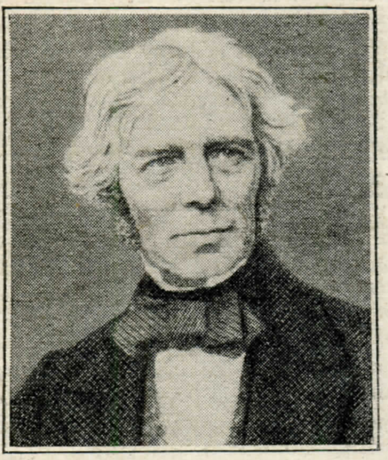
Magnetism and Electricity in 1832

FARADAY AND THE PROPAGATION OF ELECTRO-MAGNETIC FORCES. — A Newly Discovered Document



1791-1867.

THE recent opening of a letter written by Michael Faraday in 1832 has resulted in the discovery of a document of considerable historic interest, in that it has added materially to our knowledge of the early history of electricity and wireless. The importance of Faraday's researches on the subject of electro-magnetism is retold in this article

By G. R. M. GARRATT, M.A.

FOR more than one hundred years an historic document, with its red seal unbroken, has lain in the safe of the Royal Society. Its existence has, of course, been known to successive Secretaries, but until very recently the directions upon its outside—"to be deposited (by permifsion) unopened for the present"—have been rigidly respected, and thus its contents have remained unknown. As the photograph of the exterior shows, it was written by Faraday on the 12th of March, 1832, and it was received from him by the Secretary of the Royal Society on the same day. A month later—on the 12th April, 1832—it was deposited in the strong box by the assistant secretary, Peter Mark Roget, whose initials appear on the outside, and it is of interest to note that the consent of the Council of the Royal Society to the receipt and custody of "a sealed packet from Mr. Faraday" is recorded in the Society's Minute Book of the period.

It was recently decided that sufficient time had elapsed to justify the examination of the contents, and it was accordingly opened by Sir William Bragg, the President of the Royal Society, in the presence of the Council. The following is the complete text of the document:—

"Royal Institution,"
March 12th, 1832.

"Certain of the results of the investigations which are embodied in the two papers entitled, 'Experimental Researches in Electricity,' lately read to the Royal Society, and the views arising therefrom, in connexion with other views and experiments, lead me to believe that magnetic action is progrefsive, and requires time, i.e. that when a magnet acts upon a distant magnet or piece of iron, the influencing cause (which I may for the moment call magnetism) proceeds gradually from the magnetic bodies, and requires time for its transmifsion, which will probably be found to be very sensible.

I think also that I see reason for supposing that electric induction (of tension) is also performed in a similar progrefsive way.

I am inclined to compare the diffusion of magnetic forces from a magnetic pole to the vibrations upon the surface of disturbed water, or those of air in the phenomena of sound; i.e. I am inclined to think the vibratory theory will apply to these phenomena, as it does to sound, and most probably to light.

By analogy, I think it may pofsibly apply to the phenomena of induction of electricity of tension also.

