THE INVENTORS OF THE ELECTRIC MOTOR.—I.
WITH SPECIAL REFERENCE TO THE WORK OF THOMAS DAVENTPORT.

By

Henry's Apparatus for Producing Motion by Electromagnetism.
[By permission of Charles Scribner's Sons.]

Sturgeon's Apparatus for Electro-Magnetic Rotation.
[By permission of Charles Scribner's Sons.]

HE electric motor, which but a few brief years ago was regarded as but little better than a philosopher's plaything, has, with almost startling suddenness, assumed its position as one of the potent factors of modern industrial development. The story of the birth of this great invention has hitherto been given to the world only in part, and even such fragments of its early annals as were once known are now well-nigh forgotten; they linger only in fast fading written records, and in the memories of an earlier generation, of which the scattered survivors are rapidly passing from the stage. I have sought, therefore, while trustworthy evidence is yet accessible, not only from the testimony of the few witnesses yet living, but from the time-worn and crumbling pages of contemporaneous manuscripts, to rescue from impending oblivion the true story of the invention of the electric motor.

It is eminently desirable that we enter upon the field of research with a definite conception of what is meant when we speak of the electric motor in the sense of a concrete organization, in other words as an invention. What, then, let us inquire, is the essence, the fundamental principle, which finds its necessary embodiment in each and every one of the thousands of electric motors which are doing such an important and increasing share of the world's work to-day? The question happily, is not a difficult one to answer. If an expert, skilled in the law of patents, were asked to formulate in legal phraseology a definition which should concisely sum up the new and useful invention embodied in the machine which we know as the electric motor, it might be couched in language something like the following:

The method of producing mechanical power by the application of electro-magnetism, which consists in combining with a suitable source of electricity, two systems of electro-magnets; one system mounted upon a shaft rotating continuously in one direction; the other fixed in relation thereto, and a commutator actuated by the rotation of said shaft, acting to instantly reverse the polarity of one of said systems, when by reason of their mutual attraction, the revolution of the shaft has brought the poles of the moving magnetic system into coincidence with the poles of the fixed system.

The above definition, formulated in the semblance of a patent claim, will at once be recognized as embracing the essential characteristics of the practical electric motor as we find it at work in the world to-day. On the other hand, it will be observed that the definition excludes certain special organizations, among which may be mentioned the rotary motor having a field induced by the permanent magnetism of steel; the rotary motor in which the intermittent attraction of electro-magnets is exerted upon a succession of non-polarized soft iron armatures arranged upon the periphery of a wheel, and the reciprocating motor in which masses of soft iron are dragged back and forth by the alternately intermittent attraction of electro-magnets or of solenoids. While it may be admitted that these and some other less well-known devices are not without a certain utility in minor and special applications of electric power, nevertheless, in a broad sense, it may be stated without qualification, that the machine of which a definition has just been given, has no less surely proven its right to be regarded as the accepted type of the modern electric motor than has the double-acting cylinder, piston and crank to be regarded as the accepted type of the modern steam engine.

As in the melipile of Hero of Alexandria we had an example of rotary mechanical motion by the energy of steam before the advent of the double-acting cylinder and crank, so likewise did we have rotary motion by electro-magnet-
ism before the combination of the reversible and the non-reversible electro-magnets in the magnetic engine. But it was not until the unerring inspiration of the master mind of Watt had grasped the true combination, that the world was put in possession of the steam-engine, that mighty agent which was destined to work its industrial regeneration. It has been my endeavor in the present investigation, to determine to whom should be accorded the distinction of being rightfully regarded as the Watt of the electric motor.

Having gained a clear conception of that for which we are to seek, we may proceed to make a critical examination of the history, written and unwritten, of the childhood of the electric motor.

Faraday, in 1821, demonstrated for the first time the possibility of producing continuous rotary motion by electromagnetism—not by the electro-magnet, for this instrumentality had yet to be invented—but by the movement of a magnetized needle in a field of force.

Barlow, in 1829, produced his rotating spur-wheel; founded upon the principle of the movement of conductors traversed by electric currents in the field of a permanent magnet. These experiments were repeated with variations by many others. In 1833, Sturgeon discovered the electromagnet. In his hands, however, it was but a feeble instrumentality; a few turns of wire arranged in a single layer upon a bar of soft iron.

In 1831, Henry's celebrated paper appeared, containing an account of his improvements in the electro-magnet and his experiments therewith. The results which he described literally threw the scientific world of both hemispheres into a paroxysm of amazement; it marked perhaps the most brilliant epoch in the whole history of electromagnetism. By winding the soft iron of the magnet with many superposed turns of silk-insulated copper wire, this experimenter succeeded in sustaining, solely by the force of magnetic attraction, a mass of iron weighing more than a ton. The accounts of Henry's discoveries, given to the world in a scientific journal of established reputation, were soon in possession of the eminent physicists of the European capitals, and ere long many busy brains were at work, each in an endeavor to add something, however little, to the masterly researches of the American philosopher.

In the same year, 1831, Henry published another paper commencing with these words:

I have lately succeeded in producing motion in a little machine by a power which I believe has never before been applied in mechanics—by magnetic attraction and repulsion.

Not much importance however is attached to the invention, since the article, in its present state, cannot be only considered a philosophical toy; although in the progress of discovery and invention it is not impossible that the same principle, or some modification of it on a more extended scale, may hereafter be applied to some useful purpose. The piece of apparatus referred to by Henry in this communication has been carefully preserved, and now forms one of the most valued treasures of the cabinet of the College of New Jersey, at Princeton. We give an illustration of it, made from a photograph, from which its construction may be readily understood. A straight horizontal electro-magnet, wound with three insulated copper wires, is pivoted at its centre, so as to be capable of a limited vertical reciprocating motion. Just beneath and parallel to this, a permanently magnetized steel bar is fixed in a horizontal position. The ends of the respective wires of the electro-magnet being properly connected, are arranged to alternately dip into mercury cups affixed to the poles of two opposing voltaic cells, and thereby to reverse the direction of the current through the helix at end of each stroke. The contrivance illustrated the principle upon which Henry thought an electro-magnetic machine might be worked out, but having satisfied his scientific curiosity with this demonstration, he, like Faraday, was quite willing to rest content.

SHOP IN WHICH DAVENPORT AND SMALLY CONSTRUCTED THEIR FIRST ELECTRIC MOTOR; NOW OCCUPIED AS A DWELLING.

[From a recent photograph by W. L. Pope.]

...
to leave the practical development of the idea in the hands of those who might feel disposed to pursue it.

The first published description of an apparatus designed to produce a continuous rotary motion by the agency of an electromagnet is due to T. Edmondsen, Jr., of Baltimore, and appeared in 1834. A fac-simile is given of the illustration accompanying Edmondsen's account as published. The apparatus will be seen to consist of a number of neutral soft-iron armatures, mounted upon radial arms affixed to a horizontal shaft. The armatures are successively brought within the sphere of attraction of a stationary electromagnet, while a commutator is provided by which the magnetizing current is interrupted long enough to permit each armature in turn to pass out of the magnetic field. This appears to be the earliest instance on record of the use of the modern commutator; an elastic contact-spring or brush, pressing against metallic segments fixed upon a revolving shaft.

In 1838, Sturgeon, the inventor of the electro-magnet, published a description of a rotary electro-magnetic engine accompanied by an illustrative drawing, in which he stated that the machine described had been constructed and put in operation as early as the fall of 1833, and had been exhibited before a large audience in London in the spring of 1838.

Sturgeon's apparatus, though usually referred to as the earliest example of an electromagneto-rotative engine, is in fact little else than a rearrangement of Ritchie's "revolving magnet," which was described in a paper read by him before the Royal Society, March 21, 1833, and published with an illustrative plate in Philosophical Transactions, of that year. The device consisted of a straight electromagnet, mounted so as to revolve freely upon an upright axis, its poles at each half-revolution passing close to the poles of two upright permanent bar-magnets. A mercurial commutator reversed the polarity of the electromagnet twice in each revolution, as it came opposite the poles of the bar-magnets. Dr. Charles G. Page, then of Salem, Mass., improved this apparatus by the substitution of a metallic commutator, and in this form it became one of the stock pieces of electro-magnetic apparatus in the schools and colleges of America.

The engraving on page 1 is a copy of the illustration given by Sturgeon, from which it will be seen that his machine consisted of two permanently magnetized steel bars turning horizontally upon a vertical axis. The poles of these bars, as they revolve, are successively attracted by the poles of four upright electromagnets formed of straight rods of soft iron wound with helices of wire. The details of the commutator are omitted in Sturgeon's drawing, but he explains that the reversal of the polarity of the electro-magnets is effected by permitting the ends of the conducting wires to trail in the segmentally divided vessel of mercury which is seen in the centre of the machine. There is in Sturgeon's description no suggestion of the possibility of substituting electro-magnets for the permanent magnets employed by him.

Not long after the publication of the paper of Henry which has been referred to, an attempt was made by parties interested in the Penfield Iron Works at Crown Point, N. Y., to employ magnetism for separating the constituents of pulverized iron ore. A machine was devised, containing a wooden cylinder, the surface of which was armed with a great number of teeth or points of magnetized steel. These were made to revolve continuously through a mass of pulverized ore. The particles of iron were separated from the refuse by adhering to the magnetized teeth, from which they were afterwards brushed off by suitable appliances. In order to charge these magnetized teeth, there had been procured, at the suggestion of Professor Amos Eaton, of Troy, from Professor Henry, one of his electromagnets made of a 1-inch rod, and weighing about 3 pounds. The actuating current for the magnet was supplied by two zinc and copper cells, the plates of which were arranged concentrically upon a plan devised by Dr. Robert Hare. The performances of this electro-magnet, which, when excited, was capable of sustaining an iron anvil weighing over 100 pounds, were occasionally exhibited for the astonishment of the simple rustics of that somewhat remote region, to whom at that day, the philosophy of electro-magnetism was a thing yet undreamed of. Thus the fame of the Crown Point "galvanic magnet" gradually spread abroad throughout all the surrounding districts.

At the period of which I write, there had grown up in an outlying portion of the township of Brandon, near the foot of the western slope of the Green mountains of Vermont, a scattered village, consisting for the most part of the homes of laborers and other employees of a recently erected blast furnace, which had been christened Forest...
HE ELECTRICAL ENGINEER.

[Jan. 7, 1831.

dale. Among the mechanics whom the temporary prosperity of this new settlement had drawn from other places was Thomas Davenport, a man who had for some years lived and pursued his occupation of blacksmith in the village of Brandon, not more than three miles away. But he was at this time about 30 years of age; of somewhat slender physique, but of more than ordinary intelligence and acquirements, considering his educational advantages, which had been limited to those afforded during his minority, by an attendance of six weeks per year upon a common district school in a remote country town. He had, however, succeeded in getting possession of some fragmentary portions of a scientific book, which he was wont to pore over while laboring at the bellows of his forge, and by this means had learned at least enough to excite his desire to learn more. Shortly after his removal to Forestdale, Davenport formed the acquaintance of another artisan living there named Orange A. Smalley. Smalley was ten years younger than Davenport, bright, enterprising, and with a natural taste for scientific pursuits. Several years before, while at school at Rochester, a town a few miles distant, he had attended a lecture of a few dollars; and, while pursuing his trade of blacksmithing and wagon-making. While in the course of their intimacy these young men conceived the ambitious plan of increasing their scanty incomes by traveling from place to place during the winter, and delivering experimental scientific lectures. While this scheme was under consideration, and the two were endeavoring to hit upon some new feature which might add to the attractions, and consequently to the profits of their projected entertainment, Davenport chanced to hear a wonderful tale of the performances of the "galvanic magnet" at the Penfield Iron Works. His curiosity was especially aroused by the alleged suspension, by mysterious power, of a blacksmith's anvil, and he accordingly made a journey to Crown Point, 20 miles distant, to witness this extraordinary phenomenon. In this he was disappointed, owing to the inopportune absence of the proprietor. He did, however, subsequently hear that the apparatus had been purchased in Albany. With the indomitable perseverance which was ever one of his most marked characteristics, Davenport forthwith set out for that city, determined to purchase a "galvanic magnet," presumably with the intention of utilizing the material attractions of the projected series of lectures. In due time he arrived in Albany, but inasmuch as he had but the most hazy idea of what the thing was that he wished to purchase, and still less of the locality where he might expect to find it, it is perhaps not to be wondered at that his researches were not crowned with success. It is worth while to quote his own naive story of his adventures on this quest for the electro-magnet:

As I had been informed that the apparatus was a galvanic battery and possessed powerful magnetic properties, I inquired of my landlord where I should be likely to find a "magnetic battery." He replied that they "made such tubes at the tin-shops for blasting rocks," and directed me there. The tinman sent me to a lady's shop where he said they "used some of the kind in the manufacture of watches." The jeweler remarked that they had no occasion for such heavy instruments about watches, but advised me to go to the Eagle furnace where they could cast from any pattern." At this latter place I declined calling and returned home. In December, 1888, I again went to Crown Point with the intention of purchasing some instruments with high hopes of seeing an anvil suspended between the heavens and the earth by magnetic power. This long-looked-for mystery was, however, not to be found by me among the junk dealers, but in an electro-magnet weighing about three pounds, to which was attached two sets of cups consisting of copper or zinc cylinders to be placed upon the face of a common blacksmith's anvil, and as soon as the cups were immersed in the solution of sulphuric acid and water contained in the earthen mugs, the magnet adhered sufficiently to lift the anvil until the battery-cups were removed to be done by raising the two stands of cups. At length the magnet was made, and we proceeded to test it. The wires were cut in two, the ends being held in contact, the power not being suddenly renewed, and the anvil was caused to be suspended by separating the two ends of the magnet. I appeared to them that had broken one of the wires which connected the cups with the battery, and thus suspended the anvil, and sent it to Albany for Professor Henry to repair it; they had but just returned. I requested the privilege of cutting one of the wires, and connecting it together for the purpose of ascertaining this fact, but was refused, and returned the piece, and purchased the magnet for the sum of $18, instead of iron which I much needed for my shop. As soon as I became the possessor of the magnet, I immersed the piece in the solution and then severed one of the conductors, so as to break the circuit of galvanism. Of course I found the magnet wholly destroyed, but on connecting the wires together with my fingers, the magnet became again fully charged. However rapidly the connection and separation of the conductors were made, I found the charging of the magnet to be very slow. I showed the man that the magnet produced a hundred-fold more power than was required to make and break the connection.

In a flash of lightning the thought occurred to me, that here was an available power which was within the reach of man. If three pounds of iron and copper wire would suspend in the air 100 pounds suspended, why not make a steamboat propelled by this power? A bystander replied, "You mean, sir, magnetic force?""Yes, sir." I remained silent, as it was all invisible and intangible; invisible power will supersede steam; for, shall the mighty agent which suspends this ponderous mass of iron between heaven and earth, serve no other purpose than to excite our wonder and admiration? No! The human mind will not rest with so great a prospect before it, of furnishing a valuable substitute for the precious power of steam. I venture to predict that in a few years, not far off, when there will be no more need of legislation and committees of inspection on steam boilers; no more aching hearts and dissolute homes in consequence of the awful spectacle of human beings hurled into eternity, but the red lighting of heaven will be soon tamed and will become our servant.

Immediately upon the return of Davenport from Crown Point with the coveted apparatus in his possession, with the co-operation of Smalley experiments were commenced, with the object of producing a machine to be continuously moved by electro-magnetism. Davenport, like Fulton, Morse, Bell and many others of those to whom the world is indebted for its great inventions, appears to have been a man possessing in no unusual degree either mathematical or mechanical genius, or skill in handicraft. He seems rather to have been a man of broad conceptions and of prophetic foresight; one who could perceive what needed to be done, and who could select the men and the instrumentalities to do it. Above all, he was endowed with a more than common share of that indomitable perseverance and inflexible determination in pursuit of a cherished ideal, which cannot be permanently cast down nor turned aside by any obstacle, however great; which in truth can scarcely be conquered by death itself. Smalley, his associate, was a young man of acute perceptions and keen intelligence; not in any sense a trained mechanician, but rather a typical New England carpenter, mechanic, "handy with tools" either in wood and in iron; with a brain fertile in expedients and contrivances to overcome unexpected difficulties. During the greater part of the year 1834, these two worked together in the building of the machine described by Smalley as a shop. Early in the summer of that year, they succeeded for the first time in obtaining rotary motion by electro-magnetism. A permanently magnetised bar was supported at its centre of gravity like a magnetic needle. By placing the pole of an electro-magnet in proximity to the imaginary circle described by the horizontal swing of the bar, and then breaking the circuit by hand at properly timed intervals, it was found that the bar could be kept in continuous rotation. This proved to be the key to the solution of the problem of the electric motor.
After much further experimentation, Davenport and Smalley finally succeeded in completing an organized apparatus which was capable of maintaining continuous rotation by automatic means. Unfortunately, no drawing of this machine has been preserved, but the following brief description of it, written by Davenport in 1851, will serve to sufficiently explain the essential features of its construction:

In July, 1884, I succeeded in moving a wheel about seven inches in diameter at the rate of thirty revolutions per minute. It had four magnets, two of which were upon the wheel, and two were stationary and placed near the periphery of the revolving wheel. The north poles of the revolving magnets attracted the south poles of the stationary ones with sufficient force to move the wheel upon which the magnets revolved, until the poles of both the stationary and revolving magnets became parallel with each other. At this point, the conducting wires from the battery changed their position by the motion of the shaft; the polarity of the stationary magnets was reversed, and being now north poles, repelled the poles of the revolving magnets that they before attracted, thus producing a constant revolution of the wheel.

