

Feb. 25, 1936.

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2,032,199

ENERGIZING CIRCUITS FOR SPACE DISCHARGE DEVICES

Filed June 19, 1933

Fig. 1

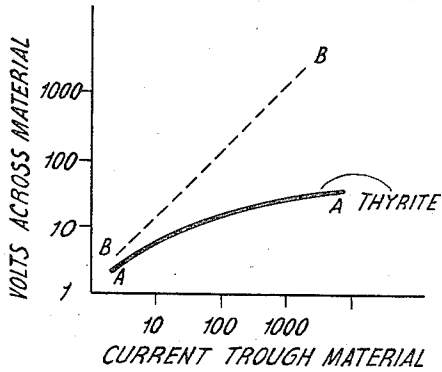


Fig. 2

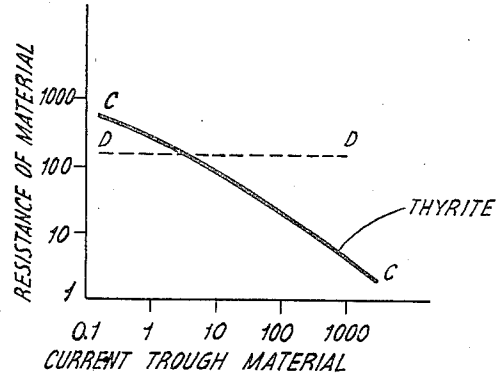
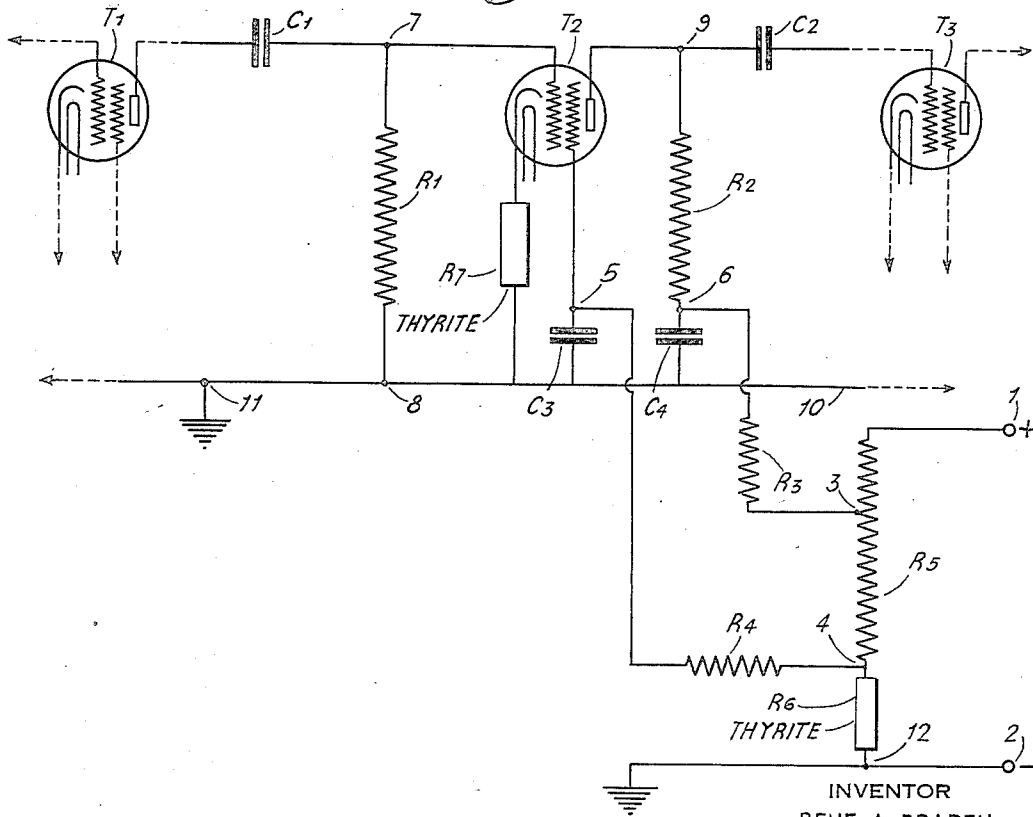


Fig. 3



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2,032,199

ENERGIZING CIRCUITS FOR SPACE
DISCHARGE DEVICESRene A. Braden, Merchantville, N. J., assignor to
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Application June 19, 1933, Serial No. 676,462

4 Claims. (Cl. 179—171)

The present invention relates broadly to electrical distribution networks and more particularly to networks which include thermionic tubes.

It is well known to energize thermionic tubes from commercially available alternating current. For this purpose the available alternating current is usually rectified and filtered before it is used. Normally the rectified and filtered current is applied across a voltage divider circuit and the various desired voltages are derived from taps on this circuit.