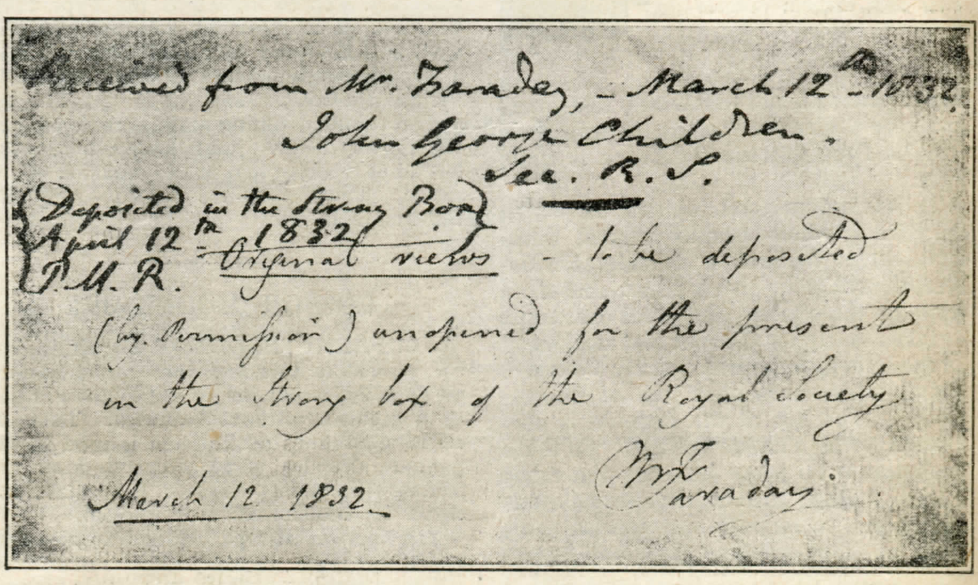
These views I wish to work out experimentally; but as much of my time is engaged in the duties of my office, and as the experiments will therefore be prolonged, and may in their course be subject to the observation of others, I wish, by depositing this paper in the care of the Royal Society, to take pofsefsion as it were of a certain date, and so have right, if they are confirmed by experiments, to claim credit for the views at that date; at which time as far as I know no one is conscious of or can claim them but myself."

Royal Institution. M. Faraday.
March 12, 1832.

To appreciate fully the contents of this letter one must recall very briefly the state of knowledge at the time the letter was written. Very little was known at all about electricity, and it had only been discovered a few years previously—in 1820—by Oersted that a current of electricity could influence a magnetic needle. In 1823 the first electro-magnet was invented by Sturgeon.

Michael Faraday, who, from humble parentage—his father was a blacksmith—had become Director of the Laboratory of the Royal Institution, argued in 1824 that since electricity can produce magnetism, it should be possible for magnetism to produce electricity. His notebooks show that between 1824 and 1831 he made no less than five attempts to solve the problem. Each, however, was doomed to failure, because, as we know now, his magnet and the wires were at rest relatively to each other.

At last, in September 1831, the answer to the problem was revealed almost by accident. Faraday was experimenting with a ring of soft iron upon which were three separate windings and he observed that upon connecting a battery to one winding there was a momentary pulse of current through a galvanometer connected to another winding. He found that a second pulse, but in the reverse direction, occurred when the battery connection was broken. Suspecting that the induced currents were caused by the magnetisation of the iron ring due to the current in the first winding, Faraday proceeded to make a series of experiments with various coils and magnets, during the course of which he discovered all the elementary facts of induction, and discovered also how to produce a continuous current of electricity by rotating a copper disc between the poles of a powerful magnet. In the course of these experiments he laid the foundations upon which the whole modern practice of electricity has been built up.


Received from Mr. Faraday, March 12th 1832
John George Children.
Sec. R.S.
Deposited in the Strong Box April 12th 1832
P.M.R.
Original views — to be deposited (by permission) unopened for the present in the strong box of the Royal Society.
March 12 1832
M. Faraday.

A photograph of the outside of the historic document showing Faraday's instructions regarding its safe custody.