The electro-magnets used in this machine were copied, with Chinese fidelity, from the Henry magnet purchased at Crown Point, which had been dissected, and the courses and direction of the convolutions of wire in its helicose carefully observed. It almost immediately occurred to the experimenters that the speed and power of the machine would be greatly increased by placing a greater number of magnets upon the revolving shaft. Being unable at the time to procure the necessary copper wire for making any more electro-magnets, they tried the effect of substituting permanent magnets, at the same time increasing the number upon the shaft from 8 to 12. The result exceeded their most sanguine expectations; the wheel now revolved at such a rate that the mechanism of the commutator—which consisted of bent wires dipping into mercury cups, moved by a cam affixed to the shaft—was utterly unable to keep pace with it.

The machine here referred to unquestionably constitutes a complete embodiment of the principles of the modern electric motor, as we have defined them in a preceding paragraph. The description of Davenport agrees in every essential particular with that recently given to the writer, from his own recollection, by Mr. Smalley, who is still living, and although almost an octogenarian, is in full enjoyment of his memory and faculties. He may be seen standing in the photographic view of his old-time shop, which forms one of our illustrations. It may be of interest to state that he did not hesitate to make a journey of several miles on one of the coldest of winter days, in order that the readers of The Electrical Engineer might be favored by the presentation of the accompanying admirable and characteristic portrait.

The successful outcome of their first attempt at the construction of an electro-magnetic engine, filled the hearts of the experimenters with pardonable elation. They flattered themselves that at least they would no longer be compelled to endure the sarcastic and derisive comments of the neighbors, few of whom could be persuaded that the scheme upon which they were at work could be anything else than the "perpetual motion," which in those less enlightened days was the ignis-fatuus of many an ambitious rural mechanic. They met, however, with scant encouragement. The village pastor, when the mysteriously moving machine was shown to him, and the enthusiastic hopes of its constructors were poured into his ear, made the characteristic observation that "if this wonderful power was good for anything it would have been in use long before this." Nevertheless, regardless alike of ridicule, disparagement and poverty—for both were dependent upon their daily toil for the most ordinary necessities of life—Davenport and Smalley prosecuted their experiments with unwearying diligence. From some of the more intelligent of their townsmen, they received, if not then a word of encouragement, and it was largely in the hope of being able to satisfy these friends that their ideas were not wholly chimerical, they determined to take the machine to Middlebury, a town 16 miles north, which boasted of an embryo college, and submit it to the inspection of those more familiar than themselves with scientific pursuits, who were presumably qualified to form a competent judgment of its merits.

97. PAUL'S ELECTRIC RAILWAY SMOKSTACK.

The smokestack of Mr. Tom Lowry's electric railway power house is just 200 feet high, and has an inside diameter at the base of fifteen feet. It took 875,000 brick and 85,000 fire brick to build it. It weighs 19,500 tons and cost $10,000. The flue, which is eleven feet in diameter for one hundred feet from the base upward, is built of fire brick. The casing of fire brick stands like a cylinder within a cylinder, and from the outside wall. The immense furnaces which are to generate steam in boilers which are to operate engines with 7,000 h. p. capacity, would heat the smokestack up for a distance of nearly 100 feet high to such an extent that it would crack unless there was a fire brick casing inside, and this fire brick casing must have room for expansion. The exterior of the stack is octagonal in shape, faced with beautiful white pressed brick, and decorated with cornice work and figures in colored brick.

BOSTON, MASS.—The West End Railway Co. proposes to increase its capital stock by $4,500,000. Its business is growing rapidly.
THE INVENTORS OF THE ELECTRIC MOTOR.—II.
WITH SPECIAL REFERENCE TO THE WORK OF THOMAS DAVENPORT.

BY

Franklin Leonard Pope

NE stormy day near the end of December, 1834, Davenport and Smalley drove over to Middlebury, taking with them their best machine, which they set up in a room at the village tavern. Davenport then set out to make the acquaintance of the Professor of Natural Philosophy at the college, and invite him to view the phenomenon. This part of the story shall be told in his own words:

As I had never before seen a college or a professor, I rather the opinion that those present were then witnessing the first exhibition of what would prove to be one of the greatest inventions of the nineteenth century.

Prof. Turner advised Davenport and Smalley to take immediate measures to secure a patent, and with characteristics kindness and generosity undertook to prepare for them a draft specification descriptive of the invention, which he recommended them to place in the hands of a competent attorney at Washington. This interesting document has fortunately been preserved, and the portions of it here presented constitutes the best possible evidence of the stage of development which the invention had reached at the beginning of 1835, the date when it was written. This paper, which is in the handwriting of Prof. Turner, is in the following words:


Middlebury, Vermont, Jan. 5, 1835.

The following is a description of the electro-magnetic engine invented by Messrs. Davenport & Smalley, of Brandon, Vt., and referred to in the accompanying application of date. (See drawing below.)

\[ a \text{ and } b \text{ are horseshoe magnets, placed vertically around the axis } ob \text{ to which they are fastened.} \]

Of these there may be any number almost; in the model which has been executed there are twelve, although for the sake of simplicity only two are represented in the drawing. It is to be observed that each pair of opposite magnets must have the same poles, as \( b \) and \( b \); that in case there should be more than one pair, the adjacent magnets must have their poles \( s \) and \( s \) alternately uppermost. \( a \) and \( b \) are galvanic magnets, or pieces of soft iron having copper wire wound around them, and susceptible of a high degree of magnetism by being connected with either pole of a galvanic arrangement. \( q \) and \( n \) are galvanic batteries, consisting each of concentric copper cylinders with zinc between them. \( 1, 3, 4, 5, 16 \) are cisterns of mercury, of which \( 1, 6, 11, 16 \) are connected with the zinc pole and \( 2, 5, 12, 15 \) with the copper pole by means of wires \( z \) and \( c \). The wires \( c \) connect \( 3 \) with \( 10, 4 \) with \( 9, 7 \) with \( 14 \) and \( 8 \) with \( 13 \). \( y \) and \( v \) are two levers, turning on pivots at \( w \) by the motion of the axis \( ob \) and carrying with them transverse slips of copper with the extremities bent downwards. When the end \( v \) of the lever \( y \) is depressed, these slips establish a communication between \( 9 \) and \( 11, 10, 12 \), and consequently the wires \( z \) and \( c \) and the upper branch of \( c \) are connected with the copper pole of the battery, and the wire \( z \) and the lower branch of \( c \) are connected with the zinc pole. It is evident that, in this case, the upper part of \( c \) will be a north pole, and therefore attracted by the \( s \) of \( a \), while the lower branch of \( c \) will be a south pole, and therefore attracted by the pole \( s \) of \( a \). In consequence of this attraction the magnet \( a \) is brought nearly into contact with \( b \) when \( y \) is raised and the end \( v \) of the lever \( y \) is depressed; thus establishing a communication between \( 1 \) and \( 3, 5 \) and \( 4 \), or by means of the wires \( z \), a communication between 1 and

From a portrait painted by the late Abel B. Moore, circa 1841, and now in the Rensselaer Polytechnic Institute, Troy, N. Y.
10, 2 and 9, while the connection between 9 and 11, 10 and 19 is interrupted. Hence the poles of the galvanic magnet C will be reversed, the upper one will be south and the lower north; therefore the polarity of the galvanic magnet A will not be reversed. In this manner a rotary motion of the magnets A and B on the axis ab is kept up so long as the galvanic action continues in the circuit. And in this manner the influence of the battery on the galvanic magnet D or any others may be illustrated. With twelve magnets on the axis and two at the sides, the axis turns round about sixty times in a minute and consequently the poles of the galvanic magnet are reversed 360 times.

To the axis, it is evident, that any machinery may be attached for the purposes of manufacture, propelling boats, cars on railroads, etc. In the drawing the machinery is supposed to be applied. The motion of the machine can be continued for any length of time by occasionally renewing the fluid.

And on the other hand, the action may be checked or entirely suspended by raising part or all of the connecting wires and z out of the cisterns of mercury.

Instead of the arrangement of magnets above referred to, it is thought that there would be an advantage in employing none but galvanic magnets either on the axis or at the sides.

The significance of the closing paragraph will not escape the attention of the reader. It confirms the written description in Davenport and the independent verbal statement of Smalley, that as early as 1834 the conception of the combination of stationary and rotating electromagnets, with a suitable pole-changing device, had been worked out and tried by them. The suggestion of applying electromagnetical apparatus to the propulsion of railway cars is also not a note. Inasmuch as it was not until fourteen years later that the steam locomotive made its advent in the state of Vermont. The Mohawk and Hudson railroad had, however, been in operation between Albany and Schenectady for some years, and it was probably from this circumstance that the suggestion in the specification originated.

The experiments were greatly encouraged by the cordial reception which the invention had received at the hands of the Middlebury professors, and the warm interest which they had manifest in the further prospects of the undertaking. It is of interest to record that Davenport now for the first time obtained access to scientific books, from which he could gain some further knowledge of the agent which he was using. Among other works he was shown Stillman's Chemistry, containing accounts of some of Prof. Henry's experiments in electromagnetism, from which, curiously enough, he first learned the proper names of the instruments and materials he had been using. Up to that time, having been ignorantly instructed by the people at Crown Point, he had called the battery the "cups" and the electromagnet the "battery." The difficulties which were inseparable from the use of the mercurial commutator when the rapidity of motion was great, have already been alluded to. Immediately after their visit to Middlebury, the experimenters constructed another machine, and correctly reasoning that the circuit might perfectly well be closed by a metallic commutator, as had been proven by touching of the wires together by hand, they substituted for the mercury contacts insulated segments upon the shaft, which were rubbed by contact-springs formed of elastic flattened wires, and were grave enough to believe that this serious obstacle to the rapid revolution of the machine was now entirely removed. This improvement was made prior to May 1, 1835. It appears to be the earliest instance of the use of the modern commutator; an elastic contact-spring or brush, pressing against metallic segments, fixed upon a revolving shaft.

Not long after the completion of this improved machine, a difference of opinion arose between Davenport and Smalley in respect to the most desirable policy to be pursued in disposing of interests and rights in the invention, in order to raise the funds to cover expenditures already incurred, and to provide the means which were urgently needed for the prosecution of further experiments, as well as for the procuring of patents. An amiable settlement was ultimately arrived at, in accordance with which Smalley relinquished his entire interest in the invention for a sum agreed upon, and Davenport was left free to seek for other assistance in the prosecution of his cherished designs.

For some months he continued his experiments, having for the time transferred the scene of his labors to Rochester, a small town a few miles east of Brandon, at which place, with the assistance of a mechanic named Richardson, he constructed no less than ten machines of different designs, some of which were capable of making 80 revolutions per minute.

The invention having now been brought to a tolerable state of efficiency, Davenport was naturally very anxious to lose no further time in securing his patent. In those days it was supposed to be absolutely necessary that the inventor should visit Washington in person in order to properly explain his ideas. At that date, 1835, this was a long, tedious and expensive journey. Being almost entirely destitute of means to carry out his design, Davenport appealed to his friend and neighbors, and succeeded, by the purchase by many entitites, in inducing six of them to form a joint purse to supply him with funds for his intended journey to Washington. In July, 1835, he set out for the capital, carrying with him his latest model, and a letter of introduction from his friend Prof. Turner to Prof. Amos Eaton, who was at that time principal of the Rensselaer Polytechnic Institute at Troy, N. Y., as follows:

MIDDLESBURY COLLEGE, June 4, 1835.

Dear Sir—I take the liberty of introducing to your acquaintance Mr. Thomas Davenport, the inventor of an electro-magnetic machine of singular interest. Mr. Davenport has long and expended much on his invention, but has not the means of prosecuting his experiments farther without the aid of some provision of taste for the science, and also of making a fair trial of the propelling power of his machine. It has occurred to me that could Mr. Van Rensselaer, of Albany, become interested, he might take pleasure in furthering an enterprise which promises so much; and in patronizing an American artist, who, it may be, will one day compete with Watt and Fulton in the glory of having added immeasurably to the honor of science and the arts. Being personally acquainted with Mr. Van Rensselaer, I presume you will be so good as to do me the favor of introducing Mr. Davenport (by letter or otherwise) to that distinguished and estimable man. This or any other attention you can conveniently render, will be considered as conferring additional obligations on one who has a strong feeling of being, Sir, your friend and fellow laborer,

E. TURNER.

Prof. AMOS EATON.

The Honorable William Slade, afterwards Governor of Vermont, who was at that time a member of Congress from the district, gave Davenport a note of introduction to the Commissioner of Patents, Hon. H. W. Ellsworth, from which the following extract is of interest as being indicative of his estimate of the man:

The bearer hereof, Mr. Thomas Davenport, goes to Washington for the purpose of obtaining a patent for the production of motion applicable to machinery by galvanism. His diligence has induced him to ask a letter to you, which I give with great pleasure. His personal worth is equal to his genius, of which he has given no equivocal evidence in the very ingenious machine for which he seeks a patent.

Upon his arrival at the Rensselaer Institute, in Troy, Davenport was most courteously received by Prof. Eaton, who endorsed upon the note of introduction, and Prof. Turner, a few lines recommending him to the consideration of General Stephen Van Rensselaer, the eminent founder and patron of the Institute, in which he said:

I have told Mr. Davenport that no one could consistently aid him without Prof. Henry's approval. I have exhorted his machine to Prof. Henry, after you have seen it. This he will do. Professor Henry has suggested the practicability of applying this great power to machinery, but I did not from him understand that any plan had been fixed on. Mr. Davenport's plan is a simple and efficient one. It appears to me that Professor Henry would be greatly delighted.
The following is a facsimile of the original draft of Davenport's Patent Specification of 1885, for his Electric Motor.
with such a satisfactory exemplification of a principle which has extended his name to the ends of the earth.

Acting upon this suggestion of Professor Eaton, General Van Rensselaer gave Davenport a line of introduction to Professor Henry, which he delivered to him in due course a few days afterwards at Princeton. Professor Henry was much interested in Davenport’s machine, and after witnessing its operation asked how large a power he intended to build, to which Davenport replied “a full one-horse power;” whereupon Professor Henry, with his usual caution, suggested that it would be better if he were to continue his experiments for a time on a smaller scale. He said to him that if it were given out that he was building a one-horse power magnetic machine, and should he fail in his first attempt, which would not improbable be the case, not only would he credit as an inventor suffer, but the electro-magnetic engine would be hastily and unjustly stigmatized as a “humbug,” a result which could not be but prejudicial to the advancement of science and the arts. Professor Henry, with the courtesy which he invariably exhibited towards deserving inventors, sent Davenport a certificate in which he spoke highly of the novelty and originality of his invention. At the same time he did not hesitate to express to him the conviction, which he is known to have entertained even at that early date, that the application of galvanic electricity was at best an indirect way of utilizing energy derived from the combustion of coal, and therefore could not economically compete with that agent as a means of propelling machinery. He nevertheless believed that it might be found useful in many cases in which the actual expense of power was a consideration not to be weighed against other more desirable objects to be attained. In his views in relation to this subject Henry was far in advance of most of his contemporaries, for the grand conception of the conservation of energy had at that day dawned only upon the minds of a few of the most profound thinkers of the period.

Before leaving Princeton, Henry exhibited to Davenport, much to the surprise of the latter, his oscillating electro-magnetic engine, made in 1831, of which an illustration has been given. This was to him the first intimation that any one prior to himself had ever conceived the possibility of producing motive power by electromagnetism.

While at Princeton, Davenport made the acquaintance of Professor Henry’s life-long and intimate friend, Alexander Dallas Bache, then professor of natural philosophy in the University of Pennsylvania at Philadelphia, and afterwards for many years superintendent of the U.S. Coast Survey. At the cordial invitation of Professor Bache, Davenport accompanied him to Philadelphia, where about the middle of July he exhibited his machine in operation in the library of the Franklin Institute. While in this place it was examined with interest by a large number of scientific men. Prior to his departure for Washington, Professor Bache gave Davenport a letter, the conservative tone of which indicates that he had been led by his association with Henry to entertain similar advanced views. He referred to the equivalence of the natural forces. This letter is as follows:

At the request of Mr. Davenport, I have examined a model of a machine applying the electro-magnetic action as a moving power. At first it appeared to me that an experiment might be made upon this model, from which the useful effects of a machine properly constructed might be inferred. But I am satisfied on examination, that such a result could be had only from a much more complete model than this, or from a working machine of a size. It would be highly interesting in a scientific point of view, and possibly in a practical light, if such an experiment could be made. The power is no doubt adequate to produce any effect required in the arts, but the question of cost can hardly be fairly answered without experimental data.

A. D. BACHE,
Prof. Nat. Philosophy,
Pennsylvania University,
Philadelphia.

July 15, 1836.

