that in the initial stages one of its ends became elongated and gradually tended to be vertical (growth of the tornado) and later it gradually bent back to horizontal and shortened (decay of the tornado) until it disappeared finally inside the cloud.

The tornado moved approximately from S.W. to N.E. and Mr. Veryard says in his paper, as he also informed me on my enquiring about it before his paper was published, that looking from south-west to north-east the tornado funnel which had an anticlockwise rotation was situated on the right-hand side of the main cumulo-nimbus tower and the rain and hail fell mostly on the left-hand side of the track. This is a very interesting and important observation from the point of view of the hypothesis of the whirl with horizontal axis. That the tornado funnel was situated on the right of the main cumulo-nimbus cloud looking in the direction of translation of the tornado is quite evident from the photographs if we take account of the fact that they were taken while the tornado was approaching the camera. On all the seven photographs the top of the funnel is bent towards the cumulo-nimbus cloud, *i.e.*, towards the right (as seen on the photographs) and it is on this side that there are indications though faint, of falling rain on some of the photographs. All these observations are strongly in favour of the hypothesis of the whirl with horizontal axis, and although from the study of only one case it is not justified to conclude with certainty about the correctness of the hypothesis in the case of Indian tornadoes in general, there is good reason to believe that the hypothesis is a very probable one; it would, of course, be necessary to have more detailed observations in order to subject it to a strict test.

Another very interesting point in Mr. Veryard's paper is the observation that the tornado funnel in question had two parts: an inner core and an outer mantle. It may be remarked that similar observations have also been made in European tornadoes particularly by Wegener and Letzmann, so that the similarity of the Peshawar tornado with those of Europe would appear to be very close indeed. It also appears to me that on the photograph showing the tornado at the fully developed stage one can even recognise three distinct zones; this would probably suggest the presence of a central core, an outer mantle and an intermediate zone as proposed by Letzmann[3] from theoretical considerations. If the velocity of the wind and the lowering of pressure in the tornado were available one might subject this tornado to a quantitative test to some extent.

[3] J. Letzmann, "Über die Einflüsse positiver und negativer Beschleunigung auf ortsfest rotierende Flussigkeitssäulen,"—*Gerl. Beitr. z. Geoph*, 1930.

Focal Region of the North Bihar Earthquake of January 15, 1934.

By Dr. S. C. Roy, M.Sc. (Cal.), D.Sc. (Lond.).

IN his note* on the North Bihar Earthquake of January 15, 1934, Dr. S. K. Banerji has quoted the following epicentral distances of the earthquake estimated from seismic records:—Bombay 950 miles, Kodaikanal 1,400 miles, Agra 450 miles, Dehra Dun 100 miles, Mangalore 1,250 miles and Kew 4,600 miles. In addition to the foregoing distances one should also take into account the epicentral distance of 70 miles estimated by Calcutta. As pointed out by Dr. Banerji, these distances do not fix up any definite epicentre, but it would be premature to express an opinion regarding the extent of the focal region without a thorough scrutiny of the seismograms of all Indian Stations. It is undoubtedly true that the origin of an earthquake cannot be traced to a point-source but it is probably equally certain that the focal region from which the seismic waves of the principal shock of January 15 originated could not have been as wide as is suggested by the epicentral distances originally reported by the Indian seismic stations. Discarding the incredibly low values of 100 and 70 miles reported by Dehra Dun and Calcutta respectively, the original estimates of the epicentral distances made by other Indian stations are, however, reconcilable to a focal region of reasonable extent when it is remembered that the seismic tables used for the estimation of the epicentral distances are different at different stations. The Dehra Dun seismograms are not available for

* *Curr. Sci.*, 2, 326, 1934.

scrutiny but a preliminary examination of the Calcutta seismogram (Fig. 1) along with the seismograms of Agra (Fig. 2), Bombay (Figs. 3 and 4) and Kodaikanal (Fig. 5) suggests that the original estimates by Calcutta

Fig. 1.

and Dehra Dun were based on some wrong identification of phases on their seismograms. In the absence of the Dehra Dun seismograms it is difficult to imagine the exact nature of identification of phases which led to the low value of epicentral distance reported by that station but the following suggestion may provide a possible reconciliation of the original estimates of Calcutta and Dehra Dun.

