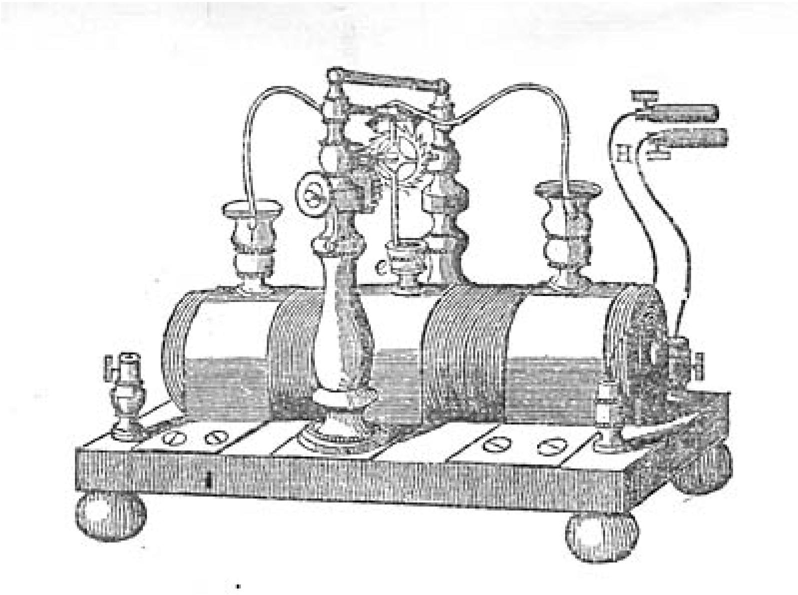

The Double Helix and Electrotome of Daniel Davis, Jr.

A BIOGRAPHICAL HISTORY OF INDUCTION COILS

By Dean P Currier

Michael Faraday's contributions in electricity changed the direction of electrotherapeutics. Almost immediately after the discovery of magnetoelectric induction by Faraday of England, and independently by Joseph Henry of the United States in 1831, inductive electricity was adopted by medicine for use in electrotherapeutics. Magnetoelectric induction is the process in which the magnetic field of a current carrying wire or device produces an electical or an electromotive force (EMF) in another wire or device located nearby without touching it. Magnetoelectric machines were soon constructed and marketed for electrotherapeutics because they were more reliable and convenient to use than the voltaic pile (battery) and static machines, and of course they were a new entity. The invention and development of the electromagnetic devices and their theory contributed greatly to the advancement of electrical science in the nineteenth century. The advances in electromagnetic technology led to the generation of electricity as an energy source, to the invention and development of the electrical light bulb, and to the development of the telegraph to advance rapid communication.(1)

Prior to 1831 Michael Faraday had anguished over a way to distinguish differences between electricity from a voltaic source and that from a magnet. Using the principles of his induction ring, he eventually built a device to generate electricity using a disc that revolved through a magnet and called it a "magnetoelectric machine." While building his magnetoelectric machine, he observed a spark with his soft iron ring and disc machine. He immediately wrote to his friend JP Hachette in France who called attention to Faraday's observation at the 26 December 1831 meeting of the French Academy of Science.(2)

Up to the 1830s only two ways of producing high voltages were possible. The oldest approach was the friction electrical machine that used a glass cylinder that when rotated rubbed against pads of various materials. Leyden jars (the first capacitors) were often used with the friction electrical machine to increase and store briefly electrical charges produced by the machine. Batteries were also used to produce voltages by varying the number of cells for a particular function. Many batteries had to be used to produce higher voltages, but until the end of the nineteenth century (after 1880) batteries were inconvenient to operate and very expensive. The induction coil offered hope for producing voltages inexpensively and conveniently.(3)

By 1832, experiments in electromagnetism were being conducted throughout England, Europe, and the United States. In the summer of 1832, the Paris instrument maker Hippolyte Pixii had devised two ways of producing sparks magnetically. Pixii had known about electromagnetism before learning about Faraday's spark produced by magnetism. During the 1820s in France, Pixii built the electromagnetic instruments used by Andre Ampere at the Ecole Polytechnique, and those used in the demonstrations of Claude Pouilett at the Sorbonne. He built the first real magnetoelectrical machine. (3)

