TABLE I. Data connected with the beta-disintegration of Ho 166, Tm 170 and Lu 177.

Z	Element symbol	Half-life	Electron energy	Interpretation	Gamma calculated	Energy probable
67	Ho 166	27.7*H*	71.7 kev	*LI, II* (9.25 kev)	81.0 kev	
			72.6	*LIII* (8.35)	81.0	
			79.0	*M* (2.22)	81.2	
			80.6	*N* (0.45)	81.0	81.0 kev
69	Tm 170	120 *D*	22.9	*K* (61.4 kev)	84.3	
			73.9	*LI* (10.5)	84.4	
			74.3	*LII* (9.95)	84.3	
			75.3	*LIII* (8.94)	84.3	
			82.2	*M* (2.41)	84.6	
			83.8	*N* (0.50)	84.3	84.3
71	Lu 177	6.7*D*	47.6	*K* (65.4 kev)	113.0	
			102.5	*LI, II* (10.7)	113.2	
			103.6	*LIII* (9.6)	113.2	
			110.5	*M* (2.60)	113.1	
			112.4	*N* (0.54)	113.0	113.1
			143.2	*K* (65.4 kev)	208.6	
			197.5	*LI, II* (11.3)	208.8	208.6

the beta- and gamma-energies by absorption. The low energy gamma-ray in each element gave rise to electron lines attributable not only to the *K*, *M*, and *N* levels but also to the sub groups of the "*L*" level. Thus in thulium the single gamma-ray gives rise to six clearly resolved lines. Failure to recognize this complexity of structure for low energy gamma-rays has led to the assumption by the present authors of non-existent gamma-rays in certain other heavy elements.

Holmium. Previous studies[1] on holmium 166 report a half-life at values from 27.0 to 35 hours, with a beta-upper limit from 1.6 to 1.9 Mev and no gamma-rays. In this investigation the decay is followed through eight octaves and the half-life is found to be 27.7 hours. By absorption in aluminum (0.724 g/cm^2) the upper limit of the beta-spectrum appears to be 1.64 Mev. In addition to the low energy gamma-ray shown in Table I, absorption in lead indicates a high energy gamma at 0.92 Mev.

Thulium. Thulium 170 has been previously reported[1,2] to decay with a half-life between 105 and 127 days and a beta-upper limit of 0.98 to 1.1 Mev and a high energy gamma-ray of 0.83 Mev. An apparent half-life in the present investigation of 120 days must be confirmed by longer observation. The beta-absorption in aluminum (0.323 g/cm^2) indicates an upper energy limit of 0.9 Mev. No high energy gamma-ray appeared to be present, and the beautiful agreement in the energy of the converted gamma-ray by the many electron lines is shown in Table I.

Lutecium. The half-life of lutecium 177, previously reported[1,3] between 6.6 and 6.98 days, appears in this investigation to be 6.8 days. The beta-upper limit by absorption in aluminum (0.092 g/cm^2) is 0.46 Mev. The electron lines (see Fig. 1) with their

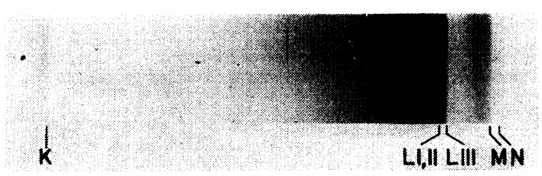

FIG. 1. Showing the electron lines associated with the 113.1 kev gamma-ray from hafnium 177, resulting from the beta-disintegration of lutecium 177.

unmistakable interpretation showing gamma-rays of energy 113.1 and 208.6 kev are presented in Table I.

This investigation was made possible by the joint support of the Atomic Energy Commission and the Office of Naval Research.

[1] W. Bothe, Zeits. Naturzorch 1, 173 (1946); M. Inghram and R. Hayden, Phys. Rev. 71, 130 (1947).
[2] G. Wilkinson and H. Hicks, Phys. Rev. 75, 1370 (1949); D. Saxon and J. Richards, Phys. Rev. 76, 186 (1949).
[3] G. Wilkinson and H. Hicks, Phys. Rev. 74, 1733 (1948); D. G. Douglas Phys. Rev. 75, 1960 (1949).

Dynamic Probe Measurements in the Ionosphere

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EXPERIMENTAL volt-ampere characteristics obtained from a V-2 rocket in the lower part of the *E* layer on December 8, 1947, have been recently analyzed using a technique reported earlier.[1]

The experimental method involves applying a scanning voltage between two collectors on the rocket and transmitting the resulting volt-ampere characteristic to the ground. In this early experiment, the voltage was applied between a cylindrical ring on the nose and the rocket warhead. Utilizable data was obtained on the ascent from around 99 to 103.5 km. Characteristics for three different altitudes are shown plotted in Fig. 1.

