CHAPTER IV

EXPERIMENTAL RESULTS

1. Apparatus.

Two sets of telescope were used in this work. Each set consists of two G.M. counters positioned parallel to each other in horizontal plane and directed along the north - south direction of the geomagnetic field. These two counters are held firmly by the rotating frame as shown in Fig. 7. The wooden frames of the telescopes can be tilted about two hinges

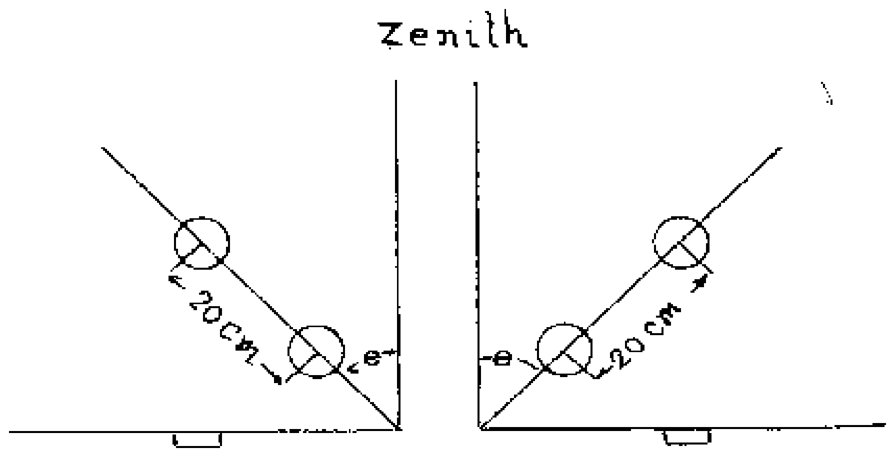

Fig. 7 : Counter Telescopes Mounted on the Rotating Frames

to desired zenith angles. Thus, we can adjust the telescopes such that one is in the east direction, the other in the west direction.

Each counter of the telescope is connected to an amplifier, then to a wave shaping circuit. The signals from the two wave shaping circuits, one from each counter, are sent to a coincidence circuit, a discriminator and a scaler. These two counters and circuits form a twofold coincidence telescope (Fig. 8).

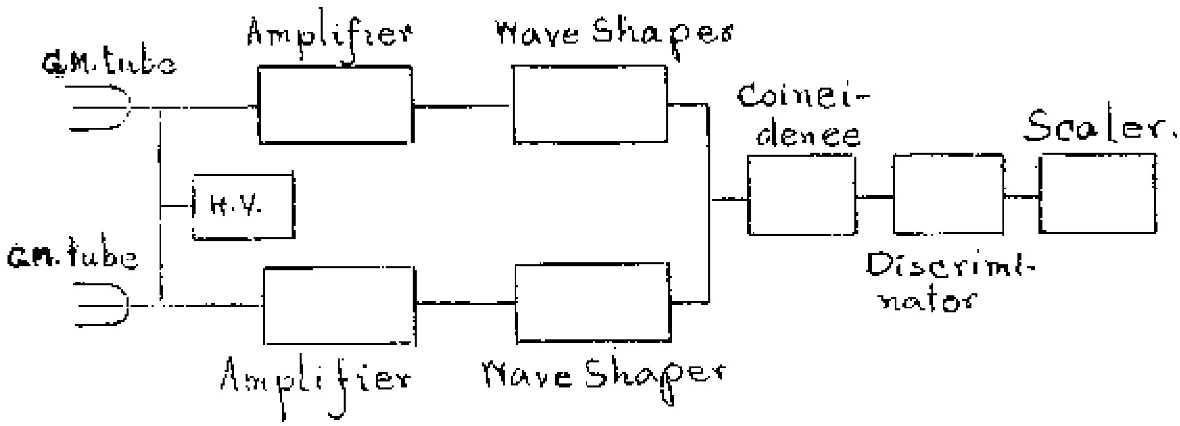

Fig. 8 : Block Diagram of a Twofold Coincidence Telescope

The high voltage supply to the G.M. tubes, the discriminator and the scaler of one telescope is from a single counting unit. The Abacus G.M. scaler, Model 123 is used for one telescope; the Atomic Instrument Company scaler, Model 101-M is for the other. A stabilised line voltage is supplied to the counting units and timer.

The voltage supply for the coincidence circuits including accessories is from a 9 volts battery. These parts are made by the author using the principle of coincidence circuit, transistorized type used in the Institute for Nuclear Study , University of Tokyo.

