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SOME PHYSIOLOGICAL EXPERIMENTS WITH MAGNETS AT THE EDISON LABORATORY.*

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Magneto-therapy has not gained such wide-spread application as has electricity in medicine, nor has it won to any great extent the confidence of the medical profession, for its effects are even more occult and less easily demonstrable than, for instance, the trophic influences of galvanism in poliomyelitis and progressive muscular atrophy. At the same time magneto-therapy has its adherents and earnest promulgators, to which any one will bear witness who has observed the transfer of singultus by a magnet from one girl to another in Charcot's dramatic realms at the Salpêtrière, or who has at the Poliklinik watched Benedikt carefully adjust a one-foot horseshoe magnet to the

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hyperæsthetic spine of a hysterical girl. There are many lesser men than these who have implicit faith in that mysterious force, and there is no dearth of theories to explain the effects of magnetism upon the human organism. Professor Benedikt has taught that erethetic forms of hysteria are better treated by the magnet than by electricity, hydrotherapy, or drugs. A magnet being applied to the sensitive vertebræ, without removal of the dress, the irritable patient soon becomes quiet and even quasi-paralyzed. The magnet, therefore, "increases the resistance to conduction in the motor nerves." The muscles gradually relax, the respiration becomes sighing, consciousness slowly disappears; the resistance to conduction in motor nerves "could easily become absolute." The two poles have different effects. Sometimes one pole to a hyperæsthetic ovary fails to relieve pain, whereas a change of the poles causes its speedy disappearance. According to him, the magnet must be employed with due caution, since patients may be injured by it.

The status of magneto-therapy in America may be inferred from some quotations from the third edition of Roberts Bartholow's *Medical Electricity*, 1887. Under the caption of Physiological Effects of Magnet Applications he says: "We know that a current circulates in a magnet. If a powerful horseshoe magnet is brought near to the skin, opposite electricities are attracted to the poles and currents are induced. About the point of application, therefore, the skin will be acted on directly by the magnetic current and by an induced current. The production of physiological effects, which can be recognized, is therefore merely a question of the magnetic strength."

He then quotes Dr. Vansant as assuming the body to be diamagnetic: "By applying north and south polarity to different parts, very extensive subjective impressions are ex-

perienced; they are of two classes—of heightened organic activity, and the opposite condition."

He then adds: "That impressions of a very decided kind are produced by the application of strong magnets is evident in the experience of Dr. Proust and Dr. Ballet, who continued a course of investigation begun by Charcot at Salpêtrière." They ascertained that magnets could not be applied with impunity, for, if applications were prolonged, pains were felt in the epigastrium and thorax, making respiration painful, digestion was disordered, and boulimia brought on. These results were so uniform that there seemed to be no doubt of their genuineness in the minds of the investigators.

Under the heading Therapeutical Application of Magnets, Dr. Bartholow quotes Dr. Hammond as preferring a horseshoe magnet, and advising that several of the same size be kept, so that by clamping them together more power can be obtained. The author adds: "Hammond insists on the necessity for the application of both poles in many cases, and therefore uses the horseshoe magnet."

"Hammond has used magnets in nine cases of chorea, in two, 'complete cures being produced in a few minutes.'"

"In two cases of hemiplegia with hemianæsthesia Hammond had very surprising results from the application of horseshoe magnets, the sensibility returning immediately, and in one the hemiplegia was recovered from in a few hours."

The magnets used by physicians are generally those of a horseshoe shape, varying from a few inches to a foot in length, and are the so-called permanent magnets. They exert a traction force equivalent to several ounces, and sometimes to from one to three or four pounds.

Electro-magnets can be made to sustain two hundred pounds to each square inch, or fourteen kilogrammes to the

square centimetre of active surface on either pole—that is to say, twenty-eight kilogrammes to the square of active surface on either pole if both poles are alike and share the load.

