

over, we find an equal symmetrical diminution of evident external polarity until we arrive at neutrality, when it has no external trace of inherent polarity, but its inherent polarity at once becomes evident by a simple return to its former position. Thus the rod has passed through all the changes from polarity to neutrality, and from neutrality to polarity, and these changes have taken place with complete symmetry.

The limits of this paper do not allow me to speak of the numerous theoretical evidences as shown by the use of my induction balance. I believe, however, that I have cited already experimental evidences to show that what has been attributed to coercive force is really due to molecular freedom or rigidity; that in inherent molecular polarity we have a fact admitted by Couloumb, Poisson, Ampère, De la Rive, Weber, Du Moncel, Wiedermann, and Maxwell; and that we have also experimental evidence of molecular rotation and of the symmetrical character of polarity and neutrality.

The experiments which I have brought forward in this paper, in addition to those mentioned in my paper read before the Royal Society, will, I hope, justify me in having advanced a theory of magnetism which I believe in every portion allows at least experimental evidences of its probable truth.

The PRESIDENT: For the last 2,000 years man has been asking nature, What is magnetism? and endeavouring by every means in his power to solve the mystery. Little by little our knowledge has been extended, and Professor Oersted in 1819 proved, by inductive reasoning, that a conductor of electricity, while a current was flowing through it, had all the properties of a magnet. That was a grand and most useful discovery, for without the knowledge of the laws then opened up our present system of electric telegraphy could never have existed.

Professor Oersted's discovery is well illustrated in the principle of Sir Wm. Thomson's siphon recorder, as used for signalling through long submarine cables. Imagine the conductor of a cable terminating in a coil of fine wire, suspended like the float at the end of a fishing rod, but placed in a strong magnetic field

instead of water. The light coil thus suspended becomes magnetic when the slightest current of electricity is passing through it, and is consequently deflected to the left or right, according to the direction of the current.

I will mention an experiment lately made by me, which I think favours Professor Hughes's observations on the molecular theory. If a flat spiral of copper wire be placed in circuit with a battery and suitable contact breaker, then any piece of iron placed in the neighbourhood of the spiral will emit a sound at each make or break of the battery. Recently I placed in front of a spiral so connected, a sheet of thin iron fastened to a sounding-board on which was placed a microphone. The microphone was then connected, as usual, to a battery and telephone, and on setting the contact breaker (an automatic tuning fork transmitter) to work, the pitch of the tuning fork was clearly reproduced in the telephone, the molecular vibrations of the iron plate being sufficient to affect the microphone.

I have often endeavoured to picture to my mind the sensation that must have been caused by Professor Oersted's discovery, but I think that what Professor Hughes has shown us this evening will be as equally exciting. I have never listened with more satisfaction to the reading of any paper than I have this evening; and I am sure that it is almost unnecessary for me to call upon you to give a hearty vote of thanks to Professor Hughes for his kindness in bringing before us the results of his investigations.

Professor W. GRYLLES ADAMS, F.R.S.: I entirely agree, Sir, with the remarks which have fallen from you as to the value of the paper we have just heard. It possesses one great merit, in that it puts before us very clearly the different theories of magnetism which have been propounded by Poisson, by Coulomb, by Ampère, by Weber, and by Wiedemann. The first part of the paper is a résumé of the different theories of magnetism, which Professor Hughes proceeds to clear away to make room for his new theory. The principal point of his theory is contained in his fourth statement, that "when we have external neutrality, or no apparent magnetism, the molecules or their polarities arrange themselves so as to satisfy their mutual attraction by the shortest

path, and thus form a complete closed circuit of attraction." Thus he gets rid of the notion that the molecules of a magnetic substance have their magnetic axes pointing in any direction indifferently when the substance is not magnetised. This is a very important point in theories of magnetism, and Professor Hughes's experiments go a long way in support of his position, that in a state of neutrality the molecules take the position which they would freely take under the action of the earth alone. Some of the experiments which Professor Hughes has brought forward are quite explained by the previous theories as to the relation between currents and magnets, and are at the same time very pretty illustrations of the relation to the principles of energy.

In one experiment Professor Hughes showed us the effect of mechanical torsion on a wire through which a current of electricity was passing: when the wire was under torsion the current deflected a magnet which was placed at right angles to the wire. This result is entirely explained by the ordinary laws of the action of currents on magnets. When there is no torsion, the current is everywhere parallel to the length of the wire, but when the cylindrical wire is twisted, the generating lines of the cylinder take the form of a helix (say, a right-handed helix) and are pulled in the direction of their length: the result of this is that the electrical resistance is increased in the direction of this right-handed helix, and consequently the current flows in a left-handed helix, crossing the generating lines.

