ON THE ABSORPTION COEFFICIENTS OF β-RAYS.*

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ABSTRACT

The absorption coefficients of β-rays from UX_2 and RaE were completely studied. Two outstanding features have been found by the authors: (1) The complete logarithmic absorption curve of β-rays is not a really straight line but a broken one consisting of several segments of straight lines which intersected at a certain point. The slopes of the segments are greater as the absorbing screens are thicker. (2) The values of the absorption coefficients are not constant but can be varied according to the surrounding conditions of measurement. Among the conditions, the substance beneath the preparation or the reflector, the substance encircles the preparation or the screen support, and the distance between the active preparation and the ionisation chamber window are the three main determinating factors which influence the variation of the coefficient.

INTRODUCTION

Heterogeneous radiations from natural radioactive sources are generally recognized as being absorbed by matter according to an exponential law, the coefficient of absorption is represented by μ in the following equation;

$$I = I_0 e^{-\mu x} = I_0 e^{-\frac{\mu}{\rho}\frac{m}{s}},$$

from which,

$$\log_e I = \log_e I_0 - \frac{\mu}{\rho}\frac{m}{s}$$

This is the equation of a straight line, the slope of the line determines the values of μ and μ/ρ, if a graph is plotted taking thickness m/s as abscissa $\log I$ as ordinate. For most natural radioactive bodies there is usually one value of μ only,

*The experiment was performed in 1941 and the manuscript was written immediately after the completion of the experiment. The publication is delayed by the difficult circumstance during war time. One of the authors, Dr. Tcheng, died in 1943.

while for other bodies the absorption curve is the sum of several exponentials containing two or more straight lines simultaneously superimposed on each other. As examples of the latter, UY has two values of μ and RaB has three values. The reason why they should obey an absorption of one or more coefficients is entirely fortuitous.

However, there is another fact which had been observed by several experimenters when dealing with the absorption of β-rays. As early as 1907, H. W. Schmidt[1] found that the absorption coefficient of RaE was not a simple one, but increased with the thickness of the absorbing material and depended upon the condition of the experiment, In a note on the absorption of the β-rays, J. A. Gray[2] stated that the exponential law of the β-ray absorption could only be approximate, and after a certain thickness the β-rays must become more and more absorbable. Kovarik and Mckeehan[3] found that the absorption of both the RaE and the thorium active deposit were not according to an exponential law, the radiation becoming more absorbable as the absorption proceeded. The same phenomena was observed by V. Douglas[4] also.

By way of the fact related above, we are interested to note from many refererences the value of the absorption coefficient of several radioactive bodies, especially of RaE and UX_2 for their popularity and ease of manipulation. The values that obtained by various experimenters are examined, the following table may show the complete list of the values of μ in aluminium absorbers:

It is clearly shown that the values of μ obtained from various experiments are widely different. The object of this experiment is to disclose the cause why this effect occurs and the other relations pertaining the determination of the absorption coefficient.

1. H. W. Schmidt, *Phys. Zeit*, **8**, (1907) 361.
2. J. A. Gray, *Proc. Roy. Soc.* A, **87**, (1912) 487.
3. Kovarik and Mckeehan, *Phys. Zeit.* **15**, (1914) 434.
4. V. Douglas, *Roy. Soc. Canada Trans.* **16**, Sect. 3, (1922) 113.

Source	Absorption coefficient μ	Corresponding Mass-absorption coefficient μ/ρ	Reference
RaE	40.0	14.8	H. W. Schmidt, loc. cit.
,,	43.0	15.9	A. F. Kovarik, *Phil. Mag.* (6) **20,** (1910) 849
,,	45.5	16.9	G. Fournier, *Ann. der Phys.* **8,** (1927) 205
UX_2	10.9	4.1	J. Gedult von Jungenfeld, *Phys. Zs.* **14,** (1913) 507
,,	,,	,,	Geiger, *Trans. Faraday Soc.* **5,** 505, 10
,,	12.5	4.7	H. W. Schmidt, *Phys. Zs.* **7,** (1906) 764
,,	14	5.26	Ruthertord, *Radioactivity*, 2nd. edition. Cambridge, (1905)
,,	14	5.3	J. A. Crowther, *Phil. Mag.* (6) **12,** (1906) 379
,,	14.4	5.34	H. W. Schmidt. *Jahrb. f. Rad. und Elektrizität* **5,** (1908) 451
,,	15	5.56	Bragg, *Proc. Roy. Soc.* A, **3,** (1906) 617,
,,	,,	,,	Bragg, *Ann. der Chemie,* **333,** (1907)
,,	15.9	5.9	O. Hahn und L. Meitner, *Phys. Zs.* **9,** (1908) 321
,,	16.0	5.93	K. Fajans u. O. Gohring, *Phys. Zs.* **14,** (1913) 877
,,	16.6	6.15	Z. V. Erchova, *Journ. de Phys. et le Rad.* VII **8,** (1937) 501
,,	17.6	6.5	G. Fournier, *Ann. de Physique,* X **8,** (1927) 205
,,	17.8	6.6	A. F. Kovarik, *Phys. Rev.* (2) **3,** (1914) 150; *Phys. Rev.* (2) **6,** (1915) 419
,,	18	6.75*	O. Hahn u Rothenbach, *Phys. Zs.* **20,** (1919) 194

*Values internationally admitted in 1930.

