face of the sample) in the air column before the sample (length D) are measured for various values of l (the length of the air column behind the sample), and α_i and β_i denote the attenuation and the propagation constant in the air column ($i = g$) and those in the sample ($i = d$) respectively, and $K \equiv \tan\beta_g l$.

We plot S (the right side of (1)) against l with measured values of Γ and x_0 and determine l_a and l_i corresponding to S_{max} and S_{min}, and then α_d and β_d are determined in a great many methods. Especially the expressions we have used for the experiments are of the following form:

$$\alpha_d = \frac{1}{D}\tanh^{-1}\sqrt{\frac{S_{min}}{S_{max}}} \quad \text{and} \quad \beta_d = \beta_g\sqrt{S_{max}\,S_{min}}. \tag{2}$$

The values of ε' and ε'' can be determined by substituting α_d and β_d calculated by any one of the methods into the following expression:

$$\varepsilon' = \left[1-\left(\frac{\lambda}{\lambda_c}\right)^2\right]\left(\frac{\beta_d}{\beta_g}\right)^2 + \left(\frac{\lambda}{\lambda_c}\right)^2 \text{ and } \varepsilon'' = 2\left[1-\left(\frac{\lambda}{\lambda_c}\right)^2\right]\frac{\alpha_d}{\beta_d}\left(\frac{\beta_d}{\beta_g}\right)^2. \tag{3}$$

Our experiments with the frequency 9450 Mc/sec have been performed on $C_{15}H_{31}CH_2OH$ and ebonite by the method (2). The reasonable values of dielectric constant ε' have been obtained: $\varepsilon' = 2.33$ and $\varepsilon' = 2.72$.

Practically, in place of the graphical determination, we can use the values of l such that $x_0 = n\lambda_g/2$ and $x_0 = (2n+1)\,\lambda_g/4$ and the corresponding measured values of Γ and the corresponding values of S. This simplification is justified by use of Schelkunoff's correspondence.

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4. Study on High Dielectric Constant Ceramics. (XIX)

The Modes of Vibration about Langevin Type $BaTiO_3$ Ceramic Vibrator

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Langevin type vibrators using $BaTiO_3$ ceramics have been studied and put to use already. But the important problems about the mode of vibration or the supporting method of vibrator, have been left alone because no suitable means of investigation was found. In order to obtain some concept about these problems, the amplitude distribution and the phase relation of the vibrating surface were measured by a piezoelectric type pick-up. Fortunately, fairly interesting results were obtained, which will be described here.

Method of Measurement:

A small pick-up having the construction of Langevin type consisting of $BaTiO_3$ ceramics and brass was used. It is 6 mm in diameter, 5.5 mm in thickness, and the thickness of the ceramic plate is 0.3 mm. The resonant frequency is about 280 kc in the first resonance and about 480 kc in the second resonance. The weight is 1.3 g. Four specimens having the construction of Langevin type consisting of $BaTiO_3$ ceramics and iron were used. All specimens are 60 mm in diameter, 33 mm in thickness, and the thickness of ceramic plate is 5 mm. The resonant frequency is about 50 kc in the first resonance and about 75 kc in the second resonance. Applying the output (about 1 volt) of C-R oscillator to vibrator, frequency was adjusted to its resonant frequency, and the output of the pick-up on the vibrating surface was amplified and connected to a Braun-tube oscilloscope in order to measure its amplitude. Then small quantity of oil was used to ensure a good contact between the surface of the specimen and the pick-up. The gain of the amplifier was about 60 db. Amplitude distribution was obtained by changing the position of pick-up and measuring the deflection of Braun-tube. For the measurement of curved surface, the contact part of specimen was ground into a plane and measurement was carried out by the same method. For the measurement of the phase relation, two pick-ups of the same form and the same characteristics were prepared. Their outputs were amplified separately, led to the horizontal and the vertical axis of Braun-tube respectively, and the phase relation was decided from the figures that appeared on Braun-tube.

After it was confirmed that nearly accurate results on the known amplitude distribution could be obtained, the measurement was carried out.

Result of Measurement:

One example of measured results about four specimens are shows in Fig. 1.

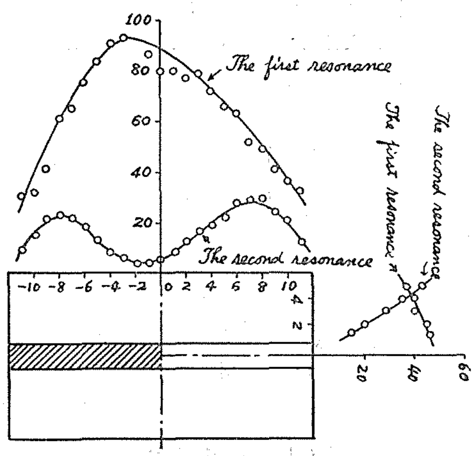


Fig. 1.

These results show that no piston motion occurs in the vibration of both resonances. In the first resonance the amplitude is maximum at the center on a plane surface and is smaller at periphery and in the second resonance the amplitude is maximum at 0.6 — 0.7 r and is minimum at the center. In the first resonance, the amplitude of vibration on the curved surface is very large everywhere and is maximum at the ceramic part, and in the second resonance, the amplitude is maximum at the edge and is minimum at the ceramic part. Fig. 2 shows the measured results of the

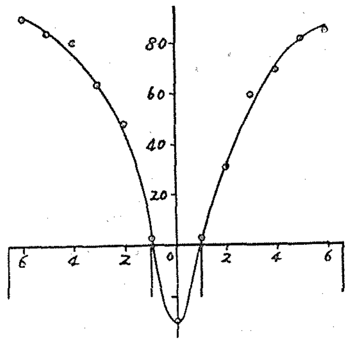
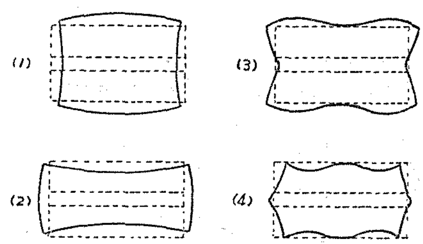


Fig. 2.

amplitude distribution on the curved surface in the second resonance. The phase relation was clearly opposite between the plane surface and curved surface in the first resonance. In the second resonance, it is confirmed that all parts of the plane and curved surface move in the same phase and only the part of the ceramic plate has the opposite phase compared with that of other parts.

The mode of vibration will be concluded as is shown in Fig. 3 from above results.



The first resonance The second resonance
Fig. 3.

sults. The first resonance has the characteristics of volume constant, and the second resonance volume change. As to the supporting method of vibrator there is no proper position to be supported in the first resonance as their surface have large amplitude everywhere on plane and curved surface. But in the second resonance it is possible to support because it has zero amplitude at the center of plane surface and at two contact parts of iron to ceramics on the curved surface.