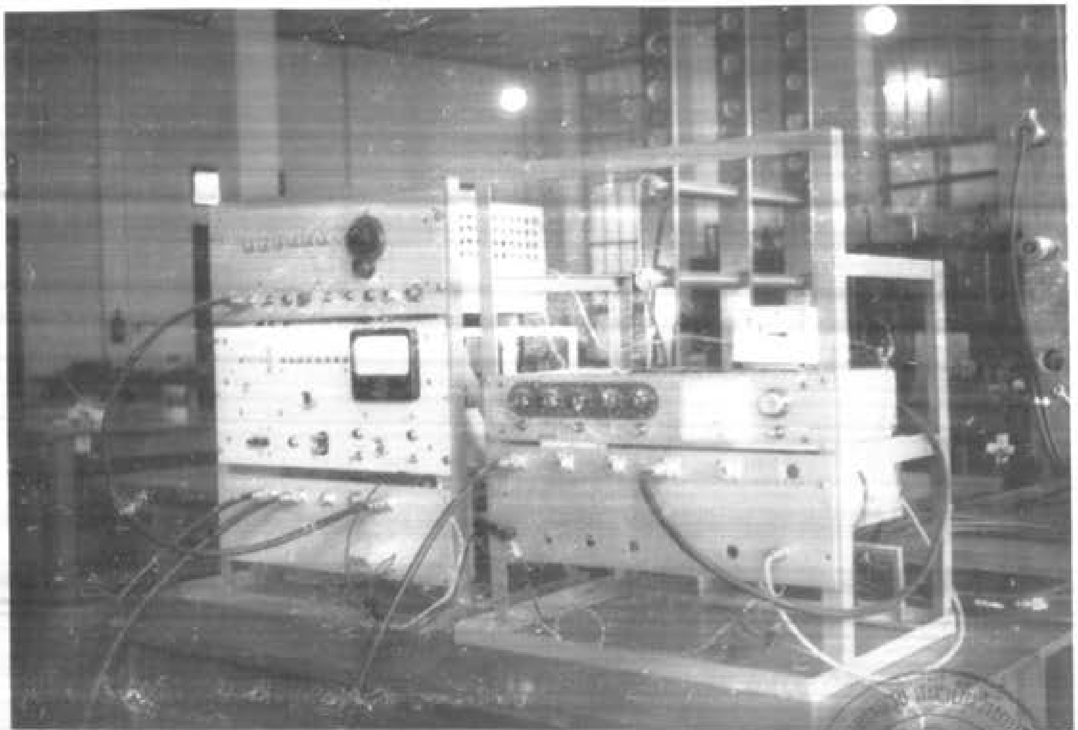

Fig. 9 : The Picture of the Apparatus

The experiment was performed in the Electronics Laboratory under the roof of the Physics building. Fig 9 is the picture of the apparatus used in this measurement. Each part is now described in detail.

A. Telescope. The telescope consists of two G.M. counters, positioned parallel with each other in the horizontal plane. The distance between two counters is 20 cm.; the overall diameter of the counter is 3.8 cm. . The overall length is 64.8 cm. with the active length of 53.4 cm.. Thus the resolution angle is 10.75° in the directional plane and 67.5° in the complementary plane as shown in Fig. 10.

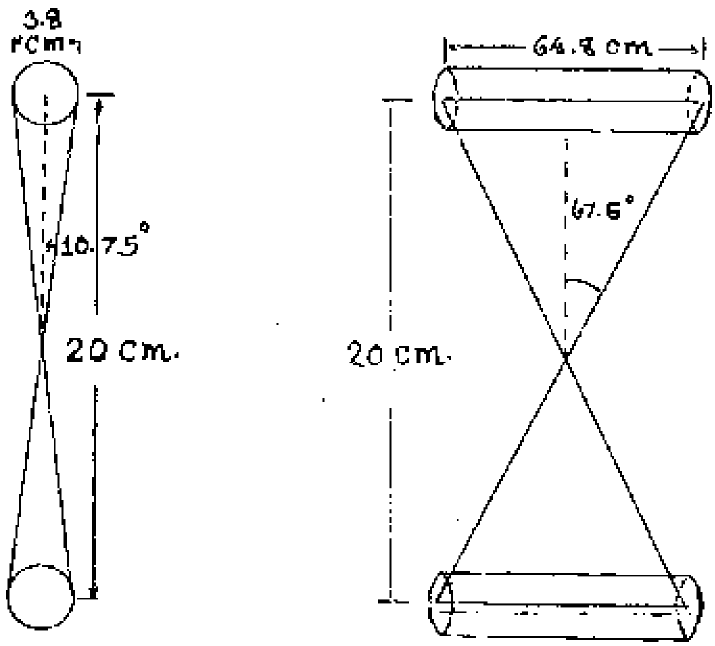

Fig. 10 : Resolution Angles in the Vertical Direction and in the Complementary Plane

The two counters are fastened to a rectangular wooden frame, through holes at both ends of each counter. The frame is, then, attached to the wooden base frame by two hinges. The base is able to rotate about the vertical shaft at its center. Two wheels at one end of the base are also used to support the structure. One telescope is set in the east direction and the other in the west direction. The axes of the counters are in the north-south of horizontal field of the earth. The zenith angles of directional telescope can be adjusted from 0° to 90°. The vertical and the horizontal directions were carefully set by a precision level. All angles were measured by a protractor.

B. G.M. Counter. In this work, Geiger counters made by the 20th Century Electronics Ltd., type C. 53, of gas self-quenching, argon and ethyl formate are used. The tube is of metal construction. The starting potential is around 1750 volts with a plateau of 200 volts (Fig. 11), slope of plateau maximum 0.1 %. The active length is 53.4 cm., overall length 64.8 cm., overall diameter 3.8 cm., and the dead time at working voltage is 100 μ sec as shown by the factory.

C. Coincidence Circuit. The transistorized coincidence unit whose block diagram is shown in Fig. 8 consists of an amplifier, a wave shaper and a coincidence circuit.

