	+ 0·2	19	36·3	— 1·0
	Chur	66·66	312	10	52·3	— 2·3			
	De Bilt	67·43	318	11	1·3	+ 1·8	19	57·3	+ 5·2
	Kew	70·85	319	11	21·3	+ 0·8	20	34·3	— 1·2
	College	75·16	23	11	45·3	— 0·6	21	22·3	— 2·1
	Brisbane	79·26	129	12	8·3	— 0·4			
	Hungry Horse	99·24	19	13	45·3	+ 0·4			
32	Chatra	8·56	264	2	6·8	— 1·3	3	48·0	+ 1·4
	Calcutta	9·32	236	2	33·0	+14·2	4	4·0	— 1·4
	New Delhi	17·19	276	4	1·0	— 2·0	7	4·0	— 9·8
	Poona	22·90	250	5	5·0	— 2·3	8	58·0	—14·6
	Bombay	23·71	252	5	15·0	+ 0·7	9	29·0	+ 2·2
	Kodaikanal	25·28	229	5	32·0	+ 2·6			
	Ksara	51·88	292	9	17·0	+ 4·8	16	46·0	+11·5
	Praha	64·31	315	10	41·0	+ 1·5	19	16·0	— 1·0
	Trieste	65·88	310	10	57·0	+ 7·4	19	40·0	+ 3·7
	Stuttgart	67·95	314	11	3·0	+ 0·2	20	8·0	+ 6·7
	Strasbourg	68·91	314	11	9·0	+ 0·3	20	22·5	+ 9·5

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc Δ	Azimuth Degrees from North z	Observed travel time for P (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for S (min)	(sec)	Obs.—Cal. (sec)
32 (*contd*)	Paris	72·10	316	11	28·0	— 0·1			
	Kew	72·76	319	11	34·0	+ 2·0	21	6·0	+ 8·5
	College	74·95	24	11	42·0	— 2·7			
	Alger Univ	76·54	304	11	52·0	— 1·7			
	Tammanrasset	80·62	290	12	15·0	— 1·0			
	Pretoria	84·91	237	12	34·0	— 3·7			
	Hungry Horse	99·11	20	13	45·0	+ 0·5			
33	Chatra	6·47	250	1	40·8	+ 1·9	2	53·8	— 0·5
	Calcutta	8·18	220	2	2·1	— 0·7	3	31·8	— 5·3
	New Delhi	14·83	271	3	29·8	— 3·0	6	6·8	—12·1
	Hyderabad	18·35	235	4	14·8	— 2·7	7	37·8	— 2·4
	Poona	21·20	244	4	49·8	+ 0·4	8	34·8	— 6·4
	Bombay	21·84	247	5	0·8	+ 4·9	8	58·8	+ 5·6
	Colombo	25·68	214	5	32·8	— 0·4			
	Ksara	49·42	291				16	8·8	+ 7·9
	Praha	62·05	314	10	25·8	+ 1·2	18	35·8	—12·9
	Messina	64·34	301	10	42·8	+ 3·0	19	17·8	+ 0·4
	Stuttgart	65·68	314	10	48·3	0			
	Zurich	66·50	317	10	50·8	— 2·8			
	Paris	69·87	315	11	15·3	+ 0·7			
	Kew	70·57	318	11	20·8	+ 1·9			
	Alger Univ	74·14	303	11	39·8	— 0·2			
	College	75·02	23	11	43·8	— 2·3			
	Alicante	76·02	306	11	49·8	— 1·0	21	39·8	+ 6·0
	Tammanrasset	78·19	289	12	2·8	— 0·1			
	Pretoria	83·42	236	12	28·8	— 1·7			
	Hungry Horse	99·07	18	13	38·8	— 5·3			
34	Chatra	7·08	260	1	55·8	+ 8·4	3	19·8	+10·2
	Calcutta	8·34	229	2	14·4	+ 9·4	3	59·4	+18·3
	New Delhi	15·64	275	3	42·4	— 0·9	6	32·4	— 5·5
	Hyderabad	18·67	238	4	19·4	— 1·9	7	56·4	+ 9·0
	Poona	21·68	248	4	56·4	+ 2·2	8	51·4	+ 0·8
	Bombay	22·36	250	5	5·4	+ 4·5	9	9·4	+ 6·8
	Ksara	51·34	292	9	4·4	+ 3·8			
	Trieste	64·49	310	10	39·4	— 1·2			
	Stuttgart	66·61	314	10	53·4	+ 0·1	19	41·4	— 3·8
	Strasbourg	67·59	314	11	0·4	— 0·1			
	Besancon	69·12	313	11	9·4	— 0·6			
	Paris	70·80	316	11	20·4	+ 0·2			
	Tammanrasset	79·09	290	12	8·4	+ 0·6			
	Pretoria	83·74	237	12	32·4	+ 0·3			
35	Chatra	6·73	269	1	43·2	+ 0·7	3	5·4	+ 4·6
	Calcutta	7·72	235	1	57·4	+ 1·0	3	29·4	+ 3·8
	New Delhi	15·41	279	3	39·4	— 1·0	6	34·4	+ 1·9
	Poona	21·20	251	4	47·4	— 2·1	8	44·4	+ 3·2
	Bombay	21·89	253	4	57·4	+ 1·0	8	58·6	+ 4·5
	Ksara	50·24	293	9	27·4	+27·5			
	Stuttgart	66·77	314	10	53·4	— 1·9			
	Besancon	69·27	314	11	13·4	+ 2·5			
	Paris	70·95	316	11	22·4	+ 1·2			
	Strasbourg	67·72	314	11	24·4	+23·1			
	Tammanrasset	78·97	290	12	5·4	— 1·7			
36	Chatra	8·78	269	2	12·7	+ 1·5	3	55·7	+ 3·6
	Calcutta	8·72	238	2	5·7	— 4·7	3	41·7	— 8·9
	New Delhi	17·68	279	4	9·7	+ 0·4	7	14·7	—10·3
	Hyderabad	19·12	232	4	28·7	+ 1·7			
	Poona	22·77	252	5	5·7	+ 0·6	9	8·7	— 1·5
	Bombay	23·50	254	5	16·7	+ 4·4	9	23·1	0

TABLE 3 *(contd)*

S. No. of shock	Station	Degrees of arc $\triangle$	Azimuth Degrees from North z	Observed travel time for P (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for S (min)	(sec)	Obs.—Cal. (sec)
36 *(contd)*	Stuttgart	69·25	314	11	10·7	— 0·1			
	Strasbourg	70·19	315	11	15·7	— 1·0			
	Besancon	71·25	314	11	24·7	— 1·3			
	Tammanrasset	81·43	290	12	20·7	+ 0·5			
37	Chatra	9·44	255	2	22·0	— 1·1	4	13·3	+ 4·9
	New Delhi	17·41	271	4	5·3	— 0·6	7	25·3	+ 6·5
	Hyderabad	21·40	240	4	52·3	+ 0·8	8	57·3	+12·4
	Poona	24·24	248	5	20·3	+ 0·9	9	43·3	+ 7·3
	Bombay	24·88	250	5	25·3	— 0·4	9	51·3	+ 4·4
	Kodaikanal	27·24	229	5	48·3	— 2·0	9	30·3	+ 4·3
	Colombo	28·53	220	5	54·3	— 6·5			
	Ksara	51·25	291	9	9·3	+ 1·6	16	35·3	+ 9·5
	Praha	62·77	314	10	31·3	+ 2·0			
	Stuttgart	66·42	314	10	51·8	— 1·5			
	Strasbourg	67·37	314	10	59·3	0			
	Besancon	68·96	314	11	8·3	— 0·7			
	Alger Univ	75·42	305	11	46·3	— 1·1			
	Tammanrasset	80·06	291	12	13·3	+ 0·2			
	Pretoria	86·50	238	12	44·3	— 1·7			
38	Tocklai	1·02	199	$(\overline{P})$0	20·7	+ 0·4			
	Chatra	6·82	263	1	51·7	+ 7·8	3	9·7	+ 6·6
	Calcutta	7·75	229	1	53·7	— 3·1	3	19·7	— 6·6
	New Delhi	15·49	277	3	41·7	+ 0·3	6	35·7	+ 1·3
	Hyderabad	18·13	239	4	8·7	— 6·1			
	Poona	21·23	249	4	48·7	— 1·0			
	Bombay	21·92	251	4	56·7	0	8	57·7	+ 3·0
	Stuttgart	66·91	314	10	56·2	0			
39	Tocklai	1·00	201	$(\overline{P})$0	20·0	0			
	Tezpore	1·95	240	$(\overline{P})$0	39·0	+ 0·2			
	Chatra	6·65	265	$(\overline{P})$1	47·0	+ 5·7	3	4·0	+ 4·2
	New Delhi	15·35	277	3	39·5	— 0·1	6	30·0	— 1·1
	Poona	21·52	249	4	51·8	— 0·8			
	Stuttgart	66·80	314	10	57·0	+ 0·4			
	Pretoria	83·09	236	12	29·0	+ 0·1			
40	Tocklai	2·53	188	0	41·5	— 1·4			
	Chatra	7·88	257	2	1·1	+ 2·4			
	New Delhi	16·29	273	3	50·1	— 0·6	6	57·1	+ 4·0
	Hyderabad	19·59	238	4	32·1	— 0·2	8	15·1	+ 7·1
	Poona	22·57	247	5	3·1	+ 0·1	9	11·1	+ 4·5
	Bombay	23·22	250	5	10·1	+ 0·6	9	24·1	+ 5·9
	Kodaikanal	25·31	226	5	27·1	— 2·6	9	56·1	+ 2·0
	Jena	64·61	316	10	44·1	— 0·4			
	Stuttgart	66·70	314	10	55·1	+ 0·2			
	Tammanrasset	79·55	290	12	8·1	— 2·2			
	Pretoria	84·65	237	12	36·1	— 0·7			
41	Tocklai	2·68	196	0	43·9	— 1·2	1	15·9	— 2·9
	Tezpore	3·40	218	1	0·9	+ 5·6	1	43·9	+ 6·8
	Chatra	7·47	251	1	54·9	+ 2·0	3	22·9	+ 3·6
	Calcutta	9·12	225	2	14·9	— 1·0	3	56·9	— 2·6
	New Delhi	15·72	271	3	42·9	— 1·5	6	33·4	— 6·5
	Hyderabad	19·33	236	4	28·9	— 0·4	7	52·9	— 9·3
	Poona	22·19	245	4	58·9	— 0·4	9	1·9	+ 2·2
	Bombay	22·84	248	5	9·9	+ 4·0	9	17·9	+ 6·4
	Kodaikanal	25·19	225	5	27·9	— 0·6	9	50·9	— 1·2
	Ksara	50·10	291	8	40·9	—17·1	16	16·9	+ 6·9
	Istanbul	54·08	301	9	28·9	+ 0·4			
	Jena	63·94	316	10	36·9	+ 0·1			

