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Graphic Records of Movements

by

F. Warner.

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A METHOD AND APPARATUS FOR OBTAINING GRAPHIC RECORDS OF VARIOUS KINDS OF MOVEMENTS OF THE HAND AND ITS PARTS, AND ENUMERATING SUCH MOVEMENTS AND THEIR COMBINATIONS. By FRANCIS WARNER, M.D.[1] Plate VI.

THE study of healthy movements and the analysis of the principal methods which have led to our knowledge of the functions of the brain have taught me to look upon the study of all kinds of muscular movements produced by the central nerve-mechanism as a promising field for accurate investigation. It appeared particularly desirable in this line of investigation to introduce an exact method and apparatus for obtaining graphic records of the various kinds of movements of the hand and its parts and for enumerating such movements and their combinations.

The apparatus consists of four principal parts:

I. An arrangement of rubber tubes to be attached to the hand, one tube to each finger or moving part (Fig. I. *A*, *B*, *C*, &c.). From these, pieces of thin conducting tubing (*a*, *b*, *c*) carry air to a set of tambours.

II. A frame supporting the recording tambours and electrical signals (Fig. II.).

III. An "electrical contact-making tambour" (Fig. III.). It is a modification of the Marey tambour adapted to the purpose of actuating an electrical counter.

IV. An electrical counter. See Fig. IV.

To explain each of these pieces of apparatus in further detail.

In the apparatus (Fig. I.) which is attached to the hand the principle employed is as follows. When a cylindrical tube closed at one end is

[1] Towards the expenses of this research a grant was made by the British Medical Association on the recommendation of the Scientific Grants Committee of the Association.

bent, flattened or compressed, its capacity is lessened and therefore air is pressed out of it and driven into the tambour with which it is connected. The tubes used are moulded for me by Messrs Warne and Co. of soft red rubber and are $7\frac{1}{3}$ mm. in external diameter, one end of the tube *x* is pointed and perforated, the other *y* is closed by a moulded cap (see Fig. I.), and a band moulded on to the top of the cap effects a means of fastening the tube to the finger. These tubes are mounted on a "foundation" of sheet red rubber fixed to the back of the hand, as in Fig. V. The arrangement represented in Fig. VI. *a* and *b* is convenient in the case of adults, in whom the thickness of the finger makes a considerable drag on the upper surface of the tube during flexion. It consists of a pair of moulded caps mounted on a ring, back to back: the septum between the two is divided half way down, and the lower portion is perforated, allowing air to pass from one cap to the other. The band is fastened to the middle of a phalanx, and the finger tube being cut at this point the divided ends are inserted one in each cap. The whole is thus rendered air-tight and the tension on the upper surface of the tube is relieved.

The tambours mounted on the frame (Fig. II.) give tracings upon a revolving cylinder, showing the amount, frequency, and coincidence of the various movements. The electrical signals indicate (1) time in seconds, (2) the opening of a dark lantern throwing light upon the subject of experimentation, (3) the period during which an electrical bell is ringing, (4) signals the time at which events occur as recorded in the notes of the experiment.

The electrical contact-making tambour is represented in Fig. III. Across the ordinary shell of a Marey tambour a main bracket *aa′* is fixed, to which three smaller ones are screwed, having holes in them to take two arbors. One arbor *b* has a beam *d, e*, with a small weight at one end *e*, and is connected by a short link with the india-rubber head of the tambour. To the other arbor *c* a block of ebonite is fixed to insulate two wires *f, g* with platinum ends which lie under and nearly touch the beam *d, e*. Each of these wires is connected with terminals *h* and *i* by a coil of thin copper wire. A light bent blade spring is inserted between the ebonite block and the bracket to resist the motion of the arbor *c*.

The beam *d, e* has platinum soldered on the part where the platinum ends of the wires are to touch. A terminal *k* is fixed to the main bracket. Increase of air pressure in the tambour raises one end of the beam *e* and depresses the other *d*, which thus comes in contact with its insulated wire *f*, completing a circuit through the terminal *i*; diminished air pressure allows the beam to move in the opposite direction, completing a circuit through the terminal *h*.

I am indebted to Prof. Hughes, F.R.S. for the suggestion that some kind of sliding contact would fulfil the purpose. The instruments are made for me by Mr W. Groves, of 89, Bolsover Street, W.

The electrical counter (Fig. IV.) consists of a clock[1], to the pendulum of which a small piece of soft iron *c* is attached, opposite an electro-magnet *d*. In use, for counting the movements of a finger the conducting tube (Fig. III. *l*) from the finger is attached to the electrical contact-making tambour. One pole of a Leclanché cell is connected with *k*, and a wire connects *i* with *a* in Fig. IV., to which *b* is connected with the other pole of the cell. Each flexion of the finger thus allows the escapement of the clock to pass one tooth, and the hands indicate on the dial the number of flexions.

It is hoped that the electric contact and counter on account of their simplicity may prove useful in various ways in physiological work.

