

Dec. 17, 1929.

S. RUBEN

1,740,202

ELECTRON TUBE APPARATUS

Filed April 11, 1922

2 Sheets-Sheet 1

Fig. 1.

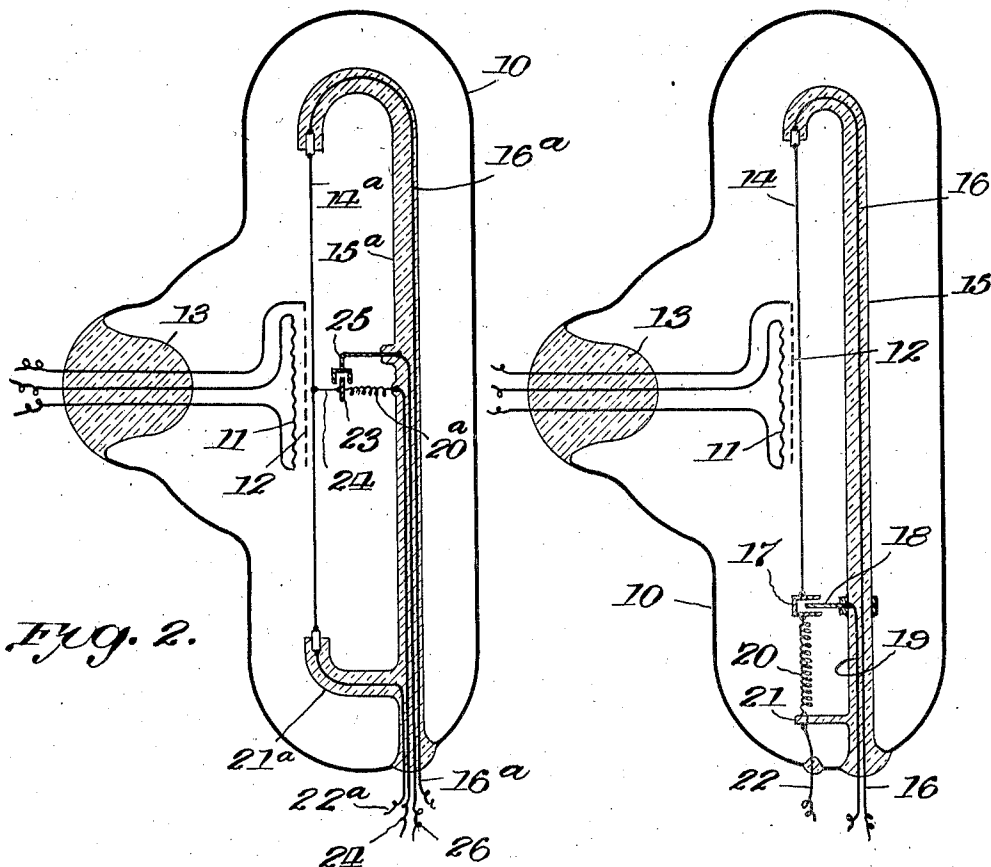


Fig. 2.

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Fig. 3.

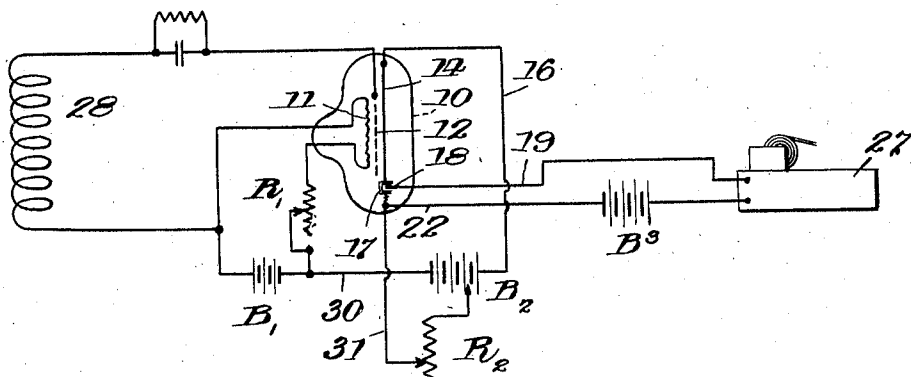


Fig. 4.

