

July 15, 1952

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2,603,753

APPARATUS FOR EXAMINING TEETH

Filed April 29, 1947

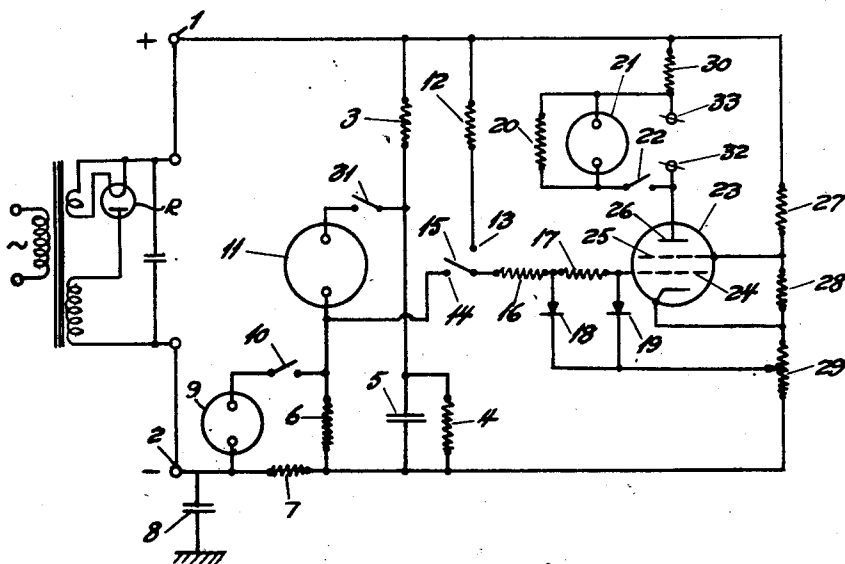


Fig. 1.

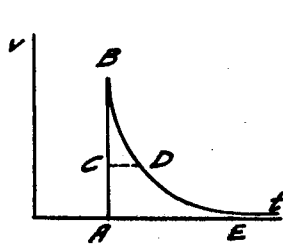


Fig. 2.

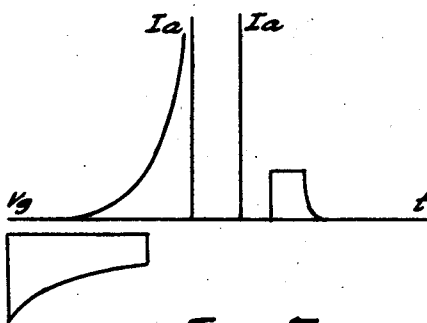


Fig. 3.

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2,603,753

APPARATUS FOR EXAMINING TEETH

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Djursholm, SwedenApplication April 29, 1947, Serial No. 744,616
In Sweden April 29, 1946

6 Claims. (Cl. 250—36.13)

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An important problem in dentistry which has not hitherto been effectively solved is the determination of the state of teeth as regards the excitability of the sensitive elements. On one hand it is possible by such determination to get an idea of the general state of the tooth and the tooth pulp and to diagnose pulp diseases, and on the other hand one can estimate the effect of applied anesthesia. The present invention relates to a method and means for making such determinations.

Systematic investigations have shown that by applying, to the tooth, electrical impulses of a suitable shape by means of an appropriate electrode and by determining the current value at which these impulses are just being perceived (threshold value) one can obtain an extraordinary good knowledge of the state of the tooth. However, in order to obtain observations which may easily be repeated, or compared, it has proved necessary to use electrical impulses of a particular shape. Thus, the impulses applied to the tooth should be unidirectional and preferably of a substantially rectangular shape. Furthermore, it is of a particular importance that the impulse exhibit a steep wave front, i. e. the current should rise suddenly from zero to the intended value, thereupon remain at this value during a certain period, and finally rapidly decline to zero. The requirement that the current should drop abruptly at the end of the impulse need not be fulfilled with the same degree of accuracy as that governing the rise of the current at the front side of the impulse, however. If the demand for reproduceable results is small one may also use triangular or other impulses, though with less advantage. The investigations carried out have also shown that the duration of the impulse is of a rather great importance. The use of too short impulses is accompanied by marked disadvantages. Thus the range of operation of the device will be narrower since with short impulses larger currents are required to obtain excitation. Moreover, unavoidable variations in the duration of the impulse may influence the accuracy of the results. On the other hand too long impulses are also undesirable since damages to the tissues may then be feared for different reasons. It has been found that the duration of the impulse preferably should be from 1 to 200 msec., the most suitable interval being from about 5 to 40 msec.

