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Isotope Analysis of Uranium Samples by means of their α-Ray Groups.

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The method depends on the fact that, in an ionisation chamber filled with pure nitrogen, saturation can be readily obtained; all the negative ions*, which in pure nitrogen are free electrons, produced along the track of an α-particle, whatever its direction or position in the chamber, can be drawn to the collecting electrode. If this electroue is connected to a linear amplifier, the pulse will be proportional to the energy of the α-particle. Thus the analysis of the pulses according to size should give groups corresponding to the α-particle groups of the isotopes 234, 235 and 238. According to Wilkins and Crawford (Phys.Rev., 54, 316) the ranges of the α-particles for 234,235,238 are 3.18 cm., 3.0 cm., and 2.63 cm. respectively; the corresponding numbers of ion pairs are 133,000, 128,000 and 118,000.

Samples.

The uranium layer must, of course, be so thin that there is no sensible absorption in the layer itself. The samples (U_3O_8) were prepared by v.Grosse's method on smooth platinum foil, 5 cm. diameter, 0.05 mm. thick. Layers of different thicknesses up to 0.1 mgm./cm^2 were used.

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* In practice only a definite proportion of the electrons are collected, since some are caught by the grid.

Ionisation Chamber.

A diagram of the ionisation chamber is given in Fig.1. The top plate, carrying the collecting electrode and the screen grid, is waxed to the main body of the chamber with a resinous wax. This joint can be easily prised open when it is required to change the sample; it is closed again by running a small flame around the joint. The screen grid (see Fig.2) consists of 0.05 mm. diameter molybdenum wires at a distance apart of 2 mm. (They should perhaps be closer than this.)

The sample is placed in the centre of the bottom tray (which acts as H.T.electrode) and is covered with a suitable diaphragm to reduce the counting rate to about 50 per min. or less.

Purified nitrogen is passed through the chamber in a slow stream, about 1 to 5 cc./sec. Nitrogen from a cylinder is passed through a reducing solution (50 gm.KOH, 100 gm.$Na_2S_2O_4$ in 600 gm.H_2O; dissolve KOH first and cool, keep out oxygen) and dried by means of H_2SO_4 and P_2O_5. After changing a sample, it is found that conditions become constant only after circulating a volume of nitrogen equal to about ten times the volume of the chamber.

Amplifier.

The amplifier consisted of a low-noise hexode valve (Mullard EF 8), two H.F. pentodes, a discriminating valve set to

cut off all pulses less than half full size, a pulse-lengthening circuit, and an output pentode. The pulses were transmitted to a loop oscillograph and recorded on moving photographic paper strip. The time constants of all coupling units before the discriminator valve were about 5×10^{-4} sec. The length of the output pulse was about 1/100 sec. This allowed recording with a moderate light intensity, and in consequence with low paper speed - about 3 cm. per minute-without undue fogging.

General Remarks.

Pure nitrogen has little (or no?) tendency to form negative ions. Spoiled by traces (0.001%?) of oxygen, and probably by other likely impurities (H_2O). Moderate fields suffice to collect practically all the electrons, and in a very short time (less than 10^{-4} sec.). The screen grid must be narrow enough to protect the collecting electrode against the field from the electrons effectively until they have passed through the grid, or the pulse sizes would vary with the direction of the α-particles. On the other hand, the grid must be open enough to let most of the electrons pass through, or the pulses would be unduly small, and the pulse-noise ratio would go down. The cylindrical shield, connected to the grid plate, forces the electrons to go to the collector rather than to the top plate. Similarly, the tray shape of the H.T. electrode helps to push the electrons towards the centre. (Small size

of collector reduces capacity and thereby improves signal-noise ratio).

Results.

A graph of one run with a sample of ordinary U is shown in Fig.3. The two groups due to 234 and 238 are clearly separate and there is an indication of the group due to 235. The distribution of pulses in each group is Gaussian but the width seems to be rather greater than can be ascribed to the effects of straggling, absorption in the source, and amplifier noise. The excess width may be due to a residual impurity in the nitrogen and to a too widely-spaced grid. Improvement in these latter respects is under investigation.

A separated sample obtained from Professor E.O.Lawrence has been examined and the result shows that the α-group due to 235 lies approximately midway between 234 and 238 groups. A graph of one run with this sample is shown in Fig.4. Conditions were not ideal during this run and better results could be obtained.

