From the foregoing formula for a constant H, $n/N = (K/H)X =$ constant. Since on the other hand it has been shown that the ratio electrons/mesotrons at sea level decreases considerably with the increase of the zenith angle,[4,5] the conclusion must be drawn that at sea level there exists an electronic component of a different nature than that arising from the decay of mesotrons which will be called residue. Also the considerable barometric effect which we recently found for the electronic component at the sea level (16 percent per cm Hg)[6] can be interpreted as a proof of the foregoing. Similar conclusions have also been reached from other considerations.[7]

On the basis of such considerations it can be shown that if the intensity of the cosmic radiation is taken at the sea level as unity, the mesotron component is 0.8, the electronic component arising from decay 0.08, the interaction component 0.04, and the residual component 0.08. At the pressure of about 8 cm Hg (maximum of Pfotzer's curve), the mesotron component increases about ten times[1] and reaches an intensity of about $0.8 \times 10 = 8$: the interaction component becomes $0.04 \times 10 = 0.4$, and the component arising from the decay (with the above given formula) has a value of 0.08 $(10/0.1) = 8$ (the mean energy of the mesotrons in the high atmosphere is actually less than that at sea level, hence X becomes smaller and the estimated value is greater than the real value). Hence these three components are responsible, at 8 cm Hg, for total intensity of about 16: since Pfotzer observed an intensity of about 46, the electronic residue component shall have an intensity of $46 - 16 = 30$. It must therefore be considered that the primary protons produce the mesotrons in the atmosphere and furthermore, directly as well as indirectly by means of processes now unknown, the photons and the electrons which are responsible for the large showers[8] and the component called residue by us.

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On the Presence of Strongly Ionizing Particles in Cosmic-Ray Showers

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July 11, 1941

IN work with a Wilson cloud chamber on narrow showers a photograph was obtained (Fig. 1) in which, beside the ordinary electron shower generated at sea level in a 60-cm thick aluminum layer over the chamber, another type of shower was observed of two strongly ionizing particles, one of them showing several delta-rays. The tracks in the cloud chamber, which was filled with argon and alcohol vapor and had a diameter of 25 cm, were photographed in two directions (under an angle of 60
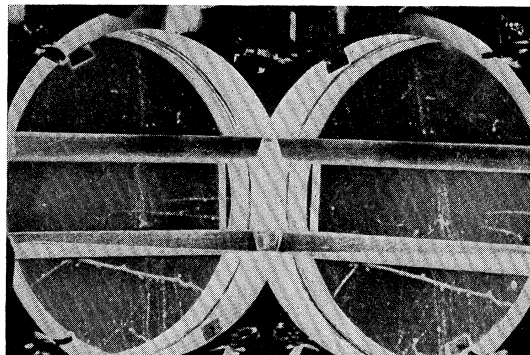

Fig. 1. Narrow shower produced by cosmic rays.

degrees between each other). The expansion of the fully automatic cloud chamber[1] was operated by four 20×4.5 cm² counter tubes arranged in accordance with the first report published on these experiments,[2] i.e., in such a way as to photograph only the narrow showers (mean angle of divergence 5°) coming from the aluminum above. Each of the two aluminum screens in the chamber is 2 cm thick. This photograph shows that in a narrow shower, made up mostly of electrons, nuclear evaporation processes can occur: in this particular case it does not appear that the primary particle leaves a visible track in the cloud chamber. On the other hand, it can be seen from Bagge's recent paper[3] that nuclear evaporation processes are closely connected with electron showers.

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A Note on the Radiochemistry of Europium

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SEVERAL questions on the radiochemistry of europium have been left unanswered. The 9.4-hour europium isotope first observed by Sugden[1] was studied by several workers.[2-6] It can be obtained by slow and fast neutron and by deuteron bombardment of europium. Slow neutron bombardment also produces a long period which has been reported in several papers. In one[7] it was said to have a half-life of 1–2 years, in another[4] no appreciable decay was observed in six months, and in a third[8] its maximum beta-ray energy was given as 0.8 Mev. Two short periods, 12 min. and 105 min. were reported[4] to be produced in europium by deuteron bombardment along with the 9.4-hour activity.

The purpose of the present experiments was to study the long period and to check the two short periods.

The europium material was kindly furnished by Professor H. N. McCoy and had partly been used in the

previous work in this laboratory.[4] It was purified by the McCoy method of reduction in a Jones reductor and precipitation as europous sulfate.[4,9] The same chemical procedure was used after bombardment. As the reduction is not complete, the europium remaining in solution was precipitated as oxalate which would carry with it any other rare earth which might have been formed in bombardment.

