March 4, 1930. A. N. FENTON 1,749,423

ELECTRIC VALVE

Filed June 11, 1927

Fig. 1.

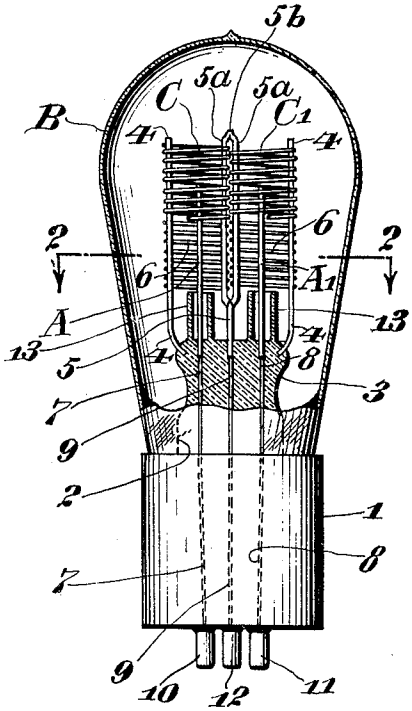


Fig. 2.

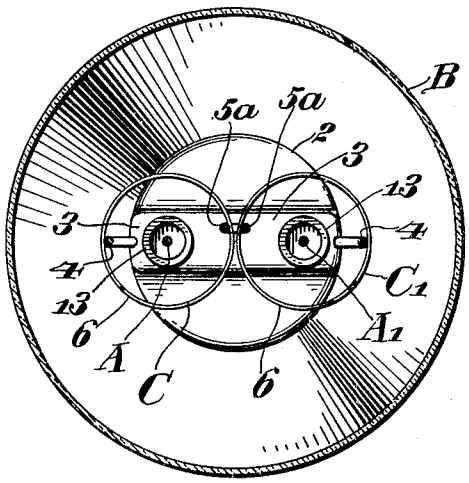


Fig. 3.

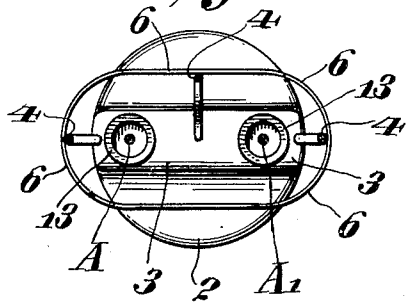


Fig. 4.

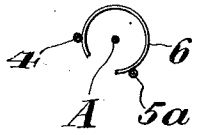
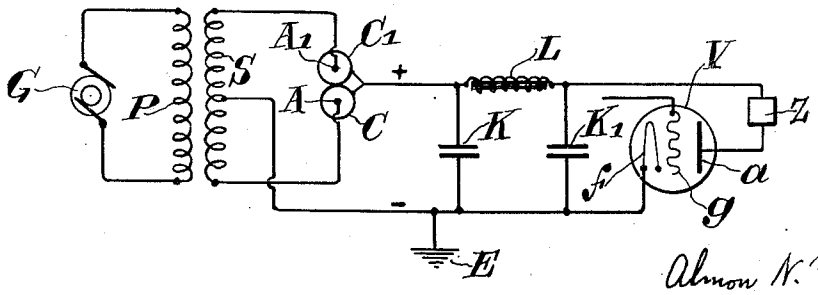


Fig. 5.



Fig. 6.



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UNITED STATES PATENT OFFICE

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ELECTRIC VALVE

Application filed June 11, 1927. Serial No. 198,181.

My invention relates to electric valves, asymmetrical electrical conductors or rectifiers of the gaseous discharge type, utilizable for any suitable purpose and particularly for procuring from an alternating current a unidirectional or preponderatingly uni-directional current for heating the cathodes, and more particularly for the anode or plate circuits, of thermionic devices, and more particularly three-electrode thermionic devices of the audion type, as utilized in radio receiving and transmitting apparatus.

In accordance with my invention the cathode comprises numerous elements of curved, preferably circular, or equivalent form of conductor or wire, of circular or equivalent cross-section, having unusually small diameter or radius of curvature, yielding, in association with other features hereinafter described, a rectifier or the like of gaseous discharge type having unusually long life and of high power output.