The nature of incidence of the first preliminary waves P_M on the Agra, Colaba and Kodaikanal seismograms (Figs. 2, 3, 4 and 5) is similar and appears to correspond to the point P_M marked on the Calcutta seismogram (Fig. 1). The very feeble movements which commenced at P_m on the Calcutta seismogram prior to the incidence of P_M and lasted for about 11 seconds, are doubtful on the Agra seismogram (Fig. 2) and are not at all traceable on the Bombay and Kodaikanal seismograms (Figs. 3, 4 and 5). An explanation that suggests itself is that the major failure which led to the principal shock was preceded by a minor failure by about 11 seconds and that Calcutta's original estimate of the epicentral distance was based on the supposition that the interval (P_M—P_m) represented the total duration of the preliminary and secondary waves of the principal shock. It is also not improbable that Dehra Dun adopted the same interval (P_M-P_m) as representative of the duration of the preliminary waves. In this connection it may be of interest to mention certain seismic phases characteristic of near earthquakes of shallow focal origin. A glance at the seismic data published annually by the Indian stations seems to show that the Indian seismology has not in the past recognised fully phases of the preliminary and the secondary waves other than the normal P and S. It is, however, well known that the preliminary and the secondary waves of shocks originating in the upper layer or crust of the earth can travel to a near station along three distinct paths. The normal primary waves P and the secondary waves S are refracted down into the ultrabasic layer where they travel with comparatively high velocities and are refracted up again to the observing stations. The longitudinal and the transverse waves can also travel directly from the focus to the observing station through the granitic layer (about 10 Km. thick) where they have comparatively low velocities. These direct waves are recognised internationally by the

