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APPARATUS FOR THE TREATMENT OF ORGANISMS WITH ELECTRICAL CURRENTS

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Fig. 1.

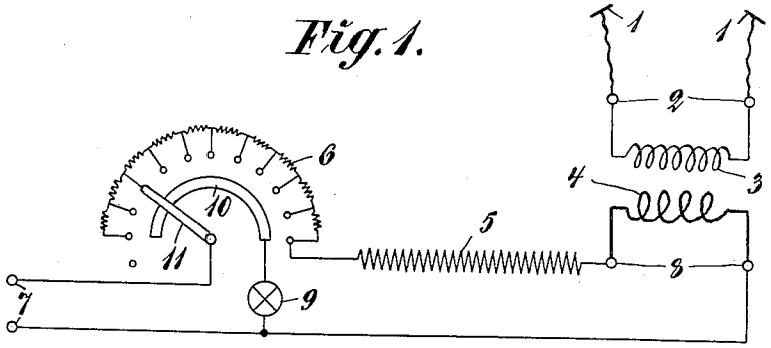

Fig. 2.

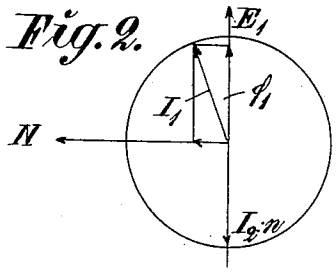

Fig. 3.

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APPARATUS FOR THE TREATMENT OF ORGANISMS WITH ELECTRICAL CURRENTS.

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It has been known for a long time to treat the human organism by means of electrical current both high frequency alternating current and direct current having been used for that purpose. The investigations underlying the present invention have proved that most favourable physiological effects are obtained by using an alternating current of a relatively low frequency, preferably 15–60 periods per second, and having a sinusoidal or approximately sinusoidal voltage curve. It has been found that the excitement of the nerves caused by such alternating current produces muscular tensions resulting in an internal muscular work and an increased renewal of substances combined with a certain heating effect, the latter being obtained as a secondary effect of the increased renewal of substances. In this respect the effects of these currents essentially differ therapeutically from the effects of the high frequency currents hitherto usually employed, which are conducted chiefly only through the outer parts of the organism and by means of which a heating effect is obtained exclusively as an electrothermical effect. This invention has for its object to provide means, whereby it may be possible to apply to the human organism or other organism a low frequency alternating current of a relatively high voltage sufficient to overcome the initial resistance of the organism. Under usual conditions such a voltage may be dangerous to weak organisms and in any case it will be uncomfortable for the patient owing to the fact that the resistance of the organism rapidly decreases immediately after the current has been applied. This inconvenience is overcome according to the present invention by using a regulating device which operates in such a way that the initial high voltage will automatically decrease, as the resistance of the organism decreases, to a voltage which is harmless to the organism, the strength of current being maintained substantially constant in spite of the changes of the resistance of the organism occurring in the course of treatment.

The invention will be more closely described with reference to the accompanying drawing, in which Fig. 1 shows a circuit diagram of one form of the invention. Figs. 2 and 3 are diagrams illustrating the mode of operation.

The electrodes 1 adapted to be applied to the organism are connected each with one of the terminals 2 of the secondary winding 3 of a transformer having a relatively high transformation ratio, for instance 25:1 between the secondary winding 3 and the primary winding 4. The winding last mentioned is connected to terminals 7 of a supply main or a generator supplying an alternating current of a sinusoidal voltage curve and of a constant amplitude. Connected in series with the primary winding 4 are a large fixed series resistance 5 and a regulating resistance 6 the ohmic resistance of which is likewise relatively high. By way of example it may be assumed that the voltage between the terminals 7 is 420 volts while the regulating resistance 6 has an ohmic resistance of about 2000 ohm and the series resistance 5 an ohmic resistance of about 1000 ohm. The voltage between the primary terminals 8, when the whole resistance 6 is included, may be for instance 10 volts provided the secondary circuit is open. The no-load voltage at the secondary side of the transformer will then be 250 volt assuming the transformation ratio being that mentioned above. If the electrodes 1 are applied to the organism before the primary circuit is closed, the secondary voltage will attain the value of the no-load voltage only during a very short moment upon the closure of the primary circuit and it will then rapidly sink to about $\frac{1}{10}$ of the no-load voltage, the electrical resistance of the organism at the same time rapidly decreasing under the influence of the high voltage in the first moment. In treating the organism with a current supplied directly from a generator such high voltage as 250 volt, which has proved to be a suitable voltage to overcome the initial resistance of the body, would involve a certain risk for weak organisms and in any case the reduction of resistance of the organism occurring immediately after the closure of the current would cause a considerable increase of current and of the physiological excitement which would have to be compensated by repeated adjustments of a series resistance. In the arrangement described, on the other hand, such adjustments by hand are obviated by the said automatic regulation whereby the physiological state of excitement of the organism once adjusted is invariably maintained. This automatic regulating effect is explained by the fact that the strength of the primary current of the transformer is maintained

practically constant on account of the provision of large series resistances. When the resistance between the electrodes 1 decreases, both the primary voltage and the secondary voltage of the transformer will automatically decrease and, as a consequence, a considerable initial voltage can be applied to the organism without any risk. As soon as a stationary condition is reached the supply of current can be increased by a successive disconnection of the resistance 6. In the arrangement described it is thus possible, as experience has proved, to increase without risk the primary current up to a value corresponding to a no-load voltage at the secondary side of about 625 volt. Having regard to this fact the regulating resistance and the fixed resistance are preferably given such resistance values as to make it possible to vary the secondary no-load voltage from 0 up to about 750 volt.

