May 1, 1945. E. G. GAGE 2,375,097

HIGH POTENTIAL APPARATUS RENDERED SAFE FOR HANDLING

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Fig. 1.

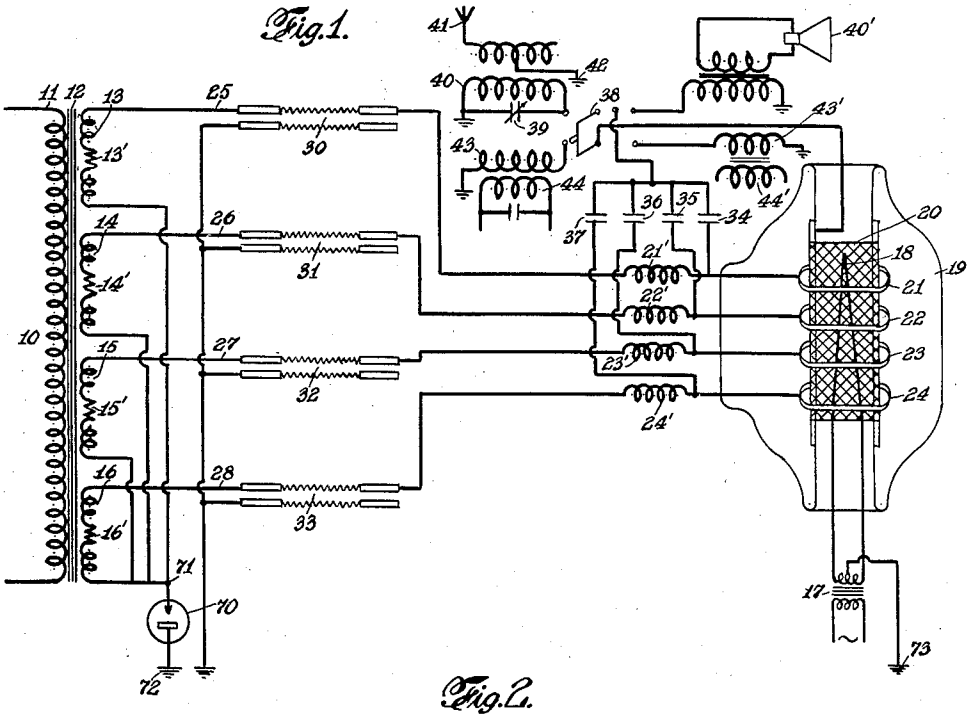


Fig. 2.

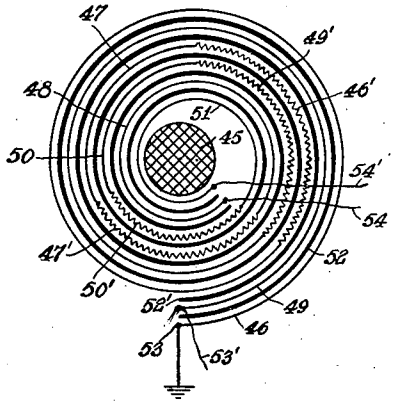
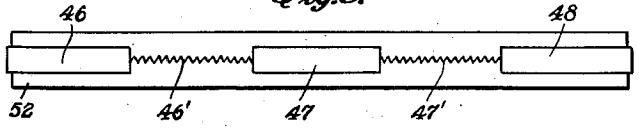


Fig. 3.



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Fig. 4.

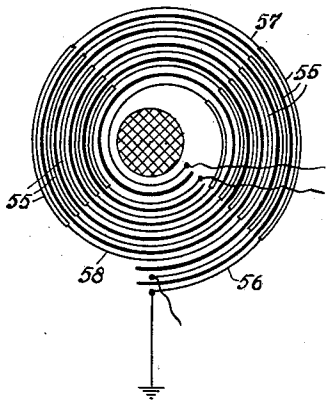


Fig. 7.

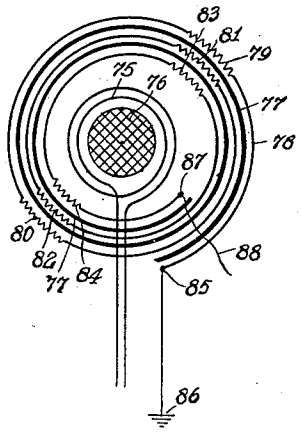


Fig. 5.