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for *P* (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for *S* (min)	(sec)	Obs.—Cal. (sec)
41 (*contd*)	Trieste	63·97	310	10	36·9	— 0·4			
	Messina	64·90	301	10	43·9	+ 0·7	19	23·9	— 0·4
	Rome	65·95	306	10	48·9	— 0·6			
	Stuttgart	66·05	314	10	50·4	— 0·2			
	Strasbourg	67·00	314	10	56·9	+ 0·1			
	Besancon	68·57	313	10	56·9	— 6·5			
	Paris	70·19	315	11	15·9	— 0·6			
	Kew	70·84	319	11	19·9	— 0·6	20	54·9	+19·5
	Rathfarnham Castle	73·39	322	11	36·9	+ 1·3			
	Alger Univ	74·65	304	11	41·9	— 1·0			
	Tammanrasset	78·88	290	12	6·9	+ 0·2			
	Brisbane	79·11	130	12	8·9	+ 1·2			
	Riverview	82·16	136				22	31·9	— 6·9
42	Tezpore	2·43	21	0	40·9	— 0·6	1	13·4	+ 0·9
	Tocklai	3·30	42	0	53·9	+ 0·2	1	32·9	— 1·7
	Calcutta	3·62	242	0	59·9	+ 1·4	1	45·9	+ 3·3
	Chatra	4·80	302	1	17·4	+ 2·1	2	14·9	+ 2·4
	New Delhi	13·66	291	3	16·3	— 1·1	5	48·8	— 2·3
	Poona	17·64	254	4	5·9	— 2·8	7	21·3	— 2·8
	Kodaikanal	19·57	227	4	32·9	+ 0·9			
43	Tocklai	2·27	180	0	39·5	+ 0·5	1	5·5	— 2·9
	Chatra	6·75	253	1	44·5	+ 1·3	3	2·0	+ 0·7
	Calcutta	8·47	221				3	35·5	— 8·8
	New Delhi	15·12	271	3	34·5	— 2·1	6	20·0	— 5·7
	Hyderabad	18·66	235	4	21·5	+ 0·2			
	Poona	21·51	244	4	51·5	— 1·6	8	43·5	— 3·5
	Bombay	22·16	247	5	1·5	+ 2·5	8	59·5	+ 0·4
	Stuttgart	65·79	314	10	49·0	— 0·1			
	Tammanrasset	78·40	289	12	4·5	+ 0·5			
44	Tocklai	1·83	172	0	34·9	+ 1·3	0	57·7	+ 0·5
	Tezpore	2·33	212	0	37·2	— 2·9	1	2·7	— 7·2
	Chatra	6·48	257	1	43·2	+ 4·1	2	57·2	+ 2·6
	Calcutta	8·03	222				3	32·7	— 0·6
	New Delhi	14·97	275	3	33·2	— 1·4	6	18·7	— 4·2
	Poona	21·17	246	4	49·7	+ 0·5			
	Bombay	21·82	249	4	54·7	— 1·1			
	Stuttgart	65·97	314	10	52·7	+ 2·5			
	Strasbourg	66·92	314	10	44·7	—11·6			
	Paris	70·16	315	11	15·7	— 0·7			
	Tammanrasset	78·39	290	12	2·7	— 0·6			
45	Tocklai	1·38	190	0	26·6	+ 0·1	0	47·4	+ 1·5
	Tezpore	2·10	224	0	37·4	+ 0·5	1	3·4	— 0·6
	Shillong	3·42	222	0	59·8	+ 4·2	1	41·4	+ 3·8
	Chatra	6·57	257	1	39·9	— 0·3	3	0·4	+ 5·5
	Calcutta	7·83	224	1	57·4	— 0·5	4	27·4	+ 0·9
	New Delhi	15·11	274	3	31·4	— 5·3	6	18·4	— 7·1
	Poona	21·12	247	4	46·4	— 2·2	8	35·4	— 4·3
	Bombay	21·80	249	4	57·4	+ 2·0	9	2·4	+10·0
46	Tocklai	3·87	209	1	2·1	0	1	51·1	+ 2·1
	Tezpore	4·65	221	1	10·1	— 3·1	2	6·6	— 2·1
	Shillong	5·98	221	1	32·6	+ 0·6	2	42·1	— 0·1
	Chatra	8·52	249	2	8·1	+ 0·4	3	52·1	+ 6·5
	New Delhi	16·42	269	3	52·1	— 1·2	6	55·6	— 0·5
	Poona	23·24	245	5	10·1	+ 0·4	9	27·1	+ 8·5
	Jena	63·76	316	10	38·1	+ 2·2			
	Stuttgart	65·88	314	10	48·1	— 1·5			
	Tammanrasset	79·22	290	12	7·1	— 1·4			

