ABRAMS' METHODS OF DIAGNOSIS & TREATMENT

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KNIGHT OF GRACE OF THE ORDER OF THE HOSPITAL OF ST. JOHN OF JERUSALEM IN ENGLAND

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CHAPTER IV

REPORT ON THE ELECTRICAL PROPERTIES OF AN OSCILLOCLAST

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EARLY in March of the present year I was asked by the Electronic Society to examine certain electromagnetic apparatus, with a view to ascertaining the nature of the electrical effects which it produces. The instrument is called an "oscilloclast," and it is said to be used with much success in the treatment of certain diseases.

A description of the apparatus and a very complete diagram of its connections, prepared by Messrs. A. S. E. Ackermann and W. Clark, has been published in *The Abrams Treatment in Practice*, by G. Laughton Scott. The drawing which accompanies the present report is a simplified diagram showing the apparatus in sufficient detail to illustrate the action and interaction of its various parts.

In this diagram C, C, are iron cores forming portions of the magnetic circuit of an electromagnet. On these cores four coils are wound, of which D, E, are connected, in series with each other and with a resistance R of about 250 ohms, to the 200-volt D.C. mains. When the switch S is closed, a current flows through these coils magnetising the cores. The coils F, G, are wound in the opposite direction on the cores, so that when current flows through them they have a demagnetising effect on the cores. An iron armature A, forming part of a rigid pendulum, can oscillate between a position in which it is in line with the cores and one in which it is well out of alignment. As the armature moves under the influence of the magnetic field towards the former position, electrical connection is established between the coils F, G, by means of a rotating arm H and a fixed contact piece J. Current then flows through these coils (which are in parallel with D, E), and the cores become demagnetised. When the armature, now swinging freely under gravity, moves in the opposite direction, contact becomes broken between H and J, and the cores become again magnetised.

It will be seen that contact of H with J is made and broken once in each oscillation of the armature. The "make" and "break," however, do not occur in the same position of the armature. This is due to the fact that the contact arm H is not rigidly attached to the armature, but is moved by a pin on A pressing alternately on the two sides of a slot in H. Contact of H with J is made when the armature is nearly in line with the cores: it is broken when the armature is far out of alignment. Consequently the rocking movement of the armature, once started, is maintained by the intermittent action of the magnetic field upon it.

Attached to the armature is another contact arm K, which passes over and makes contact with a fixed contact piece M in each half-swing of the armature. Thus M becomes connected to the negative supply main for a short period twice in each oscillation, that is, about 200 times per minute. It may be noted that contact is broken at HJ shortly after each alternate break of contact at KM.

The contact piece M is connected by insulated wire MN to a dial pattern resistance box Q, by means of which various resistances can be inserted between N and the treatment wire T. The box Q contains also two other similar sets of resistance coils, but only one set is shown in the diagram. In each dial, when the contact arm is at 0 or 11, the resistance is zero, at 1 it is 100 ohms, at 2, 200, and so on up to 10, which represents 1000 ohms. Some of the coils were tested for inductance, and found to be practically non-inductive. All three sets of coils are connected in the same way to the wire N. The neutral main is also connected to the resistance box by the wire U, which leads to a small lamp L and a plunger contact P attached to the ebonite top of the box. If this contact is closed with the treatment terminal *t*, the dial hand being on 10, the lamp glows at each contact between K and M, that is, twice in each oscillation of the armature. The lamp is only employed as a test of the connections, and is not in circuit during treatment. In practice, the subject, who is insulated, is treated by contact with the terminal *t*.

Finally, there is the apparatus indicated by Z in the diagram, consisting of a pair of coupled circuits, the primary of which includes an air core coil and the low resistance winding of a small induction coil. The primary circuit of Z is permanently closed, its ends being connected to neighbouring points at Y in the wire MN. The secondary circuit includes the high resistance winding of the induction coil and an open loop of wire wound on a wooden disc. The terminals of the secondary circuit are insulated, and since this circuit possesses self-inductance and capacity it might be expected to be the seat of electrical oscillations if suitably excited. The apparatus Z is placed underneath the electromagnet with the axis of the air core coil parallel to the cores of the latter.