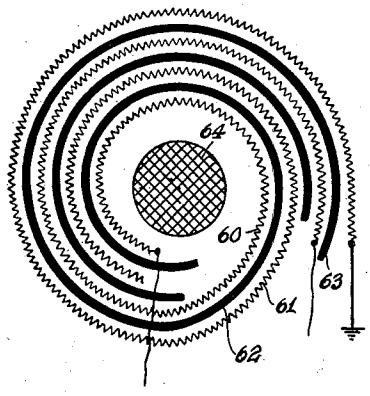
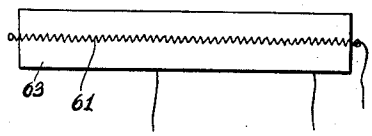


Fig. 6.



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HIGH POTENTIAL APPARATUS RENDERED SAFE FOR HANDLING

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Application July 12, 1941, Serial No. 402,066

12 Claims. (Cl. 175—294)

This invention relates to high potential means for use in electrical circuits more especially adapted for the operation of thermionic apparatus utilizing a dangerously high current and voltage.

The subject matter of the present invention is disclosed in a prior application filed by me April 20, 1940, Serial #330,636, which has eventuated in U. S. Patent #2,319,594, and a prior application filed by me May 29, 1940, Serial #337,806, which has eventuated in U. S. Patent #2,281,571; and the present application is a continuation in part of said U. S. Patent #2,319,594 and also of said U. S. Patent #2,281,571.

The invention has for an object to provide a novel construction of transformer and of a condenser operating at dangerous voltages whereby the same are rendered safe for handling.

Another object of the invention is to combine in a single unit a filter condenser, carrying a dangerous current and voltage, with a smoothing impedance.

In carrying out the invention, provision is made for two conductors insulated from each other, at least one of these having linearly disposed resistance, said conductors constituting the secondary of a transformer or the electrodes of a condenser and the resistance being of such magnitude that while it is sufficiently low to pass the required operating current it still is of such magnitude that upon contact with any exposed part of the conductor by a human body, the closed circuit afforded thereby will be of such resistance as to limit to a safe value the current flow through the included portion of the conductor and the body.

The nature of the invention, however, will best be understood when described in connection with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a vacuum tube circuit for an amplifier operating at a dangerous voltage and current and including the novel transformers and condensers.

Fig. 2 is a detail, transverse section of a combined filter condenser and impedance capable of carrying dangerous voltages.

Fig. 3 is a reduced plan view of a condenser electrode with intermediate resistance sections.

Fig. 4 is a transverse section illustrating a modification in the condenser construction.

Fig. 5 is a transverse section and Fig. 6 an elevation illustrating a further modification in the condenser construction.

Fig. 7 is a detail, transverse section of a safety transformer carrying a dangerous voltage and embodying in the secondary conductors of relatively high and low resistance connected in series.

Referring to the drawings, more particularly to Fig. 1, 10 designates a source of current voltage, for example alternating, which may, for convenience, have a frequency of sixty cycles, and it is connected to the primary winding 11 of a multiple section transformer, of which 12 is a core.

Separate transformer secondary sections 13, 14, 15, and 16 are provided on the core, each delivering the same and a relatively high voltage; and a further transformer 17 delivers a low voltage to the filament 18 of a high impedance transmission vacuum tube 19 of the three-element type having the grid 20. Voltage from the secondary sections 13, 14, 15, and 16 is delivered to the plate of said transmitter tube which is divided into a like number of sections 21, 22, 23, and 24 connected respectively to the said transformer sections through leads 25, 26, 27, and 28, respectively, and series inductances 21', 22', 23' and 24'. There is afforded thereby parallel paths each at substantially the same voltage and a safe current flow, say not in excess of 10 milliamperes. Respective filter condensers 30, 31, 32, and 33 of the novel construction hereinafter set forth are included in the different leads.

The outputs from the tube plates or anodes are connected to respective parallel connected condensers 34, 35, 36, and 37 for uniting the high frequency outputs of the plate circuits as through a double-throw double-pole switch 38 to one terminal of a tank tuning condenser 39. There is associated therewith, also, an oscillator coil 40 for coupling the radio frequency circuit to the antenna 41 and ground 42, the grid 20 being grounded at the same time through the coil 43 coupled to an input coil 44. By throwing switch 38 in the opposite direction, the condensers may be connected to operate a sound reproducer 40', the grid then being grounded through a coil 43' coupled to the audio frequency input coil 44'.