TABLE 3 *(contd)*

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for P (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for S (min)	(sec)	Obs.—Cal. (sec)
47	Tocklai	2·17	167	0	38·3	+ 0·6	1	4·7	— 1·1
	Tezpore	2·53	205	0	45·8	+ 0·5	1	13·3	— 1·7
	Shillong	3·83	211	0	58·6	— 2·8	1	40·6	— 7·4
	Chatra	6·40	254	1	41·3	+ 3·5	2	51·8	— 0·8
	Calcutta	8·15	220	2	3·3	+ 1·4	3	38·3	+ 2·0
	New Delhi	14·78	273	3	30·3	— 1·7	6	8·3	— 9·4
	Poona	21·14	245	4	48·3	— 0·6	8	26·3	—13·7
	Bombay	21·89	248	5	7·3	+12·9	9	0·3	+ 6·2
48	Tocklai	2·20	194	0	40·2	+ 2·0	1	9·2	+ 2·6
	Tezpore	3·00	221	0	50·3	+ 0·5	1	25·2	— 1·7
	Shillong	4·32	219	1	9·8	+ 1·2	2	0·7	+ 0·4
	Chatra	7·28	254	1	50·8	+ 0·5	3	12·7	— 1·8
	Calcutta	8·73	224	2	11·2	+ 0·6	3	48·2	— 2·6
	New Delhi	15·72	273	3	41·2	— 3·2	6	33·7	— 6·1
	Hyderabad	19·05	237	4	24·2	— 1·8	8	2·2	+ 6·2
	Poona	21·98	247	4	57·2	0	8	58·2	+ 2·4
	Bombay	22·64	249	5	5·2	+ 1·5	9	9·2	+ 1·4
	Kodaikanal	24·82	225	5	26·2	+ 1·1	9	51·2	+ 5·4
	Colombo	26·14	213	5	36·2	— 1·3	10	11·2	+ 3·3
	Ksara	50·23	291	9	3·2	+ 3·4	16	26·2	+14·4
	Istanbul	54·37	301	9	31·2	+ 0·5			
	Praha	62·72	314	10	30·6	+ 1·6	19	1·2	+ 4·0
	Stuttgart	66·35	314	10	52·7	+ 0·1			
	Zurich	67·18	312	10	58·1	+ 0·1			
	Strasbourg	67·32	314	10	59·2	+ 0·4			
	Paris	70·52	316	11	19·2	+ 0·6			
	College	74·92	23	11	42·2	— 1·2	21	19·2	— 0·3
	Brisbane	78·83	130	12	5·2	— 1·2			
	Tammanrasset	78·98	290	12	7·2	— 0·2			
	Hungry Horse	98·84	19	13	43·2	+ 0·1			
49	Tocklai	1·43	180	0	28·5	+ 1·2	0	47·3	+ 0·3
	Tezpore	2·17	221	0	37·8	0	1	3·8	— 2·0
	Shillong	3·48	220	0	57·8	+ 1·3	1	37·8	— 1·3
	Chatra	6·63	257	1	43·8	+ 2·8	3	0·3	+ 1·9
	Calcutta	7·90	224	1	57·5	— 1·3	3	23·8	— 6·2
	New Delhi	15·24	274	3	35·8	— 2·4	6	21·8	— 6·7
	Hyderabad	18·26	236	4	12·8	— 3·5	7	42·8	+ 4·6
	Poona	21·24	247	4	50·8	+ 0·9	8	40·8	— 1·1
	Bombay	21·91	249	4	56·8	+ 0·2	8	57·8	+ 3·3
	Kodaikanal	24·00	224	5	15·8	— 0·9	9	36·8	+ 4·9
	Colombo	25·31	215	5	29·8	+ 0·1	9	58·8	+ 4·7
	Ksara	50·00	292	9	0·8	+ 2·8	16	14·8	+ 6·2
	Istanbul	54·20	302	9	31·8	+ 2·4			
	Helwyn	54·64	288	9	24·8	— 7·9	17	6·8	— 5·2
	Budapest	60·28	311	10	14·8	+ 2·2			
	Praha	62·80	314	10	29·3	— 0·3	18	52·8	+ 0·6
	Copenhagen	62·86	321	10	30·8	+ 0·8	19	2·8	+ 3·9
	Jena	64·37	316	10	39·8	— 0·1	19	19·8	+ 2·0
	Padova	65·86	309	10	52·3	+ 2·8			
	Rome	66·18	306	10	48·8	— 2·7			
	Stuttgart	66·43	314	10	53·2	+ 0·1	19	44·8	+ 1·8
	Zurich	67·23	313	10	57·2	— 1·0	19	54·0	+ 1·3
	Strasbourg	67·40	314	10	58·8	— 0·5			
	Basel	67·83	313	11	1·4	— 0·6			
	De Bilt	67·93	318	11	2·8	+ 0·3			
	Paris	70·61	315	11	16·8	— 2·4	20	31·8	— 0·9
	Kew	71·33	319	11	22·8	— 0·7			
	Scoresby Sund	71·92	342	11	27·8	+ 0·8			
	Alger Univ	74·82	304	11	37·8	— 6·2			

TABLE 3 (*contd*)

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for P (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for S (min)	(sec)	Obs.—Cal. (sec)
49(*contd*)	College	75·53	23	11	46·8	— 1·2	21	28·8	+0·4
	Tammanrasset	78·76	290	12	5·8	— 0·1			
	Brisbane	78·81	129	12	3·8	— 2·2			
	Pretoria	83·31	236	12	29·8	— 0·2			
	Grahamstown	88·29	231	12	55·8	+ 1·2			
	Hungry Horse	99·63	19	13	46·8	+ 0·1			
50	Tocklai	4·75	204	1	14·8	+ 0·3	1	9·6	— 1·7
	Tezpore	5·47	216	1	26·8	+ 2·0	2	29·3	— 0·1
	Shillong	6·78	217	1	39·5	— 3·6	3	0·2	— 1·9
	Chatra	9·02	245	2	18·5	+ 4·1	4	1·5	+ 1·2
	Calcutta	11·12	224	2	42·5	— 0·8	4	48·5	— 1·1
	New Delhi	16·67	266	3	59·5	+ 3·0	7	4·5	+ 2·6
	Poona	23·82	244	5	15·5	+ 0·2	9	34·5	+ 5·8
	Bombay	24·42	246	5	22·5	+ 1·3	9	47·5	+ 8·5
	Ksara	50·30	290	9	3·5	+ 3·2	15	53·5	—19·2
	Istanbul	53·90	302	9	29·5	+ 2·2			
	Helwyn	55·13	288	9	36·5	+ 0·2			
	Jena	63·25	315	10	31·5				
	Stuttgart	65·40	313	10	45·0				
	Strasbourg	66·35	314	10	48·5				
	Besancon	67·97	313	11	3·5	+ 0·6			
	Paris	69·50	315	11	10·5	— 1·8	20	10·5	— 9·2
	Toledo	77·77	309	11	59·5	— 1·0			
	Tammanrasset	79·10	290	12	6·5	— 1·3			
	Pretoria	86·18	237	12	40·5	— 3·9			
51	Tocklai	4·88	206	1	20·2	+ 4·1	2	17·2	+ 1·6
	Tezpore	5·77	218	1	27·0	— 2·2	2	35·4	— 1·6
	Shillong	7·10	218	1	49·5	+ 2·0	3	9·0	— 1·0
	Chatra	9·67	245	2	23·2	— 0·1	4	10·9	— 3·2
	Calcutta	11·50	224	2	46·2	— 2·4	4	52·0	— 6·9
	New Delhi	17·54	266	4	4·2	— 3·6	7	11·7	—10·1
	Hyderabad	21·73	235	4	53·2	— 1·5	9	1·2	+10·1
	Poona	24·51	244	5	22·2	+ 0·3	9	42·2	+ 1·6
	Bombay	25·12	246	5	29·2	+ 1·1	9	53·2	+ 2·3
	Kodaikanal	27·60	225	5	53·2	+ 2·4	10	35·2	+ 3·4
	Colombo	28·94	218	6	9·2	+ 5·8	10	54·2	+ 0·9
	Ksara	51·23	290	9	10·2	+ 2·6	16	39·2	+13·6
	Istanbul	54·81	301	9	36·2	+ 2·3			
	Helsinki	54·99	324	9	33·2	— 1·9	17	16·2	— 0·5
	Helwyn	56·08	287	9	58·2	+15·0			
	Upsala	58·69	324	10	1·2	— 0·6	18	8·2	+ 2·6
	Praha	62·59	314	10	28·7	+ 0·8	18	55·2	— 0·3
	Trieste	64·35	309	10	36·2	— 4·0	19	19·2	+ 1·7
	Stuttgart	66·24	313	10	51·7	+ 0·1	19	43·2	+ 2·5
	Zurich	67·12	312	10	56·9	— 0·6	19	47·2	— 4·1
	Strasbourg	67·19	314	10	57·2	— 0·8	20	0·2	+ 8·0
	Basel	67·69	313	11	2·7	+ 1·4			
	Paris	70·33	315	11	17·2	+ 0·2	20	37·2	+ 7·7
	Kew	70·82	319	11	20·2	— 0·1	20	44·2	+ 9·0
	College	72·08	24	11	27·2	— 1·1	20	51·2	+ 1·5
	Rathfarnham Castle	73·24	322	11	34·2	— 0·5	21	6·2	+ 3·3
	Alger Univ	75·25	304	11	45·2	— 1·3			
	Tammanrasset	80·03	290	12	13·2	+ 0·4			
	Malaga	80·49	307	12	16·2	+ 0·6			
	Pretoria	86·80	237	12	57·2	+ 9·7			
	Hungry Horse	96·25	20	13	32·2	+ 1·1			

