the thick target continuous x-ray spectrum increases linearly with applied electron accelerating potential greater than the energy of the isochromat. Therefore, in a γ-

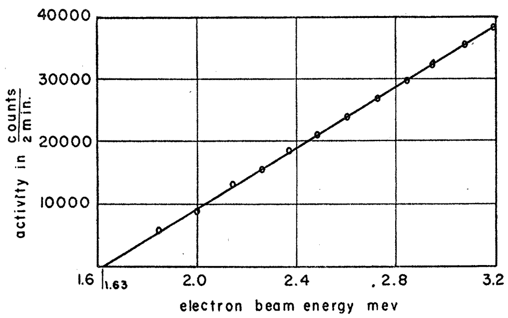

FIG. 2. Neutron counting rate *versus* accelerating potential for disintegration of beryllium. The curve was obtained without the use of paraffin.

n process, the number of neutrons of a given energy should also be linear with the applied voltage V, when

$$V \geq V_t + \frac{A}{A-1} V_n$$

(V_t being the threshold potential; A, the atomic weight of the nucleus being disintegrated; and V_n, the energy of the neutron being considered).

If no paraffin or other hydrogen-containing materials is present to slow down the emitted neutrons, the detector will be sensitive to essentially only one such neutron "line" of energy equal to the resonance energy of the detector and will not be affected by the faster neutrons. Thus the activity *vs.* accelerating potential curve should give a straight line intersecting the abscissa at the threshold potential.

This conclusion was tested with both deuterium and beryllium. The detector used was an argon-ether filled counter with a rhodium cathode. Small samples of deuterium and beryllium were bombarded for two minutes by the x-rays produced by a beam current of 100 microamperes striking a thick gold target. The activity was taken as the number of counts above background obtained during the two minutes after the irradiation was stopped.

The activity is plotted (solid curves in Fig. 1 and Fig. 2) from the threshold to 3.2 Mev as a function of the applied potential. It is seen that in both cases a straight line is obtained, which when extrapolated to zero activity, gives the threshold for the process, namely, 1.630 ± 0.006 for beryllium and 2.185 ± 0.006 for deuterium.

Thus, the threshold can be determined from a linear curve drawn through many points separated by very considerable distances. By this method the thresholds can be determined with a high degree of accuracy.

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Showers of Penetrating Particles

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COMPARATIVE studies of showers of penetrating particles at various altitudes with different materials were begun in July and August, 1944, in Campos de Jordão (Brasil) at an altitude of 1750 m and latitude 23°, and in São Paulo (altitude 750 m and latitude 23° 5′).

The multivibrator circuit,[1] elaborated by M. D. de Souza Santos, was adopted in connection with counters of fast type (alcohol-argon mixture). The resolving time of the coincidence set used was $\sim 6 \times 10^{-6}$ sec. The rate of chance 4-fold coincidences in all experiments was negligible. The efficiency was tested before and after the experiments and was >97 percent. The arrangements XV and XVI are indicated in Fig. 1. They are of the type used in previous experiments in order to observe showers of penetrating particles.[2]

Fourfold coincidences were observed between counters fully surrounded by lead of thicknesses not smaller than 10 cm Pb and separated also by 10 cm of lead.

In the experiment XVI the arrangement of counters and lead was the same as the experiment XV, and only an absorber of water was added. A total amount of about 750

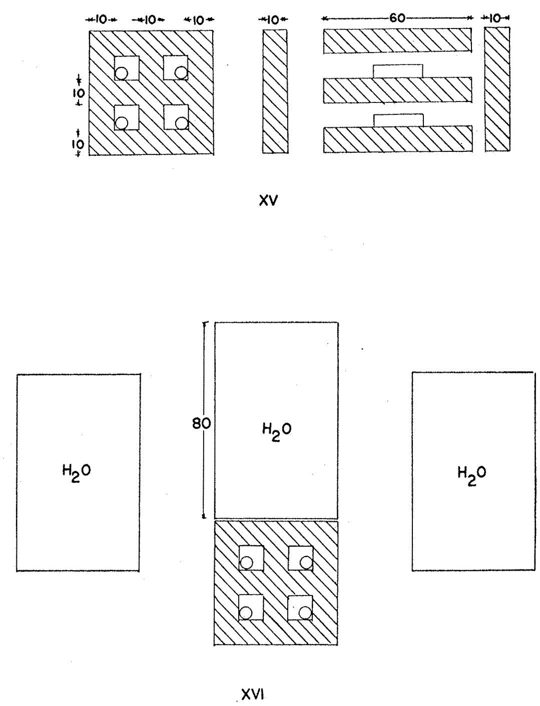

FIG. 1.

liters of water was used forming a layer of 80-cm thickness. The preliminary results are given in Table I.

