The angular variation of r at high energies will be about the same as at $q=0.6$, and the intensity at 180° approaches zero with increasing energy. The previous approximate formula due to Mott[2] gives only the correct order of magnitude of scattering intensity for a heavy element such as mercury.

Our angular distribution agrees well with that observed by Barber and Champion,[3] the numbers in the angular ranges 20°–30°, 30°–60°, and 60°–180° being in the ratio 37 : 27 : 9 (theoretical) as against the experimental ratio 37 : 30 : 8. However, the disagreement between theory and experiment concerning absolute intensities still remains.

Our polarization values are about 10 percent less than those of Mott at the maximum, so that the theory still predicts an effect which has not yet been observed.

The angular distributions at small energies will probably be modified when shielding is taken into account.

Full details will be published later.

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[1] N. F. Mott, Proc. Roy. Soc. **A135**, 429 (1932).
[2] N. F. Mott, Proc. Roy. Soc. **A124**, 438 (1929).
[3] A. Barber and F. C. Champion, Proc. Roy. Soc. **A168**, 159 (1938).

Helium and Hydrogen of Mass 3

We have now adjusted the shims of the 60-inch cyclotron so that it is possible to obtain a steady beam of 24-Mev He^{3++} ions.[1] We have compared the isotopic ratio He^3/He^4 of tank (gas-well) helium to that of spectroscopically pure (atmospheric) helium, and find that it is about twelve times as great for atmospheric helium as for the gas-well variety. The absolute values have been approximately determined with the aid of a thin-walled Victoreen R-meter. These ratios are 10^{-8} and 10^{-7} for the two types of helium. When the cyclotron chamber is filled with atmospheric helium, the He^3 beam has sufficient intensity to induce appreciable radioactivity in silicon. We have observed a 2.5-minute period with an initial intensity of 200 counts/minute, on a background of 30 counts per minute. The activity could be followed for four half-lives; it is probably P^{30} formed in the reaction.

$$_{14}Si^{28} + {_2He^3} \rightarrow {_{15}P^{30}} + {_1H^1}$$
$$_{15}P^{30} \rightarrow {_{14}Si^{30}} + e^+.$$

When the silicon was bombarded under identical conditions except for the substitution of tank helium for spectroscopic helium, the activity was reduced to a small value consistent with the abundance ratios given above.

Since we have shown that He^3 is stable, it seemed worth while to search for the radioactivity of H^3. We have therefore bombarded deuterium gas with deuterons, and passed the gas into an ionization chamber connected to an FP-54 amplifier. The gas showed a definite activity of long half-life. We have now shown that this gas has the properties of hydrogen by circulating it through active charcoal cooled in liquid nitrogen and allowing it to diffuse through hot palladium. The radiation emitted by this hydrogen is of very short range as was shown by the almost linear form of the intensity *vs.* pressure curve when the gas was pumped out of the chamber. When sufficient time has elapsed for us to make some statement regarding the half-life of this activity, we will submit the details of the work to this journal for publication.

We are indebted to Dr. S. Ruben for the use of his thin-walled counter and to Dr. A. Langsdorf for the loan of a d.c. amplifier. It is a pleasure to acknowledge the friendly interest of Professor E. O. Lawrence in these experiments, and to thank the Research Corporation for financial assistance.

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[1] L. W. Alvarez and R. Cornog, Phys. Rev. **56**, 379 (1939).

Intensity and Rate of Production of Mesotrons as a Function of Altitude

With the view of obtaining information on the intensity and on the rate of production of mesotrons as a function of altitude, we have performed the following free balloon experiment.

Four G-M counters were arranged with lead absorbers, as shown in Fig. 1. Counters 1, 2 and 3 constituted one threefold coincidence set and counters 2, 3 and 4 constituted the other. Since a particle which passes through either set of counters must penetrate at least 8 cm of lead, we are dealing here only with the penetrating component, i.e., mesotrons. The top set of counters can be actuated only by mesotrons which have originated outside of the equipment, whereas the lower set can be set off by either a mesotron entering from the outside or by one which is produced in the lead block L. If there is such a production of mesotrons in the lead block L, by a non-ionizing radiation, one should observe a greater number of counts in the lower set of counters than in the upper set.[1]

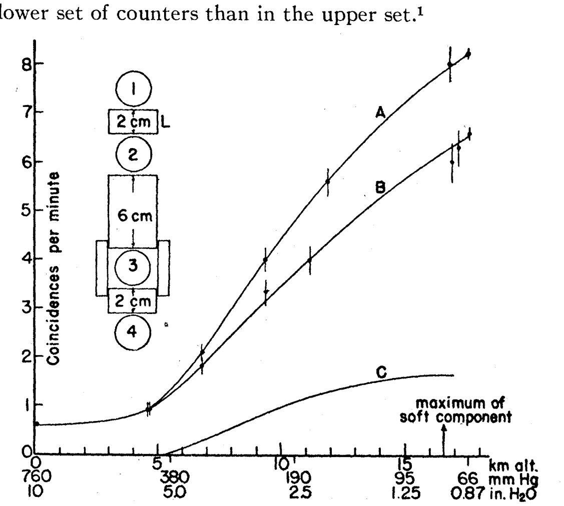

Fig. 1. Arrangement of counters and number of coincidences per minute in the lower (A) and upper (B) counters.

