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ART. I.—*Charles Grafton Page.*

Prof. CHARLES GRAFTON PAGE, whose death at his residence in Washington, D. C., was announced in the last July number of this Journal, was born in Salem, Mass., on the 25th day of January, 1812. He was prepared for College in the Grammar School at Salem, and entered Harvard University in 1828, graduating in 1832. He studied medicine at the medical school in Boston, and in the year 1838, he removed with his parents into Virginia, pursuing there the practice of his profession. About the year 1841, he was appointed one of the Principal Examiners in the United States Patent office. At that time there was but one other Principal Examiner, and the office was one of great responsibility, since upon the Principal Examiner alone generally depended the decision of all applications for patents in the classes of inventions under his charge.

In 1844, he was elected Professor of Chemistry, in the Medical Department of Columbian College, D. C., but in 1849, he resigned his professorship on account of the pressure of his duties in the Patent Office. In the year 1852, he retired from the Patent Office for the purpose of devoting himself to the effort in which he was then engaged to introduce electro-magnetism as a motive power. This enterprise having been relinquished with the failure of means to extend his experiments, he associated himself with Messrs. J. J. Greenough and Charles L. Fleischman in the publication of the *American Polytechnic Journal*, which commenced with the beginning of the year

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1853. After the discontinuance of that Journal with the close of the year 1854, Prof. Page does not appear in any public capacity until the year 1861, when he again entered the Patent Office as Examiner of Patents, a position which he held for the remainder of his life.

Prof. Page is best known to the scientific world as an electrician. We have learned, moreover, "from his mother and other near friends that he evinced a most remarkable fondness for natural science in all its branches at a very early age. Once when about nine years old he was missing during a severe thunder storm, and on being sought by his anxious friends he was found on the top of the house, holding up at arm's length a fire shovel to see if he could not catch a shock of electricity from the surcharged cloud!" It has been related also by his early friends that at ten years of age, having begged a lamp glass of his mother, he in due time surprised her with a successful electric machine made by himself. Entomology received a portion of his attention while a school boy, and he had a passion for botany and floriculture and indulged in it to the extent of his ability. Respecting his school and college life we extract the following from a communication of Dr. Henry Wheatland, President of the Essex Institute, of Salem, Mass. "My acquaintance with C. G. Page commenced when we were classmates in the Salem Latin School. At that time he had the reputation of being interested in electricity, having made or was making an electric machine. \* \* \* \* \* The same taste followed him in his college course. In our junior year several of us, including Page, organized a chemical club. Each of the members was expected to lecture in alphabetical order. Page lectured on electricity, the air pump, &c. At this time he had a large collection of apparatus for a student, an electrical machine, air pump, &c. Several of us were also interested in natural history, as botany, mineralogy, insects, &c. Page was also enrolled in our number. After leaving college, whilst a medical student, he carried his investigations still further, taking up voltaism and constructing batteries of different kinds, culminating in his extensive researches in 1836, or thereabouts, which resulted in producing motion by the magnetic power.\* During his medical studies he delivered a course of lectures in chemistry to a class in the Lyceum Hall. Page during his school and college days, was always full of fun and frolic and took a lively interest in all boyish occupations. He was a leader among the gymnasts, a famous skater, a good singer, a loved companion, and a very great favorite

\* Prof. Page, in the American Polytechnic Journal, vol. i, p. 6, attributes the invention of the first electro-magnetic engine to Prof. Henry.—L.

with all." To this, Gen. H. K. Oliver, of Salem, his early instructor and friend, adds, "I myself remember seeing during Prof. Page's residence here—at his office—a miniature railway, an elliptic curve of about twelve feet long and six wide, around which travelled a miniature magnetic engine drawing at high speed a miniature car."

The zeal and activity in the pursuit of electrical science and experiment, which marked especially these few years that he resided in Salem, after completing the study of his profession, are evidenced by his numerous contributions to this Journal about that time. He had much fertility of invention, and delighted in mechanical contrivances for the practical application and for the interesting illustration, of the laws of electric and electro-magnetic action. He was not only a skillful experimenter, well versed in the theory of electricity, but was also a ready and spirited writer, and his published papers must have contributed greatly to extend the knowledge of, and excite an interest in, electrical science. The writer of this notice can certainly testify to his own obligations to him in this respect.

