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. Because of the late closing dates for the section no proof can be shown to authors. 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.

Evidence for the Production of Penetrating Secondary Cosmic-Ray Particles in the Atmosphere

At the suggestion of Professor A. H. Compton, the following experiment of the Hsiung[1] type was performed to obtain some evidence concerning the production of penetrating cosmic-ray secondaries in the atmosphere. This subject was formerly discussed by A. H. Compton,[2] and now the problem has renewed interest because of the discovery of the heavy electron and a recent paper by Bowen, Millikan and Neher[3] in which they suggested that all radiations observed at sea level are secondaries produced in the upper atmosphere.

For the present experiment, four Geiger-Müller tubes (2.5 cm diam. and 30 cm long) were arranged for fourfold vertical coincidence according to Fig. 1. The writers are indebted to Mr. Francis Shonka for these tubes. 8.1 cm of lead were placed between tubes 2 and 3 to absorb the soft radiation, thus enabling one to record only the penetrating rays. The bottom tube was shielded from soft shower particles by 1.25 cm of lead, and a 0.625 cm lead shield was placed about tube number 3 to absorb Compton recoil electrons produced in the lead plate below. Any penetrating ionizing rays produced in the lead between the counters by a nonionizing incident ray will not be recorded since the upper two tubes will not be activated. However, if part of the lead (in this case 2.2 cm) is moved to a position above all four tubes, penetrating ionizing rays produced in the upper piece of lead will be recorded if they traverse the four tubes. Therefore, by alternately recording fourfold coincidences with the same piece of lead first between tubes two and three (position B) and then above all four tubes (position A), one may determine the relative number of penetrating rays produced in that piece of lead.

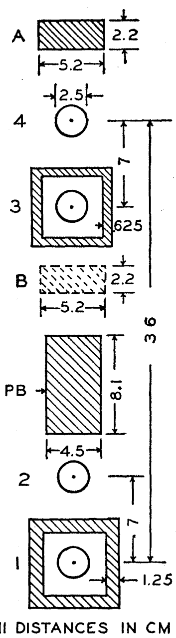

FIG. 1.

The experiment was performed in an aeroplane up to an altitude of 25,000 feet. The results are shown in Table I.

TABLE I. *Results of measurements.*

ALTITUDE	13,000 ft. to 20,000 ft.		20,000 ft. to 25,000 ft.		25,000 ft.	
Position of Lead See (Fig. 1)	A	B	A	B	A	B
Number of Fourfold Coincidences in 3 min. intervals.	7 4 6 6 1	5 5 4 7	8 9 9 11	4 7 5 5 9	11 10 10 10 10 15	2 4 11 2 6 6
Average	4.8±0.7	5.2±0.7	9.2±1.0	6.0±0.7	11.0±0.9	5.2±0.6
	Ratio $A/B=0.9$		Ratio $A/B=1.5$		Ratio $A/B=2.1$	

Three-minute readings were made with the lead alternately in positions A and B. Up to 20,000 feet no appreciable differences between A and B were observed. From 20,000 feet to 25,000 feet, the excess with the lead above is quite apparent, and at 25,000 feet the ratio $A/B=2.1$. This is well outside of the rather large statistical errors.

This experiment indicates that above 20,000 feet penetrating ionizing rays (heavy electrons) are produced by nonionizing agents (photons). It is of interest to note that the "hump" in the cosmic-ray absorption curve at about 25,000 feet is made more prominent when the apparatus is shielded with 6 cm of lead.[4] This indicates that this hump is possibly related to the production of penetrating secondaries.

The results of the present experiment are in good agreement with Heitler's[5] assumptions that the heavy electrons are formed by secondary photons which are abundant at high altitudes and are strongly absorbed by 2 cm of lead.

With the lead in position B the fourfold vertical coincidences at 25,000 feet were three times as numerous as at sea level. This represents the ratio of the intensities of the vertical penetrating component, which agrees well with Heitler's[6] calculations. Braddick and Gilbert[7] found a ratio of 9 to 1 at 35,000 feet. This high ratio is explained by Heitler as due to insufficient shielding of the soft rays (3 cm of lead).

Twofold coincidences for the upper two tubes at 25,000 feet and at sea level give a ratio of 12 to 1 for the total vertical radiation. This is in good agreement with Pfotzer's[8] data obtained by balloon flights with threefold coincidences. Special care was taken to have the efficiency of the apparatus a maximum. By activating the tubes with a radium source, conditions similar to those at 25,000 feet were reproduced in the laboratory, without any apparent change in the efficiency. The above agreements seem to indicate this also.