TABLE I. *Ratio of the number of mesotrons produced in the lead block to the intensity of the soft component as obtained by Regener.*

PRESSURE MM HG	ALTITUDE KM	Ns	Ny	Ny/Ns
66	17.6	26	1.55	0.060
100	14.7	28	1.65	0.059
150	12.1	21	1.33	0.063
200	10.2	16	1.00	0.062
250	8.7	10.5	0.70	0.066
300	7.4	8.4	0.40	0.048

The G-M counters (4″ long by 1″ in diameter) were made according to Shonka's technique.[2] A Neher-Harper[3] type of circuit was used. All the individual threefold coincidences from each set of counters were recorded photographically on a rotating drum. The pressures and temperatures were recorded by a barograph of the type used by one of us in previous flights.[4] The total weight of the equipment was about 38 lb. Fifteen balloons, each inflated to a lifting power of 3.1 lb., were used. The apparatus remained aloft for ten hours, about five hours of which were at the maximum altitude of 17.6 km (66 mm of Hg).

The results obtained are shown in Fig. 1. Curve B represents the number of threefold coincidences per minute recorded by the upper set of counters as a function of the altitude. This curve gives directly the increase with altitude of the intensity of the penetrating component, and shows that the mesotron intensity increases by a factor of 11 between sea level and 17.6 km. There is no evidence for a maximum in the mesotron intensity up to the highest altitude reached in this flight. At the position of the maximum of the total vertical intensity[5] (8 cm of Hg), our results show that 12 percent of the total vertical cosmic-ray intensity consists of penetrating particles.

The number of threefold coincidences per minute registered in the lower set of counters is shown by curve A. The fact that the counting rate corresponding to this curve increases considerably over that corresponding to curve B indicates that an appreciable production of mesotrons takes place as the altitude increases above about 7 km. The difference between the ordinates of the two curves, which gives directly the number of mesotrons produced in the lead block L at different altitudes, is represented by curve C. If photons are responsible for their creation, the intensity of the mesotrons produced in the lead should follow that of the soft component. Evidence for this is indicated in Table I. N_s represents the intensity of the soft component as obtained by Regener and Ehmert.[6] N_y gives our values of the number of mesotrons produced in the lead block L (curve C), and in the last column are tabulated the ratios N_y/N_s. The constancy of these ratios lends support to the hypothesis that mesotrons can be created by photons. On the basis of the known intensity of the soft component we can calculate a cross section for the creation of a mesotron by a photon. We obtain a value per proton in the lead nucleus of 1.7×10^{-27} cm^2, which is in qualitative agreement with the result obtained by Schein and Wilson[7] at 25,000 feet altitude.

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[1] B. Rossi, Zeits. f. Physik **82**, 151 (1933); D. S. Hsiung, Phys. Rev. **46**, 653 (1934).
[2] F. R. Shonka, Phys. Rev. **55**, 24 (1939).
[3] H. V. Neher and W. W. Harper, Phys. Rev. **49**, 940 (1936).
[4] W. P. Jesse (in print).
[5] G. Pfotzer, Zeits. f. Physik **102**, 23 (1936).
[6] E. Regener and A. Ehmert, Zeits. f. Physik **111**, 501 (1939).
[7] M. Schein and V. C. Wilson, Phys. Rev. **54**, 304 (1938).

Induced Radioactivity Produced by Bombarding Aluminum with Protons

Silicon[27] has been reported as being produced by the reactions[1] $Mg^{24}(\alpha, n)Si^{27}$ and $Si^{28}(n, 2n)Si^{27}$, and having a half-life of about 6.5 minutes with a positron upper limit of 2.0 Mev. It should be possible to produce the same isotope by proton bombardment of aluminum, since the proton energies available are well above the expected threshhold (3.8 Mev) for the reaction. However, all our attempts to find such a period have been completely unsuccessful, its intensity if present being at least ten thousand times weaker than would be predicted from (p, n) cross sections for neighboring elements. We have, however, found an activity of 3.7 seconds half-life which is produced in aluminum by protons. Fig. 1 shows a decay curve for this activity. For each point a separate sample was bombarded, placed over the ionization chamber at a time after the end of bombardment given by the abscissa, and allowed to decay completely. Suitable corrections were made for longer-lived activities which got onto the target by recoil from the air. In Fig. 2 is shown an excitation curve for this activity obtained in a similar manner to the decay curve except that the samples were placed over the ionization chamber at a fixed time (7 seconds) after the end of bombardment. The energy of the bombarding particles

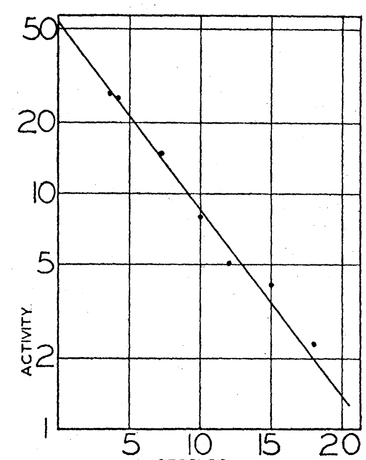

FIG. 1. Decay curve for the 3.7-second activity resulting from the bombardment of aluminum by protons.