Upon reaching Washington a few days later, Davenport discovered to his dismay that owing to the unforeseen delays and expenses to which he had been subjected by his exhibitions in Troy, Albany, Princeton and other parts of the added cost of preparing the drawings and specifications for his application for a patent would so reduce his available funds as to leave him without sufficient means to return to his home in Vermont. He was therefore compelled by the necessity of the hour to surrender all but the intention of applying for his patent, and in a very dejected frame of mind set out for home, taking his model with him. Upon reaching Troy he proposed to sell his machine to the Rensselaer Institute for $30. Professor Eaton, favoring the proposition, gave him a line to General Van Rensselaer, recommending him as a man of a deservedly high attempting to enter the grounds of Mr. Van Rensselaer’s mansion Davenport was set upon by three ferocious watch-dogs, who soon reduced his habiliments to a deplorable condition, although he was fortunately rescued by the servants before serious injury had been inflicted. Writing of this incident, he says:

Mr. Van Rensselaer examined my certificates from Professors Henry and Bache, and the line from Professor Eaton, and meanwhile the kitchen-hold tackled together my torn garments.

After receiving a check from General Van Rensselaer for the stipulated sum, and depositing his model in the Rensselaer Institute, Davenport returned to Vermont, in no very happy frame of mind. He had not only been unsuccessful in the main object of his journey, but had been brought like many others to a realizing sense of the fact that compliments are far more easily obtained than cash.

The model which formed the subject of this commercial transaction was preserved for many years in the Rensselaer Institute, but ultimately perished in the disastrous fire in Troy in 1862, in which the buildings of the Institute shared the fate of a vast number of others, and were totally consumed with all their valuable contents.

Professor Eaton, who was a man of a deservedly high scientific reputation, as well as of a somewhat enthusiastic temperament, had from the beginning conceived a warm feeling of friendship and respect for the modest and unassuming Vermont blacksmith, and exerted himself in every possible way to advance his interests. Scarcely had Davenport, dispirited and despondent, left Troy, when Professor Eaton penned the following flattering notice of his invention, and procured its insertion in a Troy newspaper. So far as can be learned, this was the first published notice of Davenport’s electro-magnetic engine.

[From the Troy Daily Journal, August 13, 1836.]

An obscure blacksmith of Brandon, Vermont, 18 miles south of Middlebury College, happened accidentally to become acquainted with Professor Henry’s discoveries in Electro-Magnetism. Possessing one of those minds which cannot be confined to the limits of a blacksmith shop—nor any shop less than the canopy of heaven—he applied this power to the astonishment of scientific mechanics. He turns three horizontal wheels around fifty times per second, with this power. The wheels and shaft weigh eleven pounds. He has convinced Professors Henry and Bache that the power is sufficient for strong machinery. A detailed account of this machine will appear in the next number of Silvanus’s Journal. The Hon. Stephen Van Rensselaer has purchased his first constructed machine (or model) for the Rensselaer Institute in Troy, as piece of school apparatus. No chemical or philosophical apparatus can hereafter be considered perfect without it. Whatever may be its fate in mechanics, it will cause the name of Thomas Davenport (the inventor) to accompany that of Professor Henry to the ends of the earth.

Professor Bache, of Philadelphia, and Professor Turner of Vermont, have given their testimony in favor of Davenport’s application of Professor Henry’s discoveries may be made to move heavy machinery for useful purposes. According to their words, that another Livingston might make another Fulton of the Brandon blacksmith.

A month later Professor Eaton wrote to Davenport at Brandon, enclosing a copy of the Troy Budget containing the article therein referred to. The letter and extract are as follows:—
Immediate reply, under date of September 21, 1838, depreciating in the strongest terms Davenport's resolution, and refusing to listen to his proposal to abandon the undertaking. Among other things he wrote:

Make my name Thomas Davenport, and I will give you five thousand dollars for your idea—rather, I mean 'the bubble, reputation.' . . . It is a thing which will progress slowly; perhaps it may never yield you anything but reputation. But you have involved friends; and it is your duty to support their pledges for you. . . . Remember, if you fail to be here on the fourteen, destiny is your portion!

This was the critical moment, the turning point, in the career of Davenport. Not only was the mere thought of throwing aside the hopes and aspirations which he had so long cherished almost unendurable to him, but his keen sense of honor instinctively revolted from the slightest imputation of bad faith towards the scientific friends who had cordially given him their countenance and support, or of reluctance to make good to the best of his ability, their pledges and expectations. On the other hand, to persevere was to be confronted with poverty, doubt, discouragement and almost with despair. To a man constituted like Davenport, however, a mental conflict waged on these grounds could have but one termination. Paraphrasing the memorable words of the elder Adams, he well might have exicted...
office. He promises to deliver you the wire. I have broken all the hardware stores, and bought all the wire in the city, and given it to Mr. Jackson.

Then came the difficulty of insulating the wire. Davenport had been led, from Henry's researches, to suppose that silk was the only material which would answer the purpose. But it was not only difficult, but in fact impossible to obtain this material in that remote region, and he was destitute of means wherewith to procure it from the city. But in this dilemma, the unselfish devotion of the faithful wife, who had loyally stood by him through prosperity and adversity, came to his rescue. Her one silk gown, the wedding dress which was her father's gift; almost her sole remaining relic of more prosperous but of perhaps not happier days, was bravely offered as a sacrifice to the cause of science. Cut into narrow strips, the treasured garment was used to insulate the helices of the new machine. Night and day the work went on with such success that punctually on the tenth of October Davenport presented himself at the Rensselaer Institute with the new motor in readiness for exhibition. On the 14th, pursuant to the pledge of Professor Eaton, it was put in operation on the Judge's bench in the court-room in Troy, in the presence of many interested and enthusiastic spectators.

Among the audience who attended this exhibition was a young artisan whose home was in Capotville, a village just north of Springfield, Mass., which then enjoyed a high reputation, as indeed it does to-day, for the skill of its mechanics and the excellence of its products. This young man became greatly interested in the new motive power, and proposed to Davenport that he should immediately accompany him to Capotville, promising to assist him to the best of his ability in bringing the invention into practical use. The proposal was accepted, and the two worked together at that place for some two months, during which time they completed a model of a circular railway 36 inches in diameter, upon which an electro-magnetic locomotive traveled with amazing rapidity. At the end of this time Davenport was informed by his associate that he was disinclined to go any further with the enterprise, but as Davenport himself says, he had little reason to complain of his conduct, insomuch as he willingly gave him the benefit of two months' labor and his board during the time, to say nothing of some small expenses which had been incurred. It was now the middle of December and our inventor was again left in a state of destitution at a distance of 150 miles from his home. Hardly knowing which way to turn next, he bethought himself of a letter which he had received just before his visit to Troy from a silk manufacturer in Dedham, Mass., who desired to apply electro-magnetism to the processes employed in his factory.

Among other acquaintanceships which Davenport had formed while in Capotville, was that of a Mr. Kimball, himself an intelligent mechanic, who had taken much interest in the project of the electric railway. In his perplexity he consulted Kimball and was advised by him to take his machine to Dedham, and in case he failed to conclude a satisfactory arrangement with the silk manufacturer, to try a public exhibition of his circular railway in Boston, by which means he might perhaps raise sufficient funds to aid him in making further experiments. In addition to his good advice, Kimball very generously handed him $40 for his expenses, and not content with that, told him if his plans all failed to let him know, and he would cheerfully render him further assistance. "Such kindness," writes Davenport, "from a stranger whom I had never seen half-a-dozen times in my life, seemed to be an omen of future prosperity." He proceeded to Dedham, and although "received most politely" by the silk manufacturer, that person did not seem inclined to take any chances in testing the capacity of electro-magnetism for winding silk, nor did he offer to reimburse Davenport for the expenses he had incurred in bringing his machine a long distance for exhibition. As a last resort the persevering inventor proceeded to Boston, hoping, as he says, "that the thinking portion of that intelligent city would be highly gratified with an exhibition of the wonderful effects of the silent, unseen and irresistible power of electro-magnetism." He accordingly exhibited his locomotive two weeks at the Marlborough hotel, and realized the princely sum of $12, just sufficient to meet the charges of his landlord for the use of the room. Davenport states that notices of this exhibition were published in some of the Boston newspapers of the day, but a diligent search through the columns of such journals as have been preserved has failed to reveal them. The exhibition, however, is well remembered by Thomas Hall, the veteran manufacturer of electrical instruments in Boston, who, although but a boy at the time, was employed in the shop of Daniel Davis, Jr., in which scientific instruments were made and repaired. According to the recollection of Mr. Hall, the machine consisted of a number of small magnets placed upon the rim of a vertical wheel, and constituting a sort of pole-armature, which revolved between the poles of two larger electro-magnets placed in a horizontal position which formed the field. His impression is that the field magnets were connected with the armatures in series. The current was supplied by a large Wollaston battery, and as the zincs became rapidly coated with oxide, necessitating frequent cleaning, two sets of batteries were provided, one of which was used while the other was being cleaned. The machine and battery were mounted upon a truck which traveled at a considerable speed. *

The Davenport Motor Exhibited in Boston, as Remembered by Mr. T. Hall.

At this juncture he received a letter from Kimball, inviting him to stay at his house for a few weeks and promising to furnish materials for building a larger machine. He accepted the proposal—there was obviously nothing else to be done—until finally, upon expressing a desire to return to his family in Vermont, the generous Kimball furnished the dejected inventor with a new suit of clothes, and the necessary cash for his journey, and when in parting from him Davenport expressed his doubts as to ever being able to repay him, this good Samarian cheerily remarked that he "need not trouble himself about that," but whenever he needed further assistance to call upon him.

Writing of his circumstances at this time, in the early part of 1838, he says:

For several months my prospects of getting assistance for a trial on a large scale, looked very dubious. My friends seemed to be worn out and tired of my talk about electro-magnetism being used as substitute for steam. Many hundreds of ingenious mechanics and wealthy people had seen the power propel machinery of various kinds, and all expressed a strong anxiety that I should persevere, and apparently wished with all their hearts that I might succeed. The great benefit it would have in saving human life was particularly mentioned by all who seemed to wish the project well, but yet I was totally unable to reach the pure strings of the capitalist. The objection urged by many was that my letters patent had not been taken out, and when I informed them that the patent could be obtained as soon as I could raise the

* The author desires to express his acknowledgments to William Lincoln Smith, Jr., of the Massachusetts Institute of Technology, and W. A. Smith, Secretary of the American Bell Telephone Company, for making an examination of the draft of the Boston papers, and to Mr. Smith especially for the information obtained from Mr. Hall.

† The author regrets that he has been unsuccessful in the attempt which has been made by him to identify the Mr. Kimball whose generous conduct towards a needy and struggling inventor, entitles him to the grateful remembrance of all electricians.
means sufficient for that purpose, the reply was that I had delayed so long already that some other person would probably anticipate me.

The necessities of Davenport's family now rendered it imperative that he should at once seek some means of livelihood. With characteristic persistence, he determined to attempt this by giving exhibitions of his circular railway and other electro-magnetic apparatus. His first entertainment of this kind was given in the public school-house in Brandon village. The occasion is well remembered by aged residents of that place who are still living. The building in which the exhibition took place now forms a part of the residence of George Parminter, Esq., and, it may be remarked in passing, enjoys the further distinction of having been the school attended by Stephen A. Douglas, a native of Brandon, in preparation for college, he supporting himself meantime by working at the trade of a cabinet maker.

During the following summer Davenport exhibited his apparatus two weeks at Saratoga Springs, which even at that early day had come to be somewhat of a resort during the warm season for wealthy people from various parts of the country. While here he formed the acquaintance of a leading citizen of the place, the late Ransom Cook, who was at that time a prosperous manufacturer, and proprietor of an extensive shop driven by steam power and supplied with superior machinery and tools for working both in wood and metal. Cook was profoundly impressed with the apparent value and importance of the invention, and at once tendered to Davenport the technical and financial assistance necessary to bring his enterprise properly before the public.

THE POSTAL TELEGRAPH CO. NOT TO SELL OUT.

A statement has been published that Jay Gould had purchased a controlling interest in the Postal Telegraph Cable Company. This report is so far unfounded. One of the officials of the company says:

"The report is entirely unfounded. Our stock is not listed on the stock exchange and there is none to be bought. This company was formed for the purpose of carrying on a legitimate business and not for the purpose of compelling the Western Union to buy us out.

"During the past two years we have built more than 4,000 miles of line, and we are now pushing rapidly toward New Orleans. As soon as that link is finished our system will extend from the Atlantic to the Pacific and from the great lakes to the Gulf of Mexico. We have direct connection with the Commercial Cable Company at the Canadian Pacific Telegraph. The men who own a controlling interest in this company do not wish to sell, nor do the Western Union Company wish to buy our property, for they recognize the fact that should they gain control of our system a new company would be formed within three months."

No better proof of the commercial success of electricity as a producer of light and power can be adduced than the fact that so many cities are at last providing themselves with stations worthy of the name, and that engineers are giving their whole attention to the erection of stations which will not only produce the desired effect of making electric light and power reliable and popular, but which will be able to take care of the rapid increase of business, and at the same time have a chance of creating some dividend for the pocket of the stockholder. As another example of such a station, I take pleasure in presenting in detail the plans of the new electric light and power station at Lowell, Mass., which is now just being put into active service. Like most of the larger cities, Lowell has passed through an interesting history in the development of its electric lighting industry. The Lowell Electric Light Corporation was organized under the laws of Massachusetts, in 1831, with a capital of $10,000, and began busi-

FIG. 1.—THE LOWELL, MASS., ELECTRIC LIGHT STATION.—SECTION OF ENGINE AND DYNAMO ROOM.
THE INVENTORS OF THE ELECTRIC MOTOR.—III.
WITH SPECIAL REFERENCE TO THE WORK OF THOMAS
DAVENPORT.

ANSON COOK, the new partner in the enterprise, in many respects no ordinary man. A native of Connecticut, he had been brought to the state of New York by his parents while yet a child, and had begun life in the then newly settled region of the upper Hudson as a journeyman cabinet-maker. Having by diligence and economy accumulated a small capital, he commenced on his own account in 1822, the manufacture of furniture in Saratoga Springs, and a few years later was able to fit up the large and well equipped shop referred to, which stood on the site of the present Grand Hotel.

Cook was a characteristic type of that self-educated, intelligent, ingenious, and enterprising class of American mechanics, the products of whose industrial skill have become known and esteemed in every country of the civilized world. From his very boyhood, every moment that could be spared from toil was utilized to the utmost in increasing the small store of knowledge with which a common school education had furnished him, and books, not only of the natural sciences, but of history, law and politics, were his unceasing recreation and delight. A man of scrupulous integrity, diligent and successful in business, cordially detesting every form of chicanery and hypocrisy, yet ever ready with hand and purse to aid the needy and deserving; distinguished no less for his sound judgment than for his self-reliance and independence, he was one who could not but occupy a leading position in any community in which his lot was cast. Touched with the narrative of Davenport's struggles and misfortunes, not only did Cook hasten to relieve his immediate pecuniary necessities, but instinctively perceiving the future possibilities of his invention, he suspended the lucrative business which he was carrying on, that he might throw himself heart and hand into the new enterprise. Writing of this period Davenport says:

My mind was now measurably relieved, and I felt that I could apply myself to the object in view, with renewed diligence. As the patent had not been obtained, we commenced building a model for the Patent Office. Mr. Cook seemed to be more and more enamored with the invention as the work progressed. Several hands were now employed in constructing models, and important alterations in the arrangement of the machine were made by Mr. Cook, which served to increase his confidence in the ultimate successful application of the power. As soon as we had completed a model for the Patent Office, I proceeded to Washington and deposited my model and papers. A great variety of experiments were made in Mr. Cook's shop, with regard to the size of the magnets and the speed of the engine, and many models of various sizes were completed.

At least two of the working models constructed by Davenport and Cook during the winter of 1836-7 are fortunately still in existence in an excellent state of preservation. The writer has had an opportunity of making a careful examination of one of these, a small electric locomotive running on a circular railway 14 ft. in circumference, and an illustration of which is given herewith. The motor proper consists of two straight electro-magnets, one constituting a stationary field, and the other an armature revolving in a horizontal plane parallel to and above the field. The armature is connected with the driving wheels by a speed-reducing bevel-gear. The field and armature magnets are each 5½ in. long, with cores 3 in. in diameter. They are each wound with two No. 18 copper wires connected in parallel, there being 24 convolutions of each wire on each core. The commutator is constructed with insulated springs rubbing upon insulated metallic segments. The connections with the battery are formed by mercury-cups. Perhaps the most remarkable circumstance about this motor is that the field and armature are connected in parallel, so that in this model we have a veritable example of a shunt-wound motor, built in 1836-7. The workmanship of the little machine is of the finest description, and would reflect no discredit upon the shop of any manufacturer of to-day. It bears in every feature the impress of the unusual mechanical skill of its designer. This model of the circular railway, together with auxiliary motors embodying the same general principles, were intended for exhibition in the city of New York. Near the close of the year 1836, Davenport, who was impatiently awaiting the issue of his patent, received a letter from Congressman Slade, conveying the unwelcome intelligence that his model and all the papers relating to his application had been destroyed in the fire which consumed the contents of the patent office. Not a paper nor a
single one of the 7,000 models contained in the hall escaped destruction. This disaster occurred on the 15th of December, 1886. Another model was immediately constructed and a new set of papers prepared, and about the middle of January, 1887, Davenport, supplied with funds by Cook, set out on his way to Washington and filed his application on January 24, 1887, for his patent, which was issued due course on the 25th of February following.