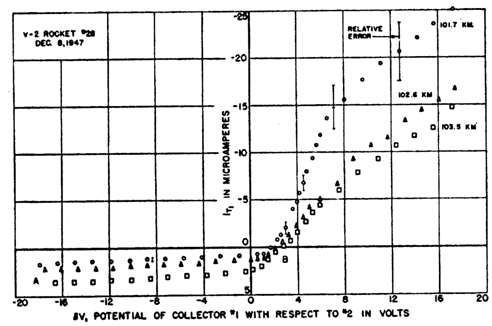

FIG. 1. Experimental volt-ampere characteristics for various altitudes.

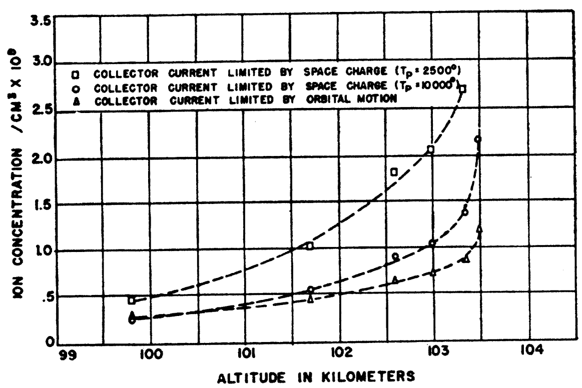

FIG. 2. Ion density *vs.* altitude.

The ion density is calculated from the region *AB* using a method which is based upon the linearity of the i_T^2 plot as a function of δV. The experimental data for this firing gives rise to fairly good straight lines. Dependent on the initial ion energy (which was not measured in this experiment), the ion density may be evaluated directly from the slopes of these lines. Figure 2 is a plot of the ion density as a function of altitude for a range of initial ion energies.

The lower curve is based upon initial ion energies high enough to establish orbital current limitation. This would be satisfied for energies greater than 3 volts. The other two curves are based upon ion energies small enough to establish more nearly a sheath area current limitation. All of the curves in Fig. 2 have been calculated considering edge effects, which are quite large in this experiment.

Indications of a very little ionization occurred around 70 km. However the sensitivity of the instrument did not permit any quantitative evaluation until an altitude of around 99 km was

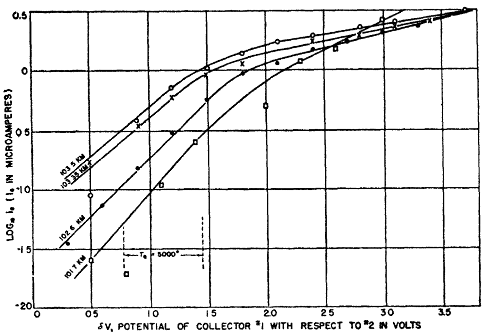

FIG. 3. $\text{Log}_{10} i_e$ *vs.* δV for a range of altitudes.

attained. Over the measurable range, 99 to 103.5 km, the results of all three calculations show progressively increasing ion density with altitude. The curves agree within order of magnitude, in spite of the uncertainty in ion energy.

At the time of this firing, the Bureau of Standards radio propagation measurements indicated a virtual E layer height of 110 km and a maximum electron density of $1.45\times 10^5/\text{cm}^3$. This is in good agreement with the experimental results shown in Fig. 2.

In Fig. 3, the logarithm of the electron current measured as a function of the retarding potential δV is also calculated from the region AB of the experimental data in Fig. 1. These plots are essentially integrated electron energy distributions for only the high energy range of the distribution.

For small values of δV (more retarding field), the $\log i_e$ curve is very nearly linear. At slightly higher δV, the dependence becomes more quadratic with δV. Beyond 3 volts, the variation with voltage is affected by the current to the rocket.

These curves indicate roughly a distribution which is more nearly Davydov than Maxwellian. Under such circumstances it is not possible to assign a temperature to the electrons. However, as a first approximation, this condition can be interpreted roughly as a Maxwellian distribution with a superimposed drift. The linear portion indicate a temperature for the Maxwellian distribution of around 5000°K. This does not appear to undergo any change with altitude. The existence of a drift tends to make this temperature, calculated from the slope, too high. For an estimated drift around 4 electron volts, a more conservative estimate of the electron temperature would be about 2500°K. The displacement of the $\log i_e$ curves, the quadratic dependence on δV, and the voltage for $i_T=0$ in Fig. 1 provide strong evidence for such a drift.