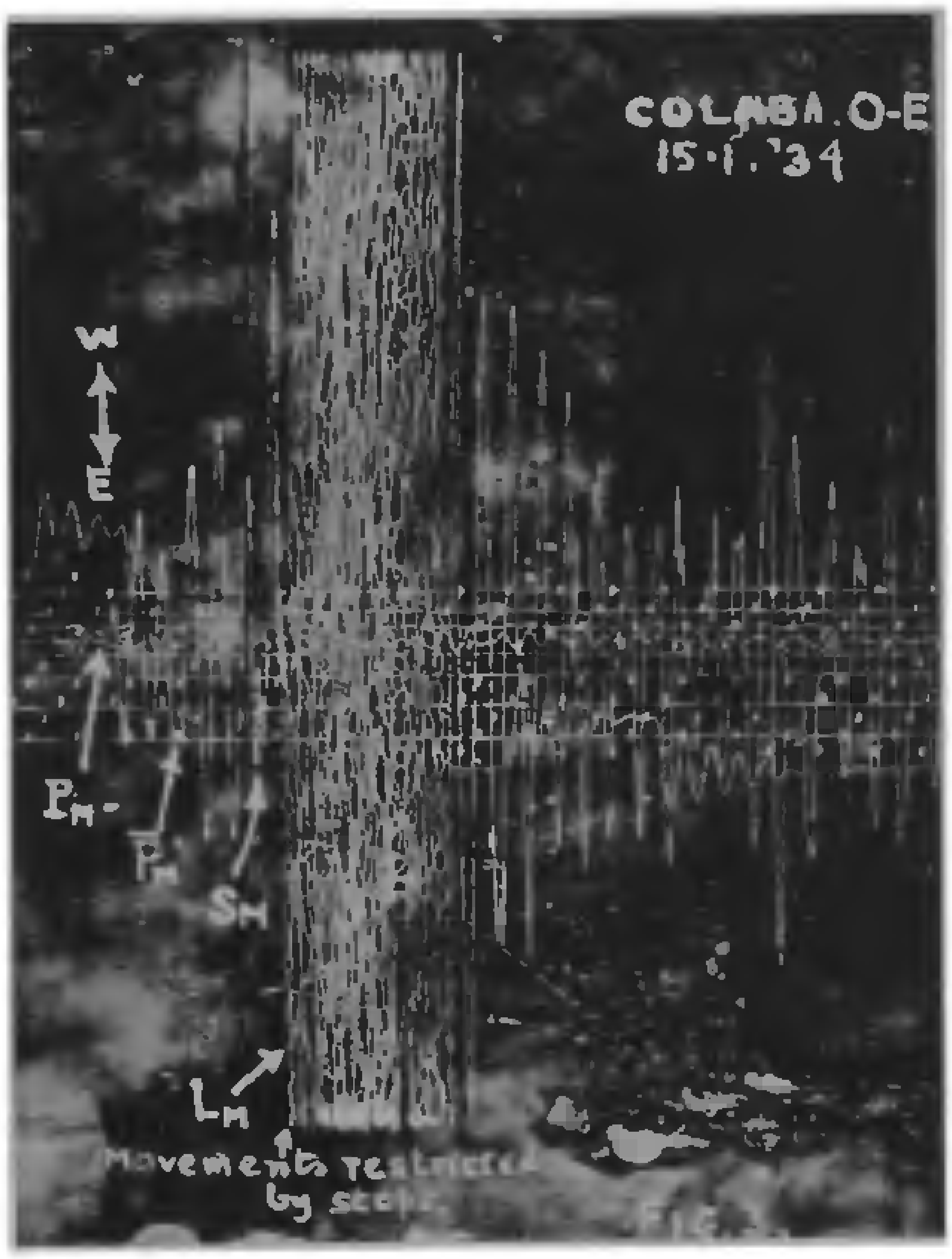

Fig. 3.

symbols $\bar{P}$ and $\bar{S}$. In addition to the two pairs of preliminary and secondary waves mentioned above there is a third pair P* and S* which travel from the focus to the

Fig. 2.

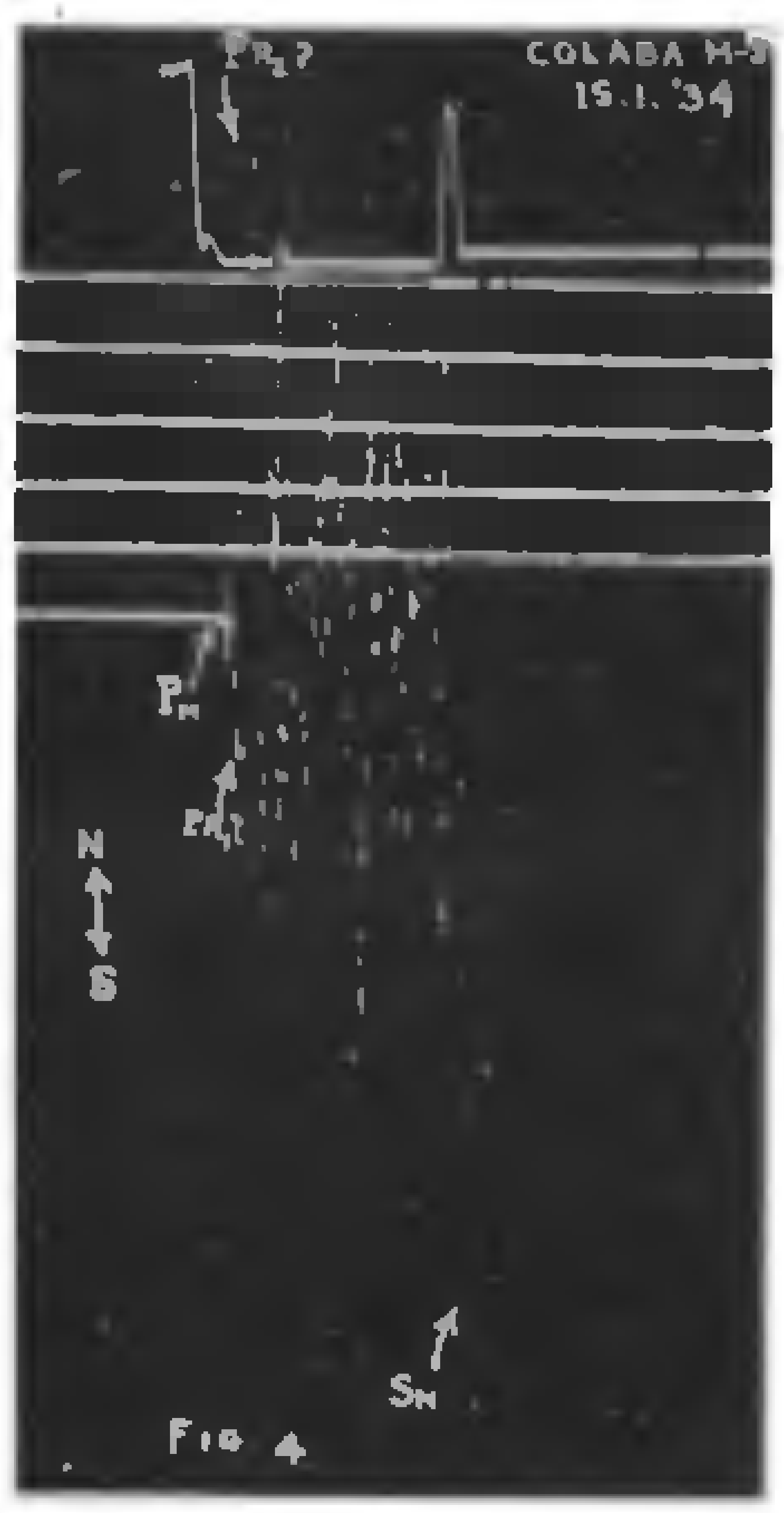

Fig. 4.