EXPERIMENTAL

The radioactive source RaE was prepared either chemically from old radon tubes according to the method described by I. Curie[5] or electrolytically from radioactive lead according to M. Haïssinsky[6]. As stated by both, they all would give satisfactory results, and we actually had observed no difference in using either of them throughout our experiment.

The UX_2 source was extracted from uranium nitrate also by means of two methods. The first method used cerium as the base which was precipitated along with UX_2 by $HF+H_2SO_4$. In the second method to extract UX_2, it was fixed on the ferric hydroxide in an ammonium carbonate solution. All the two methods had given similar results regarding their absorption measurements.

The active preparation was usually mixed with a little of chloroform to form a thick paste. This was applied to a circular plate about three millimeters thick

5. I. Curie, *Journ. de Chimie Phys.* **22,** (1925) 471.
6. M. Haissinsky, *Journ. de Chimie Phys.* **31,** (1934) 43.

and four centimeters diameter. The plate was then gently warmed to expel the chloroform and the condensed moisture. An active source was thus formed with a diameter of not more than 1 cm. and a thickness of less than 1 mm., weighing only a few milligrams. In measuring it was usually placed directly underneath the ionisation chamber with the latter's window downward, except for very rare cases when it was placed in the reversed direction. The absorption screens were interposed between the ionisation chamber and the active source, and was placed on a supporter of which the internal diameter was a little larger than the external diameter of the active disc. In order to render the direct radiation from the source to cover all the aperture of the ionisation chamber, the screen was in every case nearer to the preparation than it was to the ionisation chamber.

The metallic screens were all made from rolled sheets as flat as possible. The aluminium sheets were specified as being chemically pure, and all the carefully made screens beared an irregularity of not more than 1%. We had taken considerable pains to find out whether there would be any defect or mistake in the different screens of different thickness and of various origin, but the results were quite satisfactory. The celluloid screens were made from German material; it had a density of 1.39 approximately. Although they were not as smooth as the aluminium, we had made a reasonably good set of celluloid screens in the laboratory. The most discontent screen was the copper set. On account of the heavy density and the poor maleability of the copper, we could hardly obtain very thin screens suitable for our purpose from this metal. The unfavourable conditions prevailing in China prevented us from buying them from foreign countries and from studying perfectly the part of γ-ray absorption by copper screens thinner than 70 mg/cm. It was preferable to extend the study with other metal screens, but we regretted that we could not do it also for the same reason.

Most of the experiments stated in the following paragraphs had been performed by means of a Pohl electrometer with a single string together with its cylindrical ionisation chamber of about 10 cm. in diameter and 9.5 cm. in height attached directly under the electrometer proper. When the knife-edges of the electrometer were charged with a potential of ± 45 volts, it would have a convenient range of sensitivity and would handle the whole experiment satisfactorily. Although the ionisation current of UX_2 was saturated well below 300 volts, a high

tension of 600 volts, obtained from a battery of lead storage cells, was applied to the ionisation chamber throughout the experiment. The window of the chamber was closed by a thin aluminium foil only 0.01 mm. thick. The ionisation current

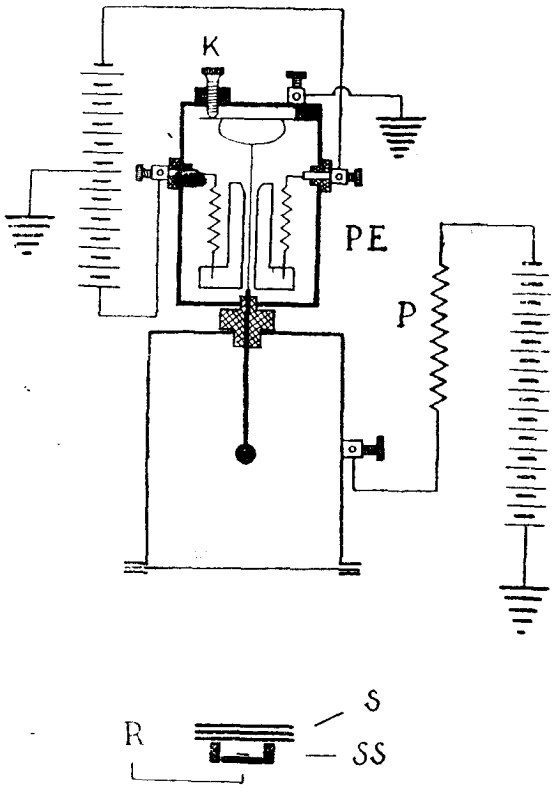

Fig. 1. The electrical circuit using Pohl's Electrometer for the measurement of absorption coefficient.