In the year 1836, he made a valuable series of experiments, published in the 31st volume, 1st series of this Journal, upon the induction of electric currents, following up the previous discoveries of Prof. Faraday and Prof. Henry on that subject. Prof. Henry (this Journal, 1st series, vol. xxviii, p. 328) had obtained sparks and shocks from the "Calorimotor" by means of the induction of the current upon itself in a long copper riband wound into a close flat spiral, after having been wrapped with an insulating covering. Prof. Page repeated and varied these experiments with a spiral riband an inch wide and 220 feet long, and made the important step of augmenting the intensity of the shock by means of a reduced length of battery circuit in conjunction with a greater length of induction circuit, the induction circuit being, of course, in part or in whole exterior to the battery circuit. Among other forms of experiment detailed in the paper alluded to, he obtained the shock from a part of the spiral entirely external to the part in the battery circuit, which is in conformity with Faraday's elementary observation of the induction of a current upon a neighboring conductor, but he ascertained that the greatest shock was obtained, with that helix and the battery of a single pair used, when the whole length of the spiral was included in the induction circuit, and a fraction only of its length in the battery circuit. He did not offer any theory in explanation of this result, but at this day, when the laws of the voltaic circuit have become not only known but familiar, and since the laws of induction have become better under-

stood than they were at the time of which we speak, especially from the extensive series of investigations made by Prof. Henry about two years afterward, it is easy to see that after a given volume of conducting metal has been filled (so to speak) with a current by an amount of battery surface proportional to the volume of metal, the effectiveness of the resistance of a break in the circuit in the rapidity with which it destroys the current, is measurably proportional to the smallness of the number of plates into which the battery surface is divided in series, with the volume of metal disposed in a length suitable thereto, and that the intensity of the shock from the induction circuit, the length of the latter remaining unchanged, will in this way be increased by reducing the length and intensity of the battery circuit. Or, to state the same otherwise, if the spark formed by a break in the induction circuit is to be of greater length (resistance) than the short spark formed by the break in the battery circuit, the length of the induction circuit must be in like ratio greater than that of the battery circuit; and it is in this point of view that Prof. Page himself has stated the primary characteristic principle upon which the voltaic induction coils depend for their effects. The step made by him in 1836, as above mentioned, was, so far as we are aware, the first step made in this direction. An account of it was carried to Europe by the late Francis Peabody of Salem, and communicated, rather imperfectly, to the English philosopher Sturgeon, in advance of its publication here. This communication would appear, by Sturgeon's account, to have given the first impulse to a quite extensive series of experiments made by the latter, and, within a year from the time of his interview with Peabody, he constructed an induction coil, described in the *Annals of Electricity* for Oct., 1837, vol. i, p. 477, in which the battery circuit consisted of an inner helix of rather thick bell wire 260 feet long, and the induction circuit of an outer helix of 1300 feet of very thin wire. This he used sometimes with, and sometimes without, an iron core in the common axis of the two helices, and obtained strong shocks in either case. In the meantime, however, Prof. Callan of Maynooth College, Ireland, had been making experiments on an extensive scale, and had carried the multiplication of the length of the induction circuit, as compared with that of the battery circuit, to a much greater extent than was done in the coil of Sturgeon, just noticed, and his results had been published in Sturgeon's *Annals*. But in his experiments he used the induction of very large solid masses of iron, and by overlooking the interference of the electric currents that must be induced in the solid metallic mass of the electro-magnet, he was prevented from dis-

covering one remaining step of primary importance in the improvement of these machines. The electro-magnet and induction coil in which he first, and several months earlier, used the shortened battery circuit, was in this particular, very nearly a repetition of Page's coil, giving an induction circuit of double the length of the battery circuit, but Page preceded him three months, as shown by the date of Page's paper in this Journal for Jan., 1837, and that of Callan's paper in the London and Edinburgh Philosophical Magazine for Dec., 1836. Mr. Peabody's communication to Mr. Sturgeon and Mr. Clarke, is stated by Sturgeon to have been made one or two weeks before the Bristol meeting of the British Association. This meeting took place Aug. 22d, 1836, and Callan's last mentioned paper was dated Maynooth, Aug. 23d, 1836. While, therefore, there appears no doubt that Prof. Callan was quite independent of Prof. Page in making this important step, it is clear that priority belongs to the latter.

We have thus dwelt at some length upon this subject because we have not found it possible otherwise to do justice to Prof. Page, and to all most directly concerned.

Related to this principle, another discovery of interest which Prof. Page made in the same series of experiments was that the intensity of the shock was increased by making the break of the battery circuit (over mercury) take place under a non-conducting liquid. The question suggests itself whether this observation might not deserve renewed attention.

