A study of Sudden Enhancement of Atmospherics on 27 kc/s band

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(*Received 24 February 1961*)

ABSTRACT. The paper reports a study of Sudden Enhancement of Atmospherics (S.E.A.) on 27 kc/s at a station in low latitudes carried out during 1958-59, which is thought to be of importance for the world-morphology of S.E.A. It is found here that S.E.A. shows maximum association with magnetic chrochet. The chances of occurrence of S.E.A. are practically the same for most of the day hours. The rise-time and decay-time of S.E.A. have average ratio of about 1:4, with a total duration of about 43 minutes. The rise-times cluster around two distinct values of 5 minutes and 15 minutes. The total duration of S.E.A. is seen to increase with its amplitude, whereas the rise-time does not increase with amplitude. Further it is observed that the S.E.A.s with rise-times greater than about 13 minutes are more in the forenoon than in the afternoon.

1. Introduction

A number of studies have been carried out on the Sudden Enhancement of Atmospherics (S.E.A.) associated with solar flares. These studies, however, refer mostly to high and middle latitude stations, while in the tropics only few investigations (Mitra *et al.* 1958) have been carried out so far, which are extensive and exhaustive. We, therefore, planned to study during the I.G.Y., the phenomenon of S.E.A. on 27 kc/s band at Poona (Geographic latitude 18° 31′ N, longitude 73°52′ E and geomagnetic latitude 9°31′ N). Thus Poona lies in the geomagnetic equatorial belt, where many anomalies concerning the different layers of the ionosphere are reported. Therefore, it is thought that the results of this investigation, would be of value for the world-wide morphological study of the S.E.A. effect. It is the purpose of this paper to present the results of analysis of the S.E.A. data recorded here during 1958 and 1959.

2. Experimental

Fig. 1 shows a general view of the equipment used in this investigation and Fig. 2 gives its schematic circuit diagram. This circuit is the one given by Ellison (1955) for the detection of solar flares. It consists of 'a straight tuned receiver with a tuned aerial, feeding into a two stage plate-tuned R.F. amplifier, followed by a low output impedance cathode follower, feeding into a detecting recorder circuit. The detecting recorder circuit is a biased diode detector with integrating time constant of one minute, feeding into a cathode follower with a recording milliammeter as the load'. We used an inverted L type of aerial. An Evershed and Vignols recording milliammeter of range 0 to 10 ma was used in 1958 which was replaced by a more sensitive type with a range 0 to 1 ma in 1959. The unit was also shifted to a more exposed site where a similar aerial was used.

The receiver was periodically checked and maintained constant as regards its operation selectivity, response etc. Fig. 3 gives the calibration curves. The half power point (3 db down) band width is about 200 c/s.

3. Results

As the integrating time constant of one minute was used, the records directly give the integrated intensity of atmospherics activity. Two typical records of S.E.A. are reproduced in Fig. 4. The results of

TABLE 1

Monthly distribution of S.E.A.

Month	Fore-noon S.E.A.	After-noon S.E.A.	Total S.E.A. obser-ved	S.E.A. cor-related with some other report	S.E.A. not cor-related with any other report
		1958			
Jan	1	0	1	0	1
Feb	7	3	10	4	6
Mar	2	13	15	9	6
Apr	0	1	1	0	1
May	2	1	3	1	2
Jun	4	1	5	2	3
Jul	0	0	0	0	0
Aug	5	3	8	7	1
Sep	2	6	8	3	5
Oct	2	3	5	3	2
Nov	1	5	6	2	4
Dec	1	3	4	1	3
		1959			
Jan	1	3	4	3	1
Feb	4	3	7	4	3
Mar	10	9	19	11	8
Apr	8	7	15	7	8
May	10	2	12	4	8
Jun	13	0	13	4	9
Jul	9	10	19	2	17
Aug	5	3	8	2	6
Sep	2	3	5	2	3
Total	89	79	168	71	97