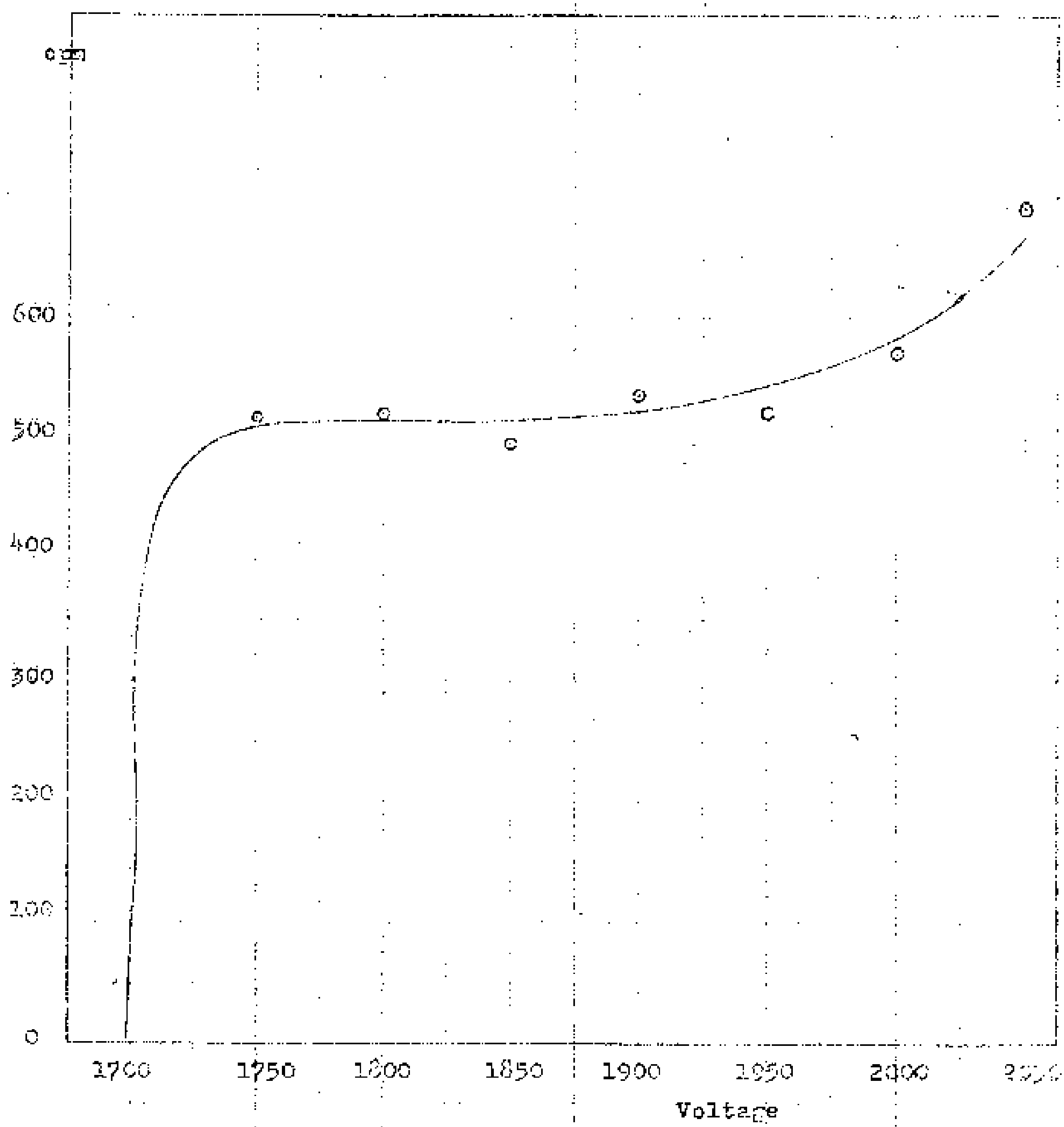

Fig. 11: The Plateau of a G.M.Counter Used in this Measurement

(i) Amplifier. Because the pulse from the Geiger counter is so small that it cannot trigger the univibrator, it is necessary to amplifier the pulse first. For this purpose, we use feedback in small-signal amplifier (15) to reduce the distortion and the feedback makes the performance of the amplifier less dependent on transistor parameters and hence less dependent on temperature. The circuit is shown in Fig. 12. The total gain of the amplifier is about 28.

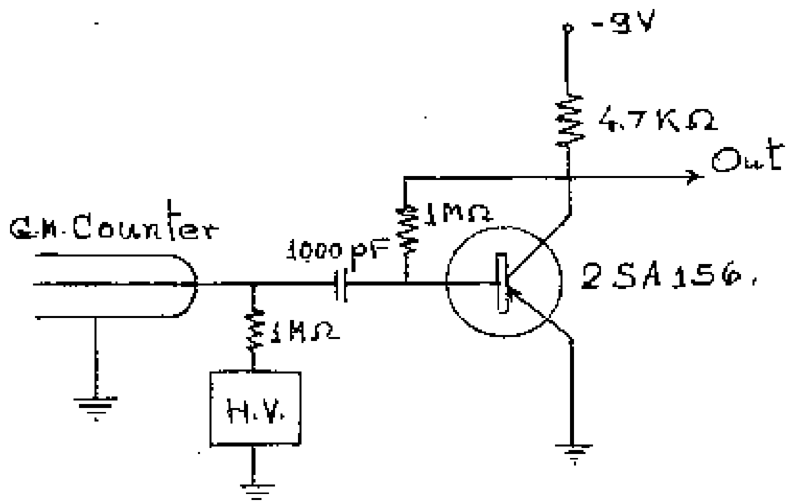

Fig. 12 : The Feedback in Small-Signal Amplifier

(ii) Wave shaper or univibrator. The output pulse from the amplifier is used to trigger a univibrator so that the pulse V output from the univibrator will be uniform square wave and constant amplitude. The duration time of the pulse is 10 sec.

