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BY JOHN H. BURCH, M. D., BALDWINSVILLE, N. Y.

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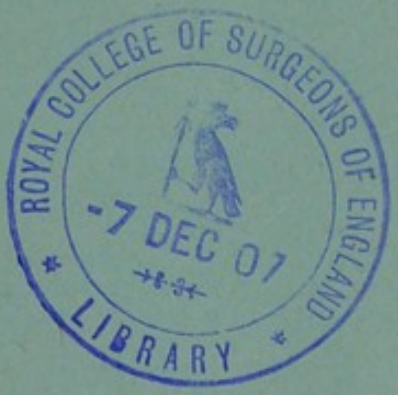

THE TREATMENT OF PULMONARY TUBERCULOSIS BY MEANS OF ELECTRICAL CURRENTS OF HIGH POTENTIAL AND FREQUENCY.*

BY JOHN H. BURCH, M. D., BALDWINSVILLE, N. Y.,

Member of the American Electro-Therapeutic Association, Member of the American Committee du I. Congrès International de Physiothérapie. Syracuse Academy of Medicine, Onondaga Co. Medical Society.

Since Tesla's brilliant demonstration of the possibilities of high-frequency electrical currents that was presented before the American Society of Electrical Engineers in the year 1880, the medical world has watched with increasing interest the role that these electrical modalities were destined to play in the cure of disease. Tesla seems to have been the first to suggest the possibility of treating pulmonary tuberculosis by means of the powerful discharge from his transformer. It was, however, the result of the experimental research of our own countryman, Dr. William J. Morton of New York, and the eminent French savant and physician d'Arsonval, that these electrical radiations were destined to receive their just recognition as therapeutic agents.

D'Arsonval's first communication was presented before the French Academy in the year 1899. Shortly afterwards Dr. Oudin of Paris perfected an apparatus producing an electrical discharge of immense voltage and frequency. By means of this transformer Oudin treated twenty cases of pulmonary tuberculosis. Of this number eight were cured, four were symptomatically cured, while the other cases, he affirms, were all benefited. Dr. Dourmer of Paris reported a series of seventeen cases in which five patients remained in perfect health after discontinuing all treatment for a period of two years, with benefit in all of the other cases treated. Dr. Gustav Reus, director of the laboratory of clinical research, Chemoga, modified the treatment adapted by Oudin, Gondil, Revière, Dourmer and Papiermeister, that consisted solely in the application of the effleuve from a high-frequency transformer directed over the affected area of the chest. Reus, however, after a long series of experimental research, demonstrated that electrical currents of extremely high voltage

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and frequency were capable of driving medicinal agents into living tissue. This had been thought to be a physical impossibility from the fact that what is known as phoresis, or the power of a continuous source of electrical energy to convey material particles suspended in a solution from one pole to the other, can only take place when the current is unidirectional. The currents under consideration, however, are not only alternating, but their rate of frequency of oscillation reach several million per second. Nevertheless, it was found that if the medicament is incorporated in a viscid menstruum of great electrical resistance these alternating currents of extremely high frequency and voltage have the power, possibly as the result of molecular bombardment, or the direct ionization of living tissue, to cause medicaments to penetrate the skin and produce both their local and constitutional effects. Reus treated a large number of patients affected with pulmonary tuberculosis by first painting the skin over the affected area with medicaments of supposed anti-tubercular action in connection with high-frequency currents. He employed the cinnemate of soda, the cacodylates and creosol. As a result of this treatment he observed in the greater number of his cases a steady diminution of fever and night sweats, a more gradual improvement in the attacks of coughing, the character of the expectoration, and the disappearance of tubercle bacilli. A considerable improvement was also noticed in the general health, together with an increase in appetite, power of assimilation, and bodily weight.

