where R and M are the radius and magnetic moment of the earth and $k^2=300\ M/V$. On the basis of the theory of Lemaitre and Vallarta this implies the existence of an azimuthal asymmetry in the intensity of the corpuscular component of the cosmic radiation in latitudes where the intensity is varying, and the sign of θ in (1) is such that positive rays should enter more abundantly from the west. As has been stated by Lemaitre and Vallarta, on the basis of the intensity measurements of Compton an azimuthal asymmetry should be detectable in latitudes between the equator and 34° geomagnetic and on the basis of Compton's own analysis of his data the greatest E–W differences should appear in latitudes between 20° and 30°.

With this prediction in mind measurements have been carried out in a tent on the flat roof of the Hotel Genéve in Mexico City at an elevation above sea level of 2250 meters and in geomagnetic latitude 29°N. Two independent sets of Geiger-Mueller counters were used, arranged as coincidence counting telescopes.[5] A summary of the data obtained during the first two weeks is contained in Table I. Each run consisted of a series of n counting periods in positions alternating between the azimuths indicated. Usually the order E W W E, etc., was maintained in order to prevent long time variations of sensitivity from favoring any one azimuth. Changes in position from one azimuth to the other were made by rotation about a vertical axis so that any possible difference between the measured and true angle was the same, independent of the azimuth. The probable error of the mean counting rate has been estimated from the internal consistency. A comparison of this value of the probable error with that calculated by statistical theory from the total number of counts in the run is an indication of the possible extent of instrumental variations.

The results seem conclusive in showing that the west intensity is greater than that of the east at angles between 30° and 65° from the zenith. Every run within this range of angles shows the effect and in some cases the E–W difference is more than six times the probable error. The results therefore accord with the Lemaitre-Vallarta theory and show that the principal corpuscular component of the cosmic radiation is *positively* charged. The disappearance of the E–W difference at angles below 65° is to be attributed to atmospheric absorption, and the rate of loss of energy which may be determined in this way is in fair agreement with the fact that no latitudinal variations of intensity occur outside of the ±34° equatorial belt.

Run 5A, including the four principal azimuths, indicates equal intensities in all but the east. Since the west value of this run is somewhat less than that of run 2A this result is somewhat questionable, but if it is correct, it would mean that the forbidden cone is sharply limited to the region below 15° to 30° east of the meridian. This result is to be predicted from the energy band deduced by Compton at $x_0=0.45$.

The Lemaitre-Vallarta theory also predicts a slight asymmetry about the E–W plane with a slightly greater intensity from the South in northern latitudes. Run 6A was made with the hope of detecting this asymmetry by comparing the NE and SE intensities at 45° from the zenith. The asymmetry for these directions proved to be too small to detect, although the measurements show that the intensity has an intermediate value in these directions.

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THOMAS H. JOHNSON

San Rafael,
Mexico,
April 11, 1933.

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A Positively Charged Component of Cosmic Rays

The relatively low intensity of cosmic rays at low geomagnetic latitudes, as recently found by our associated expeditions[1] and others,[2] indicates that a part of the cosmic rays consists of electrified particles. When interpreted in terms of Lemaitre and Vallarta's theory[3] of the deflection of electrified particles by the earth's magnetic field, these results indicate that at geomagnetic latitudes higher than about 45° the earth's magnetic field should not alter the direction of the incoming rays as observed at sea level. This is in accord with the sea-level observations of Johnson and Street,[4] which show a symmetrical East-West distribution. At the geomagnetic equator an analysis of our intensity-latitude curves suggests that most of the cosmic rays which are affected by the earth's magnetic field are too strongly deflected to reach the earth's surface. If this is correct, there should be but little asymmetry in the direction of approach of the cosmic rays near the equator. In an intermediate zone, however, where the intensity *vs.* latitude curve is steep, the rays that are being affected by

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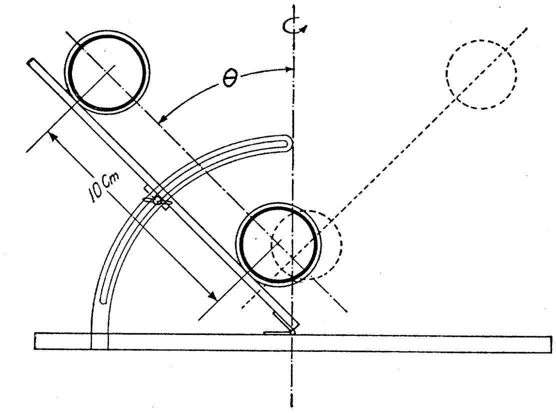

