Sept. 11, 1923. 1,467,318

W. J. HERDMAN

ELECTRON DISCHARGE DEVICE

Filed Aug. 17, 1920 3 Sheets-Sheet 1

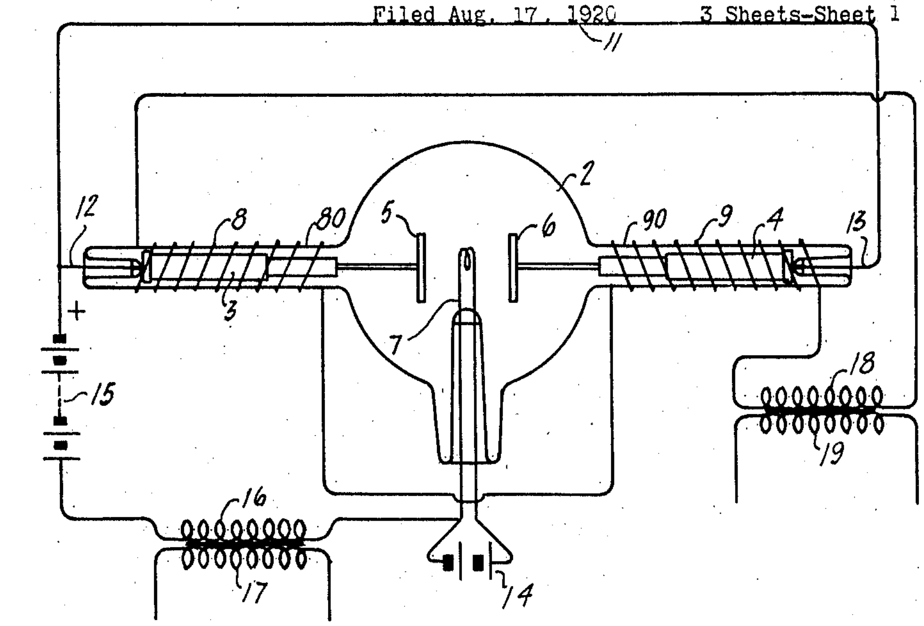

FIG. 1

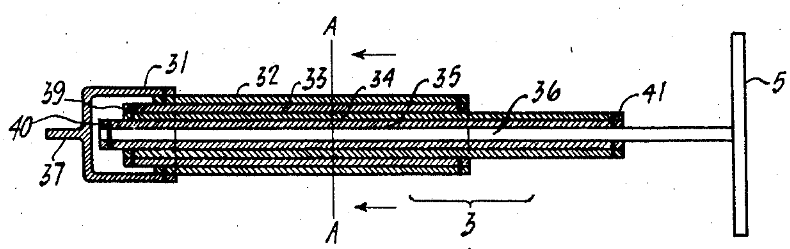

FIG. 2.

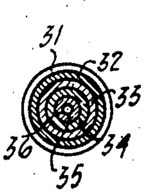

FIG. 3.

Inventor,

William J. Herdman.

Sept. 11, 1923. 1,467,318

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Filed Aug. 17, 1920 3 Sheets-Sheet 2

