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ELECTRIC CURRENT FOR MEDICAL USE

A NEW ELECTRICAL CURRENT FOR MEDICAL USE .

At the annual meeting of the American Medical Association for 1888, I briefly described a peculiar form of electrical current which I had had the good fortune to discover five years before, and have had the current in use since that time. I have continued the use of this current for some twelve years, and have mentioned it in a number of medical papers, chiefly within the last three years, at the meeting of the American Electrotherapeutic Association, and in a chapter which I contributed to the International System of Electrotherapeutics "published by F .A.Davis.

At the time I discovered the current I was unable to account for its peculiar physiological properties which in another paper I have briefly described.

Physiological Effects of the Sinusoidal Current.— The physiological effects produced by the sinusoidal current which are most characteristic of it, are, 1, its painlessness; and 2, its great penetrating power. D'Arsonval has shown that the intensity of the motor, or sensory, reaction produced by a given current is proportional to the variation of potential at the point excited. The constant alternation of the current prevents polarization of the tissues acted upon, and hence maintains the maximum exciting effect.

That important physiological significance must attach to the mode of variation in potential, as well as to the amount of variation, is clearly evidenced by the difference in the effects occasioned by the gradual or sudden withdrawal of the current in making an application of galvanic electricity, which is familiar to all medical electricians.

In the use of the sinusoidal current from my apparatus, different effects are observed, according as the machine is rotated slowly or at a high rate of speed. When rotated slowly and connected with sponge electrodes held one in each hand, vigorous contractions are produced in each arm, and in alternation, nearly all the muscles of the arm seeming to participate in the contractions. When one electrode is placed in contact with the feet and the other held between the two hands, the muscles of both extremities are made to contract vigorously. The contraction is spasmodic rather than tetanic in character, as when the faradic current is employed. By proper adjustment of the cur-

rent, strong muscular contractions may be induced without producing the slightest sensation on the skin, and without any pain sensation whatever. With one electrode placed in the rectum or the vagina, and the other upon the abdomen, strong contractions of the abdominal muscles may be produced, and even of the muscles of the upper thigh, without any sensation other than that of motion. I have frequently seen patients while receiving the current in this manner, shaking so vigorously under its influence that the office table was made to tremble quite violently with the movement.

With rapid rotation of the machine, the current obtained is capable of producing strong tetanic contractions similar to those induced by the faradic machine. The only skin sensation produced by an application sufficiently strong to induce tetanic contractions, is a slight prickling, but far less intense than that produced by a faradic current capable of exciting equally strong motor effects.

The sensory effects produced by the current are exceedingly interesting. As has been already stated, applications of the current sufficiently strong to produce vigorous muscular contraction, are attended by no sensory effects whatever. The sensory effects are best obtained by giving the machine a high velocity. Adjusting the apparatus for high velocity, and applying the sponge electrodes, well moistened, to the temples with a gradually increasing current, and with the eyes closed, one seems to see rotating waves of light, resembling a luminous whirlpool, in the region of each electrode. It is a curious fact that the position of this luminous field is not stationary; it moves with the electrode, which seems to be the center of the illuminated area. As the current is increased in strength, the display of light increases in brilliancy, finally becoming so extended and intense that the whole front portion of the head seems to be brightly illuminated. At this point, one begins to experience very slight prickling sensations in the skin, which increase as the intensity of the current increases. A remarkable characteristic of the current is, that strong impressions are made upon the optic nerves, or their centers, by a current too delicate to be recognized by the nerves of the skin. This effect must be due to the great penetrability of the current.

Duchenne showed, in his masterly work published during the siege of Paris, that there is a decided difference in the physiological properties of the currents obtained from the first and the second helix of an induction apparatus, and that these currents have very different clinical applications. The current of the second felix was found to possess much greater penetrating power than that of this first helix. The currents of the two helices differed, according to Duchenne, just "as water that is warm differs from water that is boiling, or as iron slightly warmed differs from iron that is white hot," as regards their influence upon sensibility. This fact is only cited as an analogous observation, since the sinusoidal current possesses properties very different from those of any faradic current with which I have experimented.

The therapeutic uses of the sinusoidal current are so varied that it is impossible in a brief paper, to fully enter into the consideration of this part of the subject. I have, together with my colleagues at the Battle Creek Sanitarium, made a great number of applications of this current,--fully twenty-five or thirty thousand in all. One of the most important uses of this current is as a means of exercising the muscles.

As a means of exercising the muscles, particularly muscular groups which cannot be easily brought into isolated action by voluntary effort, and in cases in which, through injury of the nerves or nerve centers, or through disability of some other organ, exercise by voluntary effort has been impracticable.

I have found this current available as a means of producing muscular contraction in cases in which degenerative changes had advanced so far as to destroy the reaction to the faradic current. I have also found the current of great value as a means of securing passive exercise in connection with the rest cure, in which respect its superiority over faradism applied as prescribed by S. Weir Mitchell is incontestable. I have used for many years, and still use, the faradic current, applying it to the various motor points of the body in such a manner as to secure vigorous muscular contraction as a means of exercise in feeble patients, but I have found the sinusoidal current very greatly superior to the faradic current for this purpose, by reason of the painlessness of the applications, and the great vigor of the contractions which are obtainable. With the faradic

current it is often difficult to obtain strong contractions, especially in fleshy persons, and in many cases almost no contraction at all can be obtained without the application of a current of such strength as to be almost unbearable in consequence of the pain produced, and the services of a person skilled in locating the motor points are necessary for its special application in a majority of cases. With the employment of the sinusoidal current these difficulties disappear entirely. It is only necessary for the patient to grasp the sponge electrodes in his two hands, to secure vigorous contractions of all the muscles of the arm; or with the patient holding an electrode in one hand, the attendant may apply the other sponge to the upper part of the arm, or the shoulder, and thereby secure the most vigorous contraction of all the muscles of the arm operated upon. By a similar application of one sponge upon one side of the abdomen and the other upon the other side, or one sponge at the lower extremity of the back, and the other at the upper extremity, vigorous contraction of all the intervening muscles is easily secured without taking the trouble to seek out the motor points, and no matter how great the quantity of overlying fat.

I find this current exceedingly valuable as an alternate treatment to be employed in connection with massage. It is not a substitute for massage, but it secures an activity of the muscular structures which cannot be accomplished by any form of passive exercise.

The special use for which I find the slowly alternating sin-

usoidal current of greatest advantage, has been as a means of strengthening relaxed or undeveloped abdominal muscles in gynecological cases. I long ago learned that a great share of the long category of symptoms complained of by women suffering from so-called female weakness, such as "backache,"

> "dragging sensations," "weakness," etc., are due, not to primary pelvic disorders, but to a relaxed condition of the abdominal walls, resulting in what Trastour terms "desequilibration," or disturbance in the static relations of the abdominal viscera. Relaxed abdominal walls allow the stomach, bowels, liver, kidneys, spleen, and other viscera to become pendent; and a constant drag upon the branches of the great sympathetic which are distributed to these organs, results in congestion and irritation of the great abdominal brain, as the semilunar and associated ganglia of the great sympathetic have been aptly termed, and through the morbid reflexes thus set up, give rise to a multitude of painful and neurasthenic symptoms, which render miserable the lives of thousands of women who are really not suffering from any disorder of the pelvic organs whatever, although perpetually under treatment for some imaginary prolapsus, or anteversion, or ovarian irritation, or other pathological myth.
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> By strengthening the abdominal muscles and thus replacing the prolapsed abdominal viscera and restoring the normal abdominal tension, so that the portal circulation recovers its normal tone, I have succeeded in curing hundreds of invalid women who had previously sought relief in vain at the hands of many gynecologists; and in the accomplishment of this, I am certain that the sinusoidal current has played a very important role. I find this current especially valuable at the beginning of the treatment of these cases, before the patient has acquired sufficient strength or sufficient confidence to engage in active gymnastic exercises, or to be subjected to the active or active passive exercises of the Swedish movement system, which I always utilize as a means of accomplishing a thoroughgoing and permanent cure.
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> I also find the sinusoidal current of great value as a means of after treatment in cases in which I have found it necessary to shorten the round ligaments or to perform other gynecological operations for the correction of displacements of the pelvic viscera not curable by non-surgical means. The neglect to employ these and other measures for developing the normal supports of the uterus and ovaries, is, I am satisfied, one of the causes which has led to the general failure of the operation of

shortening the round ligaments, in the hands of American gynecologists. I have performed this operation more than three hundred times, with less than five per cent of failures,—scarcely a single failure, in fact, within the last four years, since I have perfected the technique of my own method of operation. By the employment of a slowly alternating sinusoidal current for a few weeks after the operation, the abdominal muscles are developed so that they are able to hold the small intestines out of the pelvis, and thus relieve the pelvic viscera from unnatural strain.

In cases of facial paralysis this current affords an admirable means of exercising the muscles and stimulating the nutrition of the paralyzed structures, as one can pick out the affected muscles and put them into rhythmical action with very great facility. In the treatment of spinal curvatures due to weakness of the muscles of one side, or irregularities of muscular development, this current is also valuable. The current affects involuntary as well as voluntary muscles. It is of great service in cases of constipation, one pole being applied to the rectum and the other to the abdominal muscles. It serves a double purpose in cases of this kind, awakening the nervous sensibility of the rectum, and at the same time, rapidly increasing the strength and efficiency of the abdominal muscles.

I have also found it of great service in cases of dilatation of the stomach. By means of a stomach electrode, which I have had constructed for the purpose, with one pole applied internally,. the other externally, vigorous contractions are readily produced. I have verified this in several ways. After the current is turned on, one can easily detect the active peristaltic movement by listening over the region of the stomach with a stethoscope. The most positive evidence is afforded, however, by the fact that the stomach diminishes in size. I have sometimes noted an upward movement of the lower border of the stomach during a single treatment amounting to fully two inches. No painful sensation is produced by the current used for this purpose, even when quite strong. I have, in some instances, increased the strength of the current sufficiently to enable me to obtain the most indubitable evidence of contraction of the organ in the forcing out of the stomach contents through the tube, or

along the side of the tube containing the electrode . This effect is always produced when the current is made sufficiently strong. The ejection of the stomach contents is not accompanied by nausea, and ceases the instance the strength of the current is lessened, beginning again when the current is increased. I have used this current to the most excellent advantage in many cases of motor insufficiency of the stomach, with and without dilatation.

. The fact that such profound motor and sensory effects can be produced without the ordinary shocking, prickling, and other sensations, is a grateful surprise to the patient, and certainly enhances its value as a therapeutic means.

Employed with rapid alternations, 3000 to 7000 per minute, I have found no electrical application so valuable as a means of relieving a hyperaethetic condition of the abdominal sympathetic ganglia, especially the semilunar ganglia, the lumbar ganglia, and the lumbo-aortic plexus of the sympathetic. It is equally efficacious in relieving pains beneath the shoulder blade and in the lumbar region, which are often erroneous attributed by patients to a diseased liver, but which are due in a great majority of cases to a congested and irritated condition of the abdominal sympathetic ganglia.

A rapidly alternating sinusoidal current is one of the most efficacious means with which I am acquainted for the relief of the peculiar sensation known as "heaviness," of which dyspeptic patients often complain. This sensation is due to a perverted condition of the sensory nerves of the stomach. Its relief by

a rapidly interruoted current is an evidence of the penetrating power of this current.

The rapidly interruoted current may be applied to the stomach either externally, or by means of a flat sponge electrode, one over the stomach and the other over the spine opposite; or internally, by means of a properly formed electrode placed inside a stomach tube, with a flat sponge electrode over either the stomach or the spine opposite the stomach. I have applied the sinusoidal current in this manner in a large number of cases for the relief of stomach symptoms, especially in cases in which examination of the stomach fluid by the method of quantitative analysis, which I have elsewhere described, showed deficiency

in that form of stomach work which consists in the combination of free chlorine with albumen, as shown by the diminished amount of the combined chlorine.

The physiological laws which govern the various chemico-vital processes of stomach digestion are certainly not fully understood, but they are under more or less direct control of the nervous system, and especially of the sympathetic nervous system, particularly that portion known as the solar plexus, will probably not be disputed. The sinusoidal current seems to act by promoting a normal condition of the sympathetic, and its relations to the stomach thus facilitate the combination of the chlorine with albumen in the conversion of albumen into peptone.

An equally interesting fact which has been observed in a number of cases, is the action of the current in promoting an improved value in the quality of the digestive products. In the method of examining stomach fluid referred to, an inferior quality in the product of peptic digestion is shown by the diminished value of coefficient a. An application of the sinusoidal current seems not only to promote the quantity of combined albumen, but to improve its quality.

In the employment of the sinusoidal current for its effects upon the nervous system, I have found a current of high velocity most useful. The potential of this current is so great it can only be used by the aid of a very excellent and well graduated rheostat of large resistance. When judiciously employed, I find it more effective than any other form of electrical current in

the relief of pain and all other symptoms arising from a hyper-aesthetic state of the nerves or nerve centers. I have found it especially serviceable in the relief of pelvic pains and the various forms of headache. It is also especially valuable in the relief of various disorders of sensation included under the general term, paraesthesia. The peculiar numb, tingling, crawling, and other sensations of which neurasthenic patients often complain, are almost certainly relieved by it. The same is true of the great variety of peculiar head symptoms complained of by neurasthenic patients, especially women suffering from pelvic disease. Most of these symptoms, I am satisfied, are the result of reflex disturbance of the abdominal sympathetic, which

I believe is especially favorably influenced by the sinusoidal current.

By careful management the electrodes may be applied to the head, and a current capable of producing decided effects passed through the brain in different directions without the slightest pain or other than the most agreeable sensations. I have never seen the slightest unpleasant effect from the application of this current, while it is not an uncommon thing to find patients who seem to possess an idiosyncrasy against the faradic, and in some instances, although much less frequently, against the galvanic current. In a good many thousand applications I have never yet found a patient who has experienced any ill effects from the application of the sinusoidal current. The only inconvenience I have ever observed has been an occasional muscular soreness when a too vigorous or too prolonged application of the slowly alternating current had been employed, but this is only the effect of the gymnastic exercise, and should not be attributed to the electrical current *per se*.

A very important advantage of this sinusoidal current, is the fact that in its employment one may deal with elements as accurately known and capable of being as accurately dosed as in the use of the constant current. My apparatus is provided with a permanent magnet, so that the only element which it is necessary to determine is the rate of motion, which is easily ascertained by means of the indicator commonly employed for this purpose. In this respect the sinusoidal current possesses an immense advantage over any form of faradic current. In the apparatus employed by d'Arsonval, the source of induction is an electro-magnet, and requires, accordingly, a determination of the amount of current used to excite the magnet as well as the velocity of the apparatus.

(Since the presentation of this paper I have perfected a sinusoidal apparatus in which the permanent magnet is replaced by an electro-magnet. This arrangement gives the most absolutely perfect control of the currents in dosage, and renders easy the application of currents of extremely high tension.)

The current produced by a faradic machine is subject to continual modifications from variation in the strength of the actuating battery, and in the adjustments of the rheotome, as is

well shown by the tracings which I present with this paper. (Plates II, III, IV.) I have made a large number of tracings of the currents produced by various forms of faradic apparatus and under various conditions, and have made some experimental attempts with a view of securing an improvement upon the ordinary form of induction apparatus, but I have thus far met with little encouragement of success. I believe the faradic machine is inherently faulty as a scientific electrical apparatus for medical purposes. The rheotome is a fatal element of weakness, changing the character of the current with the slightest modification, and often, as every medical electrician knows, in a manner which, if the thing were intelligent, must be regarded as purely whimsical.

The invention of Faraday answered an excellent purpose during the embryonic period of electro-therapeutics, but now that we have learned the value of the milliamperemeter, the voltmeter, and the coulombmeter, and have acquired methods of precision in our electro-therapeutic procedures, the faradic battery, like the shocking machines of a half century ago, must give place to a more precise and more reliable instrument. The effort to overcome the weaknesses of the induction coil by the provision of some means of measuring the current obtained from it, is a task as useless as it is difficult, since nothing else than a graphic representation of the curves produced by it could enable a practitioner to regulate the machine twice alike, and such a method of regulation would be altogether too cumbersome and tedious for practical use.

In the group of tracings shown herewith, which are cuts intended to illustrate the effects of changes in the rheotome, no change whatever was made in the apparatus, except such as results from turning slightly in or out the adjusting screw of the rheotome. The increased or diminished amplitude of the curves produced are an indication of the changes in the potential current resulting from the changes referred to. There seems to be no method by which fluctuations in the character of the current can be remedied, and consequently the faradic machine, in the opinion of the writer, must sooner or later be recognized as too rude an appliance to be of value in scientific electro-therapeutics, or, at least, to be of use only in a limited class of cases in which mere excitation is the object to be accomplished.

For the last three years I have employed an electrician a considerable part of his time in constructing various models of magneto-electrical apparatus in the effort to overcome various practical difficulties which present themselves in the construction of a machine intended to cover so wide a range of uses. A very large number of machines of different forms and sizes, and of varying degrees of efficiency have been constructed, and after many discouragements and surmounting many difficulties, an apparatus has at last been perfected which I am able to exhibit here today, and which I believe will give eminent satisfaction. The advantages offered by this apparatus may be briefly summed up as follows:--

1. This apparatus produces physiological and therapeutic effects of a most decided and important character, which are not obtainable from any other form of electrical apparatus.

2. Aside from the galvanic current, it is the only form of electrical apparatus which affords a means of exact and accurate dosage, or the only apparatus with which accurate dosage, variable within large limits, is possible.

