perhaps the constant A was not a constant for all pressures, and to test this $1/i^2$ was plotted against $1/T^2$ for various pressures and for runs in which the ionization per unit density, I, was the same. The slope of this curve is A^2/I^2, and should show up any variation in A. This relation was found to be a straight line for 60 and 40 atmospheres, but was distinctly curved for 20 and 10 atmospheres. Thus it may be that for low pressures and high temperatures, A is not strictly constant.

In regard to Broxon's[5] remark that the "variation of the ionization with temperature is greater at higher temperatures," these experiments distinctly disagree with that conclusion. Furthermore, these experiments definitely lead to the conclusion that the temperature effect is greater at high pressures than at low pressures. His observation that there is an "apparent slight dependence of the ionization upon time rate of change of temperature" has been observed in these experiments. However, if sufficient time is allowed for the gas in the chamber to come to equilibrium, consistent readings can be obtained.

[5] J. W. Broxon, Phys. Rev. **40**, 1022 (1932).

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Progress of Cosmic-Ray Survey

We have recently extended our measurements previously reported[1] to include southeastern Australia, equatorial Pacific, Panama, and Peru. The results confirm our earlier conclusion, that the intensity of the cosmic rays at sea level becomes greater as we go farther from the equator. Comparison of the Australian data with those taken in New Zealand shows that for the same geographic latitude the rays in Australia are the stronger whereas for the same magnetic latitude (or magnetic dip) the intensity in the two regions is nearly the same. Our measurements to date of the cosmic rays at sea level may be expressed satisfactorily as a function only of the dip of the earth's magnetic field.

The results of these sea level measurements are shown in Table I. The quantities I_C and I_L are the intensities of the cosmic rays (reduced to sea level) and of the local radiation respectively, expressed in ions per cc per second in air at atmospheric pressure, as measured through 2.5 cm of copper and 5.0 cm of lead. The measurements 1 to 4 have previously been reported,[1] but are here corrected for a radiation of 0.14 ions from the walls of the ionization chamber itself, as determined by measurements in a deep tunnel in Peru. The absolute values of the ionization are somewhat uncertain, due to an uncertainty in the ionization by the standard radium capsule. The relative values should however be reliable.

Several series of measurements have been made in different localities to determine the rate at which intensity increases with altitude. The most significant of these were two series

[1] A. H. Compton, Phys. Rev. **41**, 111 (1932).

TABLE I. *Cosmic-ray intensity, reduced to sea level, at different localities.*

Location	Lat.	Long.	Mag. dip	I_C	I_L	Date
1. Honolulu	21°N	158°W	+39°	1.74 ions	0.12 ion	4/ 5/32
2. S.S.Aorangi	4°S	173°W	−10°	1.69	0.32	4/10/32
3. Dunedin	46°S	170°E	−70°	2.02	0.12	4/29/32
4. Wellington	41°S	175°E	−65°	1.97	0.15	5/ 2/32
5. Sydney	34°S	151°E	−64°	2.02	0.42	5/ 9/32
6. Brisbane	28°S	152°E	−57°	1.93	0.20	5/16/32
7. Auckland	37°S	175°E	−62°	1.92	0.10	5/28/32
8. SS. Mataroa	13°S	106°W	−10°	1.69	0.15	6/ 9/32
9. Panama	9°N	80°W	+33°	1.72	0.21	6/17/32
10. Lima	12°S	77°W	0°	1.69	0.20	6/30/32
11. Mollendo	17°S	72°W	−10°	1.70	0.09	7/23/32

done in Peru. In the first series the apparatus was installed in a special car, and measurements of from 12 to 24 hours made at each of five stations along the Central Railroad of Peru (Ferrocarril Central), at elevations of from 165 to 5150 meters. The second series included measurements on the top of El Misti (6280 m), Monte Blanco (5110 m), Arequipa (2520 m) and Mollendo (30 m), made on four successive days. The two series of measurements are in excellent agreement, and indicate an increasingly rapid increase of intensity with increasing altitude. At the highest point, barometer 376 mm, the cosmic-ray ionization was 9.50 ions per cc per second in air, through a shield of 2.5 cm copper and 5.0 cm lead. With only the copper shield, the ionization due to the cosmic rays would have been about 22.5 ions.

On the basis of Millikan and Bowen's and Kohlhorster's early balloon measurements, it has been inferred[2] that the ionization approaches a maximum at an altitude of not over 9000 meters, and then decreases. Millikan has indeed used this supposed fact as proof of the photon character of the cosmic rays. If a maximum exists in the neighborhood of 9000 meters, its approach should have become apparent in our work at 6280 meters. Our measurements show no suggestion of such a maximum, confirming Piccard's provisional estimate of 200 ions per cc per second at 16,000 meters rather than Millikan and Bowen's estimate of not more than 6 ions at the same altitude. Thus the intensity of the cosmic rays seems to increase continuously to as high altitudes as the measurements have as yet been made.

Further measurements of the diurnal variation of cosmic rays have also been made at a higher altitude (4930 m) than heretofore attempted. The result of 120 hours observations at Huaytapallacu, Peru, shows that the average intensity between 10 and 4 o'clock in the daytime is greater than between 10 and 4 at night by 1.6 ± 0.8 percent. Unfortunately, time did not permit a more extended series of observations; but as far as our data go, they support our results on Mt. Evans (3900 m)[3] as indicating a real difference between daytime and nighttime cosmic radiation, which is greater at the higher altitudes.

Steinke has noted[4] bursts of ionization, representing of the order of 10^6 ion pairs, occurring in his cosmic-ray ionization chamber at the rate of two or three per day. During the course of our measurements we have observed 8 or 9 ionization bursts of this type under such conditions that we have been able to check immediately the condition of the apparatus to see that the effect was not due to any instrumental defect. In these cases the sudden ionization current corresponded to the liberation of from 3 to 7×10^6 ion pairs in the individual bursts. Taking 30 electron-volts as necessary on the average to produce an ion pair in argon, this represents a sudden liberation within the chamber of from 0.9 to 2×10^8 electron-volts of energy. It would seem that these bursts of ionization are much more frequent at high than at low altitudes, for we have not noticed any when lower than 1300 meters, whereas on top of El Misti two were noted within half an hour of each other.

Steinke's suggestion of a high speed proton traversing the chamber could not account for more than 10 percent of the current observed in our chamber. It would seem rather that there must occur a shower of ionizing particles, as from a violently bursting nucleus, within the gas of the ionization chamber. The increasing frequency of these events at high altitudes suggests further that these nuclear disintegrations are excited by the less penetrating component of the cosmic rays.

It is a pleasure to acknowledge the cordial cooperation in this work of Professor Von Willer at Sydney, Professor Parnell at Brisbane, Professor Burbidge at Auckland, Captain Gaskell of the S.S. Mataroa, Mr. James Zetek and Dr. Robert Enders at Panama, and especially of Mr. Paul Ledig and Dr. J. C. Cairns of the Carnegie Magnetic Observatory at Huancayo, who gave most helpful assistance with the measurements in Peru. The work is being done by the help of a grant from the Carnegie Foundation.

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August 1, 1932.

[2] Millikan, Nature, Oct. 24 (1931).

[3] Bennett, Stearns and Compton, Phys. Rev. **41**, 119 (1932).

[4] Steinke, Phys. Zeits. **31**, 1019 (1930); Zeits. f. Physik **72**, 115 (1932).