While rather skeptical as to the practical utility of the magnet in medicine, it occurred to us that if there was any truth whatever in the claims made by various distinguished authorities, if this interesting and undoubtedly powerful force had any effect at all upon living organic matter, we were in a position to demonstrate its physiological effects by means of magnets of enormous power placed at our disposal at the Edison Laboratory at Orange, N. J., through the kindness of Mr. Edison. Accordingly we made experiments which we detail below, and which we consider as conclusive, in that they have been made with magnets of a strength possibly never before used for such purposes. The description of the magnet employed for preliminary experiments is as follows (Fig. 1):

It is of wrought iron throughout, and its principal dimensions are represented in the sketch in centimetres. Roughly speaking, it is about a foot and a half wide by two feet long and requires two men to lift it. The cross-section of the core is forty-nine square centimetres. The vertical angle of the cones is 36°, and the diameter of their plane faces 0·75 ctm. There are 2,728 turns of wire on each limb, making 5,456 in all, and the current employed in exciting it was approximately 4·5 ampères. The pole faces were 1·20 ctm. apart, and it was between them that objects were placed for observation either with the naked eye or with the microscope. The intensity of the magnetic field between these poles was about 5,000 C. G. S. lines to the square centimetre.*

* C. G. S., or "centimetre-gramme-second," is the unit of measurement employed. The earth's magnetic field, measured horizontally for

A drop of water placed on a glass slide in this field was visibly distorted in shape by the magnetic force.

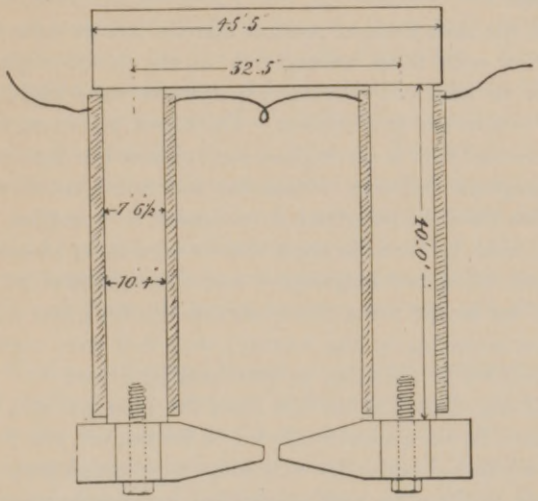

FIG. 1.—Plane section of magnet through core axes. Not drawn to scale.

The stage of the microscope was removed and wooden supports substituted. It was necessary to clamp the microscope down to the table to prevent its being drawn upward to the poles.

Nothing peculiar was noted in the effect upon iron in its finest powdered form, iron by hydrogen. It behaved just as iron filings would do, being strongly attracted. Iron by hydrogen placed in water was observed to be polarized by any ordinary magnet under the microscope.

Dry powdered hæmoglobin exposed to the strong mag-

instance, is estimated to be 0·18 C. G. S. line to the square centimetre near New York. Consequently our magnetic field was 27,778 times that of the earth's horizontal component, that aligns the compass needle.

netic field above described was not visibly affected by it. The iron it contains, however, is exceedingly minute (0·42 per cent.).

It was then thought possible that the iron in loose combination with fresh hæmoglobin in the blood-corpuscles might be affected. Several experiments were made with both human and frog's blood. The blood, placed on slides and covered with a cover-glass, was subjected to the strongest magnetic influence obtainable, and failed to show the feeblest traces of polarization, movement, or vibration.

It must be borne in mind that we were using an electromagnet which we magnetized and demagnetized at will. First one would make the observations, the other experimenter attending to the current; then they were repeated and verified by the other on our changing places.

Living ciliated epithelium from the pharynx of a frog was now in like manner subjected to the magnet, and its behavior watched under the microscope with a high-power objective, as the poles were magnetized and demagnetized by the making and breaking of the 120-volt current in the huge coils. The magnet had absolutely no effect upon the delicate ciliary movement which kept on continuously, nor did it cause the slightest change or vibration in the cells themselves, suspended in the saline solution. After the magnetic observation, a mild continuous electric current of one to two milliampères C. S. was carried through the microscopic field containing the moving ciliated cells, and this also had no effect whatever upon the movement.