The strength of the impulse, or current strength, to some extent depends upon the electrode used. With an excitation electrode hav-

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ing a contact surface area of about 3 mm.² (1.75 x 1.75 mm.) it will be found that a normal healthy tooth exhibits a threshold value of some microamperes, whereas a tooth having a diseased pulp, or one which has been anesthetized in some known manner, will react only at a higher current strength. Should no response be obtained at a current strength of from 40 to 60 micro-amperes, this is an indication that the pulp is either dead or has been deprived of its sensitivity by anesthesia.

Furthermore it should be noted that the polarity of the impulse has a certain influence. Thus, it has been found preferable to have the current pass from the tooth to the electrode, this giving lower threshold values than current flow in the opposite direction.

The application of current to the tooth is most simply effected by having the patient grip a hand electrode connected to the positive pole of an impulse source while simultaneously contacting the tooth by means of an excitation electrode connected to the negative pole of said source. Taking off the current from the tooth by means of the excitation electrode may present some difficulty. Detailed investigations have shown that the excitation electrode preferably should consist of a material which is somewhat yielding so as to conform itself to the shape of the tooth and which is also capable of absorbing an electrolyte serving as a current conducting medium. Certain woods, such as aspen, alder, birch, pine, balsam and spruce, which have been soaked with physiological saline solution, for instance, have proved excellent for the purpose. However, the invention is not limited to the use of an excitation electrode of these materials, it being possible to use also electrodes of other types, such as electrodes consisting of a conducting rubber material, wire bundles etc.

For producing the desired electrical impulses any suitable apparatus may be used. In the following a preferred form of apparatus will be described with reference to the accompanying drawing, wherein:

Fig. 1 is a circuit diagram of the apparatus;

Fig. 2 is a voltage diagram showing the form of the initial voltage impulse produced; and

Fig. 3 is a current diagram showing the form of the output current impulse.

The input terminals designated 1 and 2 are connected to a source of comparatively high voltage, such as a rectifier R. A voltage divider comprising two resistors 3 and 4 is connected across said input terminals. A condenser 5 is connected

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to the voltage divider and is charged to a voltage sufficient to cause break down of a glow discharge tube 11 through which the condenser 5 is discharged, the object of the voltage divider 3, 4 being to prevent the condenser from being charged to the whole voltage available in case the glow discharge tube 11 should fail. When the condenser 5 is discharged through the glow discharge tube 11, current will flow through a resistor 6 causing a voltage drop across the same. The voltage across this resistor 6 will have the form designated ACBDE in Fig. 2. The maximum voltage drop across the resistor 6 will be nearly equal to the difference between the break down and extinction voltages of the glow discharge tube 11. It is seen in Fig. 2 that the voltage rises practically immediately to the maximum value and then decays exponentially. The voltage impulse thus obtained is applied to the control grid 24 of an amplifier tube 23 which is shown in Fig. 1 as being of the screen-grid type but which may also be a triode or a pentode. For certain reasons it is preferable to use a tube with a high plate resistance. In order to produce the desired rectangular output current impulse the voltage impulse is applied to the control grid 24 through resistors 16 and 17 which are connected to the sliding contact of a potentiometer 29 through half-wave asymmetric rectifiers 18 and 19. Since the resistance of these rectifiers is very low in the forward direction the voltage of the control grid 24 can rise only to the value which is determined by the setting of the potentiometer 29. The impulse applied to the control grid 24 therefore will have the shape ACDE shown in Fig. 2, i. e. it will exhibit a steep front and a somewhat less steep decline which is the shape that investigations have shown to be suitable. The voltage impulse applied to the control grid 24 releases a current impulse in the plate circuit 26 of the tube in a known manner, this current impulse being of the same general shape as the impulse ACDE, as shown in Fig. 3. Since the setting of the potentiometer 29 determines the maximum voltage value applied to the control grid 24, which value corresponds to the voltage A—C (Fig. 2), it is possible to vary the strength of the output current impulse by adjusting the setting of the potentiometer. In order to obtain more uniform calibration of the potentiometer dial, the amplifier tube 23 may suitably be of the variable-mu type. If the potentiometer 29 is of the linear type, adjustment of the same through equal angles will always bring about equal percentage changes in the strength of the output current impulse. The screen grid 25 of the amplifier tube 23 is connected in the usual manner to a voltage divider comprising resistors 27 and 28.