In Fig. 13 the positive pulse enters TR_1's base which is conducting, thus makes it cut - off and causes TR_2 which is being cut - off to conduct. When the input pulse disappears, TR_1 start conducting again and also makes TR_2 to cut - off. When the next pulse arrives the cycle again repeat. Thus the

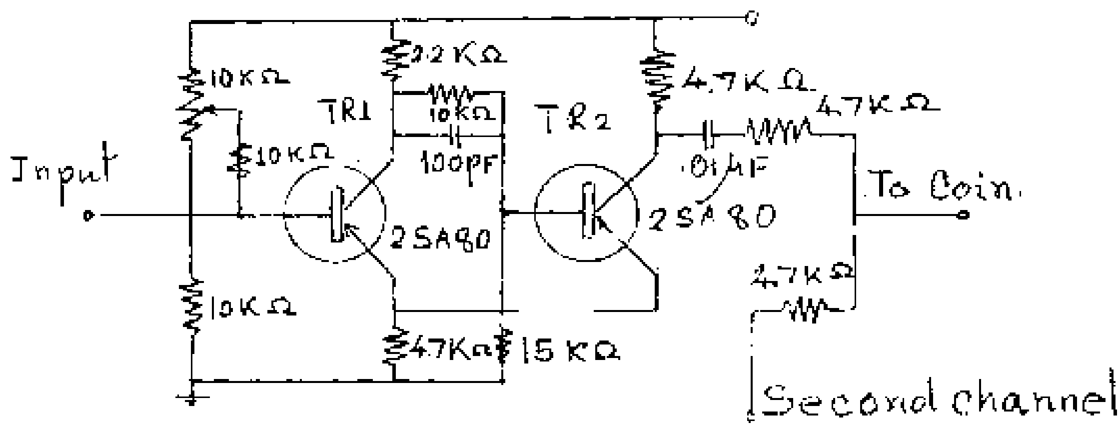

Fig. 13 : Wave Shaping Circuit

out - put of this circuit will be of uniform square - wave to be used as input to the coincidence circuit.

(iii) Coincidence circuit. The pulse from wave shapers are fed to the coincidence circuit. The divider resistance can be adjusted to trigger the scaler either by only a single pulse from one wave shaping circuit, or by simultaneous pulses from both wave shaping circuits. The divider resistance is normally adjusted such that only two simultaneous pulses from both wave shaping circuits will trigger the scaler. The output is the same shape and is sent to the discriminator of the scaler to select the pulse to count. By means of this, the fluctuation signals are cut out and only the coincidence signal from two channels are counted.

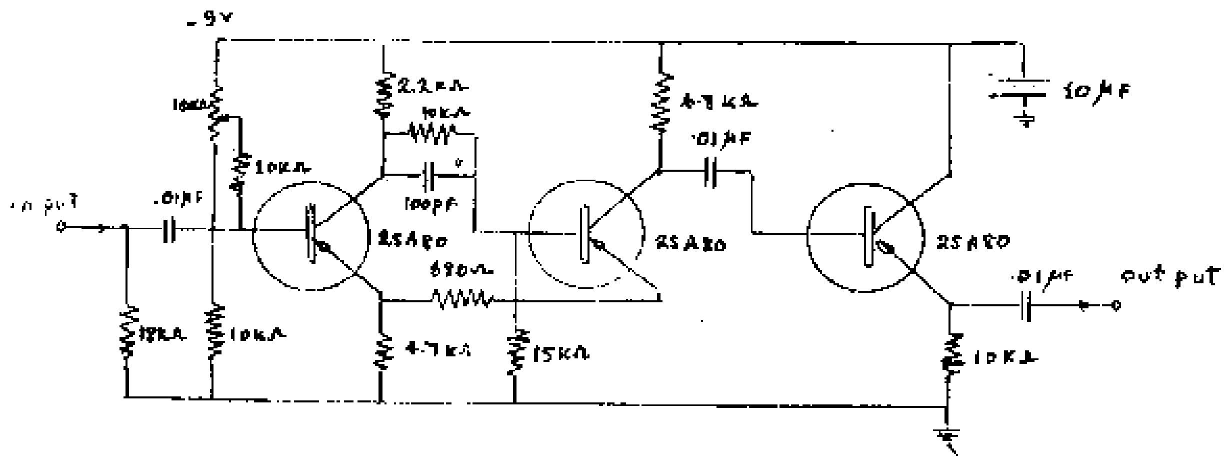

Fig. 14 : Coincidence Circuit

D. Discriminator and Scaler. The discriminator or pulse height selector is the electronic unit for selecting the pulse height to pass through the scaler for counting. If the pulse is lower than a given value, i.e., in this case 2.4 volts, the scaler does not count.