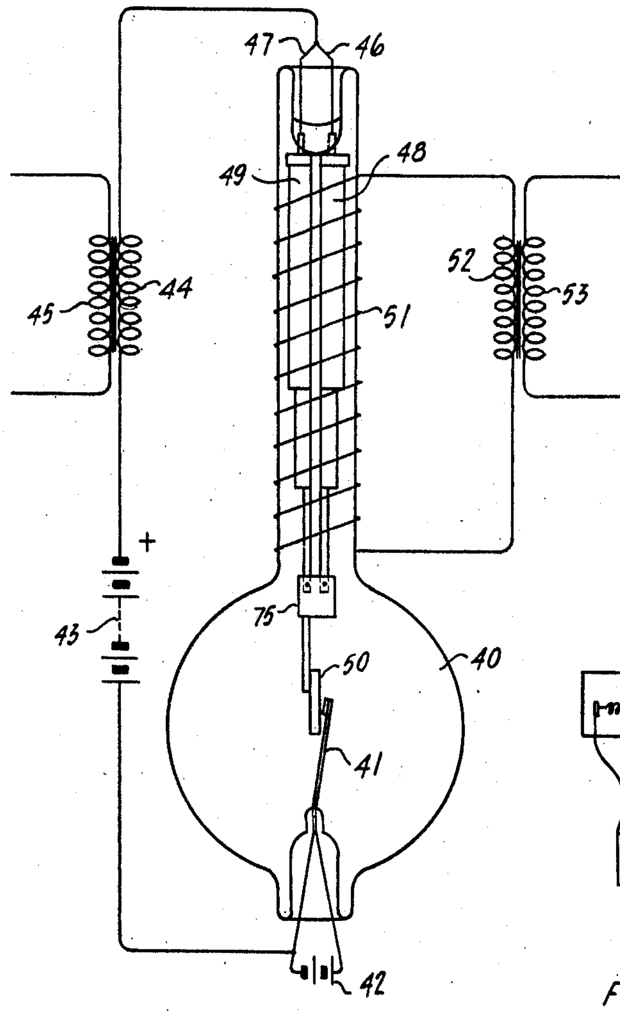

FIG. 4.

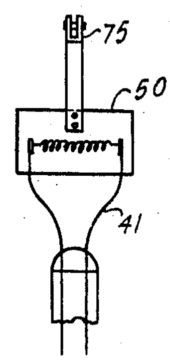

FIG. 5.

Inventor,
William J. Herdman

Sept. 11, 1923.

1,467,318

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ELECTRON DISCHARGE DEVICE

Filed Aug. 17, 1920

3 Sheets-Sheet 3

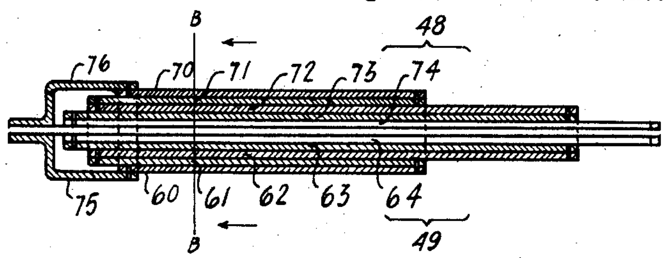

Fig. 6.

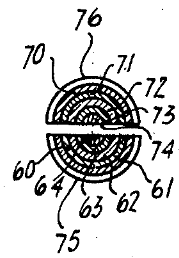

Fig. 7.

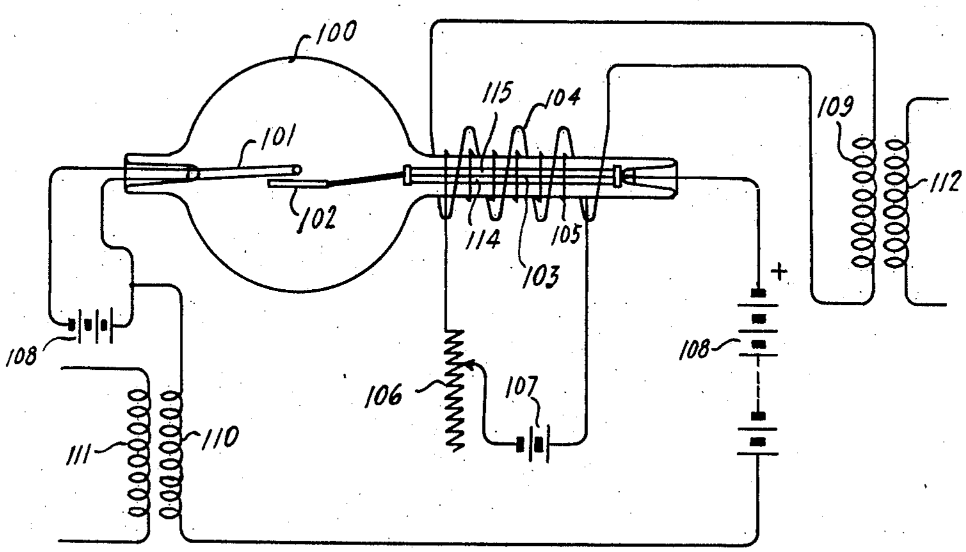

Fig. 8.

Inventor,
William J. Herdman

Patented Sept. 11, 1923. **1,467,318**

UNITED STATES PATENT OFFICE.

WILLIAM J. HERDMAN, OF TORONTO, ONTARIO, CANADA.

ELECTRON-DISCHARGE DEVICE.

Application filed August 17, 1920. Serial No. 404,065.

To all whom it may concern:

Be it known that I, WILLIAM J. HERDMAN, a citizen of the United States of America, and a resident of Toronto, county of York, and Province of Ontario, Canada, have invented a new and useful Improvement in Electron-Discharge Devices, of which the following is a specification.