By this method of investigation we obtain tracings of muscular movements due to the action of the central nerve-mechanism, and obtain some evidence as to the effects of brain action in its different parts as indicated by muscular movements.

In infancy spontaneous movements of the fingers are usual while the child is awake (see tracing 1 and 2 taken from fingers of an infant 5 months old), and spontaneous muscular movements are occurring all over the body; this movement can be arrested by light and probably also by sound. In studying the mental development of infants we mainly judge of their rapidity and stage of growth by observing the amount, kind and coordination of their movements, *e.g.* the movements of the head and eyes to a light and sound give some indication of dawning intelligence; these signs are not seen in the earliest stages of growth. Later in the course of the development of the brain the finger movements are so coordinated as to grasp an object, and still later the two hands act together. Tracings could be given of these movements, separate movements might be enumerated[2], and I believe we might enumerate the special combinations of movement, showing whether such

[1] I am indebted to Percy Neate, Esq., engineer, for kindly making the first model of this counter.

[2] In a paper on "The signs of a healthy brain and mental development in an infant as indicated principally by its movements." I have given thirteen signs all of which may probably be recorded by these methods. See *Medical Times and Gazette*, April 21, 1883.

combinations occur more commonly at one time than at another or more commonly under any particular set of circumstances. To investigate this problem I would take tracings of the spontaneous movements of an infant hand, enumerate them and their combinations. Then showing an object to the infant record the effect of the sight of the object (*i. e.* the effect of the light reflected from the object) in altering the movements, their amount and combinations. If the brain be retentive of the stimulus causing such movements, the special combinations of movement will tend to recur on the same stimulation and the impression on the brain will be strengthened. The working-out of this problem might give some idea as to how the mind is built up, or the function of mentation evolved in the individual. In many cases an increase of muscular movement may be demonstrated as an accompaniment of a low degree of voluntary power or diminished mental force, as in some cases of chorea and nervous children the subject of frequent headaches in whom spontaneous finger twitches are common. These nerve-muscular movements are to us the signs as to what part of the brain acts, a sudden nerve-muscular movement is produced by a sudden discharge of force in the corresponding nerve-mechanism. The tracings of such spontaneous movements indicate in some particulars the discharge of the nerve-mechanism corresponding; thus in spasm we see one finger or one part jerked at one time, another finger or another part at another time, showing that the various pieces of the nerve-mechanism do not discharge their motor power altogether. An interesting problem would be to investigate accurately the following phenomena. The spontaneous movement of children is nearly lost in adult age, it is apparently replaced by the function of "mentation." When the function of mentation is lessened, as by fever, the excess of movement often reappears in delirium and subsultus tendinum. In many so-called mental conditions the emotions are expressed by the action of the muscles of the face and hand, in other words we judge of the condition of the nerve-mechanism whose function is "mentation" by certain nerve-muscular movements whose exact record and measurement is the object of our enquiry.

Another possible problem may be indicated as follows: It seems to me highly probable that when two movements happen to occur together by chance, or when they occur together as the result of some external agency (*i. e.* when two portions of the nerve-mechanism coact and therefore are probably co-nourished) that a bond of union is formed, making them tend to co-act in the future unless some disturbing cause prevent. As an illustration; a number of pendula of similar lengths may be set swinging irregularly, arrest two for a second, then let them swing at the same time and they continue to swing together. If this proposition be true it may be demonstrated by the experimental method, we may determine what agencies bring about such co-acting, their relative value, &c., if new combinations of movements occur without the influence of external agencies acting on the subject, the formation of these combinations must be intrinsic, the result of growth or development.

Note. Since the above paper was written I have succeeded in counting combinations of finger movements. To record on a counter the coincident movements of three finger tubes, connect each tube with a contact making tambour 1, 2, 3. Connect *k* in the first tambour with one pole of the battery, connect *i* in this tambour with *i* in the second, and *k* in the second tambour with *i* in the third tambour, and *k* in the third tambour with the other pole of the battery, throwing the counter into the circuit.

Fig. 1.

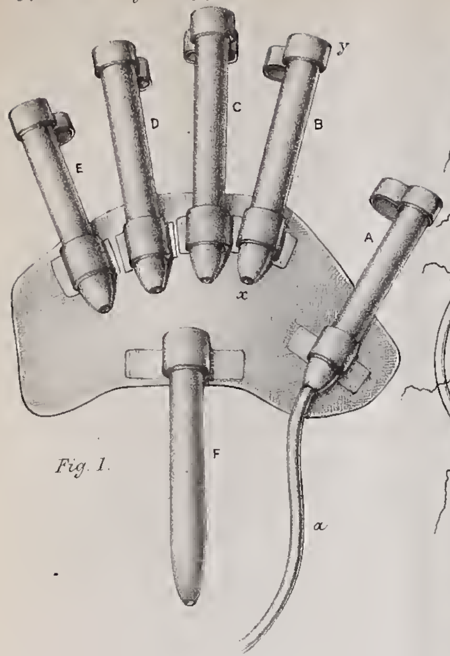

Fig. 2.