3. Its therapeutic applications are painless.

4. It affords the most efficient means possible for exercise of the muscles, producing the most marked muscular contractions without pain. It may even be applied in such a way as to throw all the muscles of both extremities into violent muscular movement, without other sensation than that of motion. The muscular effect may be localized to the nicest degree,

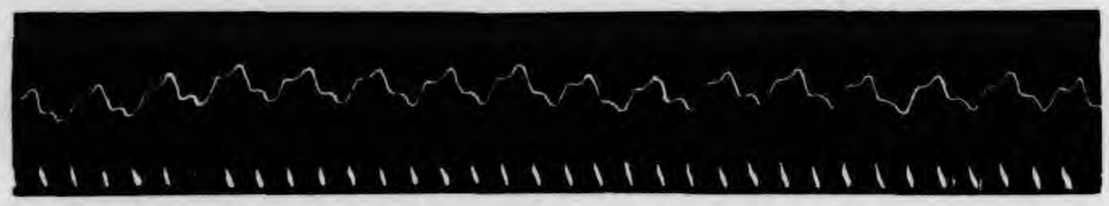
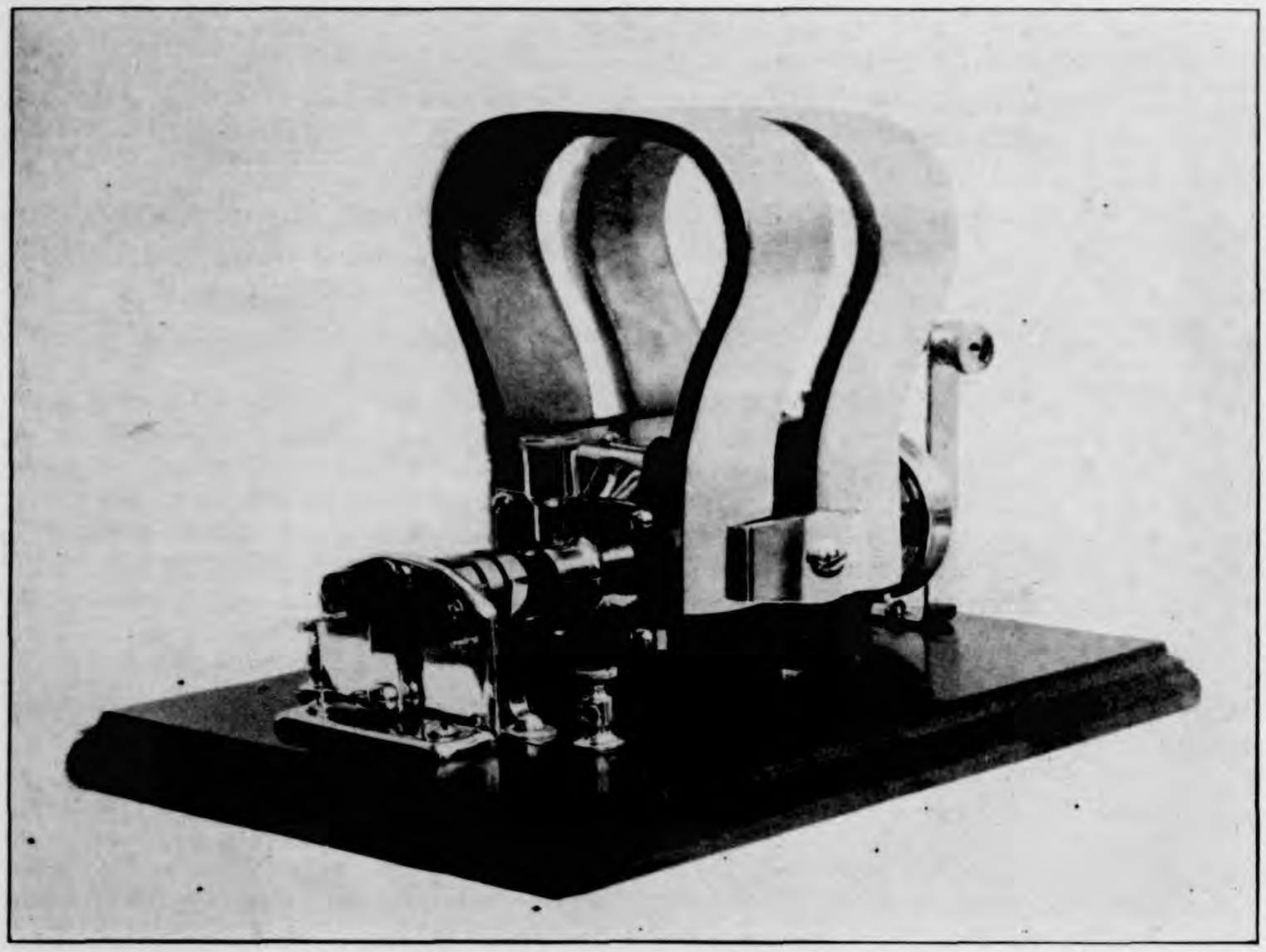


Fig. 4.

confined to a single set of muscles in the face, or to a thumb or finger, bringing all the muscles into efficient action without affecting others. When the machine is rotating slowly, a current is produced which gives a vigorous muscular contraction at each change in the direction of the current. When the machine runs at a sufficiently high rate of speed, the muscular contraction becomes tonic or continuous.

5. It is unexcelled as a means of relieving pain, or exciting the nerves of special sense. When applied to the region of the eyes, it produces a

most remarkable light phenomenon without pain, prickling, or any of the other disagreeable sensations induced by the galvanic and faradic currents. Applied to the ear of a person who is totally deaf from diease of the middle ear, strong impressions of sound are made without the production of pain, or any other sensation than that of sound. This current succeeds in relieving pain in a large proportion of cases in which the galvanic, faradic, and static currents fail.



NEW SINUSOIDAL APPARATUS.

6. This current has a larger range of adaptability than any other current.

7. The first cost of the entire apparatus is less than that of other first-class electrical outfits, while the effects obtainable are much more varied, and of a character not approached by any other apparatus.

8. The apparatus may be maintained without any expense whatever, as when the machine is used with a permanent magnet and runs with photo-spring-power, there are no battery plates or fluid to be consumed, and nothing whatever to get out of order. It is always ready to give its maximum current, and any lesser current desired.

9. The apparatus is provided with a commutator, by which the alternating current is converted into a direct current capable of producing all the effects of an ordinary direct or galvanic current, such as electrolysis, cataphoresis, and other ~~popular~~ effects. It is much more agreeable in its application than the ordinary direct current for the reason that the construction is such that a gentle sinusoidal current is superadded to the direct or galvanic current, thus producing a very desirable combined effect, the advantages of which, ~~especially in electrolysis or fibroid tumors of the uterus~~, as pointed out by Dr. Kellogg in his paper in the "International System of Electro-Therapeutics," ~~and elsewhere~~.

10. The large capacity of this apparatus is shown by the fact that **it will light an ordinary 16 C. P. electric lamp.**

11. The sinusoidal apparatus is extremely convenient in use. It is always ready for business, and the several different currents can be obtained by simply moving a switch and without adjustment of the conducting cords.

12. It is provided with a perfect speed regulator, and the current is controlled by a simple rheostat, as any other electrical current.

~~Any physician who has once used this apparatus in his office, will be unwilling to dispense with it,~~ as it furnishes all the desirable effects to be obtained from both the galvanic and faradic batteries, together with a large number of other effects which are not approached by any other apparatus. 14. It requires no cleaning of cells and brightening of contacts, gives no unpleasant fumes, does not get upset, destroying carpets and other office furniture, and never produces disagreeable or undesirable effects.

The sinusoidal current, so named by Dr. d'Arsonval, of Paris, who discovered this current, independently, some two or three years ago, is extensively used by Apostoli and other electrotherapeutists in Paris, and is highly praised by them, although the apparatus which they employ is capable of producing only a small fraction of the effects which can be obtained from the apparatus shown in connection with this paper, having too small a quantity, although giving a current of high potential. Its merits have been attested by a number of physicians in this country in whose hands the apparatus has been placed, and has been very highly commended for its admirable qualities.

THE PHYSIOLOGICAL and THERAPEUTIC PROPERTIES of the SINUSOIDAL ELECTRICAL CURRENT.

As the term Sinusoidal, applied to electrical currents, may be new to many of those who listen to this paper, a word of explanation with reference to the meaning and application of the word may be in order.

Eleven years ago, while investigating the currents afforded by various forms of electrical apparatus, including some not previously in use for medical purposes, the writer discovered a current possessed of peculiar properties, one of the most marked of which was the power of producing strong muscular contractions without pain. Attention was called to this current in a paper read before the American Medical Association at its annual meeting in 1888, and the subsequent year its properties were again described in a paper presented at the annual meeting of the American Association of Obstetricians and Gynecologists, and published in the transactions of the Association for 1889. Since that time the writer has published various papers upon the subject.

Three years ago, D'Arsonval, of Paris, discovered the same current, and found on making a graphic tracing of the current that it represented a true sinusoidal line; that is, a line the curves of which are such that the ordinates are proportional to the sines of the abscissa. From this circumstance D'Arsonval called the current Sinusoidal.

D'Arsonval described this current and made a public presentation of the graphic tracing obtained from it, in a paper read before the French Academy of Sciences, June 27, 1892. His paper was published in an early number of the Archives de Physiologie, on receiving which I at once recognized the identity of the current which he had discovered with that which I had discovered eight years previously, and had had in use during that time, and I at once set about employing means for obtaining a graphic representation of the current. By the aid of my electrician,

Mr. H. A. Dow, I constructed an Electrograph, by means of which the form of the curve produced by any alternating or fluctuating current may be graphically studied, and by obtaining a tracing from my apparatus, I was delighted to find that it corresponded exactly with that published by D'Arsonval, being a true sinusoidal curve. The form of this curve is shown in Fig. 12, Plate IV, of a paper read at the annual meeting of the American Electro-Therapeutic Association held in Chicago last year.

My observations of the properties of the current entirely confirm those of D'Arsonval, but, as stated in a paper recently read before the American Electro-Therapeutic Association at its annual meeting in New York City, I also noted other facts which he has not observed. I found that a current of high frequency may be so regulated as to produce powerful sensory effects, although producing neither muscular contraction nor pain, as when applied to the eye or the ear. In the paper above referred to I also stated that I had noted that by regulation of my apparatus I was able to produce most powerful although painless muscular contraction simultaneously with the alterations of the current as well as powerful tetanic but painless contractions by a different regulation of the apparatus. D'Arsonval's discovery was incomplete for the reason that he studied only one phase of the current, that of high tension with very small quantity. My discovery was incomplete for the reason that while I observed the peculiar effects of the current, both of high frequency and of low frequency with larger quantities than usual, I failed to discover the sinusoidal form of the curve produced by the current, not being at that time possessed of the necessary physical instruments for making such a study.

The sinusoidal current may be briefly described as a current which produces, when graphically represented, a curve perfectly sinuous in form, and differing widely from the ragged and abrupt curves produced by a faradic apparatus. The most characteristic effects of the sinusoidal

current are its peculiar sensory and motor effects. When applied to the head it produces a metallic taste and luminous flashes or flickerings; when applied over the ears, thumping sounds; when applied to the skin with sufficient intensity, a slight tingling sensation, and pain when a strong current is applied. When a current is received through electrodes held in the hands, a peculiar sensation of lightness or of great size is felt in the arms.

The motor effects differ according as the rate of alternation is slow or rapid. When the alternations are slow, or at a rate not exceeding 20 to 30 per second, the muscular contractions are clonic or distinct, occurring at each alternation of the current. When the rate is increased, the contraction becomes tetanic or continuous, although distinct pulsations corresponding with the alternations of the current can be felt until the rate of vibration becomes two or three thousand per minute. At 14,000 to 16,000 alternations per minute, and with an apparatus so constructed as to give a current of considerable quantity, effects somewhat akin to those obtained by a galvanic current are produced. I have also noticed a very decided anaesthetic effect with such a current. At a very high rate of speed, the current, when applied to the skin with sufficient strength, produces a pulling sensation. It is only possible to use the rapidly alternating current by the aid of a rheostat.

When applied to a degenerating muscle, the slow alternating current, with the machine so regulated as to give quantitative effects, acts with much more vigor than the ordinary induction current, resembling more closely the effects of the galvanic current. The sinusoidal current has the advantage over both the galvanic and the faradic currents, both of which currents it resembles in several effects, in the fact that there is not the destruction of tissue, and is far less painful when used for either motor or sensory effects.

I have made more than 20,000 applications of this current, fully half of which have been made for motor effects, and have often used it in such a manner as to produce violent muscular contractions, but I have never seen the application followed by muscular soreness, an effect which frequently follows the use of the faradic current. The reason for the peculiar motor effects of this apparatus, the excitation of strong muscular contractions without effecting the cutaneous nerves or nerves of ordinary sensation is doubtless (1) the sinusoidal character of the curve produced by it which represents the gradual and uniform increase of the current from zero to maximum and back to zero again, first in one direction and then in the other, and (2) the interesting fact developed by laboratory experiments in electro-physiology, that electrical applications produce a state of hyper-excitability in the region of the anode the instant the current ceases to flow. The consequence of this fact is that influence applied to a part which has the instant before been under anodic influence will produce more marked effects than under other circumstances on account of the hyper-excitability of the nerves produced by the influence of the anode. An alternating current thus necessarily acts more vigorously in exciting muscular contraction than the simple interruptions of the constant current. The painless muscular contractions produced by my apparatus, as compared with the faradic alternating current, is evidently the result of the fact that the greater quantity of current produces more decided polar effects.

From observations which I have made on ordinary magnetos, I am led to believe that the peculiar effects described by D'Arsonval as characteristic of the sinusoidal current, and the wide range of effects noticed by myself, are not absolutely confined to currents giving a true sinusoidal curve, but are possessed by other magneto-electric xxxxxxxx currents in higher or lower degree, depending upon the nearness of the approach of the graphic representation of the current to a truly sinusoidal curve. The effects of alternating currents of great rapidity, that is

above 10,000 per second, do not require even this, for these effects are seen in the highest perfection in induction currents induced by sparks. The effects of the sinusoidal current of high rate of alternation is doubtless due to its approximation to such forces as light and heat in its nature, and those of slower alternations, less than 10,000 per second, to the regularity of the undulations and the proportions between quantity and potential. I must not forget to acknowledge that the last thought was suggested to me by Dr. Massey when I first called his attention to my appratus in the summer of 1886--some eight years ago.

I have not had the pleasure of seeing D'Arsonval's sinusoidal apparatus, but starting with the apparatus with which my first experiments were made, and which I have with me for exhibition, with some modifications, I have had a number of machines constructed for the purpose of overcoming certain difficulties which I have experienced in its use. I found it was purely a matter of accident by which the apparatus which I first employed was capable of giving a sinusoidal current; other machines apparently identical, gave currents which were not sinusoidal. It was only by a careful study of the machine with the assistance of my electrician, Mr. H. A. Dow, that I succeeded in determining the peculiarities in the construction of the machine which gave to the current produced by it a sinusoidal character, a characteristic which was wholly unnecessary for the original purpose for which it was intended, and quite unknown to its constructors. The difficulties which are encountered in the construction of a sinusoidal machine are two:

1. To secure perfect uniformity in the current; in other words, a perfect sinusoidal curve when graphically represented. I have with me an ordinary magneto, the curve produced by which is shown on the tracing which I shall pass around. I also have a machine which I have had constructed by an expert electrician who had for a copy one of my sinusoidal machines which, by painstaking effort on the part of my electrician, had been made to give a perfectly sinusoidal current. As will be

seen by the tracing which I exhibit herewith, the current produced by this machine, though nearly sinusoidal, is not absolutely so. I think it impossible to construct these machines so as to give perfectly sinusoidal currents without testing the character of the curve ~~without~~ by the use of some graphic means of representing the current produced by them.

2. The second difficulty encountered was to make a machine capable of producing not only the peculiar sensory and motor effects characteristic of the current of high alternation, but also possessed of of sufficient quantity to give the desired motor effects with slow alternation, one of the most important uses of the machine. For a long time I was compelled to use two different machines for producing these effects, but finally succeeded in producing a single machine capable of producing the whole range of effects. A special difficulty encountered with this machine was in the control of the current by means of ordinary rheostats. When run at a high rate of speed, the electro-motor force of the current produced by one of these machines is so great that it cannot be properly controlled by any of the ordinary rheostats. In the use of any of the different forms of water rheostats, the instant the water is touched the amount of current transmitted is too great, leaving no room for regulation. I have only found it possible to use such a rheostat by using a thread for making contact with water.

In my experiments for thep puppose of finding a convenient means for controlling the machine, I devised a sponge rheostat which I find very useful, and which I also find a valuable means for controlling the current from an ordinary faradic battery, for which purpose it works admirably. The device has the advantage of being cheap as well as simple; it cannot get out of order, and the resistence can be increased or diminished by making the sponge very dry or quite moist, or by adding salt to the water with which it is moistened. I finally hit upon the idea of controlling the apparatus by means of a converter. Accordingly I had a suitable one constructed, which I herewith exhibit. This answers

the purpose perfectly, and renders it possible, also, to either increase or diminish the tension of the current at will, either by using the outer or inner coil for the exciting field, as may be desired. Recently, However, I have adopted still another method for modifying the current, which I find exceedingly satisfactory. This method consists in dividing the armature intol two segments. In the machine which I exhibit, the wire of the first segment gives a resistance of 140 ohms; that of the whole armature being 1100 ohms. By using the shorter segment of the armature the quantity of the current is cut down to such a degree that the most rapid alternations may be employed without rendering the current so strong that it cannot be easily controlled.

Therapeutic Effects.--I find the sinusoidal current of great practical value in the treatment of all forms of paresthesias, in neuralgia, in hyperaesthesias of all sorts especially; it is of great value in the treatment of headaches, and for neurasthenic pains of various sorts. In ovarian and other forms of irritation I have found it of far greater value than either the faradic or galvanic currents which I have used very extensively for the last twenty years, making, with the aid of my assistants, from fifty to twice as many applications daily.