The apparatus may also be used with alternating current, but owing to the greater constancy of the conditions under direct current supply this alone was employed in the experiments described below.

EFFECTS LOOKED FOR.—It will be convenient to enumerate here the various effects which might be expected to be produced when the apparatus is working. They are as follows :

1. *The Electrical Impulses.*—It is obvious that with the connections as in the diagram, at each contact between K and M, the wire MN, the resistance coils in Q, and the treatment wire as well as the subject, are connected for a short time to the negative main, and that in the intervals between these contacts the (negative) potential of these bodies falls to some extent owing to leakage. We may call the whole of the wire from M to *t*, including the

resistance coils of Q in series with it, the " line," and the periodic applications of potential to it at M the " electrical impulses." They are usually detected by means of a pair of head telephones, the end of one of their leads being held in the hand and the other lead near the line or the patient. The current in the telephones is the capacity current flowing into the body of the operator. The sound heard in the telephones is a click occurring twice in each oscillation of the armature, and usually followed by a musical note of short duration which can be identified with the hum of the machinery at the generating station.

Professor R. A. Millikan is reported in the *British Medical Journal* for January 26, 1924,[1] to have stated that the oscilloclast produces a frequency of the order of 400 to 500 per second. The note of the machinery was the only evidence of electrical vibration having a frequency of this order observed in the course of the present experiments.

2. *Electrical Oscillations of the Line.*—Since the line possesses self-inductance and the patient possesses electrostatic capacity, electrical oscillations might be expected (if certain other conditions are favourable) to be excited in the

[1] Quoted in *The Abrams Treatment*, p. 128.

line whenever the potential applied to it at M is suddenly changed. The effect of such oscillations, if they exist, is that the potential of the patient, instead of simply changing to − 200 volts, swings beyond that value and oscillates with decaying amplitude about it. Consequently the highest negative potential (or the "peak" potential) to which the patient is raised exceeds 200 volts by an amount depending upon the damping of the oscillation. The rate of damping depends upon the resistance in the line, so that the peak potential should vary when the resistance is changed. The rate of damping also depends upon the amount of leakage, being greater with a high than a low rate of leakage. If the damping due to line resistance or leakage is excessive, no oscillations are to be expected, but instead the potential will rise gradually to its maximum value without fluctuation.

3. *The Magnetically Induced Impulses.*—At each break of contact between H and J the flux in the magnet cores experiences a large variation, in consequence of which an electromotive force is induced in the coils D, E. This transient electromotive force is applied to the mains, and will produce, by conduction or by electrical induction, an effect in all parts of

the wiring of the apparatus, and in all electric light wires in its neighbourhood. To distinguish it from the "electrical impulse" (which is produced in the line by direct conduction from the negative main), and because of its magnetic origin, we will speak of this transient effect as the "magnetically induced impulse."

The magnetically induced impulse is produced at break, but not at make of contact at HJ, because when coils F, G, are in circuit the electromotive force induced in them by a change of flux is opposite in direction to that induced in coils D, E; and if they are exactly equal in magnitude, their resultant is zero.

It must not be supposed that the magnetically induced impulses here referred to, are the cause of the sounds which the operator hears at break when, wearing a pair of telephones (without holding one wire in his hand), he places his head near the electromagnet. These sounds are due to the direct magnetic action of the electromagnet on the telephones.

It may be noticed that when H and J are in contact a current of about 0·4 ampere flows in the coils D, E, and the same current in F, G. When contact is broken at HJ, the whole of the current (about 0·8 ampere) flows in D, E. The change of flux is therefore due not merely

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to the removal of the demagnetising ampere turns, but also to the increase of the magnetising ampere turns.

4. *Electrical Oscillations of Coils F, G.*—These coils possess self-inductance and capacity, and might therefore be expected to have oscillations set up in them when the current in them is suddenly interrupted, that is, when contact at HJ is broken.

5. *Electrically Excited Oscillations in Z.*—The apparatus Z might be expected to produce high frequency electrical oscillations whenever its terminal Y is suddenly changed in potential, the current then flowing into Z being purely capacity current.

6. *Magnetically Excited Oscillations in Z.*—The secondary of Z possesses, as already stated, the essentials of an oscillatory circuit, and any rapid change of the magnetic field in its neighbourhood (as at break of contact HJ) might be expected to set up such oscillations. They would be of less high frequency than those excited electrically.

