that two of the three observations of Barnóthy and Forró using counter trains give values for $\alpha$ of 0.42 and 0.46, respectively. The discrepancy between the observations by counter train and by ionization chamber may be due to one or more of the following considerations:

(1) The greater screening in the telescopes affords better discrimination against the soft, zero temperature coefficient, electron component, and therefore the telescope records greater percentage variations than does the less shielded ionization chamber.

(2) For a given local temperature the ionization chamber records fluctuations of cosmic-ray intensity due to variations of temperature over large surrounding areas; under certain conditions these fluctuations may depress the value of the "true" temperature coefficient.

(3) Rathgeber[4] suggests that the mesotron spectrum is principally composed of a hard component $\sim 3\times 10^9$ ev originating at altitudes of 17 km or greater, and a softer component $\sim 2\times 10^8$ ev originating at 6 km or lower. On this assumption it can be shown that oblique rays will have a smaller temperature coefficient than vertical rays. The altitude of the $100-50$ mb isobars ($\sim 16-20$ km) is practically constant, and hence the hard mesotrons originating at or above these levels are insensitive to temperature variations. The percentage of hard mesotrons being greater for oblique rays, the total percentage variation registered by ionization chamber will be smaller and hence will lead to a smaller value for $\alpha$ than that obtained by vertical counter train. It would certainly appear worth while to make a comparative investigation of the temperature effect by the use of vertical and inclined counter trains.

Grateful acknowledgment is made to Professor V. F. Hess for valuable suggestions, to Professor W. F. G. Swann of the Bartol Foundation, and to the Penrose Fund of the American Philosophical Society for aid in repairs.

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## On Microanalysis by Electrons

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RECENTLY, using 7.5-kilovolt electrons and an electron-velocity analyzer of a focusing half-circle magnetic type, G. Ruthemann[1-3] has investigated the velocity distribution in the electrons transmitted by thin collodion membranes. He found that the number of electrons suffering discrete energy losses of 298, 400, and 546 ev corresponding to the excitation of the $K$ level of C, N, and O was sufficient to produce observable peaks in the velocity distribution curve.

In the present work it has been the intention of the author to investigate the possibility of extending the