FIG. 1. Arrangement of coincidence counting tubes for studying East-West asymmetry of cosmic rays.

the earth's magnetic field should strike the earth from certain directions but not from others. If the rays are positively charged, they should come mostly from the west, if negatively, predominantly from the east, due to deflection by the earth's magnetic field. From such considerations Vallarta has suggested that Mexico City should be a good place to search for the predicted asymmetry in the direction of the incoming cosmic rays. Besides being in the favorable zone of geomagnetic latitude (29°N), its elevation (2310 meters) is sufficient to avoid some of the disturbing effects of the atmosphere.

In order to observe the direction of the incoming particles we have used a double coincidence counter, as shown diagrammatically in Figs. 1 and 2. Tests made by separating the tubes indicate that chance coincidences occur at the rate of only about 1.5 per hour, so that with a normal counting rate of about 5 per minute these were of negligible importance. The zenith angle θ of the line joining the axes of the tubes with the vertical was measured with the help of a protractor and spirit level. In order to avoid any possible change of conditions, the whole apparatus was mounted on a platform, which was rotated through 180 degrees when the changes between east and west were made. Readings of about a half hour's duration were taken alternately between east and west at the same zenith angle θ. For each angle the final series of readings totaled about fourteen hours on either side. By changing thus back and forth, enough readings were obtained to make a good estimate of

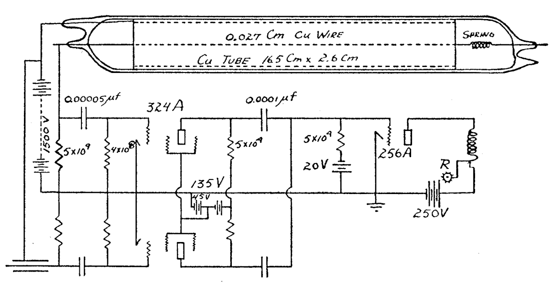

FIG. 2. Circuit used with double coincidence counter.

the probable errors of the observed counting rates. The errors thus estimated from the consistency of successive readings under similar conditions were but little greater than those calculated as the statistical error from the total number of coincidences in the series. This means that no serious disturbing factor was affecting the readings. Table I summarizes our results.

TABLE I. *East-west measurements at Mexico City, April, 1933.*

Geomagnetic latitude 29°N, elevation 2310 m, barometer, 56.5 cm.

Zenith angle		West	East	West/East
15°	Counts	5370	4856	
	Rate	6.83±0.07	6.64±0.07	1.03±0.02
30°	Counts	4897	4869	
	Rate	5.79±0.06	5.49±0.06	1.055±0.015
45°	Counts	2691	2693	
	Rate	3.70±0.05	3.30±0.05	1.12±0.02

It will be noted that at the larger zenith angles the rate at which the rays come from the west is greater than that from the east by several times the probable error of the measurements. It would appear that the asymmetry thus observed at Mexico City is considerably larger and more definite than that found by Johnson and Street[5] on Mt. Washington, geomagnetic latitude 55°N, elevation 1920 meters. This preponderance of rays from the west seems necessarily to imply the existence of a positively charged component of the cosmic rays.

Since our earlier measurements have shown that the cosmic rays at geomagnetic latitude 29° differ by only about 14 percent from those in high latitudes for this elevation, the difference in counts in the east and west directions is of the order of magnitude to be expected due to the deflection of the particles by the earth's magnetic field. The smallness of the effect confirms our earlier conclusion that most of the rays capable of penetrating the earth's atmosphere are not sufficiently bent by the earth's magnetic field to prevent them from reaching the earth. We may add that these data are consistent with the view that the positively charged component here found consists of Anderson's newly discovered[6] positrons.

We wish to thank Professor R. D. Bennett for suggesting the circuit used, Dr. M. S. Vallarta and Dr. T. H. Johnson for valuable suggestions in carrying on the experiment, and the Carnegie Institution of Washington for financial aid.

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ARTHUR H. COMPTON

University of Chicago,
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