Another frog was now taken and curarized, fastened upon a pasteboard frog-plate, and the web of the foot stretched in the usual manner to show the circulation of the blood in the capillaries under high power. As before, the object to be observed was placed between the poles of our magnet and the microscope focused upon it. The poles

had to be separated somewhat farther to admit the large foot of the frog. With the clearance thus employed to allow of inserting the frog's foot the magnetic intensity was reduced from 5,000 C. G. S. lines to the square centimetre to 1,500 C. G. S. lines to the square centimetre. Repeated observation by both of us failed to demonstrate the feeblest influence of the magnet upon the blood-cells or their movement in the vessels. At this point we determined to note the effect of the continuous current upon the circulation. A fine copper wire was placed upon one toe and another wrapped in moistened filtering paper above the ankle. The current strength in these trials never exceeded two milliampères, and generally varied between one and two milliampères.

Whenever the current was made the circulation in the foot under the microscope, which was about midway between the two electrodes (three centimetres apart), gradually grew sluggish and finally ceased, complete stasis being produced, the blood-vessels dilating. As soon as the current was cut off, gradually movement made itself manifest in the stagnant capillaries, and, becoming more and more lively, the circulation was in a few moments restored to its normal state. The effect was not due to the magnet, however, for it was observed with the current in the coils made or broken. This experiment was gone over frequently by each of us, so that the facts were fully verified.

It was now resolved to put Benedikt's statement to proof that magnetism "increases the resistance to conduction in motor nerves," thus causing paralysis. For this purpose a set of idle field magnets (Fig. 2) which converge into a cylinder two feet in diameter and seven inches deep was employed. In this cylinder a small and lively young dog was placed and kept for five hours, and subjected during all that time to the influence of a magnetic field whose

intensity was from 1,000 to 2,000 C. G. S. lines to the square centimetre. Fig. 2 is taken with a boy inside of the

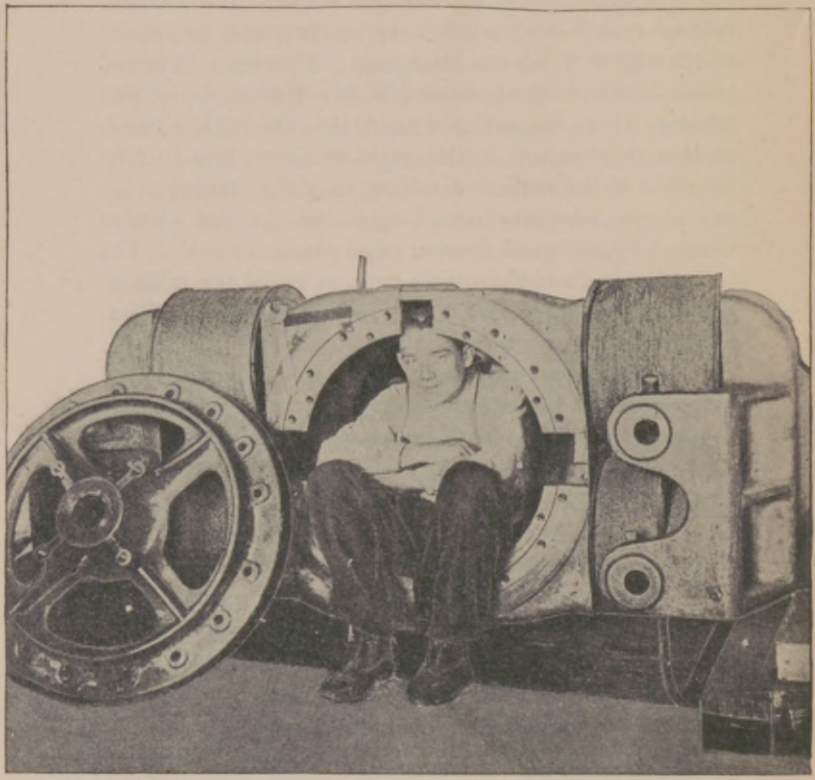

FIG. 2.—Showing field magnets in whose cylindrical cavity a dog was placed. The powerful attraction of bolts and chains is distinctly noticeable. The circular brass cover or door of the cavity is shown at the side.