The motor effects obtainable from this machine are even more useful, if possible, than the sensory effects, although not so immediately apparent. It is certainly one of the most convenient of all the methods of applying gymnastics to a weak muscle or nuscular group. I find it especially valuable in the treatment of spinal curvatures due to weakness of the trunk muscles, the application being generally made to the paretic or paralyzed parts. The readiness with which the motor effects of the current may be localized are well illustrated in its application. An ordinary electrode may be applied to the hand in such a way as to cause either finger desired to move alternately in a sidewise fashion, by action of the interossei, keeping time with the alternations of the current.

Two electrodes held in the hands produce a similar alternating movement of the muscles of the forearm.

In the use of this current I continually encounter new and interesting effects which are characteristic of it, and which suggest new and valuable therapeutic applications. It certainly is not a substitute for either the galvanic or the static currents, but I think it may well replace, almost altogether, the faradic current, which is in every way inferior to it.

Report of Cases who have taken the Sinusoidal Current.

Miss Swigert, suffering with severe nervous headache. Could not sleep. Relieved by one application of the S.R. Has not had a return of the trouble, although this was several weeks ago.

Mrs. Moorehouse, had paralysis of the left side nineteen years ago, from which she had never fully recovered. Has had the S. R. applied three times a week for about a month or six weeks. She tells me that the stiffness is gone from her leg and that it feels much lighter, and she can walk much better than she has been able to for nineteen years. The arm has also lost the feeling of heaviness and stiffness. Calls herself so well she wants to stop treatment.

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We have had a great many people suffering with pelvic pains, both acute and chronic, relieved by this treatment, some of them at once and others in a longer time. Many cases in the use of S.S. I have noticed the development of the abdominal muscles. (it is difficult to determine just whether it was the electricity, gymnastics, or their manual treatment that caused the development of the muscles, but I suppose it was due to all.)

Mrs. Kellar, suffering with long-standing pain in the face and jaws extending up into the ears. Has been entirely relieved by the applica-

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Mrs. Bowman, suffering from chronic nervous headache. Has been much relieved. She has also taken it for pelvic troubles from which she has much improved.

Mrs. Eberling, taking the local application for pelvic troubles. Is improving steadily.

Mrs. Hurd has been running down and growing weaker for some time. Right leg especially gets weak when she walks. Was had the sinusoidal current applied to leg for about a month. Is very much improved; leg much stronger.

The remarkable physiological properties of the sinusoidal current, and the surprising and most gratifying therapeutic results obtained from its use by those who have had an opportunity to observe its effects, give abundant grounds for the belief that it will ultimately take foremost rank among the several forms of electrical current which may be employed for therapeutic purposes. Apostoli, Gautier, Larat, and other eminent Parisian physicians, together with Morton, Landon Carter Gray, and other specialists of New York City, have pronounced themselves strongly in favor of this form of electrical current, and the leading specialist of nerve disorders in Chicago remarked to the writer a few days ago, after testing in his own person the physiological properties of the sinusoidal current, "I am convinced that this is the coming current in medicine. It is certainly destined to take the place of the faradic, and probably to a large extent also the ~~xxxxxxx~~ static electrical current." After more than 20,000 therapeutic applications of this current, the writer feels thoroughly convinced that it is capable of accomplishing more good in the treatment of disease than any other form of electrical current, and it has been the purpose of this paper simply to bring further before the

notice of the profession the great value of a therapeutic agent which is as yet but little known.

THE PHYSIOLOGICAL and THERAPEUTIC PROPERTIES of the SINUSOIDAL ELECTRICAL CURRENT.

As the term Sinusoidal, applied to electrical currents, may be new to many of those who listen to this paper, a word of explanation with reference to the meaning and application of the word may be in order.

Eleven years ago, while investigating the currents afforded by various forms of electrical apparatus, including some not previously in use for medical purposes, the writer discovered a current possessed of peculiar properties, one of the most marked of which was the power of producing strong muscular contractions without pain. Attention was called to this current in a paper read before the American Medical Association at its annual meeting in 1888, and the subsequent year its properties were again described in a paper presented at the annual meeting of the American Association of Obstetricians and Gynecologists, and published in the transactions of the Association for 1889. Since that time the writer has published various papers upon the subject.

Three years ago, D'Arsonval, of Paris, discovered the same current, and found on making a graphic tracing of the current that it represented a true sinusoidal line; that is, a line the curves of which are such that the ordinates are proportional to the sines of the abscissa. From this circumstance D'Arsonval called the current Sinusoidal.

D'Arsonval described this current and made a public presentation of the graphic tracing obtained from it, in a paper read before the French Academy of Sciences, June 27, 1892. His paper was published in an early number of the Archives de Physiologie, on receiving which I at once recognized the identity of the current which he had discovered with that which I had discovered eight years previously, and had had in use during that time, and I at once set about employing means for obtaining a graphic representation of the current. By the aid of my electrician,

Mr. H. A. Dow, I constructed an Electrograph, by means of which the form of the curve produced by any alternating or fluctuating current may be graphically studied, and by obtaining a tracing from my apparatus, I was delighted to find that it corresponded exactly with that published by D'Arsonval, being a true sinusoidal curve. The form of this curve is shown in Fig. 12, Plate IV, of a paper read at the annual meeting of the American Electro-Therapeutic Association held in Chicago last year.

My observations of the properties of the current entirely confirm those of D'Arsonval, but, as stated in a paper recently read before the American Electro-Therapeutic Association at its annual meeting in New York City, I also noted other facts which he has not observed. I found that a current of high frequency may be so regulated as to produce powerful sensory effects, although producing neither muscular contraction nor pain, as when applied to the eye or the ear. In the paper above referred to I also stated that I had noted that by regulation of my apparatus I was able to produce most powerful although painless muscular contraction simultaneously with the alterations of the current as well as powerful tetanic but painless contractions by a different regulation of the apparatus. D'Arsonval's discovery was incomplete for the reason that he studied only one phase of the current, that of high tension with very small quantity. My discovery was incomplete for the reason that while I observed the peculiar effects of the current, both of high frequency and of low frequency with larger quantities than usual, I failed to discover the sinusoidal form of the curve produced by the current, not being at that time possessed of the necessary physical instruments for making such a study.

The sinusoidal current may be briefly described as a current which produces, when graphically represented, a curve perfectly sinuous in form, and differing widely from the ragged and abrupt curves produced by a faradic apparatus. The most characteristic effects of the sinusoidal

current are its peculiar sensory and motor effects. When applied to the head it produces a metallic taste and luminous flashes or flickerings; when applied over the ears, thumping sounds; when applied to the skin with sufficient intensity, a slight tingling sensation, and pain when a strong current is applied. When a current is received through electrodes held in the hands, a peculiar sensation of lightness or of great size is felt in the arms.

The motor effects differ according as the rate of alternation is slow or rapid. When the alternations are slow, or at a rate not exceeding 20 to 30 per second, the muscular contractions are clonic or distinct, occurring at each alternation of the current. When the rate is increased, the contraction becomes tetanic or continuous, although distinct pulsations corresponding with the alternations of the current can be felt until the rate of vibration becomes two or three thousand per minute. At 14,000 to 16,000 alternations per minute, and with an apparatus so constructed as to give a current of considerable quantity, effects somewhat akin to those obtained by a galvanic current are produced. I have also noticed a very decided anaesthetic effect with such a current. At a very high rate of speed, the current, when applied to the skin with sufficient strength, produces a pulling sensation. It is only possible to use the rapidly alternating current by the aid of a rheostat.

When applied to a degenerating muscle, the slow alternating current, with the machine so regulated as to give quantitative effects, acts with much more vigor than the ordinary induction current, resembling more closely the effects of the galvanic current. The sinusoidal current has the advantage over both the galvanic and the faradic currents, both of which currents it resembles in several effects, in the fact that there is not the destruction of tissue, and is far less painful when used for either motor or sensory effects.

I have made more than 20,000 applications of this current, fully half of which have been made for motor effects, and have often used it in such a manner as to produce violent muscular contractions, but I have never seen the application followed by muscular soreness, an effect which frequently follows the use of the faradic current. The reason for the peculiar motor effects of this apparatus, the excitation of strong muscular contractions without effecting the cutaneous nerves or nerves of ordinary sensation is doubtless (1) the sinusoidal character of the curve produced by it which represents the gradual and uniform increase of the current from zero to maximum and back to zero again, first in one direction and then in the other, and (2) the interesting fact developed by laboratory experiments in electro-physiology, that electrical applications produce a state of hyper-excitability in the region of the anode the instant the current ceases to flow. The consequence of this fact is that influence applied to a part which has the instant before been under anodic influence will produce more marked effects than under other circumstances on account of the hyper-excitability of the nerves produced by the influence of the anode. An alternating current thus necessarily acts more vigorously in exciting muscular contraction than the simple interruptions of the constant current. The painless muscular contractions produced by my apparatus, as compared with the faradic alternating current, is evidently the result of the fact that the greater quantity of current produces more decided polar effects.

From observations which I have made on ordinary magnetos, I am led to believe that the peculiar effects described by D'Arsonval as characteristic of the sinusoidal current, and the wide range of effects noticed by myself, are not absolutely confined to currents giving a true sinusoidal curve, but are possessed by other magneto-electric [redacted] currents in higher or lower degree, depending upon the nearness of the approach of the graphic representation of the current to a truly sinusoidal curve. The effects of alternating currents of great rapidity, that is

above 10,000 per second, do not require even this, for these effects are seen in the highest perfection in induction currents induced by sparks. The effects of the sinusoidal current of high rate of alternation is doubtless due to its approximation to such forces as light and heat in its nature, and those of slower alternations, less than 10,000 per second, to the regularity of the undulations and the proportions between quantity and potential. I must not forget to acknowledge that the last thought was suggested to me by Dr. Massey when I first called his attention to my appratus in the summer of 1886--some eight years ago.

I have not had the pleasure of seeing D'Arsonval's sinusoidal apparatus, but starting with the apparatus with which my first experiments were made, and which I have with me for exhibition, with some modifications, I have had a number of machines constructed for the purpose of overcoming certain difficulties which I have experienced in its use. I found it was purely a matter of accident by which the apparatus which I first employed was capable of giving a sinusoidal current; other machines apparently identical, gave currents which were not sinusoidal. It was only by a careful study of the machine with the assistance of my electrician, Mr. H. A. Dow, that I succeeded in determining the peculiarities in the construction of the machine which gave to the current produced by it a sinusoidal character, a characteristic which w as wholly unnecessary for the original purpose for which it was intended, and quite unknown to its constructors. The difficulties which are encountered in the construction of a sinusoidal machine are two:

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notice of the profession the great value of a therapeutic agent which is as yet but little known.

D'ARSONVAL'S MODIFICATIONS OF CURRENTS OF GREAT FREQUENCY.

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In the April number of The Archives de Physiologie (April, 1893), d'Arsonval, of Paris, published a note giving the results of extended researches which he has made upon the effects of rapidly alternating electrical currents. D'Arsonval first in 1838 called attention to the fact that if alternations of sufficient rapidity were passed through the body they would produce the most terrific effects if the frequency of the oscillations was lessened. At that time, however, the apparatus which he employed did not give alternations of sufficient frequency to absolutely suppress the phenomena of excitation. He has shown by his instruments that the intensity of the phenomena of excitation increases from twenty to thirty excitations per second, the number of waves required to tetanize a muscle to a point between 2500 and 5000 oscillations per second, after which a further increase in the rate of oscillation lessens the phenomena of excitation. The apparatus with which he previously experimented gave only 10,000 oscillations per second. He had, more recently, however, by combining his apparatus with that of Hertz's, succeeded in producing alternations at the rate of several billions per second. In his paper d'Arsonval described three different modes of producing alternating currents of great frequency.

1. The induction coil of Rhumkorff,
2. A gramme alternator,

5. The alternating discharge of the condenser static electrical machine.

The coil, d'Arsonval found unreliable, being incapable of giving more than 2,000 excitations per second in consequence of the time required for magnetization of the soft iron coil. The coil is also objectionable for the reason that the waves of magnetization differ from those produced by demagnetization, and the form of these waves continually changesas the number is increased or decreased.

The alternator employed by d'Arsonval was constructed in a peculiar manner; it consisted in a bobbin wound with insulated copper wire and furnished with cheeks half a meter in diameter. On the inside of these cheeks were placed 100 iron pins in pairs, of such length as to leave a space of one centimeter between the free ends. In this free space was placed a small circular bobbin of copper wire without iron, arranged in the form of a disk, and held in position so that by the rotation of the large body each pair of pins would be in succession brought opposite the small induction bobbin. By this arrangement a double simusoidal wave is produced, the energy of which can be graduated by increasing the current which excites the magnetic field, and the rate of which can Be modified by increasing or decreasing the speed of the rotation of the large bobbin. With this apparatus d'Arsonval has succeeded in producing 10,000 alternations per second. It will be noticed that in this alternator the induction current does not depend upon the magnetization or demagnetization of the iron. D'Arsonval states as the result of his experience that "It is necessary to reject completely all apparatus in which currents are produced by variations in the iron magnet."

The apparatus which d'Arsonval finally settled upon for producing rapid alternations was the discharge from a condenser connected with some high potential apparatus. This apparatus he describes as follows:--

"This is the method employed by Dr. Hertz to produce extremely rapid electrical undulations. The phenomena was discovered by Feddersen, and studied more than forty years ago by Helmholtz and Sir Wm. Thomson, who discovered the mathematical law relating to it, which is as follows: If a Leyden jar is discharged by means of conductors, two very different cases may present themselves, according to the relative value of the capacity (C) of the coefficient of self-induction (L), and of the resistance (R) of the system. If we find $R > \sqrt{\frac{4L}{C}}$, the discharge is continuous; in a contrary case, it is oscillatory. In the case of the oscillatory discharge, the oscillations are isochronous, and their amplitude decreases in a geometrical ratio. The movements of a liquid in communicating jars will represent what occurs with the Leyden jar. According to the resistance offered to the movement of the liquid, the surface of the liquid finds a position of equilibrium, slowly and without rising above the point of equilibrium, or there may be a series of oscillations with decreasing amplitude. The duration and number of oscillations may be measured by examining the discharge by means of a turning mirror. When the resistance is so slight as to be negligible, the duration of an oscillation is given by the formula of Thomson, $T = 2\pi\sqrt{LC}$.

"We may consequently give to T, values more definite by modifying L and C. Dr. Hertz has obtained one billionth of a second; and my friend, M. Potier, has been able to lower the oscillating period so as to give to the Leyden jar a musical sound perceptible to the ear. In my first experiments, I employed a Hertz vibrator. Later I employed the more powerful arrangement suggested by MM. Elihu-Thomson and Tesla.

In my recent researches I found great advantage in the exclusive employment of the following apparatus for which the experiments of M. Lodge have given me many suggestions: Let A A' (Fig. 1) represent the armatures of two Leyden jars arranged in cascade. The armatures are joined to an electrical apparatus of high potential (as a Holtz machine, Rhumkorff coil, or transformer). The external armatures B B' are joined together by a solenoid C C', composed of coarse copper wire making fifteen or twenty turns. Each time a spark passes betreen A A', an oscillating current of extreme energy is produced in the solenoid, so that by connecting its extremities, C C', a current is produced which may bring to a white light a strong incandescent lamp held between two persons, D D'. The spark which is obtained between C C' is much longer than that which passes between A A'. This is due to the fact that in the latter case the discharge of the external armature B B' occurs suddenly, while that of the internal armature A A' is slowly developed, the difference in potential between the poles increasing until the spark passes. In these conditions the position of the solenoid plays a secondary rôle, while its self-induction becomes preponderant. The effect of these sudden discharges is analogous to those facts in mechanics relating to the action of instantaneous forces. A piece of gun cotton placed upon a piece of steel burns slowly if lighted, but will brek the piece if made to explode by means of fulminate of mercury. The same amount of energy, however, has been set free in the two cases; but in the second the pressure generated by the gas is so intense that the resistance of air becomes comparable to that of steel.

It is the principle illustrated in the difference between the electrical pressure developed gradually in A A', and on the contrary, suddenly in C C'at the moment when the jar is discharged. If it is desired to increase the tension of the current, it is sufficient to introduce into the solenoid a bobbin with a large number of turns. This bobbin is placed in a tube of glass filled with oil (Fig. 3) which insulates it completely.

"Physiological Effects of Currents of Great Frequency.--We may utilize in two different ways the currents thus obtained: First, by passing them directly through the tissues; secondly, by placing the tissues on the interior of the solenoid without making any communication with it. In the second case, the tissues placed in the solenoid are the seat of induction currents of extreme energy. They act like conductors closed upon themselves, and are traversed by induced currents of great intensity. From a physiological point of view, the effects obtained are the same in the two cases, and are chiefly as follows:

First, no effect upon the general sensibility and muscular contractility. This is the most striking phenomenon. We have currents capable of burning to incandescence a series of electrical lamps. These lamps placed between two persons, D D'(Fig. 1), completing the circuit, are lighted without producing any sensorial impressions. The current is very strong. A little heat may be experienced at the points of ~~xxxx~~ entrance and exit of the current from the body. I have been able to pass through my body, currents of more than 8000 milliamperes, when currents of a quantity ten times less would be extremely dangerous

if the frequency in the place of being 500,000 to 1,000,000 per second were lowered to 100 persecond, the usual rate of alternating currents employed for medical purposes. There has been much anxiety for an explanation of these paradoxical results to which I first called attention in my lectures at the College of France and at the Society of Biology. In my communication to the Society of Biology I suggested two hypotheses: 1. Whether these currents, on account of their enormous frequency, pass exclusively upon the surface of the body (it is well known that ordinary currents of great frequency do not penetrate but flow upon the surface of the conductor, as does static electricity); 2. Whether the sensory and motor nerves are organized to respond only to vibrations of determined frequency, as we see, for example, in the case of the optic nerve, the terminations of which are blind to the undulations of ether of a rate less than 427 billion (red), and greater than 728 billion per second (violet).