PE—Pohl's Electrometer
SS —Screen support
P —Protecting resistance
S —Absorption screen
R —Reflector
K —Electrometer sensitivity adjusting key.

in the chamber was measured with the constant deflection method. It is inversely proportional to the time necessary for the string to travel through a fixed number of divisions on the occular scale of the Pohl electrometer. The general layout of the arrangement is shown in Fig. 1.

For the sake of comparison we had occasionally used the quadrant electrometer as the indicating instrument. This was accompanied by a quartz piezoelectric apparatus and a quite different ionisation chamber "*P*". The last one had a cylindrical wall of 20.5 cm. in height and 8.1 cm. in diameter, and an electrode rod of 15 cm. long and 3 mm. diameter at its center. Surrounding the whole

chamber there was a metallic shield which was connected to the ground to get rid of all electrostatic disturbances. The form of the chamber was that of the so-called "*P*" type used in the Curie Laboratory.[7] The ionisation current was measured by the compensation method, its connection with the electrometer and the piezoelectric apparatus is shown in Fig. 2.

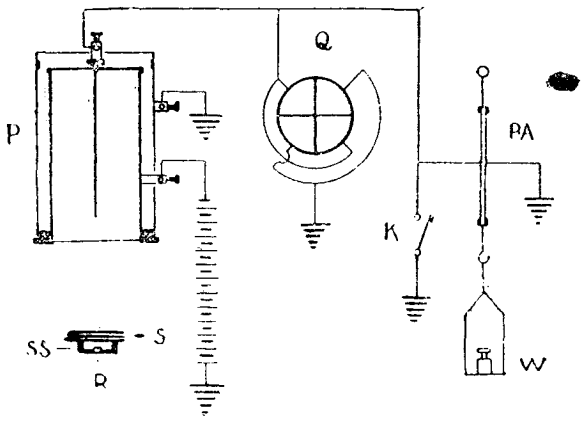

Fig. 2. The electrical circuit using quadrant electrometer and ionization chamber "*P*" for the measurement of absorption coefficient.

Q —Quadrant electrometer	S —Absorption screen
P —Ionization chamber	SS —Screen support
R —Reflector	PA—Piezoelectric apparatus
W—Weight	K —Grounding key

When the ionisation chamber "*P*" was used with the Pohl electrometer, the central electrode of the chamber was connected to the string of the electrometer, the original ionisation chamber of the electrometer being dislodged previously.

In order to study the absorption exactly the measurements were often made step by step according to the thickness of the absorbing screen, and the results plotted in a large scale on a graph paper. The sensitivity limit of the instruments also prefered to such doing. The curves shown in Fig. 3 and Fig. 4 were condensed from two to three separate graphs to the same chart. All the absorption

7. G. Fournier et M. Guillot, *Sur L'Absorption Exponentielle des Rayons-β du RaE*, Actualites Scientitiques et Industrielles **57**, (1933).

curves in this experiment were repeated at least two times to get rid of any mistake which might happen in the measurements, but each time it could be proved to coincide with each other within experimental errors. The results shown in this paper represent a part of them only.

RESULTS

The first distinguishing phenomenon that we had found from the absorption of β-rays is that the complete logarithmic absorption curve is not a simple one, but usually consists of several separate segments of straight lines, It is entirely different from the known fact possessed by certain radioactive bodies such as RaB or as UY which has two or three absorption coefficients simultaneously, superimposed on each other on their absorption curve, Their coefficients can be separated only by subtraction from the common curve. The phenomenon we have observed in the absorption curve discloses directly several discontinued segments intersected according to the range of the thickness of screens used and not superimposed on each other. The segments are usually very good straight lines.

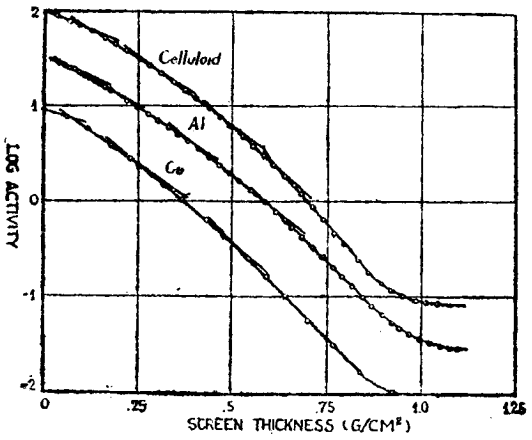

Fig. 3. General appearance of the complete absorption curve of UX_2 in different absorbers; with thick Al screen support 6 mm. high, ebonite reflector, distance 4 cm.

The value of the absorptions coefficient of an active substance is found much smaller at the range of thin absorbing screens. As the screens are added thicker and thicker when the absorption measurement is proceeding, the coefficient increases to another value suddenly at a certain thickness of screens. This point is shown by the intersection of the two succeeding segments of straight lines in Fig. 3. The slope of each segment represents one coefficient of absorption within the range of the absorber. The thicker the screens are used, the greater is the value of the absorption coefficient. It will be interesting to note that the value of

absorption coefficient for thin screens is often less than the internationally admitted value while that for thick screens is often greater than the admitted value. The absorption coefficient for moderately thick screens is often near to the value generally acknowledged.