My invention relates to electron discharge devices and pertains specifically to that class of such devices which are adapted chiefly to use in radio telegraphy and telephony and manual telephony.

The principal object of my invention comprises, producing a two electrode tube or valve of novel form, in which the internal resistance of the tube or the impedance of the gap between the cathode and anode may be varied to achieve a modulation of the space or thermionic current without necessitating the interposition of a third electrode or grid between the anode and cathode.

I accomplish this and other very desirable features that will hereinafter be pointed out and described, by a novel construction of tube and elements therein, whereby the property of magnetostriction is utilized to effect a movement of the anode or plate with respect to the cathode or filament, to thereby decrease or increase the distance between the filament and plate, and to likewise decrease or increase the effective plate area, to produce an extremely wide variation of the plate current.

Magnetostriction is a phenomenon of ferromagnetic bodies, discovered by Joule in 1842, since which time experiments have proven that all magnetic metals and magnetic alloys when magnetized, are subject to changes in length and volume. Some nickel steels exhibit the greatest coefficient of magnetostriction, or in other words, the greatest change in length and volume when magnetized and these changes are in the nickel steels proportional to the magnetizing force. It has been found that steel alloyed with 46% of nickel exhibits when magnetized, a marked extension of length. Steel alloyed with 25% of nickel shows practically no increase of length when magnetized, while pure nickel contracts or shortens when magnetized. In carrying out my idea, I employ moving members composed of rods, wires or tubes of nickel steel, preferably in combination with corresponding rods, wires or tubes of nickel or non-magnetic metal and attach these members to the plate of the vacuum tube in such manner, that the plate may be moved relative to the filament from without the tube when the moving members are influenced to exhibit the property of magnetostriction.

In the figures which accompany and form a part of this specification, and in which like reference numerals designate corresponding parts throughout:

Fig. 1 is a diagrammatic elevation of one embodiment of my idea and shows also diagrammatically a circuit connection therefor.

Fig. 2 is an enlarged sectional elevation of the plate moving means used in Fig. 1.

Fig. 3 is a sectional plan view of the plate moving means taken on the line A—A of Fig. 2.

Fig. 4 is a diagrammatic elevation of an alternative form of my idea and shows also diagrammatically a circuit connection therefore.

Fig. 5 is an enlarged plan view of the filament and plate shown in Fig. 4.

Fig. 6 is an enlarged sectional elevation of the plate moving means shown in Fig. 4.

Fig. 7 is a sectional plan view of the plate moving means taken on the line B—B of Fig. 6.

Fig. 8 is a diagrammatic elevation of a still further embodiment of my idea, together with an associated circuit.

Referring now to the simple embodiment of my idea shown in Fig. 1, the device comprises an evacuated glass vessel formed with a spherical central portion 2 and two opposed tubular arms 80 and 90. A filament 7 is situated centrally with respect to the spherical portion of the tube and the plates 5 and 6 are maintained relatively close to the filament and on opposite sides thereof by means of the plate supporting and plate moving members 3 and 4, respectively, the construction of which will be described later herein. The filament is provided with a battery 14 for heating purposes and coils comprising many turns of fine insulated wire are slipped over the arms of the tube containing the moving members 3 and 4 as shown. These coils are as indicated, connected in series, and their free terminals are connected with the primary 18 of a transformer, the secondary of which is adapted to be connected to the source of incoming signals or voice currents. The moving members 4 and 3 are provided with terminals as 13 and 12, and these terminals are connected together by conductor 11 and to the positive terminal of the plate battery 15, the negative terminal of which is connected to one terminal of the secondary 16 of a transformer, the remaining terminal of which is connected to the filament 7. The primary 17 of this transformer is adapted to be connected to any suitable receiving device or other device for utilizing the modulated current.