Lagriffoul and Denoyès made a series of experiments on guinea pigs rendered tubercular by the injection of a virulent culture of tubercle bacilli into the left thigh in the neighborhood of the inguinal fold. Upon these animals they studied the effects of high-frequency currents. It was found when the animals were subjected to treatments by means of the effleuve from a high-frequency transformer for a period of five minutes three times a week that the advance of the disease was greatly retarded. The visceral lesions were less marked and the ganglia smaller than in the control animals where no treatment was administered. These experiments seemed to positively demonstrate the favorable influence of high-frequency currents in attenuating the virulence of the morbid activity of the invading bacilli.

Dr. Charles Wright of London has recently reported a series of cases of pulmonary tuberculosis and tubercular adenitis that seem also to demonstrate the value of these electrical modalities in the treatment of tubercle bacilli infection.

In an informal address to the Technological Club on January 13, 1902, Dr. William J. Morton suggested the possibility of producing an artificial fluorescence of living tissue by means of administering certain fluorescent substances, either externally or internally, and subjecting the subject to either the radiations of radium, the X-ray, the disruptive discharge from condensers, ultra-violet radiations or the spark or effleuve from a high-frequency transformer. Dr. Morton's first paper appeared in the Electrical World and Engineer of June 20, 1903, and was shortly followed by a more exhaustive communication in the New York Medical Record of August 8, 1903. Since that time this method has been used extensively in the treatment of malignant and infectious diseases both by Dr. Morton and others with apparent success.

In a communication presented before the "American Electro-Therapeutic Association" at St. Louis September 14, 1904, I gave, in detail, the results of a series of experiments relative to the effects of electrical currents of high potential and frequency. During these experiments it was found that if strips of paper saturated with a solution of iodide of potassium and placed upon the cover of a Petri dish, while within the dish there was placed a strip of paper saturated with a starch solution, the sparks from the upper terminal of a resonator directed upon the cover of the Petri dish would cause the paper within to turn blue, thus apparently proving the power of these currents to penetrate glass and convey particles of iodine that acted upon the starch. It was also determined at that time that if strips of paper saturated with the same solution were placed beneath the hand while sparks, as strong as could be comfortably borne, were applied to the opposite side of the member, the paper was not acted upon. Strips of very sensitive photographic film wrapped in a black paper container were also not acted upon when held within the mouth while sparks were applied to the cheek. These experiments led me to believe, at that time, that electrical currents of high potential and frequency had not the power to penetrate living issue. I have since made a series of experiments that

leads me to believe that I was mistaken. By repeating the work of Lagriffoul and Denoyès, it was found that if the region over which the high-frequency current was applied was first painted with a medicament capable of killing tubercle bacilli, the animal would withstand a much more virulent culture than when the electrical modality was alone used. We also made a series of experiments with the essential oils and balsams, by which we found that the quantity of hippuric acid could be increased in the urine by painting a certain area of the body with the medicament, that was suspended in a viscid menstruum and bombarding the region covered with the pigment with painless sparks from a high-frequency transformer. A far simpler test of the possibility of driving medicaments into living tissue by means of these currents, may be made by painting an area of the integument with an oily solution of iodine and shortly afterwards examining the saliva for this element. In this experiment we always made control tests. A gram of 10 per cent. solution of iodine petrogen was applied to a certain region of the body, usually the forearm. At the expiration of forty minutes the saliva was examined by adding a few drops of fuming nitric acid and shaking the solution with chloroform. It was found in every instance that the reaction was more marked in the subjects who received in addition to the inunction an application from a vacuum electrode attached to one terminal of a Tesla coil.