If not for the influence of the surrounding conditions under which the measurement is performed, the values of the separate coefficients of a certain body are fairly constant. But even such is the case, the intersection point at which the absorption coefficient changes abruptly from one value to another is fairly fixed at a certain screen thickness, though with very few exceptions. For the same β-ray source under similar conditions the number and the slope of the segments depend on the material of the screen used. For example, UX_2 has 5 values of μ with Al screens; it also has 5 but different values of μ with celluloid screens; while it has only 4 values when with Cu screens. (Fig. 3). As shown in Fig. 4, RaE has two values of μ with Al absorbers; and has also 2 different values with celluloid screens. It has one value only with Cu screens, however.

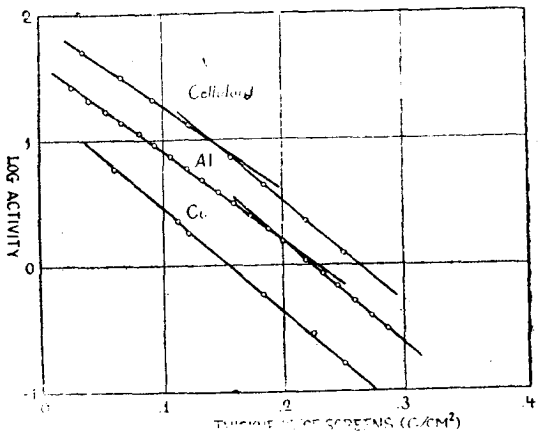

Fig. 4. General appearance of the complete aborpstion curve of RaE in different absorbers; with thick Al screen support 6 mm. high, platinum reflector, and distance 4 cm.

The second fact that we have found in the absorption of β-rays is that its coefficients are not definite and depend on the condition of measurement. The important factors are: (1) the material and thickness of the reflector, (2) the thickness of the screen-support, and (3) the distance between the source and the ionisation chamber. They will be treated separately in the following.

(1) *The Reflector*—The material of the disc on which the active preparation is placed constitutes an important factor in determining the absorption coefficient when the screens are thin. Since 2π of the total radiation is intercepted by the supporting disc, it acts simultaneously as a reflector of the β-rays emitted. Both

the material and the thickness of the reflector will accordingly modify the reflection effect. From the Fig. 5, it can be seen the relation between the different thickness of the reflecting materials Pb, Ag, Cu, Al, and celluloid with their ionisation current. The former are expressed in mg/cm², while the latter in arbitrary units. The screen by which the window of the ionisation chamber is closed is about 5 mg/cm² (Al) thick. The active source used is UX_2. It is clearly shown that when the reflector is thicker the ionisation becomes stronger, until it reaches a certain thickness then the ionisation current seems saturated. Heavy materials yield larger ionisation currents but are difficult to saturate, while lighter materials yield smaller currents and are easy to saturate.

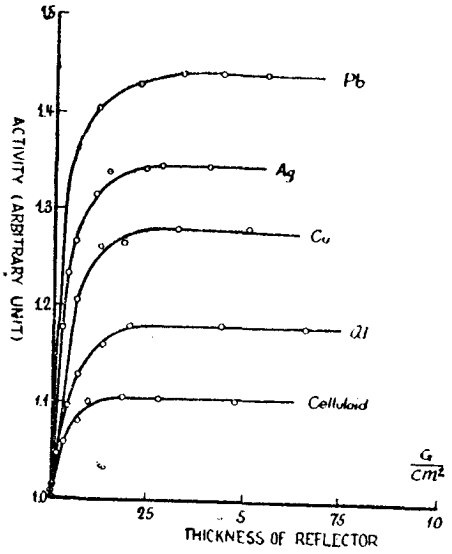

Fig. 5. Influence of the thickness of the reflector on the ionization current when the screen is 5 mg/cm². thick; source Uranium X.

Fig. 6 shows the ionisation current of different thickness of reflector when the screen covering the ionisation chamber window is 880 mg/cm² (Al) thick. Using these screens the ionisation currents are not very much different from each other whether the reflector were heavy as Pb or light as celluloid. Their saturation currents are not arranged in an orderly manner but are confused on account of the difficulty to measure the extremely small ionisation

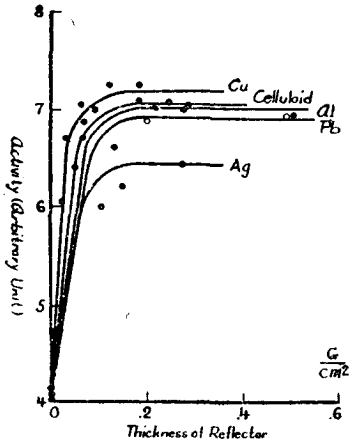

Fig. 6. Influence of the thickness of the reflector on the ionization current when the screen is 880 mg/cm². thick; source Uranium X.

currents under such heavy screens. The Ag screens are made by piling hammered foils purchased from the market; it is coarse and uneven and its results may be erroneous.