Further in accordance with my invention each of the cathode elements is secured, as by welding, to a support which may serve also as a terminal for including the cathode in circuit; and more particularly in accordance with my invention the cathode elements may be formed by a single helically disposed wire or conductor all or any suitable number of whose convolutions may be welded or otherwise secured to the support or terminal.

Further in accordance with my invention the elements or convolutions of a plurality of cathodes are secured to supports constituting a common terminal for the cathodes, and more particularly in such a structure the elements or convolutions of the several cathodes may be secured to additional supporting elements.

Further in accordance with my invention the aforesaid cathode support or terminal is secured to or sealed in the press of a bulb or tube within which the cathode and anode are disposed.

Further in accordance with my invention a tube of glass or equivalent material sealed or united at its one end in or with the glass or equivalent press surrounds and is spaced from the anode, and extends to a point adjacent that end of the cathode structure nearest the press.

My invention resides in the features of structure, arrangement and combination hereinafter described and claimed.

For an illustration of some of the various forms my invention may take reference is had to the accompanying drawing in which:

Fig. 1 is a vertical elevational view, partly in section, of an electric valve embodying my invention.

Fig. 2 is a horizontal sectional view, on enlarged scale, parts in plan, taken on the line 2—2 of Fig. 1.

Fig. 3 is a fragmentary plan view of a modified structure.

Figs. 4 and 5 are plan views of modifications of cathode elements.

Fig. 6 is a diagram of one of the various electric circuit arrangements in which my electric valve is utilizable.

Referring to Figs. 1 and 2, 1 is the base of a tube or bulb B of glass or the like having the usual tubular stem 2 and press 3, of glass or equivalent.

Secured to or sealed in the press 3 are the upstanding supports, wires, or rods 4 and the common terminal 5 in the form of a rod or wire to which are secured, as by welding, the further supports 5^a, 5^a preferably welded to each other at 5^b. Each of the foraminous cathodes C and C^1 comprises numerous elements of fine wire 6 of tantalum, tungsten, molybdenum, nickel, or other suitable material ranging in diameter from about .003 to .025 inch, effecting small radius of curvature of its surface for effecting high electron emission.

The wire 6 is disposed, in the example illustrated, in the form of a helix, all or any suitable number of convolutions of which are secured, as by welding, to either or both the supports 4, 5^a the support being essential or at least desirable because of the fineness of the wire 6 essential to the desired characteristics of the electric valve particularly as regards its long life and high electron emission from the cathode or cathodes.

Wire of the fineness characteristic of my invention is of itself not sufficiently stiff or

rigid to hold its form in position under conditions obtaining in the manufacture, shipment and particularly in the use of the valve.

The wires or rods 4 and 5^a are preferably of a diameter considerably greater than that of the wire 6 and may be, for example, of the order of .025″ and may be of any suitable material, such as that of the wire 6.

The wire 6 secured or welded to either or both the supports 4, 5^a effects a suitable rigid cage-like structure which is not subject to deformation or displacement, and maintains under all conditions its correct relation and position with respect to the coacting anode.

Disposed substantially in the axes of the cathodes C and C^1 are the coacting or associated anodes A and A^1 in the form of a wire or rod, of any suitable material, such as that of the wire 6. The diameter of the anode wire or rod is materially greater than that of the wire 6, rendering the anode sufficiently rigid to be self-supporting and non-deforming. For example the diameter of the anode wire may be of the order of .02″ though considerable variation in either direction from that magnitude is permissible.

Each anode may extend to any suitable distance into or longitudinally of the associated cathode and may extend to the upper end thereof, though as indicated it is preferred that each anode shall terminate short of the upper end of the associated cathode. The anodes A and A^1 and the terminal or support 5 are sealed in the press 3 within which they are connected with their respective lead-in wires 7, 8 and 9, sealed vacuum tight in the press 3, and connecting respectively with the base terminals 10, 11 and 12 by which, upon insertion of the base 1 in a suitable socket the anodes and cathodes are connected in the external circuit.

