A TEXT-BOOK OF ELECTRO-THERAPEUTICS AND ELECTRO-SURGERY, FOR THE USE OF STUDENTS AND GENERAL PRACTITIONERS

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BY

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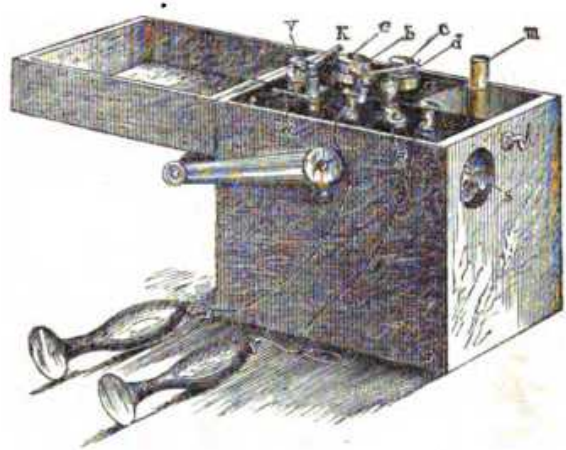
Medical Induction Coils.

A Paper read before the New York State Medical Society, February 1, 1881.

By LUCIUS E. FELTON, M. D., Potsdam, N. Y.



A complete Induction Coil consists of a Coil, a Battery Cell, a Vibrator and a Current Regulator. A Coil is generally made up of a bundle of soft iron wires, called a core, surrounded by one or more coils of insulated copper wire. If a current of electricity be sent through the Primary wire a part of it is stored up in the core as magnetism and remains there until the battery circuit is broken, when it is again transformed into a current of electricity in the surrounding coils if they form a circuit. This current has the power of overcoming several hundred times the resistance that the battery current has, depending upon its electro motive force

☞ Electro Motive Force is the exciting cause which sets up tension; it is located at the point or points where energy takes the form of Electricity. In the galvanic cell, at the surface of the zinc plate, in the induction coil, in the convolutions forming the coil, each convolution having its own E. M. F., so that the E. M. F. of a coil is in direct ratio with the number of turns of wire without regard to its size. The smaller the wire the greater number of turns in a given length of coil.

The E. M. F. of the coil varies as the number of turns of wire, the E. M. F. of each turn varies as the amount of energy from which it is derived, and that is the energy stored up in the core as magnetism.

The amount of magnetism induced in the core depends upon the quantity of current flowing through the Primary or battery wire, and upon the number of turns

of this wire. The Battery current depends upon the E. M. F. of the cell, its internal resistance and the resistance of the Primary wire. The cell which gives the greatest E. M. F. is the Bichromate; the elements are Zinc and Carbon, and the Battery Fluid a solution of Bichromate Potash and Sulphuric Acid.

The E. M. F. of this cell is a trifle over two Volts., and the internal resistance very much less than any other cell, being less than half an OHM. Hence it is best fitted for a Portable Battery, as a small cell may be used without materially increasing the resistance. There are, however, some decided disadvantages in the form usually employed—the Grenet. The Carbon plates are attached to a brass connection within the cell; the fluid very soon finds its way between them and oxydizes the brass, and breaks the circuit, and the current ceases. The same trouble occurs where the rod is screwed into the Zinc Plate, and also at the joint in the rod. Another disadvantage, the Zinc plate is carried in the cell and is subject to the action of the fluid when carried. The plate being seldom cleaned and amalgamated becomes coated with chrome alum and produces an unsteady current.

I have devised a cell which overcomes all of these objections, The cell or jar *a* [Fig. 1] is hard rubber, all sides permanently closed when vulcanized. The negative element is a rod of carbon ¾ in. in diameter, into one end of which is soldered a short piece of metal *c* for better contact. Upon this end is fitted a hard rubber ferrule *b* secured by rubber cement so perfectly that no fluid can find its way through. The end of the ferrule is closed by a hard rubber disk, having a hole for *c*, secured in same manner. Upon lower end of ferrule is a screw fitted to a hole in one end of cell *a* and screwed in with cement. The carbon reaches nearly to bottom of cell, while end with ferrule projects outside, as shown in [Fig. 1.] A hard rubber neck is screwed into another hole in top and closed with stopper *c*. The connections are thus made outside of cell so that there is no possibility of connction corroding or cell leaking whether upright or not. The cell is carried full of fluid; when used the stopper is removed, the zinc introduced and connection made with it. The zinc can be kept clean and amalgamated without trouble and is not wearing except when in use.

