XV. Electrification of air by water-jet

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To cite this article: Magnus Maclean M.A. F.R.S.E. & Makita Goto (1890) XV. Electrification of air by water-jet , Philosophical Magazine Series 5, 30:183, 148-152, DOI: [10.1080/14786449008621369](https://doi.org/10.1080/14786449008621369)

To link to this article: <http://dx.doi.org/10.1080/14786449008621369>

Published online: 08 May 2009.

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TABLE II.

Magnetizing force in C.G.S. units.	Temporary permeability in C.G.S. units of the unloaded wire at 12° C.	Ditto at 76° C.	Ditto at 167° C.	Ditto at 244° C.	Ditto at 285° C.
2.84	301	306	338	353	385
3.70	325	340	383	385	405
4.83	347	366	413		461
7.69	478	483	548		557
10.40	528	573	638		675
15.32	522				617

XV. *Electrification of Air by Water-Jet.* By MAGNUS MACLEAN, M.A., F.R.S.E., and MAKITA GOTO (*Japan*)*.

SIR WILLIAM THOMSON, experimenting in the rooms of the Old College, Glasgow, found that electrified air could pass through narrow passages, and he suggested to us to try whether electrified air can pass through a metal tube from one room to another. For this purpose a small room adjoining the Natural Philosophy Class-room of Glasgow University was used. In this room a Thomson quadrant electrometer, whose sensibility was 95 divisions of the scale, per 1 volt difference of potential, and a spirit-lamp supported on an insulating stand and connected to the electrometer, were fitted up. Through the handle-hole of the door separating the small room from the class-room, a metal tube 60 centim. long and 1 centim. in diameter and connected to a gas-pipe by a wire was passed. In the fireplace of the small room a small fire was kept burning to produce draught from the class-room to this room. The class-room was electrified by a spirit-lamp connected to one of the conductors of a large 24-plates electrical machine of Wimshurst type. By this arrangement we could observe any variation of electrification in the small room due to the passage of electricity from the class-room to it. We believe electrified air passed through the tube, but the effect was masked by the draughts

* Communicated by the Authors.

through the chinks, though we took care to close all chinks in the door by cotton-wool. Also, if the electrifying lamp connected to the electrical machine were placed nearer than 3 feet from the door between the two rooms, inductive effect was felt in the small room.

We therefore adopted an arrangement shown in fig. 1. AA is a large sheet-iron vat 123 centim. in diameter and 70

centim. in height inverted on a large tray BB. By filling the tray with water the air is confined in the vat. The jet-tube of a water-dropper C passes through the centre of the top of the vat. The water-dropper was fixed in its position by a piece of ebonite and melted paraffin poured round it, so that it is insulated from the vat, which is always kept connected to water-pipe for earth. By connecting the tube D to an aspirator the air inside the vat could be replaced by the air of the room through the tube E, which is a metallic tube or a glass tube coated with paraffin both inside and outside of the tube, and filled with cotton-wool. By this arrangement we could easily make electrified air pass through the metal tube, but with the cotton-wool tube the results were discordant, therefore we are not yet in a position to say anything definite.

While these experiments were proceeding we came unexpectedly on an interesting result. It was found that the potential inside the vat, as shown by the water-dropper on the top of the vat, and connected to the electrometer, was always about $\frac{1}{2}$ volt positive at the beginning, and gradually changed towards negative till 5 volts negative was reached in about half

an hour. To make it sure we made more than 15 observations under different conditions, but always with the same result, and we came to the conclusion that the water rushing through the air electrifies it negatively, at least it does so electrify common air full of dust. This result is in accordance with the well-known change of atmospheric electricity to negative during rainy weather.

The following are the results which prove our conclusion :—

(1) After negatively electrifying the air inside the vat by making water drop through it for some time, if it is replaced by the air outside of the vat, the electrometer-reading comes down towards zero.