The following extract from the columns of a local journal will serve to show the stage which the invention had now reached:

[From the Saratoga Sentinel, Jan. 8, 1887.]

DAVEnPORT AND COOK’S ELECTRO-MAGNETIC ENGINE

In company with Dr. Steel and several other gentlemen, we called upon Messrs. Davenport and Cook, of this village, on Saturday, with a view of examining the electro-magnetic engine invented by the senior partner.

The ingenuity, yet simplicity of its construction, the rapidity of its motion, together with the grandeur of the thought that was involved in it, carried us all into the circle of the motive wheels, the projecting galvanic magnets, which revolve as near the circle as they can be brought without actual contact. The galvanic magnets were fashioned by a battery, and when so charged, magnetic attraction and repulsion are brought into requisition in giving motion to the wheel—the poles of the galvanic magnets being charged many thousand times per minute.

We were shown a model in which the motive wheel was 5½ inches in diameter, which elevated a weight of twelve pounds. And to the conventional facilities for increasing the power of this engine, another model was exhibited to us with a motive wheel of eleven inches in diameter, which elevated a weight of eighty-eight pounds. Although these models have been for some time in progress, and we have occasionally been permitted to examine them, we have waited till the present period, when the practicability of obtaining a rapid and unlimited increase of power seems to be placed beyond a doubt, before expressing an opinion, or calling the public attention to the subject.

If this engine answers the expectations of the inventor (and we believe he can assign a reason why it should not), it is destined to produce the greatest revolution in the commercial and mechanical interests which the world has ever witnessed.

While Davenport was in Washington attending to the invention, Cook formed the acquaintance of a typical representative of a class of people who have become in later years much more widely than favorably known in electrical circles as “promoters.” This person, whose prominent position as secretary of one of the leading scientific and technical institutions in New York apparently enabled him to confidence, suggested the advisability of forming a joint-stock association to exploit the patent. To this Cook, and Davenport, after his return from Washington, willingly acceded, the more so, that they had found that the cost of procuring patents in the different countries of Europe and of building a machine of a size enough to give the public convincing proof of the value of the discovery, would be likely to be considerably beyond their individual resources. In accordance with this plan, early in March articles of association were drawn up, by which the whole stock of the company was placed in the hands of the promoter to enable him to raise funds for building models and machinery, and for testing the utility of said invention; for giving to the same its greatest possible value for the benefit of the stockholders (the constructions so made to belong to the association); also for securing to us the use of said invention in Europe for the benefit of the association.

A supplementary agreement was executed at the same time, by which the promoter pledged himself to pay Davenport and Cook $12,000 in cash within thirty days. This was a large sum of money in those days, and the struggling inventor at last felt able to congratulate himself that his pecuniary troubles at least were at an end.

Every prospect seemed as favorable as could be desired or hoped for. As a curiosity we give a fac-simile of one of the certificates of scrip of this—perhaps the first joint stock company ever organized to exploit an electrical invention, and filed on January 24, 1887, for his patent, which was issued due course on the 25th of February following.

In March, Davenport received a letter from Professor Benjamin Silliman, of New Haven, requesting information about his machine for publication in the American Journal of Science and adding:

I have no doubt you will always receive advantage from the sound and judicious advice of our friend Mr. —— (motor) whose experience in business and great zeal and fidelity in this affair will no doubt greatly aid in all the proper business parts of your concern.

The publication in Silliman’s Journal of April, 1887, of a detailed description from personal examination of two different forms of Davenport’s machine, one having revolving electro-magnets in conjunction with fixed permanent field magnets, and the other composed entirely of electro-magnets with its fixed and revolving magnets, excited a very great interest in scientific circles both in this country and abroad. At the end of the article, which is signed with the initials of Professor Silliman, the author sums up his conclusions in reference to the invention as follows:

1. It appears then, from the facts stated above, that electro-magnetism is quite adequate to the generation of motive power.
2. That it is not necessary to employ permanent magnets in any part of the construction, and that electro-magnets are far preferable, not only for the moving, but for the stationary parts of the machine.
3. That the power generated by electro-magnetism may be indefinitely prolonged, since, for exhausted acids and corroded metals, fresh acids and batteries, kept always in readiness, may be substituted, even without stopping the movement.

The power may be increased beyond any limit hitherto attained, and probably beyond any which can be with certainty assigned—since, by increasing all the members of the apparatus, due reference being had to the relative proportionate weight, size, and form of the fixed and movable parts—to the length of the insulated wires and the manner of winding them—and to the proper size and construction of the battery, as well as to the nature and strength of the acid or other exciting agent, and the manner of connecting the battery with the machine, it would appear certain, that the power must be increased in some ratio which experience must ascertain.

4. As electro-magnetism has been experimentally proved to be sufficient to raise and sustain several thousand pounds, no reason can be discovered why—when the acting surfaces are, by skillful mechanism, brought as near as possible, without contact—there should not be obtained extended rotary movement, of a degree of energy, inferior indeed to that exerted in actual contact, but still nearly approximating to it.

5. As the power can be generated cheaply and certainly—as it can be continued indefinitely—as it has been very greatly increased by very simple means—as we have no knowledge of its limit, and may therefore presume on an indefinite augmentation of its energy, it is much to be desired, that the investigation should be prosecuted with zeal, aided by correct scientific knowledge, by mechanical skill, and by ample funds. It may therefore be reasonably hoped, that science and art, the handmaids of discovery, will both receive from this interesting research a liberal reward.

Science has thus, most unexpectedly, placed in our hands a new power of great but undeveloped force. It does not evoke the winds from their caverns; nor give wings to water by the urgency of heat; nor drive to exhaustion muscular power of animals, nor operate by complicated mechanism; nor accumulate hydraulic force by damming the vexed torrent; nor summon any other form of gravitating force; but, by the simplest means—the mere contact of metallic surfaces of small extent, with feeble chemical agents, a power everywhere diffused through nature, but generally concealed from our notice—is mysteriously evoked, and by circumscribed or minute wires it is still more mysteriously augmented, a thousand and a thousand fold, until it breaks forth with incredible energy; there setting a measurable interval between this moment and all it evolution and its full maturity, and the infant starts up a giant.

Nothing since the discovery of gravitation and of the structure of the celestial system is so wonderful as the power evolved by galvanism; whether we contemplate it in the muscular convulsions of animals, the chemical decompositions, the solar brightness of the galvanic light, the dissipating consuming heat,
and more than all, in the magnetic energy, which leaves far behind all previous artificial accumulations of this power, and reveals, as there is full reason to believe, the grand secret of true natural magnetism.

We shall hereafter give an accurate drawing, made to scale, of one of three or four machines, substantially alike, which were constructed in the winter of 1836-37, by Davenport and Cook. The model in the patent office in Washington was one of these, another was sent to Europe to be used in obtaining patents in various countries, and at least one other was kept on exhibition in New York, where it was inspected by crowds of curious spectators.

The workshop and laboratory of Davenport and Cook were in a large building at 42 Stanton street, which has long since disappeared and been replaced by remen houses. Writing of this period, Davenport says:

During the spring and summer of 1837, our laboratory, which was a spacious one, was crowded to overflowing daily by visitors to examine the variety of machines and apparatus which were on hand, and in progress of construction. Among the distinguished and scientific gentlemen who visited our work, were Professor Samuel F. B. Morse, then of the New York University, frances, or $40,000, as a compensation for his wonderful invention.

In the course of this summer we constructed a great variety of machines, testing the power of each to ascertain the amount of improvement, and among these was a miniature locomotive engine which moved on a circular railway of 14 feet in diameter, moving a train of half-a-dozen cars. Many of the public prints came out in favor of the invention, recommending that capitalists should examine the operation of the machines, and aid in the enterprise by their assistance in furnishing funds.

Many of these newspaper notices are so characteristic, that I cannot forbear making a few extracts from them:

(From the New York Herald, April 27, 1837.)

A REVOLUTION IN PHILOSOPHY.—Davenport, the Navigating Engineer.

We mentioned slightly the other day a few particulars descriptive of the electro-magnetic machine now preparing for exhibition in this city. We shall now go a little deeper into this most extraordinary discovery, probably the greatest of ancient and modern times, the greatest the world has ever seen, the greatest the world will ever see.

We are in the commencement of a revolution in philosophy, science, art, and civilization. The occult and mysterious principle of galvanism is now beginning to be developed in all its magnificence and energy.

MODEL OF ELECTRIC CIRCULAR RAILWAY MADE BY DAVENPORT AND COOK IN 1836-7.

[From recent photograph and sketch by F. L. Pape.]

and Doctor Charles G. Page, then of Boston. Professor Morse frequently mentioned his intentions of experimenting on the electro-magnet for the purpose of producing signs for signals for telegraphic purposes, and stated that he had long ago conceived the idea of transmitting intelligence by electricity. A gentleman from Germany, Baron D——, purchased secretly from one of our workmen drawings of some of the best models, and in about six months from that time the German papers were teeming with the news that Baron D—— had invented a new motive power, a model of a machine, put in motion by electro-magnetism! The German Diet is said to have voted this gentleman pirate 200,000 thalers.

1. From the sworn deposition of Professor Leonard D. Gale, corroborated by other public statements of the Supreme Court in the case of U. S. v. Morse, it appears that the first crude model of Morse's telegraphic recording apparatus was constructed by him in the late fall of 1835, and that Gale became associated with him in 1836. In his deposition Gale says:—"From April to September, 1837, Professor Morse and myself were engaged together in the work of preparing magnets, winding wire, constructing batteries, etc., in the University, for an experiment on a larger but still very limited scale, in the little leisure that each had to spare. The latter part of August, 1837, the apparatus of the machine was shown to numerous visitors to the University. It must have been while this work was going on, that Morse visited Davenport's laboratory. The marked likeness between the electro-magnet in the original instrument of Morse, preserved in the cabinet of the Western Union Telegraph Company, at 135 Broadway, New York, and the magnets in some of the motors of Davenport and Cook, constructed just before they brought their apparatus to New York, furnishes grounds for the belief that Morse's knowledge of the construction of Henry's magnet may, in part at least, have been derived from observations made during his visit to the laboratory here referred to.

It is utterly impossible to give vent to all these burning thoughts which crowd upon our mind at the contemplation of this discovery. It surpasses any discovery of ancient or modern times. The generalization of this principle, and its undoubted identification with all the phenomena of nature—with motion—with animal life—with earthquakes—with gravity—with electricity—with the motion of the earth and planets round the sun, must and will create an entire revolution in all science, in all art, in all philosophy, and in all future civilization. Indeed we may go further, and however droll it may appear, we have strong suspicions that the friendship, esteem and the mysterious love which the sexes is found on the same principle with which Mr. Davenport turns his wheel, and the lightning flashes from heaven—and the aurora borealis spreads out its garments of rosy light in the sky—and the very planets themselves run their races round the sun from eternity to eternity.

Enough for the present. We have long been a student in chemistry, electricity, galvanism, and such like sciences. We shall illustrate our views at our leisure. Meanwhile we bid all prepare for an organic revolution in science, philosophy, religion, and civilization. We are just entering upon a wonderful age.

(From the N. Y. Evening Star, August, 1837.)

In concurrence, unanimously we believe, with all who have

2. The writer, notwithstanding such research, has failed in his attempts to penetrate the Ing-ooldo of the "gentleman pirate." The statement is given as it is written. Possibly others may be more successful.
witnessed the operations of this extraordinary and simple apparatus, and listened to the lucid and eloquent explanations of Mr. Cook, nothing so uttering accomplishment as the phenomena which it manifestly foretells in the application of an entire new and immeasurably agent of mechanical power; and at the same time we see and admire our want of language to sustain us, utterly incompetent to impart any correct conception of this marvelous invention to our readers.

All is not go and be convinced.

It is a sublime but not wild idea of Mr. Cook, that a ship's bottom, covered with suitable plates and the ocean for its bath, may move along with incredible velocity, at the same time generating abundance of hydrogen to light her onward upon the deep.

But it is in a commercial view that it exhibits, in prospective at least, an importance combined with the finest sublimity. It is well known that sea-water forms an active bath for the galvanic battery when kept up by frequent changes. Is there any immovable objection to arranging the sheathing of the vessel so as to form a battery, and with the ocean for its bath and the application of magnetic power, "drive the ship onward in her course and guide her to the point of destination by the same agent?"

When the use of steam is proposed in conducting our distant commerce, we cannot avoid the reflection that on the vast deep the perils of wind and waves are sufficient without adding those of fire and explosion.

(From the N. Y. Evening Post.)

We learn that some recent improvements have been made in the application of electricity as a moving power to machines of a larger apparatus than the one hitherto exhibited has been constructed under the direction of Mr. Cook, now in this city, which is to be a turning laber, in order that those who are interested in the invention may see it at work. Nothing but the difficulty of the times now stands in the way of demonstrating the application of this power on a large scale to machinery of the most ponderous description.

(From American Correspondence of London Morning Herald.)

I did not write by the packet of the 18th [August, 1837], because I had made an appointment for the next day, to go and see the electrical machines of Mr. Davenport, but I considered well worthy to be the subject of a letter, provided there were any grounds for the vast expectations founded upon them, not only by the inventor and his friends, but by every person who had examined them, and heard the explanations of Mr. Davenport. Having seen them, I am free to confess that I cannot discover any good reason why the power may not be obtained and employed in sufficient abundance for any machinery; why it should not supersede steam, to which it is infinitely preferable on the score of expense, safety, and simplicity. I do not very clearly understand the principle (something about changing the poles from positive to negative, or from north to south), and vice versa; and without exception; but this is of consequence, as I shall be able to send you, probably by the next packet, a pamphlet containing a full exhibition, with illustrative engravings. Mr. Cook has been my only representative in the patent, and engaged in preparing this pamphlet, and he has promised me the first copy that is printed. They have patented their invention in France and England.

The last machine constructed by Mr. Davenport occupies a surface of about 18 inches square, that is, 18 inches on each side, and is a framework of a platform, having a circular frame, with an arch extending from side to side above it, a spindle in the centre playing in this arch at top and in a socket below, and on this spindle an incomplete wheel, formed of two cross pieces of iron, with segments of a circle at the four extremities. It is, in fact, a wheel, with four breaks in its periphery. Some hundreds of feet of insulated, or coated, copper wire are wound around the cross pieces, and also around the fixed circular frame; the connection with the galvanic batteries, which are three small cylinders, each consisting of six concentric tubes of zinc and copper, the outer one scarcely larger than a quart pot, is, formed by small rods of copper. The revolving wheel is six inches in diameter, and weighs about six pounds. Attached to the upright spindle is a small cog-wheel, which may be made to work in other wheels, with axles, for the purpose of showing how great a power can be raised from the ground.

With the three batteries acting on it, the revolution of the wheel was 1,000 times in a minute; and these 1,000 revolutions raised 24 lbs. The first machine made by Mr. Davenport, which is much smaller and has but one battery, raised but 24 lbs. He is confident that with a number of batteries, or in the way, as big a barrel, there would be power enough to drive the largest machinery, while the cost of construction would be reduced to a fifth, or perhaps a tenth, and the steam, fuel, etc., not amounting so heavy an item in the expenses of steam-power, would be almost done away with. Half a barrel of blue vitriol, and a hoghead or two of water, would be all that was necessary to carry the machinery from New York to Liverpool: and nothing would possibly happen, beyond the breaking of some part of the machinery, which is so simple, that any damage could be repaired in half a day. Surely it is a great and vastly important discovery, and the wildest imagination at the present moment could not have in achieving which it may, and doubtless will, become the instrument.

Reference to the preceding description of the machine shown to the correspondent of the London Herald, is sufficient to show that it was quite an advanced type of motor, having a horseshoe field, and a four-pole armature fitted with segmental polar surfaces. A model of one of the machines of this type, but having two poles only, is still in existence.

Amid the general chorus of praise, there was, as might have been expected, now and then an inharmonious note, as witness the following communication:

[From the Journal of Commerce.]

Messrs. Editors: I have been much gratified with your exposure of various humbugs of late in science and politics; but if I recollect right, you have not touched upon what I consider as also inconsiderably a great humbug. I mean Mr. Davenport's machine, so far as it boasts of being of any practical utility. I am aware that Mr. Silliman speaks of Mr. Davenport's invention as "putting into our hands a new power of great but unknown energy," and opposes the power may be increased beyond any limit which can be assigned; he therefore seems to speak of the discovery as of great pecuniary value, and recommends that the investigation should be prosecuted. The power and utility of the machine, however, shown in what way any great and useful power is to be attained by Mr. Davenport's invention, and probably he would not again lend his name to this device. I am not aware also that Mr. D. is able by his machine to move a couple of tiny cars about a railroad in Barclay street, of a dozen or fifteen feet in diameter; but I propose to show that he cannot, by electromagnetism, acquire any great and valuable power, and that his machine in its grand promise is a humbug.