As these experiments seemed to prove the possibility of forcing medicaments into living tissue by means of the electrical modalities under consideration, it is perhaps reasonable to expect a more local and direct action of the drug applied in this manner. If, therefore, an agent could be found capable of destroying tubercle bacilli, and at the same time stimulating cell activity thereby increasing vital resistance, the method would prove a valuable adjuvant in the treatment of pulmonary tuberculosis. Being most ably assisted by my student, Mr. George Shaw, a large number of medicaments were tried and found worthless. We desired a drug offering great electrical resistance and capable of absorbing oxygen with facility and imparting it readily to surrounding media. These requirements were found in certain of the essential oils and balsams. Oil of turpentine readily absorbs oxygen and imparts it with equal facility. As is well known, light enhances

this process, that is without doubt due to the chemical or ultra violet end of the spectrum. As the spark discharge from a high-frequency transformer supplies both ultra violet radiations and ozone in abundance, this medicament seemed to offer possibilities in this direction. It was soon found, however, that it was not a sufficiently powerful germicide to destroy tubercle bacilli. As but few germs can resist for more than a few hours the antiseptic power of oil of cinnamon, as even its odor will destroy most micro-organisms, and as it will also produce an artificial leucocytosis, it seemed an ideal medicament for this work. When we came to experiment with it we found that careful urinary examinations failed to demonstrate an excess of uric acid after its local employment and we concluded that the electrical discharge was incapable of forcing it into the tissues sufficiently for clinical purposes. This however was not the case when combined with oil of turpentine. In the mixture of the two we were able to detect an excess of uric acid in the urine; a well-marked leucocytosis and blood serum tubes treated with this mixture and inoculated with a virulent culture of tubercle bacilli failed to develop colonies. As the electrical resistance of the mixture was increased by the addition of balsam peru, this medicament was also incorporated in the mixture. From the fact that I had used iodine inunctions in connection with high-frequency currents in the treatment of tubercular glands with success, this drug was also added. This is the preparation that I am now using, except that, in place of the crude oil of turpentine, I am employing an impure terebene, made by adding sulphuric acid to oil of turpentine until a black viscid liquid is produced. The above medicaments are combined in equal parts and applied locally over the affected area of the lung, after which the area is bombarded by means of the effleuve from a high-frequency transformer.

While this proved somewhat satisfactory from a laboratory standpoint, I felt that there was yet one essential element to be desired. As light is our most effective germicide and an all-important stimulant to protoplasm, it would seem rational to suppose that, could the tissues of the body be flooded with this form of energy, much might be hoped for. Dr. Morton, as before stated, suggested this possibility, and his clinical results have seemed to verify his hypothesis. In our tuber-

cular work we experimented with quinia bisulphate and fluorescence, giving them internally, while employing high-frequency currents. We were not exactly satisfied with either of these preparations. It was thought that if a powerful fluorescent substance could be found that at the same time is eliminated by the bronchial and pulmonary mucous membrane, more might be hoped for. This substance was found in umbelliferone the active principle of the gum resin galbanum. This substance gives a beautiful blue fluorescence by the addition of an alkali, and is largely eliminated by the respiratory mucous membrane. As we were unable to procure this alkaloid commercially, we were obliged to prepare, with no little trouble, our own product for experimental purposes. From the fact that the alkaloid could not be procured and that the gum resin itself will fluoresce by the addition of water made alkaline by a few drops of ammonia, we were compelled in our clinical work to make use of the crude drug. A pill containing five grains of the gum resin galbanum is administered to each tubercular patient after eating, with the hope that it may act as a light transformer and thereby cause the affected tissue to fluoresce.

As our work has been mostly experimental I can say but little in regard to the clinical value of this method.

Since the completion of our experimental work I have treated eight cases of pulmonary tuberculosis. Five of these cases were taken in the so-called pretubercular stage. In these cases I could find no tubercle bacilli and the diagnosis was based upon persistent fever that had existed for a period of at least six weeks, loss of weight, prolonged expiratory murmur, jerky inspiratory murmur, and in two cases, dullness over the left apex. Of the other three cases, one is a victim of fibroid phthisis of five years' duration; in the other two the disease had not advanced to the extent of cavity formation, but there are apical dullness, crepitant râles, cough, expectoration and tubercle bacilli. Of these cases, the first five mentioned are all doing well, but it must be mentioned that in addition to the electrical treatment they received the benefit of overfull feeding, open air and rest. In a period averaging six weeks in three of these cases the fever disappeared, they rapidly gained in weight and all physical signs have disappeared. The other two of the five cases still have a

slight temperature at times, and while they have also gained in weight and bodily strength there is still a prolonged expiratory murmur in each. They have been under treatment now two months. The case of fibroid phthisis has done the best of all. He has gained eight pounds, he coughs much less, he can now easily walk to the office for treatment. His appetite is good and his general condition is certainly much improved. The other two cases are also improving. There is less fever, the night sweats have ceased, they have gained in weight and seem in every way much improved.

