Sept. 9, 1930. J. S. VAN HORNE 1,775,219

THERMIONIC VALVE

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Fig. 1

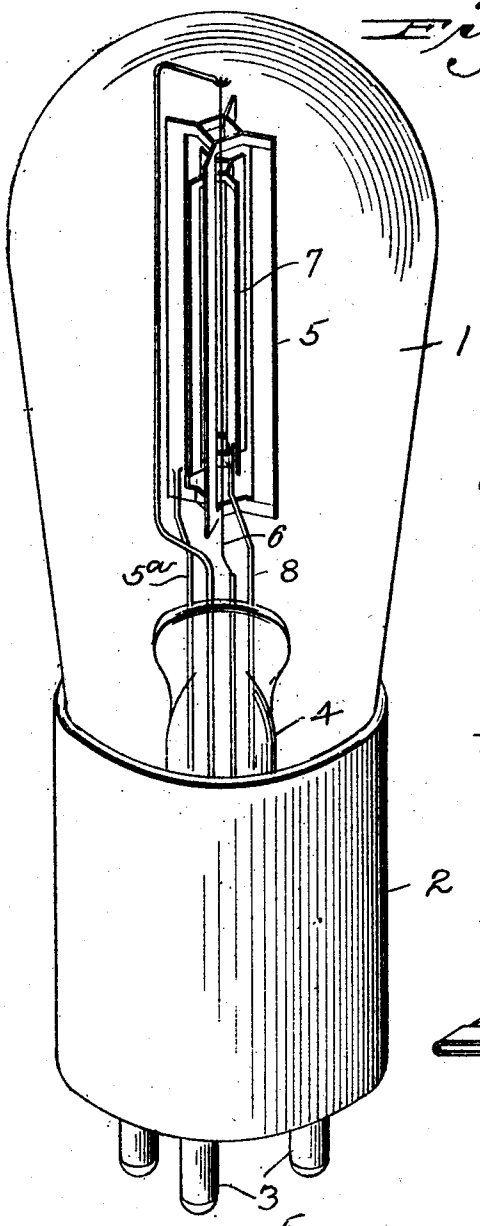


Fig. 2

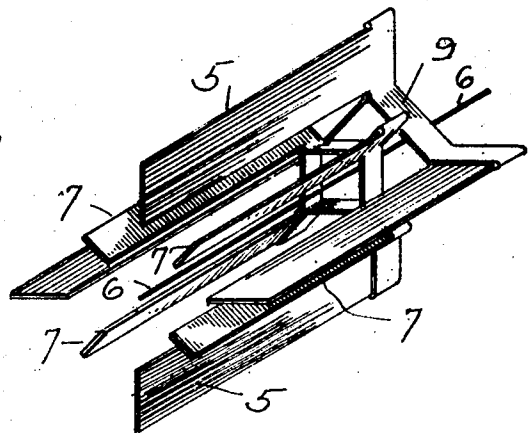


Fig. 3

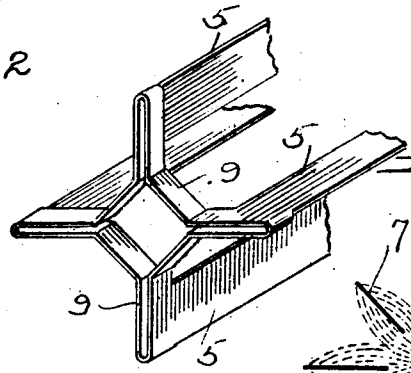


Fig. 5.

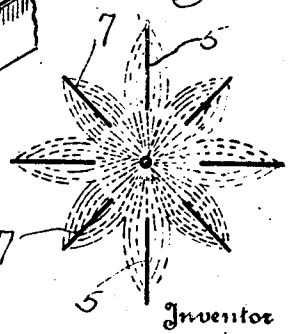
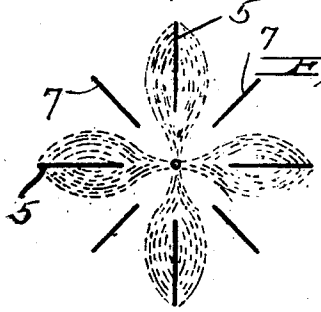


Fig. 4.