TABLE 3 *(contd)*

S. No. of shock	Station	Degrees of arc △	Azimuth Degrees from North z	Observed travel time for P (min)	(sec)	Obs.—Cal. (sec)	Observed travel time for S (min)	(sec)	Obs.—Cal. (sec)
52	Shillong	1·38	90	0	26·1	— 0·3	0	43·8	— 2·0
	Chatra	3·05	292	0	52·6	+ 2·1	1	28·6	+ 0·4
	Tocklai	3·65	72	0	59·1	+ 0·2	1	39·9	— 3·5
	Calcutta	3·70	215	1	4·1	+ 4·4	1	46·6	+ 1·9
	New Delhi	11·98	287	2	52·6	— 2·5	5	12·6	+ 2·0
	Hyderabad	13·91	236	3	18·6	— 2·0	5	40·6	—26·4
	Poona	16·94	247	3	59·6	— 0·3	7	13·6	— 3·0
	Bombay	17·61	251	4	7·6	— 0·8	7	31·6	+ 8·2
53	Tocklai	1·47	173	0	28·1	+ 0·4			
	Tezpore	1·95	215	0	35·6	+ 0·9			
	Shillong	3·27	216	0	52·3	— 1·3			
	Chatra	6·27	259	1	38·6	+ 2·6	2	48·1	— 1·3
	Calcutta	7·65	223	1	50·7	— 3·8	3	16·3	— 7·6
	New Delhi	14·82	275	3	24·1	— 8·6	6	7·1	—11·5
	Hyderabad	17·92	236	4	11·6	— 0·2	7	38·6	+ 8·1
	Poona	20·87	247	4	44·6	— 1·4	8	38·6	+ 3·8
	Bombay	21·53	249	4	55·6	+ 2·9	8	51·6	+ 4·2
	Kodaikanal	23·72	224	5	24·6	+10·2	9	38·6	+11·6
	Colombo	25·09	215	5	29·6	+ 1·9	9	56·6	+ 6·2
	Djakarta	36·35	158	7	9·6	+ 2·0	15	58·6	+ 9·5
	Ksara	49·61	292	8	59·6	+ 4·6	16	8·6	+ 5·4
	Istanbul	53·85	302	9	28·6	+ 1·7	17	0·6	+ 0·2
	Budapest	59·95	311	10	13·6	+ 3·2	18	20·6	— 1·4
	Praha	62·47	314	10	27·6	+ 0·2	18	56·6	+ 2·6
	Trieste	63·92	310	10	35·6	— 1·4	19	7·6	— 4·6
	Jena	64·07	316	10	37·6	— 0·3			
	Stuttgart	66·10	314	10	54·6	— 1·2			
	Zurich	66·90	313	10	54·0	— 2·1			
	Strasbourg	67·07	314	10	56·6	— 0·6	19	49·6	— 1·1
	Paris	70·30	315	11	17·1	— 0·1	20	30·6	+ 1·5
	Kew	71·04	319	11	20·6	— 1·1	20	33·6	— 4·2
	Scoresby Sund	71·68	339	11	26·6	+ 0·5	20	49·6	+ 4·5
	College	75·68	23	11	47·6	— 1·2	21	32·6	+ 2·5
	Toledo	78·20	309	12	2·6	0			
	Tammanrasset	78·36	290	12	2·6	— 1·2			
	Malaga	79·88	306	12	12·6	+ 0·5	22	12·6	— 2·6
54	Tezpore	2·92	210	0	47·9	+ 1·3			
	Shillong	4·22	213	1	6·1	— 1·0	1	57·7	— 0·7
	Chatra	6·73	252	1	44·3	+ 1·7	3	3·3	+ 2·4
	Calcutta	8·55	221	1	55·3	—12·7	3	6·8	—11·5
	New Delhi	14·94	272	3	32·3	— 2·0	6	17·3	— 4·2
	Hyderabad	18·64	235	4	17·3	— 3·7	7	50·3	— 6·5
	Poona	21·45	245	4	51·3	— 0·7	8	46·3	+ 0·4
	Bombay	22·08	247	4	58·3	0	8	58·3	+ 0·6
	Kodaikanal	24·56	224	5	23·3	+ 0·7	9	44·3	+ 2·9
	Ksara	49·42	291	8	56·3	+ 2·9	16	7·3	+ 6·8
	Istanbul	53·46	301	9	24·3	+ 0·2	16	54·3	— 1·8
	Helwyn	54·12	287				17	15·3	+10·3
	Praha	61·93	314	10	24·7	+ 0·9			
	Jena	63·50	315	10	34·3	+ 0·1			
	Rome	65·41	306	10	44·3	— 2·3			
	Stuttgart	65·57	314	10	47·3	— 0·3	19	38·3	+ 5·8
	Zurich	66·38	312	10	53·7	+ 0·9			
	Strasbourg	66·53	314	10	54·3	+ 0·5	19	44·3	+ 0·1
	Paris	69·73	315	11	14·3	+ 0·5	20	35·3	+12·9
	Kew	70·43	319	11	20·3	+ 2·3			
	College	74·68	23	11	41·3	— 1·9			
	Toledo	77·71	309	12	1·3	+ 1·1			
	Tammanrasset	78·21	290	12	14·3	+ 9·6			
	Cartuja	78·66	307	12	14·3	+ 8·9			
	Hungry Horse	98·73	19	13	41·3	— 1·3			

TABLE 4

Magnitudes of shocks from records of Wood Anderson seismographs

Shock Number	Chatra East	Chatra North	New Delhi East	New Delhi North	Poona East	Mean
5	6·8	6·8	6·3	6·1	6·8	6·6
6	7·2	7·3	6·4			7·0
7	7·2	7·1	6·0	6·4	6·7	6·6
8	6·9	7·2	6·5	6·1	6·7	6·7
9	6·7	6·6	6·5	5·8	6·4	6·4
10			6·3	6·2	7·0	6·5
11	6·2	6·3	5·7	5·9	6·8	6·2
12			6·6	5·8	7·2	6·5
13	6·8	6·7	6·4	5·9	7·1	6·6
14	6·6	6·6	5·8	6·0	7·1	6·4
15	6·3	6·3		5·6	6·3	6·1
16			6·2		6·7	6·4
17	6·5		6·1	5·5	6·4	6·1
18	6·5		6·0	6·0	6·2	6·2
19			6·2	5·6	6·3	6·0
20		6·7		5·9	6·2	6·3
21		7·0	6·2	5·8	6·4	6·3
22			7·1	5·8	6·1	6·3
23	6·3		6·2	5·8	5·4	5·9
24	6·7		6·6	6·7	6·8	6·7
25	6·4		6·3	6·0	6·4	6·3
26		7·1	7·2		6·6	7·0
27	6·4		6·2	5·6	6·6	6·2
28			6·2		6·0	6·1
29	6·7	6·8	6·2		6·4	6·5
30	7·1	7·1	6·8		7·0	7·0
31	6·9	6·9	6·3		6·9	6·7
32		6·9	6·2		5·7	6·3
33		7·0	6·3	6·5	6·5	6·6
34	6·4	6·4	6·1	5·7	6·5	6·2
35	6·7	6·8	6·3		6·5	6·4
36	6·0	6·0			5·9	6·0
37	6·3		5·8		6·8	6·3
38		6·7	6·3	5·9	6·8	6·4
39	6·7	6·7				6·7
41	7·0	7·1	6·5	6·2	6·4	6·6
42	6·7	6·6		6·0	6·1	6·3
43	6·4			5·8	5·6	6·6
44		6·4		5·0	5·4	5·6
45		6·3		5·5	5·5	5·8
46	5·9			4·9	5·2	5·3
47	6·0		6·0	5·0	6·3	5·8
48	6·8			6·3	6·2	6·4
49	7·0			6·2	6·3	6·5
50	6·2			5·4	6·3	6·0
51	6·7			6·6	6·3	6·5
52	6·8			6·9		6·8
53	7·0		6·4	6·6	6·3	6·4
54	7·0	7·2	6·6	6·0	5·7	6·5

TABLE 5

Computation of depth of focus

Shock No.	Observed $\frac{\bar{s}P-P}{\overline{sP}-P}$ interval in seconds								Calculated depth of focus (km)
	Tocklai	Tezpore	Shillong	Chatra	Calcutta	New Delhi	Poona	Mean	
41	—	—	—	3·0	5·0			4·0	10·3
	3·0	4·5	3·5	—	—			3·6	15·6
42	—	—	—	—	—	—	—		
	5·4	3·8		3·5				4·2	18·3
44	—	3·5	3·5	4·5		4·0	3·0	3·7	9·5
	2·6	1·8	2·5					2·3	10·0
45	—	—	—	—	—	4·5	4·5	4·5	11·5
	1·0	—	—	—	—			1·0	4·3
46	—	—	3·5	4·0				3·8	9·7
	—	—	—	2·0	—	—	—	2·0	8·7
47	—	—	—	6·0	6·0	7·0	7·0	6·5	16·7
	4·1	—	2·0	4·0	—			3·3	14·3
48	5·5	—	—	—	4·5	—	5·0	5·0	12·8
	3·6	—	1·9	3·5	—			3·0	12·9
49	—	—	—	—	—	2·0	2·5	2·3	5·9
	1·2	—	2·2	4·0?	—			1·7	7·4
50	—	6·2	6·2	6·5	6·0	—	—	6·2	15·9
	6·4?	—	3·0	5·0	—			4·8	20·9
51	2·6	2·7	3·5	—	—	3·0	3·3	3·2	8·2
	—	—	—	4·8?	—	—	—	—	—
52	5·2	—	—	3·5	7·0	6·7	7·0	5·9	15·1
	2·8	—	—	5·0	—			3·9	17·0
53	5·2	—	3·8	5·5	5·9	—	—	5·1	13·1
	—	—	—	7·0?	6·1?			6·5?	28·3??
54	—	—	4·5	5·0	—	—	—	4·8	12·3
	—	—	4·1	—	—			4·1	17·9

