A paper read at the Thirteenth General Meeting of the American Electrochemical Society, at Albany, N. Y., April 30, 1908; President C. F. Burgess in the Chair.

THE EARLY WORK OF JOSEPH HENRY.

By James F. McElroy.

Joseph Henry was born in Albany, December 17, 1797, and lived in this city the greater part of the time until 1832. It is true that the record in the old family Bible has left the date of his birth uncertain whether it occurred in 1797 or 1799, and his biographers have accepted the latter date as correct. However, this question is settled by other proof. The baptismal records of the First Presbyterian Church of Albany show that Joseph Henry was baptized January 21, 1798, and state that he was born December 17, 1797. This date can therefore be accepted as correct.

In 1826 Joseph Henry became instructor in mathematics in the Boys' Academy, of this city. If you go up State Street a couple of blocks, you will come to Capitol Park, in which our State Capitol is located. At your right you will then see a beautiful park, known as Academy Park, and in this park you will see the handsome brown-stone building of the Boys' Academy, which stands to-day just as it stood in the time of Joseph Henry. Joseph Henry continued as instructor in the Boys' Academy until the summer of 1832, and it was here that he made some of those great discoveries that have made his name imperishable in the annals of science.

In 1829 the highest development in electro-magnetism was represented by the old Sturgeon magnet. This magnet was made of a little round bar of iron, ¼ inch in diameter, which was bent into the shape of a horseshoe. It was then covered with varnish, to afford insulation for the winding. On the varnished surface was then wound 17 turns of bare copper wire, and these turns were spaced apart to prevent short-circuiting. The magnetic effects obtained with the Sturgeon magnet were very feeble.

In March, 1829, Prof. Henry read a paper before the Albany Institute (which occupied rooms on the second floor of the south end of the Boys' Academy Building), and in this paper he described improvements which he had made in the electromagnet, by which electromagnetic effects were obtained several hundred times as great as were ever obtained before. Prof. Henry's improvement consisted in first covering the wire with cotton or silk insulation and then winding the wire thus insulated into a close coil many layers deep around the iron bar. He also used a large bar of iron, many times as large as that used by Sturgeon. The result was that he obtained a magnet that would sustain over 2,000 pounds. In this way Joseph Henry produced the electromagnet as it is used to-day in various kinds of electrical apparatus in all countries of the civilized world.

If we examine a dynamo of any modern type, we will find large iron cores, which are surrounded by deep coils of insulated wire, containing many hundred turns of wire, which turns are kept from contact with each other by means of cotton or other insulation which is wound upon the wire before the coils are formed. In this coil the electric current is compelled to flow through the wire forming the coil many hundred times around the iron core. By this construction, the magnetic effects are increased to any desired amount. This is exactly the construction of the Henry magnet of 1829. All dynamos and motors depend upon this electromagnet of Joseph Henry for their operation, and no other means of exciting magnetism has since been discovered which can be employed, instead of the Henry magnet, to make dynamos and motors operative. This shows the fundamental character of Henry's contribution to the electric art. Joseph Henry thus placed in the hands of scientific investigators a new implement which made numerous discoveries in electrical science possible.

After the invention of the electromagnet and the discovery of the principles involved in producing electromagnetism, Joseph Henry constructed at Albany the first electromagnetic telegraph. In adapting the magnet for use on telegraph lines, Joseph Henry pointed out the necessity of winding the magnet with hundreds of turns of fine, insulated copper wire and using with this magnet, which he called his intensity magnet, a battery consisting of a

large number of cells connected in series. He constructed a telegraph apparatus in the Albany Academy, consisting of the intensity magnet and series battery and a long wire, which was supported on the walls of the large room in the academy. He used a suitable key for making and breaking contact and in front of the magnet was placed a movable armature, which was caused to strike against a sounding piece of metal and was so connected and arranged that by operating the key the action of the magnet upon the armature caused sound corresponding to the contacts made with the key. He further explained that the electromagnetic telegraph was now possible and that electromagnetic effects could be produced at almost any distance from the transmitting station. It will be clearly perceived that this apparatus contained the elements of the electromagnetic telegraph as it is in use to-day.