TABLE 2

Percentage association of observed S.E.A. with other related phenomena

Phenomena	Number reported	Number associated with our S.E.A.	Asso-ciation (%)
Chrochet †	26	12	46
Solar flares*†,			
Importance (3)	3	1	33
Do. (2)	26	7	27
Do. (1)	153	25	16
Sudden Fade Out † (S.F.O.) (14 to 23 mc/s)	83	18	23
Sudden Increase of Long wave signals (S.I.L.) (Mitra 1959) (164 kc/s)	144	13	8
Solar Radionoise † Burst (S.R.B.) (30 mc/s)	37	2	5
Sudden Cosmic † noise Absorption (S.C.A.) (18 mc/s)	2	0	0

*The data were kindly supplied by the Director, Nizamiah Observatory, Hyderabad, for which we are thankful to him

† CSIR, New Delhi, 1958

TABLE 3

Average times in minutes from the corresponding S.E.A. epochs

Phenomenon	Epoch		
	Start	Maximum	End
Flare	1·0	—6·8	—24·0
S.F.O.	2·3	..	—17·5
Chrochet	..	—2·5	..

analysis of the data from January 1958 to September 1959 are reported here. Naturally these observations of S.E.A. were facilitated as it was the peak period of solar activity. During 1958 when a low range recording milliammeter was not available, the detection of S.E.A. was found to be somewhat difficult; but during 1959 when a new recorder with a range of 0 to 1 ma was used, except for unavoidable circumstances like local noise or failure of power supply no difficulty was experienced. The times of the start, maximum and end, and the maximum amplitude of S.E.A. were measured directly from the records (See Fig. 4). In all 168 S.E.A.s were observed during this period. Their monthly distribution is given in Table 1.

4. Discussion

The phenomenon itself being known to be one of the inter-solar-terrestrial relationships, we have given in Table 2 the percentage associations of these observed S.E.A.s at this station with other similar physical phenomena, in the order of magnitude of association.

It may be noted that the magnetic chrochet shows maximum per cent association. Next, the solar flares show the associations decreasing in order, naturally with the decreasing importance of the flares. S.F.O.s also show a sufficiently good association. Without going further into the details of all these associations, it may be assumed that the S.E.A.s observed at this place in general do represent the true variations in the ionospheric propagation conditions.

It is significant to note that of the total 168 S.E.A.s, 89 occurred before noon and 79 after the noon; and the complete hourly frequency distribution of S.E.A. is shown in the histogram of Fig. 5. This shows that the chances of occurrence of the S.E.A. are practically the same from about 1 hour after sunrise to about one hour before sunset.

The average rise-time of S.E.A. is 9·7 minutes and the average total duration is 47 minutes, *i.e.*, the decay-time of 37·3 minutes is approximately 4 times the rise-time. In this connection it would be quite relevant to give the average values of such quantities as the time differences between the epochs of start, maximum and end of the different phenomena from those of the corresponding S.E.A.s (see Table 3).

From this table it may be seen that S.E.A.s and flares start practically simultaneously as is also observed by other workers (McIntosh 1951, Ellison 1953). The delay of S.E.A. maximum from flare maximum is also of the same order as reported by Ellison (1953).

The histograms of amplitude (Fig. 6) which are drawn separately for the two years 1958 and 1959 show similar trends for both the years. The number of S.E.A.s with smaller amplitude is larger and goes on decreasing for higher amplitudes. To our knowledge, such observations are not reported by other workers for S.E.A. but very similar trend is reported by Shain and Mitra (1954) for S.C.A.

The histogram of total duration of S.E.A. (Fig. 7) shows broad peak and sharp fall on either side indicating that practically all the S.E.A.s (about 75 per cent) have a total duration between 20 to 70 minutes. The distribution is slightly skew with median value of about 40 minutes. McIntosh (1951) has reported an average total duration of 80 minutes for S.E.A.; and Ellison (1953) has reported that decay of S.E.A. lags behind that of flare by about 30 to 60 minutes, *i.e.*, the total duration of S.E.A. may extend to about 60 to 90 minutes.