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Fig. 6

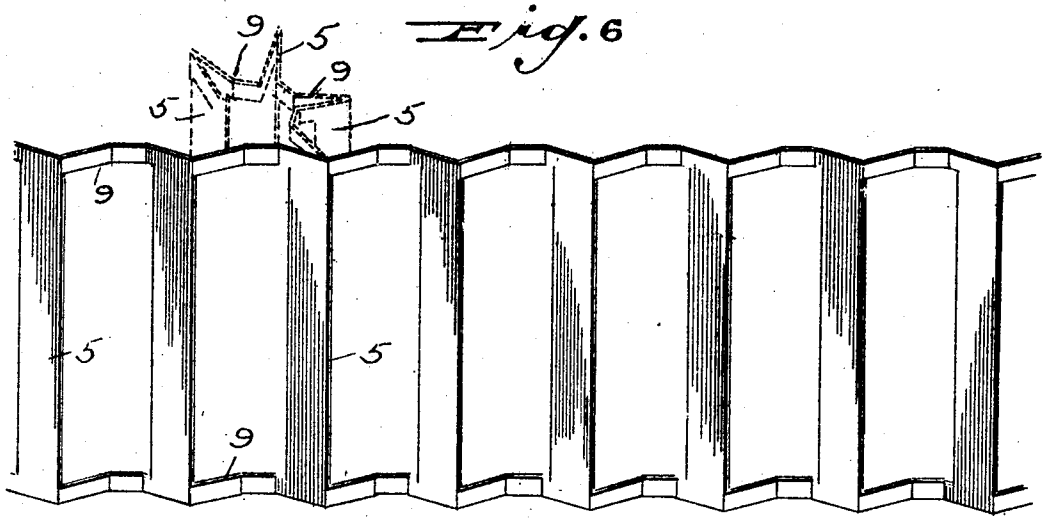
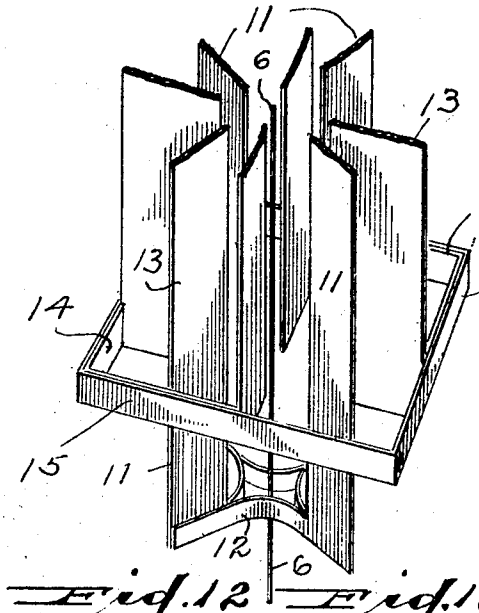
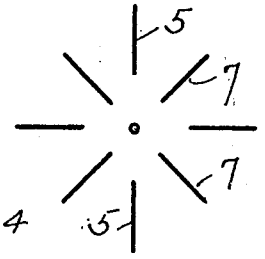


Fig. 7

Fig. 8.

Fig. 9.





