TABLE I.

No. of State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Stages in which Tube A is conducting	1	2	1 + 2	4	1 + 4	2 + 4	1 + 2 + 4	8	1 + 8	2 + 8	1 + 2 + 8	4 + 8	1 + 4 + 8	2 + 4 + 8	1 + 2 + 4 + 8	16 or 0

to the tenth state, or (2) start at the sixth state and go up to the sixteenth. In (1) we must make the circuit automatically reset itself to the zeroth state when the tenth state is reached and in (2) to the sixth state when the sixteenth state is reached.

A glance at the table shows that each state is characterized by a unique coincidence in the states of the individual stages. In (1) above, when the tenth state is reached, the second and fourth stages are made to operate a coincidence tube which *electronically* resets the circuit to zero. In (2) above, the output of the fourth stage is used to *electronically* reset the circuit to the sixth state by resetting the second and third stages when the sixteenth state is reached.

New methods of resetting have been devised which are extremely fast and entirely electronic. One method uses scaling tubes with extra grids. A negative reset pulse is applied to the grids of the appropriate tubes. Another method places a 6F6 pentode in series with the cathode leads of the scaling tubes which are to be reset. A negative reset pulse applied to the grid of the reset tube effectively breaks the cathode current of the scaling tubes. It should be noted that, for even scaling ratios, the first stage is free to record pulses even while the resetting is going on. The reset time can be made as low as the resolving time of the circuit.

A new method for the precise determination of scaling ratios at any input counting rate has been developed for testing a scale-of-10 counter using method (2) and pentode resetting. The rectified output of a beat frequency oscillator was applied to the decade counter and also weakly coupled to an oscilloscope. The output of the counter was simultaneously applied to the oscilloscope. The stationary pattern showed exactly ten input pulses for each output pulse up to 100 kilocycles. By decreasing the circuit capacitances, the speed is increased. These speeds were also verified by directly counting the output of the decade counter with a scale-of-1024.

It is obvious from the above discussion how any integral scaling ratio less than $N=2^n$ may be obtained. By selecting the output of only some of the states, using the proper coincidence circuits (and sometimes anticoincidence circuits to avoid partial coincidences), fractional scaling ratios are obtained. If m states furnish output pulses, the scaling ratio will be $N/m=2^n/m$, $(m=1\cdots N)$ when no resetting mechanism is used. If resetting is used, we can have in addition, N equal to any integer up to 2^n.

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Naval Research Laboratory,
Washington, D. C.,
January 10, 1940.

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[1] H. Lifschutz and J. L. Lawson, Rev. Sci. Inst. 9, 83 (1938).

The Energy Levels, Mass and Radioactivity of A^{41}

In continuation of a study of the proton groups from elements of medium atomic weight under bombardment by deuterons, argon has been investigated. The argon was contained in a gas cell at a pressure of 20 cm of mercury. The deuteron beam entered the cell through an Al foil of 2.7 cm air equivalent absorption. The effective bombarding energy was 2.38 Mev. Transmutation protons emerged at right angles to the incident deuterons through another aluminum window in the gas box. Defining slits limited the effective target depth to about 1.5 cm, corresponding to a target thickness of 0.54 cm air equivalent. Detection of the protons was accomplished in a manner described in an earlier communication.[1]

An absorption plot of the protons shows three distinct groups of ranges 27 cm, 35.75 cm and 53 cm. The resulting Q values are 2.23 Mev, 3.01 Mev and 4.37 Mev, respectively. The 27-cm group is of range appropriate to C^{12} (dp). However no 10.5-minute activity, representative of N^{13}, was found when the decay of the radioactivity in the bombarded gas was followed. Thus it is concluded that all three groups are due to argon and the intensity of each almost certainly requires that A^{40} is the isotope responsible, the reaction being

$$A^{40}+H^2\rightarrow A^{41}+H^1.$$

The above results infer excited states in the A^{41} nucleus at 1.36 Mev and 2.14 Mev and together with the mass of A^{40} as given by Bainbridge assign a value of 40.9770 ± 0.0006 for the mass of A^{41}.

If one assumes the mass of Ca^{40} to be 39.9738 as derived by Barkas[2] and employs the maximum "Q" value found by the author[3] from the Ca (dp) reaction, he is led to a mass 40.9736 for Ca^{41}.

Walke[4] has verified the suggestion made by the writer[3] that Ca^{41} decays to K^{41} by K-electron capture, giving the half-life as 8.5 ± 1 days. This implies that the mass of K^{41} would be expected to lie between 40.9725 and 40.9736.

Kurie, Richardson and Paxton[5] and Richardson and Kurie[6] have made a study of the β- and γ-rays from A^{41}. They find β-rays with an upper limit energy of 1.5 Mev and indications of a much smaller group extending to 5 Mev. A single γ-ray line at 1.37 ± 0.06 Mev is also present.

