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# *Secondary Electronic Emissions from Metal Foils and Animal Tissues.*

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(*Extract and Summary.*)

## *Experiments with Animal Tissues.*

We wish finally to describe experiments in which an attempt was made to make measurements with an ionisation chamber, one side of which consisted of animal tissues. The physical aspects of the results only will be discussed.

The graphited paper chamber which previously served as standard was here abandoned as still showing too great variation compared to a standard air chamber to act as the standard of comparison against tissues, since the latter were themselves likely to be approximately "air" substances. We have therefore, constructed a small cylindrical chamber of graphited cellophane, 14·7 mm. long, 12·7 mm. diameter, having walls 0·002 cm. thick. The chamber is sealed with a thin celluloid end, the cylindrical portion being made by wrapping the graphited cellophane around a brass former and sealing with a saturated solution of cellophane in amyl acetate. This chamber was tested against the air chamber as before and it will be seen that from 60 K.V. with 0·5 mm. Al filtration to 130 K.V. and 10·7 mm. Al filter, the deviation is not greater than the experimental error of 2 per cent.

| Peak voltage. | Filter. | Ratio. | Peak voltage. | Filter. | Ratio. |
|---|---|---|---|---|---|
| KV. | mm. Al | | KV. | mm. | |
| 60 | 0·5 | 1·67 | 130 | 0·5 | 1·69 |
| 80 | 0·5 | 1·70 | | 1·0 | 1·69 |
| 100 | 0·5 | 1·69 | | 2·0 | 1·66 |
| 120 | 0·5 | 1·69 | | 4·0 | 1·70 |
| 130 | None | 1·62 | | 6·0 | 1·68 |
| | | | | 10·7 | 1·69 |

During preliminary experiments it was soon found that the introduction of wet fresh animal tissues into an ionisation chamber quickly ruined the insulation of the gold leaf system but that dried tissues could very easily be used. Moreover, the dried tissues caused very definite divergences between the two ionisa-

tion chambers. We will here, however, describe the results of a set of recent experiments in which the difficulties were overcome and experiments made with wet tissues.

The ionisation chamber (fig. 1) consists of a carbon ring A on to which is

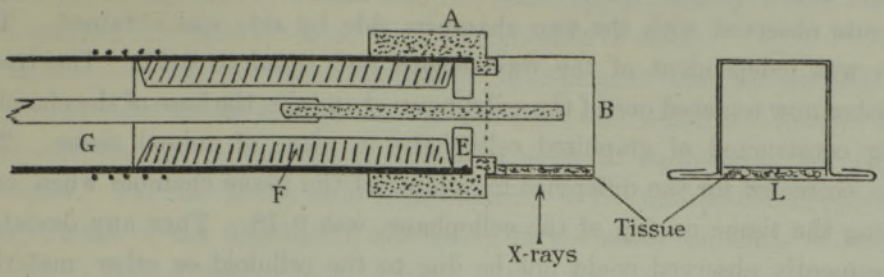


FIG. 1.

fixed a graphited celluloid cube B having one side and base removed. The animal tissue lies on a strip of graphited celluloid L which is itself held in position by means of a second strip bent round the ionisation chamber and having small flanges turned outward. The central carbon rod of the ionisation chamber passes into the chamber through a hole in a celluloid disc E 2 mm. thick, the hole being sufficiently large to allow the rod to pass without touching the celluloid; 1 mm. clearance is allowed. The rod is insulated by means of amber at G, the insulation being thus far removed from the chamber, while around the outside of the brass cable carrying the amber and carbon ring, a small heating coil ("Pladuram" wire 0·117 mm. diameter) is wound which enables the surface of the insulating material to be kept at a slightly higher temperature than the chamber itself. The brass cable is protected with lead F, 3 mm. thick, so as to avoid stray ionisation in the air, the volume of air being also reduced to a minimum. It was found that in this way the introduction of wet substances into the ionisation chamber caused no appreciable natural leak to develop. A number of preliminary experiments were performed. It was first verified that the heating of the apparatus caused no appreciable variation in ionisation current in the chamber.

In these experiments each ionisation chamber, the standard cellophane and the tissue chamber, had separate insulating cables of different lengths and therefore capacities. These cables were led to a specially constructed mercury throwover switch by means of which either chamber could be connected to the gold leaf electroscope, the switch being carefully electrostatically shielded and situated near the electroscope. The observer could, therefore, without disturbing the arrangement, make readings with cellophane chamber and tissue chamber alternately. This procedure was adopted throughout, the mean of

three readings of each chamber being taken, the readings of the two chambers being made alternately. In order to find the effects of the differences of length of cables, as nearly as possible similar cellophane chambers were fitted to each cable. For a number of equivalent wave-lengths the ratio of the ionisation currents observed with the two chambers side by side was obtained. The ratio was independent of the wave-length and equal to 0·77. The tissue chamber now replaced one of the cellophane chambers, the base of the chamber being constructed of graphited cellophane in place of animal tissue. The ratio, corrected for the difference in volume of the tissue chamber when containing the tissue on top of the cellophane, was 0·78. Thus any deviation subsequently observed could not be due to the celluloid or other materials used in the construction of the tissue chamber.

