I wish to thank Professor A. H. Compton for discussing this with me, Dr. John A. Fleming of the Department of Terrestrial Magnetism for making available the Cheltenham and Huancayo data, and Mr. D. M. Little, Principal Meterologist in charge of the Aerological Division of the U. S. Weather Bureau for supplying me with the air data for these calculations.

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January 31, 1940.

[1] S. E. Forbush, Phys. Rev. **54**, 983 (1938).

Structure and Ferromagnetism of Cold-Worked Copper Containing Iron

Copper containing small amounts of iron in solid solution is not ferromagnetic even if cold worked. On heat treatment iron precipitates very rapidly from solid solution in a relatively stable nonferromagnetic form, sometimes even in particles sufficiently large to be visible under the microscope. Cold working immediately transforms this nonmagnetic iron to the magnetic condition. The idea has been proposed[1] that the first precipitate of iron is face-centered cubic in structure and is possibly still continuous with the copper lattice. There have been no direct experimental determinations of the structure of the precipitate in either the nonmagnetic or magnetic form.

At the writer's request Dr. A. B. Greninger of the Laboratory of Physical Metallurgy, Harvard University kindly undertook a study of some samples by x-ray methods. Wire, 0.06 inch diameter, containing 2.3 percent iron was quenched after 3 hours at 1050°C. It was then very slightly ferromagnetic. Reheating at 650°C for 3 hours diminished the attraction of a strong electromagnet, but if the reheated wire were cold drawn to a reduction of area of 24 percent it became strongly ferromagnetic. Diffraction patterns were obtained with a Debye camera of 5.7 cm radius using unfiltered cobalt radiation and a 7-hour exposure (normal exposure times to show structure are about 1 hour). The wires were all of large grain size and hence it was difficult to obtain satisfactory patterns. No trace of body-centered cubic lines was observed. A filing sample taken from the reheated cold-drawn wire gave a pattern which, with a 12-hour exposure, showed two unmistakable lines corresponding to the strongest of the body-centered cubic alpha-iron pattern. The iron lines were no stronger after subsequent heat treatment for 3 minutes at 650°C. Similar filings again annealed *in vacuum* for 3 hours at 1050°C, quenched and reheated 3 hours at 650°C showed no trace of the iron lines.

These experiments show that there is little body-centered cubic iron (probably none) in copper-iron alloys containing the nonmagnetic precipitate but that it becomes detectable after cold working, coincident with the appearance of ferromagnetic properties.

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January 29, 1940.

[1] R. B. Gordon and M. Cohen, "Age hardening of copper-cobalt and copper-iron alloys," Am. Soc. for Metals, Preprint No. 39, October, 1939. See particularly the discussion of the present writer on this paper. F. Bitter and A. R. Kaufman, Phys. Rev. **56**, 1044 (1939).

Cloud-Chamber Photographs of Cosmic Rays up to an Altitude of 29,300 Feet

On December 21 Mr. Wiston Bostick and I made an airplane flight up to 29,300 feet for the purpose of taking cloud-chamber photographs of cosmic rays. A Wilson chamber of 15 cm diameter was placed between the pole pieces of a large permanent magnet which gave a magnetic field of 700 gauss. Expansions could be made either at random or controlled by counters. Stereoscopic pictures were taken.

Two hundred thirty pictures were taken in which there were more than 25 tracks of such a density and momentum as to practically exclude the possibility of their being produced by either electrons or protons. In Fig. 1 a typical

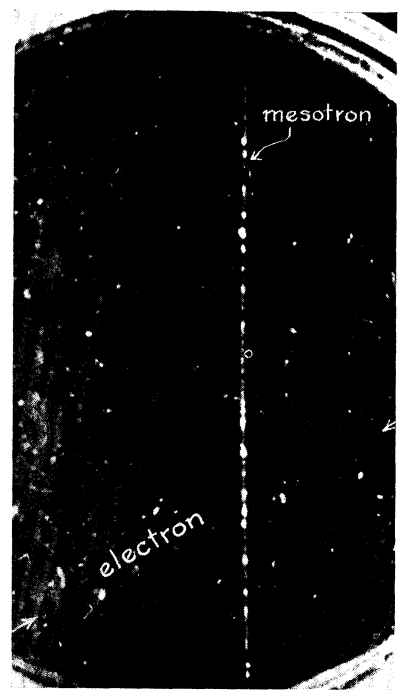

FIG. 1. Typical photograph showing both an electron ($H\rho = 4.2 \times 10^4$) and a mesotron ($H\rho = 1.4 \times 10^5$).

photograph is reproduced which shows for the same expansion the occurrence of an electron of $H\rho = 4.2 \times 10^4$ as a thin track and a mesotron with $H\rho = 1.4 \times 10^5$ for which the ionization is much greater. All the heavy tracks occurred only in the 110 photographs which were taken above 20,000 feet.

The pictures reveal further some much stronger ionizing particles which one may associate with either protons, α-particles or still heavier nuclei.

Though a full report of this work will soon appear, it has seemed worth while to call prompt attention to the surprisingly frequent occurrence of slow mesotrons at the altitudes reached in this experiment.

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February 1, 1940.

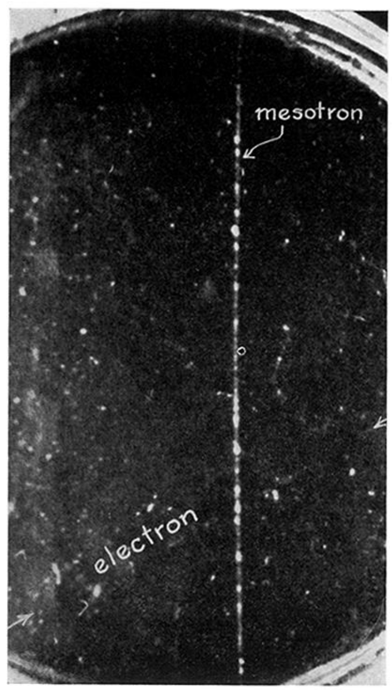

FIG. 1. Typical photograph showing both an electron ($H\rho = 4.2 \times 10^4$) and a mesotron ($H\rho = 1.4 \times 10^5$).