In 1833, after his removal from Albany to Princeton, he constructed a telegraph line supported upon insulators on poles and with the ends of the telegraph line connected to earth. He also connected to his telegraph line a local circuit containing a battery and low intensity magnet, which circuit was operated by means of a high intensity magnet placed in the main line. Thus, two other features of the modern telegraph were contributed by Joseph Henry, namely, the use of the earth as a return and the use of the relay circuit. This apparatus was shown at Princeton before his classes every year from 1833 to 1837. It did not contain what is known as the printer, which was afterwards invented by Prof. Morse. In the Morse printer, the magnet of Henry's relay circuit was caused to make depressions in a strip of paper which, by a clock movement, was caused to move over a point attached to the armature of the magnet. But the telegraph, as it is used to-day, does not use the Morse printer. It is simply a sounding apparatus as first proposed and constructed by Joseph Henry.

In the apparatus as applied by Morse to the telegraph line between Baltimore and Washington in 1844-45, and in all subsequent apparatus constructed by Prof. Morse, there was not only used the Henry electromagnet, but there was used the Henry intensity magnet in connection with the large number of cells connected in series. There was also used the relay circuit and the land line supported on poles on insulators, using the earth

return as first proposed and put in operation and explained by Joseph Henry. Henry's contribution to the electromagnetic telegraph was therefore fundamental and absolutely necessary to the operation of the telegraph, and without Henry's contribution the Morse apparatus could not possibly be made to work.

Another discovery was made by Joseph Henry at Albany prior to 1832, which has made his name famous wherever electrical science is known. It was here that Prof. Henry discovered the peculiar phenomenon known as self-induction, or the inductive effect which a long wire wound in a coil has upon itself. His discoveries in this line were extended to numerous discoveries in mutual induction or the inductive effect of one coil of wire upon a neighboring coil and to the way in which this effect was increased or decreased by the nearness of the second coil. He also discovered the effect of placing iron within the exciting coil. He also discovered that by placing a sheet of metal between the two coils the inductive effect could be cut off. He here laid down the principles which govern the construction of the induction coil and the alternating current transformer, both of which are used extensively to-day in many kinds of electrical apparatus. Henry's contribution to the subject of electric induction made his name famous wherever electrical science is known.

It is well known that in establishing the units of electrical effects, the names of eminent discoverers have been given to such units, for the reason that it was desirable to select names for the different units which would not be associated in the public mind with other meanings than the meaning given to the name by the definition of the particular unit. For this reason, the name of volt was given to the unit of electric pressure in honor of Volta, who invented the volta pile.

The name of ampere was given to the unit of rate of electric flow in honor of Ampère, who made numerous discoveries in electricity and magnetism in the early part of the last century.

The name ohm was given to the unit of electric resistance in honor of Ohm, who in 1827 explained the relation between quantity of current, electric pressure and resistance.

The name of coulomb was given to the unit of quantity of electricity in honor of Coulomb, who more than a hundred years ago invented the torsion balance.

The name of farad was given to the unit of electric charge in

honor of the great Faraday, who, in the early half of the last century, made numerous discoveries in electrical and electro-chemical science.

The name of henry was given to the unit of electric inductive effect in honor of Joseph Henry for his numerous discoveries in electric induction.

Prof. Henry is the only American philosopher who has thus been honored by the selection of his name by an international congress as the name of any one of the electric units. So that to-day the name of Henry is used in all civilized nations, speaking various languages, as the name of the unit of electric induction. This was the greatest honor ever conferred by an International Electric Congress upon an American scientist. This selection of the name of Henry has since been approved by the action of the governments in all civilized nations by proper legal enactment.