It is obvious that from the comparison of Figs, 5 and 6, the saturation ionisation currents of different reflectors differ very much when the screen is thin but very little when the screen is thick. Fig. 7 clearly shows their effect. The preparation that placed on a reflector made from heavy materials is usually absorbed more easily and has a larger value of μ when the screen is thin. Those reflectors made from light materials usually give smaller values of μ. Their difference with heavy reflectors is more difficult to detect when the screen is thicker than 600 mg/cm² or so; the value of μ then seems to be constant. Materials of ebonite, graphite, and cardboard give similar absorption curves. This may be due to the resemblance of their chemical composition.

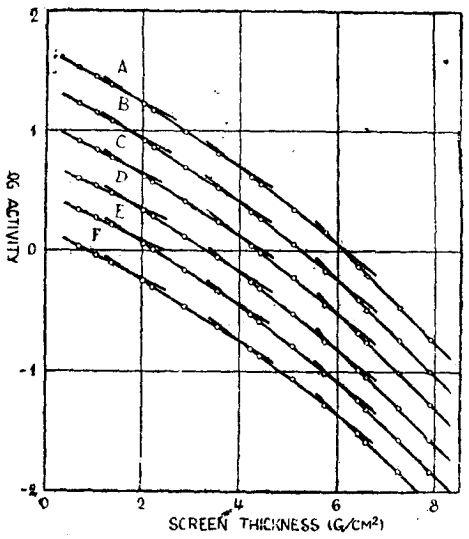

Fig. 7. Influence of the material of reflector on the value of absorption coefficient; thick Al screen support 6 mm. high, distance 4 cm.
A—Lead B—Copper C—Aluminium
D—Ebonite E—Graphite F—Cardboard

In order to simplify the various factors which would affect the value of μ, the reflector used throughout this experiment was made from ebonite and was 3 mm. thick, a thickness more than enough to guarantee the saturation of the ionisation current.

(2) *The Screen Support*.—The absorbing screens are placed on a cylindrical support, which, on account of its simultaneous action as a canalizer, is mostly responsible for the alteration of the values of μ under various conditions. According to our experiments, the slopes of absorption curves are usually flatter—thus the values of μ are smaller, especially at large thickness of absorbers, when

measured with thin screen-supports so that the complete logarithmic absorption curve of UX_2 in Al absorber shows only four segments (Fig. 8) although it shows

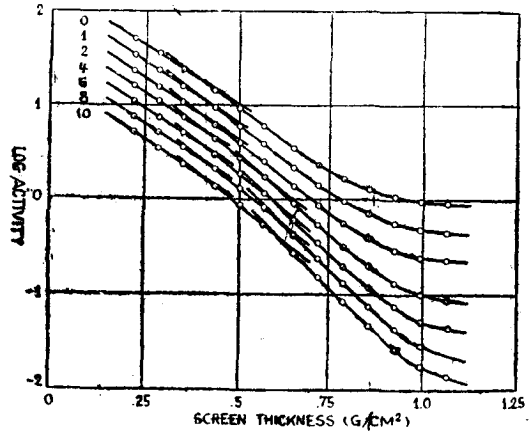

Fig. 8. The change of absorption coefficient in Al absorbers when using different thickness of screen supports. The numbers shown in the figure indicate the respective number of Al coils used to support the screen. Each coil has a thickness of 70 mg/cm². The thin screen portion of the absorption curve is not shown in the figure.

five segments with increased values of μ when measured with thick screen-supports. Fig. 9 shows the same effect of the thickness of screen-support on the value of μ, using Cu screens.

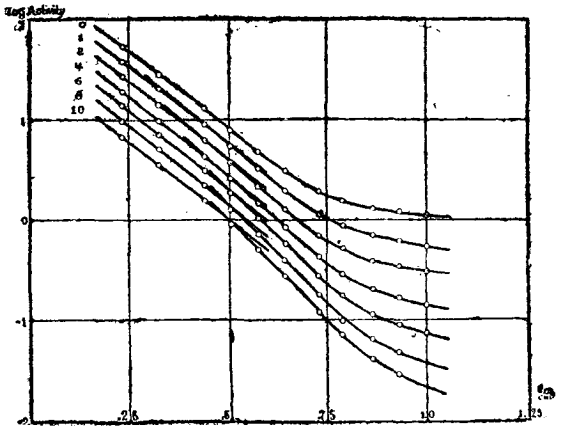

Fig. 9. The change of absorption coefficient in copper absorbers when using different thicknesses of screen-supports. The numbers shown in the figure indicate the respective number of Al coils used to support the screen. Each coil has a thickness of 80 mg/cm². The thin screen portion of the absorption curve is not shown in the figure.

The material of the screen-support bears no appreciable effect on μ, as shown by Fig. 10.