Annoying caricatures were also circulated, a fashion much in vogue at that time. One of these skits represented a boat propelled by lightning. Davenport and Smalley, with despair depicted upon their countenances were tinkerimg at the machinery, while Prof. Silliman, in an attitude of mock dignity, was expatiating to the public on the merits of the scheme.

So far as can be ascertained, the earliest account of the experiments of Professor Moritz Hermann von Jacobi, of Königsberg, Prussia, afterwards of St. Petersburgh, which reached this country, was contained in a paper published in Sturgeon's Annals, translated from Comptes Rendus. This admirable paper, which, considering the early date of its publication, displays a masterly knowledge of fundamental principles of electro-magnetism, as well as an intimate experimental acquaintance with its phenomena, especially as exhibited in the actions and reactions of the magnets of an electric motor, contains a full description of the machine, illustrated with an excellent drawing which clearly exhibits the details of its construction. From this drawing, which we reproduce in fac-simile, it clearly appears that not only is its principle the same as that of Davenport and Smalley's motor heretofore described, but that even in the details of construction the differences are comparatively unimportant. In this paper, Jacobi states that he first succeeded in obtaining rotating machinery in May, 1834, and incidentally refers to a paper partially describing it, which he read before the Academy of Sciences of Paris, on December 1, of the same year, an abstract of which was published in Philistos, No. 92, on December 3rd. The following is a translation of this note:

M. Jacobi, of Königsberg, presented to the Academy a paper on a magnetic engine of his invention, in which magnetism is employed as a motive power. The following is the description given of it:—The apparatus consists of two systems comprising eight bars each of soft iron, each 7 inches in length and 1 inch in diameter. These two systems of bars are placed at right angles, so arranged on two discs that the ends or poles of the bars are opposite one another. One disc is fixed while the other revolves on an axis, and the movable bars are thus made to pass as close as possible in front of the fixed ones. The 16 bars are wound with 230 feet of copper wire, 1/4 inch in diameter, the ends of these wires were connected with a commutator making the moving at a speed of six feet per second, giving about 50 lbs., being

3. Sturgeon's Annals of Electricity, etc., 1, 408.
a considerable six times. The work thus furnished, measured by an apparatus similar to the Prony brake, is equal to a weight of 10 or 15 lbs. lifted one foot per second. This success is principally due to a novel combination of the commutator by which the changes of polarity are worked. These take place eight times in each complete revolution; that is to say, eight times in half or three-quarters of a second, the ordinary speed of the machine, when the water in the cell is so little acidulated that the development of gas is hardly appreciable.

In 1888, under the patronage and at the expense of the Emperor Nicholas, of Russia, Jacobi constructed a much larger motor upon substantially the same principles, with which he succeeded in propelling a boat upon the Neva, at St. Petersburg. As full accounts of this experiment have been many times published, I will not occupy space by repeating them here. The illustration given will suffice to show the general character of the motor used on this occasion.

The question of actual priority, in point of time, as between the invention of Davenport and that of Jacobi is a very close one. If the rotary motion which Jacobi obtained in May, 1894, was effected by the identical apparatus described in his paper read before the Academy in November of that year, then his priority must be conceded, but it does not appear to be certain that such is the case. In any event, the discoveries here and abroad must necessarily have been wholly independent, although nearly coincident in point of time, and it is, to say the least, remarkable, that one who labored under such limitations and disadvantages as Davenport, should by the unaided force of his native genius, have achieved a result which has been universally conceded to reflect the highest credit upon the talents and perseverance of one of the most able and learned experimental philosophers of his day.

The following letter, written near the close of the year 1897, gives an interesting résumé of the progress of efforts in the laboratory at that date:

Desir—Having lately made a number of applications of the power of large galvanic magnets in propelling machinery (being independent of the large machine now constructing by the association), I have thought proper to state to you the result, believing they would not be uninteresting to you.

I have constructed a machine with two revolving magnets 2 feet in length, made of iron, 1/4 inches in diameter, and weighing, after being wound with 6 coils of No. 10 copper wire, 100 pounds each. Three stationary magnets of 2 feet diameter, were placed around the periphery, making 6 poles and weighing 100 pounds each.

With this machine I have produced 100 revolutions per minute with 6 square feet of sheet zinc exposed to action, surrounded with thin sheet copper.

Then I placed the stationary magnets, and substituted one magnet 8 inches in diameter, forming a semi-circle, with the poles directly opposite each other, and weighing about 100 pounds. With this magnet I produced 150 revolutions per minute, and the same quantity of zinc surface. With one revolving magnet I produced 175 revolutions per minute, with 4 square feet of sheet zinc. I next constructed a hollow magnet 2 feet in length and 4 inches in diameter, made of boiler iron, 1/4 of an inch in thickness, with 4 coils of copper wire, with which I succeeded in getting 100 revolutions per minute. A hollow magnet was then constructed of thin sheet-iron, of the thickness of common stovepipe iron, which revolved 150 times per minute. Hollow magnets may be used to advantage where weight is an objection; but in my experiments I generally make use of solid iron.

I also constructed a machine with simply two magnets formed of 2-inch round iron, 15 inches in length, of the stirrup form. The distance between the centres of the poles is 6 inches and the magnet revolves 450 times per minute, with 3 square feet of zinc. The stationary magnets being placed with the poles of the revolving magnet pointing downwards, the shaft to which the revolving magnet is attached passes through its centre and rests on the centre of the stationary magnet. Two of these machines (weighing in all 50 pounds) I have attached to small drilling works, which I find produce sufficient power to do any drilling of iron and steel, to the size of 1/4 of an inch in diameter.

I have adopted this form on the third machine which I have recently put in operation. The magnets are formed of 3/4 inch iron, with the centres of their poles 9 inches apart and weighing 50 pounds each; with this I produced 300 revolutions per minute, and have successfully applied it to turning hard wood of 3 inches diameter. I find the power increases in full proportion to the increase of weight and without increasing in proportion the size of the battery. The wire must be increased in size in proportion to the size of the iron used, and, consequently, the difficulty attending long wires will always be avoided.

I find no difficulty in using my machine 12 hours in succession, without changing batteries or agitating the solution.

I am erecting conveniences to test the powers of each magnet as they are increased in weight and size, and think I shall be able in season for the April number of your journal to give the exact increase of power in proportion to weight, of magnets weighing from 10 pounds to several tons.

I have also made some very satisfactory trials, while making my machines, respecting the expense for the consumption of zinc and acid, and think I shall soon be able to give nearly the precise cost of making the largest machine.

The Japanese is, I trust, destined to produce the greatest results in the most simple form, and I hope not to be considered an enthusiast, when I venture to predict, that soon engines capable of propelling the largest magnets, will be produced by the simple action of two galvanic magnets, and worked with much less expense than steam. Yours respectfully,

New York, Dec. 28, 1897.

THOMAS DAVENPORT.

Motor used by Jacobi in his experiment on the Neva in 1888.

[By permission of D. Van Nooten Co.]

THE ELECTRICAL ENGINEER. [Jan. 21, 1891.

In 1888, Frederic Coombs was sent abroad to obtain patents in Great Britain and other countries, and to exhibit the machine with the battery of existing foreign capital in aid of the enterprise. The following notices were published in the proceedings of the London Electrical Society, of its meeting of July 17, 1888:4

Previous to the chair being taken, Mr. Coombs, of New York, exhibited to the members a locomotive engine propelled by electricity. The machine, which is now on exhibition at the Royal Gallery of Practical Science, consists: 1st. Of the carriage containing the apparatus, but which, in consequence of the arrangement of the apparatus, is necessary to the working out of the plan in this country not being completed, could not be explained. 2d. Two voltaic batteries; these are made on the principle of Hare's calomel motor, excited by a strong solution of sulphate of copper. 3d. Two carriages attached to the apparatus. The apparatus, batteries, and carriages weigh 60 or 70 lbs., and are placed on a circular railroad. Upon connection of the apparatus being accomplished (by means of a cup containing mercury) with the poles of the two batteries, the apparatus is set in motion and revolves for some time with remarkable velocity, but which decreases as the action of the battery diminishes.

The exhibition appears to have been favorably received by the members present, but it does not appear that anything further was accomplished. The following is selected from a number of newspaper notices:

[From the London Morning Herald, August, 1888.]

DAVENPORT'S ELECTRO-MAGNETIC RAILWAY LOCOMOTIVE.

Mr. Davenport has at length gratified the curiosity of the English skeptics to a certain extent, by sending over a model of a locomotive engine, which is now exhibiting at the Adelphi Gallery, in the Lower Bowery, worked on the same principle as his larger stationary engines. This engine runs on a circular railroad and carries along for its own weight two other carriages, which more for the aid of two small galvanic batteries, at the rate of about three miles an hour. The weight thus propelled is nearly 90 lbs., and the carriage containing the apparatus about one foot square. The number in which the magnets are arranged is kept secret for the present; but the principle on which the application of the power depends is well known, and the chief superiority in Mr. Davenport's invention consists in his having, by some peculiar contrivance, brought into exercise a greater amount of power within a given space and weight, than has been hitherto accomplished. Though we do not anticipate that Mr. Davenport's invention as exhibited in the working model would be found applicable on a large scale with any practical advantage; yet we believe that the work accomplished is sufficient to show that important results may be expected from future improvements in the application of the same principle. We are informed by an American gentleman who has recently arrived in England that he witnessed a two horse power electro-magnetic engine, of Mr. Davenport's construction, employed in printing a newspaper in New York, and that it performed that service in a most satisfactory manner. Whether or not, however, this was done at a cheaper rate than the same power might be obtained from steam, we are not able to ascertain.

Frederic Coombs, the exhibitor of the Davenport motor in England, in his old age became mentally unbalanced, and from his harmless eccentricities of dress and behavior was, for many years, a well known character in the streets of Washington, San Francisco and New York. His personal appearance was remarkable, combining as it were, the stately dignity of a Washington with the affable and condescending benevolence of a Franklin. The portrait given herewith will be recognized by many of our older readers.

The peculiar business methods pursued by the individual who had been entrusted with the management of the financial interests of the association soon came to be of a character to excite the suspicions both of his associates and of the public. His plan appears to have been a sufficiently simple one, namely, to sell shares to any one who could afford to purchase, at any price the party could be induced to pay, and to put the proceeds in his own pocket, at the same time persistently refusing to render to his associates any account of his doings, but reluctantly disgorging; from time to time, such sums of money as were absolutely necessary to keep the laboratory going with the smallest possible number of employees. This course of conduct could have but one result. The confidence of the public generally in the integrity of the association, and of the members of the association, of the public, and of those who had purchased shares not unnaturally began to entertain suspicions that they had been duped. Ransom Cook was a man who was not only peculiarly sensitive in matters of honor, but one who was utterly without patience with fraud or chicanery in any form. He did not hesitate to express his disappointment and vexation at the conduct of the business manager, and ultimately, on the 19th of February, 1893, he sold nearly the whole of his interest for a mere pittance, withdrew in disgust from the enterprise, and returned to his home in Saratoga. During the year they had carried on operations in New York, Cook had expended on the work some $3,000, and Davenport more than $8,000 of their own money, while the total amount received from their business manager, instead of the promised $15,000, was only $1,700. After the departure of Cook, Davenport and M. W. Nelson, the party who had purchased Cook's interest, brought a suit in chancery against their unprincipled associate, the result of which was that the court compelled the latter, much against his will, to exhibit his books and render an account of his stewardship. Davenport had meantime sold a part of the patent right for the New England States which he had reserved himself, and the proceeds furnished him with means to continue his experiments for a time without other aid.

One cannot but deplore the unfortunate occurrences which led to the permanent withdrawal of such a man as Ransom Cook from further association with a department of experimental research, in which his natural tastes, no less than his remarkable talents, so eminently qualified him to achieve distinction. An artificer of surpassing skill; a diligent and observant student of nature's ways and works; an original thinker, and an inventor of a high order; the brief story of a single one of Cook's mechanical conceptions will portray more vividly than volumes of description the rare genius of the man. Ever full of intelligent curiosity regarding the cunning works of nature, he became at one time absorbed in the study of the structure and habits of the so-called "ship-worm" (teredo navalis). More than anything else, he was struck with the capacity of this little creature to apply its cutting tool with equal facility and efficacy, at any angle to the grain of the wood, and as a skilled wood-worker, his mind at once seized upon and sought to apply the hint which nature had thus given. With industry and skillfully, he constructed from steel experimental augers and bits, with cutters modelled from the teredo's mandibles, until at last the result was achieved; the curved tips of the justly celebrated "Cook bit," an implement which by sheer intrinsic merit has made itself indispensable to the "kit" of every wood-worker in the civilized world. Of his many other scarcely less ingenious and original conceptions, space forbids even a passing notice here. In the autumn of his days, retiring with a handsome and well-earned competency from the active pursuits of life, he provided himself with a well-stocked library, and a model laboratory equipped with the most improved mechanical appliances and scientific apparatus. Here it was his especial delight to entertain his chosen friends, among whom were numbered many of the most prominent of public men and scientists who were his contemporaries. He died at the age of 87, at the advanced age of 87. It is impossible to resist the conviction, that had Ransom Cook continued to devote his unusual and peculiar talents to the industrial development of electro-magnetism, many of those knotty problems, which for so many years confronted and frustrated the path of the investigator, would have received at his hands an earlier solution.

Thrown once more upon his own resources, Davenport proceeded to build several larger machines, of a type very similar to that of the model locomotive in the illustration

5. Surgeon's Annals of Electricity, etc., ill. 156.
on page 67, referring to which he says:

I increased the size of my magnets to about 80 lbs. each, and with four machines, with two of these magnets in each, I moved a large Napier printing press in the month of April, 1888. There was not, however, sufficient power for printing papers, although the machine would keep the press in motion.

While engaged in these experiments, he received a letter from Dr. Charles G. Page, then of Boston, who had been for some time engaged in exploring the same field. It is of interest as showing the views of Page at that date, and especially in view of the reference to the experiment of arresting the rotation of a magnetic bar by what is obviously an inductive action:

[Charles G. Page to Thomas Davenport.]

BOSTON, April 28th, 1888.

THOMAS DAVENTPORT, ESQ.,

Sir:—I have for a long time (as is well known to you) been pursuing the same experiment as yourself, but for many months past, I believe I have been on an entirely new and different track. My train object has been to prevent retardation or back action. My plan is to cut off the galvanic current from both systems of magnets instead of changing poles as they arrive at equilibrium.

The advantage of this I have fully tested, and my model for a patent went to the office three months ago. I have had notice from the Commissioner that it should be attended to as soon as practicable, but the certificate has not yet arrived. This experiment has been tried on a large scale, and has failed, not because of any fault in the plan, but for the simple reason that the magnets were too much crowded. I made a demand on the company for $500, to alter the machine, but as they have already exceeded their subscription by $500, they thought best to give it up. But trying off the current, but is simply a method of increasing the power of the magnet. I will engage to make any machine of yours in five minutes time half as strong again, or forfeit the value of the machine (the battery shall remain the same). I feel very sure the power will be useful to the extent I have above named, but for reasons which I can make conclusive to any one I do not believe in its indefinite increase.

I am now under obligations to no one here, and before I get up another interest I should like to know your views. I believe it would be for your advantage and mine, and contribute much to the success of the experiment, if our interests should be united. If you will make me a reasonable offer, I will take hold with you heart and hand, and there is no question but that in a short time we could make an excellent business of it, as we could cover the whole ground. Please write me immediately.

Respectfully yours,

CHARLES G. PAGE.

Acknowledging the receipt of this letter, Davenport replied briefly on Nov. 2, stating that he was “not in a situation to make or receive propositions relative to a union of interests,” inasmuch as the ownership of his invention was largely vested in the corporation which had been organized to exploit it.

HOW TO DISPOSE OF THE INDIANS.

Secretary of War Proctor’s mail is burdened with letters from cranks making suggestions as to the conduct of the Indian campaign. One correspondent proposes to exterminate the entire Sioux nation or a large part of it by establishing an electric plant at Pine Ridge and stretching a wire around the hostile camp. Then, turning on the current, the Indians are to be drawn closer and closer until contact with the wire causes wholesale destruction.
ARLY in the spring of 1888, Davenport discovered the principle of the core moving within the magnetic field of a solenoid, which afterwards came to be well known by the name of the "axial magnet." Entertaining the conviction that in this principle lay the germ of an important improvement in electro-magnetic engines, due to the possibility of greatly increasing the effective length of the stroke, he at once prepared and filed in the Patent Office at Washington, a caveat describing his discovery, and giving an outline of the manner in which he proposed to apply it for the movement of machinery. Although this discovery was no doubt original with Davenport, the phenomenon had been observed by Peter Barlow as early as 1822.1 So far as record evidence goes, however, the caveat of Davenport is believed to be the earliest proposition to apply this principle in any manner for industrial purposes. As this caveat has never been published, a copy of it is given below, procured by permission of the heirs of the inventor, from the secret archives of the Patent Office at Washington.