Fig. 5.

	Δ (Kms)	P_m	P_M	$\bar{P}_M$	S_M	$\bar{S}_M$	L_M	$P_M - O_M$
⊙ CALCUTA	493	$8^h 44^m 18^s$	$8^h 44^m 29^s$	$8^h 44^m 55^s$	$8^h 45^m 23^s$	$8^h 45^m 52^s$	—	$1^m 7^s$
X AGRA	805	45 00(?)	45 11	45 57	46 40	47 29	—	$1^m 49^s$
△ DEHRADUN	902	45 14	—	—	—	—	—	—
O BOMBAY	1610	—	46 48	48 20	49 38	—	$8^h 50^m 29^s$	$3^m 26^s$
✱ MANGALORE	1929	—	47 25	—	50 45	—	—	$4^m 3^s$
⊡ KODAIKANAL	2026	—	47 36	—	51 06	—	—	$4^m 14^s$

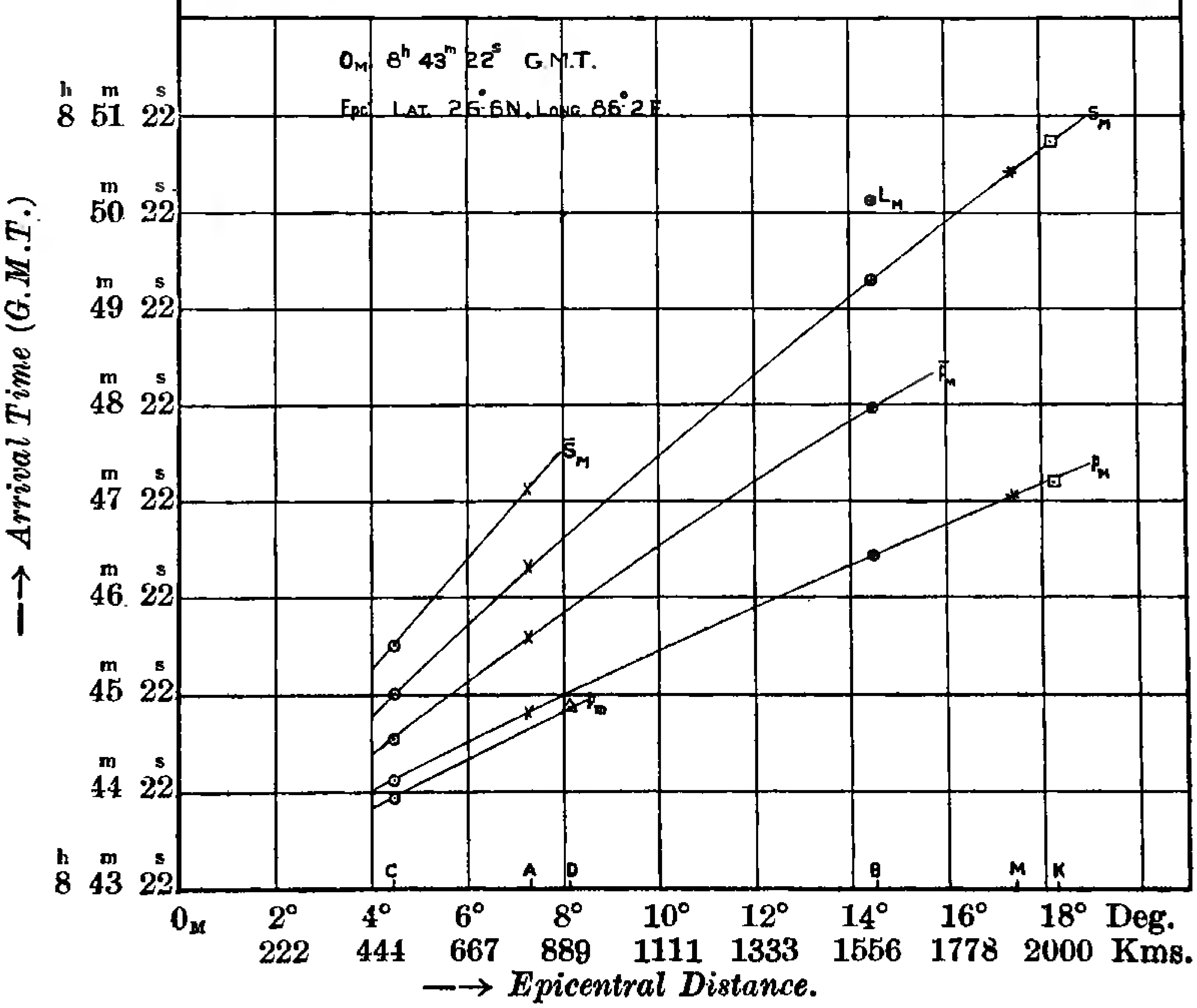

Fig. 6. Time-Distance Curves of North Bihar Earthquake of January 15, 1934.

observing station with intermediate velocities through the basaltic layer (about 20 Km. thick). The importance of the recognition of these six phases and also of the reflected primary and the secondary waves for a correct diagnosis of seismograms of near earthquakes cannot be over-emphasised. The phases P_M, $\bar{P}_M$, S_M and $\bar{S}_M$ appear to be identifiable on the seismograms of Calcutta and Agra (Figs. 1 and 2). The reflected waves are also traceable on some of the Indian seismograms (Figs. 2, 4 and 5) but the phases P_M^* and S_M^* are either absent or difficult to trace. One is naturally tempted to suggest that the phase P_m marked on the Calcutta seismogram may be taken as P_M and the phase marked P_M identified as P_M^* but the feeble nature of the movements of P_m and other characteristics of the Calcutta seismogram do not appear to support such an explanation.

The arrival-times of the important phases based on the present identification are tabulated at the top of Fig. 6. The origin time of the major shock as obtained by plotting $(S_M—P_M)$ interval against the arrival time P_M is 8 h. 43 m. 22 s. G.M.T. The epicentre is located near Lat. 26·6° N., Long. 86·2° E. in agreement with the following epicentral distances:—Calcutta 493 Kms., Agra 805 Kms., Dehra Dun 902 Kms., Bombay 1,610 Kms., Mangalore 1,929 Kms., and Kodaikanal 2,026 Kms. The time-distance curves of the important phases of the principal shock are also given in Fig. 6. The development of surface waves (Fig. 3) and the general trend of the time-distance curves of the various phases suggest that the focal region of the principal shock was of shallow depth, but a reliable estimate of the actual depth from the seismograms is not possible in the absence of records close to the epicentre.