The core should be made of a bundle of wires, as they can be more thoroughly annealed than a mass of iron; the better annealed the quicker they demagnatize and the stronger the current induced. The insulated wire should be parafined before it is wound as it makes the insulation more perfect and keeps the moisture out of the coil. It is better to connect the inner end of the Secondary wire with the outer end of the Primary, as you can get the combined effect of Primary and Secondary currents and do not get the inverse induced current from Secondary coil when contact is made

The current induced in the Primary or Battery wire at the breaking of the circuit is called the Primary or the extra current; that in the secondary coil, the Secondary current. But as there is a current upon making and breaking battery current, the former is called the inverse induced current and the latter the direct. The direct induced current has many times greater tension than the inverse, because the inverse is induced from the battery current, while the direct is induced from the magnetism stored up in the core.

THE VIBRATOR.

While the vibrator performs one of the most important offices in a medical induction coil, it has received little or no attention from electrologists in their writings. It is this which breaks the battery current and allows the energy which it has stored up in the core to form a current in the coils. The plan of a vibrator is shown in Fig. 2; *c* is vibrator, having a soft iron armature *h* and plat-

inum connection f; soldered to it a is adjusting screw having platinum point g for contact with f. When contact is made between adjusting screw and vibrator a current of electricity will "flow" from carbon through adjusting screw, which is connected with it and vibrator, to inner end of coil which is soldered to d, and through coil k to zinc. This current magnetizes the bundle of wires l and soft iron bar i; i attracts armature h, drawing vibrator away from adjusting screw, thus breaking the circuit and demagnetizing the wires and rod, which releases the vibrator the elasticity of which causes it to fly back in contact with adjusting screw, completing the circuit again. At each interruption we have a current induced, lasting according to the researches of Prof. Blaserna, about 1-1000 sec.*

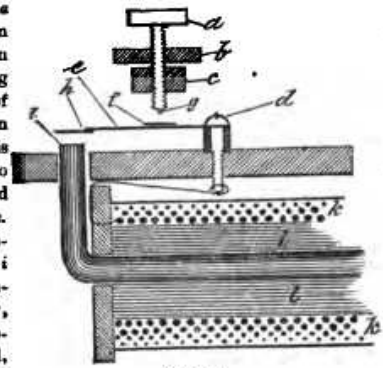


Fig. 2.

The chemical effects of a current of this duration must be very minute, but would be in a given length of time just in proportion to the number of interruptions in that time; that is, 1000 interruptions per second would produce 1000 times the chemical results that one would. Now if the therapeutic effects are due rather to the chemical effects of the current than to the simple shock, as I am led to believe by the results of the galvanic current as compared with the induced and the induced current with rapid vibrations compared with slow, we have reason to believe that the more rapid the interruptions the better the therapeutic results. The interrupters on nearly all of the induction coils are too clumsy to be called vibrators, but should rather be called oscillators. The springs are large and long, supporting on the free end a heavy iron armature and a large metal disk for the platinum. Such an interruptor can neither make rapid nor regular interruptions. A vibrator to make rapid interruptions must be constructed in accordance with the laws of vibration. These laws will be found fully discussed in works on acoustics. The vibrator must be made upon precisely the same plan as the organ reed which gives the highest pitch, as pitch depends entirely upon the number of vibrations in a given time. Temper, length and thickness as well as uniformity are important factors. It is highly important that no extra weight be put upon the free end, such as a heavy armature; the armature should be no thicker than the vibrator itself. The size of the vibrator depends upon the motive power that produces the vibrations, viz: the magnetism. From a long series of experiments I find that copper, zinc and silver, or copper and zinc, melted together, gives the best temper for rapid vibration. The tempering must be done by means of rolls and requires considerable skill to get the proper temper. I make the vibrator 1 in. long and about $\frac{1}{8}$ in. wide. On the free end I solder a piece of what is known as artists' tintype, about 1-100 in. thick, in such a manner that it makes an extension of the vibrator instead of thickening it; this is only about $\frac{1}{8}$ in. square and forms the soft iron armature. A piece of platinum foil, about same size, is soldered on surface of vibrator near middle for contact with adjusting screw [see Fig 2]. The vibrations from this interruptor are very rapid, as shown by the pitch and quality of current. I am conducting a series of experiments to determine the number of vibrations that can be produced per second, the result of which will be given at some future time.