It is clear that we would expect theoretically the animal tissues to be equivalent to a cellophane wall for very short wave radiations, say for $\gamma$-rays. The mean of the ratios of the ionisation currents observed in the cellophane and tissue chambers for $\gamma$-rays was 0·78, all types of animal tissue agreeing with this value within the limits of experimental error.

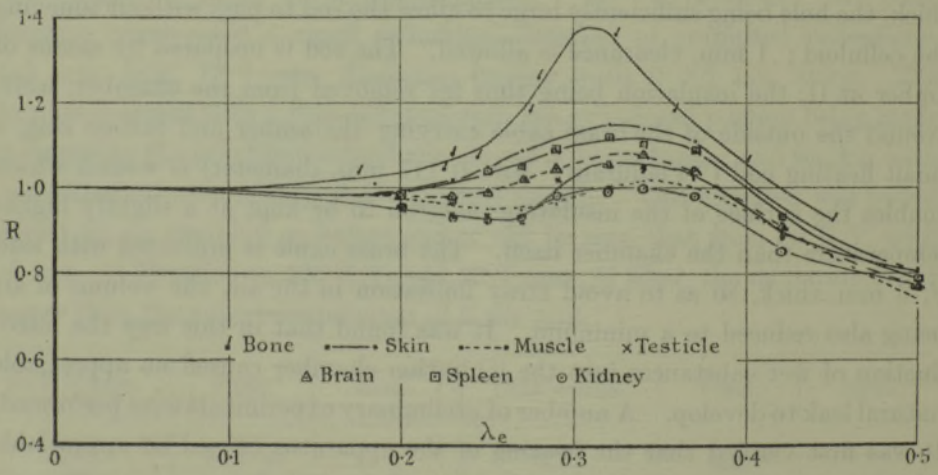


Fig. 2.

All experimental results given below have been corrected so as to give the value 1·00 throughout for an air-like substance, for instance, graphited cellophane.

A healthy rat was killed and immediately dissected, blocks of skin, testicle, brain, spleen, kidney, muscle, heart and liver being taken for examination. Each block of tissue was frozen on to the stage of a carbon dioxide freezing microtome and a section exactly 1 mm. thick was cut. This section was then trimmed to the correct size to cover the floor of the ionisation chamber, trans-

ferred to the celluloid strip and the ionisation currents in the chamber observed simultaneously with the current in the cellophane chamber as described above. The results of one set of experiments are given in fig. 2. The curve for bone was obtained by laying slips of human compact bone, approximately 1 mm. thick, in the position normally occupied by the single slice of tissue.

It will be seen that for short equivalent wave-lengths that the currents in the two chambers do not diverge very greatly from each other, but that for the longer wave-lengths the tissues diverge from strict air equivalence and from each other. The rise in the ratio is presumably to be interpreted as the rise to importance of the fluorescent absorption in the small amounts of heavy elements in animal tissues, but in view of the difficulty of estimating the relative importance of the wall radiation and the ionisation in the air itself we cannot at the moment carry the theoretical consideration further. The subsequent fall in the ratio, is, as in the case of the foils, to be interpreted as the results of absorption in the walls of the chamber and decreasing penetration of secondary electrons. It appears, however, that for long wave radiations ($\lambda_e = 0{\cdot}3$ Å) a standard air wall ionisation chamber would underestimate the energy absorption in an animal tissue, but appears to be quite suitable for very short wave-length radiations. Further experiments in order to obtain more quantitative information are proceeding.

*Summary.*

The paper describes experiments on small ionisation chambers artificially made sensitive to different X- and $\gamma$-radiations by the insertion of foils of different elements. It is shown that compared to an air chamber these ionisation chambers show a maximum sensitivity in the region of medium wave-lengths. The theory of the occurrence of this maximum is discussed.

A small ionisation chamber suitable for $\gamma$-ray measurements is described, and it is shown that the relative intensity of primary and secondary scattered beams of rays was differently estimated according to the materials of which the chamber was constructed.

The experiments were extended to include the effects to be observed with ionisation chambers containing animal tissues. It is shown that again a region of maximum sensitivity is observed and that various tissues diverge by varying extents from "air equivalence." The significance of these observations is briefly discussed.

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