HIPPOLYTE PIXII

Hippolyte Pixii (1808-1835) was born in France, and followed his father's occupation of instrument making. He built a hand-operated generator that delivered alternating current. His hand operated generator consisted of a steel compound permanent horseshoe shaped magnet (U shaped core) with poles that rotated vertically on its axis in front of two bobbins wound with spiral wire to serve as coils. The poles of the core or inductor spirals were fixed in the opposite direction of the revolving magnet. When current entered the wire on the bobbins the magnet rotated to change the direction of the current,(4) producing alternating current. While the induction spirals remained fixed on his first magnetoelectrical machine, he subsequently built the magnet to remain fixed while the horseshoe shaped soft iron, with or without induction spirals, moved. The machine along with an external electromagnet was capable of supporting 6.8 pounds (15 kg) and displaying vivid sparks, delivering painful shocks, diverging gold leaves of an electroscope, and decomposing acidulated water. The French Academy of Science awarded Pixii the Montyon gold medal and money for his experiments in mechanics.(5)

In 1832, alternating electrical current was not understood(6) nor had it any commercial use other than medicine so with the suggestion from Andre Ampere he added a commutator, and converted his alternating current generator to a direct current design.(7) (A commutator is a rotating switch that reverses the connection between magnet windings and the outside circuit each time the current changes direction in the windings to alter current direction.).(4)

Pixii apparently did not understand the relation between magnets and induction, since induction was a new concept. By using a hand crank (like the Davis/Kidder devices) current was dependent on the operator's ability to produce magnetic fields that were inconsistently strong and weak. Also, because he wound the conductor on a bobbin only a small portion of the conductor length was perpendicular to the magnetic field, but the commutator added to its effectiveness by having the heavy magnet as the rotating part of the device.(4) Despite these problems, Pixii's design endured the longest life of service in electrotherapeutics among available early electromagnetic instruments. Magnetoelectrical devices furnished larger current amplitudes than that by direct current batteries and accumulators, and were cheaper to operate.

JOSEPH SAXTON

Joseph Saxton (1799-1873) was a notable American inventor of the first half of the nineteenth century. He was born in Huntington, PA, and attended elementary school until he was 12 years of age at which time he began working in his father's nail factory. Saxton did not like factory work so apprenticed locally for two years in clockmaking and silversmithing.(8)

At age 18 years Saxton went to Philadelphia where he briefly worked for two different shops before establishing his own engraving and watch making business. He also studied engineering during these years. After 11 years of instrument making with distinction in Philadelphia where he received awards for his skill in clockmaking (e.g.,. the clock for the belfry of Independence Hall in 1824),(9) he went to London (1828-1837) to design, build, and market innovative instruments there.

In December 1832, he conceived the idea and committed his design to paper for a magnetoelectrical device. In June of 1833, he had built his first magnetoelectrical machine capable of producing painful sparks and shocks to his tongue. Later in 1833 he exhibited his magnetoelectrical machine at the Cambridge meeting of the British Association for the Advancement of Science where he demonstrated brilliant sparks, displayed intense light between points on pieces of charcoal, and discharged large pulse charges and shocks.(8)

He then improved on this version of his magnetoelectrical machine by using a strong horseshoe magnet mounted horizontally with three fixed coils to a shaft rotating around a horizontal axis. Like Pixii, Saxton turned the shaft of his machine by a handle attached to a wheel.(4) His machine was the first rotating coil machine to generate electricity of alternating current. By 1835, he had redesigned and built a magnetoelectrical machine that produced unidirectional (galvanic) pulsed current, strong shocks, and decomposed water.(2)

In 1837, Saxton returned home to Philadelphia, PA, to become the curator and maker of standard weighing devices for the United States Mint. From 1843 to 1873 he was in charge of the Office of Weight and Measures for the United States Coast Survey (now the National Bureau of Standards), Washington, DC. Saxton made and patented many inventions during his life, and was among the first members of the National Academy of Sciences, and a member of the American Philosophical Society.(8)

