THE FOURTH STATE OF MATTER.

A REFUTATION.

Translated for "SCIENCE" by Gustave Glaser, Phil. D.

It may interest the readers of "SCIENCE" to know the opinion held in Germany respecting those phenomena which led Mr. W. Crookes to believe he had discovered a fourth state of matter. For this purpose we have translated and abridged an article by Dr. J. Puluj, the well-known scientist of Vienna, published in the "*Chemiker Zeitung:*"

According to Mr. Puluj, the beautiful experiments of W. Hittorf published in 1869, under the title "Electrical Conductibility of Gases," have received too little attention from our scientists, it may be, on account of the modest title. The scientific labors of Goldstein, and some interesting researches of Reitinger and Urbanitzky have met with the same fate. W. Crookes, the renowned English chemist, to whom the writings of the above-named gentlemen were evidently unknown, made similar experiments, the results of which did not differ essentially from those of Mr. Hittorf. His conclusions were, however, entirely new; he declared that his experiments proved a fourth state of matter.

The conception was daring, still more daring the hopes which he and his friends based upon the discovery of "radiant matter." The cause of these high expectations is the following: When an electrical inductive current is led through a molten glass tube in which the air is attenuated to $\frac{1}{1000}$ of its density, there appears on the negative pole a blue (glimmering) light, which is separated by a dark space from the cluster of light at the positive pole. If a greater attenuation takes place, the cluster of light disappears and the glimmering light floats over the whole tube, while at the same time, next the electrode a second dark space appears which becomes greater with the greater attenuation. If the attenuation still further increases, the dark space fills the whole tube and the glass walls shine in a brilliant, green, phosphorescent light. Mr. Crookes now believes that this phenomenon of phosphorescence comes from the remaining gas, which at this high state of attenuation has passed into an ultra-gaseous state, a "fourth state of matter."

But these phenomena are very different at a higher pressure. Direct measurements have shown that the phosphorescence does not appear at the millionth attenuation, and that the thirty thousandth attenuation is sufficient to produce it. Besides, this attenuated gas retains its characteristic properties, which could not be the case if by this attenuation it became dissolved into the original molecules which form, as Mr. Crookes says, the basis of all.

That the physical properties of this remaining matter are not changed, but remain in strict accordance with the kinetic theory of gases, also proves that we have no new state, but simply a gaseous state of matter. For example, the above-mentioned phenomena, in experimenting with the lighter gases, are visible at a lower altenuation than in experimenting with the heavier gases. The supposition of the renowned chemist, Dumas, that our elements are only chemical combinations of higher order, and complicated aggregates of primitive molecules, has, undoubtedly, much probability about it, but even the strongest electrical currents, and the highest temperatures, have not been able to produce this final dissolution of the elements, therefore it is not likely that a high attenuation can.

Dr. Puluj's experiments go to show that Mr. Crookes' so-called radiant matter "consists of negative electric particles," which are torn off from the negative electrode and hurled away with immense rapidity. These electrode particles form a very beautiful metallic mirror on the glass walls. [Aluminum particles are the only ones which form no metallic deposits. This may be accounted for by their chemical constitution.] The conduction of the current, therefore, is effected by the convection of the electrode particles, in which static electricity is accumulated. We have here a case of molecular electric convection, analogous to that observed by Mr. Rowland in his experiments. This gentleman has demonstrated that when a movable horizontally placed metal ring, charged with static, positive or negative, electricity is made to rotate around a vertical axis, it will divert a magnetic needle suspended above it, in the same manner, as if an electric positive or negative current were to move in the same direction with, or in an opposite direction from, the rotation. These experiments of Rowland lead to the inference that an infinitely small electrical globe, in our case an electrode particle, will have a similar influence upon a magnet. As long as the globe and magnet are at rest, it is to be expected that no alternate effect will appear, but that this will be produced as soon as the little globe is put into violent motion. Because the electrode particles are negative electric, they represent a positive electric current, which moves in an opposite direction from the former. The electrode particles in motion are, therefore, real elements of an electric current, and are subjected to the law of Laplace. Their deviation takes place according to the following simple law: If we imagine that a plane is placed through the direction of the motion of the electrode-particle and through the north pole of the magnet, and suppose that a man is lying upon this electrode particle in the direction of the motion, and looking towards the north pole, then the electrode-particle will be diverted towards the left hand of this man, vertical to the imagined plane. This simple law gives a sufficient explanation for all the phenomena which a magnet produces in the radiant electrode-matter, and which were observed by Mr. Crookes as well as by Mr. Reitinger and Urbanitzky. It proves that the glimmering light at the negative pole is not a "magnetic" light, but the consequence of a molecular electrical convection, and it justifies the supposition that an electrified current or vapor which is led through a tube will deviate the magnetic needle in the same manner as an electrical current going through a telegraph wire.