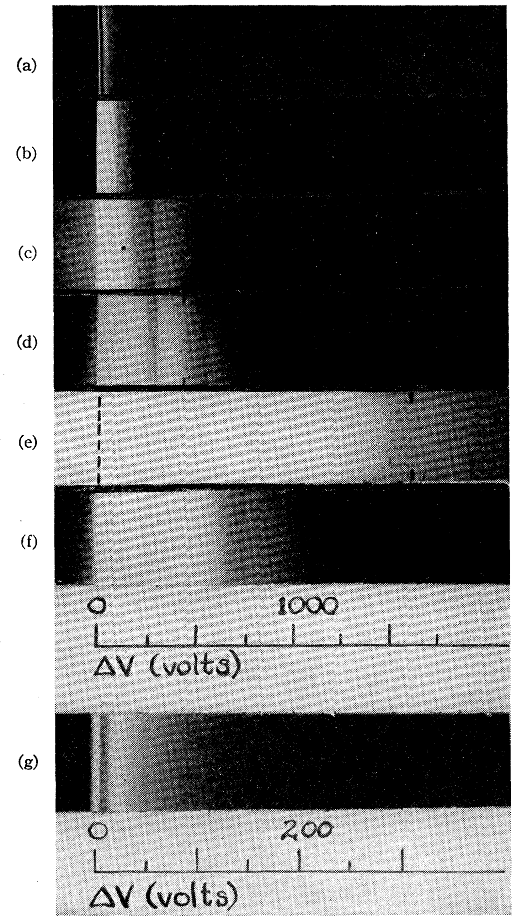


FIG. 1. Velocity distribution of electrons. (a) Specimen—collodion membrane; incident electron energy—47.5 kev; exposure—0.1 second; emulsion—Eastman Tri-X Panchromatic. This analysis shows the line due to the electrons which have been transmitted with their original velocity and a continuous distribution of electrons which have lost small amounts of energy in inelastic collisions with electrons of outer shells; most probable energy loss, 24 ev. (No attempt was made in the testing of the instrument to obtain precision measurements though the values obtained are all within $\pm 5$ percent of the values predicted from x-ray data.) (b) Specimen—evaporated beryllium film on collodion; inc. electron energy—47.5 kev; exp.—0.5 sec.; emulsion—Tri-X Panchromatic. Line due to the $K$ level of Be appears at 135 ev. (c) Specimen—collodion membrane; inc. electron energy—47.5 kev; exp.—0.5 sec. (printed light); emulsion Tri-X Panchromatic. Line due to $K$ level of C appears at 290 ev. (d) Specimen—collodion membrane; inc. electron energy—28.0 kev; exp.—3 min.; emulsion—Tri-X Panchromatic. Lines due to the $K$ levels of C, N, and O appear at 290, 400, and 550 ev, respectively. (e) Specimen—evaporated aluminum film on collodion; inc. electron energy—28.0 kev; exp.—40 min.; emulsion—medium lantern slide. The weak line due to the $K$ level of Al is indicated at 1600 ev. (f) Specimen—evaporated film of iron on collodion; inc. electron energy—28.0 kev; exp.—10 min.; emulsion—medium lantern slide. Line due to the $L$ level of Fe appears at 730 ev. (g) Specimen—iron film; inc. electron energy—28.0 kev; exp.—2 sec.; emulsion—medium lantern slide; photographic enlargement—30×. Negative was translated parallel to line during print exposure to eliminate photographic grain. A line, presumably due to an $M$ level of Fe, appears at 57 ev. A second line appears at 44 ev, but has not yet been identified.

detection of this phenomenon to heavier elements and of using it for making an elemental analysis of extremely small regions of electron microscope specimens. In the instrument[4] designed for the purpose a minute area of the specimen is irradiated by an electron probe formed by a two-stage magnetic lens system. The electrons transmitted by the irradiated area of the specimen are focused by a third magnetic lens so that the probe is reformed at the slit position of a homogeneous field magnetic analyzer of the half-circle type. The analyzed velocity distribution is recorded photographically. By turning off the deflecting field of the analyzer and properly adjusting the probe, the instrument is converted immediately into an electron microscope of the shadow type,[5] by means of which the area of the specimen being analyzed can be accurately located and identified. In its present stage of development the apparatus can be used with 15- to 50-kilovolt electrons; the analyzer gives a measured resolving power of $\Delta V/V$ of 1/4300 while the resolving power of the probe is approximately $0.3\mu$. The regulation of the power supplies is slightly better than that of a conventional magnetic electron microscope enabling exposures of as long as one hour to be made.

In testing the instrument the work of Ruthemann has been repeated with higher electron velocities. The velocity losses due to the excitation of the $K$ levels of carbon, nitrogen, and oxygen were observed in thin collodion membranes; that of nitrogen being barely detected (Fig. 1c, 1d). In the case of light elements the exposure time was a fraction of a second for the photographic emulsions and the electron beam intensities used. The $K$-level excitations of beryllium, aluminum, and silicon have been detected, but the last two were found to be quite weak and to require exposure times of around half an hour on Eastman Medium Lantern Slides (3 minutes on Eastman Kodak Tri-X Panchromatic) (Fig. 1b, 1e). The $K$-level excitation of iron could not be detected, but the $L$ level was quite sharp and strong (Fig. 1f). A line, presumably due to an $M$-level excitation, was also observed in a short exposure on the iron specimen (Fig. 1g). In all of these tests thin films of the sample material were used. Qualitatively the velocity analysis obtained appeared to be independent of the probe diameter. The quantity of material irradiated in each of the above tests was between $10^{-14}$ and $10^{-16}$ g.

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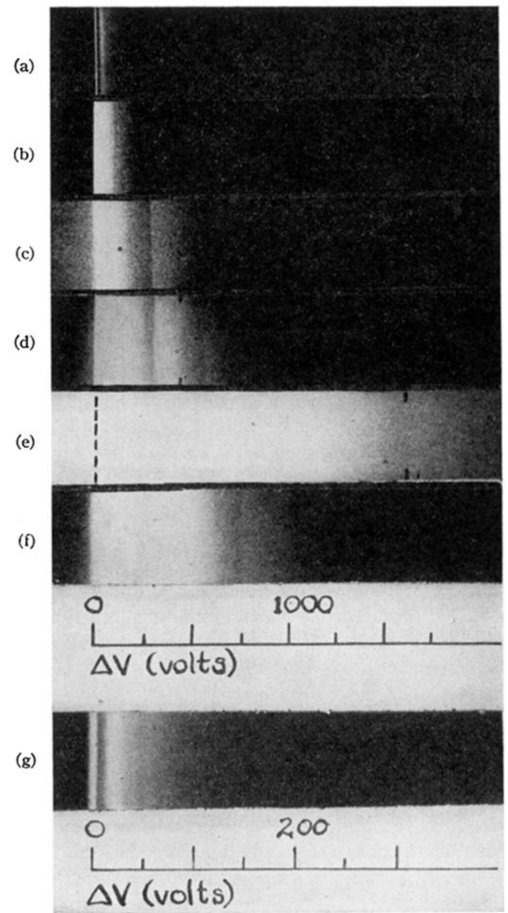


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