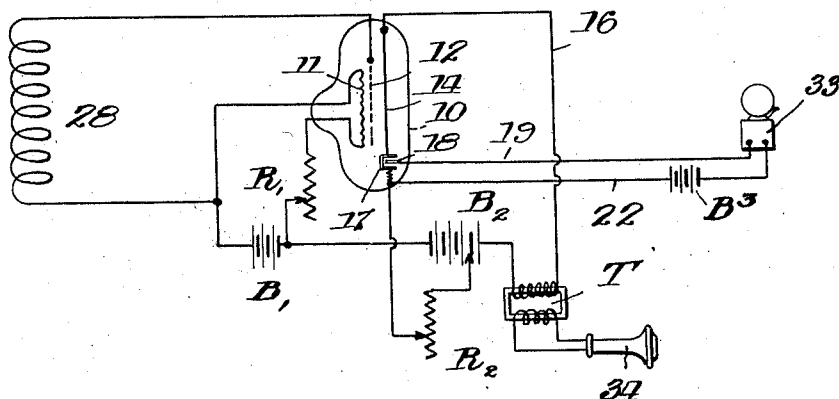
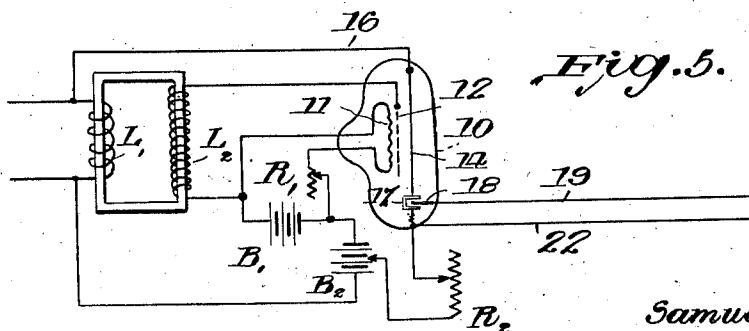


Fig. 5.



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UNITED STATES PATENT OFFICE

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ELECTRON-TUBE APPARATUS

Application filed April 11, 1922. Serial No. 551,678.

This invention relates to vacuum or electron tube apparatus; and it relates more particularly to apparatus of this general type in which advantage is taken of certain effects produced by electronic emission to accomplish the control of an electrical circuit in a predetermined desired manner, especially where this involves making and breaking such circuit by relay operation.

10 In such fields as radio control, signal recording, simultaneous telephonic and telegraphic transmission or reception, and control of electrical circuits of high current density and potential, as well as in other relations
15 unnecessary to specify here, it is commonly necessary or desirable to control or affect the flow of current in a circuit in such manner as to vary the same in a predetermined manner, as by interrupting the flow of current either
20 periodically or otherwise. In ordinary practice, where a current flow is interrupted by breaking or opening a circuit, arcing occurs across the gap formed between the gap contacts or terminals which are separated by a
25 relative movement to open the circuit. In the usual form of high potential current relay, furthermore, the practical limitation is necessarily imposed that the contacts constituting the gap terminals in the circuit must
30 be spaced apart a certain substantial minimum distance, when the circuit is open, to prevent the potential from discharging and causing arcing across the contact gap, and accordingly a comparatively large movement
35 of one or both gap contacts is necessary in closing and opening the circuit.

One of the important specific objects of the present invention is to provide a vacuum tube relay device for current control by means of
40 which the foregoing difficulties can be avoided; but more broadly, the object of the invention is to provide relay apparatus of this general character whereby the relay control is accomplished through utilization of the effects produced by electron emission or discharge, in a manner that is novel and of
45 great utility, irrespective of prevention of arcing.

In general, the present invention involves
50 the utilization of effects produced by elec-

tronic impact upon the plate or anode element of a cathode discharge in a vacuum tube device, for the purpose of controlling flow of current in an external circuit. More particularly, the invention involves the employment as the plate or anode element in a vacuum tube or electron tube, of a thermo-sensitive member that expands and contracts in accordance with temperature changes caused by variations in the electron discharge or
60 emission from a cooperating cathode element, and the actuation by such thermo-sensitive anode element of a make-and-break device or interrupter included in the circuit to be controlled.

According to one desirable practical mode of carrying the present invention into effect, the interrupter contacts included in the circuit to be controlled can be located a very minute distance apart in the vacuum tube; so that through suitable mechanical connection of the thermo-expandable anode or plate element to one of said interrupter contacts, slight variations in electron flow, and hence in temperature of the thermo-sensitive anode, can be utilized to open and close the circuit to be controlled, which may thus be made delicately responsive to electrical impulses corresponding to the charging of the grid or other modulating device employed to vary
70 the electron discharge. Due to the high vacuum prevailing in the electron tube, there is practically no current discharge between cold electrodes or terminals of an open circuit even at high potential differences and
75 even when the terminals are separated by only a very small distance.