In order to provide for easy calibration of the apparatus a switch comprising a movable arm 15 and two fixed contacts 13 and 14 is provided. When the arm 15 goes to contact 14 the impulses from the glow discharge tube 11 will pass to the amplifier tube 23 as described. If, on the other hand, arm 15 is moved to contact 13, a voltage corresponding to the setting of the potentiometer 29 is constantly applied to the control grid 24 of the amplifier tube by means of a resistor 12 connected to a positive voltage. The output current strength then obtained corresponds to the maximum current strength of the current impulse and may conveniently be determined by a meter connected in the plate circuit of 26.

When using the apparatus above described for tooth examining purposes the excitation electrode

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is preferably connected to the output terminal 32 nearest to the plate 26, whereas the hand electrode is connected to the other output terminal 33. In order to ascertain that the amplifier system functions correctly, a glow lamp 21 with a resistor 20 across it is provided which may be connected in the plate circuit of tube 23 by means of a switch 22. At a certain setting of the potentiometer 29 corresponding to a voltage drop across the resistor 20 equal to the break down voltage of the glow lamp 21 this lamp will flash each time an excitation impulse is sent out. A resistor 30 connected in the plate circuit of tube 23 serves to prevent dangerous currents from flowing in case of the tube 23 becoming defective.

In observing the reactions of the patient the operator should preferably be warned when the excitation impulse is sent out. On the other hand it is important that the patient himself be unaware of this moment as otherwise he may be inclined to respond to unduly low current strengths. For the same reason the excitation impulses should be sent out at irregular intervals, or at times determined by the operator. The strength of the impulses is generally varied between 0.1 and 15 microamperes per 1 mm.² electrode surface.

For indicating when an excitation impulse goes out a glow lamp 9 may be provided. This glow lamp may be connected in parallel with the resistor 6 by means of a switch 10 and is caused to flash by the voltage appearing across this resistor at each impulse. Since in many cases this voltage may be lower than the break down voltage of the glow lamp 9 the same may be backed by the voltage drop across a resistor 7 through which the entire current of the apparatus flows.

A push-button switch 31 is connected in the lead to the glow discharge tube 11. This switch is normally open and is closed by the operator when it is desired to produce an impulse.

Finally the apparatus may be earthed for A. C. by means of a condenser 8.

The form of the discharge curve shown in Fig. 2 is determined by the characteristics of the glow discharge tube 11 and the values of condenser 5 and resistor 6. The interval C—D depends upon the voltage at which the rectifiers or asymmetric units 18 and 19 begin to operate which in turn is governed by the adjustment of the movable contact of potentiometer 29. The interval between two impulses depends upon the values of condenser 5 and resistors 3 and 4, the characteristics of tube 11 and the voltage between 1 and 2. The output current from terminals 32, 33 depends upon the characteristics of tube 23, the screen grid voltage, i. e. the voltage drop over resistor 28, the adjustment of the movable contact of potentiometer 29 and to some degree upon the plate voltage of tube 23, i. e. upon the voltage between 1 and 2 and the value of resistor 30.

