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MEASUREMENT OF THE DIELECTRIC CONSTANT OF A ROCHELLE SALT CRYSTAL IN THE REGION OF THE MICROWAVES (X - BAND)

by

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Abstract : *This paper reports measurements of the dielectric constant on the Rochelle salt, which prove polarization along a single of its axes, according to theory.*

1. Introduction

The electric description of a homogeneous and anisotropic material is effected by the e* tensor of the dielectric constant.

In case of the study concerning the electric attitude of homogeneous and isotropic materials there are many methods like S. Roberts and A. V. Hippel or modification of it by Surber which have been applied successfully.

The advantage of a homogeneous and isotropic material is that the tensor of the dielectric constant is simplified to a simple complex form given by

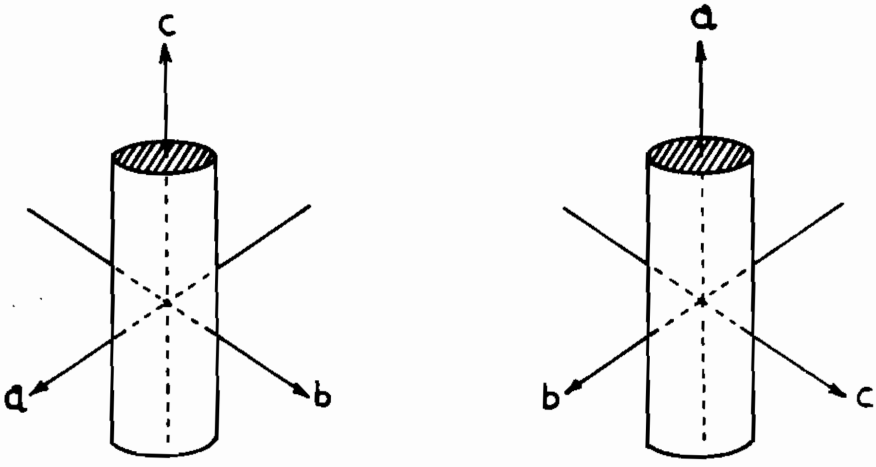
$$\varepsilon^* = \varepsilon - j\,\frac{\sigma}{\omega} \quad \text{or}$$
$$\varepsilon^* = \varepsilon_0 \varepsilon_r^* = \varepsilon_0(\varepsilon' - j\varepsilon'') \qquad (1)$$

where e′ signifies the ability of the material to store electric energy and e″ is the magnitude of the dielectric losses of the material.

2. State of the problem.

In the case of homogeneous and anisotropic materials the problem becomes more complicated since the methods above described cannot be applied with the same sample geometry and the same setup.

The problem of anisotropy is solved by constructing perfect cylinders with two axes of symmetry lying on the surfaces vertical to the lateral ones of the cylinder (Fig. 1, 2).



1. 2.

If the crystal is placed in the wave quide, its direction beein perfectly normal to the direction of propagation of the radiation, it will behave like isotropic. Thus the A. V. Hippel method can be applied in principle could a method be found enabling the crystal to be place in the wavequide (Fig. 2).

Rotation of the cylinder in the wavequide could provide information on the value of the dielectric constant of the material at every direction.

For the T.E. mode of the wavequide there is a modified Hippel method, which gives the value of the dielectric constant according to the following relation

$$_r\varepsilon = \frac{\varepsilon_r^*}{\varepsilon_o} = \frac{1}{1+\left(\frac{\lambda_c}{\lambda_g}\right)^2} + \frac{1}{1+\left(\frac{\lambda_g}{\lambda_c}\right)^2} \left| \frac{r - j\mathrm{tg}(ks)}{1 - jr\mathrm{tg}(ks)} \right|^2 \qquad (2)$$

where λ_c = cutoff wavelength of the wavequide
λ_g measurement s wavelenth
r = standing wave ratio E_{max}/E_{min}
k = $2\pi/\lambda_g$
s = displacement of maxima or minima in the presence of

the sample relative to the ones when the wavequide is shorted.

3. Experimental setup - application to the Rochelle salt.

(1) The block diagram of the setup used is shown in Fig. 3.