The writers wish to express their appreciation to Professor A. H. Compton not only for suggesting the experiment, but also for his continued support.

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[2] A. H. Compton, Proc. Phys. Soc. London **47**, 747 (1935).
[3] T. S. Bowen, R. A. Millikan, and H. V. Neher, Phys. Rev. **53**, 217 (1938).
[4] A. H. Compton and R. J. Stephenson, Phys. Rev. **45**, 442 (1934).
[5] W. Heitler, Proc. Roy. Soc. **A166**, 529 (1938).
[6] W. Heitler, Proc. Roy. Soc. **A161**, 261 (1937).
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[8] G. Pfotzer, Zeits. f. Physik **102**, 23 (1936).

A New Rydberg Series in N_2

The absorption spectrum of nitrogen below 1000A shows some interesting features that appear to have been overlooked by previous investigators because of insufficient dispersion. The lower spectrum of Fig. 1 (negative; absorption appears white) shows the general aspect between 785 and 850A at a pressure of 0.1–0.2 mm and path length 130 cm. The complex of overlapping band systems at longer wave-lengths definitely terminates at about 800A with a converging series of band heads. These are shown with greater enlargement in the upper spectrogram. They obviously constitute the higher and intermediate members of an electronic series, the lower members of which ($n<6$) are presumably confused with the complex of bands at longer wave-lengths. Diffuse absorption (O_2?) overlaps the bands $n=6$, 8, 10, 11, 12, 13, blotting out the first three and also the fourth except on two plates taken at lower pressures.

The frequencies of the heads follow a Rydberg law closely. With $n=7$ to 25 and $\alpha=0.34$ ($n+\alpha=$ Rydberg denominator) only the lowest measured member deviates appreciably, being shifted about -10 cm^{-1}. The limit of the series lies at $125,670\pm2$ cm^{-1}, or 15.503 volts. This is just the first ionization potential of N_2 computed indirectly by Mulliken[1] from the data on Hopfield's Rydberg series. The latter converge to the $^2\Sigma_u{}^+$ excited state of $N_2{}^+$, while the limit of our series is the $^2\Sigma_g{}^+$ normal state. The latter has an internuclear distance of 1.11A as compared to 1.09 for the normal state of neutral N_2, a circumstance which is favorable to the observation of such series. Further evidence that this is actually an electronic series comes from the fact that no discrete bands are observed beyond the limit, but a region of continuous absorption extends from here with gradually diminishing intensity to at least 600A. The Hopfield series just referred to does not appear on these plates, while at higher pressures the continuum below 800A is almost completely absorbed.

That the high dispersion and resolution of a 3-meter grazing-incidence spectrograph were required to show the existence of this series will be apparent from the spectrograms. We are using the Lyman continuum, which covers the longer wave-length region not accessible with the helium continuum. A thorough analysis of the whole absorption spectrum below 1000A is in progress.

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[1] R. S. Mulliken, Phys. Rev. **46**, 144 (1934).

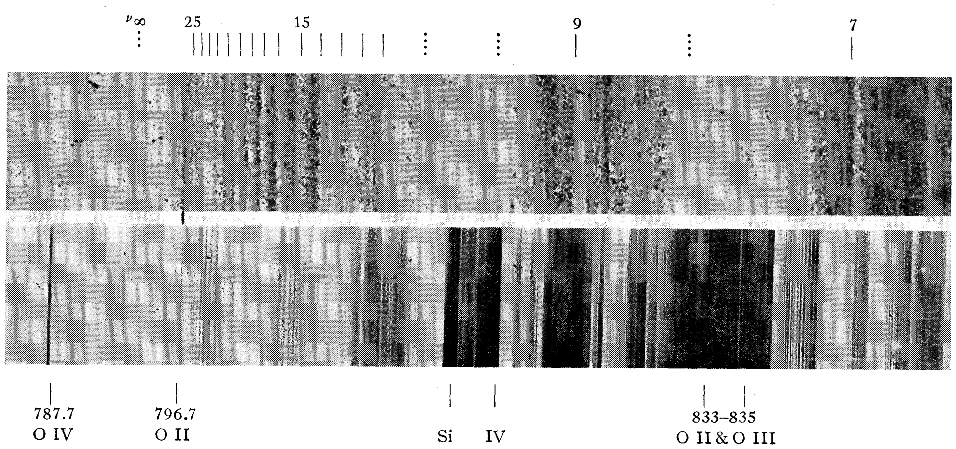

FIG. 1.