April 29, 1930. V. BUSH 1,756,628

CONSTANT POTENTIAL APPARATUS

Filed Oct. 5, 1925

Fig. 1

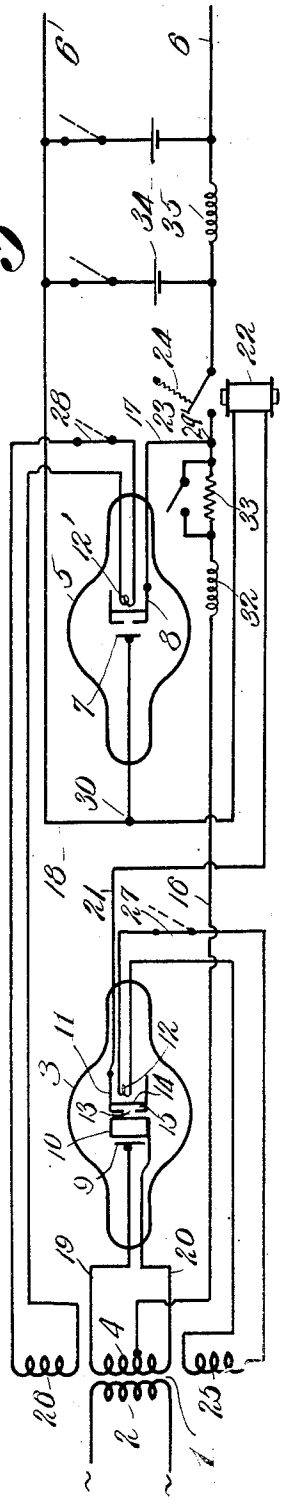


Fig. 3



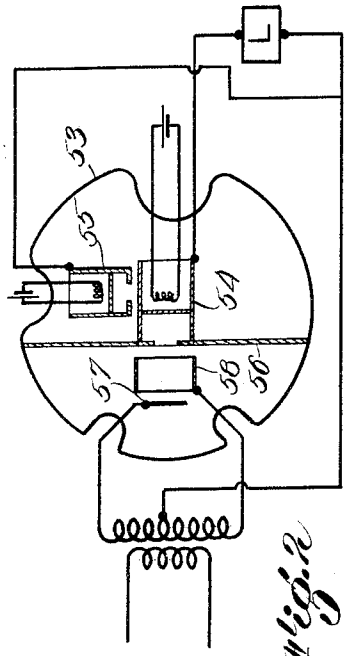


Fig. 2

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UNITED STATES PATENT OFFICE

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CONSTANT-POTENTIAL APPARATUS

Application filed October 5, 1925. Serial No. 60,502.

This invention relates to the art of smoothing pulsating potentials, that is, converting alternating current into uni-directional current of substantially constant potential or removing the ripples from pulsating uni-directional current. A typical use of the invention is for supplying substantially constant potential current of the order of one or two amperes to the filament of an audion, at six to eight volts for example, from an alternating current circuit of customary voltage such as 110 volts.

The invention involves the use of a conducting device having a characteristic curve at least a portion of which is approximately straight and parallel with one of its axes, specifically the current abscissa. The device is connected in parallel with the load circuit (e. g. the filament of an audion) and maintains the load voltage constant throughout the range represented by the horizontal portion of the curve by virtue of the fact that, throughout said range, the voltage across its terminals (and therefore across the parallel load circuit) remains substantially constant, only the current through the device varying with the variations in the applied electromotive force. In devices whose characteristic curves have only approximately horizontal portions, auxiliary devices, such as chock coils and/or condensers and/or resistances may be employed to assist the smoothing action according to well-known practices.

So far as I am at present aware, the best device having a substantially horizontal characteristic curve is that disclosed in the application of Charles G. Smith, Serial No. 55,262, filed September 9, 1925. Reference should now be had to the drawing in which:

Fig. 1 illustrates a preferred embodiment;

Fig. 2 is a modification of the embodiment;

Fig. 3 shows a charactertisic curve having a horizontal portion.

The particular embodiment of the invention illustrated in Fig. 1 comprises a transformer 1 having its primary 2 connected to a source of alternating current, a rectifier 3, which may be of the type disclosed in the aforesaid application, connected to the secondary 4 of the transformer, and a gaseous conduction device 5, having a characteristic curve a portion of which is substantially horizontal, connected in parallel with the load circuit 6, the upper side of the load circuit being connected to the anode 7 and the lower side to the cathode 8.

When using a rectifier such as disclosed in the aforesaid application, it may comprise a tube containing a disk anode 9, a cylindrical anode 10, a cup-shaped cathode 11 and a heating element 12. The hollow cathode 11 has a restricted opening 13 in the end presented to the anodes, and intermediate its ends it has a partition 14 so that the space 15 between the partition 14 and the left-hand end of the cathode constitutes the active portion, the heating element 12 in the right-hand end of the cathode transmitting no electronic current to the anodes but merely heating the cathode, either during the entire period of operation or merely while starting. The tube preferably contains a readily ionizable gas, such as mercury or cæsium vapor, which may for example be at a pressure of .01 mm. in the space exterior to the cathode, and, during operation, at a higher pressure within the cathode. A rectifier of this general type is more fully described in the aforesaid application.

