

AN X-RAY INVESTIGATION OF ORIENTATED DIELECTRICS

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Already in his papers on electromagnetic induction and its propagation Heaviside (1) indicated that a dielectric may exist in a state of permanent polarization similar to the orientation of the "elementary" magnets in a permanent magnet, and he called such a dielectric "electret." Investigations of these "electrets" have been carried out during the last ten years (2), but the nature of their properties is still doubtful. There are two different opinions to be found in the literature: According to the first theory, Eguchi, Meissner (2), the molecules or molecular aggregates are orientated by the electric field, and as a result application of mechanical stress distorting this orientation is supposed to produce a piezo-electric effect. According to the other point of view, Sato, Adams (2), the electrical effect produced by the field in a dielectric is of the nature of a displacement of ions: space charges may be set up and also phenomena which are more of the character of an electrolytic polarization may occur.

Experiments carried on in this laboratory have failed to reveal the existence of a genuine piezo-electric effect in the electrets and it was concluded that the field does not orientate the molecules and molecular aggregates. Since, however, X-ray evidence has been presented (3), which would indicate the existence of such an orientation due to the field, an X-ray examination of dielectrics solidified with field and without field has been undertaken.

The "electrets" were cast in an apparatus, the drawing of which is attached and is self-explanatory.

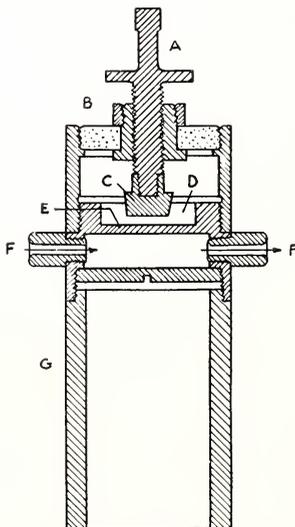


Fig. 1. The dielectric is filled into cavity D and heated by the heating coil kept in the container G. The electrodes C and E are then connected and solidification is started by having water circulated through F, assuring a definite temperature gradient. A, adjusting screw; B, insulator.

After the casting, the X-ray diffraction pattern of the samples was investigated with copper K-alpha radiation in an X-ray apparatus of our own design (4) and satisfactory exposures have been obtained in 20 to 40 milliamperere hours.

We have investigated first pure paraffin in the form of thin transparent films (5).

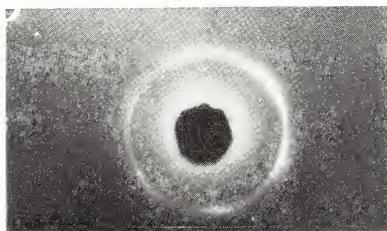


Fig. 2. X-ray diffraction of paraffin film on end of glass tube. Orientation pattern indicates formation of large crystallites and orientation of a long chain normal to the plane of the film.

We have also investigated thicker layers and some paraffin layers sliced with a microtome. Samples were cast in an electric field of 30 KV/cm or without field.

The following figures show that there is no indication of any change of orientation due to the electric field.

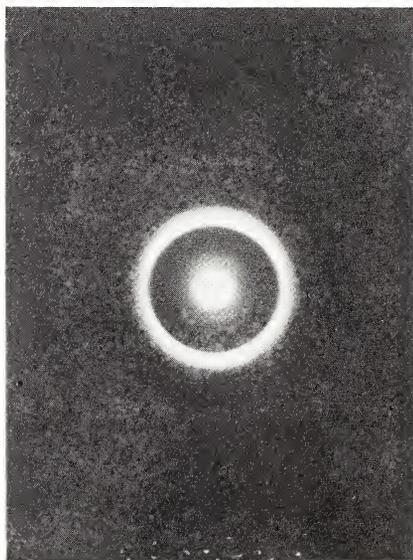


Fig. 3-A. Paraffin sample prepared in electret apparatus. No field. X-rays normal to temperature gradient.

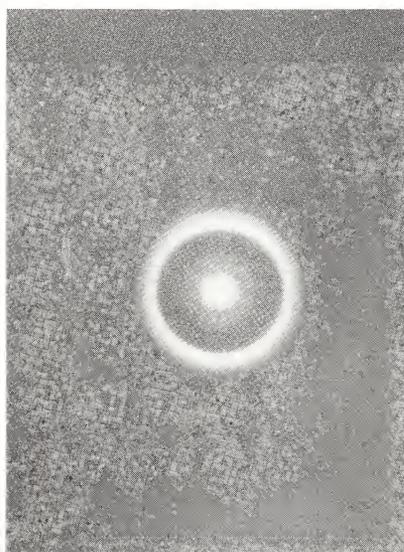


Fig. 3-B. Paraffin sample prepared in electret apparatus 30 KV/cm. field. X-rays normal to field and temperature gradient.

Note in both pictures the orientation pattern of second outer ring. Original reveals definitely also orientation pattern of inner ring.

In a similar way mixtures of caranauba wax with resin (45 per cent caranauba wax, 45 per cent resin, 10 per cent beeswax) have been prepared and again no evidence of any effect of the field was observed.

Since Meissner stated that a mixture of quartz powder with the dielectric exhibits even a greater piezo-electric effect than pure quartz crystals, such mixtures were also prepared. No definite evidence of any orientation of the quartz powder has been found.