"The acoustic nerve is in the same situation as regards sonorous vibrations. Below and above certain vibratory periods, musical sounds no longer exist, and the ear remains insensible to these vibrations. The human body does not behave like a metallic conductor. Currents of great frequency, in the place of flowing on the surface of the body, penetrate into the body and influence nerve centers deeply situated, both directly and by producing induced currents. Whether these currents are direct or induced, the sum total of the energy which traverses the body remains the same, and the result is the same in both cases. By employing a current of great frequency, the body is traversed without showing any reaction by currents, the energy of which would destroy

it if the frequency were lowered. We can explain this inconsciousness by the absence of excitations, or better still by supposing that these currents exercise upon nerve centers and muscles the remarkable special action studied by Brown-Sequard under the name of inhibition. Experiments in fact demonstrate in the most striking manner this inhibitory action of currents of great frequency, as we shall now show.

"1. The tissues traversed by these currents become rapidly less excitable to ordinary excitants. This diminution shows itself by a remarkable analgesic effect produced at the point where the current penetrates the body. This analgesic effect persists, according to the case and subject, from one to twenty minutes.

"2. The vaso-motor system is powerfully affected. If, for example, the mercurial manometer is placed in the parotid of a dog, the arterial pressure is observed to fall several centimeters under the influence of this form of electrization. We may observe the same phenomena in man by the aid of a sphygmograph. There is then manifest inhibition of the vaso-motor system aside from all conscious sensation. This fact proves that currents of great frequency penetrate deeply into the body, as I have stated above.

"3. Continue the currents a sufficiently long time in man, and the skin becomes reddened and is covered with perspiration, a natural consequence of the action of the current upon the vaso-motor centers. The same result is obtained by placing the subject upon an insulated stool in communication with one of the poles of the high potential bobbin (Fig. 2), the second pole being in communication with a metallic plate supported at a sufficient distance from it. The patient is thus sub-

mitted to the action of an oscillating electrical field.

"4. By submitting an entire animal to these currents, either directly or by placing it in the solenoid, we may observe an increase in the intensity of the respiratory combustion. The thermometer shows that there is no increase in the internal temperature. The excess of heat produced is lost by radiation and evaporation, as may be observed by placing the animal in one of the calorimeters which I have briefly described.

"5. To discern the action of these currents in a living cell, I have employed the yeast of beer, and in collaboration with M. Charrin I have studied the bacillus pyocyanic. These last researches will be the object of my next communication.

"The results which I have briefly ~~xxxxx~~ indicated, and those already obtained in clinical experiments, give me the hope that we possess in these various forms of electricity, important therapeutic resources."

In this paper d'Arsonval gives the credit of the discovery of rapid electrical undulation to Feddersen, and also states that this phenomenon was studied more than forty years ago by Helmholtz and Sir William Thompson. But no one seems to have made any practical use of this movement until it was discovered and practically utilized by Dr. William Morton in 1880, and by him made familiar to the profession of this country. Whatever credit may be due to Sir William Thompson, Helmholtz, and others, for their studies of rapidly alternating currents from a physical standpoint, Dr. Morton was clearly the first to acquaint

the profession with the physiological effects of these currents and to utilize them for medical purposes. D'Arsonval, Hertz, Tesla, and others, have, by means of special apparatus, succeeded in increasing the frequency of the undulations and producing currents of higher potential than that produced by the ordinary static machine; but, so far as I can see, these currents are not essentially different in character nor principle as regards the method of production from the current described by Dr. Morton in 1880, eight years before d'Arsonval discovered the peculiar painlessness of currents of extremely rapid oscillation.

I obtained, a few months ago, a d'Arsonval apparatus, and have made some interesting studies of the effects produced by it. I am also able to exhibit the machine itself and some of the interesting phenomena which it presents. In the experiments, the results of which I have tabulated, and shall give presently, I employed a large static machine constructed for me by Dr. H. E. White. The machine consists of six revolving glass plates, each forty five inches in diameter, and generates an enormous amount of static electricity. Under favorable conditions the entire air of the room in which the machine is placed (a room twenty feet square) is so charged, when the machine is in operation, that persons coming into the room at once observe the electrical effect. I am able, with this machine, to charge strongly a dozen persons at once standing upon an insulated platform. I find it extremely valuable in handling a large number of patients. I also obtain very marked and distinct effects from the electrical breeze and

insulation which, according to my experience with smaller apparatus, is not always very easy to observe. By means of this large machine, which I believe is the largest static machine ever constructed, I excite the d'Arsonval apparatus, employing the full power of the machine, the sparks from which are like rifle shots, and can be heard thirty or forty rods away from the building in which the machine is used.

The d'Arsonval apparatus enormously augments the energy of the current, and yet, when employing the full power of the static apparatus which I have described, the entire current after being passed through the d'Arsonval transformer can be received by electrodes and held in the hands and with not the slightest sensation. The great energy of the current is clearly shown by the fact that an electric lamp placed in the circuit is at once heated to incandescence and becomes luminous. The experiments which I have made with this apparatus have had the effect of determining the following points of interest:

1. The influence of the d'Arsonval current upon CO_2 elimination, and upon the circulation as shown by the increase or decrease of blood corpuscles. Winternitz has shown by his experiments with cold baths and exercise, that when the caliber of the peripheral vessels is increased there is a marked increase in the number of red and white blood corpuscles and a proportionate increase in haemoglobin. Any marked effect of the electrical current upon the peripheral circulation ought to be manifested in the same way.

2. The effects of the static positive and negative charges upon CO_2 elimination and the circulation, as compared with the effects of

the d'Arsonval current.

5. The effects of the Morton current upon CO_2 elimination and the peripheral circulation as compared with the d'Arsonval current.

These results may be summed up as follows:--

1. The d'Arsonval current was found to increase CO_2 elimination 16.7 per cent.

2. The static positive charge, applied with the cage, consisting of a wire coil included in a cylinder of paper, the patient being placed inside, increased CO_2 elimination 15.5 per cent.

3. The negative static charge, administered in the ordinary way, increased CO_2 elimination 10.9 per cent.

4. The induced static current, or so-called Morton current, applied to the patient by means of sponge electrodes held, one in each hand, increased CO_2 elimination 5.7 per cent.

5. The blood count was increased; the increase was not great, however, varying from 200,000 to 500,000 per cubic millimeter.

6. The chemical determinations in this investigation were made for me by Dr. Gorberg, of the Academic Department of the University of Michigan. The details of the experiments were carried out by my ~~Western~~ friends and colleagues, Drs. Paulson, Rand, and Burleigh, the latter of whom made the blood counts for me.

(Paper, dict. Sept. 21,'94.)

D'ARSONVAL'S MODIFICATIONS OF CURRENTS OF GREAT FREQUENCY.

X
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In the April number of The Archives de Physiologie (April, 1893) d'Arsonval, of Paris, publish a a note giving the results of extended researches which he has made upon the effects of rapid - ly alternating electrical currents. D'Arsonval first in 1888 called attention to the fact that if alternations of sufficient rapidity were passed through the body they would produce the most terrific effects if the frequency of the oscillations was lessened. At that time, however, the apparatus which he employed did not give alternations of sufficient frequency to absolutely suppress the phenomena of excitation. He has shown by his instruments that the intensity of the phenomena of excitation increases from twenty to thirty excitations per second, the number of waves required to tetanize a muscle to a point between 2500 and 3000 oscillations per second, after which a further increase in the rate of oscillation lessens the phenomena of excitation. The apparatus with which re previously experimented gave only 10,000 oscillations per second. He had, more recently, however, by combining his apparatus with the of Hertz's, succeeded in producing alternations at the rate of several billions per second. In his paper d'Arsonval described three different modes of producing alternating currents of great frequency.

1. The induction coil of Rhumkorff,

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The coil, d'Arsonval found unreliable, being incapable of giving more than 2,000 excitations per second in consequence of the time required for magnetization of the soft iron coil. The coil is also objectionable for the reason that the waves of magnetization differ from those produced by demagnetization, and the form of these waves continually change as the number is increased or decreased.

The alternator employed by d'Arsonval was constructed in a peculiar manner; it consisted in a bobbin wound with insulated copper wire and furnished with cheeks half a meter in diameter. On the inside of these cheeks were placed 100 iron pins in pairs, of such length as to leave a space of one centimeter between the free ends. In this free space was placed a small circular bobbin of copper wire without iron, arranged in the form of a disc, and held in position so that by the rotation of the large body each pair of pins would be in succession brought opposite the small induction bobbin. By this arrangement a double sinusoidal wave is produced, the energy of which can be graduated by increasing the current which excites the magnetic field, and the rate of which can be modified by increasing or decresing the speed of the rotation of the large bobbin. With this apparatus d'Arsonval has

succeeded in producing 10,000 alternations per second. It will be noticed that in this alternator the induction current does not depend upon the magnetization or demagnetization of the iron. D'Arsonval states as the result of his experience, that "It is necessary to reject completely all apparatus in which currents are produced by variations in an iron magnet."

The apparatus which d'Arsonval finally settled upon for producing rapid alternations was ~~one which~~ the discharge~~s~~ from ~~the~~ a condenser~~s~~ connected with some high potential apparatus. This apparatus he describes as follows: —

~~(Here insert pages [illegible])~~

This is the method employed by Dr. Hertz to produce extremely rapid electrical undulations. The phenomenon was discovered by Feddersen, and studied more than forty years ago by Helmholtz and Sir Wm. Thomson, who discovered tha mathematical law relating to it, which is as follows: If a Leyden jar is discharged by means of conductors, two very different cases may present themselves, according to the relative value of the capacity (C) of the coefficient of self-induction (L), and of the resistance (R) of the system. If we find $R > \sqrt{\frac{4L}{C}}$, the discharge is continuous; in a contrary case, it is oscillatory. In the case of the oscillatory discharge, the oscillations are isochronous, and their amplitude decreases in a geometrical ratio. The movements of a liquid in communicating jars will represent what occurs with the Leyden jar. According to the resistance offered to the movement of the liquid, the surface of the liquid finds a position of equilibrium, slowly and without rising above the point of equilibrium, or there may be a series of oscillations with decreasing amplitude. The duration and number of oscillations may be measured by examining the discharge by means of a turning mirror. When the resistance is so slight as to be negligible, the duration of an oscillation is given by the formula of Thomson, $T = 2\pi\sqrt{LC}$.

We may consequently give to T, values more definite by modifying L and C. Dr. Hertz has obtained one billionth of a second; and my friend, M. Potier, has been able to lower the oscillating period so as to give to the Leyden jar a musical

sound perceptible to the ear. In my first experiments, I employed a Hertz vibrator. Later I employed the more powerful arrangement suggested by MM. Elihu-Thomson and Tesla. In my recent researches I found great advantage in the exclusive employment of the following apparatus, of which the experiments of M. Lodge have given me many suggestions: Let A A′ (Fig. 1) represent the armatures of two Leyden jars arranged in cascade. The armatures are joined to an electrical apparatus of high potential (as a Holtz machine, Ruhmkorff coil, or transformer). The external armatures B B′ are joined together by a solenoid C C′, composed of coarse copper wire making fifteen or twenty turns. Each time a spark passes between A A′, an oscillating current of extreme energy is produced in the solenoid, so that by connecting its extremities, C C′, a current is produced which may bring to a white light a strong incandescent lamp held between two persons, D D′. The spark which is obtained between C C′ is much longer than that which passes between A A′. This is due to the fact that in the latter case the discharge of the external armature B B′ occurs suddenly, while that of the internal armature A A′ is slowly developed, the difference in potential between the poles increasing until the spark passes. In these conditions the position of the solenoid plays a secondary rôle, while its self-induction becomes preponderant. The effect of these sudden discharges is analogous to those facts in mechanics relating to the action of instantaneous forces. A piece of gun cotton placed upon a piece of steel burns slowly if lighted, but will break the

piece if made to explode by means of fulminate of mercury. The same amount of energy, however, has been set free in the two cases; but in the second the pressure generated by the gas is so intense that the resistance of air becomes comparable to that of steel. It is the principle illustrated in the difference between the electrical pressure developed gradually in A A′, and on the contrary, suddenly in C C′ at the moment when the jar is discharged. If it is desired to increase the tension of the current, it is sufficient to introduce into the solenoid a bobbin with a large number of turns. This bobbin is placed in a tube of glass filled with oil (Fig. 2) which insulates it completely.

// Physiological Effects of Currents of Great Frequency.-- We may utilize in two different ways the currents thus obtained: First, by passing them directly through the tissues; secondly, by placing the tissues on the interior of the solenoid without making any communication with it. In the second case, the tissues placed in the solenoid are the seat of induction currents of extreme energy. They act like conductors closed upon themselves, and are traversed by induced currents of great intensity. From a physiological point of view, the effects obtained are the same in the two cases, and are chiefly as follows: First, no effect upon the general sensibility and muscular contractility. This is the most striking phenomenon. We have currents capable of burning to incandescence a series of electrical lamps. These lamps placed between two persons, D D′ (Fig. 1), completing the circuit,

are lighted without producing any sensorial impressions. The current is very strong. A little heat may be experienced at the points of entrance and exit of the current from the body. I have been able to pass through my body, currents of more than 3000 milliamperes, when currents of a quantity ten times less would be extremely dangerous if the frequency in the place of being 500,000 to 1,000,000 per second were lowered to 100 per second, the usual rate of alternating currents employed for medical purposes. There has been much anxiety for an explanation of these paradoxical results to which I first called attention in my lectures at the College of France and at the Society of Biology. In my communication to the Society of Biology I suggested two hypotheses: 1. Whether these currents, on account of their enormous frequency, pass exclusively upon the surface of the body (it is well known that ordinary currents of great frequency do not penetrate but flow upon the surface of the conductor, as does static electricity); 2. Whether the sensory and motor nerves are organized to respond only to vibrations of determined frequency, as we see, for example, in the case of the optic nerve, the terminations of which are blind to the undulations of ether of a rate less than 497 billion (red), and greater than 728 billion per second (violet).

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conductor. Currents of great frequency, in the place of flowing on the surface of the body, penetrate into the body and influence nerve centers deeply situated, both directly and by producing induced currents. Whether these currents are direct or induced, the sum total of the energy which traverses the body remains the same, and the result is the same in both cases. By employing a current of great frequency, the body is traversed without showing any reaction by currents, the energy of which would destroy it if the frequency were lowered. We can explain this innocuousness by the absence of excitations, or better still by supposing that these currents exercise upon nerve centers and muscles the remarkable special action studied by Brown-Sequard under the name of inhibition. Experiments in fact demonstrate in the most striking manner this inhibitory action of currents of great frequency, as we shall now show.

1. The tissues traversed by these currents become rapidly less excitable to ordinary excitants. This diminution shows itself by a remarkable analgesic effect produced at the point where the current penetrates the body. This analgesic effect persists, according to the case and subject, from one to twenty minutes.

2. The vaso-motor system is powerfully affected. If, for example, the mercurial manometer is placed in the parotid of a dog, the arterial pressure is observed to fall several centimeters under the influence of this form of electrization. We may observe the same phenomena in man by the aid of a sphygmograph. There is then manifest inhibition of the vaso-motor system aside

from all conscious sensation. This fact proves that currents of great frequency penetrate deeply into the body, as I have stated above".

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possess in these various forms of electricity, important therapeutic resources. For many years I have studied the action of physical agents upon the phenomena of life, and I hope that these experiments will serve to show objectively that the alliance of science and physiology permit us today to establish a clearly defined science under the name of Biological Physics.

In this paper d'Arsonval gives the credit of the discovery of rapid electrical undulation to Feddersen, and also states that this phenomenon was studied more than forty years ago by Helmholtz and Sir William Thompson. ~~That Sir William Thompson studied this phenomenon is evident from the fact that he worked out the mathematical law by which the rate of rotation is controlled.~~ But no one seems to have made any practical use of this movement until it was discovered and practically utilized by Dr. William Morton in 1880 and made familiar to the profession of this country. Whatever credit may be due to Sir William Thompson, Helmholtz, and others, for their studies of rapidly alternating currents from a physical standpoint, Dr. Morton was clearly the first to present the ~~picture of the~~ physiological effects of these currents and to utilize them for medical purposes. D'Arsonval, Hertz, Tesla, and others, have, by means of special apparatus succeeded in increasing the frequency of the undulations and producing currents of higher potential than that produced by the ordinary static machine; but, so far as I can see, these currents are not essentially different in character nor different in principle as regards the method of production from the current described by Dr. Morton in 1880, eight years before d'Arsonval discovered the peculiar painlessness of currents of extremely rapid oscillation.

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The chemical determinations in this investigation were made for me by Dr. Gomberg, of the Academic Department of the University of Michigan. The details of the experiments were carried out by my friends and colleagues, Drs. Paulson, Rand, and Burleigh, the latter of whom made the blood counts for me.

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The apparatus which d'Arsonval finally settled upon for producing rapid alternations was the discharge from a condenser connected with some high potential apparatus. This apparatus he describes as follows:--

"This is the method employed by Dr. Hertz to produce extremely rapid electrical undulations. The phenomena was discovered by Feddersen, and studied more than forty years ago by Helmholtz and Sir Wm. Thomson, who discovered the mathematical law relating to it, which is as follows: If a Leyden jar is discharged by means of conductors, two very different cases may present themselves, according to the relative value of the capacity (C) of the coefficient of self-induction (L), and of the resistance (R) of the system. If we find $R > \sqrt{\frac{4L}{C}}$, the discharge is continuous; in a contrary case, it is oscillatory. In the case of the oscillatory discharge, the oscillations are isochronous, and their amplitude decreases in a geometrical ratio. The movements of a liquid in communicating jars will represent what occurs with the Leyden jar. According to the resistance offered to the movement of the liquid, the surface of the liquid finds a position of equilibrium, slowly and without rising above the point of equilibrium, or there may be a series of oscillations with decreasing amplitude. The duration and number of oscillations may be measured by examining the discharge by means of a turning mirror. When the resistance is so slight as to be negligible, the duration of an oscillation is given by the formula of Thomson, $T = 2\pi\sqrt{LC}$.

