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 twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

On the Study of Cosmic Rays at the Great Altitudes

The ionization produced by cosmic rays at different altitudes has been measured by many investigators. M. Cosyns, P. Kipfer and A. Piccard[1] have observed cosmic rays at the great altitudes by means of one counter. But it is especially interesting to determine at various altitudes the number of coincidences, produced in a train of Geiger-Müller counters, for in this way only corpuscular rays are recorded. T. H. Johnson[2] and B. Rossi[3] have studied the cosmic rays by this method on mountains at the altitude 4–2 km. T. H. Johnson has found that the number of coincidences does not increase so rapidly as it could be expected from the ionization measurements. B. Rossi has detected a great number of secondary rays at the altitude 2370 m.

It seems to be necessary to undertake these measurements at higher altitudes. For this purpose there has been constructed a portable apparatus, which can be taken by balloons. For the automatic recording of coincidences the method of Moltchanoff's radio-sounds has been used. The apparatus, which consists of 2 Geiger-Müller counters, soldered in glass tubes, registers double coincidences, selected by an amplifier similar to that of B. Rossi.

To reduce the influence of secondary rays, a lead plate 2 cm thick was placed between the counters. The potential of 1400 v was supplied to the counters by a small storage battery used in radio-sounds. A constant temperature was maintained inside the apparatus by means of a special thermoregulator, and all the apparatus was surrounded by a thermal insulation. Besides the recording of coincidences this apparatus determines from time to time the total number of discharges in one of two counters. The switching is made by a barograph, and the number of switchings gives the pressure data.

To test this apparatus the latter was taken up at the railway station Shosseynaya (10 km from Leningrad) by an airplane under steerage of the pilot S. S. Lwoff. The observation of the cosmic rays in the airplane was made by B. B. Lobatch-Joutchenko. The results, obtained in this way during the flight on July 27 to the altitude 5810 m are represented in Figs. 1 and 2. In Fig. 1 is shown the dependence of the number of coincidences per min. on the altitude (after subtraction of accidental coincidences). Because of the small number of coincidences the probable error is 10–20 percent.

The results are in accord with those of T. H. Johnson, who has found an increase of 3.78 times for the altitude 4.33 km. They also give a smaller value than that which is given by the ionization measurements. Fig. 2 represents the dependence of the total number of discharges in one counter on the altitude.

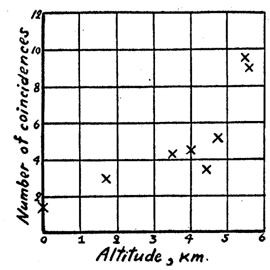

FIG. 1.

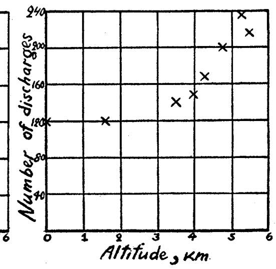

FIG. 2.

In conclusion I wish to express my sincere thanks to Professor P. A. Moltchanoff for his continued interest, his many helpful suggestions, and for permission to do this work at the Aerological Institute.

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Aerological Institute,
Slootsk,
and
State's Radium Institute,
Leningrad.
September 11, 1934.

[1] M. Cosyns, P. Kipfer and A. Piccard, Bull. de l'Acad. Roy. de Belgique, 5-me série, 19, 214 (1933).
[2] T. H. Johnson, Phys. Rev. 45, 569 (1934).
[3] B. Rossi, Phys. Rev. 45, 212 (1934).

Analysis of Recent Measurements of the Ionosphere

The broad program of ionosphere measurements at the Department of Terrestrial Magnetism of the Carnegie Institution and at the National Bureau of Standards has been under way for several years. The results are beginning to emerge in papers by Kirby, Berkner, Gilliland, Norton, Wells, Stuart and others.[1] They have identified the existence of a third region of ionization, the F_2 region, lying above the E and F_1 regions and have traced the variations in all three regions in tropic, temperate and to some extent in polar latitudes, and in temperate latitudes during a total eclipse of the sun. The data may be said to be the first approach to a world-wide survey of the ionosphere.

An analysis of the data from the view that the ionization is caused by the ultraviolet light of the sun[2] yields the conclusions stated briefly below. More complete publication will follow. I have had the benefit of helpful discussions with the authors of the papers and in many cases I have been given data either as yet unpublished or in advance of publication.

(1) From the fact that the heights of the E and F_1 regions change but little, it follows that the temperature of the high atmosphere from about 100 to 200 km above sea-level is constant within about 30°K during the day, night and season. Best agreement between the radio facts and the theoretical calculations is found if the temperature in these levels is taken to be rather warm, above 300°K.

(2) The E region diurnal and seasonal data conform with the ultraviolet theory equations[2] for ions, yielding a value of order 10^{-12} for αn, the ionic recombination loss. Theory gives the same value.

(3) The F_1 region diurnal and seasonal data are in accord with the ultraviolet theory equations for electrons, yielding a value of order 10^{-4} for bn' the loss of electrons by attachment to oxygen molecules. Theory gives $bn'=2\times10^{-4}$. The F_1 region echo data during the total eclipse of the sun gave $bn'=7\times10^{-4}$. The F_1 region electron density y_e agreed with the values derived from the skip distances[2]; for example, for zero zenith angle of the sun y_e was 2.8×10^5 and from the skip distance data y_e was 3.2×10^5.