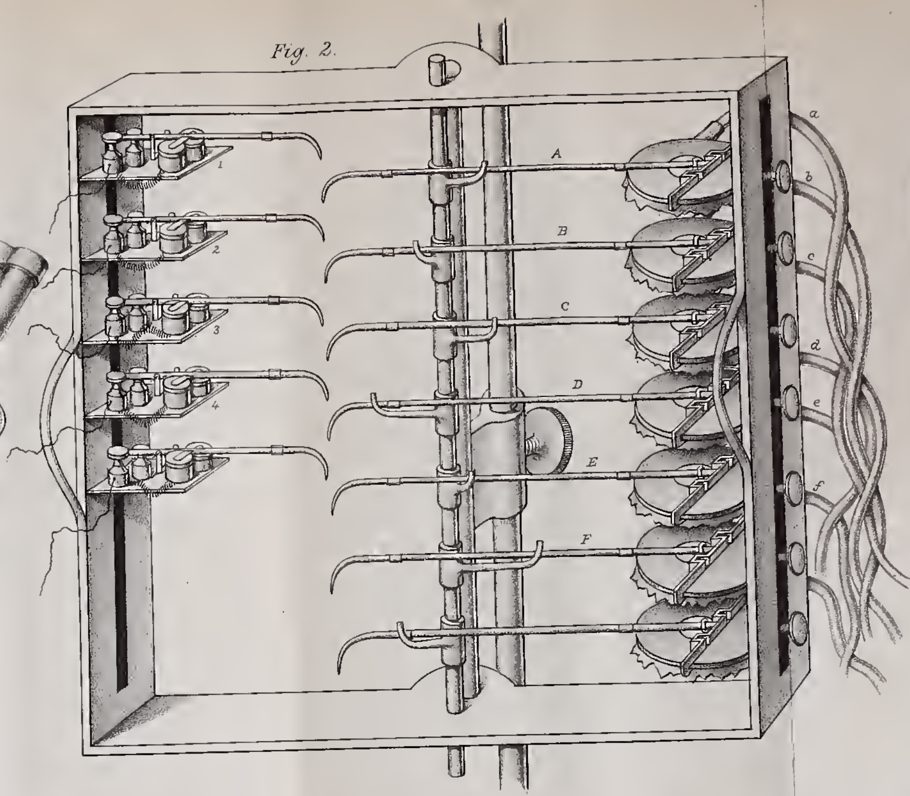

Fig. 5.

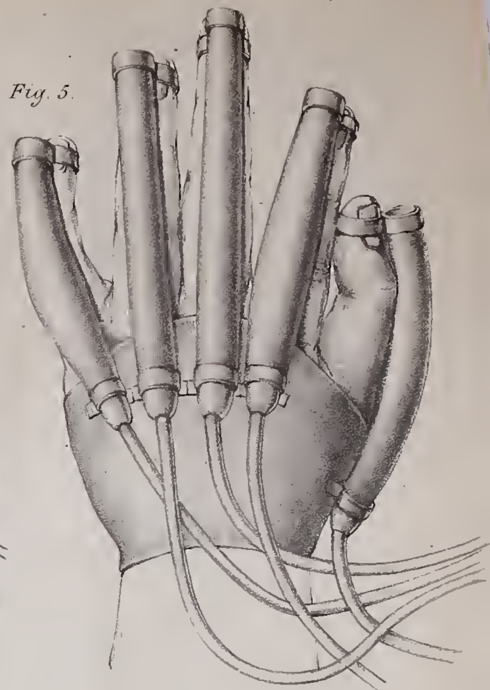

Fig. 3.

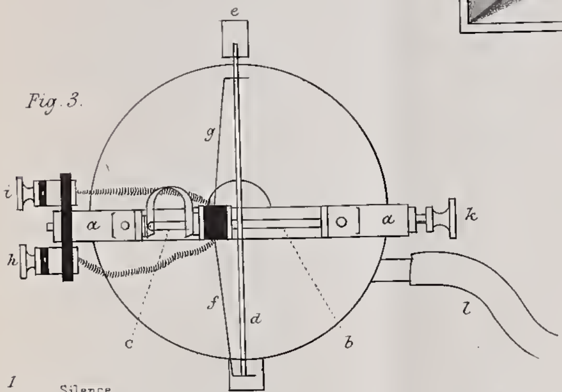

Fig. 6.

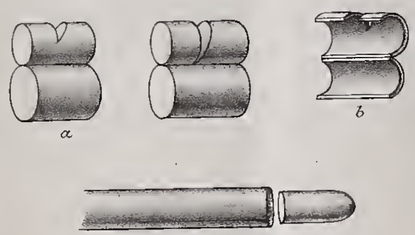

Fig. 4.