viously reported study,[1] a value of 0.07 cm^{-1} for the half-width of the CO lines, pressure-broadened by N_2 at atmospheric pressure. This value agrees with that suggested by Plyler, Benedict, and Silverman[6] from their studies in the overtone region.

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Ionization by Cosmic-Ray Mesons in Argon*

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AN electron collection ionization chamber designed primarily for use as a detector of relativistic α-particles in the primary cosmic radiation has been tested at sea level and has yielded results which are capable of rather complete explanation in terms of the present theory of ionization and the known features of the sea-level cosmic radiation.

The ionization chamber consists of a cylindrical cathode 2.5 in. in diameter and 8.0 in. long, and an axial center wire 0.010 in. in diameter encased in a 3.0-in. diameter cylindrical pressure vessel filled with 20 atmospheres of 99.9 percent pure commercial argon. The cathode was operated at 1.2 kv—about 300 volts above the minimum potential required for saturation of the pulses produced by a Po-α calibration source located at the cathode.

A fourfold coincidence G.M. counter telescope, A, B, C, D (Fig. 1) with 10 cm Pb interposed between counters A and B selected a meson beam which traversed a well-defined path length through the ionization chamber. Four anti-coincidence counters F provided partial discrimination against air showers and multiple-secondary events originating in the Pb absorber. Each anti-coincidence event ($ABCD$-F) initiated a 100-μsec oscillograph trace displaying the associated ionization chamber pulse.

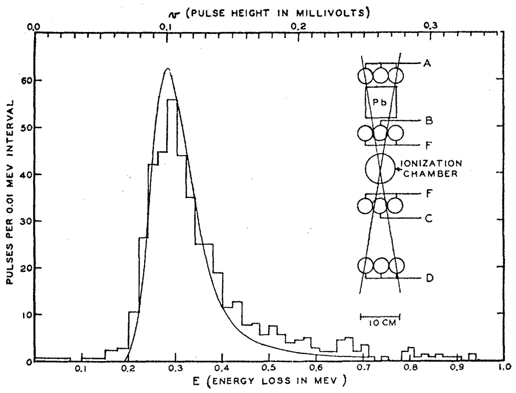

FIG. 1. Distribution of energy losses of cosmic-ray mesons in the ionization chamber. Histogram—experimental distribution; smooth curve—calculated distribution.

The differential pulse-height distribution shown in Fig. 1 was obtained from 761 oscillograph traces photographically recorded over a period of 14.1 hours. The top abscissa scale v represents pulse amplitude at the collector electrode of the chamber. The energy loss in the argon E (bottom scale) was assumed to be a linear function of the pulse height v with a proportionality constant $K=E_\alpha/v_\alpha f$, where E_α is the energy of the calibration Po$-\alpha$-particle (5.3 Mev), v_α is the Po$-\alpha$ pulse height, and f is a calculated factor of numerical value 0.84 introduced to correct for the positive ion inductive effect.[1]

The Bethe[2]-Bloch[3] theory of energy loss by ionization as extended by Landau[4] and Symon[5] was applied together with the sea-level meson momentum spectrum of Wilson[6] to the problem of calculating the distribution of energy losses of the sea-level mesons in the ionization chamber. The smooth curve in Fig. 1 represents the calculated distribution.

The following points of comparison between the histogram and the calculated curve may be noted:

(1) The most probable energy loss (0.3 Mev) determined by the measurement is in close agreement with the value predicted by the theory.

(2) The half-width of the experimental distribution is approximately 10 percent greater than that of the calculated distribution. A broadening of this nature is expected to arise from the amplifier noise which introduced a statistical uncertainty of approximately ±0.01 millivolt in the amplitude of the measured pulses.

(3) The tail of the histogram ($E>0.4$ Mev) contains relatively more events than the tail of the calculated distribution. This may result in part from neglect in the calculation of the unknown high energy end of the sea-level meson spectrum which comprises about 6 percent of the total sea-level intensity, and in part from the accompaniment of a small percentage of the mesons by knock-on electrons produced in the material above the chamber.

