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Research Article

TRAUMATIC SHOCK. III. A MODIFIED ELECTROSCOPE ESPECIALLY SUITED FOR MEASURING SUBSTANCES WITH LOW ENERGY RADIATION

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Radioactivity measurements have been made with electroscopes and Geiger-Müller discharge counters. In either case, absorption of a percentage of the radiation by the material in the various windows used lowers the sensitivity of the instrument. This is a serious disadvantage in measuring substances with low energy radiation, such as radioactive sulfur (0.107 Mev.). Recently developed Geiger-Müller counters (1, 2) possess an extremely thin mica window, the use of which is made possible by filling the chamber with helium at atmospheric pressure (pressure ionization chamber). However, the electroscope is less expensive and a much simpler type of measuring device for the biological worker who is not sufficiently well-versed in radio-engineering to keep a Geiger-Müller counter in continuous working order.

Henriques and Halford (3) have increased the sensitivity of the Lauritsen electroscope [1] by introducing the specimen to be measured into the fiber chamber, utilizing a sliding bar device, with air lock, in the side of the chamber. In addition, a drying agent (anhydrous magnesium perchlorate) is introduced into the chamber. In this way, precipitates, collected on filter paper (over an area of 1.54 sq. cm.) and placed in a brass cup in the sliding bar, are introduced in a fixed position within the chamber. In the case of sulfur, particularly, care must be taken to measure the radiation from a minimum of material in order to minimize the effects of self-absorption.

We have further modified the electroscope by so placing the introduction slot that the filter paper occupies a position directly beneath the quartz fiber and exactly 1 cm. below it. This increases the sensitivity of the electroscope about 20 per cent. The construction of the fiber chamber is represented diagramaticaly in Figure 1.

In general, counters can be constructed without sensitivity to temperature change, with greater linearity and more constant background than is possible in electroscopes, but the range of activity that can be covered is about the same for both. The error of the electroscope, due to lack of linearity, can be corrected by making standards of known dilutions sufficient to cover the range of radioactivity being measured. The error of the electroscope due to fluctuation in background [2] can be largely avoided by utilizing a working range of at least 3 to 10 times its background. In the tables below, therefore, whenever possible, this range is taken as the zero point in calculating deviations from linearity. Table I illustrates the deviation from linearity of the electroscope and the counter as shown by three sets of standards made up from radioactive sulfur precipitated as barium and benzidine sulfate. The error due to lack of linearity can be partly eliminated by selecting standards with activity close to that of the specimens being analyzed.

In a comparison of this electroscope with a

[1] Purchased from Fred C. Hanson Company, Pasadena, California.

[2] The daily variation in background amounted to 0.00002 divisions per second. Professor Evans, in a personal communication, has pointed out that ionization devices (electroscopes) have an inherently greater fluctuation in background then Geiger-Müller counters. In the counter, the entering particle or ray produces one count, no matter what its energy content may be. But in the electroscope, the degree of ionization produced by the particle depends on its energy content. The energy content of β-rays from any given artificially produced radioactive substance, varies over a wide range. Since there is an even greater variation in the energy content of background particles due to α-rays, than in the number per second due chiefly to cosmic rays, greater fluctuation in electroscope background may result. For a mathematical treatment of this subject see Evans (4) and Evans and Neher (5).

