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President's Address: The Mission and Spirit of the Pure Scientist

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PRESIDENT'S ADDRESS.

THE MISSION AND SPIRIT OF THE PURE SCIENTIST.

BY LOUIS BEGEMAN.

Michael Faraday has been called the greatest experimental scientist of all ages. No one who has read the biography of this eminent man of science will be inclined to dispute such a statement. Faraday was interested in all phases of scientific thought but devoted his energies particularly to chemical and electrical research. It is no exaggeration to say that he created modern industrial electricity. His experimental researches covered a period of forty-four years. The mere list of the titles of his papers fills several pages in the scientific catalog published by the Royal Society.

Omitting any reference to his numerous achievements in chemical research, let us notice briefly some of his most important electrical discoveries. He was the first to demonstrate that a wire carrying a current of electricity, when properly arranged, will revolve about the pole of a magnet and vice versa. He discovered the laws of current induction and stated them in exact language. The first of these, which states that a current can be induced by the relative motion of a coil and a magnet, is illustrated in the modern dynamo. Faraday constructed a number of small experimental dynamos producing continuous currents fully twenty years before the practical application of such a machine.

For the purpose of demonstrating the second method of inducing a current by means of the making and breaking of a current in a primary surrounded by a secondary, he constructed for his purpose the first transformer; a device which is now so important an adjunct to alternating current installations.

He explained clearly the phenomenon known as Arago's rotations and thus presented the idea of the modern induction motor.

He discovered the laws of electrolysis; the phenomena of diamagnetism, and the effect of the magnetic field on plane polarized light.

These are some of his most important discoveries, any one of which would be sufficient to star a man in scientific research. Yet, when all is said, it is surprising to know that his greatest achievement was not the discovery of a definite physical law but rather the enunciation of one of the most fruitful theories of modern science.

At the time of Faraday's activity it was currently believed by men of science throughout the world that such forces as gravitation; magnetic and electrostatic attraction and repulsion, were exerted between bodies in a direct manner independent of any medium that might exist in a continuous state between them. The idea of "action at a distance," however, was abhorrent to Faraday, as it was also to Newton, who could not conceive of force apart from some medium.

Faraday was the first to conceive clearly that the attraction and repulsion of magnetic poles and of electrostatic charges was due to some action going on in the intervening medium; as effects propagated continuously from point to point in space. He assumed the existence of lines of force stretching from one magnetic pole to the other and from one electrostatic charge to another of opposite sign. These lines were real to him, exerting lateral and longitudinal tension upon each other. The energy of magnetization and electrification was not in the ponderable masses, associated with these phenomena, but rather in these ether lines of force which stretched out in all directions through the invisible surrounding space. His admirable experiments illustrating the different specific inductive capacities of various dielectrics were striking corroborations of his theory. The notion of cutting these invisible lines of force when a current is induced in a conductor moving through a magnetic field was originated by him. It has been aptly said that Faraday's theory, which is now generally accepted, had the result of brushing the term "the electric fluid" into the limbo of newspaper science.

Faraday's theory was thrown into mathematical form by J. Clerk Maxwell. Before taking up the study of electricity Maxwell resolved to read no mathematics on the subject until he had made a study of Faraday's researches. He knew that there was a great difference between Faraday's way of conceiving phenomena and that of his European contemporaries. Stated in Maxwell's words, "Faraday in his mind's eye saw lines of force traversing all space where the mathematicians saw centers of force attracting at a distance. Faraday saw a medium where they saw nothing but distance. Faraday sought the seat of the phenomena in real actions going on in the medium; they were satisfied that they had found it in a power of action at a distance impressed on electric fluids."

Maxwell was so impressed with the reality of Faraday's theory that he at once undertook the production of a mathematical discussion of some of its salient points. In 1861 he published papers on "Physical Lines of Force," in which he developed the idea that the seat of magnetic energy is in the magnetic field, or rather, the dielectric which surrounds the magnet. The full fruition of his work on the Faraday theory appeared finally in his treatise on "Electricity and Magnetism" published in 1873 under the caption of the "Electro-magnetic Theory of Light."

This mathematical discussion of Maxwell's has been a veritable mine for research workers ever since. Maxwell, himself, not being a great experimentalist, feared there would never be experimental verifications of many of the conclusions he obtained. When we contemplate what has already been realized, we cannot but wonder at the greatness of such a master mind. Silvanus P. Thompson says in his treatise on "Electricity and Magnetism" that the "Electromagnetic Theory of Light" is the greatest achievement of the Nineteenth Century. This is hardly an exaggeration in the light of present attainments based on this theory.

Maxwell's mathematical discussion of the Electro-magnetic Theory of Light is based on a set of fundamental equations commonly termed "Maxwell's Equations." These equations assumed the possibility of the production of vibrating displacement currents of electricity in free space, or in any dielectric. Furthermore, they assumed that the displacement currents were accompanied by magnetic displacements in a direction at right angles to the former. These combined phenomena of electric and magnetic displacements constitute what are now denoted as electro-magnetic waves.

Maxwell's mathematical discussion led to the conclusion that these electro-magnetic waves must have the same velocity in free space as that of light waves. In fact, it was even inferred that light waves were simply electro-magnetic waves of a given frequency. Abundant experimental evidence has since been adduced to corroborate this inference, so that today we might properly include the subject of light in the domain of electricity and magnetism.