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In my recent researches I found great advantage in the exclusive employment of the following apparatus for which the experiments of H. Lodge have given me many suggestions: Let A A' (Fig. 1) represent the armatures of two Leyden jars arranged in cascade. The armatures are joined to an electrical apparatus of high potential (as a Holtz machine, Ruhmkorff coil, or transformer). The external armatures B B' are joined together by a solenoid C C', composed of coarse copper wire making fifteen or twenty turns. Each time a spark passes between A A', an oscillating current of extreme energy is produced in the solenoid, so that by connecting its extremities, C C', a current is produced which may bring to a white light a strong incandescent lamp held between two persons, D D'. The spark which is obtained between C C' is much longer than that which passes between A A'. This is due to the fact that in the latter case the discharge of the external armature B B' occurs suddenly, while that of the internal armature A A' is slowly developed, the difference in potential between the poles increasing until the spark passes. In these conditions the position of the solenoid plays a secondary rôle, while its self-induction becomes preponderant. The effect of these sudden discharges is analogous to those facts in mechanics relating to the action of instantaneous forces. A piece of gun cotton placed upon a piece of steel burns slowly if lighted, but will break the piece if made to explode by means of fulminate of mercury. The same amount of energy, however, has been set free in the two cases; but in the second the pressure generated by the gas is so intense that the resistance of air becomes comparable to that of steel.

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In this paper d'Arsonval gives the credit of the discovery of rapid electrical undulation to Feddersen, and also states that this phenomenon was studied more than forty years ago by Helmholtz and Sir William Thompson. But no one seems to have made any practical use of this movement until it was discovered and practically utilized by Dr. William Morton in 1880, and by him made familiar to the profession of this country. Whatever credit may be due to Sir William Thompson, Helmholtz, and others, for their studies of rapidly alternating currents from a physical standpoint, Dr. Morton was clearly the first to acquaint

the profession with the physiological effects of these currents and to utilize them for medical purposes. D'Arsonval, Hertz, Tesla, and others, have, by means of special apparatus, succeeded in increasing the frequency of the undulations and producing currents of higher potential than that produced by the ordinary static machine; but, so far as I can see, these currents are not essentially different in character nor principle as regards the method of production from the current described by Dr. Morton in 1880, eight years before d'Arsonval discovered the peculiar painlessness of currents of extremely rapid oscillation.

I obtained, a few months ago, a d'Arsonval induction apparatus, and have made some interesting studies of the effects produced by it. I am also able to exhibit the machine itself and some of the interesting phenomena which it presents. In the experiments, the results of which I have tabulated, and shall give presently, I employed a large static machine constructed for me by Dr. H. E. Waite. The machine consists of six revolving glass plates, each forty five inches in diameter, and generates an enormous amount of static electricity. Under favorable conditions the entire air of the room in which the machine is placed (a room twenty feet square) is so charged, when the machine is in operation, that persons coming into the room at once observe the electrical effect. I am able, with this machine, to charge strongly a dozen persons at once standing upon an insulated platform. I find it extremely valuable in handlinga large number of patients. I also obtain very marked and distinct effects from the electrical breeze and

insulation which, according to my experience with smaller apparatus, is not always very easy to observe. By means of this large machine, which I believe is the largest static machine ever constructed, I excite the d'Arsonval apparatus, employing the full power of the machine, the sparks from which are like rifle shots, and can be heard thirty or forty rods away from the building in which the machine is used.

The d'Arsonval apparatus enormously augments the energy of the current, and yet, when employing the full power of the static apparatus which I have described, the entire current after being passed through the d'Arsonval transformer can be received by electrodes and held in the hands and with not the slightest sensation. The great energy of the current is clearly shown by the fact that an electric lamp placed in the circuit is at once heated to incandescence and becomes luminous. The experiments which I have made with this apparatus have had the effect of determining the following points of interest:

1. The influence of the d'Arsonval current upon CO_2 elimination, and upon the circulation as shown by the increase or decrease of blood corpuscles. Winternitz has shown by his experiments with cold baths and exercise, that when the caliber of the peripheral vessels is increased there is a marked increase in the number of red and white blood corpuscles and a proportionate increase in haemoglobin. Any marked effect of the electrical current upon the peripheral circulation ought to be manifested in the same way.

2. The effects of the static positive and negative charges upon CO_2 elimination and the circulation, as compared with the effects of

the d'Arsonval current.

5. The effects of the Norton current upon CO_2 elimination and the peripheral circulation as compared with the d'Arsonval current.

These results may be summed up as follows:-

1. The d'Arsonval current was found to increase CO_2 elimination 16.7 per cent.

2. The static positive charge, applied with the cage, consisting of a wire coil included in a cylinder of paper, the patient being placed inside, increased CO_2 elimination 15.5 per cent.

3, The negative static charge, administered in the ordinary way, increased CO_2 elimination 10.9 per cent.

4, The induced static current, or so-called Norton current, applied to the patient by means of sponge electrodes held, one in each hand, increased CO_2 elimination 3,7 per cent.

5, The blood count was increased; the increase was not great, however, varying from 200,000 to 500,000 per cubic millimeter.

The chemical determinations in this investigation were made for me by Prof. Comberg, of the Academic Department of the University of Michigan. The details of the experiments were carried out by my ~~friends~~ friends and colleagues, Drs. Paulson, Rand, and Burleigh, the latter of whom made the blood counts for me.

T H E S I N U S O I D A L C U R R E N T .

I have been acquainted with the peculiar electrical current to which d'Arsonval has applied the term "sinusoidal" for something more than eleven years, having first discovered the current in the summer of 1883, since which time I have had it in constant use. As previously stated before this society, I first described this current in a paper read before the American Medical Association at its annual meeting in 1888, at which time I had as stated had the current in medical use for five years. In 1889 I again described this current in a paper read before the American Association of Obstetriticians and Gynecologists.

D'Arsonval discovered this current nine years after my first use of it and described it in a paper read before the French Academy of Sciences at its session June 27, 1892. D'Arsonval observed that currents having a considerable degree of intensity could be passed through the body without producing pain or muscular contraction or chemical change. He also observed that by increasing the frequency of the alternations muscular contraction could be produced, but that the contractions thus produced were, as he states, "infinitely less painful for equal intensity than when the induction coil is used." My observations of the properties of the current entirely confirmed those of d'Arsonval, but I also noted other facts which he did not observe: I found that a current of high frequency might be so regulated as to produce powerful sensory effects, although producing neither muscular

contraction nor pain. I also noted that by regulation of my apparatus I was able to produce most powerful although painless muscular contraction simultaneously with the alternations of the current as well as powerful tetanic but painless contractions by a different regulation of the apparatus. D'Arsonval's discovery was incomplete for the reason that he studied only one phase of the current, that of high tension with very small quantity. My discovery was incomplete, for the reason that while I observed the peculiar effects of current, both of high frequency and of low frequency with larger quantities than usual I failed to discover the sinusoidal form of the curve produced by the current, not being at that time possessed of the necessary physical instruments for making such a study.

The sinusoidal current may be briefly described as a current which produces, when graphically represented, a curve perfectly sinuous in form, and differing widely from the ragged and abrupt curves produced by a faradic apparatus. The most characteristic effects of the sinusoidal current are its peculiar sensory and motor effects. When applied to the head it produces a metallic taste and luminous flashes or flickerings; when applied over the ears; thumping sounds; when applied to the skin with sufficient intensity, a slight tingling sensation and pain when a strong current is applied. When a current is received through electrodes held in the hands, a peculiar sensation of lightness or of great size is felt in the arms.

The motor effects differ according as the rate of alterna-

tion is slow or rapid. When the alternations are slow or at a rate not exceeding 10-20 per second, the muscular contractions are clonic or distinct, occurring at each alternation of the current. When the rate is increased, the contraction becomes tetanic or continuous, although distinct pulsations corresponding with the alternations of the current can be felt until the rate of vibration becomes two or three thousand per minute. At 14,000 to 16,000 alternations per minute, and with an apparatus so constructed as to give a current of considerable quantity, effects somewhat akin to those obtained by a galvanic current are produced. I have also noticed a very decided anaesthetic effect with such a current. At a very high rate of speed, the current, when applied to the skin with sufficient strength produces a pulling sensation. It is only possible to use the rapidly alternating current by the aid of a rheostat.

When applied to a degenerating muscle the slowly alternating current, with the machine so regulated as to give quantitative effects, acts with much more vigor than the ordinary induction current, resembling more closely the effects of the galvanic current. The sinusoidal current has the advantage over both the galvanic and the faradic currents, both of which currents it resembles in several effects,--in fact there is not the destruction of tissue, and is far less painful when used for either motor or sensory effects.

I have made more than 20,000 applications of this current, fully half of which have been made for motor effects, and have often used it in such a manner as to produce violent muscular con-

tractions, but I have never seen the application followed by muscular soreness, an effect which frequently follows the use of the faradic current. The reason for the peculiar motor effects of this apparatus, the excitation o strong muscular contractions without effecting the cutaneous nerves or nerves of ordinary sensation, is doubtless (1) the sinusoidal character of the curve produced by it which represents the gradual and uniform increase of the current from zero to maximum and back to zero again, first in one direction and then in the other, and (2) the interesting fact developed by laboratory experiments in electro-physiology, that electrical applications produce a state of hyper-excitability in the region of the anode the instant the current ceases to flow. The consequence of this fact is that influence applied to a part which has the instant before been under anodic influence will produce more marked effects than under other circumstances on account of the hyper-excitability of the nerves produced by the influence of the anode. An alternating current thus necessarily acts more vigorously in exciting muscular contraction than the simple interruptions of the constant current. The painless muscular contractions produced by my apparatus, as compared with the faradic alternating current is evidently the result of the fact that the greater quantity of current produces more decided polar effects.

From observations whcih I have made on ordinary magnetos, I am led to believe that the peculiar effects described by d'Arsonval as characteristic of the sinusoidal current, and the wide range

of effects noticed by myself, are not absolutely confined to currents giving a true sinusoidal curve, but are possessed by other magneto-electric currents in higher or lower degree, depending upon the nearness of the approach of the graphic representation of the current to a truly sinusoidal curve. The effects of alternating currents of great rapidity, that is above 10,000 per second, do not require even this, for these effects are seen in the highest perfection in induction currents induced by sparks. The effects of the sinusoidal current of high rate of alternation is doubtless due to its approximation to such forces as light and heat in its nature, and those of slower alternations, less than 10,000 per second, and to the regularity of the undulations. It is possible also that this quality may be due to the proportions between quantity and potential. I must not forget to acknowledge that the last thought was suggested to me by Dr. Massey when I first called his attention to my apparatus in the summer of 1886--some eight years ago.

I have not had the pleasure of seeing d'Arsonval's sinusoidal apparatus, but, starting with the apparatus with which my first experiments were made, and which I have with me for exhibition, with some slight modifications, I have had a number of machines constructed for the purpose of overcoming certain difficulties which I have experienced in its use. I found it was purely a matter of accident that the apparatus which I first employed was capable of giving a sinusoidal current; other machines, apparently identical, gave currents which were not sinusoidal. It was only by a careful study of the machine with the assistance of my

electrician, Mr. H. A. Dow, that I succeeded in determining the peculiarities in the construction of the machine which gave to the current produced by it a sinisoidal character, a characteristic which was wholly unnecessary for the original purpose for which it was intended, and quite unknown to its constructors. The difficulties which are encountered in the construction of a sinusoidl machine are two:

1. To secure perfect uniformity in the current; in other words, a perfect sinusoidal curve when graphically represented. I have with me an ordinary magneto, the curve produced by which is shown on the tracing which I will pass around. I have also a machine which I have had constructed by an expert electrician who had for a copy one of my ~~skxxxx~~ sinusoidal machines which, by painstaking effort on the part of my electrician, had been made to give a perfectly sinusoidal current. As will be seen by the tracing which I exhibit herewith, the current produced by this machine, though nearly sinusoidal, is not absolutely so. I think it impossible to construct these machines so as to give perfectly sinusoidal currents without testing the character of the curve without the use of some graphic means of representing the current produced by them.

2. The second difficulty encountered, was, to make a machine capable of producing not only the peculiar sensory and motor effects characteristic of the current of high alternation, but also possessed of sufficient quantity to give the desired motor effects with slow alternation, one of the most important uses of the machine. For a long time I was compelled to use two

different machines for producing these effects, but finally succeeded in producing a single machine capable of producing the whole range of effects. A special difficulty encountered with this machine was in the control of a current by means of ordinary rheostats. When run at a high rate of speed the electro-motor force of the current produced by one of these machines is so great that it cannot be properly controlled by any of the ordinary rheostats. In the use of any of the different forms of water rheostats, the instant the water is touched the amount of current transmitted is too great, leaving no room for regulation. I have only found it possible to use such a rheostat by using a thread for making contact with water.

In my experiments for the purpose of finding a convenient means for controlling the machine I devised a sponge rheostat which I find very useful, and which I also find a valuable means for controlling the current from an ordinary faradic battery, for which purpose it works admirably. The device has the advantage of being cheap as well as simple; it cannot get out of order and the resistance can be increased or diminished by making the sponge very dry or quite moist, or by adding salt to the water with which it is moistened. I finally hit upon the idea of controlling the apparatus by means of a converter. Accordingly I had a suitable one constructed, which I herewith exhibit. This answers the purpose perfectly, and renders it possible also to either increase or diminish the tension of the current at will, either by using the outer or ~~xxhasx~~ inner coil for the exciting

field, as may be desired. Recently, however, I have adopted still another method for modifying the current, which I find exceedingly satisfactory. This method consists in dividing the armature into two segments. In the machine which I exhibit, the wire of the first segment gives a resistance of 140 ohms; that of the whole armature being 1100 ohms. By using the shorter segment of the armature the quantity of the current is cut down to such a degree that the most rapid alternations may be employed without rendering the current so strong that it cannot be easily controlled.

Therapeutic Effects.-- I find the sinusoidal current of great practical value in the treatment of all forms of parasthesias, in neuralgia, in hyperaesthesias of all sorts especially; it is of great value in the treatment of headaches, and for neurasthenic pains of various sorts. In ovarian and other forms of irritation I have found it of far greater value than either the faradic or galvanic current which I have used very extensively for the last twenty years, making, with the aid of my assistants, from fifty to twice as many applications daily.

The motor effects obtainable from this machine are even more useful, if possible, than the sensory effects, although not so immediately apparent. It is certainly one of the most convenient of all the methods of applying gymnastics to a weak muscle or muscular group. I find it especially valuable in the treatment of spinal curvatures due to weakness of the trunk muscles, the application being generally made to the paretic or paralyzed parts. The readiness with which the motor effects of the current may be localized are well illustrated in its applica-

tion. An ordinary electrode may be applied to the hand in such a way as to cause either finger desired to move alternately in a sidewise fashion by action of the interossei, keeping time with the alternations of the current. Two electrodes held in the hands produce a similar alternating movement of the muscles of the forearm.

In the use of this current I continually encounter new and interesting effects which are characteristic of it, and which suggest new and valuable therapeutic applications. It certainly is not a substitute for either the galvanic or the static currents, but I think it may well replace almost altogether, the faradic current, which is in every way inferior to it.

I have employed different forms of currents,--the faradic current, the galvanic current, the slowly interrupted galvanic current, the galvanic and faradic currents combined, and the dynamic current. The latter, which is supplied by a small machine giving a reversing current, I have found the most effective of all means of stimulating contraction in the muscular structures which support the uterus. When one electrode is placed upon the abdomen and the other in the vagina, energetic and painless contractions are produced in the abdominal muscles. These contractions occur at every reversal of the current, so that this current not only has the effect to stimulate nutritive changes in the diseased structures, but also affords a most valuable means of securing functional activity in idle and relaxed parts, thus giving them the benefit of a genuine gymnastic exercise. The

therapeutic results following the use of this current, justify me in claiming for it a decided superiority over any other form of electrical current for this purpose. I have used this current for medical purposes for the last five years.

Report of Cases who have taken the Sinusoidal Current.

Mrs. Swigert, suffering with severe nervous headache. Could not sleep. Relieved by one application of the S. R. Has not had a return of trouble, although this was several weeks ago.

Mrs. Moorehouse, had paralysis of the left side nineteen years ago, from which she had never fully recovered. Has had the S. R. applied three times a week for about a month or six weeks. She tells me the stiffness is gone from her leg and that it feels much lighter and she can walk much better than she has been able to for nineteen years. The arm has also lost the feeling of heaviness and stiffness. Calls herself so well she wants to stop treatment.

Miss Chilton says she is greatly relieved from profuse leucorrhoea which she thinks was largely due to the local application of S. R.

We have had a great many people suffering with pelvic pains, both acute and chronic, relieved by this current, some of them at once and others in a longer time. Many cases in the use of S. R. I have noticed the development of the abdominal muscles. (It is difficult to determine just whether it was the electricity

gymnastics, or their manual treatment that caused the development of the muscles, but I suppose it was due to all).

Mrs. Keller, suffering with long-standing pain in the face and jaws extending up into the ears. Has been entirely relieved by the local application of the S. R.

Mrs. Kent, suffering from nervous headache and pain in the back of neck. Although she has had but three applications already feels relieved.

Mrs. Bowman, suffering from chronic nervous headache. Has been much relieved. She has also taken it for pelvic troubles from which she is much improved.

Mrs. Eberling, taking the local application for pelvic troubles. Is improving steadily.

Mrs. Hurd has been running down and growing weaker for some time. Right leg especially gets weak when she walks. Has had the sinusoidal current applied to leg for about a month. Is very much improved; leg much stronger.

The following cases are illustrative of the good effects which may be obtained from the application of the sinusoidal current:

Case 1.--Mrs. S., a lady 55 years of age, had for several years been subject to severe attacks of nervous headache. On the occasion of one of these attacks, for which other remedies had failed to afford relief, the patient suffered extreme pain. The sinusoidal current was applied with the result that the

patient was very promptly relieved and soon fell asleep. Several months have elapsed and the patient has had no return of the difficulty.

