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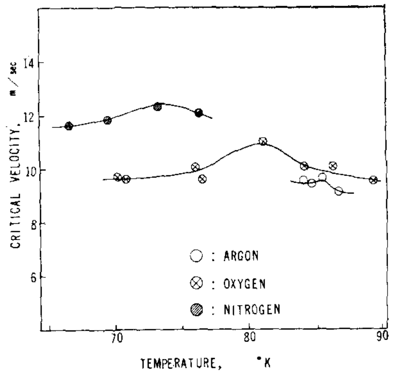

FIG. 3. Critical velocity vs temperature.

dust particles, were made to cavitate in a flow, and the condition for the inception of cavitation was investigated. In each case the cryogenic fluid in the vessel was pushed into a glass test tube with a conical nozzle at the bottom, as shown in Fig. 1. The pressures on the liquid surfaces outside and inside the test tube can be adjusted separately, thus making the rate of flow near the nozzle point controllable under various conditions. Figure 2 gives the graphical representation of the relations between ΔP and V in the case of argon, up to the critical speed of flow for the incipient cavitation. Here ΔP denotes the difference in pressure on the liquid surfaces outside and inside the test tube; V stands for the average speed of flow at the nozzle point. Isolated points in the figure show the corresponding quantities after the cavitation was recognized. The results of tests for the other liquids were much the same with respect to the critical velocity of the flow at the nozzle point as well as to the general aspect of cavitation, "vaporous" in appearence. Figure 3 shows the relation between the critical velocity of flow at the nozzle point and the temperature of the corresponding liquid. It is interesting to note that these curves are similar, and each has its maximum at an intermediate temperature between the freezing point and the boiling point of the liquid, respectively. This fact seems to suggest the existence of some kind of connection between the structural change in the liquid phase under a high shearing stress or in the violent turbulence due to the flow and the inception of hydraulic cavitation, as was supposed in the previous report. Details will be forthcoming.

[1] H. Wakeshima and K. Nishigaki, J. Appl. Phys. **37**, 4584 (1966).

Microwave Faraday Rotation in Nickel-Powder Artificial Dielectric

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THE properties of artificial dielectrics, prepared by mixing metal powders with paraffin wax, have been fairly extensively investigated in recent years. It has been shown by Nag and Engineer[1] that the direction of polarization of a linearly polarized wave propagating through an artificial dielectric may be rotated by applying a longitudinal, steady magnetic field. Study has been made of such rotation in artificial dielectric using powders of a magnetic material, namely nickel. It is the purpose of this note to describe the results obtained from this study.

Finely powdered pure nickel (99.9%) of grain size in the range 4.5–9 μ was thoroughly mixed with liquid paraffin wax at the melting point of the latter, and the mixture stirred until it solidified. The resultant material after being desiccated was pressed into shapes as required for the experiments. The ratio of nickel to wax was approximately 1:4 by volume.

The details of the experimental arrangement are shown in Fig. 1. The sample was press-fitted in a 2-cm length of cylindrical guide, having an inner diameter equal to the width of the main guide. The cylindrical guide consisted of two tubes, one fitting inside the other (as shown schematically in the insert of Fig. 1). The inner tube was soldered to the narrow face of the input guide, while the outer one was soldered to the common junction of two mutually perpendicular output guides. This arrangement allowed rotation of the ouput guides with respect to the input guide, and the rotation could be read on a scale. Of the output guides, guide (2) was terminated at both ends by matched loads, and guide (3) by a matched load at one end, and a matched detector at the second end. All the terminations had reflection coefficients less than 0.02.

The position of the short circuit in the main guide was adjusted to obtain maximum power in guide (2), and the E–H tuner then used to obtain a V.S.W.R. of unity on its input side. The magnetic field was provided by an electromagnet having $4\frac{1}{2}$-in.-diam pole pieces and a gap width of 4 in. The magnetic field was measured by a Hall probe calibrated against an NMR probe.

Initially, the nickel in the sample was demagnetized completely. Output guide (3) was set accurately perpendicular to the main guide. Under this condition no power should be observed in guide (3) if every part is symmetric and the terminations are perfect. Actually a small power was detected which could be ascribed partly to the constructional asymmetry in the junction and partly to small reflections at various output terminations. It was nullified by using a slide-screw tuner before one of the matched loads in the parallel guide (2).