1. This effect was noticed by Barlow in the course of an experiment in magnetizing a steel needle which was placed within a helix wound upon a glass tube. The core of this helix was made as follows:—

"In performing this experiment, I employed a glass tube about 5 inches in length, and 1 inch in diameter, which was closed at one end, when the needle was inserted in it, so that one-half of it projected beyond the end, that the moment the polarized needle reached the solenoid, the tube was instantly made to the middle of the helix, and while the contact was continued it was held suspended in the centre of the solenoid. The needle was then found to be having a power of suspending the whole weight of the tube, as if the power was excessive the power of gravity. (The connection of the spiral with the conducting wires is here supposed to be made before the plates are immersed in the solenoid.)"

This effect is very curious, because the needle here remains suspended in the open space, directly in the axis of the tube, and not attached to either side as in the usual case of suspension by attraction." — Barlow: Essay on Magnetic Attractions, etc., 2d edition, 1858, p. 232.

The writer is indebted to Charles L. Clarke for the loan of the exceedingly rare work from which the above extract was taken.

The following editorial note referring to the same phenomenon appears in Sturgeon's Annals, vol. 1, p. 50 (Jan., 1858);—"In answer to our correspondent, who wants to know if it is possible to suspend a needle in the air by transmitting an electric current through a helix in which the needle or bar is lying, we must say, Yes. The fact was first noticed by Mr. Barlow, at the London Institution, Manchester. The battery employed was contrived by Mr. Fage, and consisted of a single pair of plates of copper and zinc, each about 50 feet long and 3 feet broad, formed into a spiral on a cylindrical mass of wood, and placed in a barrel or circular wooden trough which held about 20 gallons of old solution. The experiment may be made, however, with a battery of one square foot of each metal, immersed in a strong solution of nitrogen; the helix must be of narrow bore, of 5 or 8 layers of spirals, and held vertically. The gravitating property of the needle may be much reduced by holding a bar magnet at a small distance above the helix."

In Alfred Valli's American Electro-Magnetic Telegraph, p. 58, it is account of an interesting Experiment of Supporting a Large Bar of Iron within the Helix. Discovered by Mr. Valli, Jan. 14th, 1858, which, so far as the writer is aware, is the earliest published account of the suspension of a soft iron bar of any considerable weight. The account is in the following words:—"It has been some years since a magnetic effect would be drawn in a coil suspended as within a helix converting a galvanic current, and that in the case of using large bar magnets, the coils of helices might be made to move over them as in the Biv's rings; but in no instance I believe it has been recorded or observed, that a bar of iron weighing a pound, or more, could be drawn into the air and there sustained in the air, as it were, without support. If the helix be connected with a battery of (6) or more, the bar may be bared of its helix, and then sustained in a vertical position by the action of the helix, forming an exceedingly interesting and paradoxical experiment."
THE ELECTRICAL ENGINEER.

[Jan. 28, 1891.

built the celebrated steamship the British Queen. It appears that Smith, who had visited America in the preceding summer, L.3 saw a model of Davenport's apparatus in operation at the Mechanic's Fair in Castle Garden, and in his letter he intimated his desire to undertake the introduction of the invention in Great Britain, on Davenport's behalf. Writing from Brandon, in reply to this and other letters from Smith, on August 15, 1889, Davenport says:

I have experimented these 18 months past with my own limited means, constructing machines on more than 20 entirely different plans; making great improvements in the power in proportion to the weight, &c.

I have no doubt but that the power is unlimited, which can and ultimately will be successfully applied to all purposes for which steam-power is now used.

The present system is making in New York by some individuals who have a machine now exhibiting in Gold street, to monopolize, as they say, the business of Electro-magnetic speculation. They have obtained a charter, and are offering for sale shares of stock; but their machine, although inferior in principle of application to any ever before exhibited to the public, is precisely on the plan of one constructed by my self in the winter of 1885, a part of which is now at this place [Brandon].

In a subsequent letter to Smith, dated in New York, December 13, 1889, Davenport mentioned that he was driving a rotary printing press with a machine weighing less than 100 pounds.

In January, 1840, Davenport commenced the publication of a journal entitled The Electro-Magnet and Mechanics. This was a small folio sheet 12 by 16 inches, and as its title-page announced, was printed on a press propelled by electro-magnetism. As a matter of curiosity we give a fac-simile in the head of this somewhat unique and not particularly well printed publication. Copies of the two first numbers issued have been preserved. It is not known how many, if any, subsequent numbers were issued. Among the editorial remarks in the second number I find the following, which are quoted as explanatory of the plan and scope of the undertaking:

The first number of the Electro-Magnet was issued on Saturday, January 18, 1840, which was the first paper ever printed by the power of Electro-Magnetism or Galvanism. The project was proposed and set on foot for the express purpose of bringing before the public some tangible illustration whereby the power might be brought forward upon as cheap and prudent scale as possible. How far we have succeeded, time must show.

As the second number of our publication is before the public, we would respectfully call the attention of those who wish to advance the cause of philanthropy to come forward and subscribe, so that we may be considered chimerical by many we doubt not; but when all things are fully proved we shall hope for a better fate than many of our predecessors.

On January 28, 1840, only three days later, in a letter to his brother, in Brandon, he feelingly portrays some of the miseries which beset the path of this, the pioneer effort in electrical journalism:

I have been obliged to bear the whole load in starting the paper and have no writer to aid me yet. I have talked with some, and find that it will cost $10 per week for editorial articles (which accounts for no more original matter), yet I intend to have friends enough soon that will help without expense to me.

The truth is, I am now in the worst pinch in regard to means for supporting my family that I ever have been, yet my prospects are the most flattering, and I think the most sure to not me something handsome as early as spring. You see I have no way to get a few dollars in a place, except by the prospect of getting subscribers, which I have not yet tried to do. I have only to take time and make my trade in a lump.

A few months later Davenport appears to have made a second essay in the way of a journalistic venture, of which, so far as is known, only a single number was issued. The new undertaking was somewhat more ambitious in character, being printed in quarto form upon a sheet 16 by 22 inches. The journal was entitled The Mechanic's Magazine, and was "edited by S. J. Burr, secretary, U. S. Society of Science and Mechanism," presumably at the munificent salary of $10 per week, which in fairness it must be stated, was every cent that the work was worth. As a matter of interest, we copy the advertisement which appeared at the top of the first column, together with the prospectus:

LIGHTNING IN HARNES.
The Printing Press Worked By LIGHTNING!

EXHIBITION.
The Greatest Discovery of the Age.

The assertion of the scientific, mechanical, and curious is respectfully invited to the exhibition of LIGHTNING IN HARNESS, which is this day opened at No. 4 Little Green street. (Little Green street is between Broadway and Nassau street, and runs from Maiden Lane to Liberty street.)

The exhibition of Davenport's electro-magnetic engine will commence on this day, for what can be more appropriate than, upon the anniversary of our nation's birth, to print the Declaration of Independence and send it by lightning throughout the whole world.

Admission free.
July 4, 1840.

PROSPECTUS OF THE MAGNET.

We present our little work to the public with great confidence and for several excellent reasons: First. It is printed upon a new and improved conical rotary press. Secondly. This press is worked by our electro-magnetic engine. Thirdly. Both are wholly American. The first number of the paper is published on the anniversary of our national independence, and offered at a cheap rate to the patrons of the lovers of truth, and those who devote time and labor to mechanical and scientific pursuits.

Though the investigation of electro-magnetism will form the principal feature of our journal, it is not intended to confine its columns to that interesting science; we shall fill our pages with such authentic matter as may come within our reach upon all scientific and mechanical subjects.

With respect to electro-magnetism, it is the intention of the publisher to advance tangible proofs that this power has already triumphed in moving machinery. It is also his design to make known all the experiments made since December, 1838, which go to corroborate his views on this subject, with wood cuts, illustrating various models and machines, together with the laws of electro-magnetism, and to prove that this wonderful power has over steam, in regard to safety, cheapness, and convenience. In the mean time, the experiments of others, more experienced in the science of electricity, galvanism, magnetism and electro-magnetism, will be noticed in order that the reader may get a general idea of the science, and the laws by which they are governed, and by which we are guided in the thrilling and working the powerful and mysterious agent. It is not our intention to make the subjects tedious, nor the articles too laborious for the ideas of readers in general.

We shall treat upon the different branches of science, and the various inventions and improvements that shall be made known, as also those in presence in operation, together with such miscellaneous and interesting matter as shall appear from time to time.

Any objections or difficulties that may be advanced by different individuals, in regard to the application of electro-magnetism as a motive power, we shall be pleased to receive, and shall consider it a favor to communicate with them through the columns of the Magnet.

Several scientific gentlemen of our city, Boston, and Philadelp-hia, have already engaged to become contributors to make our paper interesting and useful to all classes.

THOMAS DAVENPORT.

New York, July 4, 1840.

Two or three machines of different design were employed at different times, in driving the printing press. One of them was a helix machine, constructed upon the general plan proposed in the caveat of 1838 which has been given above.

The experiments of Davenport during the season had been so numerous and so costly that he again found himself at the end of his resources, and was reluctantly com-
THE ELECTRICAL ENGINEER.

56.

Jan. 28, 1891.

The electrical engineer.

For testing the capacity and usefulness of the electro-magnetic power, as a mechanical agent for the purposes of navigation and locomotion, and the probable cost of the same, according to the invention of Professor Page, the sum of twenty thousand dollars, to be expended under the direction of the Secretary of the Navy, to make practicable the development of said invention according to the plans to be proposed and conducted by Professor Page.

From time to time accounts of the experiments of Dr. Page found their way into the journals of the day, and one of these notices, coming into the hands of Davenport, led him to send a communication to a local newspaper, which is not only valuable in itself, as a connoisseur review of the author's own work, but because it was the occasion that led to an interesting correspondence between Davenport and Page, the essential parts of which are printed herewith, and which form a contribution of no inconsiderable importance to the history of the development of electro-magnetism as a motive power:

[From the Brandon Post, Sept. 26, 1850.]

Electro-magnetism Triumphant over Steam.

Mr. Welch:—Will you allow me a small space in the Post for the purpose of making a few remarks respecting Professor Page's successful experiment in applying Electro-magnetism to propelling machinery, as described in the following article which recently appeared in the National Intelligencer:

The discovery has claimed and deserves the fullest patent credit in applying magnetic and electro-magnetic power as a moving principle for machines in the manner above described or in any other substantially the same in principle.


Electro-Magnetism as a Motive Power.

Professor Page, in the Lectures which he is now delivering before the Smithsonian Institution, states that there is no longer any doubt of the application of this power as a substitute for steam. He exhibited the most imposing experiments ever witnessed in this branch of the science. An immense bar of iron, weighing 180 pounds, was made to spring up by magnetic action, and to move rapidly up and down, dashing like a feather in the air, without any visible support. The force operating upon this he stated to average three hundred pounds through ten inches of its motion. He said he had raised this one hundred feet as readily as through ten inches, and he expected no difficulty in doing the same with a bar weighing one ton or one hundred tons. It could be made a pole driver or forge hammer, with great simplicity, and could make an engine with a stroke of six, ten, twenty, or any number of feet. It looked very unlike a magnetic machine. It was a reciprocating engine of two feet stroke, the whole machine and fastening weighed about one ton. When the power was thrown on by a soldier of a lever, the engine started off magnificently, making one hundred and fourteen strokes per minute; though when it drove a circular saw ten inches in diameter, sawing up boards an inch and a quarter thick into laths, the engines made but eighty strokes per minute. There was a great anxiety to obtain specimens of this laths saved in this way to preserve as trophies of this great mechanical triumph. The force operating upon the magnetic cylinder throughout the whole motion of two feet, was stated to be 600 pounds when the engine was moving very slowly, but he had not been able to ascertain what the force was when he was running at a working speed, though it was considerably less. The most important and interesting point, however, is the expense of the power. Prof. Page stated that he had reduced the cost so far that it was less than steam under many and most conditions, though not so low as the cheapest steam engine. In the imperfections of the engine, the consumption of three pounds of a six ton per day would produce one hundred horsepower. The larger his engines (contrary to what has been known before) the greater the economy. Prof. Page was himself surprised at the result. There were a number of practical difficulties to overcome, but the battery had yet to be improved; and it remained yet to try the experiment on a grander scale, to make a power of one hundred horses or more.

As I am confident that the results of the experiments of this enterprising and scientific gentleman will open the eyes of the people and the pursuers of capitalists, sufficiently to soon place on our lakes, rivers and railroads, a safer and more convenient power than steam, I hope I may not regret so much in future as I have for ten years past, that the paralyzing hand of poverty has for-
bidden any attempt on the part of myself to prove to the world, what as early as 1881, I believed could be done within the space of a year. I determined that my experiments should be presented to the public in such a manner as to give the same relation to the power of an electro-magnet that water does to the power of a steam engine, and I had no doubt but that I could establish the whole sensible world of the fact, by applying the power of a small electro-magnet to moving the lightest machinery. But in this I was disappointed. I found the power more than a match for the minds of men, and compliments more plenty than money.

Having devoted the most part of seventeen years of my life in laboriously explaining electro-magnetism to useful purposes (without receiving any remuneration), it may not be improper for me to state to the public the power and size of some of the electro-magnetic engines of which I have invented and applied to the working of machinery, that they may be compared with the engine lately constructed by Prof. Page. Early in 1888 I ascertained that a bolt of iron could be drawn with great force into a helix whenever the battery current was made to pass through coil. I immediately constructed a small engine on this principle, which, when in motion, very much resembled a little steam engine, with two perpendicular cylinders. During the same season I filed a caveat for this improvement in the United States Patent Office, and sent several models to Europe. A patent for this invention was obtained in England and the Provinces, and money paid into several other European Patent Offices where no letters patent have ever been obtained.

In 1898 I experimented on a much larger scale with the magnetic cylinder or helix, and constructed a helix two feet in length, which I put into a barrel two inches in diameter. I put a bolt of iron 2 feet long and 2½ inches in diameter, weighing about 28 pounds, was forced into the helix when the current of galvanizing power was put through the wire. The weight of the iron was equal to 6 pounds per square inch of its diameter. The test was made with the helix and bolt placed in horizontal position, so that the weight of the iron could not be reckoned.

When the helix was in a perpendicular position and raised one foot from a platform, with the lower end of the bolt resting upon the platform, and by applying a single stroke of the helix, the battery current would raise this bar of iron with such force that it would often pass entirely through the coil, 2 feet in length, without resistance upon the platform.

In January, 1890, I completed an engine with two magnetic cylinders weighing 50 pounds each. The engine made a 12-inch stroke, weighing only 250 pounds. The battery was composed of lead and zinc plates 2 feet long and 5 inches wide, weighing in its most improved state 100 pounds. In the same month I commenced publishing a newspaper, which was printed on a press propelled by this engine. When the press worked off, 10 papers per minute, the engine made 130 strokes in the same time. Many who witnessed the working of this machine, estimated it to be a two horse power, but from my own tests, I could not make it exceed the power of one horse. The cost of zinc and acid in working did not exceed 20 cents per day. In the course of six months it would pay to the time of printing by this power, I had constructed in all more than 100 engines of various dimensions, and all different in point of construction and the purpose of some practical applications and mechanical arrangements for the increase of power. My experiments with helices, using long and short, large and small, round and square, and solid bars of iron, have been very successful. My presses were first moved by a horizontal helix engine, next by a rotary, and lastly by a perpendicular double helix engine. Page's experiment with 180 parts of iron "dancing like a feather in the air" seems to me to be precisely like the experiment I made in 1888, when the 28 pounds of iron jumped through a helix two feet in length, by magnetic action, and as Prof. Page's engine is constructed on the same plan and principle as my own above described, I presume the scientific gentlemen lay no claim to having presented any new route in his application of the power, or to have made any important improvement whatever in my invention. If Prof. Page, by the completion of his engine, has finally come to the point which I arrived ten years ago in testing electro-magnetism as a prime mover in the arts, and has expended as much money in the series of experiments which I have never been, his result would be of course better, and I should have saved him the needless expenditure of several thousand dollars, by giving him the results of some of my experiments in 1890-94, which I should have been happy to do, if I had been a member of the time.

THOMAS Davenport.

SALISBURY, Vt., Sept. 12, 1890.

The publication of this communication drew forth the following letter from Professor Page:

[Letter of Charles G. Page to Thomas Davenport.]

WASHINGTON, D. C., Oct. 2, 1890.

Dear Sir:—I have received the letters which you have written in the Brandon Post. I have been aware from the beginning of your experiments with the helix, and although we were operating entirely independent of each other, it will no doubt be gratifying to you to know of a promise of success in the common cause. I believe there is nothing in my improvements that conflict in any way with your inventions. Should it ever appear to me that I think we could make an amicable arrangement. I commenced my experiments on the helix primarily in 1888, and made several more models, and published all the results that I had. I think that you had not yet arranged any machine. My experiments and little models had been successful enough tried long before that, and I must say that I was never satisfied until I had succeeded in getting power in that way.

In 1843 I made a great improvement on this principle, and made more since, without which I am certain nothing could be done to render the power available.

I have always looked with pleasure upon your zeal and ingenuity in this matter and when speaking in public have always alluded to you in terms of commendation, and although your article was not written with feeling, yet I hope you will not repeat it until we can fully understand each other.

Respectfully, your obedient Servant,

C.W. DAVENPORT.

WASHING TON, D. C., Oct. 24, 1890.