The lateness of the hour forbids that I should speak at length of the further discoveries of Joseph Henry whilst a resident of Albany. These discoveries were along the line of electric induction, the electric motor, and especially in connection with his discovery of magneto-electricity, which discovery has generally been credited to Michael Faraday, because Faraday was the first to publish his results. Before closing, however, I would like to speak a few words of an associate of Joseph Henry in his early work here in the city of Albany.

You have, with commendable wisdom, selected, as your headquarters, the modern-equipped hotel in which we are now meeting, known as the Hotel Ten Eyck. This hotel takes its name from one of our distinguished citizens, James Ten Eyck, a descendant of Philip Ten Eyck, who was an associate of Joseph Henry. Prof. Henry states that many of his experiments in Albany were performed jointly with Philip Ten Eyck and attributes to Philip Ten Eyck alone a series of experiments to determine the variation in the strength of a magnet by a change in what we now know as ampere-turns, and also to determine the point of magnetic saturation. I refer to this as it is undoubtedly the first tests that were ever made to obtain the data which is now worked into our modern curves of magnetization of iron. As a pioneer in this branch of work, the name of Philip Ten Eyck is deserving of recognition.

DISCUSSION.

DR. H. S. CARHART: I am very greatly interested in these remarks about Joseph Henry. I am particularly interested in the early recollections of Joseph Henry, and I wish to simply impress upon this Society the fact that these discoveries were made not such a great while ago. I myself was born within 10 miles of this spot, in this county, and only fifteen years after these experiments of Joseph Henry were made, and I do not consider myself exactly an antique yet. (Laughter.)

I regard this experiment of transmitting current around the room of the Boys' Academy in Albany as the first transmission of power on record. I look on it in that light, rather than in the light of the telegraph. I think it was the first transmission of power, on a small scale, to be sure, but Joseph Henry showed us how to do it. He had to have high electromotive force, and that is what we are all aiming after yet. What I want to tell you about particularly is another matter. You all know that the word "henry" was adopted for the unit of inductance at the Chicago International Electrical Congress in 1893. There were one or two interesting incidents connected with that. I chanced to be a member of the Chamber of Delegates myself, and the incidents which I will relate to you fell within my personal experience. When it came to a choice of a name for the unit of inductance, Profesor Mascart, of Paris, rose and made a speech recounting the work that had been done and the names used previous to that date. One of the names proposed, the "secohm," had been used in England, and the other proposed, the "quadrant," had been used in France. Professor Mendenhall and myself recommended that the name "henry" should be used. When the time came for the adoption of the expression to cover the unit of inductance, Prof. Mascart proceeded historically to that point in his address, and then, very soberly and sedately said, "but out of deference to our friends of America, I propose that we adopt the name 'henry.'" It was done in the most graceful manner possible, and the proposition was seconded by one of the English delegates, and that settled it. You can imagine that the American delegates were delighted.

Then came the wording of the definition of the unit of induct-

ance. What is inductance? A committee was appointed and split in two parts. I remember Prof. Rowland was in one section, and Prof. Ferraris, of Italy, was a member of the committee. There were two definitions brought in. Neither was satisfactory to those who had the duty of framing the definitions. The definitions were reported to the Chamber of Delegates, and then, within two or three minutes after the two were reported, Prof. Ferraris, who spoke English with great difficulty and imperfectly, proposed, in English, the definition of the unit of inductance as we have it to-day. It came from a man who did not profess to speak English.

MR. CARL HERING: I am glad to see that the work of Henry is being recognized, and that the record will be published. I remember talking about Henry with Werner Siemens, the so-called father of the dynamo, in 1891, when the name of Henry was first proposed for the unit. He remarked to me that Henry's work was not of much importance. Werner Siemens was perhaps the leading electrician in the early days of the present electrical era, and he did not seem to know what Henry had done. So I am glad that the value of Henry's work is now being brought to light.