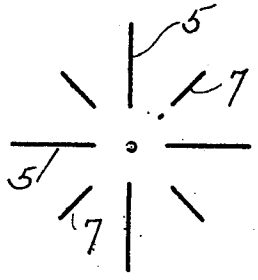
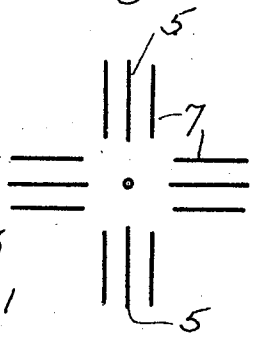


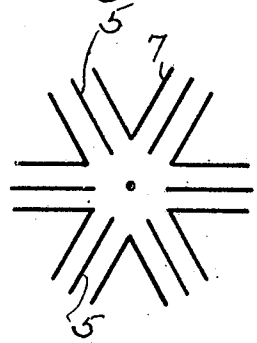
Fig. 10.

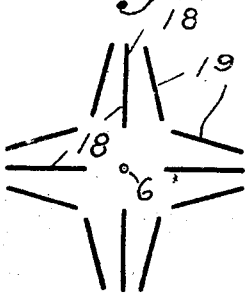
Fig. 11

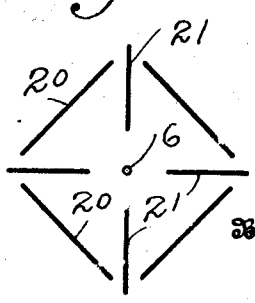
Fig. 12

Fig. 13









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Patented Sept. 9, 1930 1,775,219

UNITED STATES PATENT OFFICE

JOHN S. VAN HORNE, OF FRANKLIN, OHIO, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

THERMIONIC VALVE

Application filed May 11, 1925. Serial No. 29,545.

My invention relates to thermionic valves, popularly known, as "radio tubes" and particularly to a means and method of controlling the output current by diversion or deflection of the electronic emissions without interference with the quantitive flow or the velocity thereof.

The blocking type of valve commonly used controls the electronic stream, and thereby the out-put current by retarding or partially damming the flow of the electrons from the filament to the plate or anode by the repelling action of an interposed grid element when impressed with negative potential, and by accelerating such flow of electrons by supplementing the attraction of the anode plate by that of the grid element when impressed with positive potential. The repelling effect of the grid element negatively impressed creates an electronic disturbance and back pressure, distorting and reducing the flow of the electronic stream in velocity as well as in volume.

The present thermionic valve is designed to control the out-put by diverting a greater or less portion of the electronic stream toward or away from the anode plate, without, however, materially changing either the volume or velocity thereof. To this end a series of spaced plates is preferably though not necessarily radially disposed about a filament or other electron emitting element, the alternating plates serving as modulating and anode or out-put plates respectively. The emitted electrons passing radially from the filament between the plates are attracted toward the anode plates, which are always subject to a positive potential. The modulating plates, which are subject to fluctuating potential sometimes positive, and sometimes negative, afford a counter attraction for the electrons, when positively impressed, attracting to themselves some of the electronic flow, and causing other portions of the electronic stream to change their course, so as to avoid the anode plates, and so pass into space. When negatively impressed, the modulating plates by their repelling influence tend to bend the direction of electronic flow toward the anode plates, thus increasing the supply of electrons thereto.

Whereas in the usual blocking type of device, the electronic stream is distorted and irregular, being intermittently dammed or turned back, while at other times accelerated, the present construction permits a uniform flow of electrons at uniform velocity, and effects control solely by bending the direction of flow more or less toward and away from the anode plates. The efficiency and sensitiveness of the valve is thus increased, making it more responsive to slight fluctuations of modulating potential, eliminating abrupt variations, and the necessity for overcoming the inertia of the moving electrons, and serving to more accurately proportion the out-put current to the input potential.

The object of the invention is to simplify the construction as well as the means and mode of operation of electronic or thermionic valves, whereby they will not only be cheapened in construction, but will be more durable and more efficient in use, of increased sensitiveness, responsive to slight fluctuations of control currents, and of strong rugged construction, capable of withstanding moderately rough usage through long periods of usefulness.

A further object of the invention is to provide an improved form of construction, and an improved method of assembling, by which the valve elements may be more easily and readily formed and economically assembled.