Applying the external magnetic field, the angle of rotation was obtained by rotating the output section till a minimum was detected in guide (3). This minimum was, in general, not zero indicating thereby that the output signal was elliptically polarized. The ellipticity was also determined by comparing the readings of the input-calibrated attenuator adjusted to obtain the same output reading in the same detector attached once to guide (3) and then interchanged with one of the matched loads in guide (2). The data was taken at frequencies of 9.48 Gc/sec and 10.45 Gc/sec and for magnetic fields up to 5.5 kG. The results of the experiment for 9.48 Gc/sec are shown in Fig. 2.

The general features of the experimental results may be summarized as follows:

(i) The Faraday rotation follows a hysteresis curve analogous to the B–H curve of nickel. The direction of rotation for small magnetic fields is clockwise looking along the directin of propagation when the magnetic field is in the same direction and is anti-clockwise for the reverse direction of the field. The rotation increases with increase in the magnetic field, attains a maximum value for a magnetic field of about 1.5 kG, and then decreases for a further increase in the field, ultimately changing its sign. The

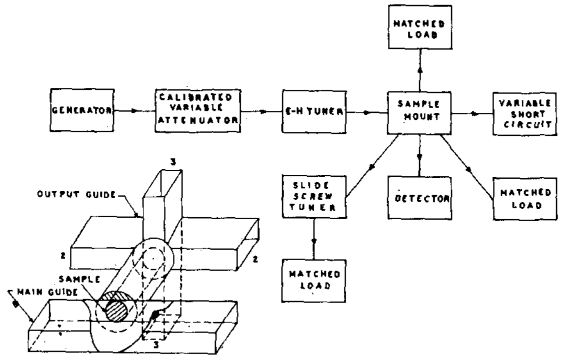

FIG. 1. Experimental arrangement.

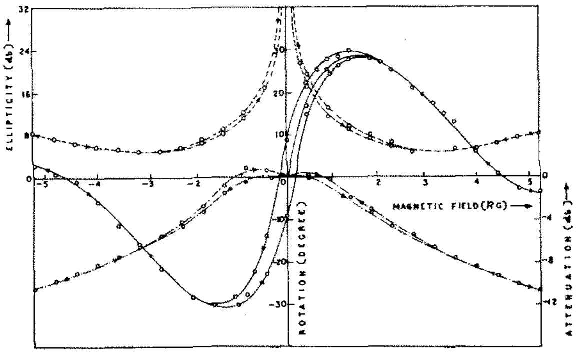

FIG. 2. Experimental curves of rotation, attenuation, and ellipticity for different magnetic fields: (a) —— rotation, (b) ---- ellipticity, (c) -·-·- change in attenuation.

magnitude of rotation at 10.45 Gc/sec is larger than that at 9.48 Gc/sec.

(ii) The ratio of the major and minor axes decreases from an initial value of infinity (linearly polarized wave) and exhibits a broad minimum in the region of decreasing Faraday rotation. Thereafter, it tends to increase. The sharpness of the minimum appears to be more pronounced at the higher frequency. The variation is symmetrical with respect to the magnetic field and a small amount of hysteresis is also present.

(iii) From the ellipticity data it is possible to obtain an estimate of the total change in attenuation of the transmitted signal as a function of the magnetic field. If α_1 is the original setting of the input calibrated attenuator for obtaining a certain power P_0 in guide (2) at zero magnetic field, and if α_2 and α_3 are the readings for obtaining the same power when the output guide is in the maximum and minimum position, respectively, in the presence of a magnetic field, then the total change in attenuation is given by,

$$A=(\alpha_1-\alpha_2)-10\log_{10}\{1+\text{antilog}_{10}[(\alpha_3-\alpha_2)/10]\} \qquad (1)$$

The change in attenuation calculated from Eq. (1) are also plotted in Fig. 2.

It is found that the attenuation, after a small initial increase, decreases continuously with the increasing magnetic field.