*Gordon, Elec. and Mag., vol. 1, p. 316.

THE CURRENT REGULATOR.

It is of utmost importance that the strength of the current can be accurately regulated by the operator. Nearly all of the current regulators are based upon the following law: Where there are two or more circuits surrounding a magnetized core a current will be induced in each inversely as the resistance. If a copper tube surrounds the core and a great resistance (like a part of the body) be included in the circuit of one of these coils, the current would nearly all be induced in the copper tube. If this tube be arranged so that it will slide on the core and a portion of the core be uncovered, a current will be induced in the coil surrounding that part of the core that has been uncovered by the tube. The tubes are generally placed between the core and the Primary or Battery coil, or between the Primary and Secondary coils. The last is objectionable, because the Primary wire should be wound as close to the core as possible so as to magnetize the core as highly as possible. A compact coil cannot be made with a tube sliding within it. I overcome these objections by sliding a copper tube over the whole coil. The current is regulated to a nicety. The tube should not be made of brass as the resistance is too great. The method of sliding the Secondary coil over the Primary is objectionable on account of the connections becoming broken while the coil is being moved, the result being to give the full force of the current induced in the Primary wire, which when applied to nervous patients, particularly if upon the head, is very pernicious.

It is held by many electrologists of authority that a different quality of current and different therapeutic results are produced by different sized wires.—Based upon this theory, coils are sometimes made up of half a dozen different sizes, each size supposed to produce its special therapeutic effect and applicable to special cases.

But a coil that has an E. M. F. sufficient to produce a tension that will overcome the resistance of the body and furnish a sufficient quantity of current for therapeutic purposes will do all that a dozen wires can do. With the Galvanic current the same quantity passing through a circuit in a given time will produce the same effects without regard to the kind of battery used. So with the Electro Magnetic Battery the same quantity of current at each interruption and the same number of interruptions per second will produce the same effect without regard to size of wire or kind of machine. Now a coil can readily be made of two wires, or even one, that will furnish a sufficient Electromotive force to give the desired quantity for therapeutic purposes and with a proper regulator any desired quantity can be obtained Where several sizes of wire are used it makes a complicated affair for the physician, requires a larger number of connections to get out of order and makes it more mysterious for the inexperienced.

With due difference to the high authorities in both this country and England, who advocate this theory, I must say, that based upon Electrical laws, and careful experiment with differently arranged coils, cells and vibrators, it is fallacious.

I will next consider slow interruptions of the Induced current as compared with slow interruptions of the Galvanic current. We are told by good authorities that slow interruptions are preferable to rapid in the treatment of paralysis, and that slow interruptions of the Galvanic are preferable to either. There must be some reason why the Galvanic current produces contractions in paralyzed muscles when the Induced fails, but I have never seen one given. I will give the one that seems to me the most plausible. Supposing the interruptions to be 1 a second with the Induced current we would have at each interruption a current lasting, say 1-1000 of a second, and in another second another current of like duration. But with the Galvanic battery, when the circuit is closed, the current passes until it is open again, and if of the same E. M. F. and R., we have several hundred times the quantity passing at each interruption as with the Induced, and so long as Electricity is just the same as long as it flows in the one case as in the other, it is safe to assume that the difference in therapeutic results is due to the difference in the quantity that flows at each interruption. Then it is reasonable to suppose that with a vibrator that will produce a large number of interruptions per second we should obtain results nearer like those of the Galvanic current, this I have found to be the case as I have repeatedly demonstrated in my experiments. In doing this, I make my slow interruptions in the Induced circuit by removing the electrode, or using an interrupting handle.

TO

WILLIAM TOD HELMUTH, M.D.,

PROFESSOR OF SURGERY, NEW YORK HOMŒOPATHIC COLLEGE, AS A TOKEN OF APPRECIATION OF HIS HIGH PROFESSIONAL ATTAINMENTS, AND AS A MARK OF PERSONAL ESTEEM AND FRIENDSHIP, THIS WORK IS DEDICATED.

THE AUTHOR.