cavity, in which the dog was kept for five hours. The magnets were excited while the photograph was being taken with the boy in it, as is evidenced by the position of the

bolt above, and by the bar of iron A B, which not only supports its own weight in this horizontal position when touching the pole-piece, but also supports the wrench at its outer extremity. The chain, too, is magnetically influenced. There was no effect upon the boy. A clearer idea of the power of this magnet may be obtained when I say that heavy bolts, chisels, and pieces of iron in the immediate neighborhood of this cylinder were drawn to it irresistibly, and that it required considerable muscular exertion to remove them. A heavy bolt placed slightly above the center or axis of the cylinder remained suspended for a moment in the air, like Mohammed's coffin, so powerful were the opposing magnetic forces upon it compared with gravitation.

The five hours' exposure to this influence had not the slightest visible effect upon the animal, which was rather livelier in his capers on being set free than before, owing to his joy at being liberated from the cage.

Our next experiments were directed to studying the influence of magnetic fields on the human brain. The type of dynamo employed for this purpose will be seen in the illustration (Fig. 3). The machine converts about 70 H. P. at full load. The armature and one journal were removed, leaving the space between the pole-pieces free. This will be best understood by reference to the figures. Fig. 4 gives a view of the pole-pieces into the cavity between which the head was to be inserted. This cavity is 35 ctm. (fourteen inches) in diameter and 60 ctm. deep. The weight of this electro-magnet is over 5,000 pounds, and the intensity of the magnetic field produced within the polar cavity after removal of the armature, though not uniform, may be estimated at a mean of 2,500 C. G. S. lines to the square centimetre. A long board was placed upon the base plate leading into this polar cavity, and the subject experimented upon lay on his back upon the board with his

head and shoulders in the cavity between the poles, and exposed thus to the full influence of the magnetic field. There would be comparatively feeble residual magnetism with no current in the coils. A switch so nearly silent in action as to be inaudible to the subject was arranged to close and

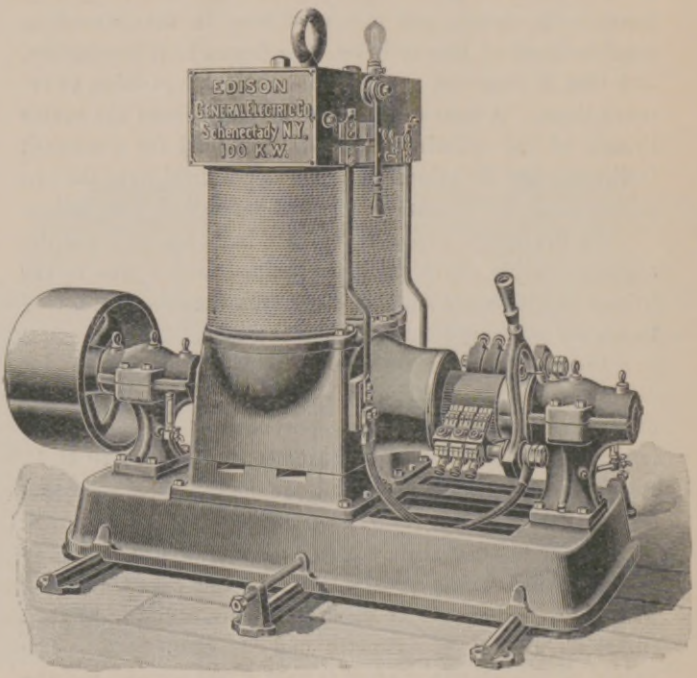

Fig. 3.—Type of dynamo used in experiments on the human head. The armature is in place.

open the exciting current circuit through the field coils. On closing the switch nearly the full magnetic intensity would be active and permeating the head within practically one second (theoretically it takes an indefinitely long

time to establish the full current and magnetism). Similarly on opening the switch, almost the whole intensity would disappear in about one second.