The tube 5 may be constructed in a manner similar to the rectifier 3 except in that only a single anode 7 is employed. A tube of this character has a characteristic curve, such as shown in Fig. 3, where the abscissæ represent current, and the ordinates represent the potential across the anode 7 and cathode 8. The reason this tube has a characteristic of this type is believed to be as follows:

This peculiar characteristic is believed to result from a close relationship between the internal drop of the tube and the excitation or resonance potential of the gas in the tube (the potential required to put the gas atoms in an excited state). For example, mercury vapor has an excitation potential of 5.0 volts, although its ionization potential (the potential through which an electron must fall in order to acquire sufficient velocity to ionize

a molecule of gas) is 10.6 volts; and when the atoms are in an excited state it is believed that they can be readily ionized by succeeding electron impact even although this may be at relatively low velocity. By constructing the tube 5 as described herein and in the aforesaid application, the internal drop of the tube may be made to correspond very closely to this excitation potential. While the internal drop may be somewhat higher or somewhat lower than the excitation potential it is preferably substantially the same. The characteristic of the tube chiefly contributing to this condition is believed to be the relatively high gas pressure adjacent the active surface of the cathode which largely if not entirely eliminates the usual potential drop at the cathode. This effect is enhanced by the localization of the ionization within the hollow cathode where ions and/or excited atoms are retained instead of being allowed to escape. The result is that when the tube is thus constructed the current through the tube may be varied while maintaining the internal drop substantially at the value corresponding to the excitation potential.

The parts above described are preferably interconnected as follows: The midpoint of the secondary 4 is connected through a conductor 16 with the lower side of the load circuit and through the branch conductor 17, with the cathode 8, the anode 7 being connected to the upper side of the load circuit through conductor 18. The opposite ends of the secondary 4 are connected to the anodes 9 and 10 of the rectifier 3 through conductors 19 and 20, respectively. The cathode of the rectifier 3 may be connected directly to the anode 7 of the device 5 through a conductor 21, although this conductor preferably includes an electromagnet 22 for automatically closing switch 23 in the load circuit when the apparatus is put into operation, the switch 23 being automatically opened by spring 24 when the operation is discontinued. It is apparent that by starting the rectifiers with the load circuit open, the initial rush of current and consequent variation of voltage is minimized.

The heating coils 12 and 12′ in the two tubes may be energized in any suitable manner, as by windings 25 and 26 on transformer 1, the switches 27 and 28 being provided to discontinue the energization of these heaters either during the operation of the system or at the end of the operation. Thus, the unidirectional circuit extends from the upper side of the load circuit 6, through conductor 18, electromagnet 22, conductor 21 to the cathode of the rectifier, and thence alternately, during alternate half cycles, from the anodes 9 and 10, conductors 19 and 20, secondary 4, and conductor 16 to the lower side of the load circuit, the tube 5 being connected in parallel with this circuit at points 29 and 30.

In operation the unidirectional current in the load circuit tends to rise and fall with the alternate half cycles of current delivered by the transformer 1 but if the parts be properly coordinated with each other and with the load these variations may be limited to the substantially horizontal portion 31 (Fig. 3) of the characteristic curve of the tube 5, whereby the electromotive force across the tube 5, and therefore across the load circuit connected in parallel therewith, is maintained substantially constant notwithstanding variations of current in the device 5.

If desired, auxiliary devices may be employed to assist in maintaining constant voltage across the load circuit in which case any suitable devices may be used. As shown in Fig. 1, for example, these devices may comprise a choke coil 32 to prevent the current through tube 3 from falling to zero value between half-cycles and condensers 34 connected in parallel with the load circuit, switches such as shown in the drawing being employed if desired to cut these devices in or out at will. A choke coil 35 may also be employed between the points of connection of the condensers 34.

Fig. 2 illustrates a modification of Fig. 1 in which the two tubes 3 and 5 are combined into a single tube 53 by making the cathode 54, corresponding to cathode 15 in Fig. 1, function also as an anode for the cathode 55, corresponding to cathode 8 in Fig. 1. A shield 56 is preferably provided between the cathode and the anodes 57 and 58, corresponding to the anodes 9 and 10 in Fig. 1, to prevent current flowing between the cathode 55 and the anodes.

From the foregoing it will be evident that this invention is characterized by the use of thermionic emission in a gaseous medium, in contradistinction to a glow discharge in a gaseous medium, for potential regulation; the former, unlike the latter, having substantially no voltage drop at the cathode. Another unique characteristic consists in the novel relationship between the resonance or excitation potential of the gas and the load potential.

I claim:

1. In combination, a source of alternating current, a load circuit connected thereto and normally inoperative, a rectifier interposed therebetween whereby unidirectional pulsatory current is derived, a device across the load circuit for removing the pulsations and means in series with the load circuit and responsive to rectified current for rendering the load circuit operative.

2. An electrical system comprising a source of pulsating current, a load circuit connected thereto, means interposed therebetween for smoothing the pulsating current and means responsive to said current for automatically closing the load circuit when current flows through said means.

3. An electrical system comprising a source of pulsating current, a load circuit connected thereto, a gaseous conduction regulator interposed therebetween for smoothing the pulsating current and means responsive to said current for automatically closing the load circuit when the gaseous medium in said regulator becomes conducting.

Signed by me at Boston, Massachusetts, this 2nd day of October, 1925.

VANNEVAR BUSH.