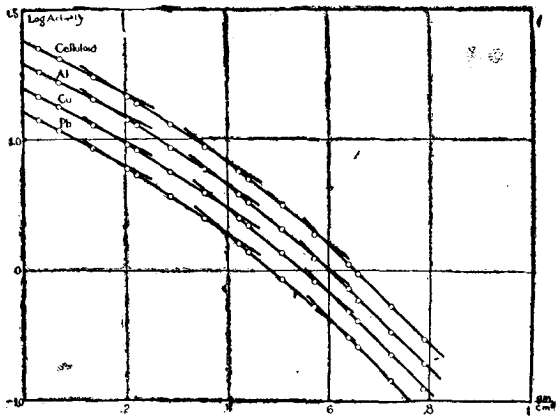

Fig. 10. The material of the screen-support has no influence on the absorption coefficient
a. Reflector: Carbon
b. Distance: 4 cm.
c. Height of screen-support: 6 mm.
d. Thickness of screen-support: 800 gm/cm².
e. β-ray source: UX.

Such a result can be clearly verified by a glance at Fig. 11. It shows the activity (in arbitrary units) of UX_2 which passes through (A) 26 mg/cm² and (B) 1095 mg/cm² of Al screens, The activity varies according to the thickness of the

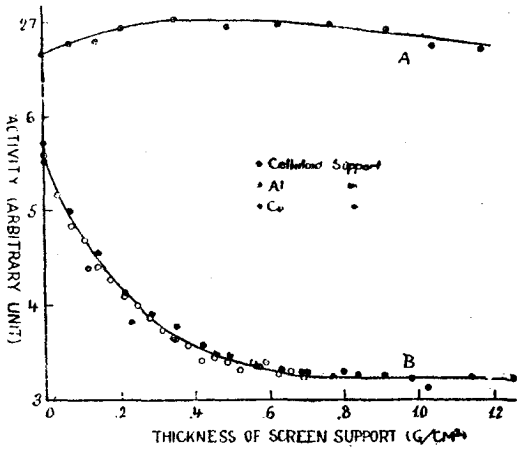

Fig. 11. The activity penetrated from different thickness of screen changes with the thickness of screen-support. Curve A: Screen = 26 mg/cm.². Al. (measured with Al supporters only). Curve B: Screen = 1095 mg/cm². All use Uranium X as source.

screen-support which is taken to be the abscissa in units of mg/cm². When the screen is thin, the activity increases very slightly at first with the screen-support, (Fig. 11(A)), till it reaches a fixed value then it changes no more with the latter. But if the screen is thick enough the contrary will be seen. The activity is greatest when the thickness of the screen-support is zero, which condition is brought about by supporting the screens on three slender Al pegs of the same height as the other supports, thus the material surrounding the preparation is practically zero. When the screen-support is added thicker and thicker, the activity decreases quickly until the support is about 800 mg/cm², then it shows no more decreasing as if a limiting condition is reached. There are three types of material that we have used to make the support, namely, the celluloid, the aluminium, and the copper. Though we had not been able to use lead as the supporting material for the sake of its softness and its heavy density, it is already quite evident to see from Fig. 11 (B) that all the three kinds of material used have similar ionisation currents for the same thickness of screen-support. This should be useful for interpreting Fig. 10 indirectly and explaining why the β-ray is more

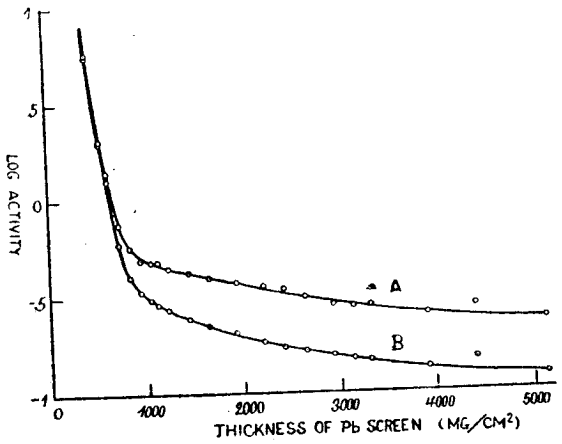

Fig. 12. The absorption of UX_2 by Pb screens in the γ-ray region is also influenced by the thickness of the screen-supporter. Curve (A) use 1 Al coil (B) use 16 Al coils as the screen-supporter.

absorbant in using thick screen-supports in the thick absorbing screen region and not so in the thin absorbing screen region.

Not only the β-ray activity is influenced by the insertion of the screen-support, but also the γ-ray activity is modified by this doing. The curve A shown in Fig. 12 is the γ-ray absorption curve of UX_2 by lead screens which are supported on only one Al ring of about 70 mg/cm^2 thick (the lead screens cannot be properly supported on three Al pegs on account of their softness), while the curve B is that which is supported on an Al ring of 16 times as thick. It can be easily seen that those with thick screen-supports often give less ionization currents in the γ-ray region as well as in the β-ray region. The steeper part in the curves in Fig. 12 indicated the β-ray absorption by Pb screens.

