

3. The Dielectric Constant of Liquids at Microwave Frequencies. (I)

An Experimental Apparatus at 3 cm Wave-Length

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An experimental apparatus for measuring the dielectric constant of liquids at 3 cm wave-length was designed and constructed in the laboratory.

The apparatus consisted of silver plated rectangular wave-guide components whose cross section is 22.9mm×10.2mm I.D., and includes a signal generator, directional couplers, crystal detectors, a liquid cell and a wave meter.

The signal generator was a reflex klystron, type 2K25, fed by an electronically regulated power supply, and its output frequency was monitored by means of a transmission type TE₀₁₁ cavity wave meter which was coupled to the signal generator by a directional coupler.

The liquid cell was a section of wave guide which was surrounded by a constant temperature water jacket, and separated from the remainder of the system by means of a very thin mica sheet clamped between a choke-flange joint. As an open-circuit plunger in the liquid-filled section, a quarter wave-length block of fused quartz was used since its electrical, mechanical and chemical properties was quite suitable for that purpose.

The reflection coefficient Γ at the input plane of liquid varies with an increase in the length of liquid column by withdrawing the plunger.

The variation of Γ , i.e. its amplitude and phase, was observed and recorded by means of a directional coupler and a crystal detector.

Since the wave-length in liquid λ_a was twice the separation between adjacent maxima of $|\Gamma|$ and the dielectric attenuation per wave-length $\alpha_a \lambda_a$ is evaluated from the damping of successive maxima with the length of liquid, the complex dielectric constant ϵ ($\epsilon = \epsilon' - j\epsilon''$) was calculated by the following equation (W.H. Surfer, Jr.: J. Appl. Phys. **19** 514 (1948)),

$$\begin{aligned} D &= \tan [2 \tan^{-1}(\alpha_a \lambda_a / 2\pi)] \\ \epsilon' &= (\lambda_0 / \lambda_c)^2 + (\lambda_0 / \lambda_a)^2 \left[1 - \tan^2 \left(\frac{1}{2} \tan^{-1} D \right) \right] \\ \epsilon &= (1/\pi) (\lambda_0 / \lambda_a)^2 (\alpha_a \lambda_a), \end{aligned}$$

where λ_0 is the free space wave-length, λ_c is the cut off wave-length in the empty guide.