LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the eighteenth of the preceding month, for the second issue, the third of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Communications should not in general exceed 600 words in length

The Paschen-Back Effect—$^2S^2P$ Multiplets in Strong Fields

In a letter to the editor under the above heading[1] P. Jacquinot explains that the article by us[2] with the same title is practically a repetition of his work reported in the *Comptes rendus*.[3] We should like to clear up this matter.

The article cited by Jacquinot in the C.R. reports in several places that the field strength used was 4400 gauss and was repeated as such in *Science Abstracts*. The conclusions drawn are in error if based on this figure. The letter[1] published after our article mentions a field strength of 44,000 gauss and is in agreement with our work at 38,000 gauss. The supposed lack of recognition is therefore the result, not of a lack of information, but of several typographical errors.

In view of these facts it would seem that priority of the results should be given to the excellent work of M. Jacquinot. The important point, however, is that the same result has been obtained by two independent observers using different methods and serves to clear up an outstanding difficulty in the theory of atomic spectra.

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October 29, 1936

[1] Jacquinot, Phys. Rev. **50**, 573 (1936).
[2] Green and Loring, Phys. Rev. **49**, 630 (1936).
[3] P. Jacquinot, Comptes rendus **200**, 383 (1935).

The Heavy Particle Component of the Cosmic Radiation

In a recent paper by the above title,[1] Brode, MacPherson and Starr have published a number of cloud chamber photographs of heavy particles which are probably protons. They conclude their paper with the statement that "It is now, however, not possible to say that the failure to observe heavy particles in the cosmic radiation in a cloud chamber is evidence against the existence of primary protons." This conclusion depends upon the fact that it is only near the end of the range of the proton that one may expect to find it in a condition such as to produce observable tracks. However, in a recent paper by W. F. G. Swann[2] the theory of this matter was developed and it was shown how one can utilize such knowledge as we have to find how many observable particles might be expected in terms of the number of rays passing through the apparatus per second. In a further paper by the writers in conjunction with W. E. Ramsey and W. F. G. Swann,[3] experiments were reported in which actual measurements were made on the bursts of ionization in an ionization chamber with the resultant conclusion that not more than 10 percent of the intensity of the hard component, or more than 5 percent of the total number of cosmic rays at sea level, can consist of primary protons.

Now, these same considerations are, of course, applicable to the experiment of Brode, MacPherson and Starr. If, in fact, we assume that the hard component of the cosmic radiation consists of primary protons, then the fraction of these protons which will end their paths within a given distance R is simply μR, where μ is the coefficient of absorption of the radiation. If the relation between the range of a proton and its specific ionization is known, we can find R for a proton which will have a given specific ionization, and so compute the number of particles having a specific ionization greater than this, which we would expect to find in the cloud chamber photographs. Since it is difficult to estimate the age of a track which occurred before the discharge of the counter actuating the cloud chamber, we shall confine our attention to those heavy particles which set off the counters. Brode, MacPherson and Starr found, out of a total of 8500 counter discharges, 7 particles having specific ionization between two and five times that of an electron, and 7 having between 5 and 20 times the electronic ionization. Let us take for μ the value of 0.08 per meter of water, and assume 0.4 as the fraction of the sea-level cosmic-ray intensity which is the hard component.[4] The range of a proton of specific ionization five times that of an electron (160 ion pairs/cm) may be taken from Bethe's theoretical values as 1430 meters of air. Hence we should expect, in 8500 rays, 510 protons having at least this ionization. This expected number is considerably smaller than the observed one, and we can, in fact, conclude from these calculations that an upper limit of 1.4 percent of the hard component of the cosmic radiation can be primary protons. There is considerable uncertainty, it is true, that the range of protons of this high energy (about 3×10^8 ev) is given correctly by Bethe's expression, and it is for this reason that no corresponding estimate can be made from the observations concerning the particles having smaller specific ionization. We therefore should place upon the numerical value of the upper limit here calculated only the significance that it is much smaller than