the part of the gamma-ray spectrum in which a step should be found if annihilation radiation were present. Also shown is the curve obtained for the Zn^{65} spectrum in this region. Zn^{65} has about 5 annihilation quanta per 100 gamma-rays.[6] The number of annihilation quanta per gamma-ray in K^{40} must be less than half the number from Zn^{65}. Therefore the number of positrons emitted must be less than 1 percent of the K capture transitions to the excited state of A^{40}. This lack of positron emission makes it improbable that there is any large number of K captures to the ground state of A^{40}.

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Zenith Angle Dependence of Extensive Air Showers

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FROM the altitude dependence of extensive air showers one can calculate the zenith angle dependence of the showers at a given depth, under the following assumptions: (1) The shower primaries are isotropic at the top of the atmosphere, (2) the multiplication and disappearance of the shower particles in the atmosphere is a function solely of the mass of matter traversed and not of the path length or density, (3) the lateral spread of shower particles at a given depth is inversely proportional to air density in accordance with cascade theory, (4) the particles in the showers have the same direction as the primary particle which produced the shower, and (5) the value of γ, defined as $d\log C/d\log A$, where C is the counting rate and A is the counter area, is known for showers incident from the vertical.

By use of an altitude curve[1] obtained by the author, the zenith angle dependence was calculated for an atmospheric pressure of 50 cm of Hg. The shower detector consisted of three Geiger counters uniformly spaced in a straight line. Spacing between adjacent counters was 1.4 meters. The effect of counter geometry was taken into account, although the calculated zenith angle dependence is only weakly sensitive to the counter geometry. The value of γ was assumed to be constant and equal to 1.5 between sea level and 50 cm of mercury.[2] By the use of a generalized Gross transformation[3] the zenith angle distribution was then obtained as:

$$M(t,\theta)=\frac{2.2C(t/\cos\theta)-(t/\cos\theta)C'(t/\cos\theta)}{2\pi}\cos^{0.7}\theta.$$

$C(t)$ is the observed counting rate as a function of altitude. $M(t,\theta)$ is the rate of showers per steradian which would be counted at thickness t and zenith angle θ, by an isotropic detector having the same vertical sensitivity as the counter arrangement.

Numerical application of this formula to the altitude curve gives a zenith angle dependence for the axes of the air showers which can be approximately represented by $\cos^5\theta$ between 0° and 40°, but which decreases somewhat more rapidly than $\cos^5\theta$ at larger zenith angles.

An experimental test of the above zenith angle distribution was attempted at Climax, Colorado, at a pressure of 49.5 cm of mercury, by using the directional sensitivity of long cylindrical counters. When the axes of such counters are vertical, their counting rate is strongly sensitive to the breadth of the zenith angle distribution of the showers. The counting rate of these counters with their axes horizontal is less sensitive to the zenith angle distribution. Table I lists the horizontal-to-vertical counting ratio for counters of lateral cross section 2.44 cm by 33 cm, having the same disposition in a horizontal plane, calculated for various assumed zenith angle distributions of the showers.

TABLE I. Values of the horizontal/vertical counting ratio (R), calculated for various assumed zenith angle distributions. The values were computed for cylindrical counters with a sensitive area of 2.44 cm × 33 cm.

Assumed angular distribution	Calculated value of R
$\cos^3\theta$	1.86
$\cos^5\theta$	2.33
$\cos^9\theta$	3.16
$\cos^{15}\theta$	4.21
angular distribution at 50 cm of Hg, calculated from altitude curve of reference 1	2.56

The counting rates of the counters shown in Fig. 1 were determined at Climax. The horizontal-to-vertical ratios (R) are shown in Table II. These ratios are not sensitive to the counter arrangement. The best experimental value of R is 2.12±0.07. This is the value of R to be expected for a zenith angle distribution of about $\cos^4\theta$. This value is lower than the value of 2.56 which was calculated from the altitude dependence.

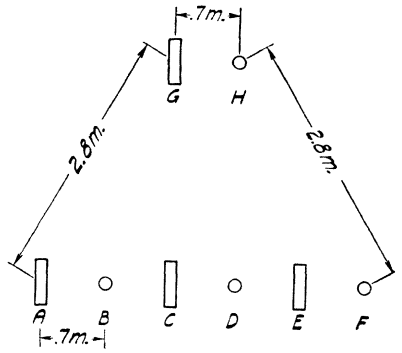

FIG. 1. Vertical view of arrangement of horizontal and vertical counters, used to test zenith angle distribution of extensive air showers at Climax, Colorado. The coincidences *ACE, AEG, ACEG, BDF, BFH, BDFH*, were recorded. Sensitive area of each counter is 2.44 cm by 33 cm.

TABLE II. Counting rates of the counter arrangement shown in Fig. 1.

Time	Coincidence type	Counts	Rate
220	*ACE*	1621	7.37±0.18*
220	*AEG*	1563	7.11±0.18
220	*BDF*	765	3.47±0.12
220	*BFH*	738	3.35±0.12
220	*ACEG*	1018	4.63±0.15
220	BDFH	474	2.15±0.10
Coincidence ratios			R
ACE/BDF			2.12±0.08*
AEG/BFH			2.12±0.09
ACEG/BDFH			2.15±0.12

* This is the standard deviation due to statistical fluctuations.

The cause of the above difference is not clear. Some of it is due to scattering of the shower particles in the air and to multiplication in material surrounding the counters. The counters were enclosed in boxes of 0.8-mm sheet iron, under a canvas tent in the open air. The tent was 10 feet from a metal shack about 15 feet square by 10 feet high. However, the fact that R did not vary with the counter geometry indicates that the shack did not appreciably affect its value.