In thermionic tubes of certain types it is customary to bias the control grid, in other words, it is customary to maintain the control grid at a negative potential with respect to the cathode of the tube. For this purpose there is usually provided an impedance or so called bias resistance which is included in both the control grid-cathode path of the tube and in the anode-cathode path thereof. The space current or anode current passing through the bias resistor causes a voltage drop thereacross which due to the direction of current flow therein maintains the control grid negative with respect to the cathode of the tube. This type of bias is sometimes referred to as "automatic bias" because of the fact that it so to speak maintains itself as long as the tube is energized. Resistance materials heretofore employed for bias purposes obey Ohm's law, that is to say, with these materials the rate of change of potential thereacross due to current flow is linearly related to the rate of change of the current flowing therethrough. It follows, therefore, that when a material obeying Ohm's law is used for automatic bias purposes, the bias is varied with variations in the plate current. Changes in plate current are due to many causes the most important of which are changes in plate current due to uncontrolled voltage variations of the available power supply and changes due to signal modulations. Both of these changes may be considered as A. C. components superimposed upon the steady current component. These A. C. components when impressed across the bias resistor produce an undesirable feed-back voltage which due to the normal amplifying characteristics of the thermionic tube may assume extremely annoying proportions.

In order to avoid this feedback action it has been customary to by-pass the bias resistor with a suitable by-pass condenser. The capacity of the condenser being such as to form a low impedance path for the undesired frequencies so as to shunt the undesired A. C. components around the bias resistor.

From what has preceded, it is apparent that the bias resistor may be considered as a portion of the voltage distribution or voltage divider circuit above referred to. As is well known with thermionic tubes of the screen-grid or multi-grid type wherein it is desired to maintain the screen or auxiliary electrode at a positive potential with respect to the cathode, the necessary positive potential is derived from a suitable tap on the voltage divider resistor. In such cases it is usually desirable to maintain the auxiliary electrode at a constant positive potential with respect to the cathode, however, it has been found that this is extremely difficult because of the fact that variations in the current drawn from the tap as when replacing tubes cause changes in the voltage drop across the voltage divider resistance due to the fact that the voltage divider material obeys Ohm's law. By "replacing tubes" is meant substituting one tube for another and/or pulling out one of two or more tubes. It is obvious that in either case there may result a sufficient change in the load across the voltage divider resistance to vary the various tapped voltages.

It is an object of the present invention to devise a system for energizing thermionic tubes capable of supplying substantially steady potentials despite variations in the plate current of the tube or in the load across the power supply network.

The object of the invention is attained by that there is utilized for the bias resistor as well as for any desired portion of the voltage divider resistance, a material that does not obey Ohm's law. For the purposes of this invention, one or more elements having such characteristics that the rate of change of potential thereacross is not linearly related to the rate of change of current therethrough are interposed in the system. A material that very satisfactorily answers the purpose is commercially known as "Thyrite", and is described in United States Patent No. 1,882,742 issued to McEachron. This material has a substantially hyperbolic resistance-ampere characteristic.

Thyrite—meaning gate or opening—is a material somewhat similar to dry process porcelain throughout the mass of which appear minute particles of conducting material. The substance is substantially an insulator at low potentials and becomes a continuously better conductor as the current through it is increased. No attempt will be made herein to discuss all the characteristics of Thyrite however, for a better understanding of the material itself and its characteristics reference may be made to the above identified U. S.

patent and to an article entitled "Thyrite; A New Material for Lightning Arresters" by K. B. McEachron, appearing on page 92 of the "General Electric Review" for February 1930.

It should be noted that the material Thyrite is usually utilized in the form of discs each face of which is provided with a sprayed metallic coating for contact purposes, however, the shape the material takes is not at all controlling and in fact it may be utilized in any mouldable shape. The resistance of Thyrite varies directly with its thickness but not inversely with its area as does the resistance of materials such as carbon or metals which have heretofore been utilized.

The novel features that are believed to be characteristic of the present invention are set forth in the appended claims. The invention itself, however, both as to its organization and its method of operation together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawing.

In said drawing:—

Figures 1 and 2 are representations of curve sheets showing certain characteristics of Thyrite compared with corresponding characteristics of usual resistance materials; and,

Figure 3 illustrates an electrical network including a thermionic tube energized through a system utilizing Thyrite in accordance with the present invention.

Referring more particularly to Fig. 1, curve B, B shows the voltage developed across a resistance material obeying Ohm's law in terms of current through it, while curve A, A shows a curve for Thyrite under similar conditions. It is obvious from the two curves that Thyrite has a much flatter characteristic than the other material. In other words compared to ordinary resistance materials the voltage across the Thyrite is maintained almost constant despite variations in the flow of current through it.

The resistance characteristics of the two materials are illustrated in Fig. 2, wherein curve D, D depicts the resistance characteristic of a material obeying Ohm's law while curve C, C is a curve which illustrates graphically the resistance characteristic of Thyrite. The difference between the two is at once apparent since in the case of Thyrite the resistance decreases as the current increases whereas for a material obeying Ohm's law the resistance remains constant despite changes in the flow of current through it. It should be noted that in both Figs. 1 and 2 the curves are plotted on a logarithmic scale for convenience.

