A Note on the Effect of the Absorber Position in the Measurement of Beta-Ray Absorption

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The effect of the absorber position in the measurement of β-ray absorption has been measured by the use of an end-window G-M tube as a detector. It has been shown that in the absorption measurement of β-rays it should be necessary to place absorbers immediately as possible before the G-M tube in order to minimize the scattered radiation from the absorber, which may reach the counter tube.

When one wants to determine the maximum range of β-rays, the Feather

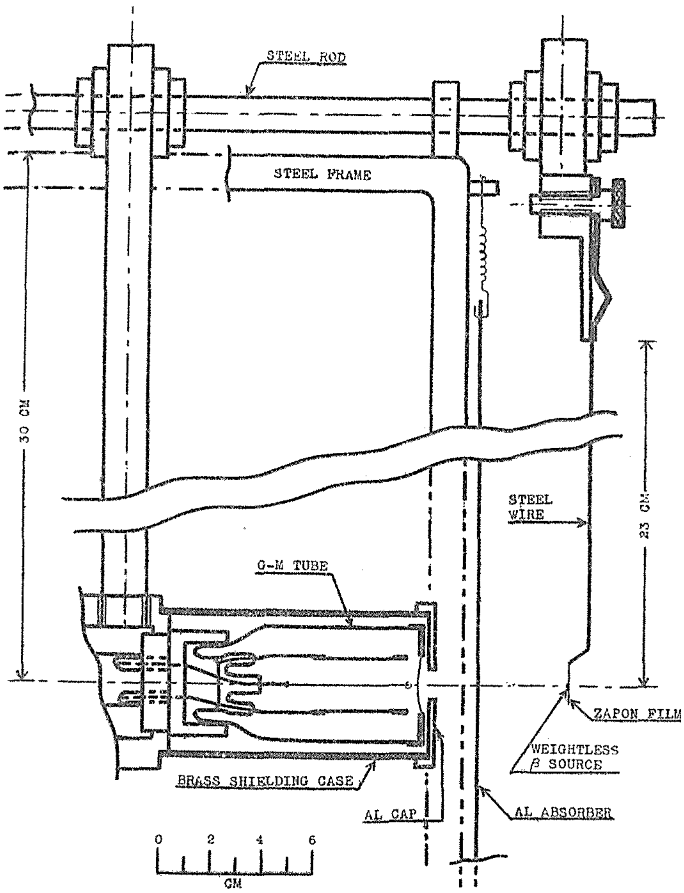

Fig. 1. Geometrical arrangement of the apparatus.

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analysis using the absorption method is often used. It has been well known that absorption curve of β-rays depends on several factors ; it depends on the maximum energy and energy distribution of β-particles, and some factors concerning the geometrical arrangement of the apparatus. However, it should be noted that the absorption curve depends especially on the position of absorbers as some workers[1,2,3] have pointed out. In this note we want to give some data concerning this effect.

The geometrical arrangement of the apparatus used in the present experiment is shown in Fig. 1. A practically weightless and point source, a mixture of Sr^{89}, Sr^{90}, and Y^{90}, which was available for us, was mounted on a thin zapon film (<300 $\mu g/cm^2$) placed at a constant distance of 58 mm from the window of the G-M tube. The thin zapon film covered on a circular aperture of 1 cm diameter on a mica plate, which was cemented on a steel wire frame as shown in Fig. 1. The thickness and diameter of a window of the end-window G-M tube were 2.9 mg/cm^2 and 2.2 cm, respectively, while the orifice of the shielding cap of the tube was 10 mm in diameter. The depth of the orifice was 3.5 mm and its front surface