In the course of his experiments with the flat spiral he obtained the spark and the shock from a thermo-electric current (this Journal, I, vol. xxxiii, p. 118), and thus added one more to the links which Faraday had already supplied to demonstrate the identity of thermo-electricity, voltaic electricity, and statical electricity. He also succeeded in charging a leyden jar by means of the induced current, a result belonging to that class of facts which warrants the use of the term *current* as correctly expressive of the actual relation existing between statical electricity and voltaic, or dynamic electricity, and after having increased his flat spiral to the length of 320 feet, he even succeeded in doing this with a voltaic battery of a single pair. It should also be mentioned that he projected the induced current (this Journal for Oct., 1837, p. 355) between charcoal points "before contact."

To Prof. Page also belongs the adaptation to the induction coil, of the self-acting circuit breaker, that is, a circuit breaker operated by the current itself. The circuit breaker he first used (1836), was Barlow's spur wheel, which turns between the poles of a permanent horse-shoe magnet. Soon afterward,

(this Journal, 1st series, vol. xxxii,) he contrived several other forms of self-acting circuit breakers, one of which consisted of a miniature vibrating lever moved by the action of the current and so limited and regulated in the extent of its motion by a set screw as to give it the extremest rapidity of oscillation desired. The breaking of the circuit of a voltaic current by the action of the current itself was done some years previously in the electro-magnetic motor of Prof. Henry, already mentioned, but Prof. Page appears to have been the first to contemplate the availability of this mode of action to produce the extreme rapidity of alternation called for in these induction machines,\* and to make and bring before the public a construction embodying this idea. This early instrument is, in this respect, the type of the self-acting circuit breakers now very generally used with the voltaic induction coil.

The discovery of the remarkable effect produced by substituting iron wires for a solid iron bar in induction coils, was made by Sturgeon, by Bachoffner, and by Page, all independently of each other, but the discovery by the English philosophers was prior in time. In April, 1838, Daniel Davis, Jr., of Boston, made, under the direction of Prof. Page, a coil machine embracing all the discoveries and improvements made up to that time by himself and others, including a provision for making the break of the battery circuit under a liquid; and with some variety in the accessory details these machines were soon manufactured in large numbers in this country. The only considerable improvements made since that time, apart from the construction by Ruhmkorff upon a greatly enlarged scale, are the invention by Fizeau of the condenser, as it is rather inaptly called, and Richie's improved mode of winding the secondary, or induction, coil of fine wire, so as to divide, in an extreme degree, the strain upon its insulation.

The United States Government has testified its appreciation of Prof. Page's share in the invention and development of this class of machines, by the enactment of a special law authorizing the grant of a patent, at the discretion of the Commissioner of Patents, which accordingly was issued to him in the last days of his life, after going through the usual course of examination in the Patent Office.

\* To guard against all possible injustice, we extract the following from Prof. Henry's paper in vol. xx, 1831, of this Journal, as republished by Prof. Page in the American Polytechnic Journal, vol. i, p. 6, premising that the oscillating electro-magnet of Henry's motor was "about *seven inches* long, and movable on an axis at the center." "If the tumblers be filled with strong diluted acid, the motion is at first *very rapid and powerful*, but it soon almost entirely ceases. By partially filling the tumblers with weak acid, and occasionally adding a small quantity of fresh acid, a uniform motion at the rate of *seventy-five vibrations in a minute*, has been kept up for more than an hour." The italics are ours.—L.

Another machine constructed by Prof. Page, and described in this Journal for Oct., 1838, consisted of a U-formed electro-magnet of iron wires, around this an extra coil of wire for induced currents in addition to the coil for the battery current, and an iron armature made to rotate before the poles of the electro-magnet, together with a rotating circuit breaker for the battery current made adjustable on the shaft of the rotating armature. Induction could be produced in the extra coil of wire, without breaking the battery circuit, by the magnetic disturbance consequent on the passage of the rotating armature across the poles of the electro-magnet. But on bringing into play, and properly setting, the breaker of the battery circuit, the motion of the armature was maintained by the battery, and by leaving opened or leaving closed the circuit of the extra, or induction coil, and varying the set of the rotating circuit breaker on the armature shaft, some curious and instructive results were produced in illustration of the influence of induced currents upon the motion of electro-magnetic engines, for the detail of which we must refer to the paper alluded to.

