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DIATHERMY DOSAGE METER

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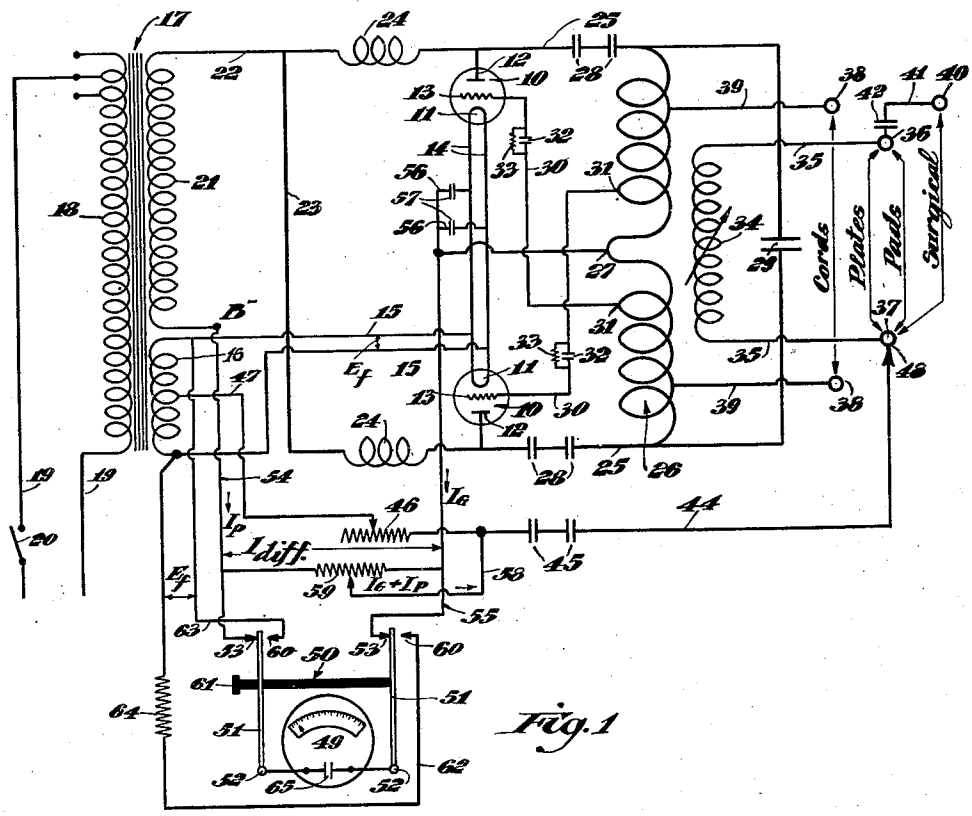


Fig. 1

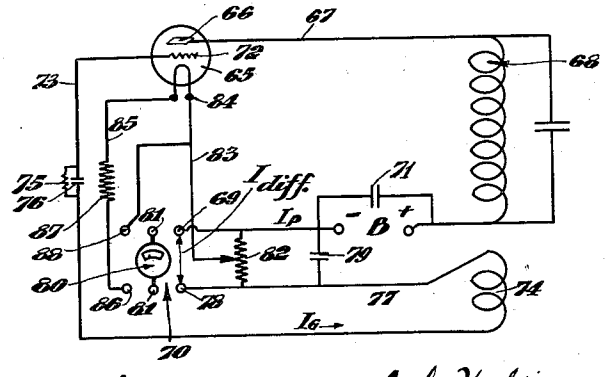


Fig. 2

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DIATHERMY DOSAGE METER

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This invention relates to electro-therapeutics. More particularly, the invention is directed to improvements in the measurement and control of dosages of electrical energy applied to patients from short wave heat machines of the type adapted to use in physical therapy.

Broadly speaking, short wave physical therapy comprehends the generation of heat in human tissues by means of electrical instrumentalities adapted to provide energy to the issues in the form of rhythmic oscillating currents, which vary in direction of flow at highly frequent intervals. At the present time the short wave heat treatments are recognized to be of value in the treatment of infections in the respiratory tracts, in various suppurative processes, in chronic arthritis, in pneumonia and in the treatment of bursitis, and in similar instances where heat is expected favorably to influence physical conditions.

In general, two methods have been used in the past to induce short wave currents into the body or into the body parts which are afflicted.