Case 2.--Mrs. M., had suffered a stroke of apoplexy resulting in paralysis of the left side some nineteen years previously; had never fully recovered from the attack. When patient came under our observation there was greatly dimfnished power in the left leg and a very uncomfortable feeling of stiffness and heaviness. Walking was considerably impeded. The strength of the left arm was also greatly diminished, and the seat of the same disagreeable sensations of heaviness and stiffness. For six weeks the sinusoidal current with rapid alternations was applied regularly three times a week. At the end of that time the strength of the affected limbs had very greatly improved; the sensations of stiffness and heaviness had entirely disappeared, and the patient pronounced herself well, although the strength of the affected side was not quite equal to the other.

Case 3.--Mrs. C had suffered for a long time from profuse leucorrhoeal discharge. The local application of the sinusoidal current with rapid alternations relieved the discharge entirely. Patient had vaginal douches at the same time, but felt confident that the sinusoidal current was most beneficial, for the reason that the douches had been used for a considerable time previously, but without permanently beneficial effects. The patient has continued to improve up to the present time, some six months since

treatment was discontinued.

Case 4.--Mrs. X., had for a long time suffered severely from pelvic pain, for which an operation for removal of the appendages had been performed but without affording the expected relief. Three weeks' treatment, during which the sinusoidal current was applied locally each day, completely relieved the patient.

Case 5.--Miss Y. aged 24, had suffered for a number of years,--in fact, almost from the beginning of her menstrual life--from ovarian neuralgia; the pain was most aggravated at each menstrual period; the patient was, however, never entirely free from pain. By the application of a rapidly alternating sinusoidal current every other day for a few weeks the chronic pain was entirely relieved. At the beginning of treatment the patient invariably came into the office suffering severely from pain, but was always promptly relieved by application of the current.

Case 6.--Mrs. K. had for several years suffered from severe pain in the face and jaws, extending into the ears. Daily application of the sinusoidal current for three or four weeks gave the patient entire relief.

Case 7.--Mrs. K. applied for relief from severe nervous headache accompanied by pain in the back of the neck. Patient was relieved by treatment, and three applications of the sinusoidal current rendered the relief permanent.

Case 8.--Mrs. B. This patient complained of chronic nervous

headache, the pain being constant; also suffered greatly from pelvic pain. Local application of the current to both the head and the pelvic region resulted in a complete cure, in the course of a month's treatment.

Case 9.--Mrs. S. had for a long time suffered from pain and peculiar paraesthesias of the pelvic viscera. Application of the sinusoidal current for a few weeks afforded most complete relief, and the patient has continued to improve since the application was discontinued.

Case 10.--Mrs. H., had suffered from general debility and anaemia. There was, especially, great weakness of the right leg, which was so great as to seriously interfere with walking. The sinusoidal current with slow interruptions was xxxxxxxxxx applied to the leg three times a week for one month. At the end of that time, the strength of the leg was very greatly improved and the patient so much relieved that further treatment was not considered necessary.

I have employed the sinusoidal current in more than 2000 cases, and have found it of such value that in my practice it has almost wholly replaced other forms of electricity, of which, for twenty years I have made extensive use, having been an office assistant and private pupil in Electro-Therapeutics of the late Geo. M. Beard, to whom the medical profession of this country are greatly indebted for the development of electro-therapeutics on this side of the Atlantic.

(Paper, Rec't. Sep. 1, '94.)

THE SINUSOIDAL CURRENT.

I have been acquainted with the peculiar electrical current to which d'Arsonval has applied the term "sinusoidal" for something more than eleven years, having first discovered the current in the summer of 1883, since which time I have had it in constant use. As previously stated before this society, I first described this current in a paper read before the American Medical Association at its annual meeting in 1888, at which time I stated ~~that I had~~ had had the current in medical use for five years. In 1889 I again described this current in a paper read before the American Association of Obstetriticians and Gynecologists.

D'Arsonval discovered this current nine years after my first use of it and described it in a paper read before the French Academy of Sciences at its session June 27, 1892. D'Arsonval observed that currents having a considerable degree of intensity could be passed through the body without producing pain or muscular contraction or chemical change. He also observed that by increasing the frequency of the alternations muscular contraction could be produced, but that the contractions thus produced were, as he states, "infinitely less painful for equal intensity than when the induction coil is used." My observations of the properties of the current entirely confirmed those of d'Arsonval, but I also noted other facts which he did not observe: I found that a current of high ~~intensity~~ frequency might be so regulated as to produce powerful

sensory effects ~~through exciting the optic nerve,~~ although producing neither muscular contraction, pain, ~~or chemical change~~. I also noted that by regulation of my apparatus I was able to produce most powerful although painless muscular contraction simultaneously with the alternations of the current as well as powerful tetanic but painless contractions by a different regulation of the apparatus. D'Arsonval's discovery was incomplete for the reason that he studied only one phase of the current, that of high tension with very small quantity. My discovery was incomplete, for the reason that while I observed the peculiar effects of currents, both of high ~~tension~~ frequency and of low ~~tension~~ frequency with larger quantities than usual, I failed to discover the sinusoidal form of the curve produced by the current, not being at that time possessed of the necessary physical instruments for making such a study.

The sinusoidal current may be briefly described as a current which produces, when graphically represented, a curve perfectly sinuous in form, and differing widely from the ragged and abrupt curves produced by a faradic apparatus. The most characteristic effects of the sinusoidal current are its peculiar sensory and motor effects. When applied to the head it produces a metallic taste, ~~numerous~~ and brilliant flashes or flickerings, when applied over the eyes, thumping sounds, when applied to the skin with sufficient intensity, a slight tingling sensation and pain when a strong current is applied. When a current is received through electrodes held in the hands, a peculiar sensation of lightness or of great size is

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felt in the arms. 9 The motor effects differ according as the rate of alternation is slow or rapid. When the alternations are slow or at a rate not exceeding 10-20 per second, the muscular contractions are clonic or distinct, occurring at each alternation of the current. When the rate is increased, the contraction becomes tetanic or continuous, although distinct pulsations corresponding with the alternations of the current can be felt until the rate of vibration becomes two or three thousand per minute. At 14,000 to 16,000 alternations per minute, and with an apparatus so constructed as to give a current of considerable quantity, effects somewhat akin to those obtained by a galvanic current are produced. I have also noticed a very decided anaesthetic effect with such a current. At a very high rate of speed, the current, when applied to the skin with sufficient strength produces a pulling sensation. It is only possible to use the rapidly alternating current by the aid of a rheostat.

When applied to a degenerating muscle the slowly alternating current, with the machine so regulated as to give quantitative effects, acts with much more vigor than the ordinary induction current, resembling more closely the effects of the galvanic current. The sinusoidal current has the advantage of both the galvanic and the faradic currents, both of which currents it resembles in several effects,--in fact there is not the destruction of tissue, and is far less painful than when used for either motor or sensory effects.

I have made more than 20,000 applications of this current,

fully half of which have been made for motor effects, and have often used it in such a manner as to produce violent muscular contractions, but I have never seen the application followed by muscular soreness, an effect which frequently follows the use of the faradic current. The reason for the peculiar motor effects of this apparatus, the excitation of strong muscular contractions without effecting the cutaneous nerves or nerves of ordinary sensation, is doubtless due, (Fig. 1) to the sinusidal character of the curve produced by it which represents the gradual and uniform increase of the current from zero to maximum and back to zero again, first in one direction and then in the other, and (Fig. 2) to the interesting fact developed by laboratory experiments in electrophysiology, that electrical applications produces a state of hyper-excitability in the region of the anode the instant the current ceases to flow. The consequence of this fact is that catalytic influence applied to the part which has the instant before been under anodic influence will produce more marked effects than under circumstances on account of the hyper-excitability of the nerves which had been under the influence of the anode. An alternating current thus necessarily acts more vigorously in exciting muscular contraction than the simple interruptions of the muscular current. The painless muscular contractions produced by y sinusoidal apparatus, as compared with the faradic alternating current is evidently the result of the fact that the greater quantity of current produces more decided polar effects.

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From observations which I have made on ordinary magnetos, I am led to believe that the peculiar effects described by D'Arsonval as characteristic of the sinusoidal current, and the wide range of effects noticed by myself, are not absolutely confined to currents giving a true sinusoidal curve, but are possessed by other magneto-electric currents in higher or lower degree, depending upon the nearness of the approach of the graphic representation of the current to a truly sinusoidal curve. The effects of ~~the~~ alternating currents of great rapidity, that is above 10,000 per second, do not require even this, for these effects are seen in the highest perfection in induction currents induced by sparks. The effects of the sinusoidal current of high rate of alternation is doubtless due to its approximation to such forces as light and heat in its nature, and those of slower alternations, less than 10,000 per second, and to the regularity of the undulations, and the proportions between quantity and potential. I must not forget to acknowledge that the last thought was suggested to me by Dr. Massey when I first called his attention to my apparatus in the summer of 1886--some eight years ago.

I have not had the pleasure of seeing d'Arsonval's sinusoidal apparatus, but, starting with the apparatus with which my first experiments were made, and which I have with me for exhibition, with some slight modifications, I have had a number of machines constructed for the purpose of overcoming certain difficulties which I have experienced in its use. I found it was purely a matter of accident by which, the apparatus which I first employed was capable of giving a sinusoidal current; other machines, apparently identical, gave currents which were not sinusoidal. It was only by a careful study of the machine with the assistance of my electrician, Mr. H. A. Dow, that I succeeded in determining the peculiarities in the construction of the machine which gave to the current produced by it a sinusoidal character, a characteristic which was wholly unnecessary for the original purpose for which it was intended, and quite unknown to its constructors. The difficulties which are encountered in the construction of a sinusoidal machine are two:

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though nearly sinusoidal, is not absolutely so. I think it impossible to construct these machines so as to give perfectly sinusoidal currents without testing the character of the curve without the use of some graphic means of representing the current produced by them.

2. The second difficulty encountered, was, to make a machine capable of producing not only the peculiar sensory and motor effects characteristic of the current of high alternation, but also possessed of sufficient quantity to give the desired motor effects with slow alternation, one of the most important uses of the machine. For a long time I was compelled to use two different machines for producing these effects, but finally succeeded in producing a single machine capable of producing the whole range of effects. A special difficulty encountered with this machine was in the control of a current by means of ordinary rheostats. When run at a high rate of speed the electro- motor force of the current produced by one of these machines is so great that it cannot be properly controlled by any of the ordinary rheostats. In the use of any of the different forms of water rheostats, the instant the water is touched the amount of current transmitted is too great, leaving no room for regulation. I have only found it possible to use such a rheostat by using a thread for making contact with water.

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means for controlling the machine I devised a sponge rheostat which I fim, ~~quite convenient~~ very useful, and which I also find a valuable means for controlling the current from an ordinary faradic battery, for which purpose it works admirably. The device has the advantage of being cheap as well as simple; it cannot get out of order and the resistance can be increased or diminished by making the sponge very dry or quite moist, or by adding salt to the water with which it is moistened. I finally hit upon the idea of controlling the apparatus by means of a converter. Accordingly I had a suitable one constructed, which I herewith exhibit. This answers the purpose perfectly, and renders it possible also to either increase or diminish the tension of the current at will, either by using the outer or inner coil for the exciting field, as may be desired. Recently, however, I have adopted still another method for modifying the current, which I find exceedingly satisfactory. This method consists in dividing the armature into two segments. In the machine which I exhibit, the wire of the first segment gives a ~~the~~ resistance of 140 ohms; that of the whole armature being 1100 ohms. By using the shorter segment of the armature the quantity of the current is cut down to such a degree that the most rapid alternations may be employed without rendering the current so strong that it cannot be easily controlled.

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Therapeutic Effects.--I find the sinusoidal current of great practical value in the treatment of all forms of parasthesias, in neuralgia, in

Mechanical Effects.

-2-

hyperaesthesias of all sorts especially; it is of great value in the treatment of headaches, and for neurasthenic pains of various sorts. In ovarian and other forms of irritation I have found it of far greater value than either the faradic or galvanic current which I have used very extensively for the last twenty years, making, with the aid of my assistants, from five to twice as many applications daily.

The motor effects obtainable from this machine are even more useful, if possible, than the sensory effects, although not so immediately apparent. It is certainly one of the most convenient of all the methods of applying gymnastics to a weak muscle or muscular group. I find it especially valuable in the treatment of spinal curvatures due to weakness of the ~~abdominal~~ trunk muscles, the application being generally made to the paretic or paralyzed parts. The readiness with which the motor effects of the current may be localized are well illustrated in its application. An ordinary electrode may be applied to the hand in such a way as to cause either finger desired to move alternately in a sidewise fashion, keeping time with the alternations of the current, ~~the current in one direction causing contraction of the finger-muscle concerned, the opposite current causing contraction of the muscle in such a way as to move the finger in the opposite direction.~~ Two electrodes held in the hands produce a similar alternating movement of the ~~flexor~~ muscles of the forearm.

by action of the interossei.

In the use of this current I continually encounter new and interesting effects which are characteristic of it, and which suggest new and valuable therapeutic applications. It certainly is not a substitute for either the galvanic or the static currents, but I think it may well replace, almost altogether, the faradic current, which ~~seems to me to be~~ is in every way inferior to it.

I have employed different forms of currents,--the faradic current, the galvanic current, the slowly interrupted galvanic current, the galvanic and faradic currents combined, and the dynamic current. The latter, which is supplied by a small machine giving a reversing current, I have found the most effective of all means of stimulating contraction in the muscular structures which support the uterus. When one electrode is placed upon the abdomen and the other in the vagina, energetic and painless contractions are produced in the abdominal muscles. These contractions occur at every reversal of the current, so that this current not only has the effect to stimulate nutritive changes in the diseased structures, but also affords a most valuable means of securing functional activity in idle and relaxedparts, thus giving them the benefit of a genuine gymnastic exercise. The therapeutic results following the use of this current, justify me in claiming for it a decided superiority over any other form of electrical current for this purpose. I have used this current for medical purposes for the last five years.

May 1888, Am. Med. Assoc.

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Report of Cases who have taken the Simusoidal Current.

Mrs. Swigert, suffering with severe nervous headache. Could not sleep. Relieved by one application of the S. R. Has not had a return of trouble, although this was several weeks ago.

Mrs. Moorehouse, had paralysis of the left side nineteen years ago, from which she had never fully recovered. Has had the S. R. applied three times a week for about a month or six weeks. She tells me that the stiffness is gone from her leg and that it feels much lighter and she can walk much better than she has been able to for nineteen years. The arm has also lost the feeling of heaviness and stiffness. Calls herself so well she wants to stop treatment.

Miss Chilton says she is greatly relieved from profuse leucorrhoea which she thinks was largely due to the local application of S. R.

We have had a great many people suffering with pelvic pains, both acute and chronic, relieved by this current, some of them at once and others in a longer time. Many cases in the use of S. S. I have noticed the development of the abdominal muscles. (It is difficult to determine just whether it was the electricity, gymnastics, or their manual treatment that caused the development of the muscles, but I suppose it was due to all.)

Mrs. Kellar, suffering with long-standing pain in the face and jaws extending up into the ears. Has been entirely relieved by the local application of the S. R..

Mrs. Kent, suffering from nervous headache and pain in the back

13.

of neck. Although she has had but three applications already feels relieved.

Mrs. Bowman, suffering from chronic nervous headache. Has been much relieved. She has also taken it for pelvic troubles from which she is much improved.

Mrs. Eberling, taking the local application for pelvis troubles. Is improving steadily.

Mrs. Hurd has been running down andgrowing weaker for some time. Right leg especially gets weak when she walks. Has had the sinusoidal current applied to leg for about a month. Is very much improved; leg much stronger.

The following cases are illustrative of the good effects which may be obtained from the application of the sinusoidal current:

Case 1.--Mrs. S., a lady 53 years of age, had for several years been subject to severe attacks of nervous headache. On the occasion of one of these attacks, for which other remedies had failed to afford relief, the patient suffered extreme pain. The sinusoidal current was applied with the result that the patient was very promptly relieved and soon fell asleep. Several months have elapsed and the patient has had no return of the difficulty.

Case 2.--Mrs. M., had suffered a stroke of apoplexy resulting in paralysis of the left side some nineteen years previously; had never fully recovered from the attack . When patient came under our observation there was greatly diminished power in the left leg and a very uncomfortable feeling of stiffness and heaviness, ~~and heaviness.~~ Walking was considerably impeded. The strength of the left arm was also greatly diminished, and the seat of the same disagreeable sensations of heaviness and stiffness. For six weeks the sinusoidal current with rapid alternations was applied regularly three times a week. At the end of that time the strength of the affected limbs had very greatly improved; the sensations of stiffness and heaviness had entirely disappeared, and the patient pronounced herself well, although the strength of the affected side was not quite equal to the other .

Case 3.--Mrs.C had suffered for a long time from profuse leu-

corrhœal discharge. The local application of the sinusoidal current with rapid alternations relieved the discharge entirely. Patient had vaginal douches at the same time, but felt confident that the sinusoidal current was most beneficial, for the reason that the douches had been used for a considerable time previously, but without permanently beneficial effects. The patient has continued to improve up to the present time, some six months since treatment was discontinued.

Case 4.---Mrs. X. had for a long time suffered severely from pelvic pain, for which an operation for removal of the appendages had been performed but without affording the expected relief. Three weeks' treatment, during which the sinusoidal current was applied locally each day, completely relieved the patient.

Case 5.--Miss Y. aged 24, had suffered for a number of years,--in fact, almost from the beginning of her menstrual life--from ovarian neuralgia; the pain was most aggravated at each menstrual period; the patient was, however, never entirely free from pain. By the application of a rapidly alternating sinusoidal current every other day for a few weeks the chronic pain was entirely relieved. At the beginning of treatment the patient invariably came into the office suffering severely from pain, but was always promptly relieved by application of the current.

Case 6.---Mrs. K. Had for several years suffered from severe pain in the face and jaws, extending into the ears. Daily application of the sinusoidal current for three or four weeks gave the patient entire relief.

