A Standard Condenser of Small Capacity.

By R. R. Ramsey.

In radioactive measurements of substances which are very feebly radioactive it is necessary to have an electroscope which is very sensitive. One of the conditions to obtain this result is, the electroscope must have a very small capacity. A capacity of one to ten centimeters. A sphere has a capacity equal to its radius when far removed from other objects but when brought near to the electroscope its capacity changes to a value which depends upon the position, size and shape of the electroscope.

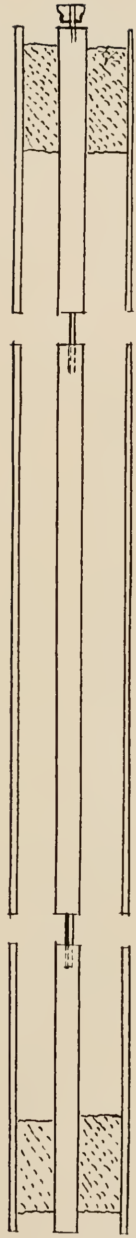
It is customary to use a cylindrical condenser. The capacity of a cylindrical condenser is

$$C = \frac{L}{2 \log_e R_1/R_2}$$

where C is the capacity; L is the length; R_1 is the inside radius of the outside cylinder; R_2 is the radius of the inside cylinder. This formula gives the capacity if the effect of the ends can be neglected. This requires that the length should be great compared to the difference of the two radii. When these conditions are met the capacity will be 100 cm. or more.

In order to correct for the end effects I have made a condenser in three sections, the construction of which is illustrated in the cross sectional drawing. The middle cylinder is made of a brass rod about 9 millimeters in diameter. The outside cylinder is made of brass tubing whose inside diameter is about 3.6 cm. The diameters are chosen large in order that the accuracy of measurement may be great. The ratio of the diameters is made large in order that the capacity per unit length may be small.

The length of the end sections is 10 cm. The length of the middle section is 20 cm. The middle rod is held in place in the end sections by means of sulphur. This was accomplished by means of two wooden discs which were accurately turned to fit in the ends of the large cylinder and hold the middle rod in the center. These discs were placed in the ends of the end sections. The end section was stood upon the outside end and melted sulphur was poured through a hole in the top disc until the cylinder was about one-third filled. The discs were removed after the sulphur had hardened. Dowel pins are placed on the middle rod to hold the middle section in place.



Standard Condenser.

The capacity of the middle section is calculated by the formula. The electroscope is charged to a potential V_1. The charge on the electroscope is divided with the condenser, all sections being used.

If C_1 is the capacity of the electroscope.

C_2 is the capacity of the end sections.

C_3 is the capacity of the middle section.

V_1 is the initial potential.

V_2 is the final potential.

then since

$$Q = C_1V_1 = (C_1 + C_2 + C_3)V_2$$

$$V_1/V_2 = (C_1 + C_2 + C_3)/C_1 = r_1$$

The electroscope is again charged to a potential V'_1. The charge is again divided with the condenser, the end sections being used.

Then we have

$$V'_1/V'_2 = (C_1 + C_2)/C_1 = r_2$$

combining the two equations involving r_1 and r_2 we get

$$C_1 = C_3/(r_1 - r_2)$$

In case that one has a steady ionization current as in the case of radium emanation in an emanation electroscope after three or four hours, one can allow the electroscope to discharge through a certain potential difference, dV, first with the electroscope alone, then with the ends of the condenser connected to the electroscope, and then with the entire condenser connected. Since $i = C\, dV/t$ and dV is constant, we have,

$$C_1/t_1 = (C_1 + C_2)/t_2 = (C_1 + C_2 + C_3)/t_3 = C_3/(t_3 - t_2)$$

Care must be taken to see that the current is constant during the observations. If the current is due to β or γ rays there is danger of the air inside of the condenser being ionized and thus producing a variable current.

The capacity of the middle section of the condenser which I have is 8.06 cm. The capacity of the end sections is found by experiment to be about 17 cm. Thus, since the combined length of the ends is the same as the middle section, the end effects plus the dielectric effect of the sulphur is about 9 cm.

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