In the same volume of this Journal he also describes a magneto-electric machine, similar to the machine of Saxton, which he constructed on a large scale, and in which he provided the rotating pair of armatures with commutators by which the alternating induced currents of the armature coils were made to pass all in one direction through a conductor joining the extremities of the wire of these coils. The armatures were straight iron bars ten inches long, parallel to the axis on which they rotated, and covered, each, with 800 feet of No. 20 copper wire, and were placed between a *pair* of powerful compound permanent magnets, one at each end of the armatures. The two coils could be used as 800 feet of double wire, or 1,600 feet of single wire. With this machine water was decomposed very rapidly, and by breaking the circuit of the coils a half inch spark was produced, and a variety of interesting results is detailed which we have not room to repeat here.

Another magneto-electric machine constructed by him, and still more remarkable for the results obtained with it, is the subject of a notice in the Patent Office Report, for 1844, reproduced in the 48th vol., 1st series, of this Journal. By the current from this machine an electro-magnet was charged to such a degree as to sustain one thousand pounds. Unfortunately, no complete description of the machine is in existence so far as we know. The machine itself was presented to the Smithsonian Institution, but was destroyed by the fire that swept away a part of the contents of the building a few years

ago. It was, however, similar in its general construction to the last mentioned machine, except that the helices around the rotating armatures were "made up of a series of copper discs, instead of wires, each disc being split, and one of its split edges joined to the edges of the adjoining disc." Prof. Page has also informed us (*History of Induction*, p. 124), that "the steel magnets weighed about sixty pounds each, and when first charged would each sustain its own weight," and that "the combined lifting power was not at any time more than one hundred and thirty pounds." It is obvious that the length of conductor in the helix of this construction was comparatively small. Of the length and size of the wire that surrounded the electro-magnet of one thousand pounds we find no direct information. But that the length was far greater than the virtual length of the rotating armature helices of the machine is fairly deducible, we think, from the result. The current induced in the rotating armature helix must be generated in a half revolution, and the limit which is set to its quantity by its induction upon itself, and by its reaction upon the magnetization of the armature, is the same for all velocities of rotation however great. But if a resistance interposed between the terminals of the helix prevent the current from reaching that limit of quantity, the electro-motive force with which it will break through that resistance may be increased indefinitely by increasing the velocity of revolution. Hence, an outside wire joining the terminals of the helix, provided only the currents of the helix are discharged, by means of a pole-changer, in one constant direction through this outside wire, so that there is no induction in it of the current upon itself, may have its length greatly multiplied beyond that of the helix conductor, without any proportionate reduction in the quantity to which the current is at any rate limited. Hence the powerful electro-magnet that can be produced by forming this lengthened outside wire into a coil around an iron bar. Admitting that this must be, in fact, the principle of action to which Prof. Page resorted in producing an electro-magnet of a sustaining power of 1,000 pounds, from magnets whose united sustaining power was not over 125 or 130 pounds, we have in this result one main element of the recent famous Wilde machine, which uses the powerful electro-magnet so formed, for the magnet of a second magneto-electric machine.

The "*History of Induction*," to which we have referred above, a work of 124 octavo pages, was written by Prof. Page in the last year of his life, while laboring under his fatal malady, and contains a detailed history of discovery and invention relative to this branch of electrical science.



The greatest enterprise of Prof. Page's life was his effort to introduce electro-magnetism as a substitute, to a greater or less extent, for steam power. He was an original, though not the first projector of electro-magnetism as a motive power, and his first investigations on that subject were made in the latter part of 1836. In 1839 he published in this Journal, vol. xxxv, p. 106, a very instructive paper on the conditions of action in electro-magnetic engines composed of electro-magnets. The peculiar difficulties of this class of engines led him to rely more on the force with which the pole of an electro-magnet is drawn into its magnetizing helix. The availability of this force for electro-magnetic motors, as we learn from his own account, suggested itself to him on seeing an electro-magnet of Mr. Vail, in which the minute force exhibited by an iron needle drawn into a small helix, was augmented to half or three quarters of a pound, though the electro-magnet and helix were still of quite small size. Our friend was quick to perceive that on further increase of the size, a prodigious development of the force was to be expected, being in somewhat duplicate ratio, and that this form of force offered far greater facilities for combining the force with a wide range of motion, than does the mutual action between pieces of magnetized iron. He accordingly projected an engine in which a large range of motion is obtained by making the pole of the electro-magnet traverse the axis of a number of wire coils in series, the voltaic current being sent first through one coil, next through a second, next through a third, and so on, following the pole of the electro-magnet. A small engine of this description was constructed, with the aid of means furnished by a friend, about the year 1846. It contained a pair of reciprocating U-shaped electro-magnets formed of one-inch round bar iron, and these were formed with brass connecting pieces, into one moving piece, in such a way as to come into action alternately with each other. The writer was present at a trial of this engine in July, 1848. The Grove's battery used contained fifty platinum plates, each four inches square. The same reciprocating engine with, we believe, the same battery, was also exhibited in a short course of public lectures on electricity and electro-magnetism which he delivered in Washington in the month of February, 1849. On that occasion, in presence of a committee of the U. S. Senate headed by Mr. Benton, the engine was used to drive a small planing machine, and pieces of board a few feet long and three or four inches wide were planed. On the same occasion a bar of iron weighing fifty pounds was lifted by its magnetizing helix. It is worth stating, as illustrative of his