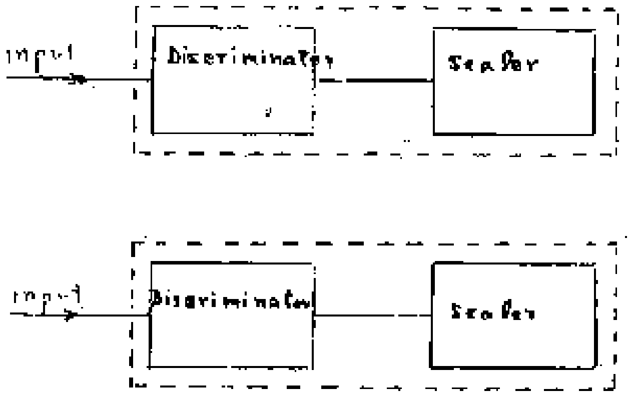

Fig. 15 : Discriminator and Scaler

The apparatus is set as decribed above. The resolving time of amplifier and coincidence circuit are so small that for this counting rate of about 500 cpm they are negligible, and in this experiment we used the method of comparison by interchanging the telescopes in the east and in the west directions. By using a compass, the line joining the telescopes was adjusted to be along the east-west direction, one in the east and the other in the west.

The observation was made in the day time from about eight o'clock in the morning to five o'clock in the afternoon in a period of three months. Before counting, each univibrator was checked for duration time to be 10 μ sec. and proper coincidence from the two channels was also checked. The measurement, then was started with telescope I in the east side and telescope II in the west side. The timer connected to the scaler was used. The counts were recorded about every 30 minutes. By interchanging the direction of telescope I to the west and telescope II to the east the counts were recorded again. However, the time of each counting sometimes was not exactly 30 minutes but we control the total time of the counters of each telescope to be equal or nearly equal in the east and west direction. The directional intensity of total cosmic radiation (cpm) was observed from the zenith angle 0° to 75° in the east at the same time as in the west. The total time of counting in each zenith angle was such that a total counts at least 10,000 counts was obtained.

2. Correction for Statistical Fluctuation.

By using the method of frequently interchanging the direction between telescope I and II (17), the error of counting rate of directional intensity is relatively small. These correspond to correct the error of fluctuation and inefficiency of the counters as follows.

A. Any Instrumental Selectivity. This means that if the two set of telescopes have not the same efficiency we can take the advantage by changing the directions of two telescopes and using the equal or nearly equal total time of measurement of each telescope in the east and west.

B. Any Short Period Change of Cosmic Ray Intensity. By frequently interchanging the position of the telescopes, if a short period change is occurred in any time, this method will correct the fluctuation.

The errors due to uncertainty of rotating the frames and the timer in this experiment is relatively small. It can be seen from the Table 2, at zenith angle 0° the asymmetry does not exist. Thus, the important part of fluctuation is due to the electronic counting instrument. The distribution of intensity of both directional telescopes are in accordance with the Gaussian distribution. We may, therefore use the standard deviation as in the following equation :

$$\sigma = \frac{0.6745\sqrt{C}}{T} \quad \text{cpm.}$$

3. Observed Data.

The result of measurement is shown in Table 1. Intensity in this measurement is used in cpm by adding the counts in each direction with two telescopes. The asymmetry is obtained by the equation

$$\text{Asymmetry} = \frac{2\,(J_W - J_E)}{(J_W + J_E)}$$

The error of asymmetry is introduced by using standard error of any function (18), to be shown in Appendix.

Table 1 is shown the asymmetry of cosmic rays against the zenith angle measured in Table 1. The West-East ratio and West-East different are also tabulated in Table 3.

Table. 1. The Total Counts with the Telescopes in Position I and II .

Zenith angle	Position I			Position II		
	Total time minutes	Train I West Total count	Train II East Total count	Total time minutes	Train II West Total count	Train I East Total co
0°	286	5653	5402	282	5253	5421
15°	1048	19400	16999	1053	18730	18256
30°	467	6306	5566	428	5832	5300
45°	1019	11275	9556	1033	11260	10017
60°	1731	9932	9917	1718	10676	8990
75°	1983	5695	5282	2000	5734	5643

The mean barometric pressure in this measurement is about 755 mm. of Hg.

Table 2. The Asymmetry at Various Zenith Angles.

Zenith angle	Azi-muth	Total time	Total count	Intensity J cpm	Asymmetry $= \frac{2(J_W - J_E)}{J_W + J_E}$
0°	W	568	10906	19.201 ± 0.124	0.008 ± 0.009
	E		10823	19.055 ± 0.123	
15°	W	2101	38130	18.149 ± 0.063	0.078 ± 0.005
	E		35255	16.780 ± 0.060	
30°	W	895	12138	13.562 ± 0.083	0.111 ± 0.009
	E		10866	12.141 ± 0.078	
45°	W	2022	22535	11.145 ± 0.050	0.141 ± 0.007
	E		19573	9.680 ± 0.047	
60°	W	3449	20608	5.975 ± 0.028	0.086 ± 0.007
	E		18907	5.482 ± 0.027	
75°	W	3983	11429	2.869 ± 0.018	0.045 ± 0.009
	E		10925	2.743 ± 0.018	

Table 3. The W-E Ratios and W-E Differences at Various Zenith Angles.