It will be seen therefore that the invention involves in general the use of a vacuum tube having an anode or plate element delicately
80 responsive to temperature variations produced by impact of the cathode discharge upon said anode, the expansion and contraction of said anode serving to actuate a current-making-and-breaking device included
85 in an external electrical circuit to be controlled or affected.

The principles of the invention can best be further explained in connection with certain illustrative embodiments of the inven-
100

tion shown in the accompanying drawings, in which

Fig. 1 is a vertical central section through an electron or vacuum tube constructed in accordance with the invention;

Fig. 2 is a similar view of a tube of somewhat different construction, also embodying the principles of the invention;

Fig. 3 is a circuit diagram illustrating a practical application of the novel vacuum tube as a relay in a system for receiving and recording radio signals;

Fig. 4 is a circuit diagram of a similar system permitting simultaneous utilization of the contact or interrupter circuit and the plate circuit for different purposes; and

Fig. 5 is a circuit diagram showing the employment of the novel vacuum tube as a generator or external circuit breaker.

Referring at first more particularly to Fig. 1, 10 represents an evacuated container of glass or other suitable material, the container being most desirably exhausted to a very high degree of vacuum in order that a substantially pure electron discharge may be obtained in the tube. At 11 is an incandescible filament of any suitable type, and 12 is a modulating element such as the ordinary grid device commonly employed in vacuum tube apparatus. The two leads of the filament 11 and the single lead of grid 12 are brought out to the exterior of the evacuated tube through sealing stem 13. At 14 is the anode or plate element which should be of such character and arrangement as to be delicately responsive to temperature changes. In the specific example illustrated, the anode or plate element consists of a fine wire of a metal having proper lineal expansion qualities, such as silver or gold. As here shown, said wire is rigidly held at its upper end in a glass standard or stem 15, which stem contains sealed therein the lead 16 which connects the upper end of the wire 14 to the exterior of the tube. Attached to the lower end of the wire 14 is a movable double contact member 17 which, in cooperation with the fixed contact member 18 rigidly mounted on the stem 15, constitutes a current-making-and-breaking device or interrupter, said contact 18 being connected to the exterior of the tube by lead 19 sealed within the stem 15. Tension spring 20 is attached at one end to the movable contact member 17 and at the other to stationary arm 21 of the stem support 15; and lead 22 electrically connects the spring 20, and hence the lower end of the fine wire anode 14, to the exterior of the vacuum tube device. The arrangement is such that the spring 20 keeps the fine wire anode always under tension and takes up any elongation thereof occasioned by rise in temperature, thus bringing the movable contact into engagement with the stationary contact 18 when the thermo-expansion anode 14 elongates slightly upon rise in temperature. Con-

traction of the anode element draws the upper arm of contact member 17 away from contact 18 against the resistance of tension spring 20, thereby opening the circuit in which the interrupter may be included. Continued contraction may close the circuit again by drawing the lower arm of contact member 17 against contact 18. As shown, contact 17 is in a mean or normal position, variation from which in either sense has the effect of closing the circuit. The spacing between contacts 17 and 18 is exaggerated in the drawing for the sake of clearness, and may be extremely small in practice.

The device illustrated in Fig. 2 is essentially similar in principle to that shown in Fig. 1 but involves a slightly different mechanical arrangement for utilizing the elongations and contractions of the thermo-expansible anode element for actuation of the device for making and breaking the circuit to be controlled. In this instance, the fine wire anode or plate element 14^a is rigidly held at both ends by the supporting stem 15^a, the leads 16^a and 22^a, sealed within said stem serving to connect the fine wire anode to the exterior of the vacuum tube. A movable contact member 23 is connected by wire 24 to said anode 14^a at a point approximately midway between the ends thereof, said contact 23 being normally held in the mean or open-circuit position shown in the drawing by the tension of spring 20^a which is secured to the supporting stem 15^a and is electrically connected to the exterior of the tube by lead 24. In the position shown in the drawings, contact 23 is between the arms of bifurcated or double-contact member 25 which is rigidly mounted upon the supporting and insulating stem 15^a and connected to the exterior of the tube by lead 26 sealed in said supporting stem. Upon rise in temperature above the normal, the wire anode 14^a elongates and permits the contact 23 to be drawn to the right by spring 20^a into engagement with the inner arm of the fixed contact member 25, thus closing the circuit which includes the leads 24, 26. Similarly, a drop in temperature of the anode 14^a below normal causes it to contract and to draw contact 23 to the left against the outer arm of contact member 25 to close the circuit. It is to be understood that in the present instance the wire anode, when in mean or open-circuit position, is slightly flexed out of rectilinear alinement by the tension of spring 23.