experimental judgment and tact, that though this last is but the second advance step he is known or believed to have made beyond the scale of the one-inch round bar of the engine, the writer had the opportunity to admire the success of both steps at the first trial of each. On the 1st of March the same engine was employed to run at the rate of 1,200 impressions per hour, a single Napier printing press, bed 24 by 41 inches, with  $1\frac{1}{2}$  square feet of printed page at each impression. The Senate committee were so favorably impressed with the experiments they had witnessed that on their report an appropriation was made by Congress to defray the expense of experiments upon a large scale. Operations were immediately commenced. Numerous preparatory experiments were made with iron bars of various sizes and qualities of iron, solid and hollow, in one series with the bars motionless in their magnetizing helices, in another series with the bars moving in a small experimental engine specially constructed for the purpose. It is much to be regretted that the record of these preliminary experiments has been lost. And, indeed, of the great engines afterward built, and the experiments made with them, with the exception of a few, the records remaining, mostly already published, are very incomplete. In the course of his experiments large round iron bars, hundreds of pounds in weight, were lifted from the floor by their magnetizing helices, with more than the weight of a full sized man in addition. Of one experiment the result is thus stated by Prof. Page, in a letter to the editors noticed in this Journal for Jan., 1851. "*The bar weighing 532 pounds placed within the helix, is made to start up in the coil and vibrate in the air without visible support.*" It requires a force of 508 pounds additional to its own weight to pull it out of the helix, so that it is equivalent to lifting a bar in the helix, of 1040 pounds in weight." Collating this with his Report to the Secretary of the Navy, copied in vol. x, 2d series of this Journal, from the National Intelligencer of Sept. 4th, 1850, where mention is made of bars from two to eight inches in diameter, and generally three feet in length, we conclude that this bar of 532 pounds was eight inches in diameter, and consequently about three feet in length.

The first large engine built, or at least the first of which we are able to give anything like a particular account, had a pair of round iron bars, each six inches in diameter and three feet long, balanced against each other in a two foot vertical stroke by means of opposed cranks on a common fly wheel shaft. The lower end of each bar played in the vertical axis of what was in effect a single continuous coil of large square copper wire, and the outside diameter of the coil, to the best

of the writer's recollection, must have been not far from fifteen inches. But the coil was composed of a large number of very short sections, of an axial length or thickness of something like perhaps three inches each, made separately and joined end to end, with a flat metallic contact piece connected to each joining, for contact with one pole or the other of the battery. The several contact pieces formed together a continuous plane surface from end to end of the entire coil, with the exception of spaces between them sufficient to secure them from contact with each other. Over these contact pieces travelled the poles of the battery, taking their motion direct from the iron bar, the one pole near the lower, or advancing end of the bar, and the other pole above or in the rear (this was the arrangement in effect, though in this one machine there was a separate line of contact pieces for each pole), so as to include between them and take simultaneously into the battery circuit a number of short sections of the coil around the advancing end of the bar. In this way, during the downward stroke, a single short section at a time would be taken into the circuit in advance, and a single short section at a time dropped off in rear. So far the induction sparks, which gave the Professor great trouble, were rendered comparatively light. The difficulty, however, in dropping the current entirely off at the end of the stroke still remained, particularly in this one engine in which the magnetism of the bar was not kept up, and in which, if the recollection of the writer is correct, the upward stroke was not used. Even in the engines which succeeded this, and in which the magnetism of the bar was kept up by using both strokes, the transfer of the current from one end of the bar to the other was not effected without a still remaining very heavy spark, very destructive to the contact pieces employed for this purpose. We shall see that he afterward devised what he thought a partial, but what we think would have been found a pretty complete remedy for this difficulty, though too late to carry it into effect.