A complete account of the work is being prepared for publication in the very near future. Improved experiments are also planned which should provide more accurate results as to ion density and electron energy distribution.

[1] A. Reifman and W. G. Dow, Phys. Rev. 75, 1311A (1949).

A Cloud-Chamber Study of Fission Fragment Ranges in Air

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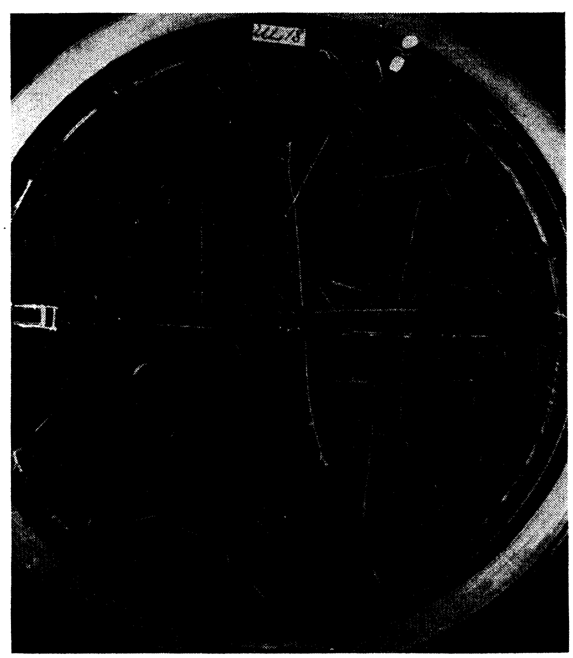
THE mean ranges in air of the ^{235}U fission fragments have been measured by means of a 25-cm cloud chamber. The experimental arrangements were similar to those used in previous investigations of fission fragment ranges in other gases.[1] The uranium layer (thickness about 0.5 mg/cm²) was evaporated on an extremely thin gold foil and suspended in the middle of the chamber. The gas mixture was air and the vapors of a mixture of ethyl alcohol and water in equal parts, the total pressure being about 20 cm of Hg. The stopping power was determined by means of polonium alpha-particles and was controlled by the tracks of the slow neutron-induced disintegration, $^{14}N(n,p)^{14}C$. A photograph of a complete pair of fission fragment tracks is shown in Fig. 1(a) together with two small photographs, Figs. 1(b) and 1(c), showing examples of $^{14}N(n,p)^{14}C$ tracks, picked out among numerous such tracks appearing in the same series of about 10,000 pictures.

Figure 2 gives the range distribution of 40 complete pairs of fission fragment tracks and, furthermore, the range statistics of the $^{14}N(n,p)^{14}C$ tracks and the UI and UII alpha-groups. The latter groups also check the experimental technique since the mean ranges measured were found to be 26.3 and 31.9 mm of air, respectively, in good agreement with the values given by Holloway and Livingstone,[2] *viz.*, 26.5 and 32.1 mm.

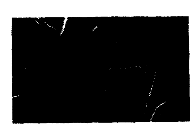
The mean ranges of ^{235}U fission fragments in air at S.T.P. were found to be short range group, 19.5 mm; long range group, 25.4 mm; range in total, 44.9 mm.

The method of radiochemical analysis of individual fission products has been used by several authors for determining ranges in air. For the ^{235}U fission masses 139 and 91, Finkle, Hoagland, Katcoff, and Sugerman[3] report maximum ranges of 18.5 and 25.8 mm, respectively. The corresponding mean ranges are bound to be appreciably shorter than those indicated by our cloud-chamber value given above, which should represent the most probable fission masses 139 and 94.

These authors, moreover, report ranges of ^{239}Pu fission fragments, but the values are considerably smaller than those found in recent measurements by Katcoff, Mishel, and Stanley[4] in their extensive study of extrapolated and mean ranges in air of ^{239}Pu



(a)



(b)

(c)

FIG. 1(a). Complete pair of fission fragment tracks in air $+\frac{1}{2}C_2H_5OH + \frac{1}{2}H_2O$, total pressure about 20 cm of Hg. (b) and (c). Tracks, in the same magnification as (a), of the slow neutron-induced disintegration, $^{14}N(n,p)^{14}C$ recognizable by their appearance as proton tracks starting from the small lumpy track of the recoiling ^{14}C nucleus.