(2) Simultaneous observations of the electrification of the air inside the vat by the same means and of the air in the room were made. After about 13 minutes the former exceeded the latter, though at that time the air of the room was being electrified negatively by the paraffin lamp used in reading the scale.

(3) After starting the water-dropper and taking the electrometer-readings for some time, say 10 minutes, if it is stopped say for 10 minutes and again started, the initial reading is the same as that just before the interval of stopping, and it again continues to go up.

(4) Whether the water-dropper was insulated or connected to water-pipe by a wire, by connecting it to the electrometer for taking the reading it shows that the negative electrification of the air inside the vat goes on increasing for about half an hour.

(5) No difference in the result was found after painting the inside of the vat. Before painting it presented the surface of rusted iron.

(6) Whether the vat is filled with air electrified positively or negatively before the observation, the electrometer-reading equally goes towards the negative side.

(7) The maximum potential obtained was $5\frac{1}{2}$ volts negative, but the more the air became free of dust the less became the maximum reached. This is shown by the curves in fig. 2. The curve No. 1 was obtained by observation after filling the vat with the air of the room. The curve No. 5 was obtained after continuous running of the aspirator for about 25 hours. Intermediate curves correspond to the intermediate state of the air as to its purity. In the curve No. 2 the water-dropper was running for some time before beginning the observation.

(8) After putting water into the water-dropper and wait-

ing as usual till the water-dropper comes to equilibrium, the initial reading is always about $\frac{1}{2}$ volt positive. This we are inclined to regard as due to the electrification of water itself and not to the potential due to the internal arrangement. This initial reading also increases little by little as the air becomes more purified.

Fig. 2.

In the course of these experiments we have observed the following phenomena, which may be of some interest :—

(1) If the air of the room is very highly electrified, continuous sparks can be drawn from any insulated conductors by presenting finger.

(2) Electrified flame is attracted or repulsed as any other electrified body. Flame electrified by the large electrical machine before mentioned takes different shapes according to the position with respect to other conducting bodies either

electrified or connected to the earth. Small spirit-lamp made of metal and put on the positive conductor of the electrical machine is extinguished by the repulsion, but not so easily when it is put on the negative conductor.

XVI. *An Electromagnetic Theory of Quartz.*

By A. B. BASSET, M.A., F.R.S.*

1. **T**HE rotation of the plane of polarization of light by a magnetic field, although presenting several features in common with the rotation of the plane of polarization by syrup or quartz, is a phenomenon of a totally distinct character, which depends upon the existence of an external magnetic force, and disappears as soon as the magnetic force is removed. A theory of magnetic rotation is given by Maxwell†, and some extensions have been made by Fitzgerald‡; but it is, I think, pretty obvious that Maxwell's theory will not apply to syrup or quartz; for the additional terms consist of the products of the magnetic force and the differential coefficients of the displacements, and are therefore terms of the second order when the magnetic force is produced by optical and not by external causes.

On the other hand, rotations produced by syrup and quartz appear to be phenomena of an essentially similar character, and therefore a theory which explains one ought to explain the other; and the object of the present paper is to endeavour to show how the electromagnetic theory may be extended so as to account for these phenomena.

2. Let us conceive a medium which possesses three rectangular planes of symmetry, and which produces rotatory polarization when a plane wave of polarized light travels through the medium parallel to any one of the axes of symmetry, and elliptic polarization when the wave travels through in any other direction, the values of the rotation per unit of length being different for each of the three axes. The physical properties of the medium, so far as rotatory polarization is concerned, will be specified by three constants, p_1, p_2, p_3 , which depend upon the amount of rotation produced when the direction of propagation is parallel to any of the three axes. In an isotropic medium the three p 's will be equal, since the rotation is independent of the direction of the wave; whilst in quartz two of the p 's must be zero, since no rotation will

* Communicated by the Author.

† Electricity and Magnetism, vol. ii. chap. xxi.

‡ Phil. Trans. part ii. 1880, p. 691.