After a variety of experiments with this engine, it was taken down "and its available parts employed" in constructing a horizontal reciprocating engine of two foot stroke. Whether in this last were used the identical coils and one of the bars (six inch) of the upright engine we are not able to affirm, but it appears that a single bar was used, with coils at each end, so as to keep up the magnetism of the bar by their alternate action upon it in the direct and return stroke. The coil at each end of the bar in this machine had precisely the same serial arrangement that either coil had in the upright engine just described, and substantially the same way of trans-

ferring the battery circuit along the serial coil. This horizontal double acting engine was exhibited in a public lecture at the Smithsonian Institution, where it was employed to do some mechanical work, sawing we believe. Systematic experiments were, however, made to measure its power. The experiments of which we have the most complete account were conducted by the late Prof. Walter R. Johnson, and his report of them appears in the Appendix to the 10th vol., 2d series, of this Journal. According to his determinations, which seem sufficiently reliable, though not very exact, the engine made, in his experiments, about seven horse-power at the maximum. In a letter to the Editors of this Journal, Prof. Page announces that the engine had subsequently reached ten horse-power. The inquiry will of course arise what fractional part this engine realized of the whole power due to the galvanic current of the battery used, which, if the determination of Petrie in 1850, may be relied on, is one horse-power for one and a half (1.56) pounds of zinc per hour consumed in a Daniell's battery, or about six tenths of that weight consumed in a Grove's battery. This point does not appear to have been tested at all in the experiments made by Prof. Johnson. Some observations were made by Prof. Page himself and his chief engineer, of the consumption of zinc to the horse power in one of the engines tried, but it was our impression at the time that they were not carried far enough to give reliable results. In fact Prof. Page thought these tests of less importance than attention to the working of some of the details of the engine, and in an important sense he was right in this, since the theoretical mechanical equivalent of zinc consumed is best found without an engine, and the elementary conditions of high economic efficiency in the action of the galvanic current in these "axial engines" are easily recognized. One of these is to avoid the waste of power in heavy induction sparks, and to the subject of these induction sparks he gave a great deal of attention, though, till after the close of his experiments, he did not hit upon a method of getting rid of the particularly heavy induction spark at the end of the stroke. Subsequently, however, he devised and described in the American Polytechnic Journal, vol. i, p. 369, a device by which this may be effected. By this device no *coil circuit* need be broken with a current in it, and we do not think, as he seems to, that its use need be restricted to a slow motion of the engine. We also believe that he modestly overrates the objection to the momentary closing of the battery, incident to this device, in a short circuit or by a resistance wire, and the spark from the immediate breaking of the battery circuit so formed. If a resistance wire

be used, its induction, as is well known, can be almost destroyed by doubling it upon itself.

Although Prof. Page failed to realize his first cherished hope of seeing electricity take the place of steam for a motive power on a large scale, for which he underwent so much labor, and for the pursuit of which he relinquished his hold upon a lucrative office, yet his labors had this result; the concentration within a moderate space, and by simple means, of a large amount of electro-motive mechanical power, and so soon as a galvanic battery shall be discovered which is easy to manage at the same time that it gives its current by the consumption of cheap materials, or as incidental to some extensive chemical manufacture,\* his engine is ready we think to perform a large part of the work done by the steam engine.

In the electro-magnetic locomotive, which our readers will remember, two engines were used to act upon the driving wheels at quarter crank. These engines did not differ essentially in their construction from the stationary engines last described. The locomotive did not allow of any exact measure of the power, and was intended chiefly as a demonstration to the public, so that the single trip which was made with it added little to the results already obtained with the stationary engine. Unluckily, the credit of the experiment with the public was greatly marred by a series of accidents in the rupture of porous cells in the Grove's battery, and in the encounter of repeated obstructions and delays on the track, so that although, according to the timing of the driving wheels by a gentleman on board, on what was said to be a level track, the highest speed noted was 19 miles per hour, the whole time occupied by the entire trip from Washington to Bladensburg and back, a distance of five miles, or a little over, from place to place, was about two hours and a half. To those who, with the writer, were on board, it was evident the machine could give a better account of itself than this. But the battery was now seriously reduced by the loss of porous cells which could not be replaced, and Prof. Page found that his expenditures over and above the appropriation from government, had left him at this unsatisfactory point without means to perfect the experiment. The Grove's battery used in this locomotive trip, before it was reduced by the breakage of cells, contained one hundred platinum plates of between 100 square inches and 1 square foot each. These particulars are derived partly from the writer's own recollection, and partly from the account of the locomo-

\* The utilization of battery products was a subject frequently discussed by Prof. Page.

tive and trip given by J. J. Greenough, Esq., in the American Polytechnic Journal, vol. iv, p. 257.