EXPERIMENTS

MEASUREMENT OF PEAK AND R.M.S. VOLTAGE OF THE LINE.—The peak potential of the end of the line (with a subject in contact with it) was measured by the valve and voltmeter method, the line being connected to the filament of a diode valve and the plate to an electrostatic voltmeter. In order to secure very high insulation, however, it was found desirable to replace the voltmeter by a condenser and a ballistic galvanometer. The condenser becomes charged to the peak potential of the end of the line and is then discharged through the galvanometer. Within the limits of error of the experiment, the peak potential was found to be the same as the voltage of the mains and was not affected by the resistance of the line. The experiment was tried with various amounts of line leakage, still with the same result. It may be concluded that the line oscillation, if it exists, does not affect the peak voltage by more than about 1 volt.

If an electrostatic voltmeter is connected directly to the line it registers the R.M.S. voltage of the line. This is found to depend greatly on the amount of leakage from the line or the subject. With fairly good insulation, the R.M.S. voltage was about 170 volts, and with the line connected to earth through 1 megohm it was 110 volts. In no case did the reading of the voltmeter show any effect of a variation of line resistance.

The leakage current through a fairly well insulated subject was not more than one-fifth of a micro-ampere. If the subject placed his hand upon a table the leakage current increased to about one-half a micro-ampere.

WAVEMETER EXPERIMENTS.—A wavemeter was set up consisting of a number of coils of known self-inductance, any one of which could be connected to a variable condenser. A sensitive crystal detector and a pair of telephones were also connected to the condenser in the usual way. The wavemeter was usually placed in another room at a distance of about 25 feet from the apparatus, in a direction at right angles to the axis of the electromagnet cores. After a number of trials a distinct click, unaccompanied by any hum, was heard in the telephones when the wavemeter was adjusted to a certain frequency. The sounds were heard only at break of contact at HJ, that is, once only in each oscillation of the armature. They were loudest when the wavemeter coil was placed in a vertical plane passing through the electromagnet, and almost inaudible when the coil was turned so as to be at right angles to this plane. The frequency was found to be about six millions per second, corresponding to a wave-length of about 50 metres. The oscillation was equally in evidence when the apparatus Z was disconnected from the line at Y, and it was traced to the coil G, the frequency being diminished when a Leyden jar was connected to the contact piece J, the outer plate of the jar being earthed. The oscillation was detected when the wavemeter was placed in various positions with respect to the apparatus, and it was the only high frequency oscillation observed in these experiments.

If the treatment wire T was extended so as to reach to the neighbourhood of the wavemeter coil, the telephone sound at break became much louder, and it now showed practically no variation when the wavemeter capacity was varied over its whole range. The condenser could in fact be removed altogether, leaving only the coil, telephones, and crystal detector in series, and the sounds were as loud as before. In the experiments made to investigate this effect, the line was usually suspended horizontally between two insulated supports, and the coil was placed in the same horizontal plane and at various distances from the line.

If the coil was very close to the line, the sound of the electrical impulses (twice in each oscillation of the armature), easily identified by the musical ring which accompanied it, was heard. This was heard quite as well without the aid of the crystal, but the much louder sounds at "break" (*i.e.* just after each alternate electrical impulse) were heard only when the crystal was in circuit. Both sounds are evidently due to electrical effects transmitted along the line, and the fact that one of them requires the crystal indicates that the effect producing it consists of a rapid change of potential followed almost immediately by an equally rapid change in the opposite direction. This is just what is to be expected in a wave of potential arising from a rapid change of magnetic induction; and the further facts that the loud sound heard in the telephone at break was also produced when the horizontal wire, instead of being connected to the resistance box, was connected to the neutral main, or when the coil in series with the telephones and crystal was replaced by a loop of ordinary flexible wire held near the line, or near one of the electric light switches, left no room for doubt that these sounds were caused by the magnetically induced impulses.

The magnetically induced impulses in the line were found to vary with the line resistance, the sounds being much louder when the dial hand was at 0 or 11 than when it was at 10, and louder at 0 than at 1, at 1 than at 2, and so on. They were audible when the dial hand was between two numbers on the dial, and then about as loudly as at 10. These results were confirmed when a subject was connected with the end of the line.