TABLE 6

Observed arrival times (GMT) of seismic waves at near stations

Shock No.	Tocklai		Tezpore		Shillong		Chatra		Calcutta	
	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.
41	P	06 27 40·0	P	06 27 57·0			P	06 28 51·0W	P	06 29 11·0W
	?	41·6	P^*	28 1·0			$\overline{sP}$	54·0	$\overline{sP}$	16·0S
	P^*	44·0	?	7·0			PP	58·5	P^*	30·0W
	$\overline{P}$	49·0S	$\ddot{\overline{P}}$	8·5S			PPP	29 4·0	$\overline{P}$	53·0S
	$\overline{sP}$	52·0S	$\overline{sP}$	13·0VS			P^*	6·5	LQ	30 42·0
	?	57·0	?	20·5VS			?	15·0	S	53·0S
	LR	28 8·0	?	25·5S			?	21·0	LR	31 9·0
	S	12·0VS	?	28·5			$\overline{P}$	26·0W	S^*	23·0W
	S^*	14·6VS	S	40·0S			$\overline{sP}$	29·5W	?	35·0
	$\overline{S}$	18·5VS	$\overline{S}$	51·0			?	42·5	$\overline{S}$	52·0
							?	51·0		
							LQ?	30 6·0		
							S	15·5		
							?	19·0S		
							SS	30·0		
							S^*	34·0		
							?	46·0		
							$\overline{S}$	31 6·0		

TABLE 6 *(contd)*

Shock No.	Tocklai		Tezpore		Shillong		Chatra		Calcutta	
	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.
42	*P*	22 36 14·0	*P*	22 36 1·0W			*P*	22 36 37·5W	*P*	22 36 21·0W
	*P**	18·8W	$\overline{P}$	8·7S			*PP*	44·0W	*P**	27·0W
	$\overline{P}$	24·6	$\overline{sP}$	12·5			*P**	46·5	$\overline{P}$	35·0S
	$\overline{sP}$	30·0S	*S*	33·5S			$\overline{P}$	56·5W	*S*	37 6·0
	S	53·0S	*S**	42·0			$\overline{sP}$	37 0	$\overline{S}$	22·0S
	$\overline{S}$	37 10·0S	$\overline{S}$	47·0			*S*	35·0		
							LR	38·0		
							*S**	47·5		
							$\overline{S}$	38 0·3		
43	*P*	21 14 52·0					*P*	21 15 57·0W		
	*P**	53·4					$\overline{sP}$	16 3·5W		
	?	54·5S					?	9·5W		
	$\overline{P}$	56·0S					*P**	11·5W		
	?	15 11·2					?	19·5		
	?	14·0					?	23·5		
	S	18·0S					$\overline{P}$	27·5		
	*S**	19·2VS					?	40·0S		
	$\overline{S}$	23·2VS					?	49·5		
							?	54·0		
							S	17 14·5		
							LR	22·0		
							SS	24·0		
							*S**	34·0		
							$\overline{S}$	52·0		
							?	57·0S		
44	*P*	23 14 0·2	*P*	23 14 2·5			*P*	23 15 8·5W	*S*	23 16 58·0
	*P**	0·8S	$\overline{sP}$	6·0			$\overline{sP}$	13·0	*SS*	17 9·0
	$\overline{P}$	2·6S	$\overline{P}$	8·7S			?	19·0W	?	34·0
	$\overline{sP}$	5·2	$\overline{sP}$	10·5S			?	26·5W	$\overline{S}$	58·0
	PP?	8·0	?	19·2W			?	32·5W		
	PPP?	13·0	*S*	28·0S			?	35·0		
	?	19·0	?	32·0			$\overline{P}$	40·0		
	S	23·0S	*S**	34·7			?	49·0		
	*S**	24·8	$\overline{S}$	40·0VS			*S*	16 22·5		
	$\overline{S}$	27·4VS					?	27·5		
							?	33·0		
							?	34·5		
							*S**	42·0		
							$\overline{S}$	17 4·0		
45	*P*	21 14 54·2	*P*	21 15 5·0	*P*	21 15 27·4W	*P*	21 16 7·5W	*P*	21 16 25·0W
	*P **	55·0S	*P**	8·0S	*P**	32·5W	*PP*	15·0W	*PP*	32·0
	$\overline{P}$	54·4VS	$\overline{P}$	11·0S	$\overline{P}$	36·5W	*P**	22·5W	*P**	43·0W
	$\overline{sP}$	57·4VS	?	20·0	?	37·5S	?	29·5	?	17 1·0W
	?	15 4·0S	*S*	31·0	$\overline{P}$	40·0S	?	33·5	$\overline{P}$	6·0W
	?	11·4S	*S**	35·0W	?	58·4W	$\overline{P}$	43·0	?	19·0S
	S	15·0S	$\overline{S}$	39·0S	*LR*	6·0	?	58·0S	?	33·0S
	$\overline{S}$	17·2VS			*S*	9·0W	?	17 19·0	*LQ*	48·0W
					?	11·5S	*S*	28·0W	*S*	55·0S
					*S**	19·9W	?	32·5	*SS*	18 7·0
					$\overline{S}$	27·4S	?	41·0	?	30·0
							?	18 5·0	$\overline{S}$	45·0
							$\overline{S}$	7·0	?	53·0

TABLE 6 *(contd)*

Shock No.	Tocklai		Tezpore		Shillong		Chatra		Calcutta	
	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.
46	P	08 24 40·0	P	08 24 48·0	P	08 25 10·5	P	08 25 46·0W		
	?	42·0	P^*	54·0	$\bar{s}P$?	14·0	$\bar{s}P$	50·0		
	P^*	44·0W	$\bar{P}$	25 4·3	?	17·5W	P^*	26 5·5W		
	$\bar{P}$	51·3	?	15·2	P^*	20·0W	?	7·5W		
	?	25 12·2S	?	28·7	$\bar{P}$	34·6	$\bar{P}$	23·0W		
	?	14·0S	S	44·5S	S	26 20·0	$\overline{sP}$	25·0W		
	LR	25·0	$\bar{S}$	26 2·5S	?	26·2	S	27 30·0S		
	S	29·0S			?	31·0	?	33·0		
	S^*	36·0			S^*	34·5	?	37·5		
	$\bar{S}$	43·0			$\bar{S}$	51·0	S^*	47·0		
							?	28 6·5		
							$\bar{S}$	14·5		
47	P	02 24 53·0	P^*	02 25 0·5W	P	02 25 13·3W	P	02 25 55·0W	P	02 26 18·0W
	P^*	54·4S	$\bar{P}$	4·2S	P^*	18·3W	$\bar{s}P$?	26 1·0W	$\bar{s}P$	24·0W
	P	56·4S	?	11·5	$\bar{P}$	24·3	P^*	11·0W	P^*	41·7W
	$\overline{sP}$	25 0·5S	?	19·0	$\overline{sP}$	26·3	$\bar{P}$	21·0W	$\bar{P}$	27 0 W
	?	4·4	S	28·0	?	38·3	$\overline{sP}$	25·0	S	53·0
	?	6·4	$\bar{S}$	33·5	?	47·3W	LQ	56·0W	?	28 1·0
	?	8·9	?	38·7S	S	55·3W	S	27 6·5W	S^*	19·0W
	S	19·4S			S^*	26 3·3W	LR	14·0	?	27·0W
	S^*	21·8W			SS	7·3	SS	16·5	$\bar{S}$	38·0
	$\bar{S}$	23·4S			$\bar{S}$	11·8S	S^*	22·0W	?	47·0
					SSS	18·3	$\bar{S}$	41·0		
48	P	18 58 54·0W	P	18 59 4·1S	P	18 59 23·6W	P	19 00 4·5W	P	19 00 25·0W
	?	55·5S	P^*	6·1S	?	24·7S	?	8·5	?	26·5S
	P^*	56·9S	PP	11·1VS	P^*	28·8	PP?	12·0	$s\bar{P}$	29·5VS
	$\bar{s}P$	59·5S	?	12·4	?	37·8	?	14·5	PP	33·0
	$\bar{P}$	59 0·5	$\bar{P}$	14·4VS	$\bar{P}$	40·8	P^*	18·0	PPP	40·0W
	$\overline{sP}$	4·1S	?	25·6VS	$\overline{sP}$	42·7S	?	21·0	P^*	45·0W
	?	6·9	?	30·4S	?	45·0VS	$\bar{P}$	37·5S	?	52·0
	?	10·1VS	S	39·0S	?	19 00 3·6	$\overline{sP}$	41·0S	?	01 3·0
	S	23·0VS	S^*	46·0	?	10·0	?	01 23·5	$\bar{P}$	10·5
	$\bar{S}$	27·9VS	$\bar{S}$	49·9VS	?	13·6	S	26·5	S	02 2·0S
					S	14·5S	?	31·5	SS	13·0S
					?	16·0VS	S^*	48·5W	?	17·0
					S^*	24·6W	?	52·5	?	28·0
					$\bar{S}$	36·6VS	?	02 3·5W	S^*	32·5W
							$\bar{S}$	9·5S	?	50·0S
									?	53·0S
									$\bar{S}$	03 0 S