(4) The experimental results are consistent with the relativistic increase in specific ionization predicted by the Bethe-Bloch theory. If the specific ionization is taken as a constant above the minimum, one obtains a calculated pulse-height distribution about one-half as broad as the histogram. The relativistic increase in specific ionization in gases has been previously confirmed by Hereford[7] and by Kupperian and Palmatier.[8]

The present results indicate that it is feasible to utilize a high pressure ionization chamber together with a G.M. counter train for discriminating between various high energy particles on the basis of specific ionization. A device based on this principle has been developed for balloon investigations of the alpha-particle component of the primary cosmic radiation.[9]

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[*] Assisted by the joint program of the ONR and AEC.

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The Energy Spectrum of the Electrons in the Extensive Cosmic-Ray Showers

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THE energy spectrum of the electrons in the extensive air showers has been studied by means of G.M. counters arranged as in Fig. 1, at Catania (40 m above sea level). Each of the counters A, B, C had an area S. Six values of S were used, namely $S=140$, 240, 400, 800, 1600, 3200 cm^2. Coincidences $T=A+B+C$ were recorded and interpreted as due to showers whose core landed within a few meters from the center 0 of the apparatus, and whose average density there was $\bar{\Delta}\simeq 1/S$. Corresponding to the values of S, $\bar{\Delta}$ varied from 70 to 3 particles per m^2. Counters D and E were covered with absorbers of either Pb or H_2O of thickness t variable from 0 to 56 g cm^{-2}. Counters D had surface S, counters E had surface S when there was no absorber; when covered with an absorber of thickness t, the surface was adjusted to a value $S_E(t)$, such as to make $S_E\Delta_E=$constant, (Δ_E being the density of the shower present under the thickness t). Preliminary

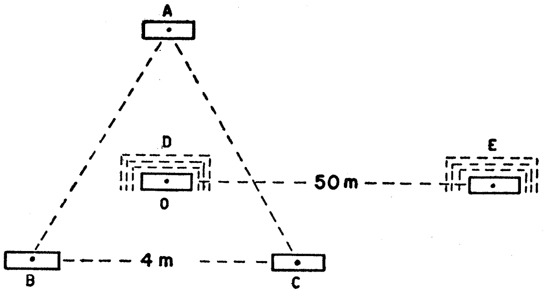

FIG. 1. Horizontal arrangement of counters A, B, C, D, E.

measurements were performed to study how this adjustment had to be made. Because of the condition $S_E\Delta_E=\text{constant}$, the probability that showers producing coincidences T hit also counter E, is practically independent of the absorber thickness t.

Assuming for the showers an integral density spectrum $F(\Delta)=K\Delta^{-\gamma}$,[1] it is possible to deduce from the values of S, S_E, T, $T+D$, and $T+E$ the density, in the showers, of the particles capable of crossing the thickness t, both near the core and about 50 m from it.

The absorption curves in H_2O, where practically no transition effect for the electrons and photons from the air is expected, show in all cases an exponential decrease followed by a plateau; the latter is interpreted as due to the penetrating component (nucleons and μ-mesons) of the extensive showers.