FIGURE 1.

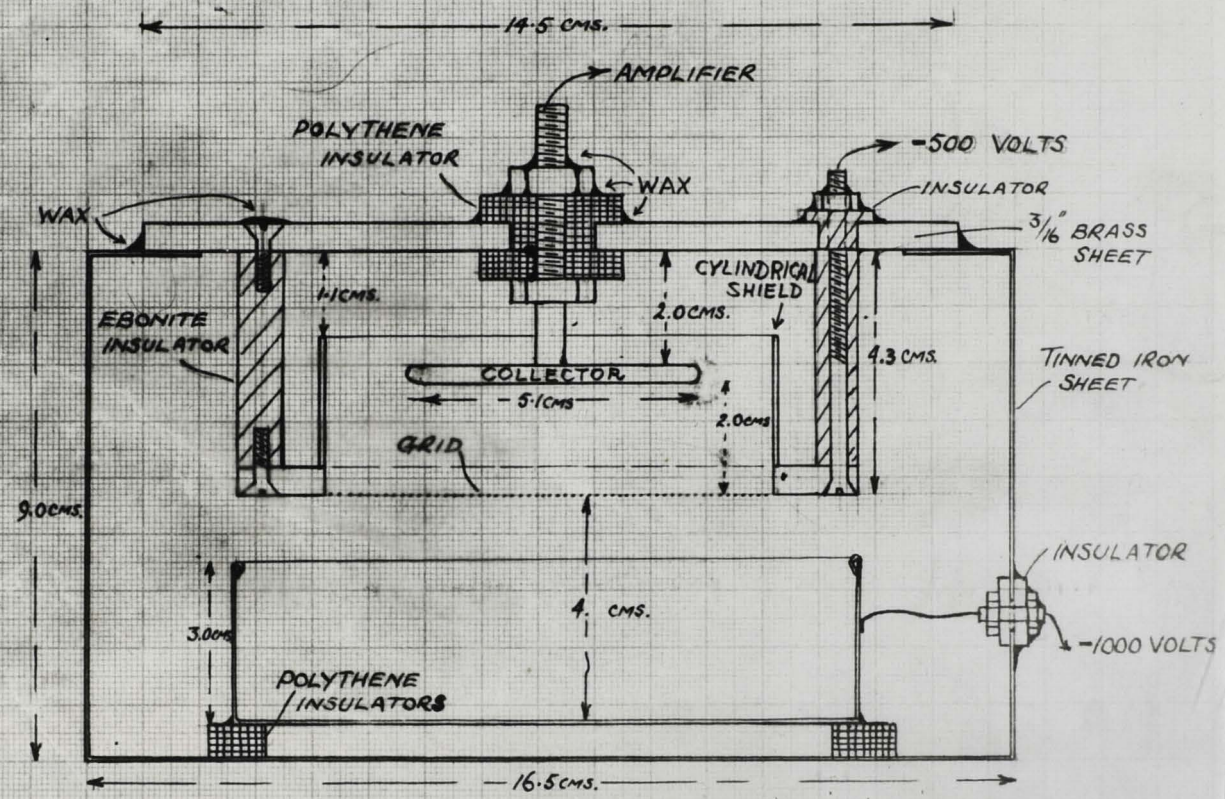
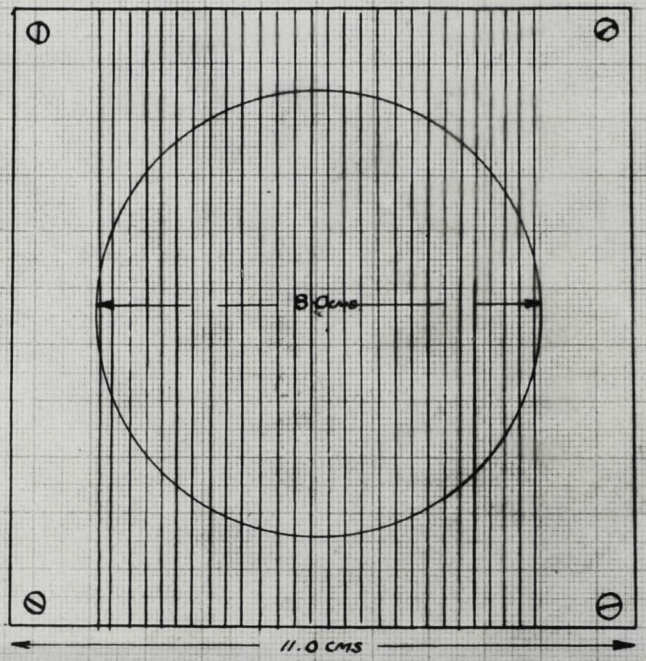

