LETTERS TO THE EDITOR.

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The Ionisation of Gases in the Schumann Region.

IN NATURE for June 12, Prof. Lyman discusses the evidence relating to the ionisation of air in the Schumann region, and concludes that ionisation of air can be produced by wave-lengths longer than λ1700.

The reasons why I consider that λ1350 is nearer to the limiting wave-length at which the ionisation of air sets in are as follows:—Using a discharge in hydrogen as a source of ultra-violet light and transmitting it through a quartz window (0·3 mm. thick), I was unable to get any ionisation in filtered air. I only obtained big effects with a certain piece of fluorite as the window. Another piece of fluorite which did not transmit the ionising light was transparent to about λ1350. Prof. Lyman's researches show that the hydrogen discharge emits very intense ultra-violet light distributed over a large number of wave-lengths between λ1200 and λ1600. Hence, with thin quartz, there was plenty of light available down to λ1450, but it produced no effect in my experiments. Similarly, wave-lengths down to about λ1350 produced no appreciable effects.

Lenard and Ramsauer used a very intense aluminium spark as their source of light, and found that the light from it transmitted through fluorite produced enormous ionisation in air. On the other hand, the light when passed through quartz did not produce any effect. According to Prof. Lyman's photographs, the wave-lengths available from the Al spark in air are a strong group of lines near λ1300, some weak lines near λ1500, and strong lines near λ1600 and λ1720–λ1800. Thin quartz cuts out the group λ1300, but allows the others to pass. We are not told explicitly whether the spark in Lenard and Ramsauer's researches was ever placed close to the quartz window to avoid air absorption; if so, the λ1500 and λ1600 groups would be effective. Fluorite, on the other hand, transmits the λ1300 group as well, and Prof. Lyman considers that the ionisation observed is probably due to these lines. He points out that my interpretation of his remarks, viz. that λ1300 represents the longest wave-lengths which are effective in ionising air, does not represent his views correctly. He considers that Bloch's recent work on the ionisation of air by a mercury lamp indicates that wave-lengths longer than λ1750 are effective.

I expect it will be agreed that by air we mean the usual mixture of oxygen and nitrogen free from all the more condensable gases. Lenard and Ramsauer found that ordinary dust-free air was certainly ionised by the light transmitted through quartz from their powerful source. It was only when very drastic methods of purification were adopted that the air was no longer ionised by the light transmitted through quartz. Although Bloch used dust-free air in his experiments, there is no evidence that he took the rigorous precautions which Lenard and Ramsauer assert are necessary to get rid of all the impurities which give rise to ionisation with comparatively long wave-lengths. In Bloch's arrangement, the mercury lamp was totally immersed in the stream of air, and consequently all the light emitted was available for ionisation, and hence the traces of impurities have every chance to be ionised. Bloch does not give any details, but I think the supports, insulated wires, &c., connected with the lamp inside the ionisation chamber might act as sources of impurities in Lenard and Ramsauer's sense.

If we consider the quantum theory of radiation to apply to ionisation of gases by light, then the energy available in the quantum, hn, must exceed the work V_0e required to separate an electron from a molecule. Palmer's experiments (*Phys. Rev.*, xxxii., p. 1, 1911) may perhaps be taken to indicate that the oxygen accounts for most of the ionisation in air. Taking the longest wave-length which ionises air to be λ1350, and $h=6{\cdot}55\times10^{-27}$, and $e=4{\cdot}65\times10^{-10}$, we get $V_0=9{\cdot}2$ volts. Now the ionising potential for oxygen according to Frank and Hertz is 9·0 volts. To maintain that λ1800 is nearer to the long wave-length limit implies that the quantum theory is not applicable to ionisation by light, for there is no reason to doubt the accuracy of the experiments of Frank and Hertz.

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The Microtropometer.

MANY roads to progress in physical investigation are brought to an abrupt end through the lack of measuring instruments of sufficient sensitiveness. In the attempt to bridge over one of these disabling chasms the writer was led to the following device, which appears capable of some development. The principle can be illustrated with reference to a particular case. Suppose we have a Boys's radio-micrometer, which we will call the secondary instrument. If we project on to the vane of this an image of a Nernst lamp filament the beam of light from the mirror of the instrument may be deflected through one thousand scale divisions. Suppose now that the image of the filament is 1 mm. wide, and that it is projected by the mirror of another radio-micrometer, which we may call the primary one.

It is evident that a movement of this primary image through a distance of 1 mm. can produce a movement of the beam of light from the secondary instrument through 1000 mm. Hence, a movement of the image of the filament cast by the primary instrument through 0·001 mm. would give a deflection of about 1 mm., and a movement of the primary image through 1/1,000,000 mm. would move the secondary image through one-thousandth of a mm. If now the secondary instrument be made to throw a similar image on to a tertiary radio-micrometer, the motion will again be magnified one thousand times, so that an original movement of a millionth of a mm. produces a final movement of 1 mm. Evidently by increasing the number of instruments in arithmetical progression we increase the magnification in geometrical progression.

I have applied the method to two radio-micrometers with very satisfactory results. The principle, however, can be applied to any instrument in which a beam of light is used as an indicator—*e.g.* the primary instrument may be a galvanometer, an electrometer, a double-thread-suspension mirror, or a string-galvanometer (in the last case the image of the string taking the place of the image of the filament). The secondary instruments may be radio-micrometers, thermo-couples, bolometers, selenium cells, or other detectors of radiation. It will appear, therefore, that the principle is one capable of wide application to cases in which great sensitiveness of measurement is required—from wireless telegraphy to physiology. In fact, we may say that any existing instrument which uses light as an indicator can be made more sensitive.

Practical difficulties arise from the impossibility of obtaining any instrument with absolutely constant zero; moreover, fluctuations in the intensity of the energy stream from the source of radiation, represented by the Nernst filament, would cause trouble