EDWARD CLARKE

Edward M Clarke (1804-1846) was born in Ireland and trained in instrument making in Dublin before working for the famous Watkins & Hill company of London in 1833. Because of his quality work he was soon asked to repair a Pixii electrical machine and get it ready for examination by a group of distinguished scientists.(2)

Earlier that year a report in the Mechanics Magazine raised the question whether Pixii or Saxton was the first to develop a magnetoelectrical machine that could produce sparks. Saxton's only response was that his device was superior to that of Pixii, but this statement led to a session of scientists wanting to test Saxton's claim on 15 November 1833 at the National Gallery of Practical Science in London. Michael Faraday was one of the examiners at the event for which Clarke had prepared a Pixii machine. During the examination, the brilliant and powerful sparks, the decomposition of water, and the heating of platinum wire by Saxton's machine was judged superior by the group.(2)

Clarke had studied both magnetoelectrical machines and soon had developed one of his own design. He soon resigned his job with Watkins & Hill, and by 1835 he was marketing his electrical machine from his own shop. His study of the Pixii and Saxton machines enabled him to build a unit of improved intensity and quantity of electrical output. Clarke's magnetoelectrical machine had two armatures so that one coil was for strong shocks while the other could produce brilliant sparks.(2)

In the October 1835 issue of the Philosophical Magazine Clarke stated that Saxton's machine was a modification of the one built by Professor Ritchie of London University. The November 1836 issue of the magazine contained an accusation of piracy by Saxton of Clarke. Saxton claimed that Clarke's machine was a version of his and differed only with a change of some parts. Since both individuals were members of the

London Electrical Society their differences developed into a heated controversy within the group. Although the controversy carried over into 1837 issues of the magazine, it was never resolved as both inventors lost their cutting edge of technology in the market of magnetoelectrical machines. Their magnetoelectrical machines were not sufficiently controlled and were too powerful for use in medicine where such devices were being used most. History has, however, assigned 1833 and 1836 for the invention of the Saxton and Clarke magnetoelectrical machines, respectively.(2)

The earliest magnetoelectrical machines were generally too powerful for use in treatment of patients by physicians, but by the 1840s serviceable and practical magnetoelectrical machines became available for medicine in England. In the United States Dr Charles Page with the instrument maker Daniel Davis (1813-1887) of Boston began to produce magnetoelectrical machines. By 1854, numerous patents and machines were using the principles of electromagnetism for machines in medicine. One of the best quality and most known was that of the Davis/Kidders design and manufacture.

Magnetoelectrical machines were built commonly using a straight bar or a horseshoe shaped magnet which really set up a major problem with its design. The design made it difficult to obtain uniform current amplitudes, voltages, and interpulse intervals from any two magnets or from the same hand cranked unit. The temper or degree of hardness of the magnets was never the same between each other, and their capability to produce magnetism was unstable due to the deterioration of the metals used in their construction. Also, the operator could not crank the gears consistently to generate currents of uniformity.

In 1861, GW Beardslee of New York City made a magnetoelectrical unit that used several V-shaped pieces of iron mounted on a revolving axis to form a radiating magnet. As the axis or wheel was rotated the pieces of iron alternately magnetized to generate current. This current could be regulated as to quantity and direction. The machine produced galvanic current easily and more economically than batteries of that period of time.(10)

CHARLES PAGE

Many new developments in electricity and magnetism took place during the 1820s when great scientists like Ampere, Faraday, and Ohm dominated that area of science. Men like Clarke, Henry, Pixii, and Saxton became well known in the 1830s for their contributions to magnetoelectrical devices. Dr Charles Page of the United States also became well known in this country for his work in electrical science. He has been, however, somewhat of a riddle to historians who have been undecided whether he was an inventor, scientist, or technician. Page was all three of these, and was an individual who achieved acclaim more when living then after death. Maurer has called him an electrical experimenter,(11) while Rowbottom and Susskin stated that he was a designer of electrical experiments and instruments.(4) Page was for sure a physician and a scientist by education, and he functioned in these fields from the 1820s into the 1850s.