With the above primary and other incidental objects in view as will more fully appear in the specification, the invention consists in the features of construction, the parts and combinations thereof, and the mode of operation or their equivalents as hereinafter described and set forth in the claims.

Referring to the accompanying drawings, wherein is shown the preferred, but obviously, not necessarily the only forms of embodiment of the invention, Fig. 1 is a perspective view of an assembled electronic valve or radio tube embodying the present invention. Fig. 2 is an exaggerated sectional perspective view of the several elements in assembled relation. Fig. 3 is an enlarged perspective view of one of the plate elements, illustrating the mode of assembly. Figs. 4 and 5 are diagrammatic

views illustrating the electronic flow stream under influence of negative and positive modulating potential respectively. Fig. 6 is a perspective view of the plate 6, from which the modulating and anode elements are formed by folding the strip upon itself. Fig. 7 is a perspective view of a modification. Figs 8 to 13 inclusive are diagrammatic views, illustrating modifications of the relative positions of the modulating and anode plates.

Like parts are indicated by similar characters of reference throughout the several views.

While the tube or valve herein described is particularly adapted for radio communication, it is to be understood that it is applicable to other purposes, such as telephonic and electrical systems, wherein it is desired to detect or amplify electric currents of very slight magnitude.

The elements of the present device may be enclosed in an evacuated bulb, or in one filled with an inert gas, affording what is known as a "soft tube", or under certain conditions of use may be exposed to atmosphere without an enclosing envelope or bulb. In the drawings, the elements have been shown contained within a bulb 1, which may be either a vacuum tube or gas filled. This bulb 1 is mounted upon a standard type of base 2, having on its bottom, projecting prongs 3, electrically connected with the several elements, and through which such elements are to be connected in corresponding electrical circuits. Projecting within the bulb 1 is the usual stem 4, through which the electrical connections extend from studs or prongs 3, to the several elements, and upon which the elements are supported. The cathode or electron emitting element comprises a filament 6, axially disposed within the tube 1, and rendered incandescent by passage of current therethrough. The electrons emitted from the incandescent filament are projected radially in all directions. The anode or out-put element which because of its positive characteristics tends to attract the negatively charged electrons, consists of a plurality of plates 5, radially disposed about the filament or cathode element 6. The radially disposed anode or output plates 5 are interconnected with each other into a unitary cage-like structure, concentrically disposed about the filament 6, and supported upon a lead wire 5^a, extending through the press or stem 4, and interconnecting the output plate 5, with one of the prongs 3 on the bottom of the tube base. The modulating element comprises a similar plurality of radially disposed plates 7, preferably of smaller dimensions than the anode plates 5, but likewise interconnected with each other, into a unitary cage-like structure, similar to that of the anode element, but of less size. This modulating element is introduced within the cage formed by the anode or output plates 5, with the modulating plates 7 alternating with the plates 5, and also in radial relation with the filament 6. This modulating element is supported upon a lead wire 8, projecting from the press or stem 4, and connecting the modulating element with one of the studs or prongs 3. Thus the anode plates and modulating plates 7 alternate with each other in radially spaced relation with the filament 6. For illustrative purposes only, and with no intent of limiting the invention to any relative proportions of the modulating and anode plates, or the spacing thereof, it may be stated that in practice for usual radio communication receiving purposes, modulating plates approximately one third the width of the anode plate are to be preferred. In commercial valves heretofore manufactured, the modulating plates have been approximately one sixteenth of an inch wide, while the output plates have been approximately three sixteenths of an inch wide, such plates being spaced respectively, approximately three thirty-seconds of an inch and from three sixteenths to one quarter inch radially away from the centrally disposed filament or cathode element 6. It has been found that by varying the relative proportion of the modulating and anode or out-put plate and by varying their relation with the filament, different results and effects may be had, which are advantageous for certain conditions of use. The plates of the respective groups may be equidistantly spaced from the central filament 6, as indicated in Figs. 4 and 5, or for slightly different effect, the modulating plates may be projected inwardly in closer proximity to the filament 6, as shown in Fig. 8. This at the present time is the preferred relationship. However, in lieu thereof, the plates 5 of the output element may be projected toward the filament 6, beyond the inner margins of the modulating plate as in Fig. 9. In any event it is to be noted that the modulating plates 7 are in no instance interposed between the filament 6 and the out-put plates 5.