Prior to the compression of the stem 2 to form the press 3 there are disposed around the anodes A and A^1 the tubes 13 of glass or equivalent material which upon formation of the press 3 are held therein or, as is indicated, united integrally therewith. The tubes 13 have an internal diameter substantially greater than that of the anode passing therethrough, and terminate preferably adjacent the lower end of each cathode structure. The tubes 13 serve to prevent the lower ends of the anodes A and A^1, adjacent their seals or unions with press 3, attaining unduly high temperature during operation of the valve, which occurs in the absence of the tubes 13, due to bombardment or other action. The tubes 13 apparently limit the bombardment of the anodes A and A^1 almost entirely to their parts directly exposed to the associated cathodes.

In Fig. 3 the cathode structure, common to the two anodes A and A^1 comprises a single helix of wire 6, each convolution of which is spaced from and passes around both anodes. The wire 6 is welded at each or any suitable number of convolutions to any one or more of the several supports 4, any one or more of which may constitute a terminal of the cathode.

Within the bulb B is contained any suitable gas, and preferably a pure monatomic gas or vapor such as neon, argon, and preferably helium at an absolute pressure of from about 5 to about 50 mm. of mercury and preferably at an absolute pressure of about 24 mm. of mercury.

The electrodes of the valve are preferably of tantalum.

A valve of the character above described, with the cathode helix about $\frac{5}{16}$″ in diameter and about $\frac{13}{16}$″ long yields at a pressure of several hundred volts a current of the order of 60 milliamperes with a useful life of upwards of ten thousand hours.

The high current or power output is dependent upon the small size of wire 6, yielding high electron emission under ionic bombardment and the life, notwithstanding such heating of the electrodes as is developed in operation, is long because the cathode structure permits free circulation of the gas through and around it and around the anode structure.

The free gas circulation apparently has the double effect of cooling or prevention of excessive rise of temperature of the electrodes, and of continuously replenishing the discharge path with gas from the idle spaces.

A valve of the character described may be considered as generically of the point-plane type, that is, of the type in which the anode surface is broadly of the character of a point in that it has small radius of curvature, and the cathode has relatively far larger active area.

The valve is self-starting and is of the cold electrode type, as distinguished from vaves utilizing hot or incandescent cathodes.

While, for simplicity and cheapness in manufacture, the wire 6 is disposed as a helix, it will be understood that each cathode structure may be formed of separate arcuate wires, either circumferentially complete or incomplete, and disposed side by side longitudinally of either or both the supporting members 4, 5^a.

As indicated in Fig. 4 each element of the cathode structure may comprise a circumferentially incomplete arcuate conductor 6 secured or welded to one or more supports or terminals 4, 5^a.

Or as indicated in Fig. 5 each cathode element is a circumferentially complete individual and separate ring secured or welded to one or more supports or terminals 4, 5^a.

Whether the wire be disposed as last above mentioned, or as a continuous helix, the numerous elements are individually electrically connected to the supports or terminals 4, 5^a,

yielding a low electrical resistance of and within the cathode structure itself.

In Fig. 6 there is illustrated a typical circuit arrangement with which a valve of the character above described may be utilized. G generically represents a source of alternating current of, say, a frequency of 60 cycles per second and 110 volts such as is commonly employed in house wiring. In circuit therewith is connected the primary P of a transformer, serving to step-up the voltage to several hundred volts. Opposite terminals of the secondary S are connected respectively to the anodes A and A^1, and the cathodes C and C^1, which are electrically connected together, connect to a typical filter system comprising the inductance L and the condensers K, K^1 as well understood in the art for minimizing the hum-producing ripple. The cathodes C and C^1 are connected to the anode or plate *a* of a three-electrode thermionic tube or audion V and its cathode or filament *f* heated by a suitable source of current, not shown, connects with a substantially middle tap on the secondary S. The filamnet or negative side of the system is preferably grounded as indicated at E. Z represents the impedance in the plate circuit of the tube V which as usual has the control grid *g*. The impedance Z may be of any suitable character depending upon the purpose and function of the tube V which may be used as a radio or audio frequency amplifier, detector, oscillation generator etc. And it will be understood from the same source of current the anode circuits of one or more tubes such as V may be simultaneously supplied.

While the anodes A and A^1 are shown connected to the opposite ends of the secondary S, it will be understood that when suitable or desirable the cathodes C and C^1, when electrically insulated from each other may be connected to opposite terminals of the secondary S, and the anodes A and A^1 may be electrically connected to each other and to the substantially mid point of the secondary S. In such event the anode *a* and filament *f* of the tube V would as always be connected respectively to the positive and negative terminals of the rectifier system.