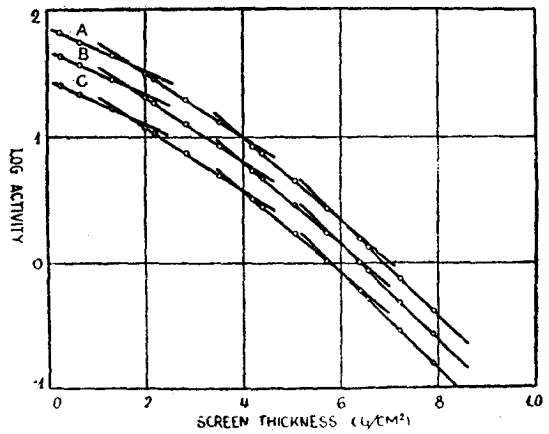

Fig. 13.

The radius of the screens-support has no influence on the absorption coefficient as shown in Fig. 13.

The height of the screens-support plays a considerable rôle on the determination of absorption coefficients at the part of thin screens. The curves in Fig. 14 show the general tendency of the change of μ of UX_2 in Al absorbers. Curves marked by "a" were measured when using a screen-support of 6 mm. high with a thickness of well over 800 mg/cm^2, those marked by "b" were measured when using a screen-support 5 mm. higher than the former (total height = 11 mm.), and those marked by "c" were measured using a screen-support of again 5 mm higher than the last (total height = 16 mm). We did not use still higher screen-supports

in order to avoid the possibility of interrupting the direct beam of radiation emerging from the active source. The curves "A" were measured when the source was 7 cm. distant from the ionization chamber; "B" was 10 cm. distant and "C" was 20 cm. distant.

Whatever the distance from the ionisation chamber to the source may be, it can be seen that when the absorbing screens are less than 200 mg/cm² thick the absorption coefficient is smaller with low screen-support than with high screen-support. However, if the screen is thicker than 200 mg/cm² or so the contrary effect will be revealed though it is detectable only by careful observation.

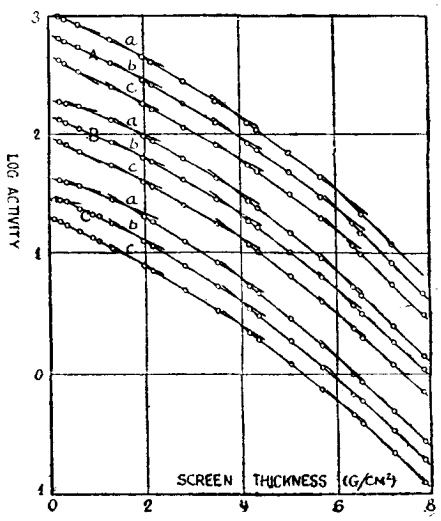

Fig. 14. The absorption coefficient changes considerably with the height of the screen-support; with Al screens and UX source, thick Al screen-support, graphite reflector.

(3) *The Distance.* – Besides the influence of the substance underneath or surrounding the active source on the value of μ there is also that of the distance from the ionisation chamber to the source. The absorption coefficient is usually greater when the preparation is nearer to the ionisation chamber. The effect is less noticeable in the region when the absorbing screens is thicker than 200 mg./cm². The curves in Fig. 15 are rearranged from the results obtained in Fig. 14 in the order of distances. The curves marked by "a" were measured when

the preparation was 7 cm. distant from the ionisation chamber, "b" was 10 cm. distant and "c" was 20 cm. distant. Those marked by A, B, C were measured when the height of screen-support was 6, 11, and 16 cm. respectively.

The dissolution of the complete absorption curve into segments of straight lines and the modification of the slopes of separate segments in different portions of the absorption curve with measuring conditions are independent of the instru-

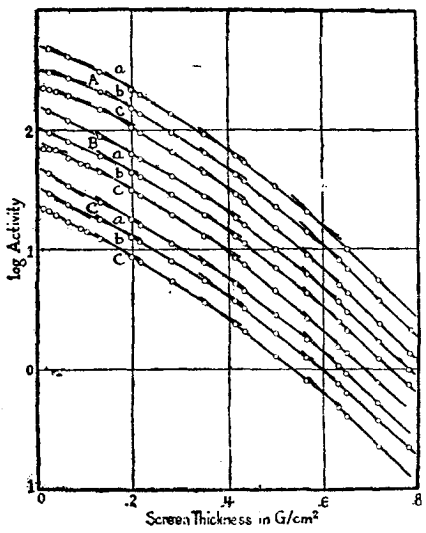

Fig. 15. The absorption coefficient changes considerably with the distance from preparation to ionisation chamber.

ments used and of the method applied. We have compared the results obtained by Pohl's string electrometer with that by the quadrant electrometer, but they show no difference at all. The absorption curve A in Fig. 16 is performed in the Pohl electrometer with its own ionisation chamber in a constant deflection method, while B is in the quadrant electrometer together with the entirely different ionization chamber "P". With UX_2 as the source, with Al screens and thick Al screen-support, we found no difference so far as the slopes of different segments and the location of the intersection points are concerned.