Mr. Editor:—I notice in your paper a communication from Mr. Davenport, in which he gives an interesting historical account of his experiments in electro-magnetism, and concludes that he was in advance of operation which he describes. According to his own statements he was in advance of me in respect to the scale of magnitude of his experiments, and from his descriptions, which I have read, I have no reason to suppose that there would have been followed. But the attempt to apply this peculiar principle of action to an engine for mechanical purposes was made and published in a difference only in degree from the experiment of Mr. Barlow in 1838 in raising a small bar, perhaps of only one ounce. But the peculiar improvements by which I raise a strong magnet coil with so small an expenditure of galvanic power are novel and original with myself. Mr. Davenport is entitled to great credit for his ingenuity and zeal in the pursuit of electro-magnetism, and I have always viewed with much interest his early perseverance in this matter. But it is due to himself, the community and myself, that I should make this statement, and to add that I am ready to go any one for the peculiar views which I have long entertained in regard to the plan of operation based upon the known fact last mentioned.

In view of the historical interest attaching to the inquiry, the author has made every effort to verify the statement made by Professor Page in the two preceding letters in respect to his publication in 1837, of accounts of experiments with the helix and core, but without success. From other publications made by Professor Page, it seems impossible to avoid the conclusion that the dates given by him must have been the result of some misapprehension.

In an article published in American Journal of Science in 1845, vol. xliii, p. 131, he says:

This new species of electro-motion, which by way of distinction I denominate the axial, or rotating engine, was most fully attempted in the year 1858, and noticed made of it in this journal (vol. xxxvii for 1858, pp. 381 and 383) together with some other experiments upon the interior. The whole failure at that time was from want of suitable batteries, etc. for the purpose.

To sustain a small needle within a helix is a trite experiment, but by the arrangements which I have adopted, a bar of iron or steel (which becomes instantly and powerfully magnetized) is
sustained entirely free from any visible support, and this too by
the action of only six small Grove's batteries. This is almost
a realization of the fable of Mahomet's coffin, or the statue of
Theamnic. When the helix is connected with six pairs Grove's
in good order, it will draw up within its centre a bar of iron or
steel weighing three or four pounds and sustain it with its upper
end projected above the helix.

He then goes on to give a description of his well known
axial reciprocating engine, for which he took a patent Jan-
uary 31, 1854, and which is described in many works on
electricity and magnetism.

Referring to the notice in vol. xxxv of American Jour-
nal of Science of which Page speaks in the above extract,
I find that it describes an apparatus consisting of a pair of
helices, with U-shaped cores thrust into them at each end,
so that the four poles will meet in the centre of the helix.

It is distinctly stated that this apparatus was contrived
Jan. 11, 1838, but it is not properly an axial magnet, nor
is any mode of application to the moving of machinery
described. The inference seems unavoidable that Profes-
sor Page must have been in error as to his dates, and that
Page's invention is really entitled to priority in the
application of axial magnetism to the movement of
machinery, as set forth in his caveat of May 5, 1838, and
as reduced to practice by him in 1838-39-40.

[Letter of Thomas Davenport to Charles G. Page.]

SALSBURY, Oct., 1850.

Dear Sir,—Yours of the 2d inst. I deeply read. When I wrote
the article which you noticed in the Brandon Post, I had no
knowledge of the fact that Congress had appropriated any moneys
for testing the availability of electro-magnetic power. Since then,

have received your report to the Secretary of the Navy on the
subject of electro-magnetism as a moving power. I am truly
grateful in that your experiments have resulted so favor-
ably. I believe, however, that if I could have had in 1840, one
half the amount of money that you have expended, I should
have produced more power and fall as economically. I do not
whether, in proportion to weight, your machine actually exceeds
in power the helix machine with which I printed a newspaper in
1840. But, the improved state of the galvanic apparatus would
probably render your power a cheaper one. I perceive that you
have made a great many experiments which were precisely like
those I had tried, excepting that yours were on a larger scale.
The impossibility of my obtaining funds to build larger caused
me much regret. In completing my engine for printing, I had
used up all the means I possessed, and all that I could get, for
I had tired my friends with my solicitations for funds. After
trying more than a year without success, I gave up all hopes of
enlisting individuals any farther in the enterprise, and I then
thought of applying to Congress for an appropriation for the purpose of testing the power on a
larger scale. I asked the opinion of many intelligent and influ-
tial individuals in regard to my plans, but they invariably gave
me unfavorable answers. In 1845-6 I wrote to some gentlemen
and members of Congress on the probability of my getting an
appropriation from the Government, but their answers were
generally discouraging. But I will not tire you at this time with
an enumeration of my misfortunes, for it pains me much to call
memory the many distressing circumstances in which I have
been placed in consequence of my zeal in the cause. You men-
tion in your letter that you are the first that ever attempted to
get power with the helix, and that you had successfully tried a
model previous to 1838; also that some of your experiments in
the autumn of 1838 were a distinct confirmation of that.


These experiments seem to be on the same principle as the 'float-
ing helix', and De la Rive's ring. 4 In your improvement of
the 'floating helix', it appears that you had no idea of accumulat-
ing power in that way, for in your letter to me dated Boston, April
16th, 1838, you said anything about experiments with the
helix, although you mention a variety of other experiments
which you have made in producing rotary motions, without
changing poles, and which you considered was an improvement
on my system of changing the polarity of the magnet. You also
stated in the same sheet, that you could show good reasons why
the power would not admit of "indefinite increase," but must be
confined to the power of that one or two men. Since I first saw
the power of an electro-magnet exhibited, any idea that the power
could not be indefinitely increased, seemed to affect me with a pe-
culiar disagreeableness. I write you thus plain, because I have
had strong feelings on the subject, and retain them yet. I believe
that my zeal and the inventions in electro-
magnetism have been of great value to science and the arts, to
government and to the whole world, and this I shall endeavor to
show in a publication which I hope to have prepared in a few
weeks, in which I intend to fully show my position in the matter.

You mention in your letter of the 2nd inst. that if your im-
provements in any way conflict with my inventions, there could
not be any amicable arrangement made between us. It strikes me
that if Government has taken the business in hand to per-
fect the application of this power to moving machinery, that
Congress would be the proper body for me to look to for com-
pen.sation for what I have done in the premises. I should be
happy, however, to receive suggestions from you with the best
interests as the course for me to pursue. In the meantime, I hope that Congress
will make still further appropriations, that you may continue on
the noble cause.

For the last four years I have been experimenting in electro-
magnetism on a plan for applying the power to new purposes;
and have succeeded to my full satisfaction. This invention I con-

sider of very great importance to the public, and hope to be
able in a few months to present you with a model for exami-
nation.

Respectfully your friend and fellow-laborer,

THOMAS DAVENPORT.

[Charles G. Page to Thomas Davenport.]

WASHINGTON, D. C., October 28, 1850.

Dear Sir: I have this day received your kind letter and
although I differ with you in opinion on its most important
points, still I believe you to be as sincere as you are zealous.
I do not remember the letter of 1838 you refer to, but it has gener-
ally been my practice in writing to others upon the subject, to
withhold such information as would give them an advantage over my-
self by giving them the benefits of my own inventions. However in
1838 and after, and in 1838-7, I was fully of the belief that an eco-

nomic power could not be obtained, unless the difficulties of the
time required to charge and discharge magnets and the influence of
secondary currents could be overcome. These difficulties al-
ways increase with any increase in the size of the engine. I
threw out all these objections in Smithsonian's Journal at that
time, but I hoped and believed there would be a remedy; I was con-
stantly searching after it, and at last I found it. It was only when I
conceived it, that I thought it capable of being applied to the
power of your engine much too high. Your printing press
was a very small one, and it would not have required, I think, the
horse-power to drive it that you refer to. I hope you find in the
pamphlet containing an account of the performance of my engine

4. De la Rive's ring is a small helix of thin wire in the form of a vertical
neculus which is mounted on a float, having a small plate of copper attached
to one and a corresponding plate of iron which hangs below the
float. The whole arrangement is then placed upon the surface of a vessel
of distilled water, which carries it on with a steady motion. The helix is
in the form of a bar magnet is presented to the ring, the latter will move towards the
centre of the magnet, passing over the bar and reversing the poles, and
then reversing back to its former position, the rings behaves precisely the same principle. (See Davids' Manual of
Magnets [2 Ed.], p. 110.)

5. See ante, p. 71.
which was made about five years since, and which after I got it into the best working order I showed to Congress, working a planing machine (small one) and afterwards carried to Tower's printing office to test it. This engine had by accurate measurement, 1
of a horse-power and yet you see how large a press it was worked at the rate of twelve hundred impressions per hour. There are some other points in your published article which do not seem to me to be correct, as to estimates, etc. But there is no reason why I should raise a discussion now about them. You will notice in the pamphlet that I had given you credit for your labors (see page 6). There seems to be no hope from Congress now. They have taken the ground that it is a matter of individual enterprise, and on that ground they refuse to appropriate further for my experiments. I applied for forty thousand dollars to build a large ship with an engine of one-hundred horse-power, which they refused without a count.

The great feature of my engine is the manner in which I overcome the difficulties I spoke of, and you will I am sure be gratified when you come to know the plan. It has never been made known in public yet, but by next spring my work will be published containing a full description. I shall be always glad to hear from you and render you any aid in my power. Meantime believe me to be,

Your friend and well wisher,

THOMAS Davenport, Esq.

Charles G. Page.

McCarthy's Electric Car Gear.

McCarthy's Electric Car Gear.

Among the new devices designed to transmit the power developed by the motor to the car axle of an electric car we note that recently patented by Mr. L. A. McCarthy, of Brooklyn, N.Y. In this arrangement the inventor has sought to effect a simple arrangement by which the motor may be kept in constant operation, if desired, and thrown in and out of gear with the axle with the least possible jar, and thus to obtain efficiency with flexibility of connection. As shown in the accompanying engraving, the motion of the armature is transmitted to an intermediate shaft c by means of driving rods. Mounted upon this shaft is a movable cone pulley p placed directly opposite a corresponding friction pulley o, mounted on the car axle.

The pulley o is normally held out of contact with the pulley p by the spring s, and under such condition the motor runs free. When it is desired to start the car, the driver, by turning a lever on the platform, draws the rod o taut, which, acting upon the bell crank lever v, moves its short arm j, and presses the cone pulley p firmly against the pulley d. In this manner the motion is transmitted without shock and is under complete control of the driver.

The Practical Value of the Phonograph.

The greatest feat of reporting that has ever been performed by the official reporters of Congress was that of preparing the Senate report for the Record Wednesday night, Jan. 14. The chief reporter is sick, and but two men were available to do the work. The Senate was in session for fourteen hours, all of which time was spent in an active discussion of the silver bill. It was after 12 o'clock at night when they adjourned, and during the session they had talked over 120,000 words. Two stenographers took the report, and, by dictating their notes into phonographs for typewriters to transcribe, they had all the copy ready for the printers by 8 o'clock in the morning, and the Record was on the desks of the Senators when Congress convened.

Laws Against the Employment of Juvenile Operators.

At its last session, the Georgia Legislature passed a law providing that in the future all railway telegraph operators must be not less than eighteen years of age before they can accept such positions, and, furthermore, they must pass an examination as to capability before the chief train dispatcher of the road upon which employment is sought. Tennessee operators will push a similar measure before the Legislature of that State. They claim that the passage of these bills means the disappearance of the boy operator and a corresponding decrease in the number of accidents resulting from the employing of inefficient, immature and inexperienced railroad telegraphers. It would be well, perhaps, if every State should adopt such a law.

Mr. W. H. McCulloch, manager for the Southern Telephone Co., at Greenville, Miss., has been promoted to the position of supervising auditor, with headquarters at Vicksburg. Mr. D. Thomas, of Memphis, succeeds him.
THE INVENTORS OF THE ELECTRIC MOTOR.—V.
WITH SPECIAL REFERENCE TO THE WORK OF THOMAS DAVENTPORT.

BY

FRANKLIN LENARD WIFE

(Conclusion.)

THE narrative of the active life and labors of Thomas Davenport in the field of electromagnetism and its application as a motive power, has now been brought to a close. It remains for me to sum up what may be, what I conceive to be the true significance of his work as a part of the general history of the industrial application of electromagnetism, and by way of preface, to say a few words regarding the personal characteristics of the man.

Although forty years have passed since Davenport was born to his humble grave under the shadow of the stately elms of Brandon, there are still living many old residents, his former friends and neighbors, who well remember him, and who by common consent, speak of him as one who received, and who in the fullest measure deserved, the respect and esteem of the community in which he lived. However visionary his schemes may have appeared to many of his townsmen, there seems to have been but one opinion as to the high character and substantial worth of the man himself.

Thomas Davenport was pre-eminently a student, a thinker and an originator; a strikingly characteristic type of a class of minds to whom the world always has been, and always will be, indebted for its greatest mechanical conceptions. Modest and unassuming in his intercourse with his fellow men, reticent in speech, but cheerful and kindly in manner, and by no means lacking in that dry humor which seems almost inseparable from such a nature, he nevertheless possessed, beneath a peculiarly mild and gentle exterior, a determined and resolute perseverance but little removed from obstinacy, which poverty, adversity and disappointment were utterly powerless to overcome.

From the very moment when he first witnessed the exhibition of the mysterious power of Henry's electro-magnet, the conception of utilizing its invisible force for the propulsion of machinery took possession of his mind and thenceforth occupied it almost to the exclusion of every other consideration. He studied, he pondered, he experimented. Seeking from the beginning to produce continuous rotary motion, with the unerring instinct of the born inventor, in his very first essay he grasped what I have defined as the essential principle of the electric motor, the combination of moving and fixed electro-magnets, one reversible and the other non-reversible; and however extensively and widely he may subsequently have experimented in other directions, he never once loosened his grasp of this fundamental conception.

It may be asked whether it is certain that this conception is due to Davenport alone. It is true that in an absolute sense, this question at this late day can only be answered by the light of internal evidence. Every one who has much intercourse with inventors must have observed that when two minds have wrought upon a mechanical problem until success has crowned their efforts, it is ordinarily quite impossible even for the parties immediately concerned to disavow and distinguish their respective contributions to the general result. Yet the experienced observer, familiar with the mental characteristics of the varying types of the creative mind, usually finds little difficulty in reaching a conclusion which is at least satisfactory to himself. He only needs to know the two men to know in what manner and by what mental processes the ultimate result must have been reached.

From the moment that Davenport declared, in the presence of the little assemblage at Crown Point, his intention of producing rotary motion by means of electromagnetism, it is certain that he never for one moment permitted himself to doubt that he would ultimately accomplish that result. He was fortunate in having a coadjutor like Smalley, young, enthusiastic, a natural mechanic and a willing worker; and it is altogether probable that to the latter is largely due the embodied form and structure of the machine, particularly the contrivance of the mechanism employed for effecting the reversal of the current which is shown in the sketch accompanying the specification of 1835. It is not unlikely that the design of the first metallic commutator may also have been due to him; but the fact remains, that the master mind, wholly absorbed in the subject, and possessing the determination and the capacity to succeed in spite of every obstacle was that of Davenport. Had Smalley not been at hand to assist him, some other person would have been found. Had it been necessary for him to carry on his work alone, he would have done it. When a mind possessing the indomitable perseverance of that of Davenport, is once in possession of an original idea—the conception of something to be done—its ultimate accomplishment, whether with or without the assistance of others, is as certain as fate.

In the argument before the Supreme Court of the United States in the Telephone case, the learned counsel for the complainant remarked:

"It is of common experience that the maker of a great invention which originates a new art, seldom has the technical skill and turn of mind which produces the improvement. It is an interesting fact that the particular forms Watt thought of when he took out his patent, were practically so ineffective that it required ten years unremitting work of himself and Boulton, the best machinist in England, before an engine was produced which was commercially satisfactory. But since he took his patent, no engine has ever been constructed which condensed the steam in the working cylinder."

Many instances might be cited as evidence as the truth of this statement. Not only Watt, but Fulton, Morse, Bessmer, Bell, and to mention a very recent instance, Rogers, the inventor of the wonderful typograph machine, were men of only ordinary mechanical skill, and were almost wholly indebted to others for devising and working out the mechanical contrivances in which their conceptions were embodied, and by which only their work could be rendered useful to mankind. Yet this fact does not in the least detract from their individual merit as inventors of the highest type, and as benefactors of the human race. I have seen this idea more forcibly expressed than in the decision of Judge Kane, rendered many years ago in an important patent case, in which he said:
All machines may be regarded as merely devices, by the invention of which the laws of nature are made applicable and operative to the production of a particular result. He who first discovers that a law of nature can be so applied, and having devised machinery to make it operative, introduces it in a practical form to the knowledge of his fellow men, is a discoverer and inventor of the highest grade—not merely of the mechanism, the combination of iron, brass and wood, the form of levers, gears and pulleys, but the force which operates through the mechanical medium—the principle—or to use the synonym given for this term by Mr. Stevins, the character of the machine. The essential principle which his machine was the first to embody, to exemplify, to illustrate, to make operative, and toannotate, is the most important point to me.