The first of these is called the condenser method and involves the use of insulated spaced plates or pads. These plates or pads are associated with a short wave current generating apparatus, and, when a body of tissue is placed between these applicators, the current flows through the body by reason of its electrical capacity. During the passage (the body in a sense acts as a resistance) some of the electrical energy is converted or transformed into heat. This heat in other words is generated in situ. When plates are used, it is conventional to mount these adjustably to provide a convenient manner for treatment, for example, of the head, knees, shoulders, ankles, etc., in instances where pressure or contact of pads is undesirable. Pads generally are placed on either side of and in contact with the particular body sector intended to be treated.

The second method of applying short wave currents to the body is known as the induction method. This method is adapted particularly to use in fever therapy, and to the treatment of the internal parts of the body, or those parts which are very irregular in size and shape. In the induction method the heating is not due primarily to currents passing through the body but rather to heating effects which are caused by the establishment and flow of secondary currents induced in the tissue being treated, by the current flowing in the applicator, which usually comprises a cable or coil wound around the afflicted tissue.

While there has been a variety of different types of apparatus adapted to use for the production of short wave currents oscillating at highly frequent intervals, machines of the spark gap type, or of the electron tube type have been most widely accepted. In the first of these types, the short wave current is provided through spark interruptions in the flow of a given source current by means of a spark gap. In the other type, a short wave current is provided through current emissions from one or more triode electron tubes. The present invention is directed to improvements in the electron tube type of generating apparatus.

While the electrical circuits and various electrical instrumentalities adapted to produce short wave currents have been understood quite fully in the past, still, it is recognized quite generally in the medical arts that the success of heat therapy in the treatment of ailments, where the technique is known to be of value, depends quite largely upon the skill and experience of the physical therapist or operator, as well as upon the regulated establishment of predetermined heat conditions.

Briefly, it is a primary objective of the present invention to provide controls in the heat machines by means of which at least some of the factors which, in their control, have depended so largely upon the skill and experience of the operator, are rendered less complex and more easily controllable.

Broadly speaking, the degree of heat established in a given mass of tissue in a patient by means of short wave currents applied to the body, either by the inductance method or by the condenser method is a function of the power or energy supplied to that body. In the actual practice of physical therapy, however, this broad generality is of little or no useful significance for the reason that the characteristics of the various masses of tissue are so variable and for the reason that, though time of treatment is controllable, still the amount of energy received by a given patient has not been subject to measurement accurately or in any practical manner. In the treatment of leg tissues, for example, the load which is imposed upon the generator is variable from patient to patient, even when there is no variation in the relationship of the applicator elements to the leg. On the other hand, the load imposed during the treatment of the abdomen of a given patient is different from

the load imposed when the shoulder for example is placed in a particular short wave circuit for heat treatment. And in either instance, the great difficulty has been that satisfactory measurement of the amount of energy received has not been possible.

The problem of measurement of energy by the part afflicted is complicated still further by reason of the fact that the load, during the treatment of any of these various parts of the body, varies in accordance with the relationship to the body parts, of the applicator elements from which the energy is provided. Thus, if pads be used, in contact with the parts, then the characteristics which influence the load upon the generator are not the same as the characteristics which influence the load when plates are used, or when a cord is wrapped around the mass of tissue in question. Likewise, the nature of the mass of tissue, its size, the regularity or irregularity of its shape and surface and the degree of adjacency of the applicator all comprise factors which affect the dosage received. And, of course, it is not possible to measure the result directly, even though the generation of a given degree of heat for a given period of time is the primary objective in heat therapy.

It is an object of the present invention to provide a control in the generating circuit of a physical therapy heat machine which is substantially directly indicative of the dosage of current to which a given patient undergoing treatment from the circuit is subjected. Otherwise expressed, it is the object of the invention to provide a meter for measuring the dosage of short wave energy applied to a patient, and to measure and control this amount of dosage.

A still further object of the invention, moreover, is to provide in a short wave current generating apparatus, control instrumentalities which enable the application of dosages of predetermined quantity to patients of different types and to the respective parts of the patient, substantially irrespective of the variations of the patient's circuit characteristics or of the variations in the relationships of the applicators to the parts undergoing treatment.

