§ 3. A few remarks must be made about our supposition, that equal numbers of electrons are falling on the plate per unit of area on corresponding parts of the photographic spectrum. Suppose, that the electrons, radiated from a point of the source in a given solid angle and of a given energy-range, fall on the plate in an element of surface s (fig. 5). After applying the electric field between the source A and the

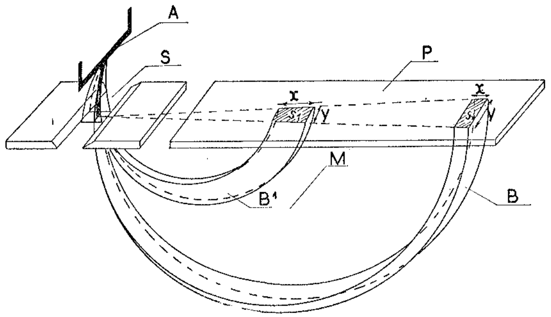

Fig. 5.

slit S, they fall on another element of surface s', and we have to prove, that the two surfaces have equal areas (as we consider in both cases the same electrons). The lengths y and y', perpendicular to the direction of the spectrum, are proportional to the radii of the circles described (there is no force working perpendicular to the plane of the electronic path). The lengths x and x' depend on the initial range of energy and it can be shown, that they are inversely proportional to the square roots of the corresponding energies, and thus inversely proportional to the radii of the described circles. It is therefore proved, that the two areas s and s' are equal.

The circumstances have been chosen in such a way, that the electric field between A and S does not change appreciably the circular form of the electronic paths between A and S, so that can be assumed that the total solid angle, in which the electrons are radiated from the source, is not altered by the electric field.

It is a pleasure to the authors to thank Dr. D. TH. J. TER HORST for his help in the construction of the β-spectrograph.

Physics. — *The conditions for the quantitative operation of a* GEIGER–MÜLLER *Counter for β-rays. The ionising power of β-rays as a function of their velocity.* By L. S. ORNSTEIN, J. M. W. MILATZ, H. TEN KATE and M. MIESOWICZ. (Communication from the Physical Institute of the University of Utrecht.)

(Communicated at the meeting of November 26, 1938.)

§ 1. For quantitative work with a GEIGER–MÜLLER counter it is necessary that the number of kicks is equal to that of the electrons, striking the counter.

To solve this problem the number of kicks was determined as a function of the pressure of the gas in the counter, using electrons of magnetically defined velocity. This number varied strongly with the pressure (comp. fig. 1) and attained a saturation-value at high pressures. The relation

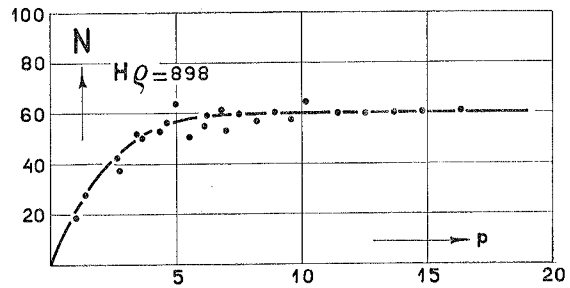

Fig. 1.

between the number of kicks $N(p)$ and the pressure (p) can be expressed by a formula of the form:

$$N(p) = N(\infty)(1 - e^{-\alpha p}), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

provided that the counting device is quick enough to detect all kicks.

§ 2. A theory of this curve can be given on the following assumptions:

a. Every β-electron produces primary ions and electrons on its path through the counter. Every primary electron forms on its turn secondary-ones. Let the quantity β represent the probability per unit of length and pressure that a primary ion is produced.

b. Let us further suppose that a kick is produced as soon as at least one primary ion is formed.

Then, d being the diameter of the counter, the probability that no primary ion is formed, amounts to $e^{-\beta d p}$. The probability for the formation of at least one ion, is:

$$1 - e^{-\alpha p} \qquad (\alpha = \beta d)$$

which gives the fraction of the β-rays causing a registered kick. This theoretical deduction shows that $N(\infty)$ in formula (1) represents the true number of incident electrons.

The probability β and also α is a function of the velocity of the electrons. The relation between β and the velocity has been determined experimentally by measuring the curve corresponding to fig. 1 for several velocities. Fig. 2 gives the result.

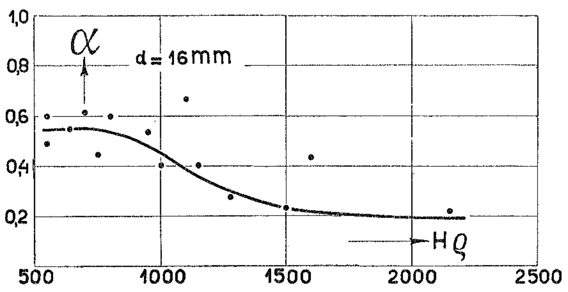

Fig. 2.

In determining a β-spectrum with the aid of counters one can proceed in two ways:

1. The pressure in the counter is chosen high enough to obtain saturation.The counter detects all electrons as is shown above.

2. For high velocities difficulties occur due to the high pressure necessary to attain the saturation. It is then more accurate to determine N as a function of p and to extrapolate by means of formula (1) the value of $N(\infty)$.

This extrapolation is based on the theory sketched. We have checked the fundamental fact that the saturation value $N(\infty)$ is the true number of β-particles in an other more experimental way, determining the curve of fig. 1 for two gases: air and hydrogen. The quantity β is then very different, the saturation value $N(\infty)$, however, is the same in both cases.

The ionising power of a β-ray can also be determined with the aid of an ionisation chamber of with the help of a WILSON cloud-chamber. As the ionisation chamber measures primary and secundary ions together, the values obtained by this instrument can not be compared with the results given above.

The number of drops formed by a β-ray in a cloud chamber per cm of

its path gives the same quantity as we have measured in our experiments [1]), as the range of the secundary electrons is so small that all generations of electrons formed by one primary electron are contained in one drop.

Comparing our results with those of E. J. WILLIAMS and F. R. TERROUX obtained with a cloud chamber, the results show to be of the same order. We wish to ackowledge our indebtedness to Professor E. STAHEL for his kindness of spending the $Ra - D + E$-source.

We express our gratitude to Mr. A. PAIS for his kind help.

---

1) E. J. WILLIAMS and F. R. TERROUX, Proc. Roy. Soc., A, **126**, 289 (1930).