The out-put or anode plates 5 being subject to positive potential and the modulating plates 7 being at zero potential, the out-put or anode plates 5 will attract a portion of the emitted electrons, while a considerable portion of the electronic stream will pass between the separated plates into space. If, however, the modulating plates 7 are subjected to a positive potential, they exert a counter-attraction upon the passing electrons, neutralizing to some extent the attractive influence of the anode or out-put plate. While the modulating plates under positive potential characteristics, will attract to themselves, some of the electrons, they will influence away from the anode or out-put plates 5 a considerable portion of the

electronic stream, thus decreasing the supply to such out-put plates. Upon reversal of the modulating potential to a negative characteristic, the repelling influence of these negatively charged plates will tend to bend the electronic stream toward the anode or out-put plate, thus increasing the electron supply. The attractive and repelling influence of the modulating plate as the case may be is exerted laterally upon the line of movement of the electrons, tending to bend such directional movement toward or from the anode or out-put plates, without opposing, resisting or materially checking the velocity or changing the volume of electronic flow. No energy is wasted in overcoming the inertia of the fast moving electronic stream, as the modulating plates take on a negative characteristic and no energy is wasted in overcoming the inertia of a slow or retarded flow of electrons, and in accelerating the flow as the modulating plates take on a positive characteristic. The elimination of such antagonistic and opposing forces renders the device extremely sensitive and quickly responsive to minute fluctuations of control current.

Fig. 4 illustrates in exaggerated diagrammatic form the electronic flow stream under influence of negative modulating potential. The out-put plates are shown attracting their maximum quantity of electrons, while none are attracted to the modulating plate. In Fig. 5 the potential of the modulating plates is reversed. These plates counteract to some extent the attractive influence of the out-put plate 5 and a less quantity of electrons are diverted thereto.

In addition to the extreme sensitiveness, quick response and uniformity of regulation of the electronic stream by the present device, the intercapacitive coupling between the plates of the respective elements has been found to afford an unexpected beneficial effect and advantageous result, particularly in radio frequency circuits. The device has been found to induce a better action and to facilitate the tuning of radio frequency apparatus.

While the plates 5 and 7 forming the cage units, utilized as out-put and modulating elements may be separately formed and interconnected by suitable intermediate ties or otherwise electrically connected in any suitable manner, the several plates of each unit together with the intermediate tie portions are preferably, though not necessarily, integrally formed from a continuous strip of sheet metal. Such sheet material is formed by punching into a ladder-like blank shown in Fig. 6. This blank consists of a succession of spaced plate portions 5, interconnected at their extremities by narrow strips 9, which are creased or bent at the time of manufacture to indicate the point at which the ladder-like blank is folded upon itself to form the cage-like unit. The manner of folding this blank is clearly illustrated in Fig. 6 and also in Fig. 3, in which the size of the parts and the folds of the blank are greatly exaggerated. It is to be noted that when folded, and the plate portions 5 adjusted to relatively right angle radial positions, the intermediate tie portions 9 at each end of such plates 5 connect the outer margin of one plate with the inner margin of the succeeding plate 5, extending in parallel relation with the lower margin of the first plate, and thence diagonally to its juncture with the inner margin of the second plate. During the assembly, such overlapping portions of the plate and tie 9 are preferably united by spot welding. In the final assembly, the unit comprises terminal polygonal frames or bands formed by the diagonal portions of the ties 9 from which extend outwardly in radial relation, the several plates 5.