Further objects, and the advantages of the present invention are disclosed in the following specification, and in the drawing in which:

Figure 1 shows the improvement of the present invention embodied in an electron tube circuit adapted to provide short wave currents appropriate to utilization through the condenser or inductance methods, as well as appropriate for use in electro-surgical sections.

Figure 2 illustrates diagrammatically a simplified electron tube circuit in which the improvement of the present invention is embodied.

In the past, control of dosage has depended largely upon the skill of the operator. According to the present invention dosage of short wave energy is measured and controlled in accordance with a measurable electrical value in the generating circuit, which I have discovered more nearly to approximate the amount of energy actually received by a patient undergoing treatment in the patient's circuit than any of the modes of controlling or measuring diathermy dosage which heretofore have been used. The invention resides first in the discovery of this relationship of factors by means of which dosage in the patient is measured, and secondly in the determination that the value measured in the electrical circuit is a guide which is substantially accurate irrespective of the nature of the type of treatment or of the type of tissue being treated. Thirdly, the invention resides in the selection of instrumentalities from the electrical art, and the arrangement of these instrumentalities to solve the problem of dosage of short wave energy in the wholly unrelated art of physical heat therapy.

Briefly, I have discovered that the linear subtractive combination, or difference between the plate current and the grid current in an electron tube type short wave diathermy machine is substantially proportional to the amount of energy received by, and thus, to the amount of heat generated in a patient or an object included as an element in the short wave circuit of the generator to receive energy therefrom or be heated thereby. Otherwise expressed, and more particularly from the point of view of heat therapy, the present invention is predicated upon the discovery and determination that the amount of heat generated or induced in a patient undergoing treatment is substantially proportional to the difference between the currents applied at the plates and grids of the electron tube elements in the generating circuit substantially irrespective of variations in the coupling of the patient in the short wave circuit.

By reason of these determinations it is the concept of the present invention differentially to measure plate current minus grid current in an electron tube short wave generating circuit. This differential or linear subtractive value preferably is plotted or indicated by a meter needle upon the scale of a meter in which the currents differentially are applied. Otherwise expressed, the grid circuit and the plate circuit are connected to the meter for opposition of the current in the grid circuit with the current in the plate circuit.

The meter preferably is adjusted to read no load at zero differential and to read full load at the maximum permissive differential. According to the present invention, therefore, the therapist measures and controls substantially directly the quantity of energy as well as the time of treatment. It is highly significant, of course, that the variations in dosage which heretofore have been caused by variations in coupling and variations in the types of tissue being treated substantially are obviated, and that a practical working dosage guide directly is provided to the therapist who heretofore has relied so completely on empirical controls and on experience alone.

In the types of electron tube generators to which the present invention is directed it is necessary usually to indicate the voltage applied to the filaments of the tube generators to protect these tubes from being subjected to a voltage too high or too low for safe working conditions. Generally, the filament voltage is metered directly through a meter display on the control panel of the machine. This metering and control of the voltage in the filaments of electron tubes in circuits of the type to which the invention relates is important in the practical electrical operation of the machine. In the first place, the voltage in the filaments controls the temperature at which the filaments operate. If the temperature is too high then the life of the tubes is very short; on the other hand, if the temperature is too low, then, particularly in the tubes of the thoriated filament type, the thorium atoms or particles do not diffuse to the surface sufficiently rapidly to provide proper electron emission. In other words if the electron emission is too low then difficulty is encountered in

producing sufficient energy for proper oscillation. Metering of the filament voltage is useful particularly in starting the machine and in its practical operation.

In view of this consideration, a further object of the invention has been to control the voltage applied to the filament elements of electron tubes of the short wave generating apparatus during the periods of starting and of operation, (to insure safe electrical circuit conditions) as well as to control the dosage received by a patient coupled with this electrical circuit. It is a concept of the invention to measure filament voltage on a meter for machine control, and to measure the difference between plate and grid currents on this meter for dosage control. It is preferred that this meter be included in the circuit normally to indicate the value of the difference between plate and grid currents, since indications of dosage are more important during the normal periods of operation. The meter, however, is partially connected in the circuit alternatively to indicate filament voltage through partial circuit completion by means of a double pole, double throw switch.

The invention therefore contemplates the embodiment, in a single meter in a short wave apparatus, of the dual function of a volt meter for operation of the machine from the electrical point of view and a dosage meter for operation of the machine from the more important point of view of the patient.

