

ART. VII.—*A New Emission Theory of Light*; by JOHN TROWBRIDGE.

It is interesting to imagine how Sir Isaac Newton would have rehabilitated his corpuscular Theory of Light if the Electron Theory had been enunciated during his lifetime. Might he not have answered the objection to his theory that light travels slower in fluids than in air by the assumption that the infinitely small electrons could pass between the atoms of the fluid and in so doing give up a portion of their energy to these atoms by setting them in vibration, thus producing absorption spectra which arise in all fluids on the transmission of light. Might he not, also, if the vortex theory of motion had engaged the attention of the mathematicians of his time, have provided his corpuscles with a whirling or vortical motion? In the periodic motion of the negative electron along a helical path, he could have supposed an apparent wave motion; and in the repulsion of neighboring vortices perhaps he could have abolished the conception of an elastic ether.

In thus imagining a new light dawning upon a mind which was capable of penetrating great secrets of the universe, I am emboldened to offer a hypothesis which may serve to lead us back to an emission theory of light, and at the same time enable us to relegate the ether to the phlogiston, the caloric, and the two fluid theories of electricity.

In the rough this theory supposes that negative electrons are shot forth from the sun in helical vortices, and in their progression provide an apparent periodic wave motion, giving, according to Maxwell's Electrodynamie Theory of Light, a pressure in the line of propagation and a tension at right angles to this line. A magnetic effect is a plane at right angles to the electrostatic effect, a repulsion between neighboring vortices which would simulate the supposed elasticity of an ether. The circular helices might become elliptical helices in passing through doubly refracting substances, and interference of light could be provided for. In support of this theory it may be urged that vortical motion is as common as rectilinear motion. The observer of the sun's surface is as conscious of vortex motion in the sun's spots as of the rectilinear uprush in the protuberances. The atomic theories are being recast to embrace the effect of supposed vortical motions. Speculation has gone so far as to suppose that atoms are mere whirls in a supposititious ether. A recent distinguished physicist has supposed that the negative electron is not matter and is provided with a vortex tail or tails to account for electrical lines of force. In this hypothesis, we appear to have two intangible essences

tied together. Can we blame the metaphysicians for smiling, and saying "You physicists are coming into our ranks"? But are we not supplanting the hypothesis of a fluid which fills all space, a fluid which is thinner than any gas, a something which has no resemblance to anything of which we have cognizance and which is more elastic than steel, by another fantastic hypothesis? We have, however, given up the fluid theories in electricity and instead of media we have motions of electrons. Light is an electro-dynamic phenomenon, and the hypothesis I frame extends the motion of electrons from the confines of electrical circuits to the extent of space.

I have said that we have abandoned the fluid theories of electricity. This is true of the two fluid theories; but we see some merits still in Benjamin Franklin's one fluid theory, in the light of the electron theory. Franklin accounted for attraction and repulsion by an excess or diminution of a fluid. His theory could become an electron theory if instead of an excess or deficit of a fluid we read excess or deficit of negative electrons. The attachment or detachment of the negative electrons explain in a plausible manner the fundamental experiment of the attraction or repulsion of electrified pith-balls. Can we extend the modified Franklin theory to account for magnetism and diamagnetism? We should be able to do this, for as Maxwell remarks: "Every phenomenon in electrostatics has its analogy in magnetism."

To answer this question I am led to the subject of canal rays, which has greatly interested me;* for in this phenomenon we are brought into close consideration of what is perhaps the most important question in the theory of electricity: "What is positive electricity?"

The negative electron has been identified in the discharge from the negative cathode in Geissler tubes and the positive rays proceeding from orifices in the cathode—the so-called canal rays—are supposed to be a phenomenon of the positive electrons. To account for the positive rays we have a multitude of theories of combination and neutralization of single entities and doublets. From the cathode in a Geissler tube, at a suitable exhaustion, proceed negative electrons from every unit of surface both toward the positive terminal of the tube and toward or into the region where the canal rays manifest themselves, that is away from the positive terminal and back of the cathode. The canal rays appear to emanate from the canals or perforations in the cathode, and also proceed in both directions, one toward the positive terminal and the other in the direction away from the terminal.

