Altitude Dependence of High Energy Atmospheric Showers*

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RECENT coincidence counter measurements in a B-29 airplane have extended the known altitude dependence of high energy atmospheric showers up to an elevation of 40,000 feet. The counter geometry used is shown in Fig. 1.

Each counter had a sensitive area of 1 inch by 13 inches. Besides the four threefold circuits shown in Fig. 1, a fifth circuit was connected to counters numbered 6 and 8 and to a third counter which was well separated from the other counters, giving a total spread of 42 feet. The coincidence counts of all five circuits were registered as marks upon a photographic film so that simultaneous discharge of the various circuits could be observed.

In Table I data are compared for the altitudes of 31,100 feet and 37,200 feet. All of the time at 37,200 feet was spent near Inyokern, California (41° north geomagnetic latitude). The data at 31,100 feet were collected between 53° and 35° north geomagnetic latitude.

The threefold coincidence counters with 13.5-foot separations were discharged nearly as frequently as the counters having 9-foot separations. The 42-foot coincidences occurred about two-thirds as often as the 9-foot coincidences.

The simultaneous discharge of circuits 1 and 2 or of circuits 3 and 4, shown on the photographic film, enabled fourfold coincidences to be observed. From the ratio of fourfold to threefold coincidences, a rough approximation to the average density of the showers selected by the threefold counters can be computed,[1] if one assumes that a Poisson distribution is approximately valid for the spatial distribution of the shower particles. The density values thus obtained at 31,100 feet and at 37,200 feet are approximately three-fourths of a particle per counter.

It is of interest that the ratio of the counting rate at 37,200 feet to that at 31,100 feet is not greatly different for 42-foot showers than for 9-foot and 13.5-foot showers.

Figure 2 shows the altitude dependence of atmospheric showers measured by the four threefold coincidence circuits shown in Fig. 1. The ordinate denotes the number of independent showers which discharged any one of the circuits 1, 2, 3, and 4 or any combination of them simultaneously. Data from previously reported measurements[2] at Wright Field, Ohio and from Hilberry's measurements[3] at lower altitudes were also plotted in order to obtain a complete altitude curve up to 40,000 feet. The Wright Field data were multiplied by a conversion factor obtained by comparing counting rates at 31,000 feet. Hilberry's data were multiplied by a factor obtained by comparing counting rates near sea level. It was then possible to draw a smooth curve which fitted the data within experimental error. This altitude dependence curve shows a definite maximum which has been drawn near 27,000 feet, but which may be a few thousand feet above or below that altitude.

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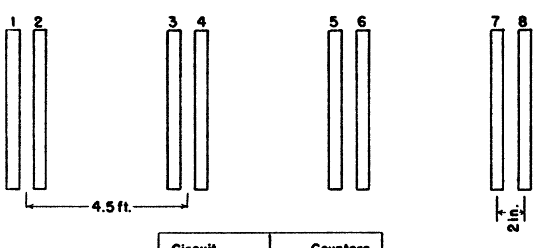

Circuit	Counters
1	1, 5, 7
2	3, 5, 7
3	2, 6, 8
4	4, 6, 8

FIG. 1. Coincidence counter arrangement.

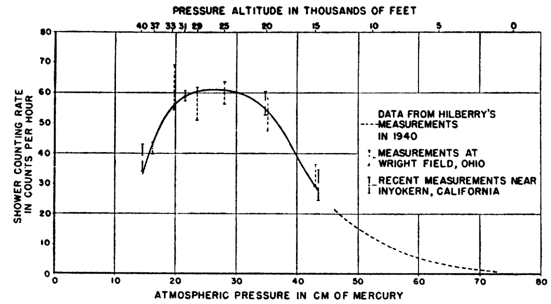

FIG. 2. Altitude dependence of atmospheric showers.

TABLE I. Comparison of shower data at 37,200 and 31,100 feet.

	31,100 ft.	37,200 ft.	Ratio of rate at 37,200 to rate at 31,100 feet
Time at altitude	1474 min.	556 min.	—
Total counts, circuit 1	592	156	0.70
Total counts, circuit 2	618	141	0.61
Total counts, circuit 3	576	138	0.65
Total counts, circuit 4	610	150	0.65
Total counts, circuit 5	348*	102	0.70
Total number of independent showers discharging any one of circuits 1, 2, 3, or 4	1457	385	0.70
Ratio of 13.5-ft. coincidences to 9-ft. coincidences	0.95	1.01	—
Ratio of 42-ft. coincidences to 9-ft. coincidences	0.63	0.70	—
Combined counting rate per hour of 9-ft. and 13.5-ft. coincidences	24.3	15.7	0.65
Counting rate per hour of 42-ft. coincidences	15.8	11.0	0.70
Counting rate per hour of independent showers discharging any one of circuits 1, 2, 3, or 4	59.3	41.5	0.70

* Based on a total time of 1323 minutes.

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[1] G. Cocconi, A. Loverdo, and V. Tongiorgi, Phys. Rev. 70, 841 (1946).
[2] H. Kraybill and P. J. Ovrebo, Phys. Rev. 72, 351 (1947).
[3] N. Hilberry, Phys. Rev. 60, 1 (1941).