The slow neutron sample, which, as previously reported, gave no decay over the first six months, showed a decay with a half-life of 6–8 years in the following 18 months. That this did not show up during the first six months was due to a flat maximum in the activity curve in the first few months.

The natural radioactivity present in the original europium preparation had been removed chemically before the bombardment. However, the maximum mentioned above showed that the contamination with foreign radioactive material was not completely removed. Further chemical study showed this to be the case and served as an additional purification. The europium sample obtained after this study gave a pure decay with a half-life of the order of 5–8 years as measured for 8 months.

Since this result has shown the original material to be less pure than could be assumed on the basis of the spectroscopic analysis which was made on it (see reference 4), we wished to check the short periods of 12 and 105 minutes obtained before by deuteron bombardment. Purified Eu_2O_3 was bombarded for 20 minutes to one hour and was immediately separated so that the samples could be measured within 20 to 30 minutes after bombardment. Only traces of any period shorter than the 9-hour were found and in several instances there was no indication of any such activity. The initial intensity of these shorter periods was never more than 5 percent of the 9-hour activity. The chemical reactions mentioned above were used and the decay of the sulfate and oxalate precipitates was similar. Thus the short periods were shown not to be produced in pure europium.

This pure material was also used in a prolonged deuteron bombardment which gave a period of the same order (5–8 years) as the neutron induced long period. It is most probably the same isotope. Since europium has two stable isotopes, (151) and (153), and the 9.4-hour isotope has been assigned to (152),[3] the most probable assignment of this long-life activity is to Eu^{154}.

Deuteron bombardment of the purified europium also produced an activity with a half-life of 155 to 170 days. It is not europium, since it is not reduced or precipitated as sulfate, but it precipitates with europium oxalate in acid solution, a typical rare-earth reaction. Its intensity, 500 times the background of the counter used, seems too great for it to be due to an impurity so that it is probably produced from europium. In that case the 160-day activity could be samarium due to a d reaction, or gadolinium due to a $d-n$ or $d-2n$ reaction. It emits negative beta-rays and x- or gamma-rays with an intensity less than 1 percent of the total.

We are indebted to the cyclotron crew of the Physics Department for the preparation of the active material

and to the Horace H. Rackham Trust Fund for financial support.

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Radioactive Bromine Isotopes from Uranium Fission

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WE have been able to identify two radioactive bromine isotopes produced by uranium fission under the influence of thermal and fast (Rn+Be) neutrons. The periods of the two bodies are: Br (1): 35 minutes; Br (2): 2.3 hours. The latter period coincides with a period noted by Langsdorf and Segrè[1] and has to be attributed to the isotope Br^{83}. We have not been able, however, to confirm the existence of a bromine isotope of 3.8 hours period, as has been stated by Hahn and Strassmann[2] though we have used sufficiently long exposures.

The chemical methods we have applied are: (1) Extraction of bromine by organic solvents. This method is analogous to the one applied by Dodson and Fowler[3] in their search for iodine isotopes in the uranium fission. (2) Distillation of bromine from the irradiated uranium solution, after addition of inactive bromide, permanganate and sulfuric acid. In the first procedure the bromine becomes separated from iodine by sodium nitrite, in the second the iodine remains quantitatively in the solution while the bromine becomes completely distillated (as we could prove by direct tests). The separation chlorine-bromine was made by treating the silver halide precipitates with ammonium bicarbonate. Both of these methods furnish the same radioactive bodies. The time dependence of the activities is in both cases exactly the same, and leads to the two periods indicated above. These periods have, therefore, to be necessarily attributed to bromine isotopes.

We have investigated by several experiments the problem, whether Br (1) and Br (2) are directly produced by the fission process or whether they have to be considered as daughter products of bodies resulting from fission. We can conclude from our experiments: (1) that none of the two bodies is a derivate of krypton, neither directly nor indirectly; (2) if selenium should be the mother-substance of Br (1) its period must be smaller than 3 min. (In this case it could have escaped observation.) Br (2) (Br^{83}) could be a derivate of Se^{83} the period of which is 30 min.[1,4] From our experiments it seems that it is not the case. As far as we know, on the other hand, Se has never been found with certainty among the uranium fission products. It seems, therefore, that Br (1) and Br (2) can be considered to be direct fission products.