The law of the indestructibility of force has already solved many problems which puzzled the scientist of earlier centuries. According to the same law, we must assume that when infinitely small projectiles of radiant electrode matter are hurled against the glass walls of the tube their motion is changed into molecular motion, and the glass walls are heated by the collisions, sometimes even to the melting point; but at a lower temperature the rays which are not very much concentrated only produce a phosphorescent light of the glass.

The extremely fine matter called ether, which fills all space and pierces all bodies, surrounds the molecules, as the atmosphere surrounds our globe. Each body and each molecule has in its normal state a certain quantity of this ether. When this quantity is greater than the normal quantity, the molecules, according to the "unitarian view" of elasticity, are positive electric; when it is smaller, they are negative electric.

Supposing now that a collision takes place between the negative electrode particles and the molecules of the glass walls of the tube, then the equilibrium will be restored at each point of collision and the molecules of the glass will lose their surplus of ether. At the same time a motion of the waves of ether will be observed, and this motion is felt by our optical nerves as phosphorescent light. Therefore the phosphorescence observed by W. Crookes is the result of the restoration of the ether-equilibrium and not of the heating of the glass, whose temperature during the appearance of this phenomenon is comparatively low.

At a lower degree of attenuation, the stream of electrode matter pushes back the attenuated gas, and this explains the dark space which appears in the tube. This dark space is analogous to the dark space in a gas flame, which is to be seen near the mouth of the gas tube, and is produced because the outstreaming gas pushes back the particles of air which, coming from an opposite direction, try to enter the tube.

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Another observation of Mr. Puluj also contradicts the conclusions of W. Crookes. Puluj has observed that, at a higher attenuation, the electrode is moving towards the aluminium side, *i. e.*, in opposite direction from that observed by W. Crookes. According to Mr. Crookes the cause of motion is a double one, the higher temperature of the electrode at the metallic side and the emission of electrode particles.

Both effects are opposite. At a lower attenuation the effect of the heat is greater, and the electrode moves in the direction of the wings of the radiometer, with the colder side ahead, at a higher attenuation, the effect of the emission of electrode particles is predominant. Radiant electrode matter and the electrode itself move in the *same* direction.

This remarkable discovery proves not only the incorrectness of Mr. Crookes' explanation, but is also in direct opposition to the principle of the preservation of the centre of gravity, which is made by Mr. Crookes the basis of his arguments.

The Vienna scientist draws from his observations the conclusion that the forces by which the electrode particles are torn off are not interior but *exterior* forces. When the electric current passes through the electrode, there is, according to his opinion, really a stream of extremely fine matter (ether) flowing, which not only tears off particles of the electrode, but also sets the whole electrode into motion.

This view seems to be a new proof of the unitarian hypothesis, which maintains that an electric current is nothing else but a current of ether.

Even if the number of scientists who follow the dualistic hypothesis of electricity is by far greater than that of the Unitarians, the view of the latter deserves at least our attention, especially when such men as Franklin, Secchi and Edlund approved it.

THE MAGNET IN MEDICINE

Translated for "SCIENCE" by Thos. B. Columbia.