Finally sulfur was cast with and without an electric field. In this case we found that large single crystals are formed during the process of solidification and that the mechanical effect as produced by the field

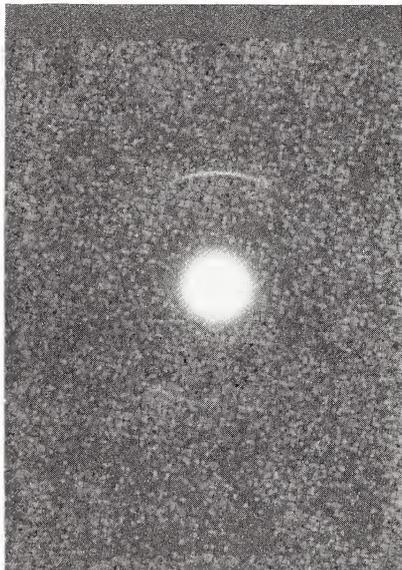


Fig. 4-A. Thin slice cut from paraffin sample prepared in electret apparatus. No field. X-rays normal to temperature gradient.

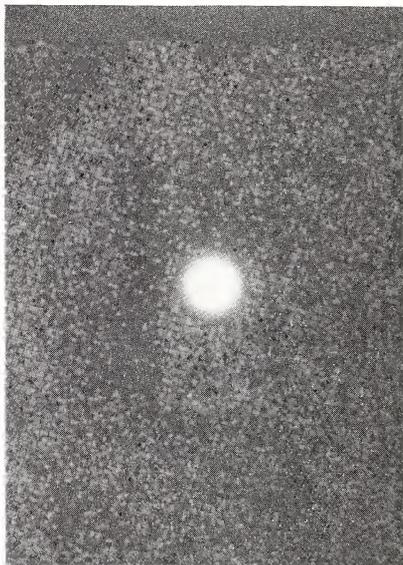


Fig. 4-B. Thin slice cut from paraffin sample prepared in electret apparatus. 30 KV-cm. Field X-rays normal to field and temperature gradient.

produces asterism as we observe it in the case of single crystals under mechanical stress.

From these experiments it is clear that the observed orientation is not an electrical phenomenon. Sometime ago Shearer and Mueller (6) found that paraffins solidified on a glass slide show definite orientation effects. This can be interpreted as similar to orientation of long chain molecules at interfaces as described by Langmuir and others. Our experiments show that only such an orientation can be observed, but no effect of an electric field. These results are in agreement with the conclusions reached from the piezo-electric experiments mentioned above.

Summary. X-ray investigations of paraffin, "electret" mixture, quartz powder suspended in solidified paraffin, and on sulphur have been carried out with the intention to determine the orientation effect of an

electric field during the solidification of the sample. In no case has any evidence of an effect of the electric field been found, and it is concluded that the orientation present is due to the temperature gradient and the effect of interfaces during solidification, but not due to the orientating action of the electric field on the molecules.

BIBLIOGRAPHY

1. Heaviside, "Electrical Papers," Vol. 1, Art. 30, Sec. xii.
2. Eguchi, Phil. Mag. 49, 178, 1925. Sato, Tokio Imp. Univ. Science Reports, I, 11, 160, 1922. E. P. Adams, 204, 469, 1927. *Journ. Franklin Inst.* Meissner, Z. F. Tech. Phys. vol. 9, 1928, page 430.
3. Ewing, Phys. Rev. 36, 378, 1930. Bennett, 211, 481, 1931. *Journ. Franklin Inst.*
4. K. Lark-Horovitz and E. P. Miller, Phys. Rev. 42, 915, 1932. E. P. Miller, Rev. Sci. Inst. 4; 379, 1933.
5. K. Lark-Horovitz and J. E. Ferguson, Phys. Rev. 37, 101, 1931.
6. Muller, Proc. Roy. Soc. A, 120, 437, 1928. Muller, Proc. Roy. Soc. A, 124, 317, 1929. Muller, Jr. Chem. Soc. London 127, 599, 1925.

THE HALL AND ALLIED EFFECTS IN CAST BISMUTH PLATES AS AFFECTED BY THE RATE OF COOLING

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While measuring the four transverse thermomagnetic and galvanomagnetic effects in a plate of bismuth cast from the molten metal certain abnormalities were noted in the results. As no published data could be found this research was undertaken to determine the effect of the rate of cooling of bismuth plates cast from the molten metal with respect to the four transverse effects and to help establish the relationship between heat and electricity.

The four transverse galvanomagnetic and thermomagnetic effects are shown schematically in figure 1, as they are most likely to be found

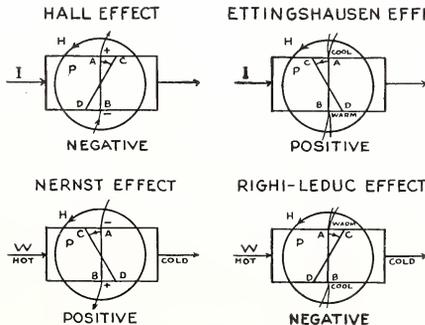


Fig. 1. Schematic diagram of the various effects.