As shown in Figs. 2 and 3, the filter condensers comprise a laminated iron core 45 which is surrounded by coiled condenser electrodes, each of which may consist of narrow strips of metal foil 46, 47, and 48, and 49, 50, and 51, respectively, with alternate conductors 46', 47', and 49', 50' connected between. These conductors may be of high resistance wire such as "Nichrome"; or, with lower power condensers, ordinary fine copper wire may provide the required resistance. Dielectrics 52 and 52' which may be of insulating paper are wound between the condenser elec-

trodes with resistance wire in series. The combined filter condenser and impedance shown constitutes, in effect, a plurality of impedances in series with condensers in shunt between each impedance, as in the standard filter network. The advantage of such construction lies in the fact that the entire network is combined in a single unit with but four exposed terminals 53, 53', 54, and 54', one of which, preferably the outside foil terminal 53, may be grounded.

As all conductors as well as the foil portions are rolled up in a compact roll, it is not possible to contact any portion accidentally without including resistance in series with one's body sufficient to limit the condenser discharge, as determined by the capacity of the condenser, to a safe value.

The condenser capacity plays an important part in the safety feature of the device. Because the filter network is divided up into sections, a separate section being used for each plate section of the vacuum tube, the capacity of each condenser-impedance unit is only a fraction of the total capacity required for current smoothing, in the case cited being but one-fourth of such capacity as there are four plate sections. This means that the voltage and current through the body from accidental contact with any one section is reduced to one-fourth of what it would be if the capacity were combined in a single condenser.

Instead of using high-resistance wire to provide inductance and resistance between condensers, small carbon resistors in the form of short flat strips 55 or rods, Fig. 4, may be used in between the electrode portions 56, 57, and 58, and rolled with the condensers.

The filter condensers also may comprise electrodes 60 and 61, Figs. 5 and 6, which are of elongated conducting material in the form of very thin, narrow strips of high resistance metal or alloy such as "Nichrome," or a metallic film, or an extremely thin deposit of metal or carbon, or a conductive composition of both, with a dielectric 62 between two such electrodes. This dielectric may be heavy paraffined paper with an insulating follower such as an extra strip 63, all being wound spirally substantially into a cylindrical form as in the well-known rolled type of condenser. This form of condenser provides, of course, a certain degree of inductance which may be enhanced by the introduction of a central core 64 of iron. Because of the large number of turns due to the great length of the electrodes necessary to obtain a protective resistance value, the condenser may provide a high inductance even without the iron core.

It is to be understood that because the protective resistances protect a person from injurious shock from the instantaneous surge discharge of the filter condenser only, and not from the transformer current, the resistance value of the electrode may be only one fourth that which would be necessary for a continuously applied current such as from the transformer. It has been found that the body can safely withstand an instantaneous current of approximately four times that of a continuously applied current. This allows for a corresponding reduction of protective resistance value necessary for safe handling of the condenser or connected circuit portion. The coiled form also prevents bodily contact with more than one electrode and thus adds to the safety feature provided by the inherent high resistance of the electrodes themselves.

Each of the transformer sections 13, 14, 15, and 16 are similarly provided with linearly distributed resistance, for example, with one or more intermediate protective resistances 13', 14', 15', and 16'. Provision is also made, as by means of a high-voltage rectifier 70, for rectifying all currents passing from the common terminal 71 of transformer sections 13, 14, 15, and 16, which is connected to one terminal of the rectifier, the other being grounded at 72. The filament 18 of the vacuum tube 19 is also grounded as at 73.

A convenient arrangement for interposing the secondary resistances in a transformer is illustrated in Fig. 7 of the drawings. As indicated therein, a primary winding 75 is coiled about a central core 76 of laminated iron and about this is wound in the required number of convolutions, together with an intermediate layer of insulation 77, the secondary wire winding 78 having interposed at different portions along its length safeguarding resistors 79, 80, 81, 82, 83, and 84. One terminal 85 of such secondary may be grounded as at 86, and to the other terminal 87 a lead 88 connects to the desired means to be operated. Different secondary sections similar to that hereinbefore described may be mounted adjacently along the core 76 to provide the desired number of paths for the energy to be supplied.

The maximum low frequency or direct current that may be obtained from the divided supply circuits shown in Fig. 1 would be determined by the lowest resistance which might be interposed between the points of contact of the body. If contact were made between ground and any one of the filter condenser output sections, then the lowest value would be the sum of the resistances in the transformer secondary section and the resistances in the filter condenser section.