Some recent researches made under the direction of Prof. Charot in his laboratory at the Salpêtrière have drawn attention anew to a therapeutic agent known for a long time, but to-day almost abandoned. We find, in fact, even in the works of the oldest authors, traces of attempts made by physicians to apply the magnet in the treatment of disease.[1] But the want of precise rules in its application and the appearance of mystery and of fancy which is attached to this kind of research explain the discredit into which this means of treatment has fallen.

We are indebted to Prof. Maggiorani for having undertaken, in about 1869, the restoration of magnetic therapeutics, by seeking to establish it upon rational and truly scientific principles.

It was in the train of the experiments undertaken by the Commission appointed by the Biological Society, of Paris, with the object of verifying the facts collected by M. Burq under the generic title of Metallotherapy,[2] that the first attempts toward the application of the magnet were made at the Salpêtrière. After the results obtained by the application of metals, it was natural to seek to clear up the singular phenomena by varying as much as possible the conditions of the experiment. In this way it was shown that the plates of the different metals were not the only agents capable of acting upon a certain class of diseases (neuroses, and particularly hysteria, organic affections of the cerebral nervous system). Similar results were attained with many physical agents: feeble currents, statical electricity, vibrations of sonorous bodies, differences of temperature, magnetized bars, electro-magnets, solenoids, etc. Very soon the magnetic bars were noticeable for the constancy of their action and facility of their use.

Magnets are, therefore, not endowed, from this point of view, with specific properties; they form part of a group of physical agents which, to different degrees, possess the same power of impressing the nervous system and of giving rise to biological phenomena; and although magnets are here particularly spoken of, it must not be forgotten that they are not the only ones concerned.

The status of the question has been clearly exposed by Dr. Vigoroux in the *Medical Annual* (1879). To this article I must refer those who wish to become acquainted with the *ensemble* of phenomena, which are included under the name *metalloscopic*. These studies, begun at the Salpêtrière, have given rise to active discussions. The facts announced have been confirmed, wholly or in part, in Germany by Müller of Grätz, Westphal, Vierordt, Schiff, Adamkiewicz of Berlin; Benedick of Vienna, Rumpf of Dusseldorf; in Italy, by Seppilli, Maragliani, and especially Maggiorani; in England, by Gamgee, Sigerson, H. Tuke; in France, outside of the work of the Commission, I will mention only the thesis of M. Aigre and the observations of MM. Dumontpallier, Vigouroux, Landouzy and Debove, who have verified the therapeutical action of the magnet. But the results obtained were sharply attacked on the other side of the Channel by Hughes, Carpenter and Noble, who attempted to explain them by "expectant attention." In a thesis read before the Faculty of Medicine of Paris in 1878, Mr. Oscar Jennings made himself the champion of the ideas expressed by these English writers.

As to what relates to the magnet itself we are going to show, summarily, the arguments upon which are based its physiological action and its therapeutical use.

The action of the magnet, among effects produced by other physical agents of which we have spoken (plates of different metals, electricity, vibrations of the diapason), presents itself in a more surprising way, and, indeed, in a way *à priori* prone to excite incredulity. The application is not direct. The magnet is not placed in contact with the skin of the subject upon whom the experiment is tried, as it is necessary to do with other metalic plates, its action being exerted at a distance. It is sufficient to influence the organism, and produce the same effects as other metals, to place the magnetized bar at a distance of one to two centimetres from the portion of the body upon which we wish to make an impression. All the experiments at the Salpêtrière have been made with these conditions. The effects produced in these cases were not attributed to the action of the metal, and belong properly to magnetism itself.

The magnet, let us say, acts in some way on the organism when in these special morbid conditions. Before speaking of the facts which prove peremptorily that this action exists, can we not, if not explain it, at least conceive of the possibility of such an effect. The action of

[1] Among the authors who have given attention to the action of the magnet in medicine, we may cite: Pliny the Younger, Paracelsus, Albert the Great, the older Hell (1770), Mesmer (1779), Andry and Thouret (1780). Becker (1829).

[2] See *La Nature*, Feb. 17, 1877.