14·5 CMS.
AMPLIFIER
POLYTHENE INSULATOR
WAX
-500 VOLTS
INSULATOR
WAX
3/16" BRASS SHEET
CYLINDRICAL SHIELD
1·1CMS.
2.0CMS.
EBONITE INSULATOR
4.3 CMS.
TINNED IRON SHEET
COLLECTOR
5·1CMS
2.0CMS
GRID
9.0CMS.
INSULATOR
4. CMS.
3.0CMS
-1000 VOLTS
POLYTHENE INSULATORS
16·5CMS.

FIGURE 2.



GRID PLATE
VIEWED FROM BELOW.

FIGURE 3

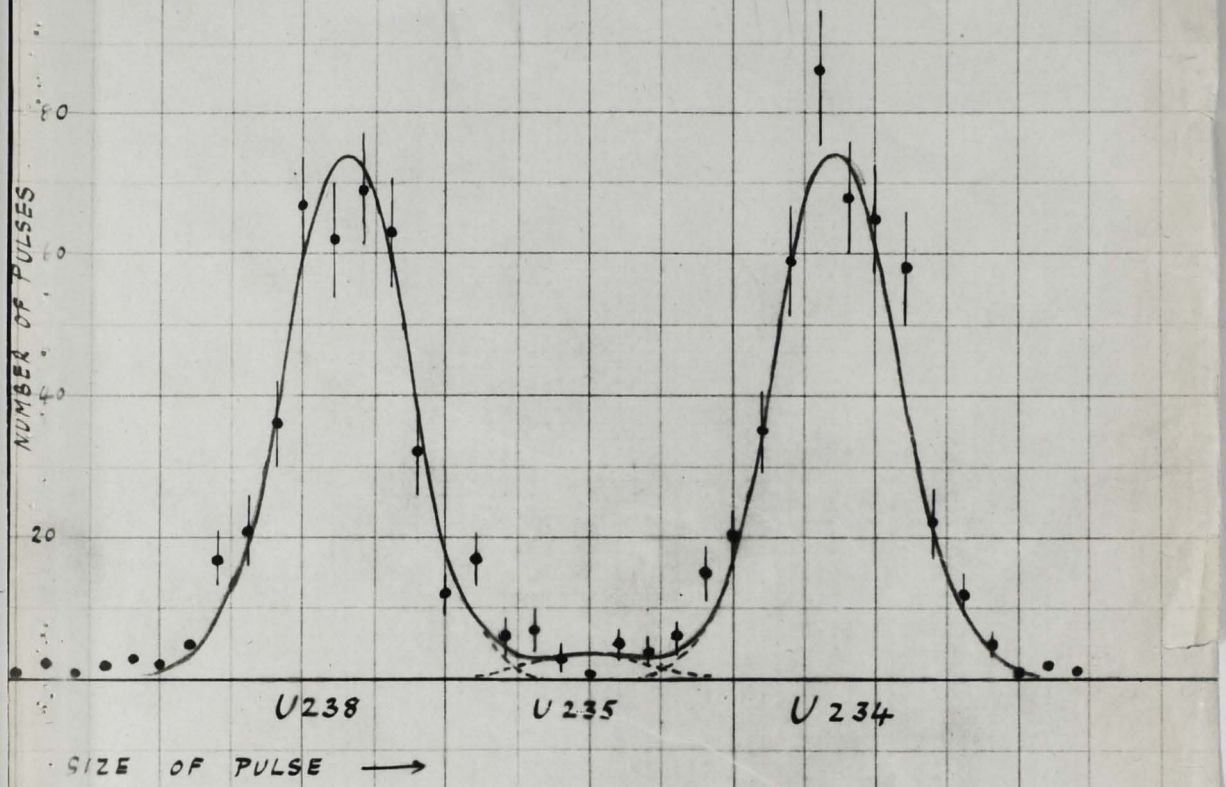


FIGURE 4