supplied us. The ionization chamber of diameter 15 cm. was covered with 11 cm. of lead and was left at each place for about 24 hours. The vertical thickness of rocks varied from 1,230 m. to 120 m., corresponding to about 3,400 m. and 340 m. of water-equivalent respectively.

The results of the measurements are given in the accompanying table. The minimum thickness of rocks overhead was calculated from the contour lines of a map and is naturally not exact. The ionization values were calculated according to the constant of the instrument determined and communicated to us by Dr. Neher. They should be taken as relative values rather than absolute, because the difference in the surrounding conditions might have caused a minute change in the constant of the instrument.

Vertical thickness of rocks (m.)	120	175	220	325*	650	1230
Its water-equivalent (m.)	340	490	620	910	1800	3400
Minimum thickness of rocks (m.)	120	175	175	290	540	880
Its water-equivalent (m.)	340	490	490	810	1500	2500
Ions/cm.^{3}/sec./atm. (Cosmic rays + residual)	0·230 ± 0·001	0·223 ± 0·003	0·224 ± 0·003	0·222 ± 0·004	0·221 ± 0·002	0·220 ± 0·004

* A burst of about 10^7 ions was observed at this position.

Unfortunately, the residual ionization which Dr. Neher determined by going 70 m. underground is rather large (0·23 ions/cm.^{3}/sec./atm.) and the instrument is not suited for the present purpose. From the decrease of ionization with depth shown in the table we see the indication of the penetration of cosmic rays through much thicker layers of matter than has hitherto been observed[2]. The fluctuation of the ionization, however, is larger than the difference of ionization between the succeeding depths, and no definite inference in this regard can be made at present.

One conclusion, however, which we can draw from our results, is that the cosmic rays can definitely pass through more than 800 m. of water, and probably go much deeper. We observed, for example, a burst of the size of about 10^7 ions at a vertical depth of 325 m. (min. depth 290 m.), corresponding to a much greater penetration than has hitherto been directly observed. Both Kolhorster and Corlin[3] made measurements with an ionization chamber down to 800 m. water-equivalent underground. The cosmic ray intensity at this point was tentatively assumed to be zero. From the above results, however, we see that there still remains a very small part even at this depth.

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[1] Cf. R. A. Millikan and H. V. Neher, *Phys. Rev.*, **50**, 15 (1936).
[2] W. Kolhorster, *Sitz. Pr. Ak. Wiss.*, 689 (1933); NATURE, **132**, 407 (1933). A. Corlin, NATURE, **133**, 63 (1934); *Ann. Observatory Lund*, No. 4, A, 95 (1934).
[3] loc. cit.

Radioactive Isotopes of Nickel and Copper

IT has been shown by Fermi and co-workers[1] and by Bjerge and Westcott[2] that the activity induced in zinc through neutron bombardment is due to an isotope of copper. Considering the well-known possibilities of the formation of active substances by a neutron bombardment, it is evident that the possibility of forming an active isotope of nickel is implied. Now, by means of an apparatus formerly described[3], the formation of active nickel from zinc irradiated with neutrons has been actually shown.

The experiments were carried out with metallic zinc powder. After activation, it was dissolved in nitric acid and a trace of cupric oxide and of nickel sulphate was added. The copper was precipitated from the acid solution by means of hydrogen sulphide. After filtration, ammonium chloride in excess was added to the filtrate, next dimethylglyoxime was added, and finally the acid solution was made alkaline by the addition of ammonium hydroxide. The red precipitate was ignited and placed in a counter in a manner formerly described[4]. The activity decayed with a period of nearly 100 minutes. McLennan and others[5] have found a period of 100 minutes produced by slow neutrons in metallic zinc. Perhaps this is the same activity as that mentioned here. Rotblat[6] and Naidu[7], however, found a period for nickel formed by means of neutron irradiation of nickel to be 3 hours. These results may indicate the possibility of the existence of two active isotopes of nickel—possibly $^{63}_{28}$Ni and $^{65}_{28}$Ni.

The period of the active copper has also been measured. The copper sulphide was dissolved in nitric acid and transformed to cupric oxide. The period of this product was measured and found to be 17 hours. This result is not in accord with the results of Fermi and of Bjerge and Westcott, who found 10 hours and 6 hours respectively. Special care was taken in the measurements during the first twenty hours to find, if possible, a shorter period, but the decay curves only gave the 17-hour period. Van Voorhis[8] has reported an activity produced in copper by deuteron bombardment, supposed to be due to an isotope $^{64}_{29}$Cu, with a period of 12·8 hours, emitting both positrons and electrons. It seems difficult at present to reconcile these observations, apparently giving four different decay periods for the same isotope. As the experimental method only allows detection of active products with fairly long periods, the 5-minute period of copper was not found.

The number of particles counted from the nickel is only one tenth of that from the same amount of copper.

Attempts to isolate active chlorine from irradiated potassium gave negative results. This may be due to the possibility that it is not $^{34}_{17}$Cl, but $^{38}_{17}$Cl which is the bearer of the chlorine activity already known.

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[1] Fermi and others, *Proc. Roy. Soc.*, A, **149**, 522 (1935).
[2] Bjerge and Westcott, NATURE, **134**, 286 (1934).
[3] Madsen, *Z. Phys.*, **101**, 72 (1936).
[4] Buch Andersen, *Z. Phys.*, **98**, 597 (1936).
[5] McLennan and others, NATURE, **135**, 505 (1935).
[6] Rotblat, NATURE, **136**, 515 (1935).
[7] Naidu, NATURE, **137**, 578 (1936).
[8] Van Voorhis, *Phys. Rev.*, **49**, 876 (1936).