V the potential difference between them. In analogous work on positive rays which was done in collaboration with M. Goyer and R. Herzog, we were able to show[2] that this assumption does not hold in general. The experimental curves which were very similar to those obtained by Allison *et al.* are shifted to the right or left according as the outer or inner plate of the analyzer is grounded. Measurements with a velocity filter of the Smythe type[3] in front of the analyzer proved definitely that the energy outside the analyzer is given by the expression above only if the ratio $\Omega_1 : \Omega_2$ of the resistances of the two analyzer plates to ground is equal to 1. The explanation put forward was that the particles on entering the analyzer have to run up against the stray field which in first approximation is

$$V_s = V\left(\frac{\delta}{r_1-r_2}+\frac{\Omega_1}{\Omega_1-\Omega_2}-\frac{1}{2}\right).$$

Here δ denotes the distance of the median ray from the circle of radius $\frac{1}{2}(r_1+r_2)$ at the point of entrance. Henceforth in all our experiments we took care to make $\Omega_1=\Omega_2$. Later this potential drop V_s at the entrance (and exit) of a radial electric field was made by Herzog[4] the starting point of his theory of electrical cylinder lenses. Though this paper is quoted by Allison *et al.* the potential drop seems to have been overlooked.

Since Allison *et al.* took great care to find the voltage at which the particles were describing exactly the average radius $\frac{1}{2}(r_1+r_2)$ of the deflector we may take it that $\delta=0$. However, according to Fig. 1 of their first paper, the outer analyzer plate was grounded which means $\Omega_1=0$. The energy of the particles is therefore increased at the entrance of the deflector by the amount $\frac{1}{2}zV$ or approximately $E/40$. If one uses the experimental data of Allison *et al.* as stated in the two Tables II of their papers and retains the errors given by them, the corrected energy releases of the reactions $\mathrm{Be}^9(p,d)\mathrm{Be}^8$ and $\mathrm{Be}^9(p,\alpha)\mathrm{Li}^6$ are found to be $Q_1=0.534 \pm 0.006$ Mev and $Q_2=2.078\pm0.04$ Mev, respectively.

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[2] J. Mattauch, Physik. Zeits. **33**, 899 (1932).

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Corrections to Electrostatic Analyzer Measurements

It is clear that some correction of the type suggested by Mattauch[1] should be applied to our measurements of the energies of disintegration particles with the electrostatic analyzer. This correction is due to the fact that the energy of the particles as they leave the target is not the same as the energy with which they pass through the deflector. Mattauch has, however, applied the correction computed for an ideal analyzer, in which there are no end effects. Actually, the Mattauch correction is a kind of end effect, and cannot be discussed separately from such an effect.

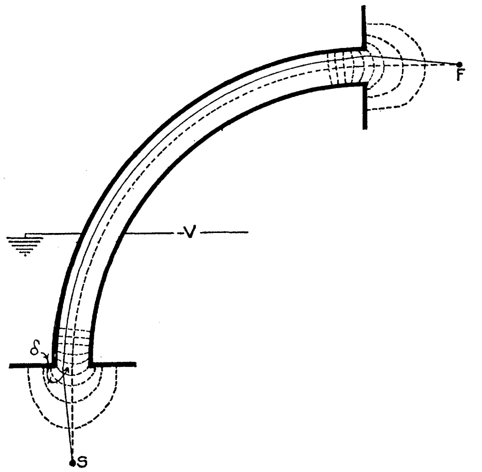

FIG. 1. Path of a charged particle through an electrostatic analyzer when end effects are considered.

The effect of the stray electrostatic field at the exit and entrance to an electrostatic analyzer similar to ours has been computed by F. T. Rogers, Jr.[2] In formulating the following remarks we are indebted to him for conversations on the subject. The solid line through the condenser in Fig. 1 shows the path of a particle which leaves the source S, passes through the condenser along a circle concentric with the plates, and arrives at the focus F. The points S and F are conjugate points of the equivalent lens, and are equidistant from the analyzer. For an ideal analyzer, with no stray fields, the particle moving from S to F and describing a circle concentric with the plates as it passes through the analyzer, would traverse the dotted path from S to F, along the mean radius. It is seen that in the presence of a stray field a particle which traverses the analyzer along a concentric orbit whose characteristic energy is given by $E=\frac{1}{2}zeV\ln(r_1/r_2)$ must enter the analyzer nearer the grounded plate than in the ideal case.

In the construction of our analyzer, no precautions were taken to minimize the stray field effect. Although the geometry of our analyzer near the entrance and exit of the plates is not as simple as indicated in the figure, qualitative calculations, in which we were aided by Professor Carl Eckart, show that the field was not significantly distorted by the grounded vacuum walls in the vicinity. We may therefore use the calculations of Rogers, which show that δ (which is essentially the same as y_c in his paper) is about 0.2 cm. This means that the potential difference between the target and the entrance point of the plates is $(0.118/0.635)$ v and the corresponding energy correction ΔE is $-0.0093E$, where E is the energy of the particle. For the reaction $\mathrm{Be}^9(p,\alpha)\mathrm{Li}^6$ the correction to the Q value is $-1.67\Delta E$, where ΔE is the magnitude of the correction to the alpha-particle energy, and for the reaction $\mathrm{Be}^9(p,d)\mathrm{Be}^8$ the corresponding correction is $-1.25\Delta E$, where ΔE is in this case the correction to the deuteron energy. Recalculation of our results from Tables II of our papers[3] shows $Q=2.115\pm0.04$ and 0.547 ± 0.006 Mev, respectively. The resulting changes in the mass values are small; Be^9 is reduced from 9.01486 to 9.01482 ± 0.00013 and Be^8 from 8.00766 to 8.00765 ± 0.00015.

