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 illumination (NATURE, June 21, 1917). The prism system is rotated by means of the index arm until a dark shadow comes into the field of view of the telescope, and the edge of the shadow is adjusted exactly on the cross-lines. The refractive index for sodium light is then read directly on the scale of the instrument, the accuracy of reading being one or two units in the fourth decimal place. When white light is employed, the dispersion of the emergent light is neutralised by means of an Abbe compensator. It is satisfactory to find that British firms have produced instruments which are undoubtedly superior to the German pattern, and that they have been able to supply the demand in various Government Departments that has arisen during the war. The firm of Adam Hilger now produces standardised instruments in which not only the mechanical, but also the optical, parts are interchangeable (Fig. 1). Tables of refractive indices of industrial substances are in course of publication, and should prove of great value.

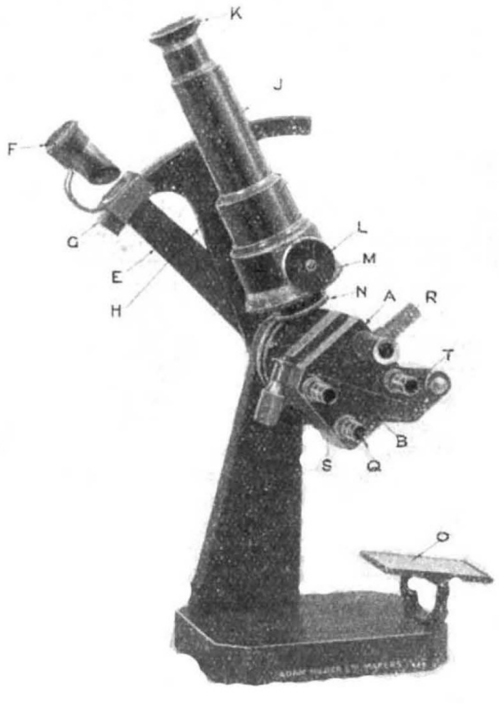

FIG. 1.—Abbe Refractometer (Adam Hilger, Ltd.). A, Upper prism jacket; B, lower prism jacket; E, reader arm; F, reader; G, scale; H, scale arm; J, telescope; K, telescope eyepiece; L, milled head for Abbe compensator; M, scale for Abbe compensator; N, adjusting ring for lower D.V. prism; O, mirror; Q, S, and T, prism jacket nozzles; R, nozzle with thermometer chamber.

Messrs. Bellingham and Stanley have produced an instrument of distinctive design, embodying several improvements on the German type (Fig. 2). The prism-box is now designed to open away from the operator, which makes it much easier to examine plastic or solid substances. It is no longer necessary to reverse the instrument, and full use may be made of the illuminating mirror. At the same time, the change permits of greater rigidity of construction. The reader arm is provided with a slow motion by a simple friction device, and the halves of the prism-box may be separated automatically by a small movement of the clamping head. The lower half is so constructed that it can be removed quickly without tools.

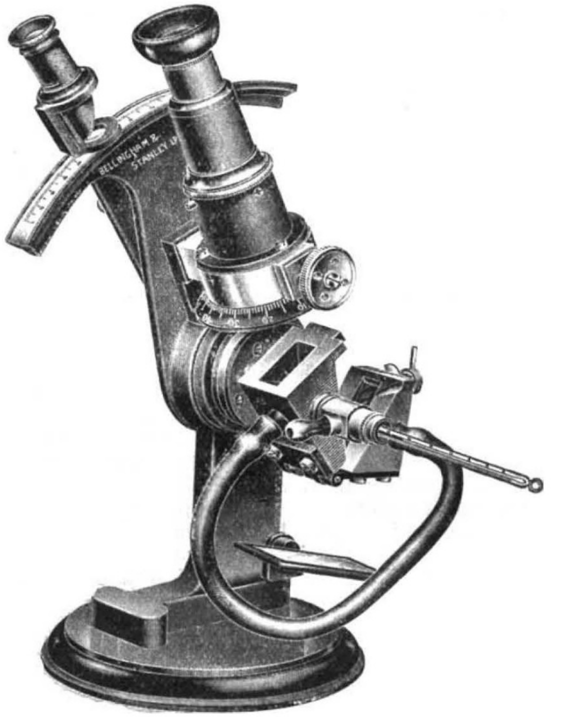

FIG. 2.—Abbe Refractometer (Bellingham and Stanley, Ltd.).