Charles G Page (1812-1868) was born in Salem, MA, and became interested in botany, electricity, and floriculture early in his life. As a young man he had access to one of the best libraries and museums in the country with the Salem Athenaeum. By age of 10 years he had constructed (without a Heath kit) an electrostatic device that he used to shock his friends. While in college he built a device for increasing voltage that turned out to be the prototype for an induction coil. He also wired separate insulated supporting structures whose exposed surfaces were in contact with two semicircular troughs of mercury. He had built a commutator into the device to reverse the direction of the direct current.(12) Page submitted the description of his invention for publication in 1836, and it was printed as a letter in a 1837 issue of Silliman's American Journal of Science and Art. He received a degree in science from Harvard University in 1832, and then went to medical school in Boston.

Page had read works by Faraday and Henry on electrical induction, and as a result was able to construct a crude autotransformer (a device having only one coil but acting as both a primary and secondary coil) that he called a dynamic multiplier. His multiplier was the first closed core transformer and was used by Cromwell F Varley in his coil design for which he received credit for the invention in 1856. Page was a product of Jacksonian science, which subscribed to haphazard methodology without predetermined goals.

After graduating from medical school in 1836, Dr Page practiced medicine in Salem, but he wanted more of a challenge so continued experimentation with electricity. He rearranged the components of his multiplier in 1838 to build a new device. In the published 1839 description he used the term "compound" to say that his magnetoelectrical machine used a common single magnet, and claimed that his machine's output equaled a galvanic battery having 1,000 pairs of plates. His machine produced alternating current that was then converted into direct current by using a pole changer that he termed a "unitrep."

His machine was then unique because of its control or regulation of pulse frequencies by an attached device that he called an "electrotome." His electrotome, however, was primitive and unlike the interrupters of the 1870s-1920s. His machine was too powerful to be used in electrotherapeutics but it did have an effect on the future design of induction coils that were used in medicine. In 1837, Page built a rocking magnetic interrupter or circuit breaker that was automatic for current altering. This was the first magnetic operating interrupter for an induction coil.(13)

Dr Page apparently connected with Daniel Davis Jr of Boston who then became the leading manufacturer of magnetoelectrical machines. Page designed devices and Davis built them and marketed them. Davis assigned Page credit in his catalog of 1838 for the listed revolving electromagnet.(12) The version of the induction coil used in Page's magnetoelectrical machine of 1838-1839 was a unit similar to that by Ruhmkorff in 1851 (who was credited with its invention). The induction coil by Page had separate primary and secondary windings, and an integral self-acting circuit breaker that produced extreme alterations characteristic of coils.(11)

Researchers usually do not work in isolation, but work with colleagues and read every publication in their field. Such was probably the case of Ruhmkorff who may of known about earlier discoveries of George Bachhoffner, Charles Page, and William Sturgeon.(11) In 1838, Page moved to northern Virginia to practice medicine and continue his experiments in electricity. In 1839, he used the idea of Sturgeon's bundles of iron wires in one of his new induction coils.

Dr Page was aware of Sturgeon's improved effects produced by induction coils when bundles of iron wires were substituted for solid iron bars as cores. Sturgeon had been working with bundles of iron tubes, iron wires, gun barrels, iron bars, and rolled iron foils when he discovered the effect of the bundle of iron wires.(14)

In 1841, Dr Page left medicine to take a job in the United States Patent Office in Washington, DC. He continued building and experimenting with electricity while he worked off and on over the next 26 years as a patent examiner, examiner's adversary, and as a private agent.(15 p48-59) He taught night school in the medical department of Columbian College (now George Washingon University) from 1844 to 1849. He built equipment for Morse's telegraph, and like Joseph Henry's experience with Samuel Morse the association became a controversy over who built the equipment.(15 p60-83)