The histogram of the rise-time of S.E.A. (Fig. 8) shows somewhat abnormal trend. It shows two peaks one at 5 minutes and the other at 15 minutes. To our knowledge, such a double peak is not reported by any worker. McIntosh (1951) and Ellison (1953) report a single mean value of about 13 minutes.

In order to study the relations, if any, between the above three quantities, *viz.*, amplitude, total duration and rise-time, different scatter diagrams were drawn (Fig. 9). (*a*) The scatter diagram of total duration of S.E.A. against the amplitude of S.E.A. was plotted separately for 1958 and 1959. Both the years show practically identical trends. It is observed that duration of S.E.A. increases with its amplitude, at first very gradually, but after about 50 minutes' duration, comparatively rapidly. A similar trend is reported by Shain and Mitra (1954) in case of S.C.A. (*b*) In the case of the scatter diagram of rise-time against amplitue it is observed that there is a slight tendency for rise-time to increase with amplitude of S.E.A. The results in (*a*) and (*b*) are not quite unexpected. Because rise-time will be mostly governed by the rate and duration of the extra-ionisation produced by the flare, *i.e.*, on the rate of flux and duration of the incident radiation. But once, the ionisation and hence atmospherics level, has reached its maximum value, the decay-time will be governed by the difference between this maximum value and the mean level of atmospherics that is to be reached finally; naturally the total duration also will depend on this differential amplitude.

A scatter diagram of rise-time against hour of the day was plotted (Fig. 10). The diagram shows a peculiar trend; S.E.A.s with large rise-times (above about 13 minutes) are seen to occur more frequently during the earlier hours of the day. To bring out this point more definitely the ratio of the difference in the pre-noon and the post-noon number of S.E.A. to the total number of S.E.A. for a particular value of rise-time was plotted against the rise-time (Fig. 11). The curve definitely shows that there is high preponderance of pre-noon S.E.A.s for rise-times above about 12 minutes and slight preponderance of post-noon S.E.A.s for rise-time below it.

5. Acknowledgement

The junior author (R. N. Karekar) is indebted to the Government of India for a grant of a Senior Research Training Scholarship to him, which made this work possible.

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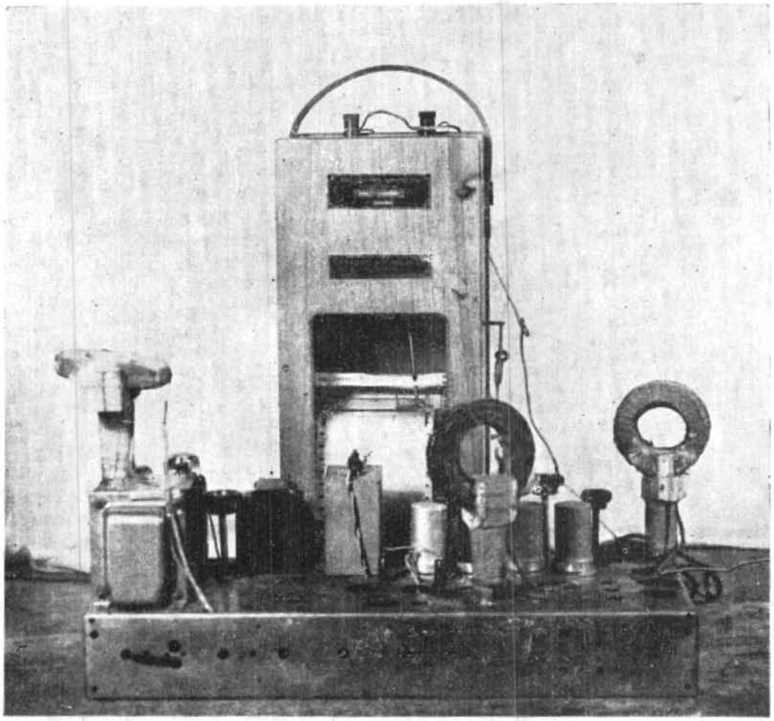