The main object of the present note is to point out that a preliminary examination of the available Indian seismograms does not suggest that the focal region of the principal shock of January 15 was very abnormal in extent. A detailed discussion of the seismograms of the principal shock and its aftershocks will be published elsewhere.

Some Foreign Weeds and their Distribution in India and Burma.

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MR. A. C. JOSHI'S note on the occurrence of *Croton sparsiflorus* in the United Provinces, published in *Current Science*, **2**, 344, 1934,[6] prompts me to put down my observations regarding the distribution of some of the common harmful exotic weeds established in this country.

The interesting study of migration of foreign plants dates from a very early period, as far back as 1786, the date of the foundation of the Royal Botanic Garden, Calcutta (the then Hon. East India Company's Botanical Garden, Calcutta) and the Serampur Botanical Garden—generally known as Dr. Carey's Garden. During this time Roxburgh, "the father of Indian Botany", and Dr. Carey of great fame started cultivating in their gardens at Sibpur and Serampur, various species of foreign and indigenous plants with a view to have a suitable botanical garden of scientific value near Calcutta. This work was followed by such eminent botanists as Voigt, Wallich, Griffith, Buchanan, Hamilton, Falconer, Thomson, Anderson, Clarke, King, Gamble and Prain. Thus by the time Brühl published his *Recent Plant Immigrants* in 1908,[3] the Botanic Garden at Sibpur during the course of one hundred and twenty-two years, formed a centre of distribution of a large percentage of plants at present found in the neighbourhood of Calcutta in the district of Hooghi-Howrah and the 24 Parganas. Coastal invasion of foreign plants either by sea or by ships calling at the various ports of this country may be considered another source of migration of foreign plants. Exchange relation in plants with different gardens and introduction of seeds by private individuals may be other important factors of local migration of plants. The problem of distribution and dispersal of plants is too large to be discussed here. I refer the reader to the book entitled *The Dispersal of Plants throughout the World* by H. N. Ridley, 1930,[10] for sufficient information on this subject. The authors of the local floras such as Prain, Cooke, Gamble, Brandis, Duthie,