A DEMONSTRATION METHOD OF MEASURING DIELECTRIC COEFFICIENTS AT HIGH FREQUENCIES

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One of the members of my science journal reading class recently reported on a paper assigned him on "Dielectric Coefficients at High Frequencies." The author of the paper had found no change in the coefficient at frequencies up to 70 kilocycles. I mentioned the fact that some experiments I made in 1897 had led me to a like conclusion for frequencies of more than a million kilocycles. Although all the students in the class were advanced physics majors from one or another of a dozen universities and colleges, not one of them could recall the Hertz-Lecher experiment—a modification of which I used in my demonstration. Indeed, on examining a number of recently published texts, I was surprised to find that Hertz's name does not appear in the index of several of them, and that few of them give his work more than passing notice. It would appear that many do not know that electric waves can be produced and detected without the use of vacuum tubes, and that radio communication was not only an accomplished fact but that it was in practical use before radio tubes were invented.

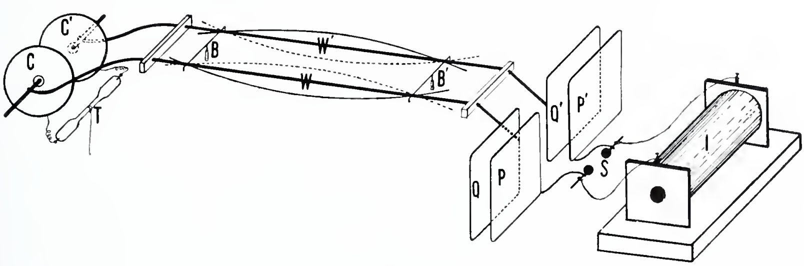

Fig. 1.

The accompanying figure shows the arrangement of the apparatus used by the writer. What may be called the secondary oscillating system consists of C, C′, two circular parallel metal plates of an adjustable air condenser connected respectively to the wires W, W′, and to the metal plates Q, Q′, which are charged by induction when the plates P, P′, of the primary system are charged by the induction coil I. When P and P′ discharge through the spark gap S, oscillations are set up in the wires W, W′, causing brilliant flashes in the Geissler tube T.

Although the frequency of the oscillations in the secondary are largely independent of the rapidly damped oscillations in the primary, nevertheless, their intensity and duration can be considerably increased by adjusting the two systems to resonance. And if the dimensions of the secondary system be adjusted properly, standing waves are formed along the wires, as indicated in the figure, where the curves represent potential fluctuations. Clearly, these standing waves should be affected but little by short circuiting the wires W, W′, at any potential nodal point. The Geissler tube should continue to glow. Short circuits at other than nodal points cause the tube to "go out."

Short circuiting is effected by a thick copper wire (a bridge) bent as shown, and provided with an insulating handle by which the operator can slide the bridge along the wires to determine the positions of the nodal points. The writer used two bridges, B, B′. Obviously, twice the distance between the middle points of adjacent bridges is the wave length, L. Assuming the velocity of standing electric waves along straight wires to be equal to V, the velocity of light, the oscillation frequency N equals the ratio of V to L.

To measure the dielectric coefficient of sulphur the writer cast a sulphur disk about 25 cm. in diameter and 4 cm. thick. The disk diameter was made some 10 cm. greater than that of the condenser plates, to minimize uncertainties due to edge effects. The disk was placed directly between the plates C and C′ and in close contact with them. The system was then adjusted and bridge positions found for which the Geissler tube glowed brilliantly. Without changing anything else the sulphur disk was removed and the distance between C and C′ adjusted until the tube glowed as before. The ratio of the thickness of the sulphur disk to that of the equivalent air space gave the dielectric coefficient of sulphur. A similar procedure gave results for hard rubber and glass.

To obtain the best quantitative results one must select a vacuum tube of the proper sensitivity. If too sensitive the tube will glow regardless of the position of the bridges. If not sensitive enough the distances through which the bridges may be moved and the tube remain dark is too great to permit of an accurate location of the nodal points.

For demonstrations before large audiences where tube brilliancy is of prime importance, the writer uses a neon spectrum tube of the dumb-bell type. Usually the glow is confined almost entirely to the two ends of the tube. The capillary portion glows brighter if one end of a thin wire three or four feet long is wrapped, a turn or two, about the capillary at its middle point, the other end of the wire dangling toward or to the floor. No doubt a larger and longer neon tube would give even more striking results. The little neon bulbs used for testing spark plugs and coils are too sensitive for satisfactory use with equipment of the size usually employed for class demonstrations.

Adjusting the apparatus for stationary waves and resonance is done by changing the length of the spark gap, of the wires W and W′, the capacitances of the three condensers C C′, P P′, and Q Q′, and the positions of the bridges. This is largely a "cut and try" procedure and may require considerable time and experimentation of one performing the experiment for the first time. The result is quite worth the effort. When properly adjusted one can exhibit standing waves to an audience of several hundred people, and can demonstrate the effect on the waves of changing the capacity or dimensions of the oscillators. He can show how different dielectrics function and give a concrete concept of the meaning of "dielectric coefficient."