May 9, 1933. C. G. SMITH 1,907,598

ELECTRICAL CIRCUIT

Original Filed March 15, 1928

Fig. 1

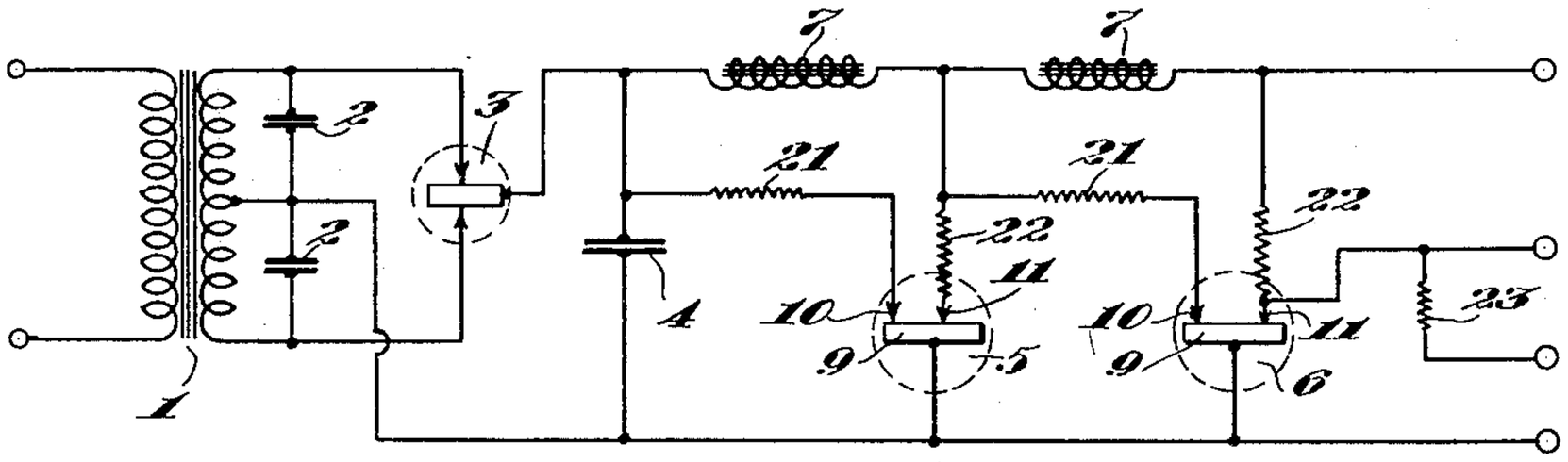
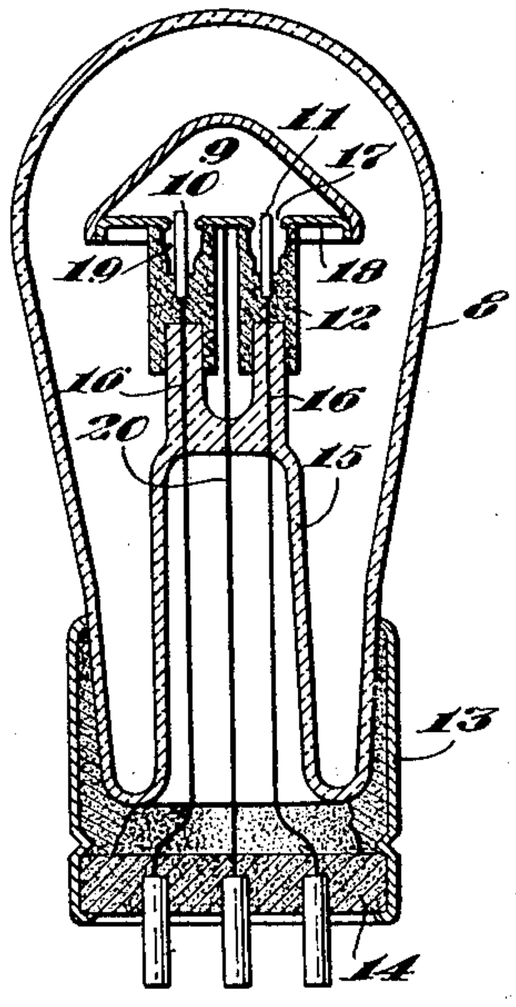