The curves C, D, E in Fig. 16 were measured when the screen was supported on three pegs and the thickness of the support was considered as zero. In C the

the Pohl electrometer and its own ionisation chamber were used, in D the quadrant electrometer with the ionization chamber "P" was used, while in E the Pohl electrometer was used with the ionisation chamber "P" instead of its own. Other conditions surrounding the active source were all the same. The curves again show not the least discrepancy. Thus we should have no doubt about the phenomena described above.

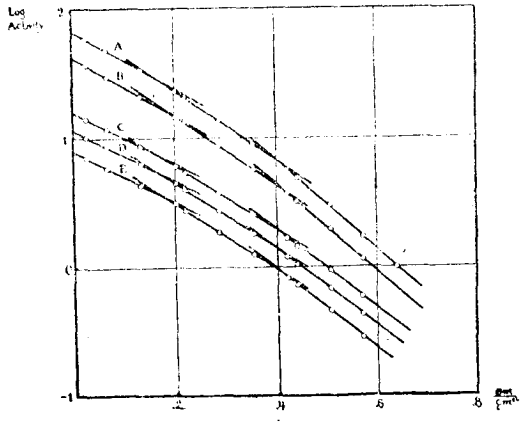

Fig. 16. The absorption measurements are not influenced by the instruments used nor the method applied in the measuring.

Though it is difficult to say under which conditions it would give the true value, it will surely be more discernable to give a detailed numerical value of the coefficients of different portions on the absorption curve, using different screens. The following is the average result of many experiments which may represent most of the measuring conditions commonly occurred in a laboratory. The reflector disc is made from ebonite, about 3 mm. in thickness (about 400 mg/cm²). The screen-support is 6 mm. high, its net distance to the preparation is 3 mm, and it is thicker than 800 mg/cm². The distance from the preparation to the ionisation chamber is 4 cm. approximately. The mass-absorption coefficient of UX_2 and RaE in different absorbing media at different ranges of screen thicknesses are given in the following table:—

Source	Absorbing screen						
UX_2	Celluloid	Range $\left(\frac{mg}{cm^2}\right)$	0	116	300	460	690 — limit of β-ray.
		$\frac{\mu}{\rho}$	3.6	5.3	6.6	8.2	10.1
,,	Al	Range ,,	0	70	160	385	610 — limit of β-ray.
		$\frac{\mu}{\rho}$	4.2	4.8	6.0	7.4	8.9
,,	Cu	Range ,,	0	75	230	470	limit of β-ray.
		$\frac{\mu}{\rho}$	3.1	6.3	7.4	9.2	
RaE	Celluloid	Range ,,	0	170	limit of β-ray.		
		$\frac{\mu}{\rho}$	16.6	19.7			
,,	Al	Range ,,	0	200	limit of β-ray.		
		$\frac{\mu}{\rho}$	16	19.4			
,,	Cu	Range ,,	0	limit of β-ray.			
		$\frac{\mu}{\rho}$	19				

DISCUSSION

The absorption of β-rays is well known to be a complicated phenomenon, and the exponential absorption law established by many investigators has not yet been theoretically explained. Most authors, however, consider the absorption law as a statistical one resulted from the combination and compensation of various effects such as alteration of velocity distribution spectrum, reduction of velocity, filtration effect, scattering, etc. Among these effects, scattering is the easiest to consider. The change of value of the absorption coefficient with measuring conditions is due principally to scattering. As we have shown in our experiments, the material surrounding the β-ray source has a great influence on the absorption coefficient.

This has not drawn due attention from most investigators. This is the reason why a great discrepancy exists in the value of the absorption coefficient of the same β-ray source obtained by different authors.

When a β-radiation passes through the absorbing screen, the composition of the emerging radiation undergoes a considerable change, especially for the first steps of absorption (that is, with thin absorbers) when the scattering regime is not yet established. The dissolution of logarithmic absorption curve into several segments indicates that within a certain range of the absorber thickness, the absorption follows a certain statistical law, while it follows another one when within another range of absorber thickness. The intersection of two succeeding segments on the curve locates the abrupt change of the value of the absorption coefficient, and also the absorption law, which cause may be found out in the sudden revision of the composition of the β-radiation under this thickness of absorber. What and how the composition is revised is a thing remained to be seen.

The absorption coefficient was long ago considered to be an important constant of a β-ray substance. Recently Guillot and Fournier[8], in an extensive study of β-rays emitted by RaE, declared that it was indifferent to the measuring conditions and emphasized the accuracy with which it was determined. However, Rutherford and his colleagues[9] neglected intentionally the importance of the absorption coefficient and mentioned nothing at all in their book. As we have shown in this study, the absorption coefficient is neither a single value, nor a fixed value; its determination has no more interest. Since under ordinary conditions, the value of the absorption coefficient obtained with a simple measurement is near to a mean value thus published in most old books, its determination can be utilized only as a practical means to identify quickly, if not accurately, a β-ray substance.

8. Loc. cit.

9. Rutherford, Chadwick, and Ellis; *Radiations from Radioactive Substances*, Cambridge. (1930).