*Proc. Am. Acad., xlv, No. 19. Ibid., xliii, No. 20.

We find that the negative electrons exhibit the greatest penetrating and impulsive effects. They are extraordinarily sensitive to a magnetic field; whereas, the positive rays are comparatively insensitive and require a strong magnetic field to affect them, which is in the opposite direction to that taken by the cathode rays or streams of negative electrons.

If we adopt Franklin's hypothesis of excess and deficit and make the assumption that all space is filled with negative electrons, which pass through matter, modifying atomic movements, we might suppose that the positive discharge in a Geissler tube is due to an effort of the electrons of space to re-establish an electrical equilibrium disturbed by chemical action of a battery or the motion of a dynamo. This disturbance appears to be shown in more Protean ways at the cathode than at the anode. The stream of negative electrons in passing through the glass of the Geissler tube communicate some of their energy to the atoms of the rarified gas, aiding perhaps the cathode electrons in driving the atoms in both directions from the perforations in the cathode, thus causing the Doppler effect, and transforming their ultra-violet radiations into longer wave lengths, and the diminished velocity of the wave lengths of the visible spectrum. The positive column of the discharge in Geissler tubes may also be regarded as the effect on the atoms of the gas of the electrons entering from outer space to re-establish the electrical equilibrium, disturbed by the agency which produced the electric discharge in the tube.

But how shall we explain the effect of a magnetic field on the positive rays? The electrons of the cathode do not appear to affect the canal rays, although the directions of both the retrograde canal rays and the direct canal rays coincide with the directions of the cathode rays from the two surfaces of the cathode. Experimenters have always been careful to drive the cathode rays out of the field before applying a magnetic field to the positive rays. Is it not possible, however, that negative electrons can be so entangled among the atoms of the gas that the effect of a magnetic field on the motion of these atoms and the effect on the electrons of the environment which come from outer space, and not from the local electrical disturbance, might produce a deflection of the atoms in a direction opposite from that taken by the cathode rays? We appear to have an analogy in magnetism and dia-magnetism. We can suppose that the magnetic metals afford a greater receptivity to the vortical motion of the negative electron of space than the non-magnetic metals, or that the energy of the electrons is less consumed in iron than in copper. The strong magnetic effect necessary to produce an apparent effect in deflecting non-magnetic metals may be

regarded, as in the case of the canal rays, of a balance between the effect on the atomic motions and the effect on the environment. The difference of phosphorescent effect of cathode and positive* rays is mainly a question of energy and not a difference in kind.

As I have previously remarked, our experiments on electrons in Geissler tubes are conducted in an environment filled, on my hypothesis, with electrons. The magnetism of the field is also an exhibition of a certain selectivity of path of the electrons of outer space.

If the sun is constantly throwing forth negative electrons, it is, according to Franklin's hypothesis, being positively charged every instant, and recharged, perhaps from the electrons of outer space. Every flame throws off negative electrons and is constantly being reduced to a positive state. Perhaps in this interchange we can trace the intermittent action, amounting to billows of pulses, of the waves of light. If we examine the tendencies of Physical Science from the time of Sir Isaac Newton, we see a tendency to abandon intangible media and to base all phenomena upon the motion of matter. Indeed, I am tempted to paraphrase Tyndall's much-quoted remark, that we may be led to discern "in matter the promise and potency of all terrestrial life" † by substituting motion and matter for "in matter." It has become a serious question, how the physicist, in entertaining a belief in an intangible ether, the whirls of which constitute matter,—a belief that electricity is another intangible something not matter, in an electron which is an essence with an essential tail tied to it by a knot of something thinner than any gas,—can escape being welcomed into the ranks of the metaphysician and philosopher. To escape this suppression of his identity, I believe the physicist must resolutely cling to a belief in both motion and matter.

* It may be suggested that the effect of magnetic fields on non-magnetic metals is feebler than that on the positive rays. An atom of gas, however, has a finer suspension than any we can accomplish in the case of a metallic filament.

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