The lines of magnetic force of the current will no longer be at right angles to the length of the wire, and so the magnetic needle at right angles to it is deflected. This is very well illustrated by a pretty experiment first made in my laboratory, by Mr. Bottomley and myself, some years ago. A brass tube was firmly fixed at one end and placed at right angles to the magnetic meridian; a magnetic needle with a mirror attached, as in a reflecting galvanometer, was suspended within the tube; a scale and lamp were placed opposite the open end of the tube, to which torsion could be applied by means of two arms projecting from the end. On sending a current along the brass tube, the magnetic needle within it was not deflected, but on

applying torsion to the tube whilst the current was still on, the needle was immediately deflected.

Professor W. E. AYRTON, F.R.S.: All of the experiments made by Professor Hughes have interested me very much, but that part which referred to the reaction of the magnet on the current had especial interest. In 1872 a somewhat similar idea struck me, viz., that if you were to act magnetically on a wire you would probably change the path of the current, and so alter the resistance of the wire. For that purpose (I was at Messrs. Hooper's works, Millwall, making certain tests on the Great Western cable at the time) I had constructed a coil of iron wire, by the side of which an insulated copper wire was placed, the object being to ascertain whether the resistance of the iron wire was not altered by being transversely magnetised. Some preliminary experiments showed that a certain change was produced in the ordinary electric resistance of an iron wire by keeping it in a constant state of transverse magnetism—that is to say, the facility for electricity to pass along the iron wire was altered by being magnetised. Having to leave at the beginning of 1873 for Japan, I was unable to complete those experiments, and therefore the numerical results were never published, although the fact, I believe, gained publicity. Since that time far more elaborate experiments have been carried on at King's College, and also by Beetz and by De Lucchi, and some very perceptible changes in the electric resistance of iron wires by magnetising them have been observed. Professor Hughes' very pretty experiment, showing the action on the current due to the molecular magnets composing the bar, of course gives additional confirmation to this idea.

I do not know that I quite understand the exact arrangement he imagines for the little molecular magnets when the bar does not show any trace of magnetism. Perhaps Professor Hughes will be so kind as to add a word or two on this point. I would ask him what is the exact arrangement he pictures in his mind's eye as being taken up by the molecular magnets when the bar is not magnetised? When, for example, you have a very thick iron rod on which the effect of the earth would not be felt by the

experimental inside bar, I would ask what he then thinks is the arrangement of the molecular magnets in an iron bar inside such a room ?

Professor Hughes' experiments are certainly very novel and most interesting, but may, I venture to think, be explained in accordance with the older theories of magnetism. One of Professor Hughes' objections to Ampère's theory of magnetism is "that we have no knowledge of any elementary electric currents continually flowing without any expenditure of energy." But we all, I presume, admit that the molecules in any body are in a state of rapid vibration and possibly of rotation; consequently, if they possess static charges of electricity, the rotations of the molecules will cause these charges to act like currents, and without any expenditure of energy. I do not, of course, say that this is the explanation of magnetism, but I would point out that it is quite in conformity with Ampère's theory of magnetism.

Professor D. E. HUGHES, F.R.S. : In reply I would say that I quite agree with Professor Adams, who has very kindly explained the true mechanical operation which really takes place. I was afraid that time would not allow me to go into the explanation, but it is clearly shown in Wiedemann's book that every molecule is capable of turning in a spiral to 45° , when a rod is under the influence of torsion.

As regards Professor Ayrton's remarks regarding the mutual action of magnetism and electricity, I quite agree with them, as I have shown that the action and reaction on each other is equal. If a magnetic needle, or even a molecule, is perfectly free, then the current rotates the magnetic needle, but if the needle or molecule is rigid and cannot turn, then the electricity is deflected, producing the results I have shown this evening.

Professor Ayrton asks a very pertinent question regarding neutrality, but I believe he will find the answer to his question in my paper, where I have shown that we cannot obtain perfect neutrality in soft iron whilst under the influence of the earth's magnetism, but that we can produce a perfect external neutrality when the molecules form a closed circle of mutual attraction, as in circular or superposed magnetism.

If it were possible to place a piece of iron in a perfect neutral field, free from the earth's directing influence, then the molecules would react upon each other, through their mutual attraction, producing the closed circuit of mutual attraction, as I have already shown.

The PRESIDENT: The time has now arrived for us to close, and I have to remind members that a ballot will now take place, and then the meeting will adjourn to the 8th of November. The vacation appears a very long one, but I think that what we have heard this evening will provide sufficient entertainment to last us until we meet again.

At the conclusion of the ballot it was announced that the following were elected:—

As Foreign Members:

Eric Gerard. | Hermann Sedlacek. | Julius Timm.

As Member:

Edward Tyer, F.R.A.S., F.R.G.S.

As Associates:

John Bailey, jun.		Colonel George E. Gouraud.
Leslie C. Bell.		Henry Sutton.
L. Binet.		Edwin C. Wallis.
Lieut. A. E. Wrottesley, R.E.		

As Students:

Pedro Juan Gomez. | Alfred Edward Ruddock.

The meeting then adjourned until November.