Five men, ourselves among the number, were subjected to trial. One case described will describe all.

The subject lay back upon the board and concentrated his attention upon his sensations. His right wrist was extended and was grasped by one observer, who took sphygmographic tracings of the pulse. A second observer placed a hand on his chest to observe any irregularity that might occur in respiration. A third observer, in view of these two but unseen by the subject of the experiment, opened and closed the switch that excited and relaxed the field, signaling to the first two observers as he did so. The strong magnetic influence was therefore turned on or off at will and without the knowledge of the subject. Several sphygmographic tracings were taken in each of our subjects, and in one the knee-jerk was tested continuously.

The sphygmographic tracings taken continuously during the *séance* show no change in regularity, in spite of the making and breaking of the enormous magnetic influence during its registration. The respirations were not changed in the least. The knee jerk also presented absolutely no change. As to common sensations, there were none that could be attributed to the magnetic influence, and the subject could not discover when or whether the field had been excited. The testimony of all five subjects was alike. In one experiment the subject held a steel screw in his mouth, and was then able to tell when the poles were magnetized or demagnetized, but only by the pulling of the screw to one side or another, not by any peculiar sensation or taste.

Our last series of experiments was in connection with reversed magnetism.

A large coil of stout, cotton-covered copper wire, about 30 ctm. high and 25 ctm. internal diameter, composed of nearly 2,000 turns and weighing about 70 kilogrammes, was

supported horizontally in such a manner that the head of the subject experimented upon could be freely introduced within the coil, and subjected to the electro magnetic field created there by passing a current through the wire. The resistance of the coil was 10 ohms, and its inductance 0·73 henry. An alternating electro-motive force of 1,200 volts, making 140 cycles or 280 alternations to the second, was connected with this coil, the current supplied being 1·85 ampères. The magnetic field in the coil would thus be reversed 280 times to the second. Each of the authors acted as subjects in the experiments, permitting the 1,200-volt alternating current to be made and broken frequently in the huge magnetic coil surrounding his head. No effect whatever was experienced. The coil itself hummed with the current, and a strip of sheet iron held in the cavity of the coil, but not touching it, vibrated perceptibly in the hand and gave a distinct, loud sound which was determined to be middle C of the musical scale by means of Helmholtz resonators.

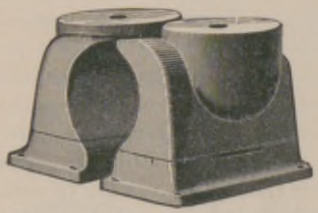

FIG. 4.—Showing merely the pole-pieces of the dynamo, with the armature removed. The head was placed in the cavity between them.

The authors conclude that the human organism is in no wise appreciably affected by the most powerful magnets known to modern science; that neither direct nor reversed magnetism exerts any perceptible influence upon the iron contained in the blood, upon the circulation, upon ciliary or protoplasmic movements, upon sensory or motor nerves, or upon the brain.

While our observations with reversed magnetism indicate that no appreciable influence is exerted upon the brain

when subjected to 280 magnetic reversals to the second, we were unable to experimentally alter this frequency, and the possibility remains that some particular frequency or frequencies might affect the nervous system. We hope to decide this question, within a suiable range of frequency, at some future time.

The ordinary magnets used in medicine have a purely suggestive or psychic effect, and would in all probability be quite as useful if made of wood.

While we have demonstrated conclusively the above facts, we do not deny the possibility of there being invented some day magnets enormously more powerful than any yet known to us, which may produce effects upon the nervous system perceptible to some of the sensory organs; for magnetism is certainly a remarkable force, and we find it very difficult to understand why it seems to have no influence whatever upon the human body and its wonderfully delicate neuro-electric mechanism.

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