



Fig. 2. Arrangements of counters with lead and paraffin absorbers at Macdonald College.

Experiments are being started which will determine how this ratio varies with (i) thickness of paraffin used, (ii) thickness of absorber above lower counter, (iii) thickness of lead scattering block. A more complete study of the apparently high absorption of penetrating cosmic rays by paraffin is also being initiated.

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<sup>1</sup> W. Heitler, Proc. Roy. Soc. **A927**, 529 (1938).

<sup>2</sup> M. Schein and V. C. Wilson, Phys. Rev. **54**, 304 (1938).

<sup>3</sup> G. L. Locher, Phys. Rev. **44**, 779 (1933); **45**, 296 (1934); **50**, 394 (1936).

### Neutron Induced Radioactivity in Columbium

The neutron induced activity in columbium is so weak that it has been reported to be almost completely inactive.<sup>1</sup> According to the survey reported by Pool, Cork and Thornton,<sup>2</sup> two weak periods 7.3 minutes and 3.8 days were found. But neither a test for the sign of the  $\beta$ -rays emitted nor any attempt for the assignment were given yet.

A study of the activity produced in columbium has been made with the Tokyo cyclotron which gives a 3-Mev deuteron beam up to 50 microamperes in intensity.

The results obtained so far are given in Table I.

To test the activities due to some impurities, several runs were made on the special samples which had been purified with extreme care by one of the authors (M. I.) from columbium oxide powder of Kahlbaum.

The relative intensities of 7.5m, 66h and 11d were almost the same as those obtained in other samples. As for the 8h period, however, only a trace of its activity was noticed. This fact suggests that this period must be due to a tantalum impurity which is very hard to separate from columbium.

TABLE I. Results on activity of columbium.

Slow neutrons (Be+D paraffin)	$W 7.5 \pm 0.5m$	—	$VW 66 \pm 10h$	—
Fast neutrons (Li+D)	—	$VW 8 \pm 2h$	$W 66 \pm 3h$	$W 11 \pm 1d$
Sign of $\beta$ -rays	$e^-$	$e^-$	$e^-$	$e^-$
Chemical test	—	Cb	V	Cb
Assignment	Cb <sup>94</sup>	Ta <sup>180*</sup>	Y <sup>90</sup>	Cb <sup>92</sup>
Reaction	$(n, \gamma)$	$(n, 2n)$	$(n, \alpha)$	$(n, 2n)$
Upper limit derived from K-U plot (Mev)	—	—	$2.3 \pm 0.3$	$1 \pm 0.2$

\* Impurity (see reference 1).

The 7.5m period is in good agreement with Pool, Cork and Thornton. The 66h period is undoubtedly identical with the 3.8d period found by Pool and others. A correction made for the 11d is responsible for the difference. The K-U plot for this activity is in good agreement with that for Y<sup>90</sup> produced from Y<sup>89</sup>.

In conclusion the authors wish to thank Dr. Y. Nishina and Professor K. Kimura for their valuable discussions and encouragement.

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<sup>1</sup> Oldenberg, Phys. Rev. **53**, 35 (1938).

<sup>2</sup> Pool, Cork and Thornton, Phys. Rev. **52**, 239 (1937).

### Raman Effect of Dibromofluoromethane

We have observed nine Raman shifts of dibromofluoromethane using our three prism Steinheil spectrograph (dispersion 8A/mm at 4358A). Eight concentric neon-mercury lamps furnished the radiation. No filters were used. The sample was kept at about 40°C by means of an air blast. The results are shown in Table I.

Three types of photographic plates were used: Two Eastman Ortho-Press Plates (exposure 11.5 hours), one Eastman Spectroscopic Plate Type IG (exposure 41.5 hours) and one Eastman Spectroscopic Plate Type IJ (exposure 47 hours). Only on the type IG plate were the Raman lines excited by 5460A noticed and in this case

TABLE I. Fundamental frequencies of dibromofluoromethane.

$\Delta\bar{\nu}$ ( $\text{cm}^{-1}$ )	Percent mean deviation	Exciting lines	Number of Readings	Relative Intensity
93.2	0.343	a b	4	6
171.4	0.375	a c	12	9
295.1	0.251	a c	9	5
358.3	0.304	a b c	13	9
559.7	0.084	a c	7	3
619.4	0.210	a c	11	10
700.9	0.034	a c	3	1
3016.6	0.016	a c	5	2
3058.9	0.034	a c	4	2

$a=4046\text{A}$ ;  $b=4077\text{A}$ ;  $c=4358\text{A}$ .

they were located too near the plate-edge for accurate measurement and hence they were not included in the average values given in Table I. These lines correspond to 171.4, 295.1, 358.3 and 700.9  $\text{cm}^{-1}$ . The Raman shifts of 93.2  $\text{cm}^{-1}$  scattered by 4358A were noticed on our plates but were partially covered by the halo of the exciting line and hence were too indistinct for measurement.