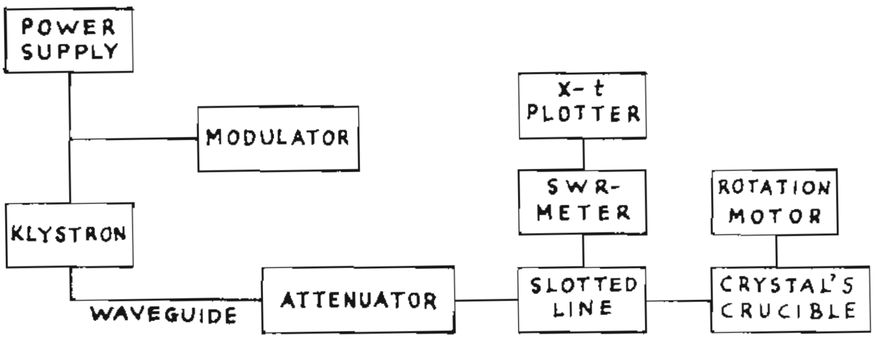


Fig. 3.

(2) The shape of the small cylinders made are shown in Fig. 4,α, β, γ.

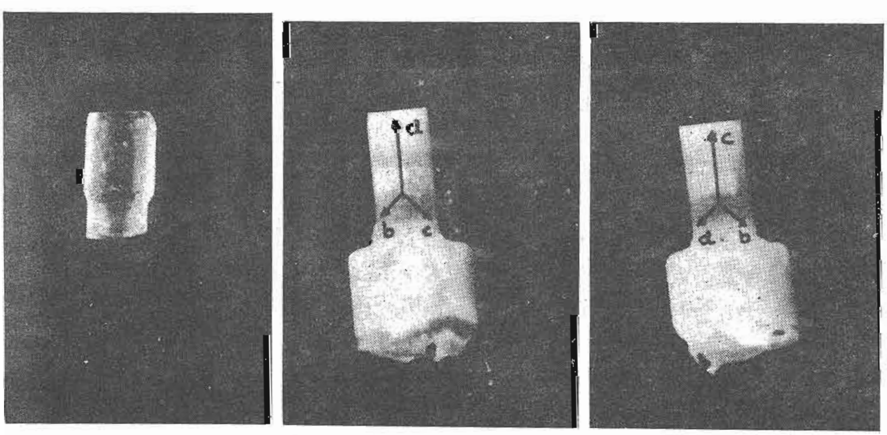


Fig. 4,a *Fig. 4,β* *Fig. 4,γ*

Salt monocrystal

(3) The first measurement was effected on the sample of Fig. 4a

in order to test the stability of the value of the dielectric constant.

During the rotation of the samples a staight line was observed on the plotter. Based on the above experiment the dielectric constant was measured of the isotropic material and found to agree with the results obtained by other investigators.

(4) The experiment was repeated with the samples of Fig. 4β, γ and the corresponding curves of fig. 5α, 5β were taken on the plotter.

The above mentioned curves give information on the value of (r) from which an further derive ε_r.

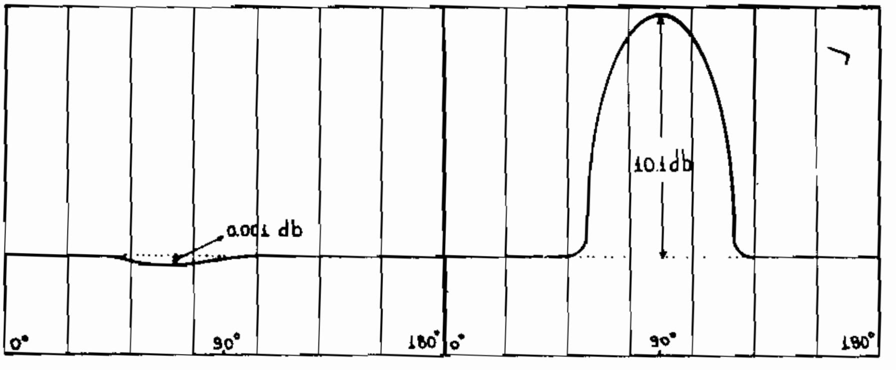


Fig. 5,α *Fig. 5,β*

(5) Since the Rochelle salt is ferroelectric care was taken for the stabilisation of temperature.

4. Results.

According to the curves taken from the plotter the dielectric constant was found as a function of the angle of rotation of the Rochelle salt crystal, and is shown in Fig. 6α, β.

5. Conclusion.

a. According to the curves of Fig. 6 the theory of polarisation of the Rochelle salt is confirmed, taking place only one of its axes.

b. The value of the dielectric constant of the above material is found to vary within a maximum and minimum which includes in this region the value of the same polycrystalline isotropic salt.