These considerations show that by placing our source and detector exactly on extended tangents to the mean radius we have been using the instrument so that many particles were lost by hitting the grounded outer plate. Increased intensity should result from moving S and F to the calculated positions, that is, about 2 mm nearer the center of curvature.

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[2] F. T. Rogers, Jr., Rev. Sci. Inst. **11**, 19 (1940).

[3] S. K. Allison, L. S. Skaggs, N. M. Smith, Jr., Phys. Rev. **54**, 171 (1938); L. S. Skaggs, Phys. Rev. **56**, 24 (1939).

The Transmission of Neutrons of Different Energies Through Quartz Crystals

Recent experiments[1,2] on crystals of iron, nickel, quartz, and nickel-iron alloys (Permalloy) have shown that single crystals are very transparent to the slow neutrons which are readily absorbed by cadmium. This high transparency for C neutrons has been attributed[1,4] to the fact that only a few narrow bands in the neutron spectrum satisfy the wave-length conditions for coherent scattering. The neutrons in these bands are scattered into the appropriate diffraction patterns by the nuclei in the crystal lattices while the neutrons in the other parts of the spectrum go through the crystal practically unhindered, except for possible capture or collision resulting in incoherent scattering. Additional measurements have been made using a large single crystal of quartz and neutrons of both higher and lower energies than were used before. The observations on quartz were alternated with similar ones on carbon.

The neutrons of greater than thermal energies were obtained from 600 milligrams of radium mixed with beryllium placed about 2 cm below the top surface of a paraffin cylinder 15 cm in diameter. Two boron carbide doughnuts 15 cm in diameter with central holes 8 cm in diameter were used to improve the geometry. One of these was placed directly on top of the paraffin cylinder and the other directly under the sample. The scattering samples and the detectors were placed 12 cm and 27 cm, respectively, above the top surface of the paraffin.

The transmissions of the samples for C neutrons and for the neutrons which pass through 0.4 g/cm^2 of cadmium were measured using indium and rhodium as detectors. These cadmium filtered neutrons which activate rhodium and indium have energies of approximately 1.5 volts.[3]

The transmissions of these same samples of quartz and carbon were measured using the neutrons from paraffin cooled with liquid air. The temperature of the paraffin was checked by a system of thermocouples which indicated a constant value of about 100°K. A boron chamber connected to a linear amplifier was used as a detector of the neutrons in this case. The geometry of the apparatus was such that no correction for nonparallelism of the neutron beam was considered necessary.

It was believed desirable to measure the transmission of the quartz crystal for C neutrons since the earlier measurements on quartz were made with small samples, and furthermore, it is of interest to know whether the cross section per molecule varies appreciably with thickness of sample. This particular piece of crystal is 4.2 cm thick and has 10.97 g/cm^2. The parallel faces are perpendicular to the principal or optic axis of the crystal, and are of such size that a usable cylindrical section 4.2 cm long and 10.70 cm in diameter was available. The results of these measurements, expressed in terms of cross sections per molecule, are shown in Table I.

TABLE I. *Total cross sections for quartz crystals* ($\times 10^{24}$ *cm*$^{-2}$). (*Detectors used are shown in parenthesis.*)

COLD NEUTRONS (BORON)	RES. NEUTRONS (IN. RH.)	C NEUTRONS (IN. RH.)	C NEUTRONS (BORON)
2.3 ± 0.7	7.2 ± 1.2	3.2 ± 1.2	3.0 ± 0.7

These results afford additional proof that the increased transparency of material in the form of single crystals is due to interference effects, since this high transparency largely disappears when the wave-length of the neutrons is decreased by a factor of about seven. The cross section obtained for this quartz for C neutrons is lower than the value of $4.3 \pm 0.6 \times 10^{-24}$ cm^2 found by Whitaker and Beyer using thinner samples. While this difference may not be significant, it is in the direction to indicate a decrease in interaction cross section with increase in thickness of crystal. The results with neutrons from cooled paraffin show that the changes which take place in the energy distribution of the neutrons are not very important in changing the transmission of the quartz. This result was not unexpected. The carbon sample showed no change in cross section with change in the energy of the neutrons. The average value obtained was 4.9×10^{-24} cm^2.

The total C neutron cross section of single crystal quartz gives an upper limit for the sum of the cross sections due to incoherent scattering and capture.[4] The latter is believed to be negligible. This upper limit of the incoherent scattering cross section must be considerably higher than the actual value because of the high energy tail (extending up to the cadmium cut-off at about 0.3 volt) on the neutron distribution.

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