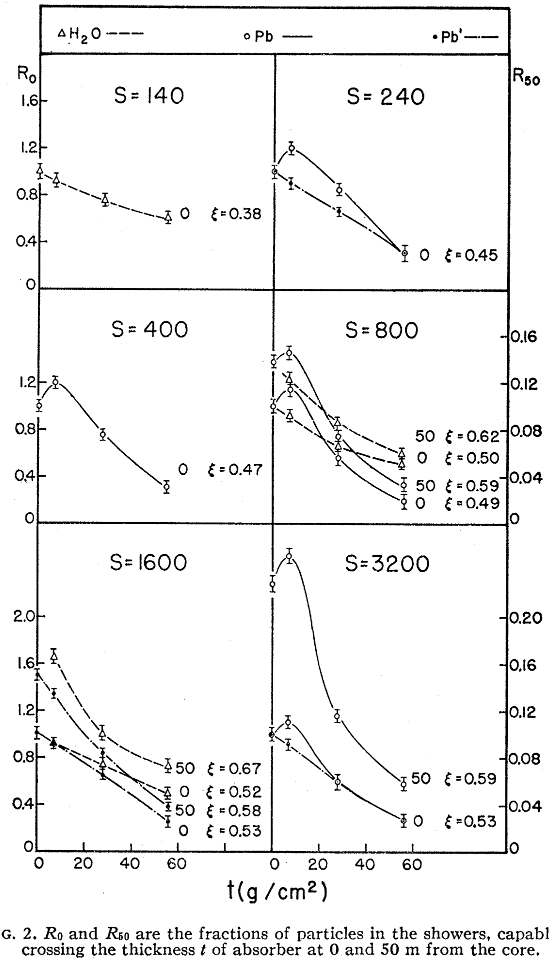

FIG. 2. R_0 and R_{50} are the fractions of particles in the showers, capable of crossing the thickness t of absorber at 0 and 50 m from the core.

In lead, instead, a transition curve has been found due to the conversion of the photons in the absorbers. The true absorption has been measured in this case by registering, besides the coincidences $T+D$ and $T+E$, the coincidences $T+D+D'$ and $T+E+E'$, where, D' and E' were counters placed at the top of the absorbers above counters D and E respectively. The results of these measurements are labeled Pb' in Fig. 2. All curves in Fig. 2 give the results of the measurements after subtraction of the tail due to the penetrating component. These curves are interpreted as representing the absorption of the soft component of the extensive showers.

Both in H_2O and in Pb the curves are well described by the expression

$$I(t)=I_0(E+E_C)^{-\xi}, \tag{1}$$

where ξ is a constant, E_C is the characteristic energy of air, and E is the energy for an electron to cross the thickness t. The energy-range relation used is that given by Clay[2] which fits well the experimental data thus far available. The values of ξ which fit our results are given in Fig. 2.

The theoretical expressions for the energy spectrum in an electron shower, calculated by several authors,[3] are of the same form as Eq. (1). However, assuming that the showers are produced near the top of the atmosphere by a primary electron or photon of $10^{14}-10^{16}$ ev (which is the energy required to generate at sea level the showers detected by our apparatus) the theory predicts $\xi=1.6$ to 1.7. These values are in strong disagreement with the experimental values ($\xi=0.5$ to 0.6). Besides, at 50 m from the cores, the cascade theory predicts less than 1 percent of the electrons to have energies 10^9 ev, while our measurements show that there, 25 percent of the electrons satisfy this condition.

Better agreement between theory and experiment can be reached if one assumes that the primary electron hypothesis is wrong and that instead the electrons found in an extensive shower near sea level are produced mainly in the air not far (a few radiation lengths) above the apparatus.

The present results then suggest that the development of the extensive showers in the air is mainly due to the cascade multiplication of the nucleonic component; this is in agreement with the results of other experimenters (presence in the extensive showers of the N component, observation of locally produced soft showers). A more detailed account of these experiments is going to appear in *Nuovo cimento.*

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Natural Radioactivity of Lanthanum-138†

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WE have sought beta-particles and x-rays from natural lanthanum with the large proportional counter used in the study of neodymium.[1] The search was prompted by the discovery of the rare (0.089 percent) La^{138} isotope in natural lanthanum[2] and stimulated by the discovery of gamma-radiation from this nuclide.[3] This was presumed to follow electron capture decay to Ba^{138}, and K x-rays of barium were subsequently found.[4] Early searches for beta-particles[5] were inconclusive because of insensitive detectors or incomplete purification. Recently reported upper limits to the number of hard betas per second per gram of lanthanum are ~1,[2] 0.4,[3] and 0.2.[4]

Commercial lanthanum oxide (98 percent pure, Lindsay Light and Chemical Co., West Chicago, Illinois) was purified by three passages through a cation exchange resin column[1] and by numerous scavenging precipitations of zirconium iodate, barium sulfate,