About 1850, Dr Page received $20,000.00 in congressional support to build two special electromagnetic engines for a locomotive. On 29 April 1851, the engines were ready for testing over 5 miles of track. After 1 mile and 39 minutes the batteries supplying the engines of the train loaded with dignitaries failed near Blandensburg, MD. After repairs the train took 2 hours to return to Washington. Page was convinced that with additional money the problem could be solved and the electrical train could become a reality. Because of political delays, and President Johnson's impending impeachment proceedings Page was never given the needed money. Page went into debt for the remainder of his life. Upon his death his wife sued Western Union over her husband's patents that were never paid to him by the company. Dr Page's survivors lived more comfortably after his death than during his last several years of life.(15 p162-183) The money received by Page from Congress was really one of the first grants for science, and it caused Page to become an outcast among scientists in the United States because taking government money for research was considered unethical in 1850. Today, researchers could not function if it was not for financial support from the government.(15 p84-107)

Dr Page invented a reciprocating electromagnetic engine and many other notable devices. In 1863, a mob of Union soldiers broke into his laboratory and destroyed most of his equipment. Page never returned to science after that event. Before his death he asked Congress to save his honor for the invention of the induction coil over the recognition given Ruhmkorff. Just before death in 1868, Congress passed a petition and gave Page his patents for recognition. This petition also gave the Page family the right to sue companies using his devices without authority.

From the late 1830s through the 1850s the induction coil grew into a marketable device with numerous improvements in design and construction. Several notable individuals of science played a prominent role in its development during this period of time such as: William Sturgeon (1783-1850), George H Bachhoffner (1810-1879), Alexander Kemp, Christian Neef (1782-1849), James W McGauley (1806-1867), Dr Golding Bird (1814-1854), and Dr Guillaume Duchenne.(16) Of course others also made minor changes in the development of the induction coil, and these were mostly instrument makers such as: Edward Palmer, Watkins & Hill, and EM Clarke. Englishmen dominated the development of the induction coil.

DANIEL DAVIS, JR

Daniel Davis, Jr. (1813-1887) was born in Princeton, MA, and moved to Boston at the age of 20 years (1833). He worked for William King of Boston who specialized in making lightning rods and static electrical machines.(12) Davis apparently made the static electrical machines because he acquired a credible reputation as a skilled instrument maker by 1837.

In 1837, Davis set up business for himself and specialized in making only electrical machines. He was among or was the first American to specialize only in making electrical devices. Davis began making his instruments for local scientists, one of which was Dr Charles Page, the physician in Salem, MA.(15 p84-107) He also became the first American maker of mechanical machines that generated constant electrical current for electrochemical experiments.(12)

Page designed his induction coil in 1836 and had Davis build his electrical induction devices. The two established a very good business relation. Davis published a catalog entitled <u>Descriptive Catalogue of Apparatus and Experiments, Electro-Dynamics, Magnetism, Electro-Magnetism, Magneto-Electricity, Thermo-Electricity</u> of his electrical instruments for sale in 1838. Davis listed and described 68 instruments within the 72-paged catalog, and also described electrostatic machines although they were not part of the title. The catalog of 1838 had improvements on 41 of the previously listed instruments.(15 p37-47) Six instruments in the catalog were accredited to Page by Davis and were: 1) the reciprocating armature engine, 2) an induction coil, 3) a galvanometer, 4) a double helix for inducting magnetism, 5) a revolving armature for displaying motion by magnetism, and 6) a vibrating armature.(12) Davis marketed Page's rocking beam motor for $12.00, and his magnetos from $35.00 to $75.00.(15 p37-47)

Dr Page invented a battery in 1837 that used released hydrogen to depress the electrolyte. Davis built the battery for Page, although it was never reproduced because of its ineffectiveness. Davis did not list or mention the battery in any of his catalogs.

Davis, like the Englishman Francis (d 1713)Hauksbee early in the eighteenth century, conducted his own experiments in electricity. He was acknowledged in an 1838 scientific article by Dr Page for discovering the improved effect of fine steel wire over iron wire in electrical machines.(12)

At the 1839 exposition of the Massachusetts Charitable Mechanics Association he won a gold metal for his workmanship and display of a variety of magnetoelectrical devices and engines. Davis was given a commendation for understanding the rationale of the instruments that he displayed and constructed.(15 p142-161)

