$$H = E_{1\Delta}\ (2/3)e^{-E_{1\Delta}/RT} \qquad (2)$$

$E_{1\Delta}$ can be evaluated from (2). It turns out out to be 0.75 ± 0.05 volts. The new theoretical specific heat curve which includes the contribution from the above determined $^1\Delta$ level, fits the experimental values of specific heats very well over the whole temperature range investigated—i.e., 1400° to 2500°K.

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A Remark on Erikson's Measurements of the Ionization by γ-Rays at Various Pressures and Potentials

In the Physical Review of July 1, 1932, I. S. Bowen has published measurements on the ionization of air by γ-rays under pressures from 1 to 93 atmospheres applying collecting fields from 1.55 to 1009 volts per cm of a high degree of uniformity.

This author as well as others working in this field recently do not seem to have noticed the work of H. A. Erikson[1] who, as early as 1908, carried out measurements with air for pressures varying from 20 to 400 atmospheres and collecting fields up to 2500 volts over a distance of about 0.8 cm, hence 3100 volts per cm. He also investigated the influence of the temperature on the ionization at a pressure of 200 atmospheres and carried out measurements for carbon dioxyde. The purpose of the present note is to call attention to this beautiful paper of Erikson, which somehow seems to have been overlooked by most of the workers in this field.

[1] H. A. Erikson, Phys. Rev. **27**, 473 (1908).

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Dependence of the Ionization Produced by γ-Rays upon Pressure and Temperature

Broxon[1] has measured the variation of ion current with pressure alone, up to 170 atmospheres. Upon a beta-ray absorption hypothesis, he could explain the form of his *i vs. p* curve very well. However, Millikan and Bowen[2] and Compton, Bennett and Stearns[3] have independently offered an explanation of this curve, based on the idea that at high pressures, there is a lack of saturation. On the basis of their suggestion, Compton, Bennett and Stearns[4] have derived an equation relating ion current to density and temperature. This equation is

$$i = I\rho(1 + A^2\rho^2/T^2)^{-1/2}$$

where A is a constant for each gas, and from this, the temperature coefficient of ionization is found to be

$$\beta = di/idT = (A^2\rho^2/T^3)/(1 + A^2\rho^2/T^2)$$

In order to test this theory, the writer has performed experiments in which β was measured when the temperature range was from 8°C to 38°C, and others in which the ion current was measured when the temperature was varied from room temperature to about 160°C. Though the results obtained seem sufficiently definite to report at this time, it is hoped that several features can soon be investigated further.

A cylindrical steel chamber with inside dimensions of about 30 cm long and 6 cm diameter was surrounded by a brass cylinder to contain the water or glycerine bath. No gas leak was detected at any pressure over a period of a weak. Gas and electric heaters heated the bath evenly, and its temperature was read with a mercury in glass thermometer. The collecting rod was insulated with amber from a brass guard ring which in turn was insulated from the chamber with hard rubber. Protection for the insulators from the heat was provided. The electrical leak was found to be negligible at both low and high temperatures though it appeared to be slightly greater at high temperatures. The Lindemann electrometer was used usually at 80 divisions per

[1] J. W. Broxon, Phys. Rev. **37**, 1320 (1931).
[2] R. A. Millikan and I. S. Bowen, Nature **128**, 582 (1931).
[3] A. H. Compton, R. D. Bennett and J. C. Stearns, Phys. Rev. **38**, 1565 (1931).
[4] A. H. Compton, R. D. Bennett and J. C. Stearns, Phys. Rev. **39**, 873 (1932).

volt, together with a chamber voltage of 180 volts. At 40 atmospheres pressure, an increase of the chamber voltage from 90 to 135, caused an increase of 3 percent in the ion current, but with an increase from 135 to 180 volts, no detectable further increase was noted. The γ-ray source was placed in a fixed position during each run, and it was found that using different intensities led essentially to the same result. Commercial air at high pressures was introduced directly from the two large tanks to the chamber. Finally, one test was made for the difference in absorption of the bath at high and low temperatures, but no effect was observed.

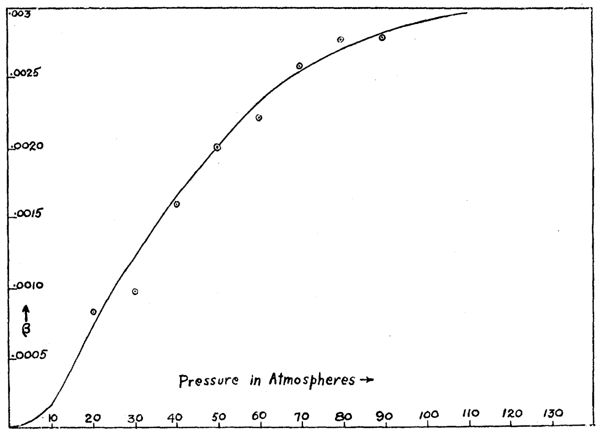

Fig. 1. Showing variation of the temperature coefficient of ionization with air pressure at 293°K.

Fig. 1 shows the values of β obtained at different pressures when the temperature range was nearly 8°C to 38°C in all cases. The solid line represents the theoretical value of β for air at 293°K. It was found necessary to wait almost half an hour after the bath reached a constant temperature before consistent current readings could be obtained, and the values at the lower pressures are, perhaps, less reliable than those at the higher pressures.

Fig. 2 shows the ion current as a function of the temperature between room temperature and about 160°C. Two or more runs were taken in each case, and the points for each run are marked alike. The solid curves are plotted from the first equation above, with ρ a constant for each case. The constant I was adjusted so that the theoretical curve would pass through the first experimental point in each case. The observed and predicted slopes agree well in the case of 60 atmospheres pressure, but they do not agree well in the cases of 20 or 40 atmospheres. Some work with 10 atmospheres indicated a greater increase of current with temperature than would be expected, also. Tests for electrical leakage and for the change of density of the bath with temperature, failed to reveal any cause for these discrepancies. Though the pressure gauge was not calibrated, it is improbable that an explanation could be found in faulty calibration since an error of about 10 atmospheres would be necessary to make agreement in the 20 atmosphere case. It was thought that

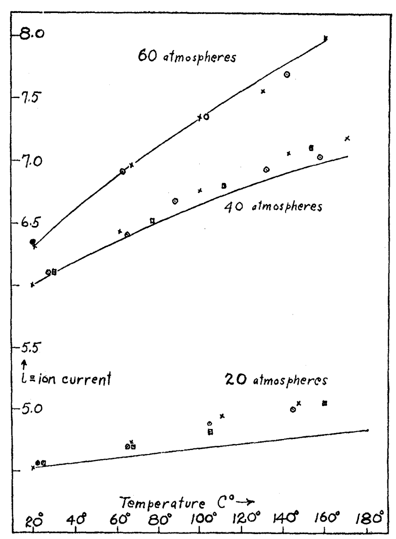

Fig. 2. Showing variation of ion current with temperature at different densities.

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).

The writer is indebted to Professor R. D. Bennett and Dr. L. A. Young for their suggestions in connection with this work.

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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