In general the operation of a vacuum tube device embodying the principles of the invention, such as either one of those shown in Figs. 1 and 2, for example, is substantially as follows: Let it be assumed that the filament 11 is heated to the necessary temperature for electron emission by means of a suitable battery, and the grid 12 connected to a variable potential circuit; also that the leads 16, 19 (in the case of Fig. 1) and the leads

24, 26 (in the case of Fig. 2) are connected in the circuit to be controlled or affected in accordance with the variations in the circuit to which the grid 12 is connected. The electronic impact upon the wire anode or plate element produces a heating effect upon said element which, so long as it does not depart perceptibly from the average for which the apparatus is initially set or adjusted, does not close the circuit which includes the make-and-break device. Variations in the circuit to which the grid is connected, however, cause the latter to impress varying potentials upon the electronic field, and the resultant variations in the electronic impact upon the thermo-sensitive anode element cause the latter to expand and contract alternately in such manner as to close and open the circuit to be controlled in accordance with the variations in the actuating circuit. It is to be noted in this connection that, as compared to the arrangement shown in Fig. 1, that shown in Fig. 2 is somewhat more sensitive by reason of the fact that the movement of the contact 23 is due not merely to lineal expansion of the wire anode as in Fig. 1, but also to distortion of said anode caused by pressure of the electrons exerted transversely of the anode.

Referring now to the arrangements shown in the circuit diagrams of Figs. 3, 4 and 5, Fig. 3 illustrates how vacuum tube apparatus of the invention, such as that shown in Fig. 1, for example, can be employed as a relay actuating a recording device such as a Morse tape recorder indicated conventionally at 27. In this instance the vacuum tube device has its grid electrically connected to a source of potential impulse such as a common radio or other circuit indicated generally at 28. The heating current for the filament cathode is supplied by battery B_1 and is adjustable by a variable resistance R_1 in series therewith. The battery B_2 supplies the potential necessary to discharge across the vacuum space between the anode and cathode elements, said battery being connected, as shown to said elements by leads 16, 30. It is also to be noted that by providing a circuit that includes battery B_2 , lead 16, anode 14, lead 31 and variable resistance R_2 , so that a small current can be passed through the anode 14, the distance between the make-and-break contacts 17, 18 can be very accurately adjusted by manipulation of said variable resistance. This current heats the anode sufficiently to allow this external control of the gap distance for accurate adjustment in the initial setting of the device for means or open-circuit position of the movable contact. The circuit which includes the recorder 27 contains battery B_3 which circuit is connected to the make-and-break device through leads 19 and 22.

In the system shown in Fig. 4, impulses

from the radio circuit 28 impressed upon the grid 12 effect variations in the electronic impact upon the anode 14, which in turn cause actuation of the contact or interrupter circuit to produce signals by means of a bell 33 or other signaling device, while at the same time the normal or ordinary vacuum tube characteristic is simultaneously utilized by placing a transformer T and telephone receiver 34 in the plate circuit. The use of the two circuits may of course be either simultaneous or separate, as desired.

Fig. 5 shows the vacuum tube relay used as a generator or external circuit breaker. The inductance L_1 is assumed in this case to be in a low frequency generating circuit, and by means of the inductance L_2 arranged as shown, the anode is made to follow the frequencies of the generating circuit oscillations. The leads 19, 22 may be connected in this instance to any circuit or device in which the current is to be interrupted accurately at definite time intervals.

In general, it should be understood that while a grid is here shown as the modulating element, said modulation may be effected in any other suitable way, as by magnetic control.

