(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.

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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

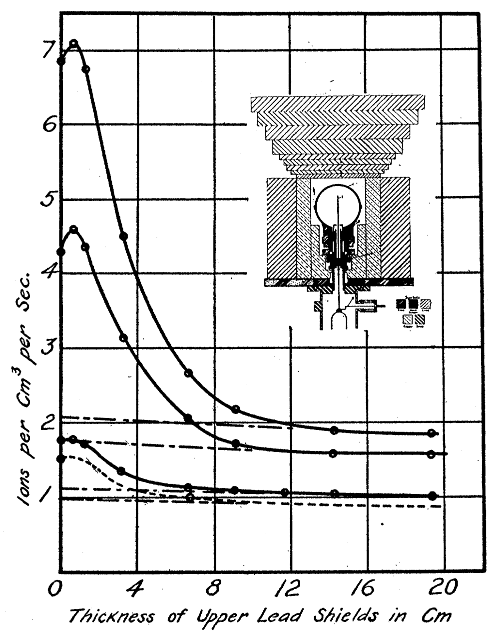

FIG. 1. Transition curves—air to lead. (a) Lima—barometer 76, magnetic latitude 1 S. (b) Cambridge—barometer 76, magnetic latitude 53 N. (c) Huancayo—barometer 51.3, magnetic latitude 1 S. (d) Cerro de Pasca, barometer 45, magnetic latitude 1 S.

The values in Table I are the observed ionization rates, corrected for barometer effect and local radioactivity. The curves were obtained by subtracting from the observed values an estimated ionization attributed to radiation which does not pass through the cone subtended by the lead disks. This estimate was made for each curve by applying Johnson's[3] angular distribution data to the observation for 6.6 cm lead above the chamber (condition of approximate symmetry of shielding). The Lima curve (a) with only two observed points was traced in by comparison with the Cambridge curve (b). The Cambridge curve (sea level) fits Schindler's data within experimental error, and therefore our results may be compared directly with his.

The principal characteristic of an air to lead transition is the abnormal decrease in ionization for the first 10 cm of lead, indicating a lower equilibrium ionization under lead. In Table II we give the equilibrium ionization under air, the equilibrium ionization under lead (obtained by extrapolation back along the dot dash curves, which are based on a primary absorption coefficient in lead of 0.0064 per cm Pb), and the difference between these values representing the transition decrease. This table shows that the magnitude of the transition increases much more rapidly with altitude than the equilibrium ionization under lead. This suggests that the apparent soft component deduced from depth ionization data is due to a changing equilibrium condition rather than to a true soft primary component. The idea of a secondary shower producing radiation with much greater equilibrium intensity in air than in lead has been proposed by Bhabha[4] and Gilbert[5] to explain coincidence data on showers. Gilbert explains the transition effects in terms of variations in the shower producing radiation. This view is supported by the close parallel between the rapid increase of showers with altitude reported by Johnson[3] and our nearly identical increase of transition magnitude. A similar increase was observed in the relative number of "kicks" (presumably due to showers) which appear on our records.

TABLE II. *Comparison of transition effect for various altitudes.*
Col. 1 location; col. 2 mag. lat.; col. 3 barometer; col. 4 equilibrium ionization under air in ions per cm^3 per sec.; col. 5 equilibrium ionization under lead in ions per cm^3 per sec.; col. 6 transition difference.

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
Cambridge	53 N	76	1.78	1.14	0.64
Lima	1 S	76	1.53	0.98	0.55
Huancayo	1 S	51.3	4.27	1.77	2.50
Cerro de Pasca	1 S	45	6.85	2.09	4.76

It is of interest to note that the Cambridge to Lima latitude effect for zero upper shields and for 6.6 cm upper lead shields, is the same, namely, 14 percent. This implies that the magnetically deflectable component undergoes the same transition as the rest of the radiation. This conclusion is based on small differences and possible systematic errors limit its certainty. This point will be more definitely decided with completion of our observations at high altitudes in northern latitudes.

The research was supported by grants from the Carnegie Institution of Washington and the Harvard Milton Fund. Active cooperation was given by the late Dr. J. L. Dunham, and by Professor H. R. Mimno, Dr. J. E. I. Cairns and the staff of the Huancayo Magnetic Observatory.

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Jefferson Physical Laboratory,
Harvard University,
September 27, 1934.

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Ferromagnetism and Liquid Mixtures

The physical feeling of most physicists for the spontaneous magnetization of ferromagnetics is behind his grasp of the mathematical formulation of the phenomenon. In this letter the writer wishes to strengthen this physical feeling by pointing out the close analogy between the development of magnetization, as the temperature is lowered below the Curie point, and another phenomenon with which everyone is familiar. This phenomenon is the separating out, as the temperature is lowered, of two phases from a homogeneous liquid mixture of two types of atoms. Bitter[1] first suggested a similarity between the two phenomena.

In a given volume v let us have x gram moles of liquid A and $1-x$ gram moles of liquid B. The mixture will be homogeneous throughout v (one phase) for all concentrations $0<x<1$ only if the temperature is above a certain critical value T_c. Below this critical temperature two phases are present for a definite range of x, say $X_1(T)<x<X_2(T)$. When x lies in this range, the concentrations of the two phases are X_1 and X_2, respectively, their relative amounts depending upon the precise value of x. This information is illustrated by the usual phase diagram in Fig. 1. We shall consider the particular case

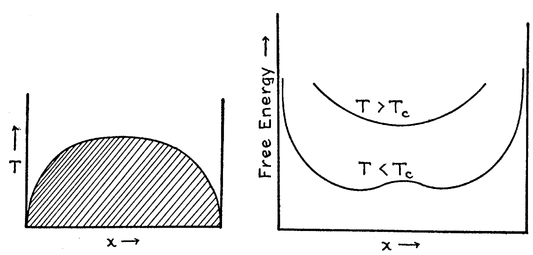

FIG. 1. FIG. 2.

FIG. 1. *Phase diagram.* Shaded region represents unstable concentrations. FIG. 2. *Free energy.* Concentrations between the two minima are unstable.

where atoms A interact with each other in identically the same manner as atoms B interact with each other. Then the phase diagram is symmetrical about $x=1/2$, and the quantity $Y(T)=X_2-X_1$ is analogous to the magnetization $J(t)/J_0$ of a simple ferromagnetic (one valence electron per atom, s state). Thus if each atom A had the magnetic moment μ, and each atom B had the magnetic moment $-\mu$, the average magnetic moment per atom of the two