The rotation produced in the nickel-powder artificial dielectric is similar to that in ferrites. Hence, these may be used to produce rotation of the plane of polarization of a linearly polarized wave or to produce a circularly polarized wave from a linearly polarized one. In the latter case, its behavior is somewhat different from that of the ferrites. While in ferrites, the circular polarization is produced due to increased attenuation of one of the circularly polarized components at resonance, in the artificial dielectric it is due to the decreased attenuation of the same component at resonance. The sense of rotation for any particular direction of the steady magnetic field is also opposite for the two media. These distinctive features may make the dielectric suitable for particular applications. In order to estimate its suitability, the attenuation constant in the material was measured by the impedance measurement technique[2] and found to be 6.95 dB/cm. The figure of merit for a rotator would therefore be 2. This value is two orders lower than that of ferrites. However, suitable choice of the magnetic material, the grain size, composition of the dielectric and of the ambient condition such as the temperature, may lead to improvement in this figure. Such detailed studies have been undertaken by the authors and the results will be published in near future.

The authors are grateful to Professor J. N. Bhar, F.N.I., for his kind interest in the work.

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[2] J. M. Kelly, J.O. Stenoien, and D. G. Isbell, J. Appl. Phys. 24, 258 (1953).

Coexistence of Space-Charge-Limited Current and Current-Saturation Phenomena in Piezoelectric Substances

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THE space-charge-limited current (SCLC) in solids is well-investigated experimentally and theoretically, and is believed to be proportional to μV^2, in the ideal case, where any effects of traps are neglected.[1] When the mobility μ is not a constant, as in the recently studied high-electric-field phenomena, the SCLC is no longer described by the quadratic law with respect to the applied voltage V.[2]

The current saturation which occurs in piezoelectric materials[3] is of much interest in this sense. The mobility defined by $\mu=v_d/E$ is roughly proportional to $1/E$ (i.e., v_d=const.) so long as the local field exceeds the threshold. Thus, the SCLC linear in V is expected, if there exists some saturation mechanism.

To affirm this, we calculated numerically the voltage vs current characteristics on a sample under ultrasonic amplification with the following assumptions:

(a) Only one type of carriers is concerned.
(b) Diffusion current is negligible.
(c)
$$\mu(E)=\begin{cases}\mu_0 \text{ (ohmic mobility)} & \text{for } E<E_{th}\\ \mu_0 E_{th}/E & \text{for } E\geqq E_{th}\end{cases} \qquad (1)$$
(d) The sample is trap free.
(e) Current and electric field are time independent.

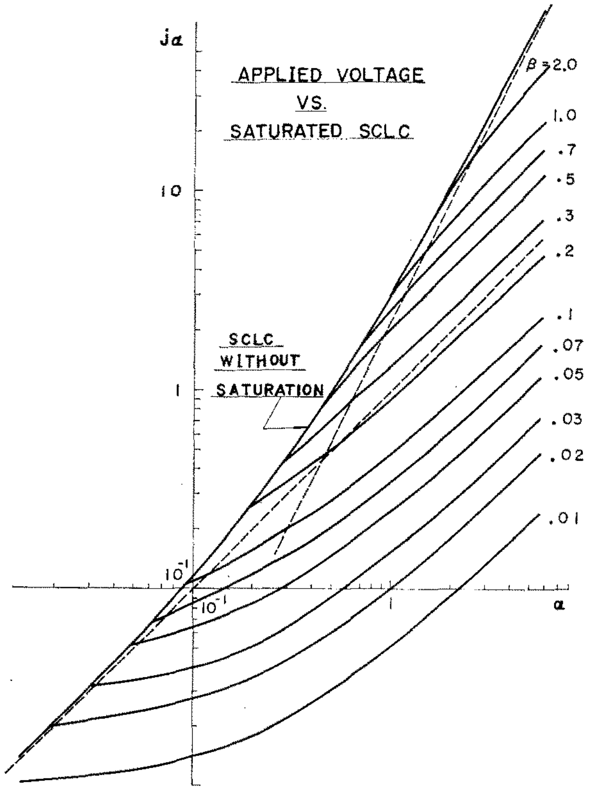

FIG. 1. Calculated $j\alpha=J\cdot\epsilon/2(\bar{n}e)^2\mu_0 l$ vs $\alpha=V\cdot\epsilon/2\bar{n}el^2$ characteristics. The broken lines show two asymptotes: one is $j\alpha=\alpha$ (or, $J=\bar{n}e\mu_0V/l$) for $\alpha\ll1$ and the other is $j\alpha=(9/4)\alpha^2$ (or, $J=(9/8)\epsilon\mu_0V^2/l$) for $\alpha\gg1$.