Case 7.-- Mrs. K.applied for relief from severe nervous headache accompanied by pain in the back of the neck. Patient was relieved by treatment,and three applications of the sinusoidal current rendered the relief permanent.

Case 7.--Mrs. B. This patient complained of chronic nervous headache, the pain being constant; also suffered greatly from pelvic pain. Local application of the current to both the head and the pelvic region resulted in a complete cure, in the course of a month's treatment .

Case 9.--Mrs. E.had for a long time suffered from pain and peculiar paræsthesias of the pelvic viscera. Application of the sinusoidal current for a few weeks afforded most complete relief, and the patient has continued to improve since the application was discontinued.

Case 10.--Mrs. H. had suffered from general debility and anaemia. There was, especially, great weakness of the right leg, which was so great as to seriously interfere with walking. The sinusoidal current with slow interruptions was applied to the leg three times a week for one month. At the end of that time, the strength of the leg was very greatly improved and the patient so much relieved that further treatment was not considered necessary.

I have employed the sinusoidal current in more than 2000 cases,and have found it of such value that in my practice it has almost wholly replaced other forms of electricity, of which, for twenty years I have made extensive use, having been an office

assistant and private pupil in Electro-Therapeutics of the late Geo. M. Beard, to whom the medical profession of this country are greatly indebted for the development of electro-therapeutics on this side of the Atlantic.

T H E S I N U S O I D A L C U R R E N T .

I have been acquainted with the peculiar electrical current to which d'Arsonval has applied the term "sinusoidal" for something more than eleven years, having first discovered the current in the summer of 1883, since which time I have had it in constant use. As previously stated before this society, I first described this current in a paper read before the American Medical Association at its annual meeting in 1888, at which time I had as stated had the current in medical use for five years. In 1889 I again described this current in a paper read before the American Association of Obstetriticians and Gynecologists.

D'Arsonval discovered this current nine years after my first use of it and described it in a paper read before the French Academy of Sciences at its session June 27, 1892. D'Arsonval observed that currents having a considerable degree of intensity could be passed through the body without producing pain or muscular contraction or chemical change. He also observed that by increasing the frequency of the alternations muscular contraction could be produced, but that the contractions thus produced were, as he states, "infinitely less painful for equal intensity than when the induction coil is used." My observations of the properties of the current entirely confirmed those of d'Arsonval, but I also noted other facts which he did not observe: I found that a current of high frequency might be so regulated as to produce powerful sensory effects, although producing neither muscular

contraction nor pain. I also noted that by regulation of my apparatus I was able to produce most powerful although painless muscular contraction simultaneously with the alternations of the current as well as powerful tetanic but painless contractions by a different regulation of the apparatus. D'Arsonval's discovery was incomplete for the reason that he studied only one phase of the current, that of high tension with very small quantity. My discovery was incomplete, for the reason that while I observed the peculiar effects of current, both of high frequency and of low frequency with larger quantities than usual I failed to discover the sinusoidal form of the curve produced by the current, not being at that time possessed of the necessary physical instruments for making such a study.

The sinusoidal current may be briefly described as a current which produces, when graphically represented, a curve perfectly sinuous in form, and differing widely from the ragged and abrupt curves produced by a faradic apparatus. The most characteristic effects of the sinusoidal current are its peculiar sensory and motor effects. When applied to the head it produces a metallic taste and luminous flashes or flickerings; when applied over the ears; thumping sounds; when applied to the skin with sufficient intensity, a slight tingling sensation and pain when a strong current is applied. When a current is received through electrodes held in the hands, a peculiar sensation of lightness or of great size is felt in the arms.

The motor effects differ according as the rate of alterna-

tion is slow or rapid. When the alternations are slow or at a rate not exceeding 10-20 per second, the muscular contractions are clonic or distinct, occurring at each alternation of the current. When the rate is increased, the contraction becomes tetanic or continuous, although distinct pulsations corresponding with the alternations of the current can be felt until the rate of vibration becomes two or three thousand per minute. At 14,000 to 16,000 alternations per minute, and with an apparatus so constructed as to give a current of considerable quantity, effects somewhat akin to those obtained by a galvanic current are produced. I have also noticed a very decided anaesthetic effect with such a current. At a very high rate of speed, the current, when applied to the skin with sufficient strength produces a pulling sensation. It is only possible to use the rapidly alternating current by the aid of a rheostat.

When applied to a degenerating muscle the slowly alternating current, with the machine so regulated as to give quantitative effects, acts with much more vigor than the ordinary induction current, resembling more closely the effects of the galvanic current. The sinusoidal current has the advantage over both the galvanic and the faradic currents, both of which currents it resembles in several effects,--in fact there is not the destruction of tissue, and is far less painful when used for either motor or sensory effects.

I have made more than 20,000 applications of this current, fully half of which have been made for motor effects, and have often used it in such a manner as to produce violent muscular con-

tractions, but I have never seen the application followed by muscular soreness, an effect which frequently follows the use of the faradic current. The reason for the peculiar motor effects of this apparatus, the excitation of strong muscular contractions without effecting the cutaneous nerves or nerves of ordinary sensation, is doubtless (1) the sinusoidal character of the curve produced by it which represents the gradual and uniform increase of the current from zero to maximum and back to zero again, first in one direction and then in the other, and (2) the interesting fact developed by laboratory experiments in electro-physiology, that electrical applications produce a state of hyper-excitability in the region of the anode the instant the current ceases to flow. The consequence of this fact is that influence applied to a part which has the instant before been under anodic influence will produce more marked effects than under other circumstances on account of the hyper-excitability of the nerves produced by the influence of the anode. An alternating current thus necessarily acts more vigorously in exciting muscular contraction than the simple interruptions of the constant current. The painless muscular contractions produced by my apparatus, as compared with the faradic alternating current is evidently the result of the fact that the greater quantity of current produces more decided polar effects.

From observations which I have made on ordinary magnetos, I am led to believe that the peculiar effects described by d'Arsonval as characteristic of the sinusoidal current, and the wide range

of effects noticed by myself, are not absolutely confined to currents giving a true sinusoidal curve, but are possessed by other magneto-electric currents in higher or lower degree, depending upon the nearness of the approach of the graphic representation of the current to a truly sinusoidal curve. The effects of alternating currents of great rapidity, that is above 10,000 per second, do not require even this, for these effects are seen in the highest perfection in induction currents induced by sparks. The effects of the sinusoidal current of high rate of alternation is doubtless due to its approximation to such forces as light and heat in its nature, and those of slower alternations, less than 10,000 per second, and to the regularity of the undulations. It is possible also that this quality may be due to the proportions between quantity and potential. I must not forget to acknowledge that the last thought was suggested to me by Dr. Massey when I first called his attention to my apparatus in the summer of 1886--some eight years ago.

I have not had the pleasure of seeing d'Arsonval's sinusoidal apparatus, but, starting with the apparatus with which my first experiments were made, and which I have with me for exhibition, with some slight modifications, I have had a number of machines constructed for the purpose of overcoming certain difficulties which I have experienced in its use. I found it was purely a matter of accident that the apparatus which I first employed was capable of giving a sinusoidal current; other machines, apparently identical, gave currents which were not sinusoidal. It was only by a careful study of the machine with the assistance of my

electrician, Mr. H. A. Dow, that I succeeded in determining the peculiarities in the construction of the machine which gave to the current produced by it a sunisoidal character, a characteristic which was wholly unnecessary for the original purpose for which it was intended, and quite unknown to its constructors. The difficulties which are encountered in the construction of a sinusoidal machine are two:

1. To secure perfect uniformity in the current; in other words, a perfect sinusoidal curve when graphically represented. I have with me an ordinary magneto, the curve produced by which is shown on the tracing which I will pass around. I have also a machine which I have had constructed by an expert electrician who had for a copy one of my ~~sixteen~~ sinusoidal machines which, by painstaking effort on the part of my electrician, had been made to give a perfectly sinusoidal current. As will be seen by the tracing which I exhibit herewith, the current produced by this machine, though nearly sinusoidal, is not absolutely so. I think it impossible to construct these machines so as to give perfectly sinusoidal currents without testing the character of the curve without the use of some graphic means of representing the current produced by them.

2. The second difficulty encountered, was, to make a machine capable of producing not only the peculiar sensory and motor effects characteristic of the current of high alternation, but also possessed of sufficient quantity to give the desired motor effects with slow alternation, one of the most important uses of the machine. For a long time I was compelled to use two

different machines for producing these effects, but finally succeeded in producing a single machine capable of producing the whole range of effects. A special difficulty encountered with this machine was in the control of a current by means of ordinary rheostats. When run at a high rate of speed the electro-motor force of the current produced by one of these machines is so great that it cannot be properly controlled by any of the ordinary rheostats. In the use of any of the different forms of water rheostats, the instant the water is touched the amount of current transmitted is too great, leaving no room for regulation. I have only found it possible to use such a rheostat by using a thread for making contact with water.

In my experiments for the purpose of finding a convenient means for controlling the machine I devised a sponge rheostat which I find very useful, and which I also find a valuable means for controlling the current from an ordinary faradic battery, for which purpose it works admirably. The device has the advantage of being cheap as well as simple; it cannot get out of order and the resistance can be increased or diminished by making the sponge very dry or quite moist, or by adding salt to the water with which it is moistened. I finally hit upon the idea of controlling the apparatus by means of a converter. Accordingly I had a suitable one constructed, which I herewith exhibit. This answers the purpose perfectly, and renders it possible also to either increase or diminish the tension of the current at will, either by using the outer or ~~xxxxx~~ inner coil for the exciting

field, as may be desired. Recently, however, I have adopted still another method for modifying the current, which I find exceedingly satisfactory. This method consists in dividing the armature into two segments. In the machine which I exhibit, the wire of the first segment gives a resistance of 140 ohms; that of the whole armature being 1100 ohms. By using the shorter segment of the armature the quantity of the current is cut down to such a degree that the most rapid alternations may be employed without rendering the current so strong that it cannot be easily controlled.

Therapeutic Effects.-- I find the sinusoidal current of great practical value in the treatment of all forms of parasthesias, in neuralgia, in hyperaesthesias of all sorts especially; it is of great value in the treatment of headaches, and for nourasthenic pains of various sorts. In ovarian and other forms of irritation I have found it of far greater value than either the faradic or galvanic current which I have used very extensively for the last twenty years, making, with the aid of my assistants, from fifty to twice as many applications daily.

The motor effects obtainable from this machine are even more useful, if possible, than the sensory effects, although not so immediately apparent. It is certainly one of the most convenient of all the methods of applying gymnastics to a weak muscle or muscular group. I find it especially valuable in the treatment of spinal curvatures due to weakness of the trunk muscles, the application being generally made to the paretic or paralyzed parts. The readiness with which the motor effects of illustrated in its applica-

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In the use of this current I continually encounter new and interesting effects which are characteristic of it, and which suggest new and valuable therapeutic applications. It certainly is not a substitute for either the galvanic or the static currents, but I think it may well replace almost altogether, the faradic current, which is in every way inferior to it.

I have employed different forms of currents,--the faradic current, the galvanic current, the slowly interrupted galvanic current, the galvanic and faradic currents combined, and the dynamic current. The latter, which is supplied by a small machine giving a reversing current, I have found the most effective of all means of stimulating contraction in the muscular structures which support the uterus. When one electrode is placed upon the abdomen and the other in the vagina, energetic and painless contractions are produced in the abdominal muscles. These contractions occur at every reversal of the current, so that this current not only has the effect to stimulate nutritive changes in the diseased structures, but also affords a most valuable means of securing functional activity in idle and relaxed parts, thus giving them the benefit of a genuine gymnastic exercise. The

therapeutic results following the use of this current, justify me in claiming for it a decided superiority over any other form of electrical current for this purpose. I have used this current for medical purposes for the last five years.

Report of Cases Who have taken the Sinusoidal Current.

Mrs. Swigert, suffering with severe nervous headache. Could not sleep. Relieved by one application of the S. R. Has not had a return of trouble, although this was several weeks ago.

Mrs. Moorehouse, had paralysis of the left side nineteen years ago, from which she had never fully recovered. Has had the S. R. applied three times a week for about a month or six weeks. She tells me the stiffness is gone from her leg and that it feels much lighter and she can walk much better than she has been able to for nineteen years. The arm has also lost the feeling of heaviness and stiffness. Calls herself so well she wants to stop treatment.

Miss Chilton says she is greatly relieved from profuse leucorrhoea which she thinks was largely due to the local application of S. R.

We have had a great many people suffering with pelvic pains, both acute and chronic, relieved by this current, some of them at once and others in a longer time. Many cases in the use of S. R. I have noticed the development of the abdominal muscles. (It is difficult to determine just whether it was the electricity

gymnastics, or their manual treatment that caused the development of the muscles, but I suppose it was due to all).

Mrs. Keller, suffering with long-standing pain in the face and jaws extending up into the ears. Has been entirely relieved by the local application of the S. R.

Mrs. Kent, suffering from nervous headache and pain in the back of neck. Although she has had but three applications already feels relieved.

Mrs. Bowman, suffering from chronic nervous headache. Has been much relieved. She has also taken it for pelvic troubles from which she is much improved.

Mrs. Eberling, taking the local application for pelvic troubles. Is improving steadily.

Mrs. Hurd has been running down and growing weaker for some time. Right leg especially gets weak when she walks. Has had the sinusoidal current applied to leg for about a month. Is very much improved; leg much stronger.

The following cases are illustrative of the good effects which may be obtained from the application of the sinusoidal current:

Case 1.--Mrs. S., a lady 53 years of age, had for several years been subject to severe attacks of nervous headache. On the occasion of one of those attacks, for which other remedies had failed to afford relief, the patient suffered extreme pain. The sinusoidal current was applied with the result that the

patient was very promptly relieved and soon fell asleep. Several months have elapsed and the patient has had no return of the difficulty.

Case 2.--Mrs. M., had suffered a stroke of apoplexy resulting in paralysis of the left side some nineteen years previously; had never fully recovered from the attack. When patient came under our observation there was greatly diminished power in the left leg and a very uncomfortable feeling of stiffness and heaviness. Walking was considerably impeded. The strength of the left arm was also greatly diminished, and the seat of the same disagreeable sensations of heaviness and stiffness. For six weeks the sinusoidal current with rapid alternations was applied regularly three times a week. At the end of that time the strength of the affected limbs had very greatly improved; the sensations of stiffness and heaviness had entirely disappeared, and the patient pronounced herself well, although the strength of the affected side was not quite equal to the other.

Case 3.--Mrs. C had suffered for a long time from profuse leucorrhoeal discharge. The local application of the sinusoidal current with rapid alternations relieved the discharge entirely. Patient had vaginal douches at the same time, but felt confident that the sinusoidal current was most beneficial, for the reason that the douches had been used for a considerable time previously, but without permanently beneficial effects. The patient has continued to improve up to the present time, some six months since

treatment was discontinued.

Case 4.--Mrs. X., had for a long time suffered severely from pelvic pain, for which an operation for removal of the appendages had been performed but without affording the expected relief. Three weeks' treatment, during which the sinusoidal current was applied locally each day, completely relieved the patient.

Case 5.--Miss Y. aged 24, had suffered for a number of years,--in fact, almost from the beginning of her menstrual life--from ovarian neuralgia; the pain was most aggravated at each menstrual period; the patient was, however, never entirely free from pain. By the application of a rapidly alternating sinusoidal current every other day for a few weeks the chronic pain was entirely relieved. At the beginning of treatment the patient invariably came into the office suffering severely from pain, but was always promptly relieved by application of the current.

Case 6.--Mrs. K. had for several years suffered from severe pain in the face and jaws, extending into the ears. Daily application of the sinusoidal current for three or four weeks gave the patient entire relief.

Case 7.--Mrs. K. applied for relief from severe nervous headache accompanied by pain in the back of the neck. Patient was relieved by treatment, and three applications of the sinusoidal current rendered the relief permanent.

Case 8.--Mrs. B. This patient complained of chronic nervous

headache, the pain being constant; also suffered greatly from pelvic pain. Local application of the current to both the head and the pelvic region resulted in a complete cure, in the course of a month's treatment.

Case 9.--Mrs. H. had for a long time suffered from pain and peculiar paraesthesias of the pelvic viscera. Application of the sinusoidal current for a few weeks afforded most complete relief, and the patient has continued to improve since the application was discontinued.

Case 10.--Mrs. H., had suffered from general debility and anaemia. There was, especially, great weakness of the right leg, which was so great as to seriously interfere with walking. The sinusoidal current with slow interruptions was ~~xxxkkxxxkxx~~ applied to the leg three times a week for one month. At the end of that time, the strength of the leg was very greatly improved and the patient so much relieved that further treatment was not considered necessary.

I have employed the sinusoidal current in more than 2000 cases, and have found it of such value that in my practice it has almost wholly replaced other forms of electricity, of which, for twenty years I have made extensive use, having been an office assistant and private pupil in Electro-Therapeutics of the late Geo. M. Beard, to whom the medical profession of this country are greatly indebted for the development of electro-therapeutics on this side of the Atlantic.

We have now two sets of apparatus for giving diathermy, so that proper attention can be given to a considerable number of patients.

Diathermy differs from the galvanic current in that it produces thermic effects instead of chemical effects. The two poles placed in a solution of iodid of potash and starch heat the water, while the two poles of the galvanic current produce decomposition of the iodid of potash, setting free the iodine and coloring the water blue. The high frequency current produces thermic effects, while the galvanic current produces chemical effects.

Diathermy employed with the solenoid of with large electrodes applied to the trunk lowers blood pressure, hence is useful in insomnia and in arteriosclerosis.

Application to the glands increases their secretion.

Every internal organ—the kidneys, liver, pancreas, stomach—can be reached by diathermy.

The flow of bile and of urine is increased by proper applications.

Severe headaches can be relieved by application to the temples or the forehead and neck.

Nagelschmidt claims that the pain of tic douloureux and of tabes is relieved very promptly.

Nodules of gout are removed, the uric acid compounds becoming insoluble under the influence of a high temperature.