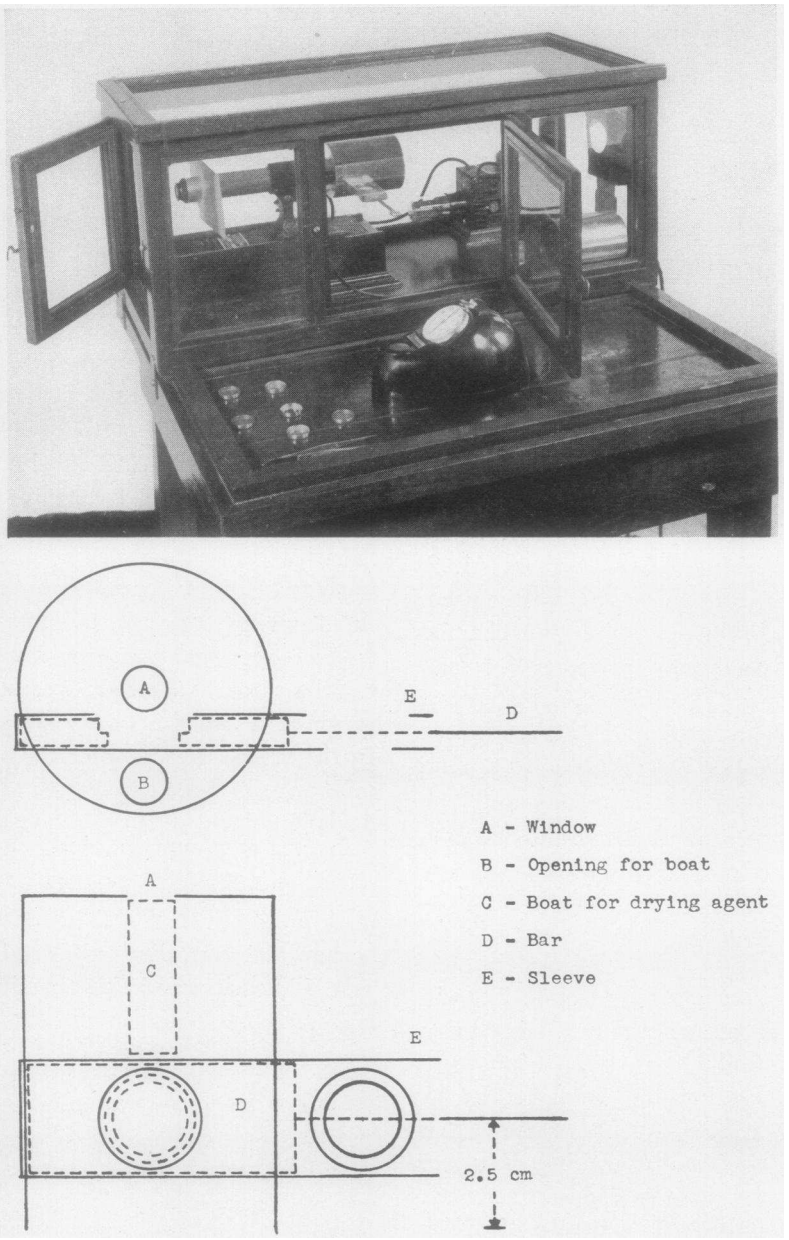

FIG. 1. PHOTOGRAPH AND DIAGRAMATIC REPRESENTATION OF CASE FOR LAURITSEN ELECTROSCOPE

Geiger-Müller counter developed for measuring radioactive sulfur, it was found that the activity of the weakest specimen of sulfur measurable with accuracy in the electroscope was of the same order of activity as the weakest specimen measurable with accuracy in the counter. Measurements of a specimen having 0.1 of this activity were off in both instruments (Table I).

Although primarily developed for measuring the soft radiation of radioactive sulfur, it was found that the electroscope also measures the more penetrating radiation of other elements, accurately and conveniently (Table II).

That most of the error was inherent in the method of oxidation and handling of the silver salt precipitate was shown by comparison of meas-

TABLE I

Comparison of sensitivity and linearity of electroscope with Geiger counter in measuring radioactive sulfur

		Electroscope			Geiger counter		
Dilution of radioactive standard	Weight of precipitate*	Radioactivity§	Ratio of radio-activity to background	Deviation from linearity	Radioactivity¶	Ratio of radio-activity to background	Deviation from linearity
	mgm.	*divisions per second*		*per cent*	*counts per minute*		*per cent*
	†						
1	7.6	0.00036	4	0	250	12	0
10	7.4	0.000038	0.5	+5	32	1.6	+28
100	7.0	0.0000021	0.09	−46	10	0.5	+300
	‡						
1	8.8	0.00047	7	0	260	13	0
10	9.0	0.000064	0.9	+36	28	1.4	+7
100	8.9	0.000013	0.18	+175	5	0.2	+90
	‡						
1	10.5	0.033	250	−13			
25	9.7	0.0015	10	−1.3			
100	9.5	0.00038	3	0	165	16	0
1000	9.3	0.000028	0.2	−26	18	2	+9

* The radioactive standard was diluted with inert sulfate before precipitation.

