LETTERS TO THE EDITOR.

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Ionisation and Radiation.

WHEN X-rays pass through a gas, only a very small fraction of the molecules—in favourable circumstances, one in a billion—is ionised by them, and the extent of this ionisation is unaffected by temperature. Writers on radiation seem to have difficulty in reconciling this with the wave theory of light. I venture to suggest that the difficulty arises from an imperfect comprehension of what the wave theory requires.

The inverse square law of intensity ought not to hold for very small spaces and very small times. The uniform spherical wave spreading out from a point source is a mathematical fiction. What we really have is a very great number of spherical wavelets, each diverging from a different electron, criss-crossing in various directions, and consequently interfering with one another. For example, suppose that there are n electrons in the source, all close together, and that the intensity of radiation is required at a point P at a distance r, great in comparison with the linear dimensions of the source, and so sensibly the same for all the electrons. Let the intensity at P due to a single electron be I/r^2. Then the resultant intensity may be anything from 0 to n^2I/r^2, according to the number of wavelets coincident in phase at P, the lower values predominating. If the phases of all the different waves are absolutely at random, the problem reduces to a celebrated one solved by Lord Rayleigh, and the chance of a particular intensity J is

$$\frac{r^2}{In}e^{-Jr^2/In}dJ.$$

It follows simply from the laws of chance that the intensity must be exceptionally great at some points; the very existence of an average value implies this. If one in a billion molecules is ionised, the ionising intensity works out at 27·6 times the average intensity at P. If there is any regularity of structure in the source, Lord Rayleigh's expression may not do justice to the higher intensities.

Thus it is not necessary to assume that X-rays consist of neutral atoms, or that the ether has a fibrous structure, or to take refuge in the nebulous phraseology of the quantum theory; the explanation follows naturally from the principle of interference as expounded by Fresnel.

R. A. HOUSTOUN.

University, Glasgow, April 11.

The Whiteness of the Daylight Moon.

WATER holding in suspension fine particles of mastic scatters a blue light. Place behind the containing vessel a yellow surface. (1) If this is bright, its light, transmitted through the vessel, prevails, and we see the yellow. (2) Subdue the illumination of the yellow surface sufficiently, and the water appears white, the yellow and the blue just compensating each other. (3) Subdue the yellow still more, and the scattered blue again becomes evident. If in case (2) we use a Nicol, then, for minimum transmission, the white changes to yellow; but, for maximum transmission, to blue, because the scattered blue light is largely polarised.

Now Nature supplies us on a large scale with an admirable example of similar phenomena. Suppose the moon to be at her first quarter in daylight. The moon's reflected light is yellowish, that of the sky is blue, due to scattering, and is considerably polarised 90° from the sun. Between us and the moon there is sky. The whiteness of the daylight moon is, in my opinion, an example of case (2) above, and at the first quarter I find that she behaves to a Nicol in the way already described. I have not previously met with any account of this grand natural example of the fact that a mixture of blue and yellow lights produces white.

C. T. WHITMELL.

Invermay, Hyde Park, Leeds, April 15.

REFRACTOMETERS.

AMONGST the physical properties which are characteristic of a substance, the refractive index is one of the most important. From a theoretical point of view, the fact that refractivity is mainly an additive quantity—the molecular refractivity being approximately the sum of the atomic refractivities—is highly significant. From a practical point of view, the ease and accuracy with which refractive indices can be determined by modern methods are of great service, both to the physicist and to the chemist, in the examination of the materials with which they have to deal. Whether for purely scientific or for technical purposes, such a determination affords a rapid method of finding the concentration of solutions and the purity of oils, fats, waxes, and foodstuffs. New applications are continually arising in a variety of industries dealing with drugs, sugars, paints, varnishes, glue, gelatine, and other colloids. The physicist finds the method of service in the identification of optical glasses or in the study of singly or doubly refracting crystals.

A ray of light passing from an optically dense to a rarer medium is bent away from the normal to the surface, and when the angle of incidence assumes a certain definite value the emergent ray just grazes the common surface. For angles of incidence greater than this *critical angle*, the light is no longer refracted, but undergoes total internal reflection. The refractive index, in passing from the rare to the dense medium, is the reciprocal of the sine of the critical angle. It is interesting to learn that the first to apply this property as a practical method for finding the refractive index was Wollaston, who constructed and described in the *Philosophical Transactions* in 1802 a critical-angle refractometer, using a right-angled prism as adopted later by Pulfrich.

In 1874 E. Abbe, of Jena, described the refractometer which, as constructed by the firm of Zeiss, has been familiar for the past forty years. In this instrument the substance to be examined is placed on the hypotenuse face of a right-angled prism, having one of its angles accurately 60°. When the substance is a solid, optical contact with the prism is made by means of a liquid of higher refractive index than the solid; when a liquid is to be examined, one or two drops are enclosed as a film between two similar prisms. It has been pointed out previously in these columns that *both* these prisms should be made of glass of high refractive index, in order to secure sufficient illu-