The primary current I_1, the magnetic flux N in the iron core of the transformer, the primary voltage E_1 and the secondary current I_2 may obviously be represented by vectors in a vector diagram as shown in Fig. 2 in which the radius of the circle is equal to the length of the vector of I_1 the amplitude of which is practically constant.

As the secondary resistance R_2 which is practically free from inductance and capacity is determined by the relation

$$R_2 = \frac{E_2}{I_2} = \frac{E_{20}}{I_{2k}} \cdot tg\ \phi_1,$$

where E_{20} is the no-load value of the secondary voltage and I_{2k} the secondary short circuit current, it is possible to illustrate in a co-ordinate system, the variations of the secondary voltage and the secondary current when altering the secondary resistance, i. e. the resistance of the body of the patient between the electrodes.

The diagram in Fig. 3 shows the curves for E_2 and I_2 as functions of the secondary resistance R_2 in a particular measured instance in the arrangement described. The transformation ratio n was 22.7. The resistances 5 and 6 in the primary circuit had each a value of 2000 ohm. In no-load running the primary voltage was 10 volt, and, as a consequence, the secondary voltage E_{20} was 227 volt. In short-circuiting the secondary current I_{2k} was 10.2 milliamp. Thus in this case the following equations are obtained:

$$tg\ \phi_1 = \frac{I_{2k}}{E_{20}} \cdot R_2 = \frac{10.2}{227000} \cdot R_2$$

$$I_2 = 10.2 \times \cos \phi_1 \text{ milliamp.}$$

$$E_2 = 227 \times \sin \phi_1 \text{ volt.}$$

As the resistance of the body including the variable intermediate contact resistance at the electrodes usually varies during the course of treatment between about 2000 and 8000 ohm (the shaded part in Fig. 3), the strength of current in the body of the patient will, as seen from the drawings, remain practically constant during the treatment even at very strong fluctuations of the resistance, owing to the fact that the current curve has a relatively flat form within the said resistance limits. In known systems for therapeutical treatment with electrical current, on the other hand, strong fluctuations of current will occur during the treatment partly, as mentioned above, on account of the variations of the resistance of the body itself and partly on account of the variations of the intermediate resistance at the electrodes which variations are often very large. In the arrangement described the said inevitable resistance fluctuations have no noticeable influence on the strength of current. It is thereby made possible to maintain during the treatment an even and uniform physiological state of excitement producing a strong therapeutical effect.

Instead of ohmic series resistances other alternating current resistances may be used, for instance choking coils, if the regulating resistance 6 is replaced by a choking coil, the required regulation may be obtained in known manner by making the air gap adjustable.

It is evidently important that the electrodes 1 should not be applied to the organism at such high voltages which exist when the regulating resistance is disconnected wholly or to a great extent. When making the contact with the body the primary circuit should preferably be broken. In order to secure the disconnection of the source of current before the beginning of the treatment a warning signal controlled by the switch arm 11 of the regulating resistance may be provided said signal, in the example shown, consisting of a signal lamp 9 interconnected between one of the terminals 7 and a contact bar 10 so that the lamp circuit is closed through said bar and the switch arm 11 as soon as any part of the regulating resistance 6 is cut in, but is opened on the latter being disconnected and the primary circuit broken. In case the regulating resistance should be connected in circuit before the beginning of the treatment attention is called thereto by the light from the warning lamp 9.

I claim:

1. An apparatus for the treatment of organisms with electrical current supplied to the organism by means of electrodes, characterized by the electrodes being connected to the secondary circuit of a transformer the primary winding of which is connected through a series resistance to a source of low frequency alternating current the voltage of which is relatively high and adapted

to be reduced by the said series resistance to a suitable low primary terminal voltage which in turn is stepped up by the transformer to a secondary terminal voltage sufficient to overcome the initial resistance of the organism, said secondary terminal voltage automatically decreasing, upon the electrodes being applied to the organism, to a value which is safe to the organism with regard to the subsequent decrease of its resistance.

2. An apparatus as claimed in claim 1, characterized by the series resistance being large enough to maintain the primary current practically independent of the variations of resistance of the secondary circuit.

3. An apparatus as claimed in claim 1, characterized by the primary winding of the transformer being connected to the source of current through a fixed resistance and a regulating resistance.

4. An apparatus as claimed in claim 1, characterized by the primary winding of the transformer being connected to the source of current through a fixed series resistance chosen so as to prevent the secondary voltage to exceed a safe value (for instance 75 volt) on short-circuiting the regulating resistance (6) while the secondary circuit is closed, whereas the no-load secondary voltage may amount to a many times higher value (for instance 750 volt).

5. An apparatus as claimed in claim 1, characterized by the provision of a signal device preferably consisting of a lamp the circuit of which is controlled by a switch arm of the regulating resistance in such a manner that the lamp will be lighted, as soon as any part of the regulating resistance is switched in, but is disconnected, when the primary circuit is broken.

In testimony whereof I affix my signature.

WILHELM T. ARNBERG.