Referring now to Figs. 2 and 3, the plate moving members 3 and 4 before referred to comprise, a series of telescoping tubes of nickel steel and nickel. Tube 32 is of nickel steel and is provided with a supporting cup 31, having a stem 37 by which the arrangement of tubes is supported in the glass containing tube. The free extremity of tube 32 is rivetted or otherwise secured to a tube 33 of nickel, which is likewise rivetted or otherwise secured at its free extremity to a tube 34 of nickel steel within which a further tube 35 of nickel is disposed and secured to the free extremity of tube 34, and within this latter tube 35, a rod 36 of nickel steel is secured as shown. The rod 36 bears rigidly attached at its free extremity, the plate or anode 5. It will be observed that if the coil 8 be energized to magnetize the moving member 3, that the nickel steel tube 32 will elongate to carry the various tubes which it encircles and consequently, the plate 5 nearer to the filament 7, that the tube 33 of nickel will contract to likewise carry the tubes which it encircles and consequently, the plate 5 nearer to the filament, that the tube 34 of nickel steel will expand to carry its encircled tubes forward, that the tube 35 will contract and the rod 36 will expand to complete a series of five motions, which are cumulative and result in carrying the plate 5 closer to the filament 7. Experiments have shown that this expansion and contraction is molecular in nature and will follow the fluctuations of the current in the coil 8 for extremely high periodicities. When the plate 5 is by this means moved nearer to the filament, obviously, the effective area exposed for the reception of electrons from the filament by the plate, is increased, while the impedance of the space gap between the filament and the plate is actually reduced due to decreasing the distance between the plate and the filament, and conversely, as the plate is moved away from the filament, the effective area of the plate is reduced and the impedance of the gap is increased. There is therefore generated in the plate circuit and consequently in secondary 16 of the transformer an exact reproduction and further as shown by experiment, an amplification of the current traversing the coils 8 and 9.

Obviously, what has just been said with regard to the movement of plate 5, is equally true of plate 6, the use of two plates merely increasing the total quantity of plate current.

It will be noted that the plate moving members regarded from the standpoint of their thermal expansion, constitute a compound thermostat, the nickel steel members having a coefficient of expansion of 8.22×10^{-6}, while the nickel members have a coefficient of expansion of 12.8×10^{-6}, or an expansion ratio of 2 to 3. Hence, by choosing proper proportioned lengths of the nickel steel and nickel members, the expansion of the various component parts of the moving members may be so balanced that changes of temperature can be entirely compensated and the position of the plates relative to the filament maintain constant, irrespective of temperature changes.

Referring now to Fig. 4, I have shown an alternate embodiment of my idea, comprising an evacuated glass vessel 40, within which is located substantially centrally a filament 41. The vessel is provided with a tubular extension positioned opposite the filament supporting stem and within this tubular portion there is located and maintained a plate moving member composed of the two members 48 and 49. These as shown in Figs. 6 and 7, each consist of a nest of alternate half cylinders of nickel and nickel steel. Member 48 is adapted to shorten when influenced by magnetism to exhibit the property of magnetostriction, and for that reason the outside half tube 70, to which is attached the support 76, is composed of nickel. The free extremity of the half tube 70 is rivetted or secured to a half tube 71 of nickel steel, the free extremity of which is rivetted or otherwise secured to a half tube 72 of nickel and the free extremity of this tube is rivetted to a half tube 73 of nickel steel, which in turn, is secured at its free extremity to a half rod 74 of nickel. The member 49 is adapted to expand when magnetized, and for this reason, the outside tube 60 attached to the supporting member 75 is of nickel steel, the free extremity of which is secured to a half tube 61 of nickel and the free extremity of this latter tube is secured to a half tube 62 of nickel steel, which encloses and is attached at its free extremity to a half tube 63 of nickel. This latter tube encloses and supports at its free extremity a half rod 64 of nickel steel. The bars 64 and 74 are pivoted at their free extremities in a support or arm 75 as shown in Fig. 4, which carries a plate 50, and as shown in Fig. 5, this plate is positioned normally in a plane parallel to that occupied by the longitudinal axis of the filament 41. The members 48 and 49 are encircled as shown by a magnetizing coil 51, the terminals of which are connected to the secondary 52 of a transformer, the primary of which is adapted to be connected to any source of incoming signals or speech currents. The terminals 46 and 47 of the plate moving members 48 and 49 respectively, and consequently, the terminal of the plate 50 are connected to one terminal of the secondary 44 of a transformer, the other terminal of which is connected to the positive terminal of a plate battery 43, the negative terminal of which is connected to the filament 41, which is adapted to be heated by the battery 42. The primary 45 is adapted to be connected to any suitable receiving device. It will be observed that when the magnetizing coil 51 is energized by incoming signals that the members 48 and 49 will be influenced to exhibit the property of magnetostriction and as the degree of magnetization increases, member 48 will contract and member 49 will expand to rotate the arm 75 and move the plate 50 nearer to the filament 41, to decrease the impedance of the gap between plate and filament as hitherto described. Further, as the degree of magnetization decreases, member 48 will expand and member 49 will contract to move the plate 50 away from the filament to increase the impedance of the gap. It will be noted that regarded from the standpoint of their thermal expansions, members 48 and 49 constitute compound thermostats and consequently, as has hitherto been explained herein, they obviously may be so constructed that the position of the plate relative to the filament may be maintained constant irrespective of temperature changes.