The circuit diagram shown in Fig. 3 is now referred to to illustrate the invention. In said figure, tubes T₁, T₂ and T₃ are intended to illustrate generally a multi-stage amplifier. The output of tube T₁ is coupled to the input of tube T₂ through a coupling condenser C₁. The usual grid leak resistance R₁ is shown connected to the control grid and cathode of tube T₂ at points 7 and 8. The lower end 8 of R₁ is grounded as at 11. The output circuit of tube T₂ is coupled to the input of tube T₃ through a suitable coupling condenser C₂.

For the sake of simplicity, only the energization of tube T₂ is here considered although it is to be understood that the principles hereinafter set forth may be applied to any desired number of tubes. The output of a socket power unit is adapted to be connected to terminals 1 and 2 in

any desired manner. The socket power unit may comprise a half wave rectifier, and filter or a full wave rectifier and filter or it may even comprise a voltage multiplier circuit and filter.

Across the two terminals 1 and 2 there is provided a voltage divider circuit comprising a resistance R₅ and a resistor R₆ in series. The negative end of R₆ is grounded as at 12. The voltage divider R₅, R₆ is arranged with taps 3 and 4 from which may be derived the desired voltages to energize the various elements of the tube or tubes. In the case at hand the anode of tube T₂ is connected to tap 3 through an output or load resistance R₂ and a filter resistance R₃ in series. A by-pass condenser C₄ may be provided as shown connected from the lower end 6 of R₂ to ground 11. The auxiliary grid of tube T₂ is connected to tap 4 through filter resistor R₄ and a by-pass condenser C₃ is connected between the upper end 5 of R₄ and ground 11. Since it is usually desirable to maintain the potential on the auxiliary grid of tube T₂ constant, resistor R₆ is constructed of Thyrite. In this way the voltage across R₆ remains substantially constant, despite changes in current drawn from the socket power unit through R₆. For biasing the grid of tube T₂ there is provided a resistor R₇ which is included in both the input and output circuits of tube T₂. In this way the space current of the tube flows through R₇ with the result that the drop across R₇ maintains the control grid negative with respect to the cathode of T₂. Since as previously pointed out it is sometimes desirable to provide a substantially constant bias, resistor R₇ is in accordance with the present invention made of Thyrite, hence, the signal or control grid of tube T₂ is maintained at a substantially constant negative potential with respect to the cathode thereof despite variations in the anode current.

It is obvious that if a resistance material obeying Ohm's law were substituted for the Thyrite resistor R₇ it would be necessary to provide a by-pass condenser of such a capacity that a low impedance path is formed for the A. C. components due to signals so as to prevent undesired feedback voltages being developed across the bias resistor.

It is to be understood that the present invention is not limited to the use of "Thyrite" or an equivalent material since many modifications will at once be apparent to those skilled in the art to which the invention pertains.

I claim:

1. In combination with a thermionic tube having input and output circuits, a source of unidirectional current, resistance devices interposed between points in the output and input circuits of said tube and said source for energizing said tube, at least one of said resistance devices comprising a resistance material including a mass of silicon carbide crystals and a binder holding adjacent crystals in contact, said material having a hyperbolic resistance characteristic which is unaffected by variations in the rate of change of voltage applied to the material to produce a flow of current therethrough, the resistance of the material being always substantially the same for a given density of current flowing through it whether the value of the said current density is attained by increasing or decreasing the current flow.

2. In combination with a thermionic tube having input and output circuits, a source of space current for said tube and a resistance element

including granular material having a hyperbolic resistance-ampere characteristic and having free carbon as an ingredient and means for holding the grains together under pressure, said characteristic being unaffected by variations in the rate of change of voltage applied to the element to produce a flow of current therethrough, the resistance of the element being always substantially the same for a given density of current flowing through it whether the value of the said current density is attained by increasing or decreasing the current flow, said element being common to both the input circuit and the output circuit of said electronic tube for generating a bias potential for said tube of substantially constant value despite variations in the flow of space current through the tube.

3. In combination with a load requiring different potentials for the energization thereof, a source of current, a distribution circuit connected across the source, connections between the load and points in said distribution circuit, said distribution circuit comprising a plurality of resistors in series, at least one of said resistors comprising a resistance material including a mass

of silicon carbide crystals and a binder holding adjacent crystals in contact, said material having a hyperbolic resistance characteristic whereby the potential drop developed across it by the flow of current therethrough remains substantially constant despite variations in said current.

4. An amplifier system including at least one electronic tube having input and output circuits, a source of uni-directional fluctuating current, a distribution circuit connected across said source, said distribution circuit including a voltage divider resistor and independent resistance elements interposed in series between points in the output circuit and input circuit of said tube and points in said distribution circuit for energizing the electronic tube while preventing interference in said tube circuits from the fluctuating component of the uni-directional current, at least one of said resistance elements comprising a granular resistance material having a hyperbolic resistance-ampere characteristic and having free carbon as an ingredient and means for holding the grains together under pressure.

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