TABLE 6 (*contd*)

Shock No.	Tocklai Phase	Tocklai A.T.	Tezpore Phase	Tezpore A.T.	Shillong Phase	Shillong A.T.	Chatra Phase	Chatra A.T.	Calcutta Phase	Calcutta A.T.
49	P/P*	14 52 45·7S	P	14 52 58·0	P	14 53 14·5S	P	14 54 1·0	P	14 54 14·7S
	$\bar{P}$	46·7S	?	53 0	P*	18·3S	PP	7·5	?	29·7
	$\overline{sP}$	47·9VS	?	10·0	?	20·5W	P*	14·0	P*	35·8
	?	50·3VS	?	12·0	PP	22·8S	PPP	19·5	$\bar{P}$	51·5
	?	54·9S	S	21·0VS	?	23·7S	?	25·0	S	55 41·0S
	?	58·3S	S*	24·0VS	$\bar{P}$	25·3S	$\bar{P}$	32·5	S*	56 9·5
	?	53 2·3	$\bar{S}$	30·5VS	$\overline{sP}$	27·5	$\overline{sP}$	36·5S	$\bar{S}$	30·7
	?	2·7			?	32·0VS	?	39·5S		
	S	4·5VS			?	49·5	S	55 17·5W		
					S	55·0S	SS	28·5		
					S*	59·8S	S*	34·5W		
					?	54 2·5	?	43·5		
					$\bar{S}$	8·5S	$\bar{S}$	52·5S		
50	P	13 58 12·3	P	13 58 24·3	P	13 58 37·2	P	13 59 16·0W	P	13 59 40·0S
	?	14·7	$\overline{sP}$?	30·5W	$\overline{sP}$	22·5	$\overline{sP}$	22·5	$\overline{sP}$	46·0W
	P*	23·8	P*	34·3W	P*	52·5W	P*	37·5	?	14 00 2·0
	$\bar{P}$	29·5	?	39·3S	$\bar{P}$	59 10·7W	$\bar{P}$	14 00 0·5W	?	20·0
	$\overline{sP}$	35·9S	$\bar{P}$	49·3S	$\overline{sP}$	13·7	$\overline{sP}$	6·5	?	26·0W
	?	43·3	?	57·3	?	17·7W	S	59·0W	$\bar{P}$	40·6
	?	50·8	?	59 9·3S	S	57·7	?	01 10·0S	?	14 01 42·4
	?	59 0·3	S	26·8S	?	14 00 11·2W	?	15·5	S	46·0S
	S	7·1	S*	36·8	SSS	16·2	S*	24·5W	?	02 7·0
	S*	17·6S	SS?	39·3W	S*	18·2	?	32·0	?	12·0
	S	28·3S	SSS	51·8	$\bar{S}$	35·2S	?	37·5	S*	25·0W
			$\bar{S}$	54·3S			$\bar{S}$	52·0S	?	44·0
			?	59·8VS					$\bar{S}$	03 2·0S
51	P	04 28 50·6	P	04 28 57·8W	P	04 29 20·3	P	04 29 55·0W	P	04 30 17·0
	$\overline{sP}$	53·2	$\overline{sP}$	29 0·5S	$\overline{sP}$	23·8W	PP	30 1·4	P*	51·0S
	P*	59·0W	P*	11·1W	P*	39·8W	PPP	6·8	$\bar{P}$	31 25·0
	?	29 2·6	$\bar{P}$	16·8VS	$\bar{P}$	47·3	P*	15·8	S	32 22·8
	$\bar{P}$	6·6S	?	32·9S	?	30 3·3	$\bar{P}$	38·7	?	50·0
	?	28·0S	?	38·4S	?	17·8W	$\overline{sP}$	43·5	?	33 15·0W
	?	33·0	?	49·9S	LQ	20·8W	LQ	31 27·1W	$\bar{S}$	37·0
	S	48·0	S	30 6·2	S	39·8	S	41·7S	?	55·0S
			S*	13·1	?	41·8	SS	51·1W		
			?	20·4	?	46·8	SSS	32 4·2S		
			$\bar{S}$	28·9VS	S*	55·8	S*	5·8W		
					?	31 9·8	?	23·7		
					?	12·8S	?	31·2S		
					$\bar{S}$	18·8VS	$\bar{S}$	40·9S		
							?	48·1VS		

TABLE 6 (*contd*)

Shock No.	Tocklai		Tezpore		Shillong		Chatra		Calcutta	
	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.	Phase	A.T.
52	P	20 30 11·5			P/P*	20 29 38·5	P	20 30 5·0W	P	20 30 16·5
	sP	16·7W			?	40·0	?	7·0W	sP	23·5
	PP	17·7			$\overline{P}$	41·0VS	sP	8·5	$\overline{P}$	31·7S
	P*	19·1S			?	47·0VS	P*	10·0	?	39·1
	?	22·3W			?	49·0S	PP	12·5	LQ	50·0W
	$\overline{P}$	25·0			?	52·0S	$\overline{P}$	16·0S	S	59·0
	$\overline{sP}$	27·8			?	54·0W	$\overline{sP}$	21·0S	$\overline{S}$	31 14·0S
	S	52·3S			S	56·2	LR	38·5W	SSS	24·5S
	?	57·8			$\overline{S}$	57·8VS	S	41·0S		
	S*	31 1·0					S*	49·5S		
	$\overline{S}$	6·9VS					$\overline{S}$	54·5VS		
53	P*	23 47 17·5S	P*	23 41 25·0S	P	23 41 41·7	P	23 42 28·0W	P	23 42 40·1
	$\overline{P}$	19·5	$\overline{P}$	26·0VS	sP	45·5W	sP	33·5W	sP	46·0
	$\overline{sP}$	22·7VS			P*	48·5S	P*	40·0W	P*	56·7
					$\overline{P}$	51·5S	?	49·0	?	43 8·0S
							$\overline{P}$	52·5S	$\overline{P}$	15·8
							$\overline{sP}$	59·5S	$\overline{sP}$	21·9
							?	43 6·0	LQ	57·5W
							?	18·5S	S	44 5·7S
							LQ	25·0S	S*	38·0S
							?	32·5	?	45·5S
							S	37·5S	$\overline{S}$	53·0VS
							LR	43·5S		
							SS	47·5		
							S*	51·5		
							$\overline{S}$	44 7·5S		
54			P	03 38 28·6	P	03 38 46·8	P	03 39 25·0		
			sP/P*	33·6	sP	51·3	?	27·0		
					P*	54·3	sP	30·0		
					$\overline{P}$	39 0·7S	PP	33·0		
					$\overline{sP}$	4·8S	P*	39·2		
					?	12·3	?	46·0		
					?	27·3S	?	51·0		
					LR?	33·8	$\overline{P}$	55·3S		
					S	37·8	S	40 44·0		
					?	42·3	?	46·5S		
					S*	45·8S	?	41 3·5		
					$\overline{S}$	52·3VS	?	11·0		
							$\overline{S}$	21·0S		
							?	27·5S		