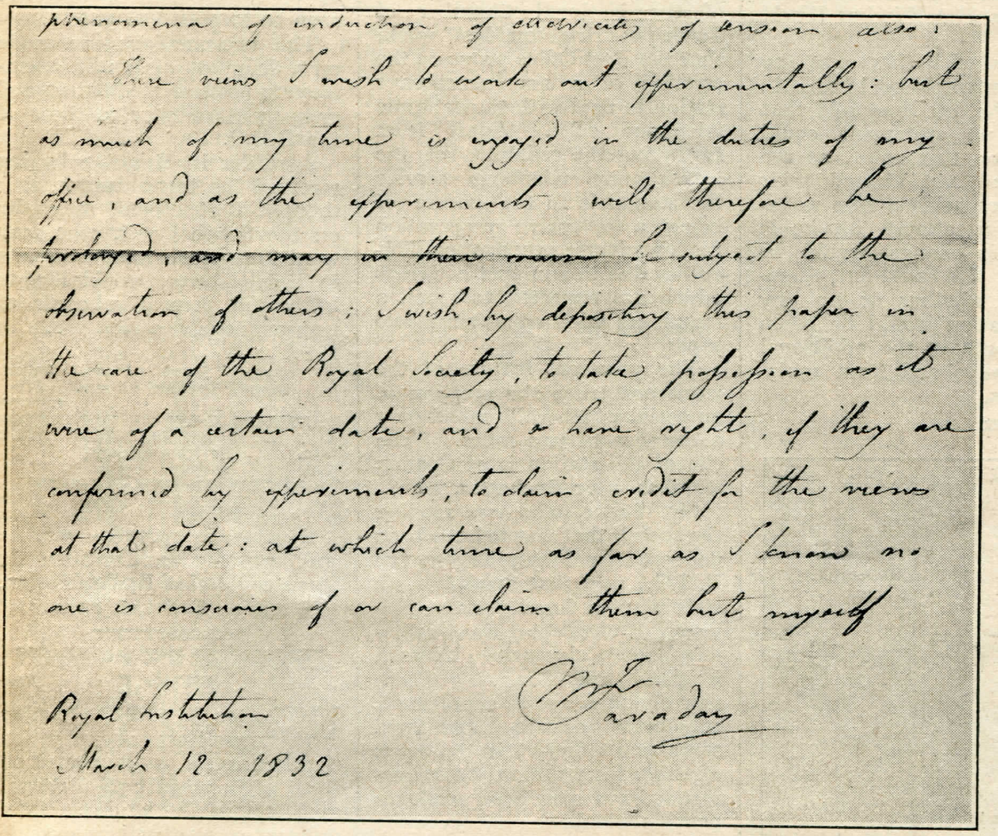
Magnetism and Electricity in 1832—

He described the experiments in great detail in two papers[1] which he read to the Royal Society on the 24th November, 1831, and the 12th January, 1832, respectively. These two papers form the first and second of his celebrated series of "Experimental Researches."

While he was making the experiments which these papers describe, it is evident from the document just unsealed that he conceived the theory that electro-magnetic forces require time for their transmission, though it is also evident document, however, is one of conviction in the truth of a theory of which, however, he is lacking an immediate and positive proof.

Whatever may have been the source of his inspiration, I feel, therefore, that one must regard it, not as a fortunate guess, but as the instinctive deduction of an experienced and brilliant experimenter.

In explanation of Faraday's apparent desire to establish his claim to priority by depositing this document, it must be said that it was contrary to his principles to patent any discovery. He always in-



phenomena of induction of electricity of tension also: these views I wish to work out experimentally: but as much of my time is engaged in the duties of my office, and as the experiments will therefore be ~~prolonged, and may in their course~~ be subject to the observation of others; I wish, by depositing this paper in the care of the Royal Society, to take possession as it were of a certain date, and so have right, if they are confirmed by experiments, to claim credit for the views at that date: at which time as far as I know no one is conscious of or can claim them but myself

M Faraday

Royal Institution
March 12 1832

The conclusion to the document reproduced from a photograph lent by the Science Museum.

sisted, however, that he should receive acknowledgment for original work, and his normal practice was to publish his results immediately. On this occasion he was not ready to publish his theory, but since his rights had been unjustly disputed on two occasions in earlier years he had grown cautious and preferred to safeguard his claim—a perfectly understandable procedure!

that he considered that an appreciable length of time might be required, instead of the very short time which we now know to be involved. It seems quite inconceivable that Faraday could have actually detected the transmission time with the very primitive apparatus at his disposal, and, unfortunately, a careful examination of the two papers referred to has failed to disclose any clue as to the actual results which lead him to formulate his theory.