Zenith angle	Azimuth	Intensity J cpm	W/E	W-E difference
0°	W	19.201 ± 0.124	1.008 ± 0.065	0.146 ± 0.175
	E	19.055 ± 0.123		
15°	W	18.149 ± 0.063	1.082 ± 0.005	1.369 ± 0.087
	E	16.780 ± 0.060		
30°	W	13.562 ± 0.083	1.117 ± 0.010	1.421 ± 0.114
	E	12.141 ± 0.078		
45°	W	11.145 ± 0.050	1.151 ± 0.008	1.465 ± 0.070
	E	9.680 ± 0.047		
60°	W	5.975 ± 0.028	1.090 ± 0.005	0.493 ± 0.039
	E	5.482 ± 0.027		
75°	W	2.869 ± 0.018	1.046 ± 0.009	0.126 ± 0.026
	E	2.743 ± 0.018		

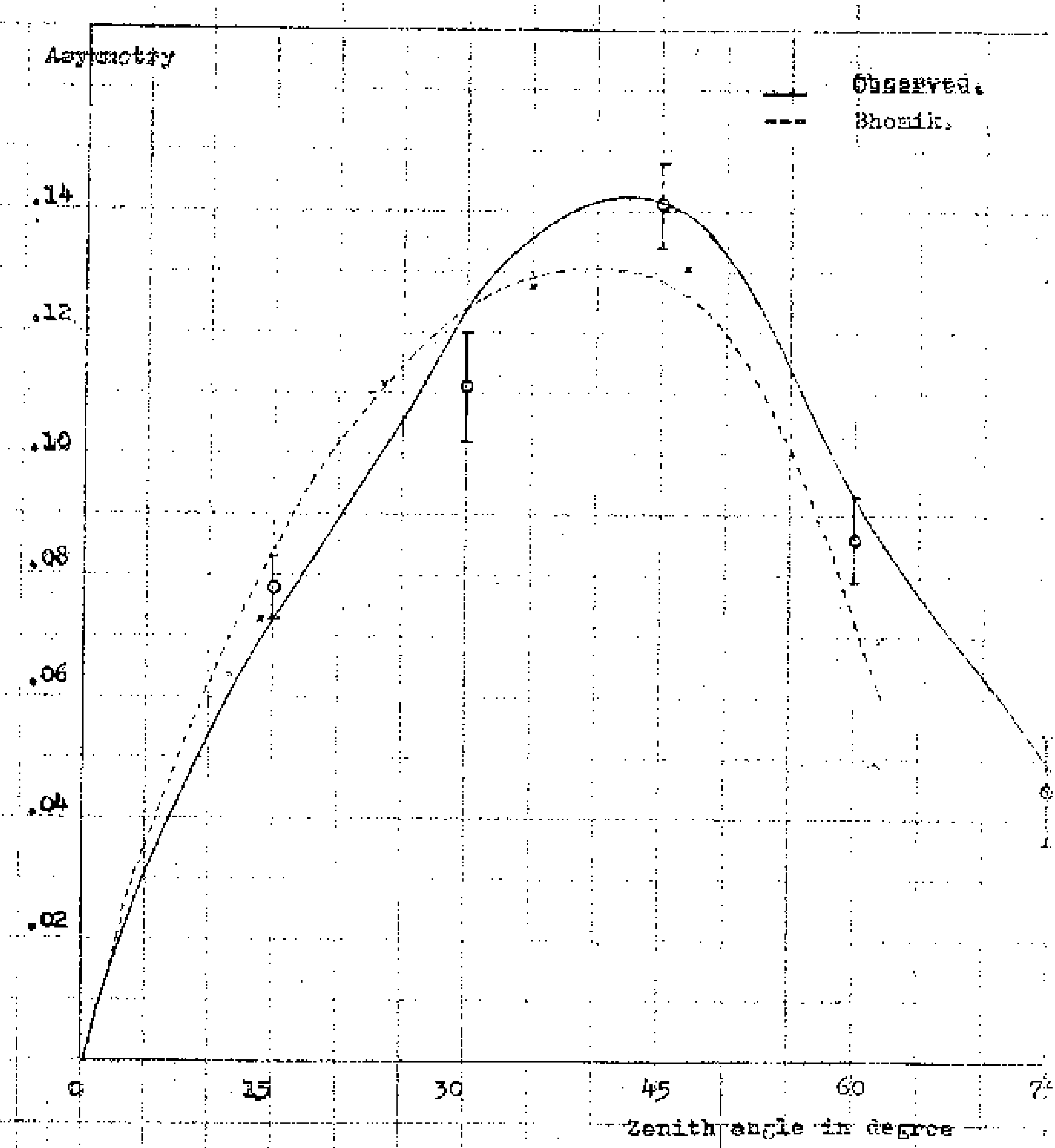

Fig. 16: East-West Asymmetry at Various Zenith Angles

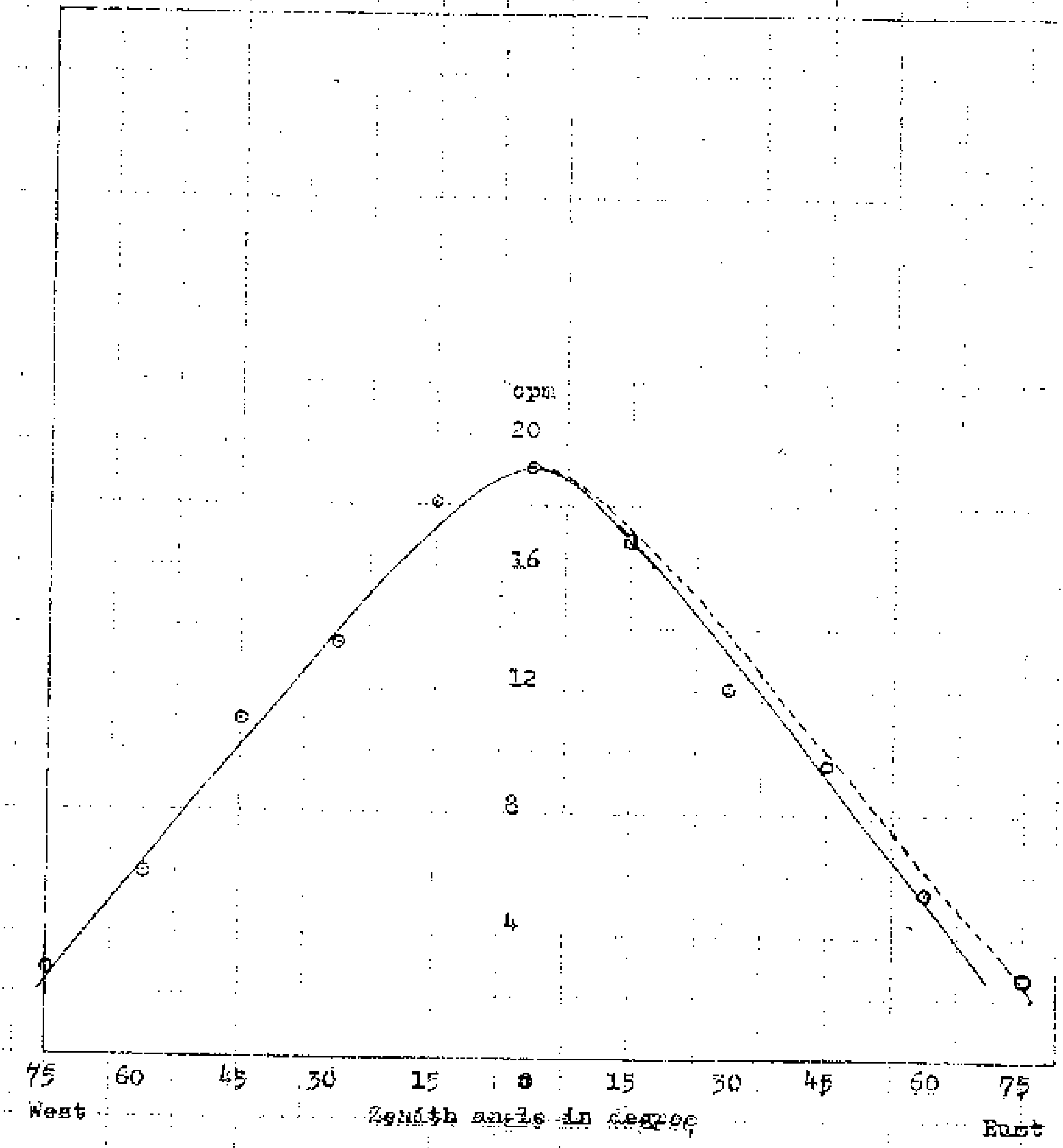

Fig. 27: East-West Intensity Distribution Due to the Directional Intensity at Ground Level, $\lambda = 13^{\circ} 46' N$