If it is assumed that A^{41} emits a 1.5-Mev β-ray going to an excited state at 1.37 Mev in K^{41}, the mass here obtained for A^{41} allows one to establish 40.9739 ± 0.0008 for the mass of K^{41}. This is quite in agreement with the limits previously set, when the possible errors involved are considered. However, the assumption that A^{41} emits a 5-Mev electron would make the mass of K^{41} too small by an amount outside the assigned limits of error. Hence one is forced to conclude that the energetic electrons observed arise from a radioactive body other than A^{41}. Traces of another radioactive element with half-life approximating that of A^{41}, produced either from small amounts of impurities in the argon gas or resulting from some as yet undiscovered argon reaction could possibly explain the presence of such fast β-particles.

I should like to express my appreciation to Professor Ernest Pollard for his advice in this work.

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Yale University,
New Haven, Connecticut,
January 16, 1940.

[1] W. L. Davidson, Jr., Phys. Rev. 56, 1062 (1939).
[2] W. H. Barkas, Phys. Rev. 55, 691 (1939).
[3] W. L. Davidson, Jr., Phys. Rev. 56, 1061 (1939).
[4] Harold Walke, private communication.
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[6] Richardson and Kurie, Phys. Rev. 50, 999 (1936).

The Contributions of Showers to the Coincidences Recorded at High Elevations

The absence of an east-west asymmetry in the cosmic radiation at very high elevations found by our balloon flights in Panama[1] was interpreted as indicating that the primary rays of the soft component consist of equal numbers of positives and negatives, a characteristic which distinguishes these rays from the primaries of the hard component since the latter are known to be almost entirely positive. On the basis of this finding we concluded that the primaries of the hard component could not be electrons but were probably protons. As we pointed out in the report of the Panama flights equal intensities from the east and west could not be otherwise interpreted unless many of the counts recorded by our coincidence counters were produced by particles whose primaries entered the atmosphere from directions other than those described by our counter train. In seeking possible causes for such deviations between the directions of the primary and secondary rays the two effects considered, namely, nuclear scattering and deviations of slow secondary particles in the earth's magnetic field,[2] were found inadequate to account for the observed lack of asymmetry. Recently Oppenheimer[3] has sought to revive the possibility that the mesons of the hard component are produced by primary electrons (or their photon secondaries) admitting that these may be entirely positive, and he has asked if in our measurements coincidences produced by air showers might have obscured the asymmetry of the primary rays.

In answer to Oppenheimer's suggestion we have made two flights in which the three coincidence counters were arranged alternately in line, position A, Fig. 1, with the principal axis inclined 60° from the vertical, as in our Panama flights, and then, with nearly identical spacing, in the out-of-line position B. The contributions to the counting rates by showers from the air or from the batteries beneath the counters should be the same in both arrangements, but single rays would not be recorded in the out-of-line position. Care was taken to have the spacings of the counters and their positions relative to the batteries as nearly as possible the same as in our Panama flights, and except for a small electric motor which moved one of the counters between the two positions A and B at two-minute intervals, these instruments were identical with those used in Panama.

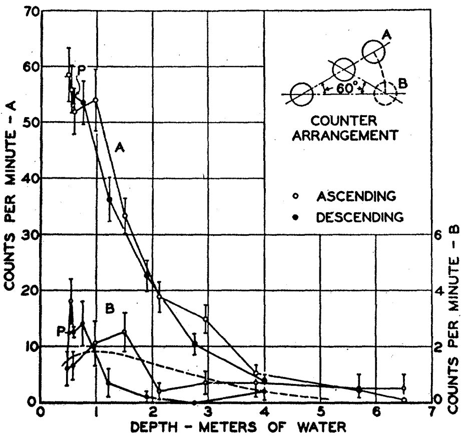

Fig. 1. The variation of in-line, A, and out-of-line, B, coincidences with atmospheric depth. The points PP are based upon 45-minute averages, the other points upon 5-minute averages.

On the first flight the counters failed when the apparatus reached the equivalent depth of 2 meters of water, but at that depth the in-line counting rate was many times the out-of-line rate. The record of the second flight was complete and the results are shown in Fig. 1 where the counting rate with each arrangement of counters is plotted against atmospheric depth. This flight ascended to an atmospheric depth equivalent to 47 cm of water and signals were received for four and one-half hours. The upper curve plotted to the scale on the left shows the in-line counting rates based upon 5-minute averages while the lower curve plotted to the scale on the right shows the out-of-line counting rates, also based upon 5-minute averages. *At the higher elevations the air showers contribute only about five percent of the in-line counts and it is impossible to attribute the lack of asymmetry observed by our flights in Panama to this cause.* Thus there seems to be no escape from our conclusion that mesons are not produced by rays of the soft component but are probably produced by primary protons.

The small increase of air shower intensity with elevation is a matter of some interest although it is readily interpreted if account is taken of the lower concentration of air at the higher elevations. If showers of a given type are considered, namely, those in which a pair of particles diverges at a given angle θ, it is clear that such a shower may produce a coincidence in the out-of-line arrangement if it originates at some distance x to $x+dx$ above the counters, a distance independent of the atmospheric pressure and depending only upon the angle θ. Thus the probability that a ray will produce a shower capable of giving a coincidence varies as the amount of matter in dx, or in proportion to the atmospheric depth h. Since the intensity of the soft component varies at depths below that of maximum intensity according to the law[4] $j_s = j_0 e^{-0.5h}$