Fig. 2



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UNITED STATES PATENT OFFICE

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ELECTRICAL CIRCUIT

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The present invention relates generally to apparatus for obtaining a constant potential from an electric circuit subject to voltage or current changes or both, more particularly to gaseous conduction devices that function to by-pass excess currents. The arrangement has special adaptation to the furnishing of potentials having invariable magnitude to the plate circuit of a vacuum tube amplifier demanding the superlative degree of potential constancy and flatness of regulation. While the network hereinafter described exhibits remarkable cooperation with a rectifier to form a "B" eliminator so-called, its utility is not limited to radio but has broad application to circuits in general that require steady potential under varying loads or in case the primary source of energy is subject to potential variations. My device may be considered as having a combined voltage and regulating characteristic and is adapted for use in addition to a filter of standard design; in its preferred form, it constitutes an integral part of the smoothing network.

The primary object of my invention is to provide an improved filter and smoothing system.

Referring to the drawing which represents a preferred embodiment of the invention,

Figure 1 shows a schematic view of a combined rectifying, voltage smoothing and regulating arrangement; and

Figure 2 is a cross-sectional view taken lengthwise of a space discharge device which may be advantageously employed as a rectifier and smoothing element.

In Figure 1, numeral 1 designates a transformer, the primary of which is energized by a source of potential ordinarily that of the house supply. Across the secondary, I connect the usual surge or buffer condensers 2 and a rectifier 3 preferably of the full wave Raytheon type BH so-called, as disclosed and claimed in the patents of C. G. Smith, No. 1,617,179, and V. Bush, No. 1,880,014 and shown in Figure 2; however, all forms of single and double wave rectifiers are adapted to my system. The output circuit consists of a number of impedances connected in series and in shunt to the load, the shunt members comprising condenser 4 and space discharge devices 5—6. Between each pair of shunted elements an inductance 7 is inserted serially in the line. For the devices 5—6, I prefer to employ the same type of apparatus as was proposed for the rectifier, i. e. the double anode-single cathode Raytheon type supra, although satisfactory results may be obtained by all forms of gaseous conductors, e. g. glow discharges, in which the voltage across terminals remains substantially constant irrespective of the current passing therethrough. The discharge devices should have a voltage-current characteristic with substantial portion in parallel to the current axis; this characteristic may be derived by a particular arrangement and shape of electrodes and pressure of gas. The portion of characteristic selected for operation in the embodiment of this invention is such that substantial changes in current through the tube result either in no voltage variations across the terminals or such variations as are substantially immaterial in magnitude.

Referring to Figure 2, numeral 8 designates a glass envelope containing hollow cathode 9, anodes 10—11, each of refractory material, insulating thimbles 12 preferably of lavite and a base comprising metallic cylinder 13 sealed by suitable compound to the tube in the usual manner. The bottom of the cylinder is closed by porcelain disk 14 into which the connector plugs project. The envelope 8 has re-entrant stem 15 provided with two tubular projections 16 which extend into recesses in the bottom of the thimbles 12, the latter being slipped over the projections 16 and held in position by cathode 9. The anodes are mounted in openings in members 12 concentrically with projections 16 and openings 17 in the cathode. The cathode is preferably formed in two parts, the upper part comprising a conically-shaped element and the lower part 18 a cover fitting the open end of the cone. As stated in the applications supra, thimbles 12 are spaced from the anode a distance comparable to the mean free path of electrons present and serve to prevent the passage of current between

either anode and the outer surface of the cathode. The ionic activity is thus confined to the space enclosed by the cathode, i. e. the region adjacent the inner surface of the cathode.

In order to minimize the internal losses of the device, I may coat the active portion of the cathode with a substance, as alkaline earth or alkali metal to increase electronic emission. The cylindrical members 12 contain circular recesses 19 adjacent to the openings 17 to prevent or reduce to a negligible factor the tendency of current to flow between cathode and either anode along the surface of insulation. The openings 17 are of such size as to provide space between the cathode and operating anode, comparable to the mean free path of electrons within the region of the cathode. While the latter may be supported solely by cylindrical members 12, I prefer to partly depend for support on the centrally located cathode lead 20 which is joined electrically to one of the connector parts. After evacuating the tube and removing the occluded material, monatomic gas of the helium group or a mixture of the same is admitted at a pressure approximating 14 mm. Hg.

