On the Permanent Electret by **Mototaro EGUCHI**, Professor of Physics, Higher Naval College, Tokyo, Japan.[1] From "Philosophical Magazine" Vol 49 (1925) pp178.

Introduction

"**ELECTRET**" is the name given to the dielectric which is electrized[2] permanently by a special treatment due to the author. Some waxes and resinous materials have moderate conductivity in their liquid state, while they are very good insulators in the solid state. The electrical conductivity of these materials varies gradually with the degree of solidification, and when the materials get moderately hard the conductivity becomes practically nil. The author let solidify a mixture of these materials in a strong electric field applied through all the time in which the solidification went on. The dielectric taken out of the field, after having been cooled sufficiently, showed very strong polarities on its two surfaces which were kept in contact with the electrode plates during the preparation. The electrization of such a dielectric could not he destroyed by several treatments, such as touching by Bunsen flame, exposure to X-rays, planing with knife, washing with some solvents, &c. Nor did it die away after the lapse of many years. From several subsequent studies, it has become evident that the electrical change of the dielectric is not of a superficial nature, but that it is a permanent internal change within the material.

The name "Permanent Electret" or simply " Electret" was given to the special dielectric at the ordinary meeting of the Physico-Mathematical Society of Japan, February 21, 1920[3]. Later, I found in Oliver Heaviside's ' Electrical Papers' the section with the title "Electrization and Electrification - Natural Electret" [4]. In this paper he proposed for the first time to use the term "Electret" to fill the want for describing an intrinsically electrized body, and some possibilities of electrets were discussed on the theoretical point of view. The present method of preparation was, [p179] however, obtained independently and also in a way utterly different from his discussions.

The electret shows so great an intensity of electrization that the electric force exerted in front of the surface of the electret may attain the greatest sustainable value in the atmosphere. The permanency is also so good that we have detected no sensible decaying for these three or more years since the preparation.

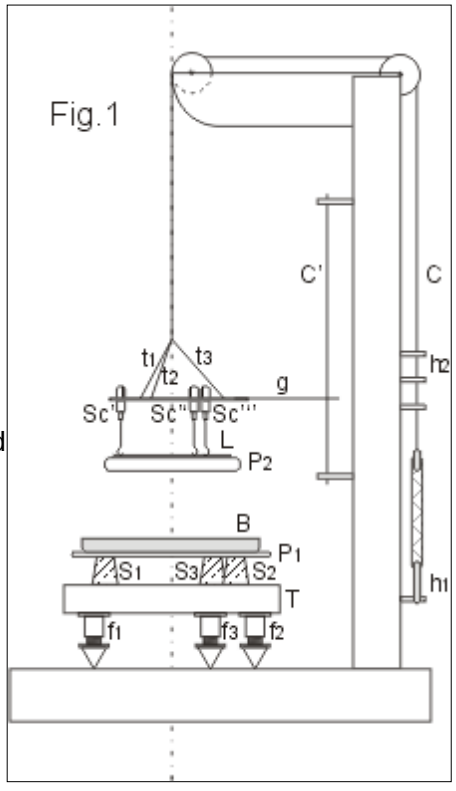
Ch.1 - Preparation of the Permanently Electrized Dielectric

From the study of the variation of conductivity with the solidification of waxes and some other materials[5], I came to think it possible to get a permanently electrified or more correctly electrized dielectric by allowing some kind of waxes to solidify in a strong electric field. After many trials, it has been ascertained that the disk-shaped electret of a certain size is one of the most convenient forms for several reasons, except for the cases in which special studies are wanted. The method of preparation of the disk-electret is, therefore, briefly described here.

A shallow circular metal basin B (fig. 1), depth 1 cm., diameter 20 cm., is put on a pole-plate P_1, a little larger in diameter than the basin. The plate itself is placed on three sulphur insulators S_1, S_2, S_3, which are laid on a wooden tripod stand T capable of levelling by the three screws f_1, f_2, f_3.
As the other electrode, a hollow metal disk P_2 is suspended by three insulating cords, t_1, t_2, t_3. These cords are made of Japanese fishing-lines, Tegusu (a kind of thick silk thread), whose surfaces have been treated with a mixture of some waxes and resin to get rid of the surface leakage. The basin and the disk-electrode are coated with tin-foils (not shown in the figure). The lead sheet L is used as a weight to cause the foil tightly to attach itself to the disk.
As the preparatory adjustment, the levelling of the basin B is first effected by three screws f_1, f_2, f_3; secondly, the hook at the end of the cord C is transferred from the arrester h_1 to another h_2, and the plate P_2 is so regulated by three screws Sc', Sc'', Sc''' that its lower surface comes [p180] just up to the margin of B. Another cord C' stretched through a hole perforated near the

end of the guider g serves to prevent the oscillation of the electrode P_2.

After raising the disk-electrode P_2 up to a sufficient height, the material melted at a temperature far above its melting-point (about 130º C.) is poured in to fill up the basin B, and then P_2 is put on the melted dielectric so that it rests just on the surface of the dielectric. The air bubbles, if any, on the surface of the melted material may [p181] be easily taken off by touching with a small Bunsen flame.
Care was taken to adjust the voltage of the high tension source in order to prevent any undesirable effect such as brush discharges between the electrodes along the surface of the dielectric when it solidified partially. Tin-foils were applied on the electrodes, so that not only did the dielectric not adhere directly to the metal surface, but it might also contract freely as it cooled, and when the dielectric solidified completely the disk-shaped material might be easily taken off from the basin. Moreover, with the disk-electret thus obtained, both surfaces upper (Up) and lower (Lo) might be studied at will.



Ch.2 - The Charge of Temporary Nature and the Permanent Electrization of the Electret.

As the material for the permanent electret, a mixture consisting of equal parts of carnauba-wax and resin with or without a certain amount of bees'-wax was found to be very good as regards the intensity of electrization and the permanency. If we prepare a disk-electret of this material, joining for instance the upper surface (Up) to the positive pole of the high tension source, and the lower surface (Lo) to the negative, we first detect in general a surface charge of negative sign on the upper surface, and one of positive sign on the lower, soon after we take the electret out of the preparing arrangement. But these kinds of charges are of temporary nature, and they die away gradually, in a comparatively short time (in one or two days). After the complete decay of such charges, the surface charges of opposite signs respectively to the above gradually grow up. The positive charge on the upper surface and the negative on the lower, which are respectively of the same signs as those of the applied poles of the source during the preparation, tend to grow to their ultimate values in a few days. The manner of growth of these charges on both surfaces and their values do not vary much even when the method of preparation is modified in some way: for example, when both electrodes are completely insulated from the earth, or when either one of the electrodes is completely earthed and the other insulated. The permanency of these charges is so good that we cannot detect any sensible decay after many years. We shall call these surface charges of the electret the free charges due to its proper electrization.

[1] Communicated by the Author.
[2] The term "Electrization" is used after Heaviside to signify the internal electrical change of a material, which is different from superficial electrification.
[3] Mototaro Eguchi, Phys.-Math. Soc. Japan, ser. 3, vol. ii. no.7(1920).
[4] Oliver Heaviside, ' Electrical Papers,' vol, i. # xii.
[5] Mototaro Eguchi, Phys.-Math. Soc. Japan, ser. 3, vol.i. nos. 10-11 (1919).