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Mechanism of Ferromagnetic Dispersion

FURTHER experiments have been made to elucidate the mechanism responsible for the magnetic dispersion and absorption of γ -ferric oxide at centimetre wave-lengths, previously reported¹. Using the wave-guide impedance method^{2,3}, the high-frequency permeability $\mu = \mu_R - i\mu_I$ of γ -Fe₂O₃-wax mixtures has been measured in a coaxial transmission line, when a static magnetic field H is applied perpendicular to the axis. Typical results obtained on specimens containing 32.6 per cent by volume of γ -Fe₂O₃ are plotted in Fig. 1, together with measurements of the incremental static permeability, μ_0 .

Various theories of ferromagnetic dispersion have been proposed. Skin effect, suggested by Page⁴ and Kittel⁵ as the dispersion mechanism for powders and metals respectively, is negligible in γ -Fe₂O₃ at centimetre wave-lengths³. Becker⁶ has developed a theory of dispersion, due to eddy-current fields produced by oscillatory displacements of the domain-walls. Irreversible displacements, corresponding to the peak in the $\mu_0 - H$ curve, should disappear at low frequencies, and the present results substantiate this.

Fig. 1

Fig. 2

It does not appear, however, that the micro-wave dispersion is attributable to Becker's other mechanism, the relaxation of reversible displacements. The insensitivity of μ to applied fields of a few hundred gauss indicates the action of a strong- and not a weak-field effect, while the experimental $\mu - \lambda$ curves have the characteristics of a damped resonance and not a relaxation.

It appears rather that the primary mechanism in the high-frequency magnetization is domain-spin rotation. For large H , μ is real and equal to μ_0 , but as either λ or H is decreased, μ_R falls below μ_0 while μ_I increases, indicating a phase lag of the spin-rotation behind the high-frequency field. Landau and Lifshitz⁷ have developed a theory of dispersion due to spin-rotation, and they predict a resonance occurring when the applied frequency is equal to the spin precession frequency in the internal crystalline field. Allowing for their neglect of eddy-current damping, the observed dispersion is in good agreement with this theory. The peak which might be expected in the $\mu_R - \lambda$ curve lies outside the measured wave-length range for γ -Fe₂O₃, but such a peak has been observed in measurements on Fe₃O₄, plotted in Fig. 2.

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Location of the Currents Causing the Solar and Lunar Diurnal Magnetic Variations

IN 1882 Balfour Stewart¹ put forward the view that the solar and lunar diurnal magnetic variations were produced by currents in the upper atmosphere. He suggested that these currents were produced by the 'dynamo' action of thermal or tidal motions of conducting air across the earth's main magnetic field. Schuster² put these suggestions on a quantitative basis. It was later realized (Chapman³) that there were difficulties in assigning both the solar and lunar variations to a single ionized region. For example, the amplitude of the former is some 2.4 times larger