Narrow showers[4] incident at large zenith angles would tend to

favor the vertical counters and produce the discrepancy observed. However, the narrow showers have appreciable effect only at counter spreads less than 90 cm. Thus the arrangements *AEG* and *BFH* of Fig. 1 are not affected by narrow showers from any direction.

I am indebted to the Climax Molybdenum Company for the use of their facilities while carrying out this experiment, and to the University of Chicago for lending some of the equipment which was used. I also wish to thank Professor C. G. Montgomery for helpful discussions.

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The "1947 Values" of the Atomic Constants and the Revision of the Faraday Constant*

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IT is well known that the two precision determinations of the Faraday by electrochemical methods (1) by the silver voltameter,[1] (2) by the iodine voltameter[2] fail to agree by considerably more than their estimated probable errors warrant.

$$F_{Ag}=9650.5 \text{ e.m.u./g} \quad \text{(physical scale)},^{3}$$
$$F_{I}=9652.2 \text{ e.m.u./g} \quad \text{(physical scale)}.^{3}$$

Nevertheless, F_{Ag} has long been the value accepted, perhaps in part because it has been regarded *as correct by definition.*

It seems to the writer that such an empirical definition is unfortunate and this universal constant should preferably be defined in a *fundamentally significant* way, i.e., as the quantity of electricity, N_0e, (N_0=Avogadro's number and e=the electronic charge) or the charge *associated with* one gram-atomic weight of singly ionized atoms. Fortunately, in this more fundamental sense of the Faraday it can now be, and recently has been precisely measured. J. A. Hipple, H. Sommer, and H. A. Thomas at the National Bureau of Standards[3] determine by means of their newly developed "omegatron" the charge-to-mass ratio e/M_{H^+} for gaseous H^+ ions. After multiplication by the isotopic weight of H^+ (1.007580 ± 0.000003) they obtain the Faraday (in the sense here proposed). A preliminary result is

$$F=9652.8\pm0.8 \text{ e.m.u./g (physical scale)}$$

indicating that the iodine Faraday (rather than the silver) was nearer the truth.

The Faraday can be computed from certain spectroscopic data without appeal to electrochemistry and R. T. Birge was the first to point out[4] that when this is done one obtains a value somewhat higher than F_{Ag} (though less accurately). Now both F_{Ag} and F_I were determined before the discovery of isotopes and it occurred to the writer of this letter as early as 1940 that the facts (1) that iodine is isotopically pure and (2) that silver consists of two isotopes in nearly equal abundance might explain the F_I-F_{Ag} discrepancy.

In 1948, E. R. Cohen and the writer published[5] a least-squares analysis (here designated D and C '48) of the existing data on the atomic constants. Some eleven different precision measured values each representing a different function of the four unknowns, F, N_0, m, and h, formed the basic input data from which an overdetermined set of observational equations was adjusted by least-squares to obtain compromise output values of the above four unknowns. The adoption of four unknowns F, N_0, m and h (instead of three, $e(=F/N_0)$, m and h) for the least-squares adjustment (designated in the paper as the "new viewpoint") was a new departure in such analyses (expressly introduced because of the uncertainties in F) which led to a complete reclassification of several of the eleven input data. Other important influences beside the direct electrochemical data were thus free to operate in the least-squares adjustment leading to the output value of F. For the direct electrochemical data on F the average of F_{Ag} and F_I was used in D and C '48. The final least-squares-adjusted output value for F obtained from this analysis came out

$$F=9652.2\pm0.7 \text{ e.m.u./g (physical scale)}$$

in close agreement with F_I rather than F_{Ag}.

Largely because of this higher output value of F there has been a perhaps natural reluctance among some physicists to accept the revised values obtained in D and C '48 (some 33 values of different important constants and conversion factors were there computed). A chief purpose of this letter is to point out that the new corroboration from the work of Hipple and his associates now largely removes the cause of this reluctance. Also, since D and C '48 appeared, further evidence[6] in favor of the higher Faraday has been obtained as a by-product of a measurement[7] of the wavelength of the annihilation radiation.

Undoubtedly, the entire least-squares analysis should be repeated using the final Hipple value of F (when it is available) and perhaps ignoring F_{Ag} and F_I completely unless improvements can be made in these electrochemical determinations as regards at present unknown systematic errors. Although the results in D and C '48 were very insensitive to the directly measured x-ray value of h/e, it might also be wise to postpone such a final least-squares analysis until the h/e discrepancy (now under investigation at this Institute) can also be cleared up. In the meanwhile, the writer believes the values given in D and C '48 can now be provisionally used with considerably more confidence than heretofore.

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A Note on the $Li^7(p,n)Be^7$ Reaction and an Excited State of Be^7

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BECAUSE of interest in the homogeneity of the neutrons produced in the $Li^7(p,n)$ reaction, we have re-examined data obtained two years ago with a Van de Graaff generator, using this reaction as a monoenergetic neutron source to study the resonance scattering of neutrons on helium.[1] In this experiment the neutrons crossed a proportional counter containing helium, and the energy distribution of the helium recoils was recorded. Since the neutron energies studied (0.8 to 1.6 Mev) were too low for significant D-wave scattering, the distribution curves should have been parabolas, corresponding to superposition of S and P waves. Instead, for all neutron energies used above 1.2 Mev (and for no lower energies), well-defined distortions in the curves were observed. From the largest recoil energy where distortion appears, one can calculate an excitation energy of Be^7, assuming that such a state has made the neutron beam di-energetic. The results are shown in Table I for all five curves where the effect was noted.