The sample undergoes photochemical decomposition, turning light brown with the formation of a tarry material, which is insoluble in the ordinary organic solvent (ether, alcohol, acetone, benzene, toluene, carbon tetrachloride, etc.). After the liquid had discolored appreciably, the sample was vacuum-distilled before it was used further. We found that we could expose the sample to the radiation continuously for 47 hours without causing too much background on the photographic plate. The material was furnished by the E. I. du Pont de Nemours Company, and was specified "Laboratory fractionated, boiling range 0.5°C." About 6 cc of the sample were available. We wish to express our gratitude to Dr. A. F. Benning of the Jackson Laboratory for the loan of this substance. Further details concerning these findings will be published later.

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#### Comments Concerning Anderson's Paper on Contact Difference in Potential Between Barium and Magnesium

In a paper which has just appeared Anderson<sup>1</sup> has described an exhaustive series of experiments on the measurement of the Volta potential between barium and magnesium for the purpose of making a crucial test of the Sommerfeld-Eckart equation,  $V_{ab} = \phi_b - \phi_a$ . For values of  $\phi$  Anderson used photoelectric work functions determined in this laboratory<sup>2, 3</sup> for magnesium and barium and the value obtained by Mann and DuBridge<sup>4</sup> for magnesium. This choice seems valid since the technique of forming the metal layers was identical in all cases. This technique, developed by the writer as a result of studies on the "clean-up" of gases by alkaline earths, involves a fractional distillation of the metal in high vacuum supplemented by multiple vaporization of the middle fractions. The first fractions "getter" the tube of active gases. This

standardized technique for preparing metal layers together with the sensitive electronic method for measuring Volta potentials has enabled Anderson to obtain one of the first conclusive verifications of the theory.

I wish to call attention to certain facts which support Anderson's results and improve the agreement with the Sommerfeld-Eckart equation. First the photoelectric work function for magnesium, 3.60 ev,<sup>2</sup> used by Anderson is an *apparent* work function obtained from the last observable reading of the photoelectric current near the threshold. The true work function must be used in the Sommerfeld-Eckart equation and this can be determined photoelectrically by means of a Fowler plot. Later measurements by the writer of the light intensities used in these experiments permitted the calculation of the true work function by Fowler's method. These results together with a number of others from different phototubes<sup>5</sup> yield the average value  $3.67 \pm 0.02$  ev for the work function of magnesium *deposited on glass*. The "spread" of  $\pm 0.02$  ev for different tubes is apparently caused by the temperature of the glass when the deposit is made. This value compares well with 3.68 ev obtained by Mann and DuBridge.

Subsequent work<sup>6</sup> on the photoelectric properties of barium has verified the earlier value<sup>3</sup> 2.51 to 2.52 ev used by Anderson. Small changes of the order of 0.02 ev have been observed when barium was deposited on different backing surfaces at different temperatures. With 3.67 and 2.51 ev for the work functions of magnesium and barium respectively, the value for  $\phi_1 - \phi_2$  is 1.16 ev. The unweighted mean for  $V_{12}$  obtained by Anderson is 1.15 ev.

The small "spread" of values for the Volta potential which Anderson found for different backing surfaces, which was caused by changes in the work function of magnesium, can be explained, I believe, on the basis of slight changes in the surface crystal structure as Anderson has suggested. This conclusion is based on results<sup>5</sup> from tubes containing in effect two cathodes, one having glass as the backing surface, the other nickel. During the deposition of magnesium the glass was kept at room temperature but the nickel was at a higher temperature, being heated by radiation from the evaporator. The coating on the glass was mirror-like whereas the coating on the nickel resembled a finely etched surface. The work functions were 3.67 and 3.79 ev, respectively. It is significant that Anderson obtained a value of 3.78 ev for the work function of a "macrocrystalline (matte) surface" of magnesium on barium ( $\phi = 2.52$  ev).

If the above interpretation is correct, one should, when giving the work function of an evaporated metal, specify the backing surface and its temperature when the deposition of metal occurred unless the actual crystal structure is known.

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<sup>1</sup> Paul A. Anderson, Phys. Rev. **54**, 753 (1938).

<sup>2</sup> Cashman and Huxford, Phys. Rev. **48**, 734 (1935).

<sup>3</sup> Jamison and Cashman, Phys. Rev. **50**, 624 (1936).

<sup>4</sup> Mann and DuBridge, Phys. Rev. **51**, 120 (1937).

<sup>5</sup> Cashman (unpublished data).

<sup>6</sup> Cashman and Bassoe (in process of publication).