With a less eminent worker, one might be tempted to ascribe his theory to pure guess-work. Faraday, however, was one of the most brilliant experimentalists ever known to science, and, as a study of his work very quickly reveals, he was not given to guessing. On the rare occasions when he allowed free-play to his imagination he frankly admitted that he was putting forward only a tentative idea. The whole tone of the newly disclosed

Faraday was no mathematician, and he relied on practical experiments to provide the proofs for all his theories. Thus it remained for Clerk Maxwell to translate Faraday's theories into mathematical terms and to deduce the equations for the propagation of electro-magnetic waves in space. It was Faraday's researches and his conception of the magnetic field as consisting of lines of force which formed the data upon which Maxwell developed his electro-magnetic theory. Maxwell proved mathematically in 1865 that electro-magnetic phenomena are propagated through space in the form of a wave motion with the velocity of light, and in so doing he laid foundations upon which wireless communication has developed.

As is well known, the theory, proved mathematically by Maxwell, remained unconfirmed experimentally until 1888 when Heinrich Hertz showed how to produce and detect electro-magnetic waves, and so laid the practical foundations which have developed to such an extraordinary extent in only fifty years.

To Faraday, however, must belong the honour of having put forward the first suggestion that time is required for the transmission of electro-magnetic forces. That he should have simultaneously suggested that their propagation is comparable with "waves on the surface of disturbed water" within such a brief period of his epoch-making experiments is of considerable interest and a further proof, if one were needed, of the genius of one to whom the world must ever be indebted for his many fundamental contributions to the development of electrical science.

The two photographs of the document are reproduced by courtesy of the Royal Society.

[1] Phil. Trans., Vol. CXXII, 1832, p. 125, *et seq.* "Experimental Researches in Electricity" and Phil. Trans., Vol. CXXII, 1832, p. 163, *et seq.* Bakerian Lecture, "Experimental Researches in Electricity."

Tungsram Photo-Elements

Range of Photo-Electric Cells

BARRIER-LAYER type photo-cells are now being marketed by Tungsram Electric Lamp Works, Ltd., Tungsram House, 82-84, Theobald's Road, London, W.C.1. They are available in three types: The S44 with and without housing at 50s. and 42s. 6d. respectively, the S204 without housing at 42s. 6d., and the S5 with special housing at 50s. The S44 has a circular metal base-plate with a working area of 10 sq. cm. and is intended for use in a photometer; the S204 has a rectangular plate with a working area of 4.5 sq. cm. and is advised for photographic exposure meters. The S5 is intended for use in talkie apparatus and is of tubular construction, with a slit for the admission of light; the working area is 5 sq. mm.

The open-circuit voltage generated by these cells rises rapidly with increasing illumination up to about 100 lux; thereafter, the rise is slower but saturation is not soon reached and at 1,000 lux an output of about 0.4 volt is obtained. On short-circuit the current sensitivity is 460 μA/Lumen, and the response is linear up to 1,000 lux.

With 400 lux illumination, maximum power output is obtained with a load of 1,400 ohms, the power being 27 micro-watts. Owing to the internal capacity of the cell the response is frequency dependent, and with a 0.25MΩ load the response at 10,000 c/s is about -12 db. This can, however, be corrected by the use of a compensating circuit which includes a 2-H inductance and a 0.1-MΩ resistance.

The curve depicting the colour sensitivity of the cell shows a response similar to that of the eye, but extending over a wider range. Light filters are consequently only needed for high accuracy, and for liquid filters a 0.24 per cent. solution of potassium bichromate and a 10 per cent. solution of copper sulphate, both in 5 mm. containers, are recommended.

The cells have a negligible temperature error below 45 deg. C., but at higher temperatures a change in the molecular structure of the barrier may occur. For the measurement of high temperature light sources, therefore, it is advised that the heat content of the radiation be filtered out by a transparent water trap.