Fig. 1. A General view of the equipment

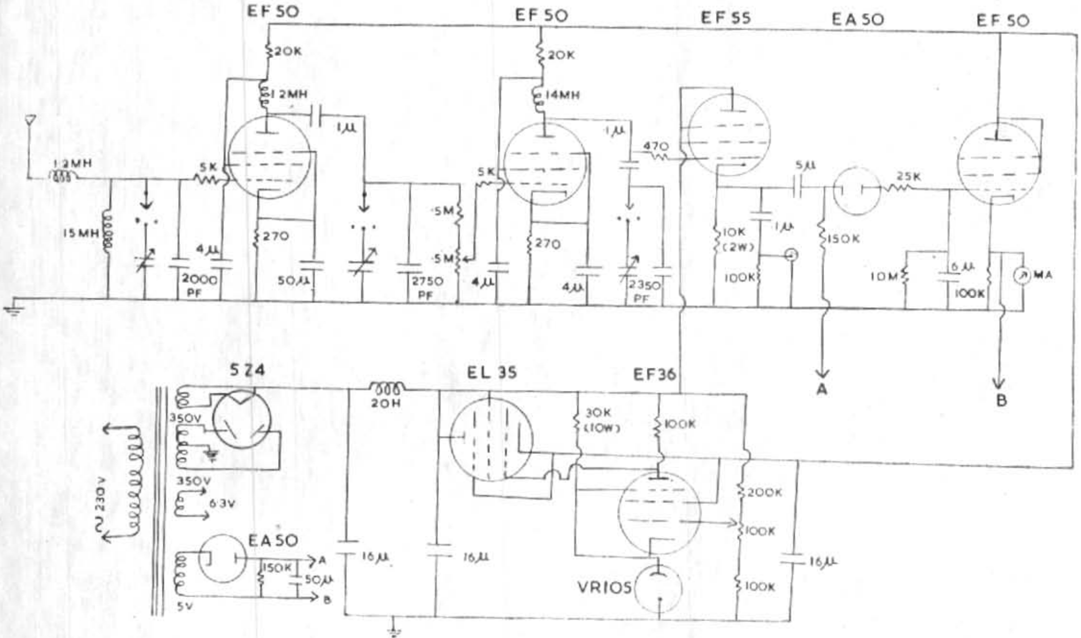

Fig. 2

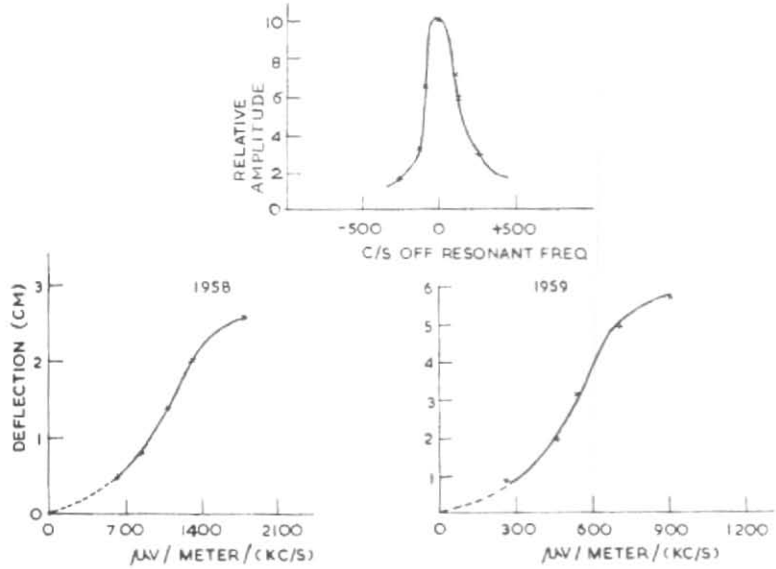

Fig. 3. The calibration curves

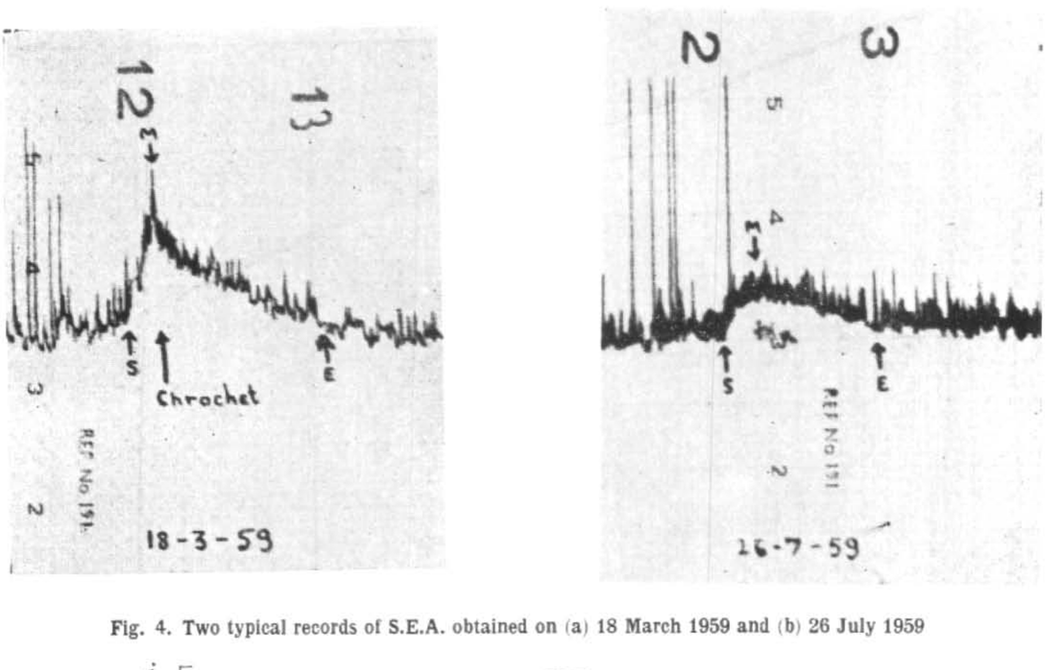

Fig. 4. Two typical records of S.E.A. obtained on (a) 18 March 1959 and (b) 26 July 1959

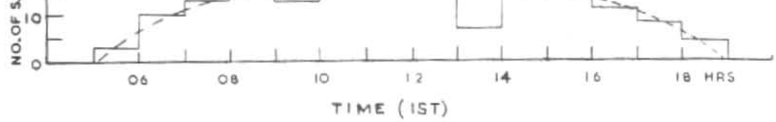

Fig. 5. Hourly frequency distribution of S.E.A.