In the accompanying drawing I have shown the improvements of the present invention embodied in an oscillating circuit which employs a pair of electron tubes. The particular type of circuit which is shown in the drawing at Figure 1 has been found to be well suited to use in electro-therapeutic machines. It will be understood, however, that the invention is not limited to this particular type of circuit which is disclosed. The improvements are adapted generally to use in the more simplified types of circuits, such as the one shown in Figure 2, as well as to circuits of a more complex nature.

The circuit shown in Figure 1 employs a pair of vacuum tubes 10 of the type having heating filaments 11, plate elements 12 and grid elements 13. The filaments 11 are connected in parallel relation through leads 14, 14, which respectively are supplied with energy E_f through leads 15, 15 taken from a secondary winding 16 of a transformer indicated generally at 17. Primary winding 18 of the transformer is supplied with energy through input terminals 19—19 which, during the operation of the machine, are connected to a suitable alternating current source through main control switch 20.

The plates 12 of the electron tubes are mounted in parallel relation to receive current from a second secondary winding 21 of the transformer 17. One end of the transformer secondary winding 21 is connected through a lead 22 to one of the plates 12 and another lead 23 is taken from the lead 22 to the other plate element 12. Both the leads 22 and 23 respectively include impedance elements 24, 24.

The plates 12 are connected respectively through conductors 25—25 to the opposite ends of an inductance coil 26 having a center tap 27 which normally is in circuit connection with the remaining terminal of secondary 21 through a switch and meter circuit that is referred to in detail at a later point in the specification. The conductors 25—25 respectively include appropriate pairs of condensers 28—28 and a condenser 29 is shunted across the opposite terminals of the inductance 26 to facilitate proper oscillation.

The grid elements 13 of the electron tubes 10 are cross connected through leads 30—30 to taps 31—31 located on opposite sides of the center tap 27 of the inductance 26. The cross connections 30 each respectively include condensers 32—32 and resistances 33—33 shunted around the condensers.

A variable output coil 34 inductively is coupled to the inductance coil 26, with the terminals of the coil respectively connected through leads 35, 35, to out-put terminals or posts 36 and 37. Output terminals 38, 38 also are provided through taps 39, 39 respectively connected to the inductance or tank coil 26 on opposite sides of center tap 27.

A type of current (other than diathermy current) which the circuit of Figure 1 is adapted to provide is a surgical or cutting current possessed of dehydrating properties found through experience to be suitable for providing hemostasis under normal condition in operations of the general type for which electro surgery has been found to be particularly efficacious. This circuit likewise provides coagulating current adapted to stop the flow of blood when a particularly vascular tissue is dissected or when blood vessels or small arteries are encountered.

Now, to accommodate usage of the circuit of Figure 1 for surgical cutting and coagulating, as well as for diathermy, an output terminal 40 is provided on a lead 41, connected to terminal 36, and including a condenser 42. The electro-surgical scalpel is plugged in at the terminal 36 and the patient is grounded to the terminal 37, which acts as the indifferent electrode terminal, or when current for coagulating vascular tissue is desired the scalpel is connected to terminal 40, and the indifferent electrode likewise is connected to terminal 37.

For the various diathermy operations, the machine is used as follows:

When the induction method of heat treatment is desired a cord is connected across the terminals 38. This cord usually comprises a metallic conductor sufficiently flexible to be wound around the afflicted body parts intended to be treated.

When the pad method of treatment is desired, the terminal of one of the pads is connected to the terminal 36 and the terminal of the other pad is connected to the terminal 37. The pads are placed on opposite sides of the particular body section for treatment.

When the plate method of treatment is desired to be used one of the plate terminals is connected to the output terminals 36 and the terminal of the other plate is connected likewise to the other terminal 37. Usually the plates mechanically are mounted on arms made adjustable to facilitate arrangement of the plates on opposite sides of, and adjacent to the body section undergoing treatment.

A lead 44, which includes a pair of condensers 45, and a resistance 46, is positioned to connect the terminal 37 with a center tap 47 on the secondary element 16 of the transformer through a switch 48 (indicated by the arrow).