It is important, therefore, that the lowest resistance possible to place between body and ground be such as to allow only a safe current to pass at the maximum voltage.

Because the resistances in series with a secondary winding of the transformer sections are wound up inside the secondary or suitably encased, only the outside terminals can be contacted, and this always includes the enclosed resistances in series. The same is true of a filter condenser. Because the foil or outside terminals only can be contacted, it is not possible to contact these without including in the circuit the resistances rolled up with the foil which are inside the roll and cannot be contacted.

As an example of safe values, the lowest resistance which should be allowed in circuit with 10,000 volts would be 1,000,000 ohms, which would pass 10 milliamperes, a safe current. For such high voltage the human body may be considered practically a short-circuit. This resistance should be divided between copper loss and loss through concentrated resistance such as the "Nichrome" wire winding or carbon resistors inserted in series with the copper winding as in both a transformer secondary and the filter condenser impedance circuit. The problem then becomes a simple economic one. With no concentrated resistance in series, the amount of copper wire, even of the smallest size, would have to be enormous, several hundred pounds being necessary in a transformer section alone, for a 200-watt transmitter.

Therefore, a combination should be chosen for the highest general efficiency. The actual total resistance of the plate circuit is, of course, only a fraction of that of each separate plate section

path, in the present case one-fourth, since there are four sections.

I claim:

1. The combination with an electrical circuit and apparatus of an impedance substantially greater than the normal resistance of the human body, permanently connected in the circuit and operating at a dangerously high potential but relatively small current; of high potential means permanently included in series in the circuit and comprising two elongated parallel conductors insulated from each other, at least one of said conductors including linearly disposed resistances of a total resistivity sufficiently low to pass the required current for operating the apparatus at the rated voltage and of such high magnitude with respect to the rated voltage that, upon establishment of a closed circuit through the said means and the human body, the current flowing in such closed circuit and through the body and the voltage applied to the body are reduced by said resistivity to a safe value.

2. The combination of claim 1, wherein the one conductor is composed of alternate sections of relatively high and relatively low resistivity.

3. The combination of claim 1, wherein the high potential means comprises a condenser and at least one of the conductors is composed of alternate sections of relatively high resistivity and low capacity and of relatively low resistivity and high capacity.

4. The combination of claim 1, wherein the high potential means comprises a condenser and the other of the parallel conductors is grounded.

5. The combination of claim 1, wherein the high potential means comprises a transformer and the secondary of said transformer is the conductor having the linearly disposed resistances.

6. The combination of claim 1 wherein the high potential means comprises a filter condenser and at least one of the conductors is composed of alternate sections of relatively high resistivity and low capacity and of relatively low resistivity and high capacity, an input terminal connected to said one conductor, and an output terminal separate from the input terminal and connected to said one conductor.

7. The combination of claim 1 wherein the high potential means comprises a filter condenser and at least one of the conductors is composed of alternate sections of relatively high resistivity and low capacity and of relatively low resistivity and high capacity, an input terminal connected to said one conductor, and an output terminal separate from the input terminal and connected to said one conductor, and a common input and output terminal connected to the other conductor.

8. The combination of claim 1 wherein the high potential means comprises a filter condenser and at least one of the parallel conductors has a total dangerous capacity value distributed among individual shunt-connected capacitors each of relatively harmless smaller capacity value arranged alternately along the one conductor with respect to the linearly-disposed series-connected resistances thereof.

9. The combination with an electrical circuit and apparatus of an impedance substantially greater than the normal resistance of the human body, permanently connected in the circuit and operating at a dangerously high potential but relatively small current; of a filter condenser permanently included in the circuit and comprising two electrodes, the first of which has a ground connection serving as a common input and output circuit respectively to and from the condenser, and the second electrode includes separate input and output circuits with respective exposed terminals connected thereto, and resistance included between one of said terminals and said second electrode, both the said second electrode and resistance being shielded against bodily contact, the resistance being sufficiently low to pass the required current for operating the apparatus at the rated voltage and of such high magnitude with respect to the rated voltage that, upon establishment of a closed circuit between the terminal connected to the second electrode and the human body to ground, the current flowing in such closed circuit and through the body and the voltage applied to the body are reduced by said resistance to a safe value.

10. The combination of claim 9, wherein the included resistance is located between the output circuit terminal and the said second electrode.

11. The combination of claim 9, wherein the said second electrode consists of alternate sections of shunt-connected capacitors and series-connected resistors.

12. The combination of claim 9, wherein the electrodes and resistance are lumped.

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