(4) The complex and at first sight curious facts of the F_2 region agree in the main with the following theory. Assume that the atmosphere above 250 km, the domain of the F_2 region, lying directly under the sun is ionized and strongly heated by the sunlight. Due to the heating the atmosphere expands and winds blow from this region away in all directions, blowing a wave of ionization with them. Eastward from the subsolar point and hence in the afternoon hemisphere, the wave moves in the same direction as the rotation of the earth and hence the ionization is in a large smooth wave, whereas westward and hence in the morning hemisphere, the wave moves against the rotation of the earth, is checked and is caused to whitecap, as in a tide rip. This is in accord with the F_2 observations which on the equator record a greatly disturbed and erratic layer in the morning with a maximum ionization at about 10 A.M., a minimum at noon and a smoother, less disturbed ionization in the afternoon with a broad maximum at 6 or 8 P.M. The waves which progress to the north and south are by the rotation of the earth diverted toward the east yielding a maximum in the early afternoon around 2 to 4 P.M. Exactly this is observed in temperate latitudes, there being only a single maximum in the F_2 region which occurs in the afternoon, being nearer to noon with increasing latitude. At night the F_2 region cools and the F_2 layer merges with the F_1 layer, as is observed.

E. O. HULBURT

Naval Research Laboratory,
October 4, 1934.

[1] Terr. Mag. and Atmos. Elec. **39**, 215 (1934); Bur. Standards J. Research **12**, 15 (1934); and references *infra*.
[2] Hulburt, Phys. Rev. **39**, 977 (1932) and references therein.

Transition Effects in the Cosmic Radiation

As a part of a program of investigation of the variation of the Schindler[1] transitions with altitude and latitude we have obtained the transition from air to lead at several stations (see Table I). The results represent the ionization in a spherical chamber of 230 cc volume, filled with argon at 30 atmospheres pressure (see Fig. 1), as a function of the thickness of the lead disks A, B, C, etc. placed above the chamber. These disks subtend a cone of 41° at the center of the chamber. The sensitivity of the apparatus was checked with a radium capsule and corrections were made for local gamma radiation by methods closely similar to those employed by A. H. Compton.[2] The ionization current was measured by means of an electrometer tube with continuous photographic recording. Our sensitivity gave a precision of ½ percent for a three minute interval for the smallest rates observed, although the statistical fluctuation for this interval was about 6 percent. Each point represents approximately twelve hours observation time.

TABLE I. *Variation of ionization with upper lead shields for various altitudes.*

Col. 1 thickness of Pb above chamber (cm); col. 2 Cambridge, barometer 76, mag. lat. 53 N, ions per cm³ per sec.; col. 3 Lima, barometer 76, mag. lat. 1 S, ions per cm³ per sec.; col. 4 Huancayo, barometer 51.3, mag. lat. 1 S, ions per cm³ per sec.; col. 5 Cerro de Pasca, barometer 45, mag. lat. 1 S, ions per cm³ per sec.

Col. 1		Col. 2	Col. 3	Col. 4	Col. 5
0	no side shields	4.67	4.41	7.22	11.83
0	with side shields	2.48	2.14	5.62	8.69
.64	"	2.48		5.95	9.03
1.27	"	2.43		5.70	8.57
3.18	"	2.05		4.51	6.39
6.66	"	1.84	1.59	3.42	4.49
9.2	"	1.79		3.06	4.01
11.7	"	1.75			
14.3	"	1.74		2.94	3.74
19.4	"	1.70		2.91	3.68

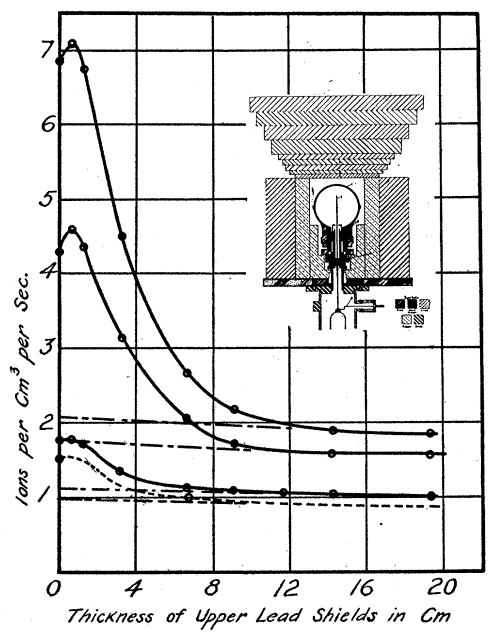

FIG. 1. Transition curves—air to lead. (a) Lima—barometer 76, magnetic latitude 1 S. (b) Cambridge—barometer 76, magnetic latitude 53 N. (c) Huancayo—barometer 51.3, magnetic latitude 1 S. (d) Cerro de Pasca, barometer 45, magnetic latitude 1 S.