I have expressed the opinion that the combination of the moving and fixed electro-magnets, one reversible and the other non-reversible, must be regarded, in the light of our present knowledge, as the essential principle of the electric motor. The experience of the past few years has demonstrated beyond question, that the largest motors yet made, show as high, if not a higher, net efficiency than the smaller sizes, and in fact it has not as yet been found practicable to construct an efficient motor of any considerable power upon any other principle. A recent and clear re-examination of the impracticability of organizing a large motor, either with permanent magnets as in Sturgeon’s plan, or with non-reversible electro-magnets and neutral armatures as in Edmondson’s plan, while on the other hand, by employing the principle introduced by Davenport, the πιστική μορφή of 1834, no apparent limit to the dimensions or power of the motors which it is possible to construct has yet become manifest.

In our own time, when the doctrine of the conservation of energy is so inextricably interwoven with every conception of the mechanical and chemical interactions of the natural forces, it is wellnigh impossible for us to realize that in Davenport’s day, this fundamental law was wholly unknown, or at most had been only dimly perceived by one or two of the most profound philosophers of the day. Davenport himself lived and died in the full conviction that the day which should witness the triumph of electro-magnetism over steam was close at hand. There is much reason to hope that ere many years have passed, his cherished belief and expectation will prove to have been not wholly without foundation. Undoubtedly he also believed that voltaic energy was in like manner destined to take the place of coal energy. In his time science had not sufficiently advanced to enable the latent fallacy of this idea to be detected and demonstrated. It is not to have been expected that a humble village artisan, knowing literally nothing of science beyond that which his own discovery had taught him, should have mistrusted the existence of a law of equivalence between the forces of nature, which was as yet undiscovered and even unsuspected by the most learned philosophers of the day. The following extracts, selected at random from many which might be cited, give ample evidence of the views which generally prevailed among scientific men in relation to this subject, prior to the year 1840. In his treatise on the steam engine, then recently published, and considered a work of high authority, Dr. Lardner had said:

Professor Page, in a communication containing an account of some of his quantitative experiments and investigations in electro-magnetism, expressed himself as follows:

I can scarcely doubt that electro-magnetism will eventually be substituted for steam in propelling machinery. If the power of the engine is in proportion to the attractive force of its magnets, and if the attractive force is as the squares of the electric force, the economic effect will be in the direct ratio of the quantity of electricity, and the mass of metal of the magnets reduced ad infinitum. It is to be determined, however, how far the effects of magnetic electricity may disappoint these expectations.

So late as 1851, Professor Page, in discussing the question of the relative cost of steam and electric power, as affected by the then recent investigations of Joule, remarked:

We have no proof of any such relation of electricity to heat as to make the mechanical power of the electric current one measure of the mechanical power of the other. Whatever may be the connection and analogy between heat and electricity, we must consider them as distinct forces in their action on bodies.

The subsequent researches of Grove, Mayer, Liebig, and more particularly of Joule himself, ultimately established the law of the equivalence of forces upon the firm and enduring foundation of experimental demonstration, and confirmed the opinion long before expressed by Henry, that the endeavor to find in voltaic electricity a substitute or a rival to coal-power, must, from the nature of things, be an utterly hopeless one.

The publications made by Professor Page at various dates between 1837 and 1855, and the interesting correspondence between Page and Davenport which has already been given, show that the conceptions of the two men, both in respect to the most desirable principle of construction of the electro-magnetic motor, and as to the possible limits of its power, were widely at variance; but time, which proves all things, has shown conclusively, that of the two, the views of Davenport were the more correct.

The opinions of Page are indicated in the extracts which follow, taken from articles written by him at various times:

Since the announcement of Mr. Davenport’s invention, the innumerable experiments which have been performed in this country, in England, on the continent of Europe, and even in the East Indies, have all contributed to prove that the smallest engines which have been made, have had by far the greatest proportionate power. Since I first gave the subject any attention, I have had sixteen different models constructed, each involving distinct principles. From all these experiments the inference is still the same, viz., the fewer the magnets, and the smaller their size (within certain limits), the greater the ratio of mechanical power obtained.

Practically we have already been taught, that (unlike other powers, where the largest engines are the most simple and least expensive) electro-magnetic engines, above a certain limit, increase in complication and cost, and in a much greater ratio than the power obtained. To ascertain this limit, the precise point where economy ceases, is now the great, and ought to be the only, object of research.

I must premise here (as I have heretofore expressed myself) that I do not suppose this power capable of indefinite increase, and in giving this description of the public I am only selecting from the multitude of machines I have constructed, such forms as obviously economize a given galvanic power. A number of ma-

1. Sturgeon’s Annals of Electricity, etc., vi, 159.
2. Ibid., iv, 135.
3. Ibid., xvi, 135.
Fig. 1, elevation.—Fig. 2, plan.—Fig. 3, vertical transverse section.—Fig. 4, horizontal transverse section in plane of a b. of Fig. 3.—Fig. 5, plan of arrangement of magnets.

B platform; C base; D battery, consisting of concentric cylinders of copper E and zinc F, immersed in vessel G containing sulphate of copper solution; H I, positive and negative conductors; K L insulated commutator segments fixed upon vertical shaft R. M N O P cores of electro-magnets; Q Q Q Q helices of insulated copper wire; a b bearings of shaft R. c d e f commutator springs; V support for electro-magnet; S T semi-circular permanent steel magnets; 5 5 north poles and 6 6 south poles of permanent magnets.
THE ELECTRICAL ENGINEER.

[Feb. 4, 1891.

Ducting further experiments on a scale large enough to demonstrate the utility of the invention, met at the time with a considerable amount of adverse criticism, an example of which among many may be found in a paper on Electro-Magnetism as a Motive Power, by Professor Page, published in 1839, from which the following is an extract:

"It is much to be regretted, that in our country the invention should be a subject of much speculative suspicion, when in reality it has no value except as an experiment, and that the public have been so far misled, as to withdraw that countenance and encouragement which the experiment will really merit. We cannot but deplore, that such an interesting branch of science should be so treated, and that the very name of electro-magnetism should be coupled with empiricism."

So also, a prominent scientific journal in an editorial paragraph, observed:

"We rather regret that this interesting application of electro-magnetism is attempted to be sustained by an appeal to the hope of immediate profit."

I cannot but regard this implied censure as unjust and unwarranted. Examine critically as one may every line of the correspondence and writings of Davenport and I venture to say there can be found not one trace of a self-seeking spirit, not the faintest expression of a desire to make money from his invention, beyond the modest and reasonable expectation of a comfortable existence for himself and those dependent upon him. It is but seldom that he refers, even casually, to the innumerable hardships and inconveniences which he and his family must have not infrequently suffered from want of means; but on the other hand, when we find more than once, expressions of profound regret at being unable to command the financial support which was essential to him in perfecting and carrying out his self-imposed task of giving to the world an economical and efficient substitute for what he calls, and was at that time justified in calling, the murderous power of steam."}

For my own part, I can see no reason why the action of Davenport and Cook, in taking part in the organization of a stock-company whose earnings were expected to come from the future development of the invention, was not in every respect as legitimate and proper at that day as it would be at this. It is certain that neither of the principals could have entertained the slightest intention of misrepresenting the circumstances, or of misleading the public. It appears to have been perfectly well understood by all concerned, that the invention was not claimed to have passed beyond the stage of a promising experiment, but that the beneficence of the improved steam engine to have enabled a large engine to be constructed and put in successful operation, the future of the enterprise might reasonably be expected to be highly profitable to the shareholders. It is not impossible that misrepresentation and even fraud may have been practiced upon some of the shareholders by the agent who had been entrusted by Davenport and Cook with the management of the business of the company, but the records show that no effort was spared by them to put a stop to his irregular proceedings as soon as they became aware of them. One needs but to read the letters of Davenport, to be impressed with the conviction that he was a man of childlike simplicity and transparent integrity of purpose, and that the single object to which he devoted every energy of his life, was not the accumulation of money nor the gratification of self, but the development of an invention destined to confer priceless benefits upon his fellow men.

In conversation with some of the more elderly residents of Brandon, among whom were a number of acquaintances and friends of Davenport during his lifetime, I have been more than once assured that he was the real originator of the electric telegraph. This statement has recently been made with some particularity in the columns of the local press:
There are but very few outside this immediate vicinity that are aware of the fact that the first telegraph line in the world for transmitting signals over a wire by electricity was erected in Brandon, and by a Brandon man. Yet such was the case, and this town has the honor of being the first spot where this mighty invention of modern times was put to practical use. . . . Mr. Davenport, then living in Brandon, in connection with Mr. Smalley, now living at Forest Dale, experimented considerable in electric appliances. Long before Prof. Morse had projected anything of the kind, these gentlemen had a wire that connected their two residences, on which were transmitted dispatches by means of electricity, using a battery, and which gave by machinery the sound as now heard from machines in ordinary use. After this wire had been in operation for some length of time, Mr. Davenport moved to New York and began the publishing of the Electro-Magnet, being printed by a machine propelled by electro-magnetic force, as the paper claims upon its title-page. While in New York we are informed that Prof. Morse called upon Mr. Davenport, and was struck with his discovery, and then began to make improvements thereon, inventing the Morse alphabet. He then applied it to Mr. Davenport's discovery which has proven to be such a magnificent success. To Prof. Morse belongs a great deal of honor for bringing before the public the wonderful merits and advantages of telegraphy, but the discovery and origin of this great invention justly belongs to Thomas Davenport of Brandon.

No claim of this kind is asserted or even remotely hinted at in any of the letters or papers of Davenport which I have examined. On the other hand, in response to a specific inquiry as to the telegraph line which Davenport and himself are reputed to have constructed and used, Mr. Smalley has stated that in the course of their experiments in 1834, they discovered that physical effects could be produced by an electro-magnet through a considerable length of wire, and that any length at their command seemed to make no difference in the time required to effect the result, but that no attempt was made by them to transmit intelligible signals, or to construct apparatus for that purpose. The fact first mentioned by Mr. Smalley, was, however, well known at the date mentioned (1834), having been fully demonstrated in the experiments made by Henry in Albany in 1830-31.

The source of this telegraphic legend may undoubtedly be traced to a conviction which Davenport is known to have entertained, and honestly so, that Morse's telegraphic apparatus was an infringement upon his own patent of 1837. He, after written from Davenport, under date of April 18, 1846, to Dr. Thomas P. Jones, of Washington, he writes:—

I learn from Mr. . . . who has recently been in Washington, that it is your opinion that Prof. Morse's application of electro-magnetism to propelling his machinery for the telegraph is an infringement on my patent. I have long thought so myself, but not knowing how to proceed in consequence of my poverty-stricken situation, I have to this day considered the claim granted me is for "applying magnetic and electro-magnetic power as a moving principle for machinery," it is as clear as the solar light that Morse must be using what of right belongs to me.

In explanation of this erroneous opinion on the part of Davenport, it must be borne in mind that at the date when the above letter was written, the history and chronology of the invention of the telegraph had never been made public; it was first brought to the notice of the exhaus tive legal investigations consequent upon the interference proceedings between Morse and Bain, and the suits against O'Reilly and others by the Morse patentees at a still later date. The very earliest published notice of Morse's invention appeared in the New York Journal of Commerce, a communication over Morse's own signature, accompanied by a sample of the writing of the apparatus then used, which was dated September 4, 1837. As this was some two or three months after his visit to Davenport's laboratory, the latter, by a very natural process of reasoning, assumed that Morse had merely applied his (Davenport's) idea to the movement of another kind of machinery for a different purpose. But at a later date it was established, upon evidence which cannot be gainsaid, that Morse had actually constructed and operated his electro-magnetic recording apparatus in a short circuit in his rooms in the New York University building, as early as November, 1835, more than a year before Davenport and Cook came to New York with their machinery for exhibition.

It is not improbable that Morse was indebted to Davenport for a more effective construction of the electro-magnet than he had hitherto employed, but even granting this, the electro-magnet was a feature which Davenport himself had borrowed from Henry, and which formed no part, per se, of his own discoveries.

The patent of Davenport was granted February 25, 1837, under the title of "An Application of Electro-Magnetism to Propelling Machinery." The claiming clause of this patent has been criticised by unfavorable implication, as "a remarkable instance of the granting of a broad claim by the Patent Office to an inventor." It may not be out of place to consider for a moment whether such a critic is well-founded. The statement is in the following words:

The discovery here claimed and desired to be secured by Letters Patent, consists in applying magnetic and electro-magnetic power, as a moving principle for machinery, in the manner above described, or in any other manner incident thereto.

Within a few months after the issue of the patent, Davenport, referring to his invention, wrote:

No departure from the principle of the original invention has been or can be made. That principle was the production of rotary motion by repeated changes of magnetic poles; this is which is secured by patent; and no peculiarity of arrangement or modification of the magnets can be made to work without adopting the essence of the first invention.

This assertion, although in a strictly literal sense inaccurate, is nevertheless substantially true, in much as every practical motor in use at the present day involves the principle. 12.

12. In the case of Morse v. O'Reilly in the United States Supreme Court, the following was the operative passage: "Neither the prior machine of Edison nor any described (ante, p. 1) nor the pulley and core machines, subsequently constructed by Davenport (ibid.) and by Prof. Page, make use of the principle of "magnetic poles." But none of these types of machines have achieved permanent industrial success, in comparison with the pole-changing type, for reasons which are now well understood.

Working Model of Davenport's Electric Locomotive.

(Photograph from the Original in the Cabinet of the Troy Female Seminary. Supposed to have been constructed circa 1837.)
picle of the "production of rotary motion by repeated changes of magnetic poles." If, therefore, we read into the claim of the patent the mode of operation neither with Davenport, viz., the combination of reversible and non-reversible "galvanic magnets" which is described in
the specification, as being the organization referred to in
the words "in the manner above described," we find that
its scope is not only not unwarrantedly broad, but
that it defines with accuracy and clearness the precise
invention which Davenport made; no more; no less.

Justice Curtis, in his decision in a leading patent case
before the Supreme Court of the United States, has
remarked:

"It is this new mode of operation which gives it the character
of an invention and entitles the inventor to a patent; and this
new mode of operation is, in view of the patent law, the thing
entitled to protection. Specifications are to be construed liberally,
in accordance with the Constitution and the patent laws of the United States, to promote the progress of the useful arts, and allow inventors to retain to their own use,
not anything which is a matter of common right, but what they
themselves have created."

"In that case," says James J. Storrow, confessedly one
of the most learned and able advocates of our own day,
the matured judgment of the Court was announced by a
jurist whose peculiar faculty it was to perceive both the
groundwork of a legal rule, its limits, and the limits of its
application, and to formulate the whole in language which
defined as well as stated." And in a more recent case de-
cided in the same court the venerable Justice Bradley has
remarked:

The whole subject-matter of a patent is an embodied concep-
tion, outside of the patent itself, which to the mind of those
expert in the art, stands out in clear and distinct relief, while it
is often unperceived, or but dimly perceived, by the uninformed.
This outward embodiment of the terms contained in the patent
is the thing invented, and is to be properly sought, like the explana-
tion of all latent ambiguities arising from the description of
external things, by evidence in pais.

If, therefore, we interpret the claim of Davenport's pat-
ent, not only in its relation to the state of the art at the
date of its invention, but in the light of the well-considered
utterances of the highest tribunal of the land, and
compare it thus understood with the definition of the
fundamental principle of the modern electric motor which
was formulated at the beginning of this series of papers,
we shall find that they are substantially identical. The
conclusion necessarily follows, that the invention thus
identified and embodied in concrete order and shape,
form by Thomas Davenport at least as early as July, 1834,
is exhibited and described to others prior to January 5,
1835, and was covered by his Letters Patent of February
25, 1837. If, therefore, this patent, which expired in Febru-
ary, 1883, were in force to-day, it is not too much to say,
that upon a fair judicial construction of its claim, every
successful electric motor now running would be embraced
within its scope.

Thomas Davenport was born in Williamstown, Orange
County, Vermont, on July 9, 1802. He was descended
from the family of the same name prominent in the early
annals of the New Haven colony, and was the eighth in
a family of eleven children of Daniel and Hannah (Rice)
Davenport. His father, who was a farmer, died when he
was but ten years of age, leaving the family in indigent
circumstances. At the age of 14 he was apprenticed to
Samuel Abbott, of Williamstown, with whom he learned
the blacksmith's trade. Upon the expiration of his
apprenticeship, about 1823, he removed to Brandon, Vt.,
where he set up business for himself. He married, February
18, 1827, Emily, daughter of Capt. Rufus and Anna
Goss, of Brandon, born March 29, 1810. The mother of
Rufus Goss was a daughter of the celebritated American
traveler, Jonathan Carver. Davenport was prosperous in
in the employment of alternating currents. One general
type of these consists of a machine with, say, four poles,
between which is mounted an armature, generally wound
with closed coils. On two opposite poles of the field are
primary coils connected up in the main circuit. On the
same cores are also wound secondary coils which are closed
through coils on the other pair of poles. When an alter-
nating current is caused to pass through the primary coils,
it energizes directly one set of poles, and induces currents
in the secondary coils, which in turn energize the other
poles; but the phases of the current in the secondary coils
may differ in time from those of the primary current, and
hence a shifting of the poles is effected, that imparts a
rotation to the motor.

In the new motor designed by Mr. Tesla, however, two
energizing circuits are brought into inductive relation in
the motor itself, and the employment of an external in-