TABLE 7

Observed travel times and residuals for near earthquake places

	P		P^*		$\bar{P}$		S		S^*		$\bar{S}$	
Δ in degrees	Observed travel time t_P (sec)	ϵ_P (sec)	t_{P^*}	ϵ_{P^*}	$t_{\bar{P}}$	$\epsilon_{\bar{P}}$	t_S	ϵ_S	t_{S^*}	ϵ_{S^*}	$t_{\bar{S}}$	$\epsilon_{\bar{S}}$
1·00					20·0	+0·2					32·0	−1·1
1·02					20·7	+0·5						
1·38	26·6	−1·2	27·4	+0·3	28·6	+1·2	47·4	+0·7			49·6	+4·2
1·38	26·1	−1·7	26·1	−1·0	28·8	+1·4	43·8	−2·9			45·5	0
1·43	28·5	0	28·5	+0·6	29·5	+1·1	47·3	−0·7				
1·47			28·1	−0·5	30·1	+0·9						
1·83	34·9	+0·8	35·5	+0·8	37·3	+1·0	57·7	−0·2	59·5	+2·1	61·1	+1·1
1·95			35·6	−1·1	36·6	−2·1						
1·95					39·0	+0·3						
2·10	37·4	−0·5	40·4	+1·2	43·4	+1·7	63·4	−1·2	67·4	+2·2	71·4	+2·7
2·17	38·3	−0·6	39·7	−0·7	41·7	−1·4	64·7	−1·7	66·8	−0·4	73·3	+2·4
2·17	40·8	+1·9					63·8	−2·6	67·1	−0·1	68·7	−2·2
2·20	42·2	+2·9	43·1	+2·2	47·0	+3·3	69·2	+2·1			74·1	+2·2
2·27	39·5	−0·8	40·9	−1·2	43·5	−1·6	65·5	−3·5	66·6	−3·6	70·6	−3·6
2·33	37·2	−3·9			43·4	−2·9	62·7	−7·7	69·4	−2·4	74·3	−1·8
2·43	40·9	−1·6	48·6	+0·3			73·4	+0·6	81·9	+7·2	86·9	+7·5
2·53			45·8	−0·7	49·5	−0·8	73·3	−2·0			78·8	−3·8
2·68	43·9	−2·2	49·9	−1·1	52·9	−0·4	75·9	−3·1	78·5	−3·4	82·4	−5·1
2·92	47·9	−1·5	52·9	−0·2								
3·00	50·3	−0·3	52·3	−2·1	60·6	+1·0	85·2	−1·8	92·2	+1·1	96·1	−1·7
3·05	52·6	+1·3	57·6	+2·3	63·6	+2·9	88·6	−1·0	97·1	+4·5	102·1	+2·7
3·27	52·3	−2·0	59·1	+0·1	62·1	−2·9						
3·30	52·9	−1·9	58·7	−0·7	64·5	−1·1	92·9	−1·6			109·9	+2·4
3·40	60·9	+4·7	64·9	+3·7	72·4	+4·8	103·9	+6·9			113·9	+3·1
3·42	59·8	+3·3	64·9	+3·4	72·8	+4·8	101·4	+3·9	112·3	+9·0	119·8	+8·4
3·48	57·3	0	61·1	−1·5	68·1	−1·1	97·8	−1·1	102·6	−2·4	111·3	−2·1
3·62	60·9	+1·6	66·9	+2·0	74·9	+2·9	105·9	+3·5			121·9	+4·0
3·65	59·1	−0·6	66·7	+1·3	72·6	0	99·9	−3·2			114·5	−4·4
3·70	64·1	+3·7	71·1	+4·8	79·3	+5·7	106·6	+2·2			121·6	+1·1
3·83	58·6	−3·6	63·6	−4·9	69·6	−6·6	100·6	−7·0	108·6	−7·6	117·1	−7·6
3·87	62·1	−0·7	66·1	−3·1	73·4	+3·4	111·1	+2·5	118·6	+2·4	125·1	−0·9
4·22	66·1	−1·6	73·6	−1·5	80·0	−3·9	117·1	−0·3	125·1	−1·2	131·6	−5·7
4·32	69·8	+0·7	75·0	−1·8	87·0	+1·1	120·7	+0·8	130·8	+1·6	142·8	+2·3
4·65	70·1	−3·6	76·1	−6·3	86·4	−6·1	126·6	−1·5				
4·75	74·8	−0·3	85·3	+1·2	92·0	−2·5	129·6	−1·0	140·1	−1·5	150·8	−3·7
4·80	77·4	+1·6	86·4	+1·5	96·4	+0·9	134·9	+3·1	147·4	+4·3	160·2	+4·1
4·88	79·8	+2·8	88·2	+1·9	95·8	−1·3	137·2	+3·4				
5·47	86·8	+1·5	96·8	+0·5	111·8	+3·0	149·3	+0·8	159·3	−3·1	176·8	−1·0
5·77	87·0	−2·5	100·3	−1·1	105·8	−9·0	155·4	−0·5	162·3	−8·7	178·1	−9·4
5·98	92·6	+0·2	102·1	−2·8	116·7	−2·3	162·1	+0·9	176·6	−0·5	193·1	−1·2
6·27	98·6	+2·1			123·1	−1·7	168·1	−0·3	182·1	−3·4	198·1	−5·6
6·40	100·3	+2·0	116·3	+4·3	126·3	−1·0	171·8	+0·2	187·3	−1·9	206·3	−1·6
6·48	103·2	+4·7			134·7	+5·8	177·2	+3·6	196·7	+5·2	218·7	+8·2
6·57	99·9	−0·8	114·9	0	135·4	+4·7	180·4	+4·5			219·4	+6·0
6·63	103·8	+2·2	116·8	+0·9	135·3	+3·4	180·3	+3·0	197·3	+1·5	215·3	0
6·73	104·8	+1·3	118·5	+0·9	134·6	+0·7	183·3	+3·5			220·3	+1·7
6·75	104·5	+1·3	119·0	+1·0	135·0	+0·7	182·0	+1·7	201·5	+2·2	219·5	+0·3
6·78	99·7	−4·0	115·0	−3·5	133·2	−1·7	180·2	−0·8	200·7	+0·5	217·7	−2·5
7·10	109·5	+1·3	129·0	+5·1	135·5	−4·8	189·0	−0·1	205·0	−4·4	228·0	−2·5
7·28	110·7	0	124·2	−2·7	143·7	−1·2	192·7	−0·9	214·7	+0·1	235·7	−0·7
7·46	114·9	+1·7	130·4	+0·4	149·3	+0·9	199·4	+1·4	217·9	−1·9	249·9	+7·7
7·65	110·7	−5·2	127·3	−5·9	146·4	−5·8	196·3	−6·5	228·6	+3·3	243·6	−4·7
7·83	117·4	−1·0	135·4	−0·8	158·4	+2·6	207·4	+0·2			257·4	+3·2
7·90	117·5	−1·9	138·6	+1·2	154·3	−2·9	203·8	−5·1	232·3	−0·3	253·5	−2·9
8·03							212·7	+0·5				
8·15	123·3	+0·4	147·0	+5·3	165·3	+3·1	218·3	+3·1	244·3	+4·6	263·3	−1·2
8·52	128·1	0	147·6	−0·3	165·1	−4·5	232·1	+7·7	249·1	−1·3	276·6	+0·1
8·73	131·2	+0·1	151·2	−0·3	176·7	+3·0	228·2	−1·4	258·7	+2·3	286·2	+2·9

TABLE 7 (*contd*)

Δ in degrees	*P*: Observed travel time t_P (sec)	*P*: ϵ_P (sec)	*P**: t_{P*}	*P**: ϵ_{P*}	$\overline{P}$: $t_{\overline{P}}$	$\overline{P}$: $\epsilon_{\overline{P}}$	*S*: t_S	*S*: ϵ_S	*S**: t_{S*}	*S**: ϵ_{S*}	$\overline{S}$: $t_{\overline{S}}$	$\overline{S}$: $\epsilon_{\overline{S}}$
9·02	138·5	+3·4	160·0	+3·6	183·0	+3·5	241·5	+4·7	267·0	+2·2	294·5	+1·8
9·12	134·9	—1·6	153·9	—4·2	176·9	—4·6	236·9	—2·4	266·9	—0·8	295·6	—0·3
9·67	144·2	—0·1	165·0	—2·4	187·9	—4·6	250·9	—2·1	275·0	—8·5	310·1	—3·6
11·12	162·5	—2·1			223·1	+1·8	288·5	—0·5	327·5	+2·1	364·5	+3·8
11·50	166·2	—3·8	200·2	+1·8	234·2	+5·3	292·0	—6·4			366·2	—6·8

TABLE 8

Velocities of *P* and *S* waves in Assam region and their apparent delays of starting

Phase	v (km sec—1)	σ_v	Limits of error of v	a (sec)	σ_a (sec)	Limits of error of a
P	7·91	·067	±·02	8·41	4·56	±1·2
*P**	6·55	·055	±·02	3·62	5·11	±1·4
$\overline{P}$	5·58	·042	±·01	0·12	5·62	±1·4
S	4·46	·030	±·01	12·34	6·58	±1·8
*S**	3·85	·033	±·01	4·60	8·56	±2·8
$\overline{S}$	3·43	·024	±·01	0·70	8·72	±2·4