In 1842, Davis published a manual entitled <u>Magneto-Electricity, and Thermo-Electricity</u> which was authored for students of various institutions. He illustrated and described a small magnetoelectrical machine designed in 1837 by Dr Page that included a device for making and breaking the circuit. Davis had a section that stressed galvanic electricity and its magnetic effects. He also described the electrotype process, electroplating, and some electrolytic experiments in the catalog. One of his machines was described as being useful for electroplating, but it was adopted by educational institutions for scientific demonstrations rather than for commercial use. Electroplating was a new process at the time, and not yet perfected or well understood.(12)

Professor Silliman of Yale College and editor of the American Journal of Science praised the manual written by Davis. The manual was used by the United States Military Academy and other institutions as a textbook, and was successful enough to have 13 editions between 1842 and 1872.(12)

Davis, in 1846, published a manual The Medical Application of Electricity, Boston, and a pamphlet The Medical Application of Electricity with Descriptions of Apparatus and Instructions for its Use in Boston. In the pamphlet he discussed galvanic belts and rings that were made using two different metals that contacted the skin when used. He indicated that the belts produced small amounts of current, but conjectured that they could not pass current through the organs of the body. He even concluded that the galvanic belt (very popular 1880s-1890s) was a device of quackery.(4)

Davis and Page continued their business relation after Page moved in 1838 to Washington, DC. Page even made several trips to Boston after moving to consult with Davis on the construction of electrical devices, but after 1849 began to look for a local instrument maker.(15 p142-161)

Davis published his second manual in 1852 which was entitled Manual of Magnetism,(17) but used the same year to retire from instrument making and dissolve his relation with Page. In Page's book History of Induction of 1867 he cited Davis several times for his catalog listings and descriptions.(15 p142-161)

ARI DAVIS

When Dr Page was searching for a skilled instrument maker with whom he could do business in the Washington, DC, area he found Ari Davis, brother of Daniel. Ari was probably recommended to Page by Daniel. Page soon afterwards had Ari Davis build a thermogalvanometer, and assist him with his public lectures on electricity. From this point Page and Ari Davis established a successful business relation that lasted for several years.(15 p142-161)

Ari Davis patented the earliest (1854) compact magnetoelectrical machine for use in medicine. He went into business with Dr Jerome Kidder of New York City to build one of the most popular units in the United States that has become known as the Davis/Kidder magnetoelectrical machine for the treatment of nervous diseases. The labels of the earliest units carried endorsements by Page and Silliman. This particular unit had a bone handled crank to operate brass gears with a pulley drive that rotated two small coils. The electrical system was housed in a small attractive mahogany box. A great number of these magnetoelectrical machines were sold in the United States to attest to its popularity.

Ari Davis was, like his brother Daniel, an outstanding instrument maker, and as a result of his skills and business relations he made a comfortable living. He also invented a wood working machine.(15 p142-161)

JEROME KIDDER

Jerome Kidder, MD, of New York had dealings with Dr Page and the United States Patent Office between 1861 and 1867. Page denied Kidder patents until his inventions met specific requirements of the Patent Office. History shows that Kidder was annoyed over these circumstances. In 1876, Kidder published a disclaimer about Page.(15 p162-183) Dr Kidder was a leading manufacturer of electrotherapeutic equipment between 1872 and 1898 and by then held several patents on components of his electrical machines. Kidder received negative publicity over his patent difficulties with Dr Page which also probably cost him business losses. In 1876, Kidder attacked the dead Dr Page (d 1868) by denying that Page ever invented an electrical coil or any other device used in electrical instruments. Kidder posted such information in some of his equipment advertisements.(15 p162-183)

The Jerome Kidder Manufacturing Company was located at 820 Broadway, New York City. His company made several types of electromedical machines such as the Davis-Kidder magnetoelectrical machine, and at the turn of the century was making X-ray machines.(18)

NICHOLAS CALLAN

Nicholas Callan (1799-1864) was a priest and professor of natural philosophy at St Patrick's College Maynooth (near Dublin), Ireland. He was an inventor, researcher, and teacher. Callan was one of the pioneers of electrical batteries, electromagnetism, electromagnets, and the induction coil. Like Page, he never received credit for his outstanding contributions to science.(19) Callan did not publish often, and since his college was a theological rather than a school of science his colleagues often tried to dissuade him in science pursuits.(20)

Callan was credited for inventing the induction coil in the 1910 edition of The Encylopaedia Britannica however by the 1973 edition his name was mentioned with the subject "induction coil." In 1953, a physics textbook cited Callan for the invention of the induction coil. He along with Page in 1836 built the first induction coils for practical use in medicine, although Michael Faraday and Joseph Henry independently invented the coil.