The electrical effects in the apparatus Z were examined by connecting the telephones (with or without condenser and crystal) to the secondary terminals of the small induction coil, to a number of turns of insulated wire wound round it, or to a small coil placed near it. The only effects observed were two kinds of impulses similar to those found in the line. The sounds were quite unaffected by opening or closing the primary circuit or by short circuiting the secondary. No evidence was found of any current flowing in the circuits of Z as such, or of any high frequency oscillations generated in this portion of the apparatus or in the line.

SUMMARY

The effects produced by the oscilloclast examined, as found in the experiments recorded in the present report, may be described shortly as follows :

1. If the connections of the apparatus are as

shown in the diagram accompanying the present report, a person in contact with the treatment wire is subjected twice in each oscillation of the armature, that is, about 200 times per minute, to an electrical impulse due to his being brought for a short period into electrical connection with the negative main. At each impulse a certain charge of negative electricity is communicated to the person. In the intervals between the impulses his negative potential falls to a value depending upon the amount of leakage. With ordinary good insulation his R.M.S. voltage is about 170 volts. The electrical impulses are not affected to any appreciable extent by the resistance in series with the lead to which the subject is connected.

2. Shortly after every alternate electrical impulse, another impulse, of electromagnetic origin, is produced in the apparatus, and is transmitted along the treatment lead to the patient. These magnetically induced impulses are of very short duration, and are produced at the moments when the demagnetising coils of the electromagnet are thrown out of circuit.

3. The intensity of the magnetically induced impulses transmitted along the treatment lead varies when the resistance in series with the

lead is changed, being greatest when contact is at 0 or 11, and, diminishing as the resistance is increased, becomes least when contact is at 10.

4. An electrical oscillation is produced in the apparatus, the seat of which is one of the demagnetising coils of the electromagnet. It is excited each time the current in this coil is interrupted, that is, about 100 times per minute. The frequency of the oscillation is about six millions per second, corresponding to a wave-length of about 50 metres. The oscillation can be detected by a suitably tuned wavemeter placed in the neighbourhood of the apparatus if it is not too near the treatment lead or any other conductor along which the magnetically induced impulse is transmitted.

BANGOR, *April* 1925.

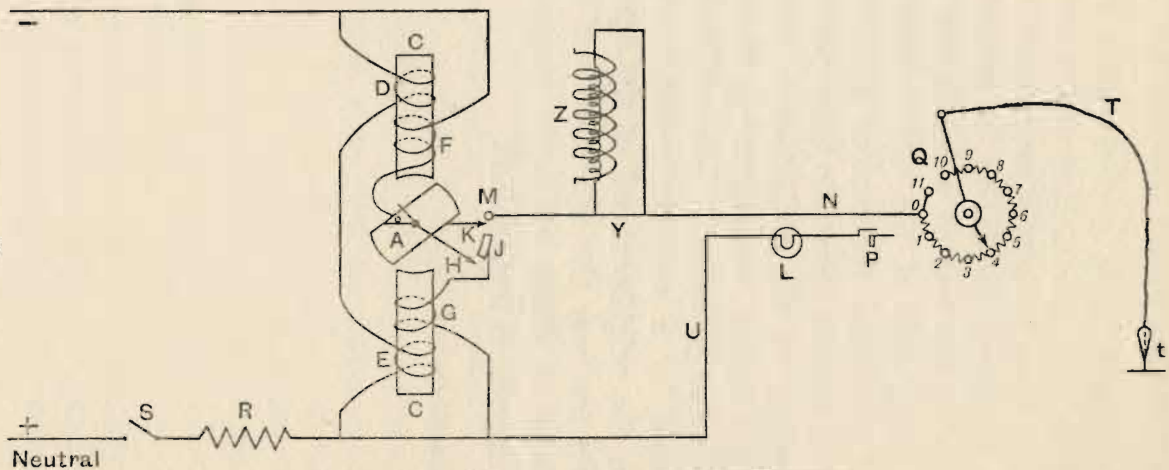

Diagram of Connections of an Oscilloclast.