Radiation Pressure of Centimetre Waves

THE pressure exerted on a perfectly specular surface by a normally incident beam of electromagnetic waves travelling in free space can be calculated with the known formula

$$p = 2S/c,$$

where S is the Poynting vector and c the speed of light.

Many experiments have been performed in order to measure the pressure exerted by light waves, among which those by Amerio¹ seem to be particularly elegant. Lebedew² has found for the radiation emanating from the sun a pressure of the order of 10^{-5} dyne/cm.². The radiation pressure of electromagnetic waves produced by ordinary radio transmitters is smaller still and cannot be detected by direct means, since the wave-lengths involved are too large and the power does not reach adequate levels. The invention of new tubes (magnetrons) capable of generating high-power centimetre waves has made it possible to measure the radiation pressure of such radiation.

Using a 725 A.-type magnetron generating bursts of radio-frequency energy ($\lambda = 3$ cm., duration of each burst 1 μ sec. with a recurrence of 1,000 cycles per second) of a mean value of 50 watts, the pressure exerted by the energy impinging on a surface of 2 cm.² (cross-section of rectangular wave-guide) is of the order of 10^{-2} dyne/cm.².

In order to detect such a pressure we have carried out the following experiments: before the mouth of a rectangular wave-guide excited by the above-mentioned magnetron, we placed the aluminium blade (6 cm.² cross-section) of a symmetrical torsion balance, having an arm 2 cm. long, protected by a glass cover. Observation was carried out in a rarefied atmosphere of 10 mm. mercury pressure approximately in order to minimize radiometer effects. The distance between the blade and the mouth of the wave-guide was never less than 4 cm. in order to avoid ionization under the action of the intense radio-frequency field.

Thus the blade was picking up only a fraction of the radiated energy. Different observations have been made at various points of the field. When intercepting the maximum radiation (approximately one fifth of the total available power), the balance indicates a torque of 10^{-2} dyne/cm. Diffraction phenomena explain this result, which is smaller than the theoretical torque corresponding to a force obtained by calculating the product of the pressure of the intercepted radiation by the effective cross-section of the blade.

In a theoretical paper³, in which the propagation of the electromagnetic field in a wave-guide has been studied starting from relativistic considerations, we have demonstrated that within a (rectangular) wave-guide the pressure must be calculated with the formula:

$$p_g = 2Sv_g/c^2,$$

where v_g is the group velocity, which is known to be less than c . We deduce from it a radiation pressure within the wave-guide less than the free space radiation pressure.

Measurements of p_g are under way, and since v_g is a calculable quantity, we hope to be able to obtain

as final result the value of S and consequently the generated power.

N. CARRARA
P. LOMBARDINI

Centro delle Microonde,
Viale Morgagni 48,
Firenze.

¹ Amerio, A., *Nuovo Cimento*, 5, série XVII-XVIII, 424 (1909).

² Lebedew, P. N., *Drud. Ann.*, 6, 233 (1901)

³ Carrara, N., *Nuovo Cimento*, 5, 249 (1948).

Dielectric Strength of Liquids for Short Pulses of Voltage

EXPERIMENTS in progress here show a systematic increase in the dielectric strength of pure organic liquids as the duration of the pulse of voltage is decreased. In other words, between the instant of applying a field and the instant of breakdown there is a time-delay which becomes less as the field-strength is raised above the normal breakdown value. A suggestion of this delay can be seen in the early oscillograms of Rogowski, Flegler and Tamm¹.

We have used pure organic liquids of relatively simple molecular structure, both polar and non-polar. The accompanying graph shows the experimental relation between breakdown field-strength and pulse duration for benzene and alcohol. The experiments were performed at room temperature.

Dependence of dielectric strength upon pulse duration for benzene and alcohol

To avoid the considerable errors due to minute amounts of impurity, an apparatus has been constructed in which the liquid can be distilled *in vacuo* into the testing vessel. Single rectangular pulses of voltage are applied from a thermionic pulse generator to a pair of polished metal spheres immersed in the liquid and capable of being rotated from outside the vessel to present a fresh surface to the gap after a spark has occurred. We find that this apparatus reduces the 'spread' in the measurements, though a small proportion of the pulses still produce breakdown at field-strengths below the minimum value for consistent rupture, which we regard as the 'breakdown field-strength'. However, accidental lack of