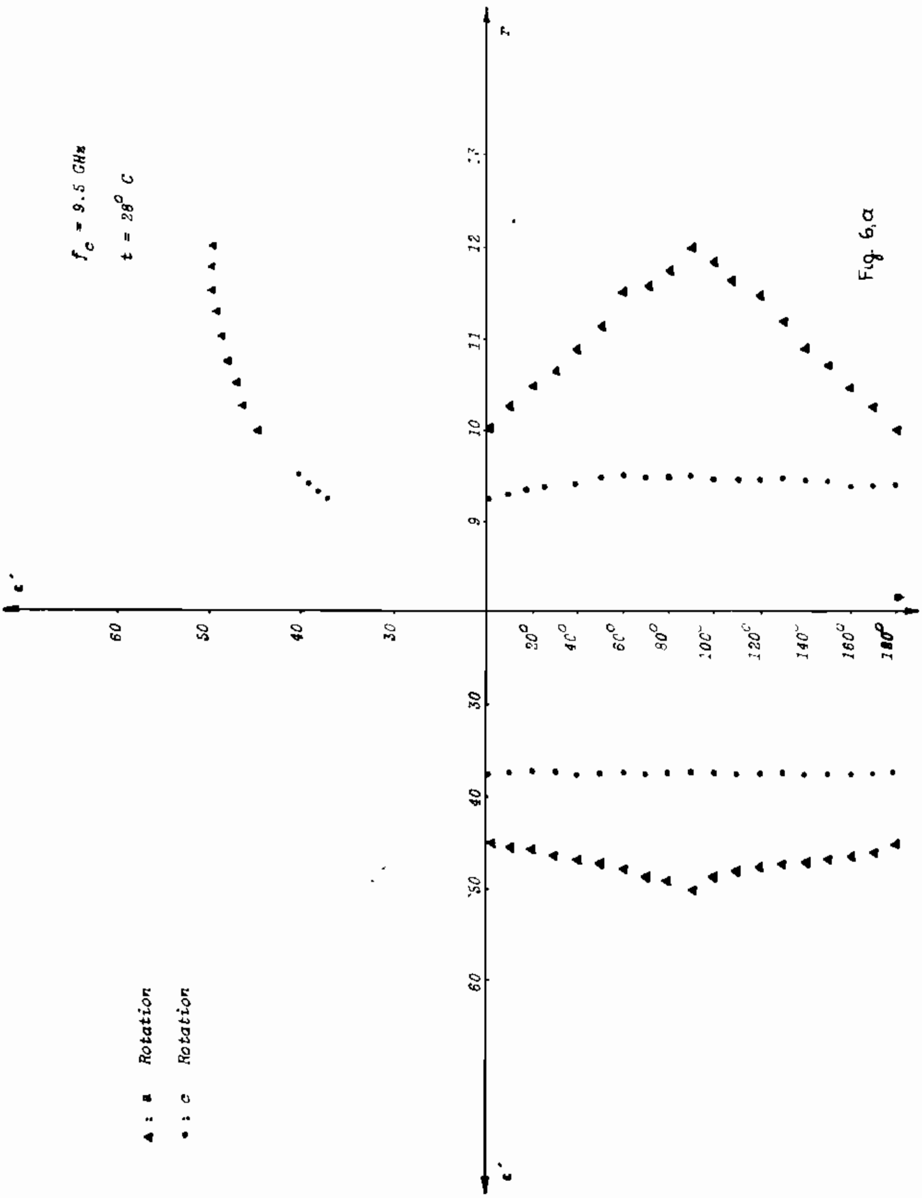


Fig. 6,α

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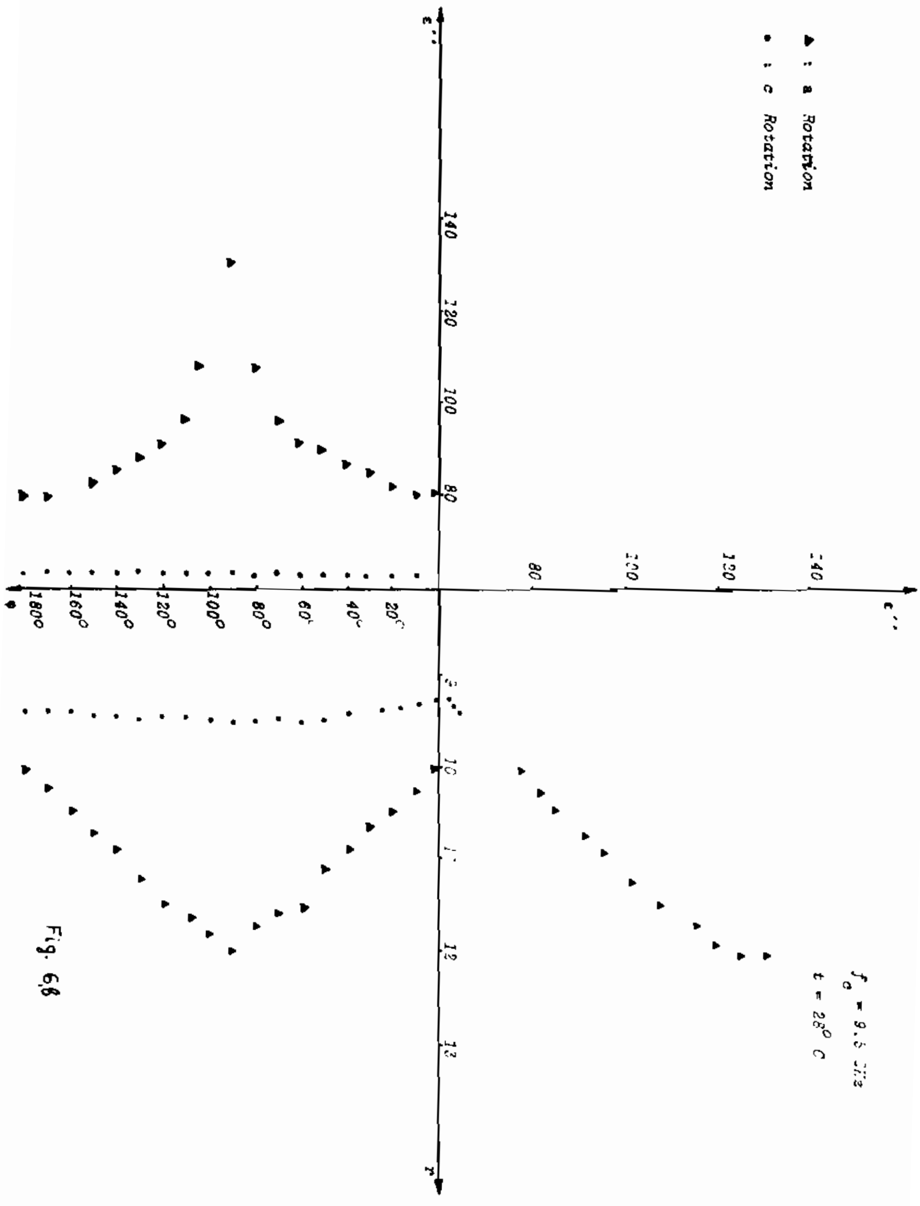
▲ : a Rotation
• : c Rotation
ε''
ε'
140
120
100
80
180°
160°
140°
120°
100°
80°
60°
40°
20°
10
12
13
t = 28° C

Fig. 6,8

- 9 -

Note added in Proof.

Additional experiments are being conducted in our laboratory aiming at an explanation of the behavior of the salt on a microscopic basis based on the variation of the dielectric constant as a function a) of the angle of rotation of the Rochelle salt and b) of the temperature.

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ΜΕΤΡΗΣΙΣ ΤΗΣ ΔΙΗΛΕΚΤΡΙΚΗΣ ΣΤΑΘΕΡΑΣ ΚΡΥΣΤΑΛΛΩΝ ΤΟΥ ΑΛΑΤΟΣ ROCHELLE ΕΙΣ ΤΗΝ ΠΕΡΙΟΧΗΝ ΤΩΝ ΜΙΚΡΟΚΥΜΑΤΩΝ (X - BAND)

ὑπὸ

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ΠΕΡΙΛΗΨΙΣ

Μετρήσεις τῆς διηλεκτρικῆς σταθερᾶς τοῦ ἅλατος Rochelle γενόμεναι εἰς τὴν περιοχὴν Χ τῶν μικροκυμάτων καὶ ἐπὶ δειγμάτων ἰσοτρόπων καὶ ἀνισοτρόπων δεικνύουν τὴν ὕπαρξιν πολώσεως κατὰ μῆκος ἑνὸς μόνον ἄξονος. Εἰς τὸ αὐτὸ συμπέρασμα ὁδηγοῦν καὶ τὰ θεωρητικὰ δεδομένα.