† $BaSO_4$ precipitate.

‡ Benzidine sulfate precipitate.

§ One division per second represents 20 small scale divisions of the electroscope, at least 4 small scale divisions were clocked in each determination.

¶ Data provided by Dr. Frederick Henriques, Harvard University, and Dr. Robley Evans, Massachusetts Institute of Technology.

urements of plasma treated by both the oxidation technique and evaporation to dryness (Table III). The greater deviation from linearity shown with oxidized specimens in Table III as compared to Table II may be due to an excessive weight of silver precipitate.

TABLE II

Illustrating the linearity shown in 2 sets of standards prepared from radioactive bromine precipitated as silver bromide

Dilution of radio-active standard	Weight of silver bromide precipitate*	Radioactivity	Ratio of radio-activity to background	Deviation from linearity
	mgm.	*divisions per second*†		*per cent*
1	16.7	0.0074	60	+27
10	14.8	0.00058	5	0
100	14.9	0.000064	0.5	+10
1	13.8	0.0041	35	−14
10	16.5	0.00048	4	0
100	15.5	0.000080	0.7	−17

* The radioactive standard was diluted with inert bromide before precipitation.

† One division represents 20 small divisions on the scale of the electroscope. At least 4 small divisions were clocked in each determination.

It was found when radioactive bromine possessing a high order of radioactivity (approximately 0.3 divisions per second) was measured in the electroscope, the background of the instrument was affected unfavorably for a period of weeks to months. In one case, the background changed from 0.00006 divisions per second to 0.0005 divisions per second. That the change was not due to foci of secondary radiation in the electroscope chamber was shown by transferring the chamber to another electroscope. The change was probably due to ionization of the insulating material supporting the fiber, allowing leakage from the charge on the fiber. On 2 occasions, a spontaneous return to normal background occurred over a period of weeks. The phenomenon exhibited a threshold; for repeated measurements of potent specimens of a lesser order of activity did not alter the background of the instrument. It is therefore wise to have on hand a second electroscope, if specimens of a high order of activity are to be dealt with. In the routine use of the instrument, the fiber was charged at least one hour before use to saturate the insulator material.

TABLE III

Comparison of measurements of plasma treated by both oxidation and evaporation

Dilution of radioactive standard	Oxidation method				Evaporation method	
	Weight of silver bromide precipitate	Radioactivity	Ratio of radioactivity to background	Deviation from linearity	Radioactivity	Deviation from linearity
	mgm.	*divisions per second*		*per cent*	*divisions per second*	*per cent*
1	25	0.0356	500	−51	0.0769	−2
2	25	0.0227	320	−34	0.0416	+6
4	24	0.0146	200	−11	0.0192	−2
8	23	0.0092	130	+15	0.0099	+1
16	22	0.00403	57	0	0.0049	0

SUMMARY

A modification of the Lauritsen electroscope, which increases its sensitivity, is described. This makes it possible to measure the soft radiation from radioactive sulfur with an accuracy comparable to that of Geiger-Müller counters constructed for the same purpose. Other radioactive elements may also be measured with this instrument.

It is expected that this simple instrument will be particularly useful to biological investigators unable to procure and maintain in continuous running order the more complicated Geiger-Müller counter.

We are indebted to Dr. Frederick Henriques of Harvard University, and Professor Robley D. Evans of Massachusetts Institute of Technology, for the comparisons with their Geiger-Müller counters. Dr. Henriques gave valuable advice and assistance in the construction of the electroscope chamber.

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