While the conductor 6 is shown and described as a wire of substantially circular cross section, it shall be understood that any other suitable cross section is comprehended by the term "wire", and may be polygonal, including such cross sections as are afforded by strips or ribbons whose edges or flat sides may be presented to the coacting anode.

In the case of wire 6 of substantially circular cross section the diameter, lying within the aforesaid range from about .003 to about .025 inch, is, for lengthening the life of the valve, the larger as the gas pressure is higher, as the atomic weight of the gas is higher and as the load or current is higher. When helium is utilized, as an absolute pressure lying within the hereinbefore described pressure range, and the wire 6 is of tantalum, tungsten, molybdenum or nickel, its diameter will lie within the range from about .003 to about .015 inch, the larger diameter being utilized with the less refractory metal. The preferred combination is that of helium gas with a cathode conductor 6 of tantalum.

The preferred material for the anode is tantalum. While the anodes have been shown in the form of straight wires or rods, it shall be understood that each may comprise a plurality of straight wires or rods, or there may be utilized wires or rods formed in any suitable shape and of any suitable cross section, all of which it will be understood are included in the term "rod-like".

The cathode structure hereinbefore described is foraminous, permitting the desirable freedom of passage of gas around and past the active surfaces, and it will accordingly be understood that in addition to the preferred structure described other and equivalent foraminous cathodes may be employed.

What I claim is:

1. An electric valve of the gaseous discharge type comprising an anode, and a cathode comprising a series of spaced wire-like elements whose surfaces have radii of curvature lying within the range from about .0015 to about .012 inch.

2. An electric valve of the glow discharge, cold electrode type comprising in an atmosphere of helium an anode and a cathode comprising a wire-like helix of tantalum whose surfaces have radii of curvature lying within the range from about .0015 to about .012 inch.

3. An electric valve of the gaseous discharge type comprising a plurality of anodes, and a cathode structure coacting therewith comprising wire-like elements spaced from each other and whose surfaces have radii of curvature lying within the range from about .0015 to about .012 inch.

4. An electric valve of the gaseous discharge type comprising a plurality of anodes, and a coacting cathode structure comprising wire-like helical elements spaced from each other, and a terminal to which said elements are individually secured.

5. An electric valve of the gaseous discharge type comprising a plurality of anodes, a wire-like helix surrounding each anode, and a terminal structure to which the spaced helical convolutions are secured.

6. An electric valve of the gaseous discharge type comprising a plurality of rod-like anodes, a tube-like cathode structure surrounding each anode, each cathode structure comprising a series of spaced wire-like elements, and supporting members disposed re-

spectively within said cathode structures and secured to each other.

7. An electric valve of the gaseous discharge type comprising a plurality of rod-like anodes, a tube-like cathode structure surrounding each anode, each cathode structure comprising a series of spaced wire-like elements, supporting members disposed respectively within said cathode structures and secured to each other, and a terminal connected to said supporting members.

8. An electric valve of the gaseous discharge type comprising a bulb, a press therein, a cathode comprising a series of spaced wire-like elements, a support secured in said press and to which said elements are individually secured, a rod-like anode secured in said press and extending within the said cathode elements, and a tube of insulating material secured to said press, said anode extending through said tube in spaced relation therewith, said tube extending to a point adjacent said cathode.

9. An electric valve of the glow discharge cold electrode type comprising, in an atmosphere of helium, a hollow foraminous cathode structure of tantalum, and a plurality of rod-like anodes disposed therein.

10. An electric valve of the glow discharge cold electrode type comprising, in an atmosphere of helium, a hollow foraminous cathode of tantalum, and an anode of tantalum therein.

11. An electric valve of the glow discharge, cold electrode type comprising in an atmosphere of helium at a pressure of from 5 to 50 millimeters of mercury, a hollow foraminous cathode structure of tantalum, and a rod-like anode disposed therein.

12. An electric valve of the glow discharge type comprising in at atmosphere of helium, a plurality of tantalum electrodes, and a coacting cathode structure within which an anode extends comprising wire-like elements of tantalum spaced from each other and having small radius of curvature.

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