In 1888 Heinrich Rudolph Hertz succeeded in producing and detecting electro-magnetic waves by means of an open Leyden jar oscillating circuit. It is unfortunate that Maxwell did not live to realize this great achievement, since he feared so keenly that it would never be accomplished and that his mathematical discussion would thus forever rest upon an undemonstrated hypothesis.

Hertz not only produced electro-magnetic waves in conductors but also in free space. By means of a simple ingenious detector he was enabled to measure their length as they were transmitted from his oscillator to a reflecting conductor and back again in the form of stationary waves. He found that these waves, which were centimeters and meters in length, obeyed all the ordinary laws of light waves whose lengths are expressed in the sixth decimal of centimeters. By means of simple contrivances he reproduced the phenomena of reflection, refraction and polarization of such waves.

The discovery of the transmission of electro-magnetic waves through free space is thus the special achievement of Hertz. Maxwell in his mathematical dissertation pointed out the probability of these waves, but it was Hertz who brought them into the realm of practical realization and application. Hertz's experimental work is preeminent in its thoroughness and detailed exactness. It was unfortunate, indeed, to mankind that so subtile a mind should have been so soon lost to civilization through his early death. Sir Oliver Lodge wrote of Hertz as follows: "The front rank of scientific workers is weaker by his death. Yet did he not go till he had effected an achievement which will hand his name down to posterity as the founder of an epoch in experimental physics."

In Hertz's experiments were all the suggestions necessary to blaze the way toward the attainment of modern wireless telegraphy. Soon after the publication of his work a multitude of scientists in various parts of the world, inspired by Hertz's achievements, took up the experimental investigation of these new phenomena. Hertz's detector of these waves was rather crude but improved devices were soon forthcoming. Among these were the coheror devised by Edward Branley and extraordinarily sensitive to electric waves. Thus the last link was supplied for the practical accomplishment of one of the greatest and most useful inventions of civilization.

In 1894 a young Italian, Marconi, then a student in the University of Bologna, witnessed a reproduction of Hertzian experiments by one of the professors in the physics lecture room of that institution. He was greatly impressed with the phenomena and was led to conceive the idea of signalling through space by means of these Hertzian waves. After a careful study of the attainments of those who preceded him, he managed to construct an apparatus by means of which he succeeded in sending communications a distance of 300 feet between the British Post Office and the Thames Embankment. After many experiments resulting in great improvements of his apparatus, the distance was increased to 18 miles; then to 300 miles, until today we hear of signals being successfully sent across the Atlantic Ocean.

I have thus briefly presented to you the history of Wireless Telegraphy so that I might bring before you in a striking manner the mission of the pure scientist. History is replete with similar recitals in the various lines of scientific research. For more than half a century the pure scientist devoted time and energy, with no idea of material remuneration, to thought and experimentation, in the phenomena of electric waves. Faraday, Maxwell and Hertz! What a magnificent trio of truly learned men! The names of these men are rather obscure to the average citizen who rarely gets beyond the daily paper, or popular magazine, for information on the achievements in science and art.

These names do not appear in Andrew Carnegie's list of the world's twenty great men. Carnegie's list contains the names of such men as Bessemer, Hargreaves, Arkwright; men who played the Marconi roll in practical invention. Carnegie's list is just such as one would expect from a self-made pseudo-educated man, and reflects accurately the popular judgment of the world's greatest achievements.

Many have heard of our great Edison but few know anything about Faraday, and yet, comparing these two, which one is it that has played a really great roll in the progress of civilization? How the masses wonder at the apparently wizard achievements of a Burbank and how little they know of a Darwin! It was Darwin who enunciated the great, basic laws of animal and plant life. These laws definitely grasped supply the zeal for practical attainment to such men as Burbank. Joule worked fifty years before he succeeded in making an accurate experimental determination of the mechanical equivalent of heat. We know the value of this determination to engineering science of today. Should not the name of Joule stand out in equal glory with that of Watt? And so we might go on and multiply instances to show that the labors of the pure scientist invariably precede the attainment of great practical ends in civilization.

The mission of the pure scientist, then, is to prepare the soil, plant the seed and cultivate the crop. This he does and rests content with the excellence of his labor. The practical inventor gets the harvest which brings to him material gain and the plaudits of the masses. And yet, the former is the last to envy the latter. It has been truly said that every achievement in scientific research, however unrelated to practical ends it may seem at the time of its accomplishment, is pregnant with future possibilities in the realm of invention. Franklin was once asked this question by a skeptical, practical friend: What is the use of all this experimentation which leads to nothing practical? Franklin's rejoinder was: "What is the use of a baby?" Which is the greater, to write a great drama or to stage it? The answer to this question presents to my mind the relative value of pure and technical achievement in the realm of progressive civilization.

And what is the spirit of the pure scientist? It can be no more fittingly presented than in the words of the immortal Faraday: "I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction than of exalting the force of those already obtained; being assured that the latter would find their full development hereafter."

The spirit of pure science has many times been expressed in the unselfish sacrifice of some great man's life in the cause of truth in order that humanity might be brought to higher standards of living. It is the spirit which glories in victory over ignorance, prejudice, and unreasoning tradition.