In a practical embodiment of the apparatus the voltage between 1 and 2 was about 800 volts. Tube 11 was a type OA4G, resistor 3 was 4 megohms, condenser 5 was 1 μ d., resistor 4 was 5 megohms, resistor 6 was 10,000 ohms and the voltage drop over resistor 7 was about 30 volts. The asymmetric units 18 and 19 were constituted by the two diode-systems of a type 6H6 tube, the resistors 16 and 17 (not very critical) were each .5 to 2 megohms. Tube 23 was a 6K7, and the voltage drop over resistor 28 was 45 volts and over potentiometer 29 about 60 volts.

If the movable contact of the potentiometer 29 was placed at about 10 volts from the lower end,

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the plate current of tube 23 (resistor 30—about 1 megohm) was inferior to 1 microampere, and when the movable contact was placed at about 35 volts from said lower end, the plate current was about 100 microamperes. With an electrode surface of about 3 mm.² this gives a variation in the output current of from 0 to about 30 microamperes per 1 mm.².

With the above values for the resistors, condensers and voltages on the rectifiers 18—19 an impulse duration of about 15–20 milliseconds was obtained the impulses being sent out at a frequency of about 1 impulse per second.

The smaller the resistor 3, the greater will be the number of impulses generated per second, and the greater the condenser 5, the lesser will be the number of impulses generated per second. The smaller the resistor 6 and the smaller the condenser 5, the more rapid will be the discharge and the shorter will be the impulse duration, other factors remaining constant. The higher the voltage is between the movable contact of the potentiometer 29 and the lower end of the potentiometer resistance, the shorter will be the duration of the impulse.

While we have described our invention in connection with a preferred embodiment of the apparatus, it is to be understood that various modifications may be made without departing from the spirit of the invention as defined by the appended claims.

What we claim is:

1. In an apparatus for examining teeth by an electrical excitation method, a generator for producing electrical impulses of a substantially triangular shape and exhibiting a steep front, an amplifier including an amplifier tube, means including a resistance element for applying said triangular impulses to the control grid of said amplifier tube, and a rectifier connected between said control grid and an adjustable voltage source, said rectifier serving to determine the maximum voltage applied to the control grid so as to produce substantially rectangular current impulses in the output circuit of the amplifier tube.

2. An apparatus as claimed in claim 1, wherein the amplifier tube is of the variable- μ type.

3. In an apparatus for examining teeth by an electrical excitation method, a generator for producing electrical impulses of a substantially triangular shape and exhibiting a steep front, said generator comprising a condenser and a glow discharge tube for periodically discharging said condenser, a resistance element connected in the circuit of said glow discharge tube, an amplifier including an amplifier tube, means including a resistance element for conveying said triangular impulses from the first-mentioned resistance element to the control grid of said amplifier tube, and a rectifier connected between said control grid and an adjustable voltage source, said rectifier serving to determine the maximum voltage applied to the control grid so as to produce substantially rectangular current impulses in the output circuit of the amplifier tube.

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4. In an apparatus for examining teeth by an electrical excitation method, a generator for producing electrical impulses of a substantially triangular shape and exhibiting a steep front, said generator comprising a condenser and a glow discharge tube for periodically discharging said condenser, a resistance element connected in the circuit of said glow discharge tube, an amplifier including an amplifier tube, means including a resistance element for conveying said triangular impulses from the first-mentioned resistance element to the control grid of said amplifier tube, a rectifier connected between said control grid and an adjustable voltage source, said rectifier serving to determine the maximum voltage applied to the control grid so as to produce substantially rectangular current impulses in the output circuit of the amplifier tube, and a glow lamp connected across said first-mentioned resistance element and serving to visually indicate the impulses generated.

5. In an apparatus for examining teeth by an electrical excitation method, a generator for producing electrical impulses of a substantially triangular shape and exhibiting a steep front, an amplifier including an amplifier tube, means including a resistance element for applying said triangular impulses to the control grid of said amplifier tube, a rectifier connected between said control grid and an adjustable voltage source, said rectifier serving to determine the maximum voltage applied to the control grid so as to produce substantially rectangular current impulses in the output circuit of the amplifier tube, and a glow lamp with a parallel resistor connectable in the output circuit of said amplifier tube.

6. An apparatus as claimed in claim 3, wherein means are provided for manually triggering the impulse generator.

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