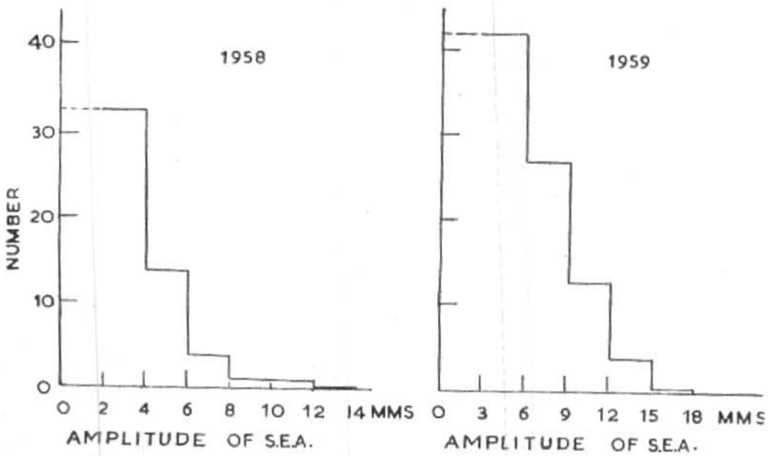

Fig. 6. Histograms of amplitude of S.E.A. for 1958 and 1959

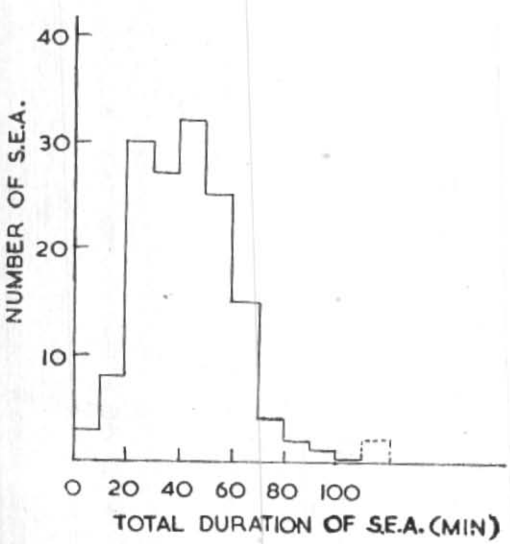

Fig. 7. A histogram of total duration of S.E.A.

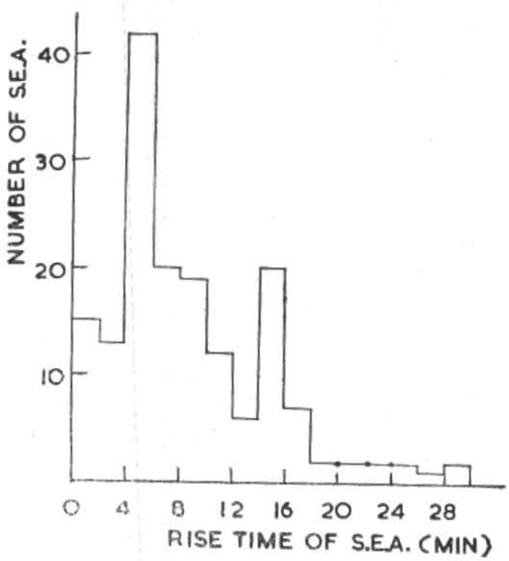

Fig. 8. A histogram of rise-time of S.E.A.