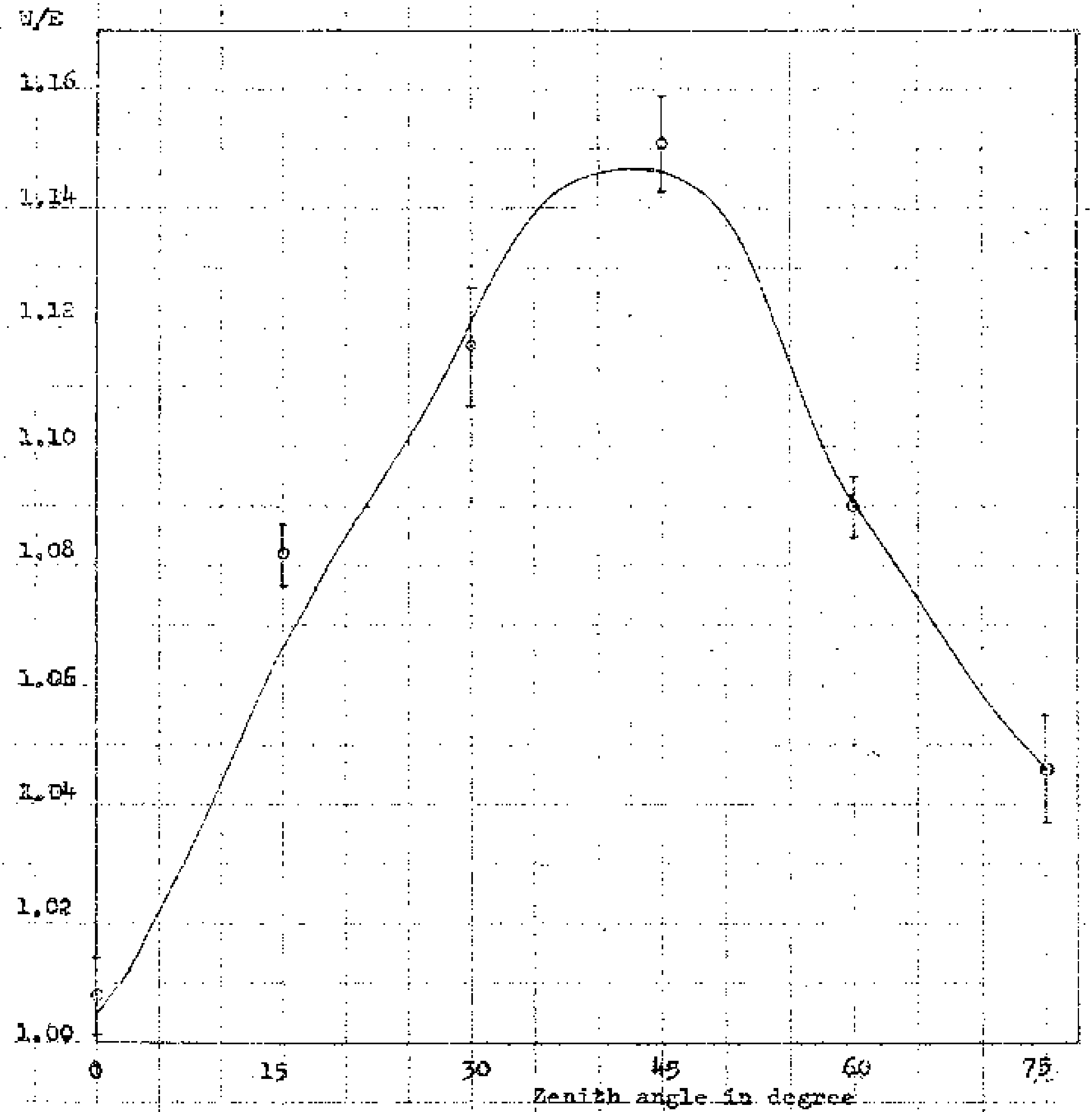

Fig. 18: West-East Ratio at Various Zenith Angles

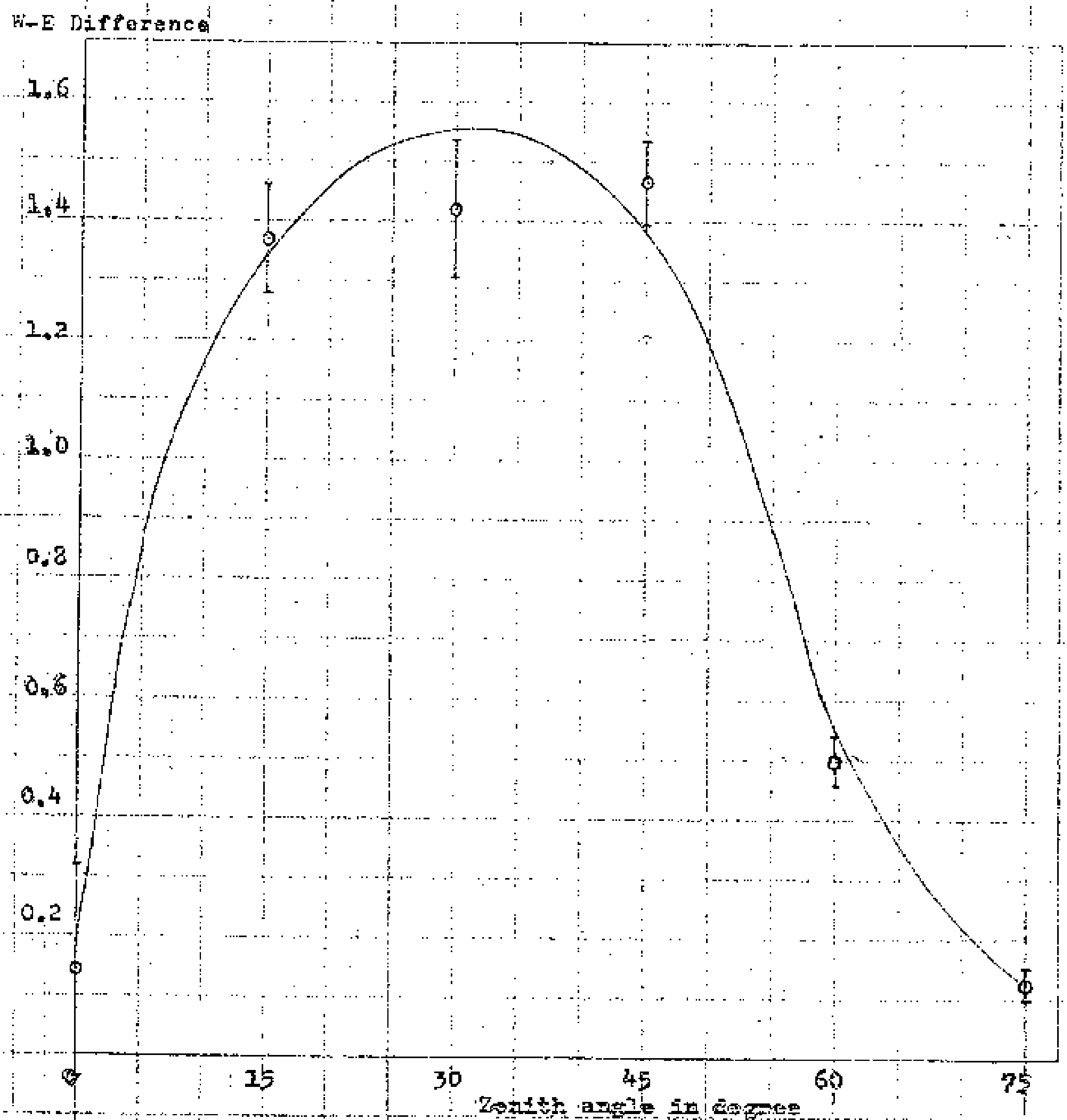

Fig. 19: West-East Difference vs. Zenith Angles