Hemorrhoids may be treated painlessly by means of cocaine.

Both small and large tumors may be removed.

Fistula may be made to heal by applications through metal sounds.

Papilloma and other tumors of the bladder may be treated after opening the bladder.

Parenchymatous bleeding is quickly controlled.

Diathermy, using a small electrode, is useful in controlling hemorrhage.

May be used to destroy vegetation in the uterus; to remove large or small tumors.

Its use permits the free flow of lymph.

It is of great service in lupus, accomplishing more in a few seconds than the Finsen ray in hundreds of applications.

Bony tissue may be treated as well as soft parts.

Diathermy is recommended by Nagelschmidt in Angina pectoris or arteriosclerosis of the heart, using two small electrodes—one at the apex and the other at the base of the heart.

Diathermy is also recommended by Nagelschmidt for dilatation of the heart and myocarditis. He says the X-ray shows the heart diminishing in size under the influence of the current.

In arteriosclerosis—presclerous stage—Nagelschmidt reports fall of blood pressure from 210 to 117 millimeters in four sittings; in another case from 220 to 140 in nine sittings. The good effect continued for months.

Intermittent limping, due to partial occlusion of the femoral arteries. Nagelschmidt reports several cases, in some of which sinuses existed. Patients entirely cured in 4 to 15 treatments.

In one case of general arteriosclerosis the patient, 69 years old, of marked senility, walked only with crutches. Fifteen treatments wonderfully relieved. He could walk without crutches. Greatly improved.

Angina Pectoris. Nagelschmidt reports a considerable number of cases in which suffering was arrested and all symptoms disappeared.

Obliterating arteriosclerosis and diabetic gangrene cured by Nagelschmidt.

Method of Application

For the heart--a large electrode on the back and a smaller electrode over the heart, of sufficient size to admit a current of 1000 to 1200 milliamperes without overheating the skin; duration five minutes. The heart beat should rise from 80 to 100 or 110, except in feeble cases. For stimulating effects on the heart, apply condensation electrode to the back.

For sciatica the current is applied to the painful points, 500 to 1000 milliamperes, five minutes. Pain diminishes as soon as current begins. Firm pressure should be made on the nerve. Indifferent electrode should be opposite the smaller movable electrode. Applications should be made also at the roots of the sciatic nerve at the sacro-iliac synchondrosis. After treatment, application is made with a condensator electrode, a thick glass tube filled with graphite, mms with which the muscles around the nerve are massed. Skin should get very hot, but it should not be burned.

k-5-16-12--jhk

Light. Lighthouses & Torchbearers

From the moment when God said, "Let there be light," light has been the wonder of the world, and that glorious light bearer, the sun, has been for ages, and still is, the object of worship, not by ignorant savages alone, but by some of the highly cultivated people in the world. One of the most impressive relics of the ancient Egyptian civilization is a sculptured representation of that most wonderful of the Pharaohs, a

over

Akhnaton, the successor
of Tut-ankh-amen, and his
wife, Hotep; in the attitude of
adoration, with outstretched
arms, doing homage not
to the sun, but to the [illegible]
power behind the sun, [illegible]
he took care to explain in
a beautiful poem, an apos-
trophy to light. in which
he sees the creative
power and handiwork of
Omnipotence.
Who can behold the
orb of [illegible] day emerging into view
above the horizon. without

2

feeling that he is in the
majesty, the monarch
of the Universe. I always
feel on such an occasion
the impulse to worship,
and recall with pleasure
that my Irish ancestor,
a Druid priest who lived and died
a thousand years B.C. when
he met his end, stood
worshiping the rising sun.
What a thrill the dis-
coverer of the making of
making a light, a fire,
must have gotten as he

for the first time
created a star, then
a blaze and then per-
haps a whole conflag-
ration.

A "sleeping" limb only very
rigid test. Experiment Byrne

good quantity and variety: and canned

of fresh & cooked fruit. carry in bag

Emphasize in regularity

of meals - Eating when not hungry

making a meal of lettuce

of fruit

Memo. from Bardet.

INTRODUCTORY.

Electricity employed to produce light, heat, mechanical work and chemical work.

May also be used to restore health.

To employ electricity successfully in the treatment of disease, exact ideas of its properties are necessary.

Classification of the medical use of electricity:

1. Physics.
2. Therapeutics.
3. Diagnosis.

Deal only with physics.

Static electricity, so called because supposed to be electric fluid in repose.

Dynamic electricity supposed to be electric fluid in movement.

EXPERIMENT.--Rubbing a glass rod with a silk handkerchief--rod positive, silk handkerchief negative.

Would preserve the charge indefinitely if it were not slowly removed by the air.

Glass retains the charge only because it is a poor conductor.

Phenomena appears on case of a metal only when well insulated.

EXPERIMENT.--Decomposing water by a static current.

EXPERIMENT.--Show charging power of continuous current by means of electroscopic condenser, connecting the poles with the two poles of the condenser.

When one plate is withdrawn, the gold leaves separate.

Show the same with a tin-foil condenser.

Compare static electricity, to small reservoir of water at great

height with a voltaic pile, a large reservoir of little height.

Electricity is the movement set up by an E.M.F.

The quantity of electricity depends on the quantity of mechanical or chemical force expended.

The amount of heat obtained from ~~an electrical current or~~ a voltaic pile is the same as that produced by burning the zinc.

Resistance of 1 ohm represented by a copper wire 1 mm. in diameter, 48 metres long; or a telegraph wire 4 mm. diameter, 100 metres long.

Make a gas battery.

Show relation between a gas battery and a storage battery.

EXPERIMENT.--Gas battery-see Fig. page 165, Bardet.

Secondary battery--Plante.

The two plates of lead under the action of the current, the oxygen and hydrogen are fixed upon the lead plates. Oxygen by combining with lead, making PbO_2; hydrogen by reducing the PbO of the negative plate, lead always being covered with a thin layer of peroxide.

The action ceases when the positive place becomes completely covered with the brown peroxide so as to protect it from the action of the peroxide.

When the circuit is closed, the hydrogen and oxygen combines until all the oxygen that has been stored up has been used, the current travelling in the opposite direction, making the secondary battery the charging current.

Used eight days in alternation so that both plates become oxidized, thus the quantity of charge is gradually increased.

Thermo Electricity.

The simplest thermopile a coil of wire.

EXPERIMENTS.-- Fig. 57, page 171, Bardet.

Fig. 60, page 173, ,,

Animal electricity.

The surface of a muscle transverse to the cut surface while the muscle is alive .

Not true of dead muscles.

The temsion of a current in a muscle diminishes when the muscle contracts.

If the contraction is exceedingly strong, the surface of the muscle may become negative, the tendanous portion positive.

The muscle may be considered as a dynamo electric machine.

Deathurney v. Thermo-penetration

Curative

~~PERMANENT~~ EFFECTS OF HIGH FREQUENCY CURRENTS.

Through the discoveries and ingenious invention of Dr. Nagelschmidt, of Berlin, a very important addition has been recently made to the list of physiologic therapeutic measures. The remarkable influence of heat upon conditions giving rise to pain has long been known and utilized, not only by means of hot fomentations, poultices, subbaths, hot water bags and other ordinary means of applying heat, but more recently by the application of luminous heat rays by the aid of the arclight and the incandescent light. Luminous heat rays have the advantage over all other means of applying heat in that they penetrate the tissues to a considerable depth, the light being converted into heat through the resistance offered by the opacity of the tissues.

Dr. Nagelschmidt discovered that by employing high frequency currents of suitable voltage it is possible to convert electricity into heat in the tissues, and by proper management of the electrodes to localize the heat in any part of the body, internal as well as external. The apparatus employed by Dr. Nagelschmidt consists of a spark ~~gauk~~ gap and circuit enclosing a capacity and an inductance, in which electric waves are produced by oscillating impulses. The length of the waves ranges from a few hundred feet to a half million or more. The frequency of the oscillation varies from a hundred thousand to a million or more per second. Various modifications of the effects produced are secured by damping. The apparatus is operated by alternating current, the periodicity of which should be 40 to 100 cycles. Currents of any

ordinary voltage may be employed. The apparatus includes transformer by means of which the proper voltage is produced. A condenser connected with a pri ary circuit gives rise to oscillations of uniform frequency, by means of which oscillations are induced in a secondary circuit, which, when applie l to the body, give rise to no sensations whatever, except that of heat. The abs nce of the usual electrolytic sensory and motor effects of the Galvanic current are not present. By means of suitab le electrodes applie l to the surface, the current may be applied tc any part of the body, internal as well as external.

One notable peculiarity of this current is the fact that the effects, when the application is made in the proper way, are not localized at the electrodes but at some intermediate point. For example, if the electrodes are placed at the two ends of a shallow trough containing egg albumen, no change in the albumen will occur at the electrodes,but midway between the electrodesa sufficient degree of heat will be generated to cook the albumen, which at this point has the appearance of having been boile l. By suitable adjustment of the electrodes heat of any desired degree may be thus applied to the brain, the liver, kidneys, heart, or any other internal organ. An ampere meter placed in circuit with the body shows the exact amount of current employed, which with proper electrodes may be raised to two or three amperes without injury.

In practical application diathermy has been found of very great value in a considerable variety of conditions. Perhaps its most notable success has been in the treatment of gout. By raising the temperature of the tissues in the region of gouty deposits, the solubility of the urates is increased to such a degree that they may be readily removed and carried out of the body through the kidneys by daily applications of the current in connection with copious water drinking. Painful and inflamed gouty

joints are quickly relieved by diathermic applications. All painful affections of joints, as well as the pain of neuralgia and migraine, are speedily relieved by diathermy. The heart diminishes in size, the pulse becomes regular, and when frequent is slow after being at first accelerated. In arteriosclerosis of the vessels of the brain and abdominal region marked and highly favorable effects are produced. It is possible by this means to relieve the distressing pain of gastric crisis and abdominal angina. The lancinating pains of locomotor ataxia and hyperesthesia of the skin are likewise relieved.

The labored breathing of asthma is relieved in one or two minutes by proper application, and the viscid, advesive phlegm becomes fluid and is easily expectorated. ~~Katxmpli~~ Heated applications appear to produce decided curative effects. Tic douloureux and various affections of the eye and ear, as well as pleurisy and the conditions left in the lung after an attack of pneumonia, may be in most cases promptly relieved by diathermic applications.

By means of suitable electrodes, tissues may be coagulated, a method which is especially applicable to inoperable cases of cancer. Such applications may be made by means of local anesthesia, employing novocaine.

Diathermy may also be used for cautery purposes. The cautery knife, when this cautery is employed, makes a clean cut without hemorrhage and without the unpleasant odors produced by the galvano cautery and other thermo cauteries.

The application of diathermy is still in its infancy. It is promising, however, to prove one of the most valuable of therapeutic agents, especially since it affords means of applying heat of any degree desired to any part of the body, no matter how remote from the surface, thereby

relieving pain or stimulating function, as may be required, in the individual case.

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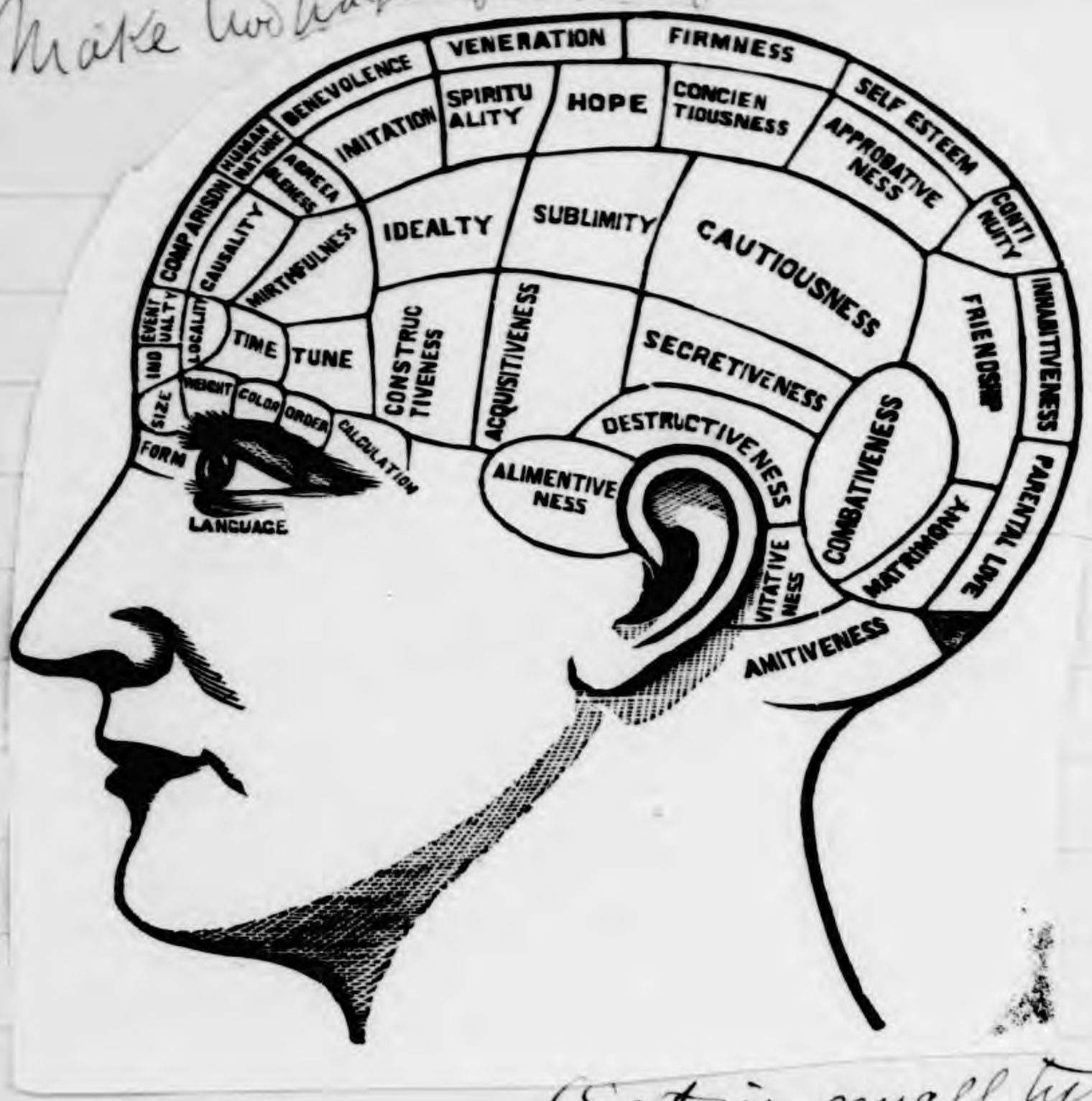

Conjugality

(Set in small type in double column to finish out page.

Amativeness.— The faculty of physical love.

Conjugality.— Matrimonial love.

Parental Love.— The love of children.

Inhabitativeness.— Love of home.

Friendship.— Love of companions and companionship.

Continuity.— The faculty which inclines a person to give undivided attention to a subject until it is finished.

Combativeness.— The faculty which gives courage and force of character a disposition to contend.

~~Stativeness.~~ —

Restrictiveness. — The faculty which gives a person thoroughness and severity.

Vitativeness. — Love of life.

Alimentiveness. ~~desire for food.~~ Love of eating.

Acquisitiveness. — Desire to accumulate, especially to acquire property.

Secretiveness. — Disposition to concealment, to the use of policy.

Cautiousness. — Timidity; ~~leads~~ to prudence.

Approbativeness. — Desire to please.

Self-Esteem. — ~~Do~~ Independence, dignity; self-reliance.

Firmness. — Decision of character; resoluteness of purpose.

Conscientiousness. — Faculty which distinguishes between right and wrong; moral sense.

Hope. — The faculty which looks
of the future with bright anticipations.
Spirituality. — The religious element.
Veneration. — The disposition to
worship; ~~R~~ reverence for deity.
~~Sublimity. —~~
Benevolence. — Philanthropy;
charitableness; desire to do good.
Sublimity. — Love of the
grand, especially in nature.
Ideality. — Love of the
beautiful.
Constructiveness. — The
mechanical faculty.
Imitation. — Power and
disposition to copy.
Mirthfulness. — Love of
fun.
~~Individuality. — Observing~~
~~faculty.~~ ~~Form. —~~
Time. — Consciousness of
duration.
Tune. — Ability to appreciate and
remember musical sounds.

Agreeableness.— Gravity;
Human Nature.— The power to
read the character and motives of
strangers.

~~Causality~~
Causality.— Faculty of abstract
thought and comprehension of prin-
ciples.

Comparison.— Power to com-
pare, to illustrate, to discern
analogies.

Eventuality.— Memory of words.

Locality.— Love of travel and
memory of places.

Individuality.— Observing
faculty; memory of objects.

Form.— ~~Size~~ Memory of out-
lines, of faces.

Size.— Power to measure
distances and quantities by the
eye.

Weight. Power to balance
and judge of weight.

Color. — Power to discriminate nice differences of shades and tints.

Order. — Faculty for arranging, organizing, systematizing.

Calculation. — Power to enumerate with ease and rapidity.

Language. — Memory of words and readiness in the use of language.

Draft

This creative intelligence is universal and it may be that there are some minds that are particularly sensitive, ~~so that they in some way~~ come in contact with this universal intelligence so that they got a glimpse of this intelligence, of things that are outside their own bodies, because everything that is going on is known to the Universal Intelligence. This Universal Intelligence manifests will and purpose. One of the most striking illustrations to me is when you wound a tree. When a limb is taken off, pretty soon you see a bit begin to grow and develop, and it gives the tree much the same form it had before. The tree wants to have a branch there in that spot. This represents purpose and will.

There are two wills at work in the body, the human will that controls the muscles, and the heart, also a muscle, and another will that controls the skin, makes it a better non-conductor. If it were not for that, when we came in contact with with cold, we would suddenly ———

The universal will controls the heart and all the automatic functions. These automatic functions are often a combination.