As shown in Figure 1, the device may be connected as a rectifier 3 in the usual manner but when employed as a voltage smoothing apparatus, I prefer to assign to each anode different functions, thus anode 10 of devices 5—6, takes on the starting function, the other anode serves during the remainder of the operating period. Electrode 10 derives a higher initial voltage than its companion element by reason of acquiring a relatively high static potential through resistor 21 tapped into the main circuit immediately prior to the series inductance 17. The magnitude of this resistance should be sufficiently large so that upon passage of the first current impulse, the voltage available between anode 10 and cathode 9 is insufficient to maintain an electrical discharge therebetween. The operating anode 11 has in series therewith across the line, a resistance 22 to furnish a potential drop of magnitude such that the voltage remaining across the last discharge device of the group is commensurate with a standard voltage tap for plate circuit energization, this resistance is purely optional with respect to the other tubes of the group.

Upon producing ionization within the hollow cathode 9 reducing the initial impedance of the device, the starting anode 10 may cease to function temporarily if resistances 21 are of relatively large magnitude, however, the starting anode is always in position to initiate anew an ionized condition. Under other conditions of operation the collection of the static charge on anode 10 may be sufficiently rapid to produce a permanent discharge to the cathode but in any event, a discharge is established between the operating anode 11 and the cathode which serves to by-pass excess current, and may be considered as a variable resistance whose magnitude changes in an inverse sense with respect to the variations of current passing therethrough. In case there are fluctuations of voltage in the house supply or other primary source, or in the rectifying system itself, the potential difference across the terminals of the gaseous resistors remains substantially constant. Moreover, these resistors lend themselves admirably to flat regulation by tending to keep the output voltage constant irrespective of changes in load drain, thus for loads varying between 0 and the maximum amount of plate current necessary for the largest radio set there is obtainable voltage regulation of a relatively close order. If an additional voltage tap is desired, a resistance 23 may be employed in the manner shown.

From the foregoing, it will be evident that apart from the storing condenser 4, the smoothing network comprises one or more sections each of which may include a series inductance and a shunted discharge device of individual design according to its position in the network. Due to the relatively large amount of energy which can be dissipated in the form of heat by the gaseous discharges, each filter section is more effective than the usual series inductance-shunt capacity network. Other filtering systems that employ the glow discharge device to advantage will readily suggest themselves to those skilled in the art in view of the foregoing and hence are covered by the broad concept of my invention.

I claim:

1. In a filter, a plurality of gaseous discharge devices characterized by a constant voltage drop across terminals regardless of the magnitude of current flowing through the device and a reactance connected directly between each pair of devices.

2. In a smoothing network, a circuit, a condenser and a gaseous discharge device connected across said circuit, and separated by an inductance in series with the line, said device having two electrodes, connected across said circuit and an additional electrode which derives its potential from a point in the circuit immediately prior to said inductance.

3. In a filter, a circuit comprising two inductances connected in series in one side of the line, a condenser connected across the line before the inductances, a gaseous discharge device having two anodes and a cathode, one of said anodes being connected through a resistance to the inductance side of the condenser, the other anode being connected between the two inductances through a resistance, the cathode being connected to the other side of the line, a similar gaseous discharge device having one anode connected

through a resistance to a point beyond the inductances, the other anode being connected through a resistance between said two inductances and the cathode being connected to the other side of the line.

4. In a filter circuit a pair of inductances serially connected forming one side of the line, a condenser connected before the inductances to the other side of the line and a pair of gaseous discharge devices having a cathode and a pair of anodes, the cathodes of both devices being connected to the other side of the line, the anodes thereof being connected through resistances to the inductance side of the line, the two anodes of each device being connected on opposite sides of each inductance.

5. In combination a source of direct current, an inductance in series with said source, a pair of glow discharge devices in parallel with said source and connected on opposite sides of said inductance.

In testimony whereof, I have signed my name to this specification.

CHARLES G. SMITH.