When measurements of a higher degree of accuracy are desired than is possible with the Abbe type of instrument, the dipping refractometer (Fig. 3) may be employed, but with a single fixed prism readings can be obtained only over a limited range of refractive index. The prism of the instrument dips into the liquid, which is placed in a small containing vessel, and the refractive index is determined by the position of the border-line of total reflection seen in the eyepiece. The eyepiece carries a photographic scale, and a micrometer screw adjustment is provided whereby the position of the border-line with respect to the scale division may be measured directly. A table is supplied giving the refractive index in terms of the scale reading. In the German type of instrument the prism is cemented into its holder, and can be used only for solutions of refractive indices between 1·325 and 1·367. In hot and moist climates the solution frequently creeps up through the cement on to the upper face of the prism. When this occurs, or when the prism is damaged, it is necessary to return the entire instrument to the makers. Messrs. Bellingham and Stanley have improved the design of the instrument, and arranged for the prism to be capable of easy removal for cleaning purposes or for renewal. An additional advantage of this method of construction is that a series of prisms may be employed, giving further ranges of refractive indices up to 1·55, with an accuracy of three or four units in the fifth decimal place.

FIG. 3.—Dipping Refractometer (Bellingham and Stanley, Ltd.).

For measurements of still higher accuracy, the Pulfrich refractometer is available (Fig. 4). In ordinary use this instrument will give results four or five times as accurate as those obtained by means of the Abbe refractometer. Mr. J. Guild, of the National Physical Laboratory, claims that, with proper care in design and use, the Pulfrich refractometer will give results accurate to the fifth decimal place, not only in the dispersion, but also in the absolute index. In this instrument the substance to be examined is placed on top of the horizontal surface of a block of glass of known refractive index. Rays entering the substance from one side can pass out from the opposite vertical surface of the Pulfrich prism only when they enter above the horizontal boundary surface. A sharp line representing the rays which have just been able to enter the prism is observed in the telescope. The angle of emergence is measured by rotation of the telescope, which is attached to a divided circle. Messrs. Hilger have designed a new instrument in which all screw-heads are brought within reach of the observer's right hand. Direct readings on the vernier of the divided circle are accurate to one minute, and on the divided drum of the slow motion to six seconds. In accurate measurements the questions of temperature control and of the source of light employed must receive careful consideration.

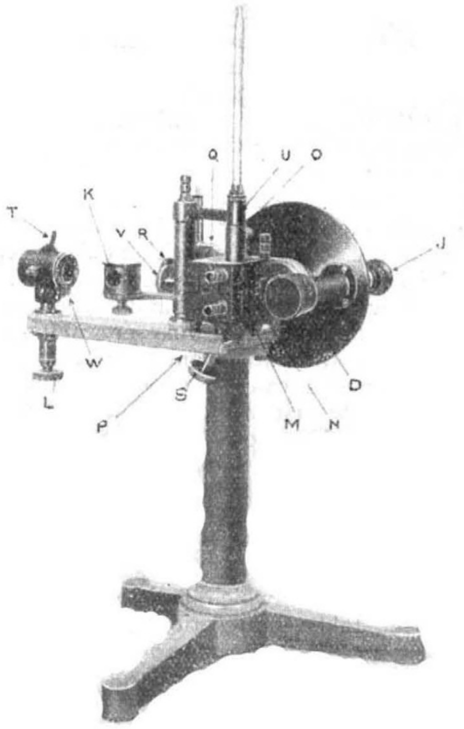

FIG. 4.—Pulfrich Refractometer (Adam Hilger, Ltd.). D, Telescope object-glass and prism dust cover; J, telescope helical focussing E.P.; K, prism for use with sodium burner; L, condenser height-adjusting milled head; M, bottom water jacket with Pulfrich prism; N, top water jacket; O, thermometer case; P, circle slow motion (position only indicated); Q, slow motion vernier (position only indicated); R, slow motion arm clamp milled head; S, clamp screw for bottom water jacket; T, light screen; U, thermometer adapter case; V, thermometer case operating milled head; W, clamp for vacuum tube holder.

THE ATLANTIC FLIGHT.

THE first attempt to cross the Atlantic by aeroplane will go down to posterity as one of the milestones in the progress of aviation, and there seems little reason to doubt that this feat will soon be accomplished. The two main factors affecting the result are the trustworthiness of the engine and the state of the weather. The best engines of to-day are capable of running for periods considerably longer than that required for the crossing, and, although it is impossible to say that a given engine will accomplish a twenty-hour run without mishap, the chance of failure due to engine breakdown is by no means exceptionally great. On the other hand, the weather is extremely difficult to forecast, and very little information is obtainable as to the conditions prevailing at a height of 10,000 ft., even though the surface conditions are fairly well known. Every possible provision will be made for the safety of the aviators in the case of a forced descent at sea, but the element of risk is naturally a very serious one, and we can but admire the men who are so ready to face it.

Mr. Hawker, on his Sopwith machine, is carrying a collapsible boat, attached to the upper side of the fuselage, containing signalling devices and provisions for two days. Even with such a precaution the risk would be very great in a rough sea, and the chance of attracting the attention of ships would be small. It is understood that Mr. Hawker will not be able to send, but only to receive, wireless messages. This is unfortunate, for in the event of a forced descent the machine would take about ten minutes to glide from a height of 10,000 ft., and there would be ample time to get into communication with any vessels in the vicinity. It is intended to drop the under-