Referring now to Fig. 8, in which I have illustrated a still further embodiment of my idea, the evacuated glass vessel 100 is provided with a filament 101 and a tubular extension positioned opposite the filament supporting stem. The tubular extension serves to enclose and support a plate moving member 103, which in this instance, is composed of two flat members 114 and 115, one of nickel steel and the other of nickel, which are rivetted or welded together in the form of a bi-metallic thermostat, one extremity of this member is rigidly maintained in the tubular extension of the tube 100 and the free extremity of the member bears rigidly attached a plate 102. Obviously, when this member is magnetized, the nickel steel portion thereof, 114 tends to expand, while the nickel portion thereof, 115 tends to contract to cause the member to bend or flex, resulting in carrying the plate 102 nearer the filament 101, to modify the impedance of the gap between the filament and the plate as hitherto described. The filament is adapted to be heated by the battery 108 and the moving member and plate are connected to the positive terminal of a plate battery 108, the negative terminal of which is connected to one terminal of the secondary 110 of a transformer, the remaining terminal of which is connected to the filament 101. The primary of this transformer 111 is adapted to be connected to any suitable receiving device. A permanent magnetizing coil 105 encircles the tubular extension of the tube 100 and consequently, the plate moving member 103 and is connected in series with an adjustable resistance and a battery 107. A further coil 104 encircles the primary 112 of which is adapted to be connected to any source of incoming signals or speech currents. It will be observed that by means of the permanent magnetizing coil 105, I may selectively position the plate member 102 with respect to the filament 101, and through this means obtain some measure of control over the impedance of the gap between the plate and filament.

While I have illustrated and described methods of moving the plate relative to the filament it is obvious that these same methods or others similar could be used to move the filament relatively to the plate, to achieve the same results.

It will be observed from the foregoing, that my novel valve requires no third electrode or grid to achieve modulation of the space or plate current, and that further, I am enabled to accomplish in a novel way, a very substantial variation or modulation of the space current by means of but two electrodes.

While I have thus illustrated and described several embodiments or forms of my device, I wish it to be clearly understood that I may vary the details thereof without departing from the spirit or narrowing the scope of my invention.

Having thus completely described and disclosed my device, what I desire to secure by United States Letters Patent is as follows:

1. In an electron discharge device, an evacuated vessel, an electron emitting member therein, an electron receptive member adjacent to said emitting member, and magnetostrictional means for moving said receptive member relatively to said emitting member.

2. In an electron discharge device, an evacuated vessel, an electron emitting member therein, an electron receptive member adjacent to said emitting member, and magnetostrictional means for moving said receptive member relatively to said emitting member from without said evacuated vessel.

3. In an electron discharge device, an evacuated vessel, a cathode therein, an anode adjacent to said cathode, and magnetostrictional means for modifying the impedance of the gap separating said anode and said cathode.

4. In an electron discharge device, an evacuated vessel, a cathode therein, a plurality of anodes adjacent to said cathode,

and magnetostrictional means for moving said anodes to modify the impedance of the gap between said anodes and said cathode.

5. In an electron discharge device, an evacuated vessel, a cathode therein, anodes therein, and magnetostrictional means for varying the distance between said cathode and said anodes.

6. An electron discharge tube, comprising an evacuated vessel, a cathode therein, anodes positioned opposite said cathode, and magnetostrictional means for modulating the impedance of the gap between said cathode and said anodes, from without said vessel.

7. In an electron discharge device, a cathode, an anode adjacent to said cathode and magnetostrictional means for modifying the impedance of the gap separating said anode and said cathode.

8. In an electron discharge device, a cathode, anodes and magnetostrictional means for varying the distance between said cathode and said anodes.

9. In an electron discharge device, a container, cathodes and anodes therein, and magnetostrictional means for varying the relative relation between said anodes and said cathodes.

WILLIAM J. HERDMAN.

Witnesses:
R. H. DOUGHERTY,
J. S. LIGHTBOUND.