Of the experiments subsequently made in a course of lectures delivered in New York city, some account was given in the Scientific American, and they need only be mentioned here, as they were chiefly a repetition of such as we have already described.

The grand scale on which these experiments were conducted afforded a rare opportunity for observing some very interesting and instructive incidental phenomena, which were published by Prof. Page partly in this Journal at the time, and partly in the American Polytechnic Journal, and are worthy to be recalled here. When the battery circuit through the great coil around the great electro-magnet was broken, the prolongation of the falling current by the induction upon it of itself and of the falling magnetism, became so extraordinary as to be distinctly cognizable to the senses, and when the battery was cut out by making metallic contact of the extremities of the coil, then a renewed break in the metallic circuit showed a spark at any time within half a second. With the coil alone he estimated the time of the rise and fall of the current, by aid of a metronome, at  $\frac{1}{4}$ th or  $\frac{1}{5}$ th of a second, and with the soft iron bar included at from  $\frac{1}{4}$  to  $\frac{3}{4}$ ths of a second. He concluded that the time of fall of the current on *breaking* the battery circuit was about the same as the time of rise of the current. But the time of rise, with abundant battery surface, is probably about the same as the time of fall in the *closed metallic circuit*, and hence it seems probable the result mentioned was incidental to the intensity of the particular battery used, which may have been somewhat equal to the resistance of the "arc of flame." In the case of the electro-magnet of 532 pounds, before mentioned, he found the "full time required to charge this magnet and raise the voltaic current to its maximum" to be two seconds. "Nine-tenths of the charge is attained in one second."

When the break of the circuit took place at a distance from the electro-magnet, the induction spark, though heavy from the quantity and unusually long continuance of the current, was quiet; but when the break was made near the pole of the electro-magnet, the connecting wires being drawn somewhat quickly and widely asunder, the conflict of the current in the opening with the powerful deflecting force of the electro-magnet was very remarkable, and produced a loud report, and vivid flash of light. Prof. Page varied and studied the conditions of this interesting phenomenon with considerable care, and described them in this Journal for March, 1851.

Of similar interest are other phenomena of which we extract the following account from a paper by him in the American Polytechnic Journal, vol. i, p. 305, on the subject of the difficulties encountered in the great electro-magnet engines, from the destruction of metallic contact pieces by the induction sparks. "In the attempt to remedy this defect, our first efforts were directed to the entire suppression of the combustion. The current was first broken under oil, naphtha, and other hydrocarbons, with the expectation that the absence of oxygen would give a favorable result. To our surprise, however, we found that when the current was broken between two metallic surfaces entirely covered with oil, the consumption of the metal was much greater than when the break occurred in the air between clean metallic surfaces. The hydrocarbons were rapidly decomposed by the intense heat, and a black powder formed which appeared to be a carburet of the metal, though it was not chemically examined. This curious result we explain as follows:—The hydrocarbons are non-conductors of electricity and heat, and when the metallic surfaces are separated, the secondary spark is concentrated, and its action upon the metal becomes topical and intense. The action is analogous to that in the familiar experiment of perforating a glass bottle with the electric spark; a very feeble spark passing through oil, being sufficient to make a hole through a thick glass bottle. When the secondary current is one of great power, the oil is thrown about with considerable force. To illustrate this, we broke the circuit under oil contained in a small cavity in a block of wood, having first driven by a hammer a small bullet into the cavity over the oil. The spark from a large magnet drove the bullet out with some force.