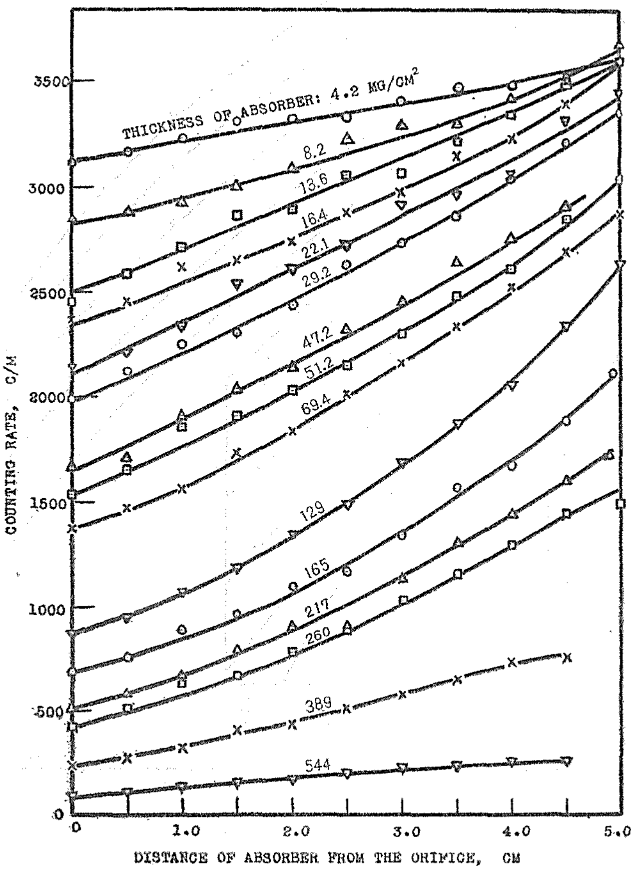

Fig. 2. Aluminium absorption of the β-rays from a mixed source of Sr^{89}, Sr^{90}, and Y^{90} as a function of absorber position.

was situated 5 mm from the window of the counter. The aluminium absorbers thinner than 70mg/cm² were 40cm×42cm wide, while those thinner than this thickness were foils of 38 cm × 38 cm stretched on a aluminium frame. Both G-M tube and source supporter were fixed to a steel rod, and by its horizontal movement it was able to change the relative position of the absorber. By this device we could easily observe the effect of the position of absorbers by measuring the counting rate for each absorber at various positions.

In Fig. 2 are given the counting rates obtained for various thicknesses of absorbers at each position, while in Fig. 3 the absoption curves corresponding

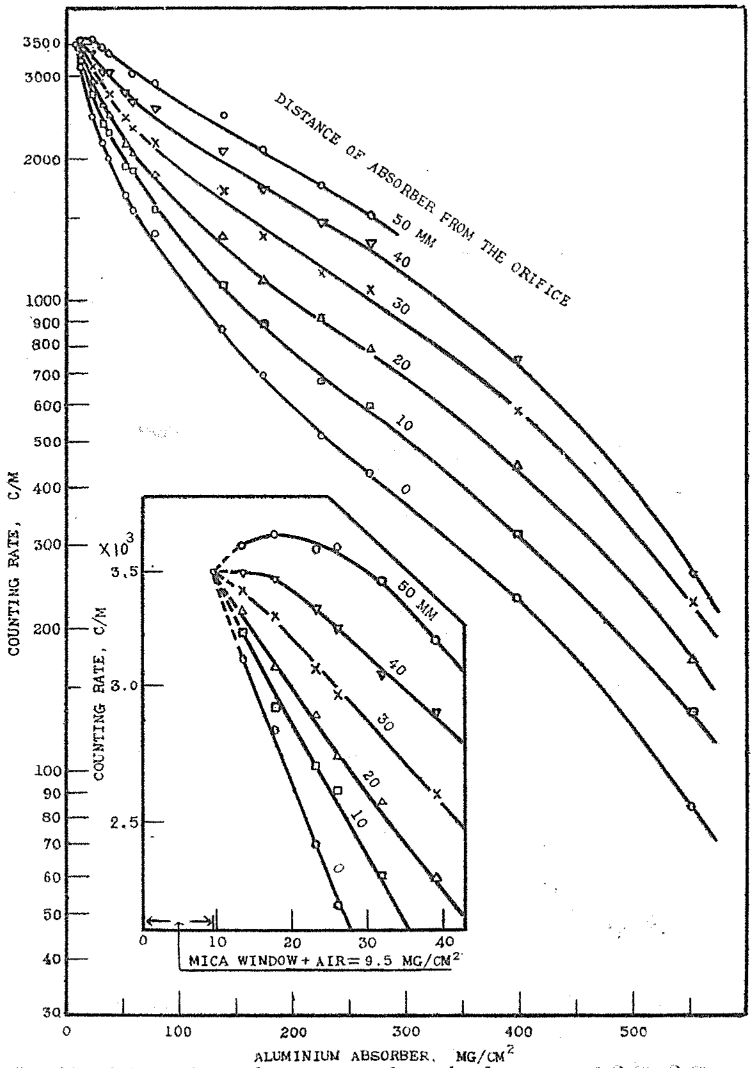

Fig. 3. Aluminium absorption curves of a mixed source of Sr^{89}, Sr^{90}, and Y^{90}.

various relative absorber positions are shown. From these results it is apparently seen that the counting rate for an absorber increases with the increase of the distance of the absorber from the orifice. It is also to be noted that the so-called negative absortion is observed when a thickness of the absorber is thinner than about 30 mg/cm^2 and it is situated immediately before the β source. This effect may be explained by the fact that when the position of an absorber is closer to the source, the fraction of the scattered radiation from the absorber reaching the G-M counter becomes larger.