TABLE 9

Velocities of *P* and *S* waves in other regions of the world

Region / Author / Phase	Europe / Jeffreys (1940)	Southern California / Gutenberg* (1944)	New England / Leet (1936)	Central California / Byerly (1939)	Canada / odgson (1947)	Central Asia / Rozova (1936)	Heligoland / Schulze and Foertch (1950)	Japan / Mutuzawa (1928) (1929)	Central India / Mukherjee (1942)	Gangetic Valley (India) / Roy (1939)
P	7·76±0·01	8·06±·01	8·0	8·02±0·5	8·2	7·82	8·19	7·5	7·73	7·80
*P**	6·50±·03	6·95±·18 } 6·05±	6·77±·02	7·24±·04 } 6·72±·05	6·45	5·99	6·2 to 6·6	6·2	6·44	6·21
$\overline{P}$	5·57±·02	5·58±·01	6·01±·01	5·61±·05	6·15	5·54	5·34	5·10	5·47	5·26
S	4·36±·01	4·45	4·6		4·75			4·5	4·38	4·38
*S**	3·74±·03	4·10 } 3·65	3·93±·01		4·37 } 3·75	3·79		3·7	3·66	3·71
$\overline{S}$	3·36±·01	3·26	3·45±·01	3·26±·09	3·34	3·29		3·15	3·38	3·29

* In another later paper Gutenberg (1951) has revised these values and has concluded that the velocities of *P* wave is 5·8 km sec^{-1} up to a depth of 5 km when it increases to 6·5 km sec^{-1}. At a depth of 11 km it increases to 6·8 or 6·9 km sec^{-1} The average velocities of the *P* and *S* waves up to a depth of 16 km is 6·35 and 3·67 km sec^{-1} respectively. Below the Mohorovicic discontinuity the velocity of *P* is 8·16 km sec^{-1} and that of *S* about 4·5 km sec^{-1}.

TABLE 10

Frequency analysis of P residuals

	-10	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	Mean
1- 3·9	—	—	—	—	—	—	—	—	2	—	4	12	6	2	—	1	—	1	—	—	—	—	+0·33
4- 6·9	—	—	—	—	—	—	—	1	1	1	1	2	5	4	3	4	1	1	—	1	—	—	+1·88
7- 9·9	1	—	—	—	1	—	1	1	2	1	11	8	8	9	3	2	—	—	—	2	1	2	+0·62
10- 12·9	—	—	—	—	1	—	—	—	—	3	2	1	—	1	—	—	—	—	—	—	—	—	-1·65
13- 15·9	—	—	1	—	—	1	2	3	4	6	8	3	1	—	—	—	—	—	—	—	—	—	-2·34
16- 18·9	1	—	—	—	—	3	1	7	5	4	7	4	—	2	1	—	—	—	—	—	—	—	-2·43
19- 21·9	—	—	—	2	1	1	—	—	3	12	11	15	6	3	1	1	1	—	—	1	—	—	-0·60
22- 24·9	1	—	—	—	—	—	—	1	1	2	10	19	25	8	4	3	1	2	—	—	2	2	+1·00
25- 27·9	—	—	—	—	—	—	1	1	1	4	4	6	4	4	2	2	—	—	1	—	—	1	+0·64
28- 30·9	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	1	—	—	—	—	—
31- 33·9	—	—	—	—	—	—	—	—	—	1	1	3	—	—	—	—	—	—	—	—	—	—	-0·6
34- 36·9	—	—	—	—	—	—	—	—	—	—	1	—	1	1	1	—	—	—	—	—	—	—	+1·25
37- 39·9	—	—	—	—	—	—	—	—	1	—	1	1	2	1	—	—	—	—	—	1	—	—	+1·14
40- 42·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
43- 45·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
46- 48·9	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	+1·5
49- 51·9	—	—	—	—	—	—	—	—	—	—	—	4	6	6	6	4	4	—	—	—	—	1	+2·64
52- 54·9	—	—	—	1	—	—	—	—	—	—	—	6	1	3	1	—	—	—	—	—	—	—	+0·17
55- 57·9	—	—	—	—	—	—	—	—	—	2	—	7	3	1	—	—	—	—	—	—	—	—	+0·07
58- 60·9	—	—	—	—	—	—	—	1	—	1	1	4	7	2	1	—	—	—	—	1	—	1	+1·32
61- 63·9	—	1	—	—	—	—	—	1	—	2	11	19	10	4	—	—	1	1	—	—	—	—	0
64- 66·9	—	1	—	—	—	—	—	1	5	10	16	52	14	1	2	—	—	—	1	—	—	—	-0·34
67- 69·9	—	—	—	—	—	1	—	1	2	8	18	34	12	3	1	—	—	—	—	—	—	—	-0·36
70- 72·9	—	—	—	—	—	—	1	1	—	1	12	25	22	5	2	—	—	1	—	1	—	—	+0·41
73- 75·9	—	—	—	—	—	1	—	—	3	9	22	9	7	2	1	1	—	1	—	—	—	—	-0·55
76- 78·9	—	—	1	—	—	—	—	—	1	5	12	19	4	2	—	—	—	—	—	—	1	1	-0·15
79- 81·9	—	—	—	—	—	—	—	—	—	4	7	14	11	4	4	1	—	1	—	1	—	—	+0·72
82- 84·9	—	—	—	—	—	—	1	1	1	4	4	7	3	2	—	—	1	—	—	—	—	—	-0·50
85- 87·9	—	—	—	—	—	—	—	3	—	1	2	2	—	1	1	—	—	—	—	—	—	1	+0·09
88- 90·9	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	+1·0
91- 93·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
94- 96·9	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	+1·5
97- 99·9	—	—	—	—	—	—	1	—	—	—	—	9	5	4	1	—	—	—	—	—	—	—	+0·55
100-102·9	—	—	—	—	—	—	—	—	—	—	1	1	3	—	—	1	—	1	—	—	—	—	+1·71

TABLE 11

Frequency analysis of S residuals

	-10	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+10	Mean
1- 3·9	—	—	—	—	2	—	—	—	3	5	3	3	2	2	2	1	—	—	1	—	—	—	—	-0·5
4- 6·9	—	—	—	—	—	—	—	—	—	5	3	4	1	3	1	1	2	1	2	—	—	—	—	+1·7
7- 9·9	3	7	2	1	1	2	2	1	5	4	5	1	6	3	—	7	2	2	1	—	1	1	4	-0·2
10- 12·9	—	—	—	1	1	—	—	—	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	-3·4
13- 15·9	8	1	1	2	4	6	1	1	1	1	2	—	1	1	—	—	—	—	—	—	—	—	—	-5·1
16- 18·9	8	3	1	1	—	1	—	1	2	3	—	1	—	—	1	1	1	—	1	2	2	1	2	-0·3
19- 21·9	—	2	1	1	—	2	3	2	2	2	2	4	4	—	4	6	4	8	1	—	—	2	2	+1·0
22- 24·9	1	—	—	1	—	2	2	—	1	4	7	7	7	6	5	11	5	6	3	—	3	2	6	+2·2
25- 27·9	1	—	—	—	—	1	—	—	—	—	4	—	3	2	4	3	3	6	—	1	—	—	1	+3·0
28- 30·9	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	-0·3
31- 32·9	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
33- 35·9	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
36- 38·9	1	—	—	—	—	—	—	—	—	—	—	2	1	1	—	1	—	—	—	1	—	—	1	+2·5
40- 42·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
43- 45·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
46- 48·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—
49- 51·9	1	—	—	—	—	—	—	—	—	—	1	1	1	1	2	1	1	4	3	2	1	1	10	+5·1
52- 54·9	—	—	1	—	—	—	1	—	—	1	1	—	—	—	—	—	—	—	1	1	—	1	—	+1·0
55- 57·9	1	—	—	—	—	—	—	—	—	1	3	1	—	—	1	—	1	—	—	—	—	—	2	+0·4
58- 60·9	—	—	—	1	—	—	—	—	3	—	1	2	3	1	2	2	—	1	—	—	—	—	—	+0·4
61- 63·9	2	—	—	—	—	2	3	2	1	6	1	4	1	3	5	5	2	1	—	—	—	—	1	+0·2
64- 66·9	2	—	—	—	2	1	2	2	5	2	7	9	3	8	3	1	3	4	—	1	—	—	2	+0·3
67- 69·9	1	—	1	—	1	1	—	1	1	1	4	6	5	7	2	2	3	1	2	1	1	1	2	+1·5
70- 72·9	—	—	—	—	—	1	—	1	—	—	4	5	4	4	2	3	3	2	1	2	2	—	5	+2·5
73- 75·9	—	—	—	—	—	1	3	—	—	2	—	5	1	1	2	1	—	—	1	—	—	1	2	-0·3
76- 78·9	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	1	1	—	1	—	—	—	+4·2
79- 81·9	—	—	1	—	—	—	—	1	2	2	2	2	1	1	—	—	1	1	—	—	—	—	2	-0·8
82- 84·9	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
85- 87·9	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
88- 90·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
91- 93·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
94- 96·9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
97- 99·9	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
100-102·9	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—