



LIX. The rôle of water vapour in gaseous conduction

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To cite this article: Professor Percival Lewis (1902) LIX. The rôle of water vapour in gaseous conduction , Philosophical Magazine Series 6, 3:17, 512-514, DOI: [10.1080/14786440209462796](https://doi.org/10.1080/14786440209462796)

To link to this article: <http://dx.doi.org/10.1080/14786440209462796>



Published online: 15 Apr 2009.



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The theory of the experiment does not admit of any accurate calculation of the permeability (μ) from the results, as the depth in the wire at which the magnetizing force has sunk to an insignificant fraction of its value at the surface itself involves μ . An attempt was, however, made to work out an approximate value for μ from the measurements obtained; and the mean of some ten values gave $\mu=110$ for a certain specimen of soft iron for about 10,000 oscillations per second. which is just about the value obtained by Klemenčič under similar conditions by a totally different method, but it is much smaller than that got by St. John for much more rapid oscillations.

In conclusion, may I offer my best thanks to Prof. F. Braun of Strassburg, in whose laboratory the experiments were carried out, and to Prof. M. Cantor, for their many kindnesses during the progress of the research.

Cavendish Laboratory, Cambridge,
March 1901.

LIX. *The Rôle of Water Vapour in Gaseous Conduction.*

By PROFESSOR PERCIVAL LEWIS*.

IN a recent number of this Magazine † Professor Trowbridge expresses his conviction that pure gases, hydrogen in particular, are perfect insulators, and that the presence of a trace of water-vapour or oxygen is necessary to produce the dissociation or other conditions upon which conduction depends. When we consider the more or less analogous phenomena of electrolytic conduction in solutions, this view does not seem improbable; but some facts may make us hesitate to accept the conclusion that water-vapour is so essential an agent in discharges through gases.

In the first place, some of the reasons given by Professor Trowbridge for believing pure hydrogen to be an insulator do not seem to me conclusive. He cites the fact, discovered by Schumann ‡, that hydrogen at atmospheric pressure seems perfectly transparent to ultra-violet radiation, as demonstrating that pure hydrogen is an insulator under all conditions. It may be that hydrogen has a finite but very small absorption-coefficient, no more noticeable within the limits of a laboratory than the absorption of carbon dioxide for visible radiation under the same conditions; but whether this be so or not does

* Communicated by the Author.

† Trowbridge, *Phil. Mag.* [6] ii. p. 379 (1901).

‡ Schumann, *Ann. der Physik* (1901).

not seem material, for we know that all fairly dry dust-free gases are insulators under ordinary conditions. It is still to be shown that pure hydrogen under electric stress in a vacuum-tube is an insulator.

Another reason assigned by Professor Trowbridge for holding hydrogen to be an insulator, is that when occluded by platinum or palladium the resistance of these metals is increased. It must be remembered, however, that alloys usually have a greater specific resistance than that of either of their constituents. Silver added to platinum gives an alloy with more than twice the specific resistance of platinum, yet no one can claim that silver is an insulator. Nor is the condition of hydrogen when occluded, or when liquefied, the same as that in vacuum-tubes.

In the second place, it seems that the complete removal of water-vapour from vacuum-tubes is perhaps possible, and that still the hydrogen or other gases contained therein may transmit the current and give their characteristic spectra. All who have worked with vacuum-tubes know how pertinaacious water-vapour is; but some experiments by Deslandres* and by the present writer† indicate that it may be effectively removed by the prolonged heating of metallic sodium in the tube. Deslandres states that only by such treatment could he cause the characteristic water-vapour lines to disappear from the spectrum of nitrogen, and it also causes the disappearance of that group of bands in the extreme ultra-violet spectrum of nitrogen attributed by Deslandres to an oxide of nitrogen, while the remaining part of the nitrogen spectrum was as bright as or brighter than before.

E. Wiedemann‡ heated metallic sodium in vacuum-tubes containing hydrogen or nitrogen. As the vapour-density of the sodium increased, its spectrum grew in intensity at the expense of that of the other gas; but on cooling the tube, the hydrogen or nitrogen spectrum reassumed its original appearance.

In order to again test the matter, the writer recently placed a quantity of metallic sodium in a vacuum-tube containing hydrogen. The sodium was repeatedly heated to drive off its more volatile impurities, and the tube pumped out and filled with fresh electrolytically prepared hydrogen. After the tube had been well covered with sodium "dew," it was closed. For two weeks it was frequently heated, and the spectrum examined by a pocket spectroscope. After heating, or in parts of

* Deslandres, *Ann. de Chim. et de Phys.* [6] xv. p. 46 (1888).

† Lewis, *Ann. der Physik* [4] ii. p. 465 (1900).

‡ E. Wiedemann, *Wied. Ann.* v. p. 517 (1878).

the capillary where sodium was most abundant, the hydrogen spectra, both simple and compound, were weak ; on cooling the tube, they both increased in intensity and showed no signs of approaching dissolution. The tube was finally accidentally broken, and on being immediately examined it was found that there were large patches of sodium with clean metallic lustre. Whatever other impurities might have been there, it is difficult to see how any free water-vapour or oxygen could have been present. Moreover, as the hydrogen spectrum had its full intensity at the first flash through the tube, it seems improbable that the current, first passing through the sodium-vapour, could have set free oxygen from any of its compounds present, thus enabling hydrogen to take subsequent part in the conduction.

Some experiments by Warburg* appear to have some bearing on this matter. He found that in a hydrogen tube containing some pure electrolytically prepared metallic sodium, the cathode fall of potential had a minimum value of 168 volts. With measurable traces of oxygen present the fall was 240 volts, gradually falling to a minimum of about 200 volts as the oxygen, after combination with the hydrogen, was removed by the ordinary drying-tubes. Only after the more nearly perfect drying produced by metallic sodium was the lower minimum reached. This indicates that, so far as the processes at the cathode are concerned (and here the current meets with the greatest opposition), the current can pass with more facility through perfectly dry hydrogen than through that containing traces of oxygen or water-vapour. In the case of nitrogen, Warburg found that small traces of these impurities lowered the cathode fall, but in dry nitrogen it had a definite upper limit. The writer has used one of Professor Warburg's nitrogen tubes, and although the gas had been in contact with sodium for about ten years, the current passed with ease and gave the ordinary spectrum of nitrogen.

It certainly seems impossible to eliminate all traces of impurity from vacuum-tubes, and it may be that one or more such impurities may take a very active and essential part in the processes which transform a gas into a conductor ; but if, under the conditions referred to, comparatively small electromotive forces can drive a current through hydrogen or nitrogen, it seems at least doubtful whether water-vapour is necessary to gaseous conduction.

University of California, Berkeley,
January 1902.

* Warburg, *Wied. Ann.* xl. p. 1 (1890).