What I claim is:

1. The combination, with a vacuum discharge device having anode and cathode elements located in a vacuous space and an external circuit connecting them, of another circuit which includes a gap located in said vacuous space and arranged to be closed and opened in response to physical changes in the anode element produced by the operation of said vacuum discharge device.
2. The combination, with an electron emission element and a cooperating plate or anode element separated therefrom, both elements being located in a vacuous space, of a circuit including circuit-making-and-breaking means located in said vacuous space and operable by action of electronic discharge upon said plate or anode element to make or break said circuit.
3. The combination, with an electron emission element and a cooperating plate or anode element separated therefrom, both elements being located in a vacuous space, of a circuit including contact means within the vacuous space associated with and operable by movement of said plate or anode element to make or break said circuit.
4. The combination, with an electron emission element, a plate or anode element separated therefrom, both elements being located in a vacuous space, and a modulating device operable to vary the electron stream between said elements, of a circuit-making-and-breaking contact element mechanically connected to said plate or anode element within the vacuous space for mechanical actuation by the latter.

5. The combination, with a vacuum tube having a thermo-expansible anode, an incandescible cathode, and a grid, of circuit making-and-breaking means located within the evacuated space of said tube and operable by expansion and contraction of said anode.

6. The combination, with a vacuum tube device having an incandescible cathode and a thermo-sensitive anode, of a circuit operatively associated with said anode, being adapted and arranged to be made and broken at a point within the vacuum space of the tube by thermal changes in said anode.

7. The combination, with a vacuum tube device having an incandescible cathode and a thermo-sensitive anode, of a circuit operatively associated with said anode, and current-control means disposed within said tube device and included in said circuit and arranged to be operated by thermal changes in said anode.

8. The combination, with a source of electrical signal impulses, of an electron discharge device adapted and arranged to be electrically influenced thereby and having an anode or plate element operatively thermo-sensitive to variations in electron impact in the normal operation of the tube, a circuit to be controlled, control means arranged to be actuated by mechanical movement of said anode or plate element in response to said impulses and operatively associated with said circuit for control of current therein, and means for maintaining a substantially constant potential on the said plate element independently of the condition of said controlled circuit.

9. In vacuum tube apparatus, the combination, with an evacuated container, of an incandescible cathode and a thermo-expansible anode mounted therewithin, a circuit-controlling device connected to said anode for actuation thereby, and means comprising a variable resistance circuit that includes said anode, for adjusting said circuit-controlling device.

10. In vacuum tube apparatus the combination, with an evacuated container, of an incandescible cathode and a thermo-expansible anode mounted therewithin, circuit-controlling means situated in the vacuous space within the tube including cooperating members of which one is movable and is connected to said anode for actuation thereby, modulating means for affecting the electronic discharge, and an energy-consuming circuit in which said circuit-controlling means is included.

11. In vacuum tube apparatus the combination, with an evacuated container, of an incandescible cathode and a thermo-expansible anode mounted therewithin, circuit-controlling means including cooperating members of which one is movable and is connected to said anode for actuation thereby, modulating means for affecting the electronic discharge, an energy-consuming circuit in which said circuit-controlling means is included and a circuit, in which said anode and an adjustable resistance are included, for adjusting the temperature of said anode.

12. In vacuum tube apparatus, the combination, with an evacuated container, of a cathode and an anode mounted within said container in spaced relation, said anode comprising a thin metal member, means including a movable part mounted within said container and operable to make and break a circuit at a point within the evacuated container, said movable part being mechanically connected to said anode for actuation thereby, and conductors leading from such make-and-break means to the exterior of said container.

13. In vacuum tube apparatus, the combination, with an evacuated container, of an incandescible cathode mounted therewithin, a fine wire anode terminally supported within said container in operative relation to said cathode, resilient means maintaining said anode under tension, a movable contact mechanically connected to said anode, a stationary contact adapted and arranged to cooperate with said movable contact, and leads for electrically connecting said contacts in a circuit.

14. The combination, with a vacuum tube having a thermo-expansible anode, and an incandescible cathode, of circuit-making-and-breaking means operable by expansion and contraction of the anode, and means for electrically heating the anode independently of the action of the cathode to adjust the mean temperature of the anode.

15. An electron discharge device comprising an anode, a cathode, a control electrode, and a circuit closing member supported by one of said electrodes, and having a circuit closing contact surface situated wholly outside the overall dimensions of said supporting electrode.

16. The combination, with a vacuum tube having a thermo-expansible anode and an incandescible cathode, of a contact device situated within the vacuous space in the tube and operable in the expansion and contraction of the anode, and means for adjusting said contact device controlled exteriorly of the tube.

In testimony whereof I hereunto affix my signature.

SAMUEL RUBEN.