Switch 48 controls circuit connection of the transformer center tap 47 to the terminal 37. The switch is adjusted so that the lead 44 is connected to the terminal 37 when the circuit is to be used for electro-surgical purposes. To prevent the application of high voltage to the

patient in the event of short circuiting in the main generating circuit at a time that a patient is being treated, condensers 45—45 are connected in lead 44. The connection of lead 40 to the indifferent electrode terminal 37 maintains this terminal at low ratio frequency potential to prevent the operator from being burned in the event that he should touch the patient during the course of operation. But, when the circuit is being used for the generation of heat in heat therapy the lead 44 is disconnected from the terminal 37 through switch 48.

In the practice of the present invention, a meter 49 is utilized to indicate the grid-plate current differential. This meter preferably is a relatively sensitive meter of the type in which an armature or vane revolves in accordance with the magnitude of the current or the voltage applied to field coils disposed on either side of the armature. Briefly, the meter 49 is connected in the electron tube circuit to measure the differential of the plate current and the grid current. More specifically, it is the concept to provide connections to the meter from the respective plates and grid connections in the circuit so that the grid current tending to flow in the meter is opposed by the plate current tending therein to flow. Otherwise stated, the meter is connected so that it will deflect according to the extent that the current in the plate circuit exceeds in value the current in the grid circuit.

By reason of the discovery that this difference closely approximates the quantity of energy received by a particular patient in the output circuit of the generator, the needle deflections therefore provide the guide by means of which diathermy or short wave dosage to a patient either is adjusted or controlled.

The preferred embodiment of the present invention is embodied in the circuit of Figure 1 as follows:

A double pole, double throw switch preferably of the push button variety, as indicated generally at 50, is provided, with movable elements 51, 51 of the switch connected to terminals 52, 52 respectively of the meter 49. This switch 50 preferably is adjusted so that the movable contacts 51, 51, normally contact stationary contact elements 53—53 which are in circuit connection with the electron tube circuit so that the meter normally reads the differential of the plate and grid circuit currents. More specifically, in the circuit shown, one of the contacts 53 is connected through a lead 54 to the B− terminal leading from the transformer secondary 21 (through the switch and meter, to the center tap 27). This lead is designated I_p or the "plate current" lead. The other contact element 53 is connected through a lead 55 to complete circuit connection from the terminal of the secondary 21 to the center tap 27. From lead 55 which is designated I_g, or "grid current" lead, connections 56, 56 are taken respectively to the filament connectors 14, 14, through filament by-pass condensers 57, 57, one for each lead 56. (The filament by-pass condensers do not relate particularly to the present invention of diathermy dosage control, but are used to facilitate general short wave circuit operation.) The lead 54 places the meter 49 in partial circuit connection for measurement of the plate current, and the lead 55 places the meter 49 in partial circuit connection with the grid current.

To complete the grid and plate circuit connection to the meter 49, a filament return lead 58 is taken from connector 44 to a variable resistance 59 which is shunted across the terminals 54 and 55. This resistance is made variable in order to adjust the meter 49 to exhibit zero deflection when no load is on the generating circuit and to exhibit full scale deflection when full load, or the maximum permissive load, is on the generator. By moving the variable resistance contact element either to the right or to the left more resistance is thrown in the plate, or the grid circuit connectors respectively to the meter, and, in this manner the subtractive combination of plate and grid currents is adjusted so that the meter reads zero or substantially zero at no load.

Contact elements 60—60 of the double pole, double throw switch 50 are placed respectively on sides of the movable elements 53—53 opposite to the sides on which the plate I_p and grid I_g contact elements respectively are disposed. The elements 60—60 are disposed for contact with the movable elements 51—51 when push button actuator 61 is depressed. Leads 62 and 63 respectively connect the contact elements 60, 60 with the terminals of the secondary winding 16 of the transformer 17. Lead 62 may include a resistance 64, to adjust the filament voltage E_f to a value suitable for meter reading. A condenser 65 is shunted across the terminals of the meter 49.

When the push button switch is in the normal position (as with the actuator 61 distended) then the meter 49 reads the amount of energy being provided to a patient in the output circuit of the generator, through connection of the movable contacts 53, 53 and the plate and grid contact elements 54, I_p and 55, I_g. The meter under these circumstances acts during the course of treatment as a guide to the dosage being received by a patient, in that the meter needle deflects in accordance with the difference by which the plate current exceeds the grid current. On the other hand, when the push button actuator 61 is depressed, then the meter 42 reads filament voltage E_f and in this respect the value indicated by the meter is utilized particularly to adjust the machine to optimum operative, or oscillating conditions. Likewise this indication guides the operator and safeguards against the application of too great a voltage to the tube filaments.