"We next tried breaking the circuit in the following manner:—We procured two thick plates of glass, ground carefully together so as to exclude the air from between their surfaces. Through each of these plates we drilled a hole one quarter inch in diameter, and when the plates were so arranged that the holes corresponded with each other, they were filled with mercury in the following manner:—The under side of the hole in plate *b*, fig. 1, was stopped by a plate of copper, and mercury then poured in so as to form one column. Another plate of copper was laid over the hole in plate *a*, and thus between these two plates of copper there was a complete metallic circuit. The proper connection being formed, it will be seen that by sliding the plates *a* and *b* upon each other, the mercury in *a* must separate from that in *b*, and the break produced under the entire absence of air. Here occurred a brilliant and unexpected phenomenon. Whenever the break was made, the spark

was intense, and it was soon noticed that the glass around the edges of the holes was undergoing decomposition, and upon separating the plates, loose gritty particles were found between them, and their surfaces furrowed so as to present the appearance represented in fig. 2. The mercury was also oxydized at the expense either of the alkali or silicic acid of the glass. The most interesting result, however, of this experiment, was a fitful repetition of sparks after the circuit was broken. That is, the secondary sparks were kept up in quick succession without any repetition of contact. It would be foreign to our present purpose to discuss now the cause of this singular phenomenon. We next tried breaking the circuit in vacuo, in the ordinary mode of producing the *arc of flame* in the receiver of an air pump. But we were also baffled here. The metals were rapidly wasted by mere volatilization from the intense heat."

Of the large number of machines invented by Prof. Page in the early part of his career, illustrative of electrical science, we cannot in this notice even give a list. Among the instruments of his invention we will mention, as not having been described in this Journal, a voltameter of very convenient use, which measures the volume of the gas by that of the displaced liquid. This is described in the American Polytechnic Journal, vol. ii, p. 15.

Among his earlier discoveries, in 1837, was the production, in a horse-shoe magnet, of musical vibrations, like those of a tuning fork we believe, by the establishment, and especially the interruption, of a voltaic current in a flat spiral placed between the prongs of the magnet, with the plane of the spiral at right angles to the line of the poles of the magnet. A year or two afterward he made a series of experimental investigations on the action of the voltaic battery, which were published in this Journal.

While engaged in his college lectures as professor of chemistry, he discovered the curious action of the rocking of a rounded metallic bar, laid across a pair of parallel horizontal metallic rails, made to form the poles of a voltaic battery. The action is apparently similar to that of the heated brass bar of Trevelyan, rocking upon a cold plate of lead. But the new voltaic experiment does not depend upon dissimilarity of composition in the bar and rails, which may be all of the same metal, though it may depend, as its discoverer supposes, upon heating at the points of contact. The rocking of the bar is maintained by the passage of the voltaic current through its points of contact with the rails, at which it shows frequent slight sparks. This experiment was reproduced about ten years since by the English philosophers, with some variations,



but they must have overlooked the much earlier discovery of Page, as they made no mention of it.

After the close of his experiments with electro-magnetic engines, he discontinued, for the most part, his labors in electrical science, and devoted himself largely to horticulture, in the rural homestead where he then dwelt, near the suburbs of the city of Washington. It was here that he had conducted the greater part of his experiments on electro-magnetic power. It was here, too, that during the war of the rebellion, a party of soldiers broke into an outhouse containing the most of his philosophical apparatus, and destroyed nearly the whole, the accumulation of thirty years labor, little thinking, and, it may be feared, too little caring, that their owner was as good a friend as our government had.

Professor Page was married to Miss Priscilla S. Webster in 1843, who survives him with three sons and two daughters. He always took a lively interest in the great questions of the day, and in his home circle, and in all the relations of life, he was ever distinguished by the same lively geniality and amiability of temper that was so characteristic of him in his school and college days.

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ART. II.—*On Hortonolite, a new member of the Chrysolite group*; by GEO. J. BRUSH, with measurements and observations on the crystalline form of the mineral, by JOHN M. BLAKE.

SEVERAL years since Mr. Silas R. Horton called my attention to peculiar dull black crystals from an iron mine at Monroe, in Orange county, New York. On a simple inspection I determined that the crystals represented two species, the one, magnetite, in dodecahedrons; the other a prismatic mineral with somewhat rounded planes, which I took to be pyroxene. At the time I was deterred from making a chemical examination of the latter mineral by the fact that the crystals appeared to be very impure from admixture with magnetite and graphite. I have, however, never been quite satisfied that it was correctly determined, and on recently selecting with care a portion of the substance free from impurities, it proved to gelatinize with acids and to have the pyrognostic characters of an iron chrysolite; and on a more careful examination of the crystals they seemed to be orthorhombic rather than monoclinic, a conclusion confirmed by Mr. Blake's measurements, further on.

The mineral has a yellow to dark yellowish green color on the fresh fracture and a vitreous to resinous luster, although the