In an issue of the 1836 Annals of Electricity Callan described his transformer as a bar of soft iron shaped like a horseshoe that was wound first with thick copper wire, and then wound with thin copper wire over the first winding. The thick wire winding acted as the primary circuit while the two windings in series was the secondary circuit. Callan was able to break and make the circuit between 500 and 610 times per second, and because of this repetition he called the current breaking part the "repeater." By 1837, he did not connect the two different sized wires.(4)

His repeater was the first successful mechanical current breaker. He used a hand crank that turned a cogged wheel that was connected to a horizontal copper rod attached to an escapement engaging the wheel (axle of a double ratchet).(20) In 1853, Fizeau, a French physicist, added a capacitor to the induction coil to resonate the secondary coil so as to obtain even more voltage than previously.(14) Up to the time of Callan's interrupter the clockworks and manual methods of breaking and making the circuit had been unsatisfactory. Other versions of the interrupter by Bachhoffner, Neef, Page, Sturgeon, and Wagner followed Callan's type. Sturgeon's interrupter was a cam that raised a lever from a mercury cup 36 times per second, and Page developed a rocking magnet interrupter that worked only with currents of large amplitude.(4)

Callan was successful in identifying the elements required to produce the most forceful electrical shocks. His elements included: 1) a specific diameter and length of wires, 2) voltage of the primary coil, 3) space between coils and the core, 4) placement of the axis of the core, 5) wire that was insulated, and 6) a specific diameter of the core. Callan used the force needed to retract the keeper bar across the horseshoe magnet as a measure of the force of the magnetic field.(14)

Nicholas Callan was born in Dervir, Ireland, and went to the academy in nearby Dundalk. Callan was encouraged to enter the priesthood by his local parish priest, but he first went to Maynooth College in 1816. He studied electricity and magnetism under professor Cornelius Denvir. After Maynooth he became an ordained Priest in 1823 and soon went to Rome to study the works of science of Galvani and Volta. In 1826, Dr Denvir resigned and Callan became chairman of natural philosophy at Maynooth for the next 38 years (until death in 1864). Callan invented a two fluids battery in 1854, and a single fluid battery in 1855. He successfully reduced the cost of existing batteries by using a cast iron casing. While experimenting and developing his batteries he invented a method of protecting iron from rusting.(20)

JAMES MCGAULEY

James McGauley (1806-1867) was a student of Callan's at St Patrick's College Maynooth in 1826, and from 1836 to 1856 he was professor of natural philosophy to the Board of Education in Ireland. In 1837, at the meeting of the British Association for the Advancement of Science in Liverpool, McGauley described a device similar to that by Dr Page in 1838. McGauley had suspended a soft iron knob that was attached to a rocking lever from a copper wire above the solid iron core of his coil. The soft iron knob moved downward when the core was magnetized, and this movement broke the circuit of the induction coil by bringing the lever out of the mercury contact cup. The weight of the lever brought the soft iron knob upwards to make contact with the mercury, and the process was repeated as desired.(16)

In 1856, McGauley went to Canada for awhile, and upon his return to England some time later became one of the editors of the Scientific Review, a member of the Council of the Inventor's Institute in London, and managing director of the Inventor's Patent Right Association. Hackmann suggested that McGauley may have been the inventor of the trembler interrupter or of its principle about 1837,(16) although the invention of this device is usually assigned to Neef.(5)

CHRISTIAN NEEF

Christian Neef (1782-1849) of Frankfurt am Main, Germany, was the first physician to apply his type of interrupter or rheotome on induction coils of electromagnetic machines for use in medicine.(21) His interrupter of 1839 was an important advancement for the induction coil, and was still in use in 1902.(22)