In the circuit shown in Figure 2 a single electron tube 65 is used. The plate element 66 of the tube is connected through a lead 67 to one end of an inductance coil 68, the other end of which is connected through a "B" battery to a "plate" contact 69 of a double pole, double throw switch indicated generally at 70. A radio frequency by-pass condenser 71 is shunted around the "B" battery, for safety purposes. Grid element 72 of the electron tube is connected through a lead 73 to one end of a second inductance coil 74, the lead 73 including a resistance 75 and condenser 76 in parallel connection with one another. The other end of inductance coil 74 is connected through a lead 77 to "grid" contact 78 of the double pole, double throw switch 70. A radio frequency by-pass condenser 79 likewise is shunted across leads 77 and 67 for safety purposes. Meter 80 is connected, as in the manner shown in Figure 1, preferably to movable contact element 81, 81 of the switch 70.

A variable resistance 82 likewise as in the manner shown in Figure 1, is shunted across the

connector to the plate contact 69 and the connector to the "grid" contact 78 and a filament return connection 83 to the variable resistance 82 in turn is connected to one of the terminals 84 of the filament of the electron tube 65. A lead 85 connects one terminal of the filament with "filament" switch contact 86, through a voltage control resistance 87. The other "filament" contact 88 is connected respectively to the filament return connector 83.

In the circuit shown in Figure 2 the meter 80 is shunted across the movable contactors 81—81 of switch 70. The meter functions in substantially the same manner as the meter shown in Figure 1. When the switch is thrown so that the meter is in connection with contacts 69 and 78, then the meter reads the subtractive combination of I_p and I_g. On the other hand, when switch 70 is thrown for connection of meter 80 across terminals 86 and 88 the meter reads voltage E_f impressed on the filament of the electron tube.

The control of diathermy dosage in the past has been particularly difficult because of the complexity, and because of the variety of the factors which influence the amount of energy received by a patient undergoing treatment. By reason of the simple controls of the present invention which are predicated upon the discovery of the peculiar relationship of the grid and plate circuit current values and the patient's energy, the empirical guides upon which the diatherapists heretofore have relied largely are obviated. In the present improvements two controls, one protecting the patient and the other the machine, cooperate through simple circuit instrumentalities, which are low in cost and sturdy and reliable in operation.

Having described my invention, I claim:

1. An electro-therapeutic apparatus for diathermy treatments, means for indicating power output of the apparatus to a patient being treated, comprising, an oscillating circuit having an electron tube, the tube having grid and plate elements, a grid circuit including the grid element of the tube, a plate circuit including the plate element of the tube, a meter in circuit connection with the grid circuit and the plate circuit to indicate the difference between the current in the grid circuit and the current of the plate circuit, whereby the meter is actuated to indicate power output of the therapeutic apparatus, and means in circuit connection with the meter for adjusting the meter to read zero deflection at no load and to deflect to a maximum degree when the oscillating circuit is operated at maximum permissive load.

2. In an electro-therapeutic apparatus for diathermy treatments, a circuit generating oscillating diathermic currents, including an electron tube having a grid element and a plate element, a grid circuit including the grid element of the tube and a plate circuit including the plate element of the tube, means for indicating the power output of the apparatus to a patient being treated, comprising, a meter, circuit connections from the grid circuit and the plate circuit to the meter for effecting opposition of the current of the grid circuit to the current of the plate circuit, whereby the meter is actuated to respond to the difference between the plate and grid currents to indicate power output of the therapeutic apparatus to a patient being treated.

3. In an electro-therapeutic generating apparatus for producing diathermic oscillating currents comprising, a circuit including an electron tube having a grid element and a plate element, a grid circuit including the grid of the tube and a plate circuit including, the plate of the tube, means for indicating the diathermic power output of the apparatus to a patient being treated, comprising, a meter having terminals respectively interconnecting the plate circuit and the grid circuit, whereby the meter is in circuit connection to read the difference between the current of the grid circuit with the current of the plate circuit, and thus to indicate the power output of the therapeutic apparatus and a variable resistance in circuit connection with the meter for adjustment of the meter deflection to zero reading at no load and maximum deflection at maximum permissive load upon the diathermic current generating apparatus.

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