I/I_c was determined for various thickness of the absorber as a function of the absorber position as shown in Fig. 4, where I is the counting rate for an absorber

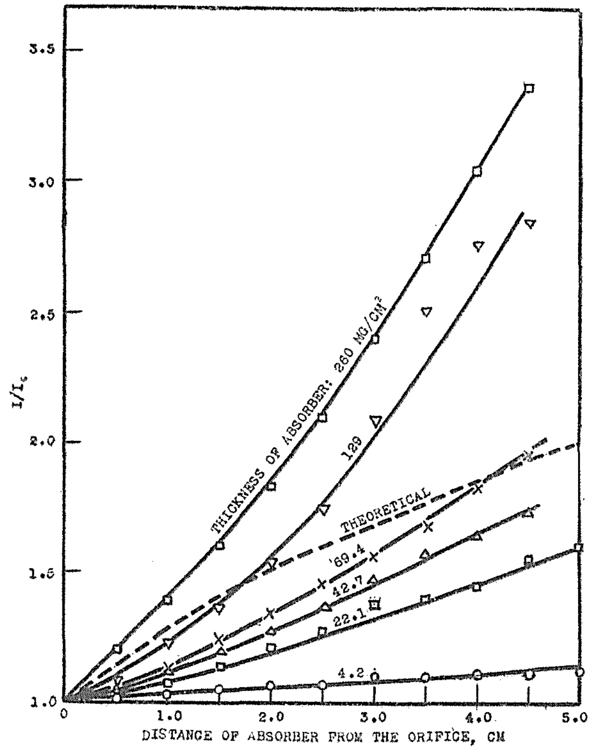

Fig. 4. Ratio of the counting rates, I/I_c, as a function of absorber position, where I is the counting rate for an absorber at each position and I_c is that for the same absorber placed just before the orifice. A β source is a mixture of Sr^{89}, Sr^{90}, and Y^{90}. The theoretical curve for a sufficient thick absorber is caluculated according the simple formula given by Elliott and Shapiro.

at each position and I_c is that obtained with the same absorber placedjust before the orifice. The curves corresponding the absorber thickness larger than 260 mg/cm^2 are, although not shown in the figure, lying very near that with the absorber of 260 mg/cm^2. A broken curve in the figure is the theoretical result calculated according to the simple analytical treatment given by Elliott and Shapiro[2], which is based on some assumptions, viz., both the weightless β source placed on the axis of the end-window G-M tube and the sensitive area inside the counter where the scattered radiation is measured being points, and the radiation of the primary β-rays from the source being isotropic while the scattered radiation from the absorber being obeyed a cosine law $I=I_0 \cos \alpha$, where α is the angle between the normal direction of the absorber and the direction in which the scattered radiation is measured. The last assumption seems to be plausible for the reason that for the sufficiently thick absorber the β-particles may undergo multiple scattering and move at random within the absorber as if produced there in the first place by radioactive process, and the scattered radiation may be expected to leave the absorber surface according to a cosine law. However, a considerable difference is observed between the theoretical and and experimental curves. This discrepancy seems to be explained by the following reasons: (1) in the present experiment an orifice of finite area and depth was used just before the window of the counter and only a fraction of the radiation passing through this orifice could be detected and some backscattering effect from the inner wall of the orifice shold be taken into consideration, (2) the cosine law mentioned above seems to be not rigorously realized, and (3) the scattered radiation is considerably scattered or absorbed by air.

In this connection further studies on the effect reported here are now in progress by the use of a source containing only one pure β emitter. However, the results of the present experiment would be somewhat suggestive for the workers who are engaging in the measurement of β-ray absorption.

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REFERENCES

(1) F. Johnston and J. E. Willard: *Science*, **109**, 11 (1949).
(2) N. Elliott and E. Shapiro: Paper 2, National Nuclear Energy Series, Division IV, Vol. 9 (McGraw-Hill Book Company, Inc., New York, 1951).
(3) T. B. Novey and N. Elliott: Paper 3, *ibid*.