Neef as a physician using electrical machines was dissatisfied with existing interrupters so worked on their improvement by modifying them. He developed a simple spring hammer that vibrated to control the frequency of current. His hammer break consisted of a spring contact that operated automatically to break the electrical circuit when displaced by the action of the electromagnet. This action was powered by a battery and eliminated the use of an assistant to manually operate the break and make contacts. Neef first presented his device to members of the Freiburg Scientific Society and then published its description in an 1839 issue of Annalen (then edited by Poggendorff). William Sturgeon of London published the first English version of Neef's device in his Annals of Electricity in the 1839-1840 issue.(4)

The common wooden box was developed about this time to enclose the electrical machines in an effort to make them small and portable (which was successful). By the 1850s natural philosophers were using induction coils in their experimental work. Their requirements were high voltage for work in X-rays (after 1895), and men like Hertz (1886-1888) and Marconi (1896) paved the way for new uses of the technology of the induction coil. By the 1920s the induction coil was used in radio, doorbells, and with applications of high powered electron tubes.

REFERENCES

1. Turner GLE: Nineteenth-Century Scientific Instruments. Berkeley, CA, U CAL Press, 1983, 171-202

2. Gee B: The early development of the magneto-electric machine. Ann Sci 50:101-133, 1993

3. Shiers G: The induction coil. Sci Am 224:80-87, 1971

4. Rowbottom M, Susskind E: Electricity and Medicine: History of Their Interaction. San Francisco, CA, San Francisco Press, 1984, 57-65

5. Meyer M (trs Hammond WA): Electricity in its Relation to Practical Medicine. New York, NY, D Appelton and Co, 1869, 1-8

6. Travers B (ed): World of Inventions. Detroit, MI, Gale Research, 1994, 220

7. Sharlin HI: The Making of the Electrical Age: From the Telegraph to Automation. New York, NY, Abelard-Schuman, 1963.

8. Malone D (ed): Dictionary of American Biography, vol. viii, 1963, 400

9. Frazier AH: Joseph Saxton's first sojourn at Philadelphia, 1818-1831, and his contributions to the independence hall clock. Smithsonian J Hist 3:45-76, 1968

10. Engelmann GJ: The Faradic or Induced Current; Electromagnetism; Electromassage, and Instruments. In Bigelow HR (ed): An International System of Electro-Therapeutics. Philadelphia, PA, FA Davis, 1898, A117-A177

11. Maurer JF (ed): Concise Dictionary of Scientific Biography. New York, NY, Charles Scribner's Sons, 1981, 135-137

12. Sherman R. Joseph Henry's contributions to the electromagnet and the electric motor. Rittenhouse 12:97-106,1999

13. PageC: Method of increasing shocks and experiments. Am J Sci 31:137-141, 1837

14. Geddes LA: A short history of electrical stimulation of excitable tissues. The Physiologist 27 Suppl S1-S47, 1984

15. Post RC: Physics, Patents and Politics: A Biography of Charles Grafton Page. New York, NY, Science History Pub, 1976

16. Hackmann WD: The Induction Coil in Medicine and Physics, 1835-1877. In Blondel C, Parot F, Turner A, Williams M (eds): Studies in the History of Scientific Instruments. London, Roger, Turner Books, 1989, 235-250

17. Mottley PF: Bibliographical History of Electricity and Magnetism. New York, NY, Maurizio Martino Pub, 1984, 284

18. Grigg ERN: The Trail of the Invisible Light. Springfield, IL, CC Thomas, 1965, 52

19. Heathcote NhdeV: NJ Callan inventor of the induction coil. Ann Sci 21:145-167, 1965

20. Mollan C, Upton J: The Scientific Apparatus of Nicholas Callan and Other Historic Instruments. Ireland, St Patrick's College Maynooth, 1974, 11-13

21. Rockwell AD: The Medical and Surgical Uses of Electricity. New York, NY, EB Treat, 1907, 189

22. Colwell HA: An Essay on the History of Electrotherapy and Diagnosis. London, William Heinemann, 1922, 56-73

Comments and corrections to build on the history and improve accuracy are invited.