Although the number of observed 4-fold coincidences is very reduced it seems to us that the results can be considered as an indication of an increase of 23 percent in the frequency of penetrating showers, because of the additional layer of water. Indeed the observed increase is more than 3 times the standard error. Obviously this layer functions as an absorber and as a source of secondary radiation. Our observations seem to indicate that groups of particles penetrating more than 30 cm of Pb are produced in a layer of water of only 80 cm.

TABLE I. Number of 4-fold coincidences in arrangements XV and XVI.

	arrang.	4-fold coinc.	time min.	freq. 10^3 min.$^{-1}$
S. Paulo	XV	73	36300	2.0 ± 0.3
C. de Jordão	XV	155	21830	7.1 ± 0.5
C. de Jordão	XVI	290	32440	8.9 ± 0.5

Recently V. Regener[3] and Schein, Iona, and Tabin[4] observed production of particles in paraffin. Jánossy and Rochester[5] observed production of groups of penetrating secondaries in lead. Evidence on production of groups of penetrating particles in heavy materials was obtained also in cloud-chamber photographs.[6]

The comparison of frequencies in the arrangement XV at two altitudes (1750–750) gives an increase by a factor $\sim$3.5. Thus the shower producing radiation is rapidly absorbed in a layer of 1000 m of air (at an atmospheric pressure $\sim$66 cm Hg, the absorbing mass being $\sim$100 g/cm^2). This finding and the fact that shower producing radiation generates showers of penetrating particles in layer of water $\sim$80 g/cm^2 seems to indicate that this radiation could not be responsible for showers of penetrating particles under clay in a depth of 50 m water equivalent[7] (observed in S. Paulo). It seems possible that there exist several types of showers of penetrating particles produced by different kinds of rays. Further studies are in progress.

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The Two-Body Problem in Birkhoff's and Einstein's Theories

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In a recent article by the late G. Birkhoff and others,[1] a new general theory of relativity (with a flat space-time) was further advanced.[2] The authors contend, in support of their theory, that it provides a solution of the two-body problem while Einstein's theory does not. However, Einstein, Infeld, Hoffmann, and Robertson in 1939 and in 1940[3] submitted a solution of the two-body problem which, to the approximation desired, predicts a rate of advance of periastron per revolution of

$$P_e=(m_1+m_2)\cdot\frac{6\pi}{a(1-e^2)}.$$

Relativistic units of mass (cm) are used.

Birkhoff's theory predicts, to his approximation, a value of

$$P_b=\frac{3m_1^2+7m_1m_2+3m_2^2}{m_1+m_2}\cdot\frac{2\pi}{a(1-e^2)}.$$

This gives

$$\frac{P_b-P_e}{P_e}=\frac{1}{3}\cdot\frac{m_1m_2}{(m_1+m_2)^2},$$

or, for $m_1\simeq m_2$ (the optimum test case):

$$P_b-P_e=P_e/12.$$

Hence, the maximum difference obtainable between the two theories certainly falls within the limits of experimental error, and may arise from differences in the approximation methods employed by the two theories. If any preference can be given to Birkhoff's theory, it must be on the ground of simplicity of its general mathematical (geometrical) structure. All other predictions are the same as in Einstein's theory. The special assumption, in Birkhoff's theory, of a "disturbance velocity of matter equal to c" for subatomic particles, seems a reasonable postulate in the light of the equations of retarded potentials in Maxwell's electrodynamics. The assumption of flat (homaloidal) space-time in a gravitational field is as acceptable *per se* as it is in N. Rosen's[4] or in A. N. Whitehead's[5] theory of relativity.

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