It will be readily inferred that these clinical results are as yet of but very little value. Pulmonary tuberculosis, as is well known, is a disease subject to long periods of quiescence, during which time its victims seems to apparently improve. This is especially true under new and novel methods of treatment. Therefore, with our present meager knowledge of the therapeutic value of electrical radiations in the treatment of pulmonary tuberculosis, a physician should be held criminally responsible who would employ this method at the expense of open air, overfull feeding, climatic, or other well-recognized modes of treatment. As an adjuvant, however, in the treatment of this dreaded disease, I honestly believe something may be hoped for by means of this method of treatment.

Some of the patients that I have treated suffered from a more or less severe reaction after the first few treatments. This reaction is manifested by an increased temperature.

In the successful application of this method of treatment I believe that much depends upon the efficiency of the apparatus employed. In our experimental work we found that the resonator actuated by means of the static machine was less effective than when excited by a Ruhmkorff coil. The Tesla type of apparatus has given me the best satisfaction from the fact that it is bipolar. By this arrangement the patient receives the benefit of an electrostatic charge while the effleuve is being applied over the affected area.

The technic is very simple. The medicament is first painted over the region to be treated. The vacuum electrode is next applied for a period of from five to ten minutes, using a current output of from 50 to 100 ma. The patient is then connected by means of a hand electrode to one terminal of the apparatus while the spray electrode is attached to the other

side of the machine. A hot effleuve is directed over the affected area for a period of from three to ten minutes, that is followed by a like application of the spray over the dorsal region.

Discussion.

Dr. Baer: In regard to the treatment of tuberculosis, my experience extends chiefly to the reports of tent colonies where there are technique cases and where the principal treatment is to feed the patients properly and to give them outdoor and tent life. In this way they have the grandest of successes. I was a little surprised that the doctor did not bring in that part of the treatment. In reference to electrical treatment I would say that we cannot treat tuberculosis successfully without feeding the patient properly and without getting him away from excessive turmoil and forcing him to eat. I would like to call the attention of the members present to the papers that were read before the Illinois Medical Society at Rock Island last May. I am personally much interested in the entire subject.

Dr. Snow: I am very much interested in the curative power of the high potential and high frequency current. That the currents of high frequency do not penetrate and are largely superficial in their effect, we are taught by the physicist. From the results we obtain, however, in these cases, if we are unable to destroy the tubercle bacillus we do seem to remove the element of mixed infection. If we have increased phagocytosis, we are then thus enabled to get nearer the infectious element than we are in cases of simple, non-complicated tuberculosis. The best evidence of the efficacy of these currents is shown by the fact that the temperature after the first reaction ceases to be high, when mixed infection is present.

Results have been recorded from this method which are very gratifying. I believe that each one of us is concerning himself with the treatment of tuberculosis. Whatever other methods we emphasize, we should certainly try the one described in the paper before us. Dr. Burch is to be congratulated on the scientific way in which he has approached the subject, and I hope we shall have another paper from him of this character.

Dr. Burch: In regard to mixed infections I found that the addition of silver salt, applied the first time in solution, over the infected region, seems to give more benefit in these cases. In regard to treatment of these cases, I would not for one moment advise electricity to the exclusion of other methods. I use every hygienic measure and give all suggested improvements a trial, but I also conduct the experimental work as described in my paper, although I do not know yet what the clinical results will be.