The modulating unit is preferably formed in identically the same manner as the anode units, except that it is smaller in size. In assembling the device the modulating unit is introduced in the out-put unit in concentric relation with the radial plates 7 of the modulating unit disposed mid-way between those of the out-put unit, or elements. The elements are held in such relation by the lead supports 5^a and 8 to which they are attached by spot welding or otherwise. The filament 6 extends centrally or axially through the assembled modulating and out-put elements, and is suitably supported upon and connected to positive and negative terminals, which extend through the press or stem 4.

In Fig. 7 there is shown a modification, wherein the several plates are separately formed and subsequently united into two groups. The inner group comprises a series of radially disposed plates 11, from the inner margins of which project tie arms 12, bent laterally into parallel relation with the succeeding plate 11 of the group to which the arms are united by spot welding or otherwise. The outer group of plates shown in Fig. 7, comprises radially disposed members 13, interconnected in pairs by tie portions 14, shown as angularly bent into right angle relation. These interconnected pairs of plates are in turn connected by rectangular bands 15. The plates of the respective groups alternate with each other in radial relation with the centrally disposed filament or cathode extending parallel with the plate. Obviously, either group of plates may be used for modulating purposes, and the other for the out-put or anode element. However, as heretofore employed, the inner element comprising the plate 11, has been employed for out-put purposes, while the plate 13 has served as modulating plates. In such use no portion of the modulating element is interposed be-

tween the filament or cathode and out-put or anode element.

The radially disposed plates heretofore described are divergent in relation with each other. Obviously, the counter-acting influence of the modulating plate upon the anode plate will vary somewhat throughout the width of the plate in such angular relationship. In Fig. 10, there is shown a modification, wherein this differential is overcome and the repulsive and retractive influence equalized thruout the width of the modulating plate to meet such condition of use by arranging the modulating and anode plates in parallel relation. In Fig. 11, such modulating plates as shown in Fig. 10 have been extended and interconnected to form angle plates, affording between the wings of such angle plates and the anode plates, electron passages of equal width. In Fig. 12, there is shown a further modification, wherein, the divergence or angularity of the anode and modulating plates is reversed, the anode plates being radially disposed as before described. The modulating plates, however, are inclined in reverse direction to the anode plates, with their outer margins closest thereto, and their inner margins widely separated. Thus the influence of repulsion and retraction will be less at the inner margins of the plates, where electrons are more plentiful and more effective at the outer margins of the plates, where fewer electrons will remain to be acted upon. The inclination of the modulating plates has been increased in Fig. 13 until such modulating plates form a rectangular figure, the angles of which are bisected by the anode plates. While not shown in the diagrams, Figs. 4, 5 and 9 to 13, it is to be understood that plates forming each group are electrically interconnected, or are connected to a common terminal.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statue the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific details shown, but that the means and construction herein disclosed comprises the preferred form of several modes of putting the invention into effect and the invention is, therefore, claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

Having thus described my invention, I claim:

1. An element for thermionic valves comprising a plurality of radially disposed plates and integral laterally projecting arms formed adjacent to opposite ends of the plates interconnecting each plate with a succeeding plate of the plurality.

2. An element for a thermionic valve comprising a ladder like strip of sheet material folded upon itself with the transverse portions of the ladder like strip disposed in radiating planes and the longitudinal tie portions of the ladder like strip connecting the outer margin of one radially disposed portion with the inner margin of another such radially disposed portion.

3. The method of forming an element for a thermionic valve, consisting in forming in a strip of sheet material, a succession of holes to afford spaced parallel transverse plate portions and longitudinally disposed marginal tie portions connecting the transverse spaced plate portions into a ladder like succession, and subsequently folding the strip upon itself to position a succession of the transverse plates in radial planes.

In testimony whereof I have hereunto set my hand this 11th day of April, A. D. 1925.

JOHN S. VAN HORNE.