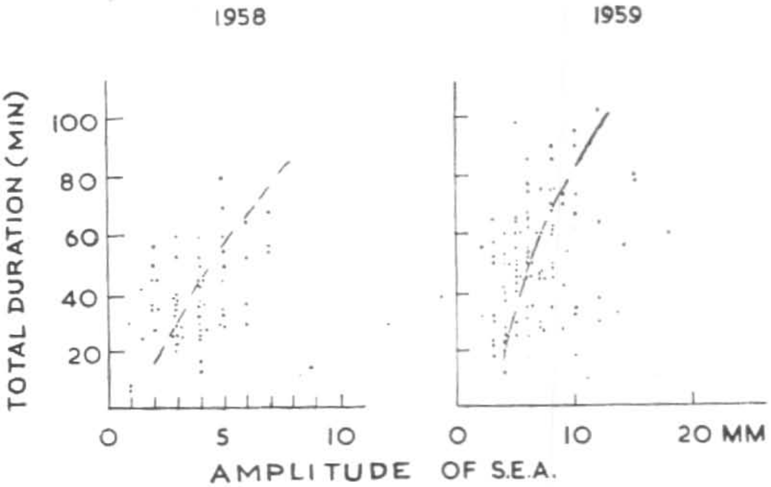

Fig. 9(a). Scatter diagrams of total duration of S.E.A. against its amplitude

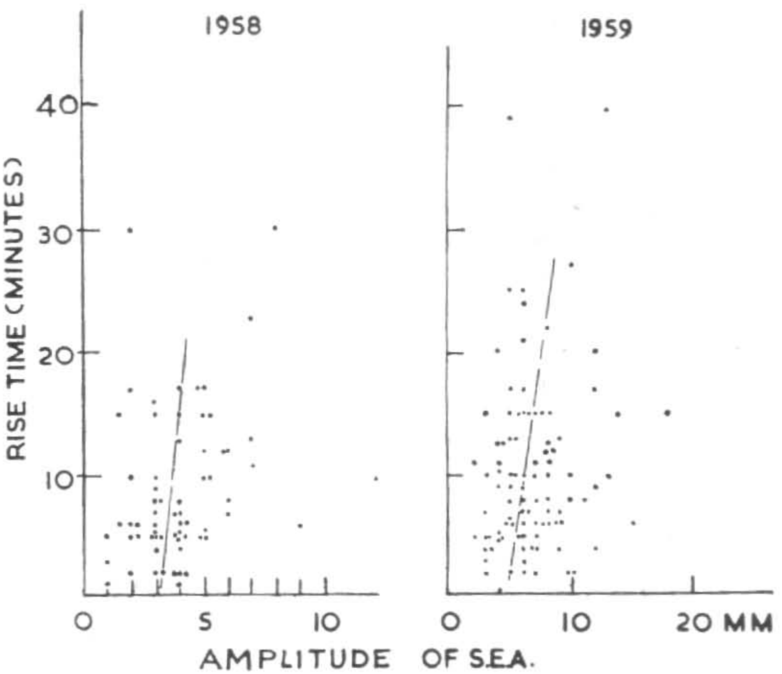

Fig. 9(b). Scatter digarams of rise-time of S.E.A. against its amplitude

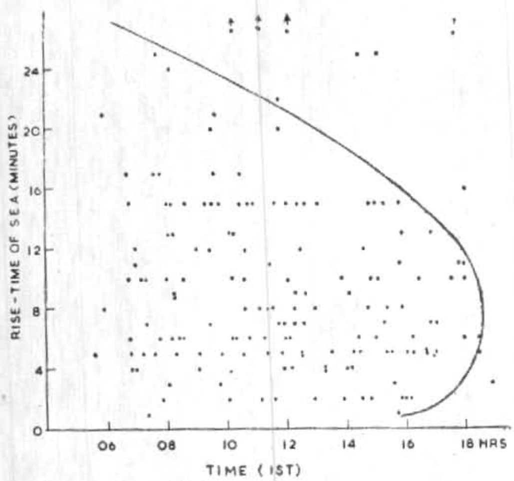

Fig. 10. Scatter diagram of rise-time of S.E.A. against the hour of the day

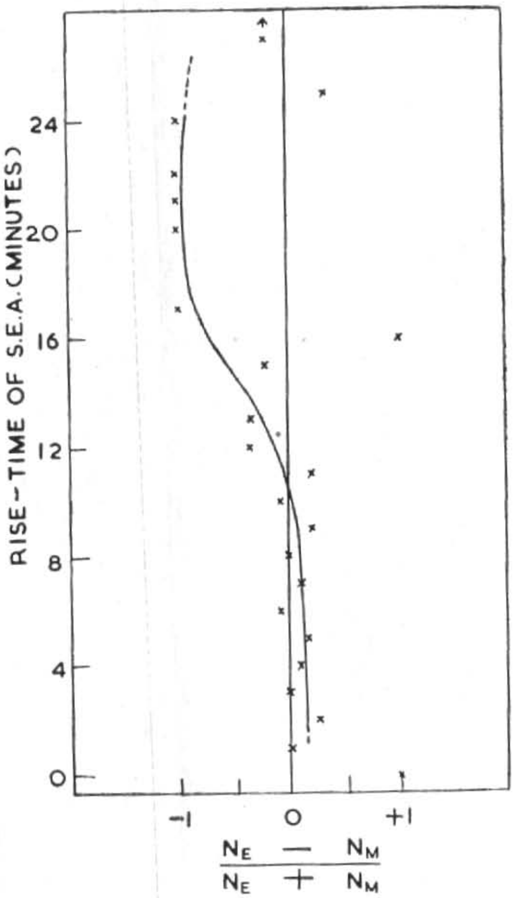

Fig. 11. Comparison of rise-time of S.E.A.s in the forenoon and the afternoon

N_E—Number of forenoon S.E.A.s

N_M—Number of afternoon S.E.A.s