July 4, 1944. L. M. POTTS 2,352,657

ELECTROMAGNETICALLY CONTROLLED THERMIONIC RELAY

Filed June 9, 1941

FIG. 1

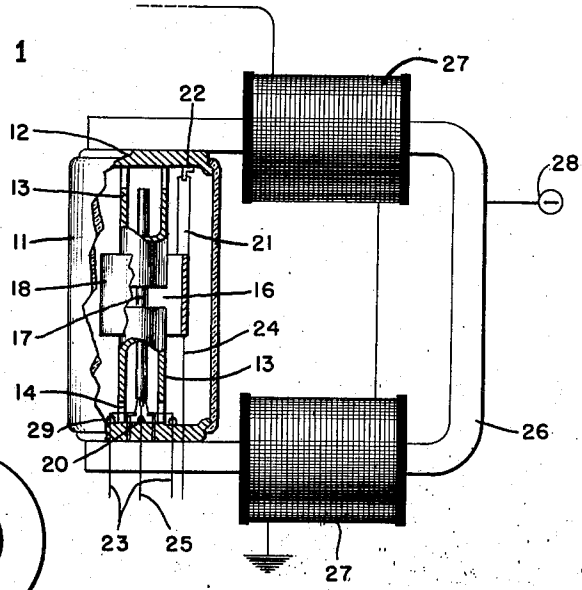


FIG. 6

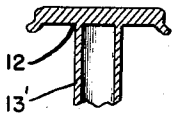
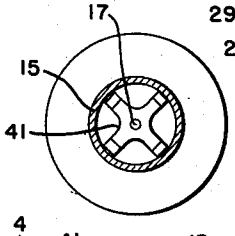


FIG. 4



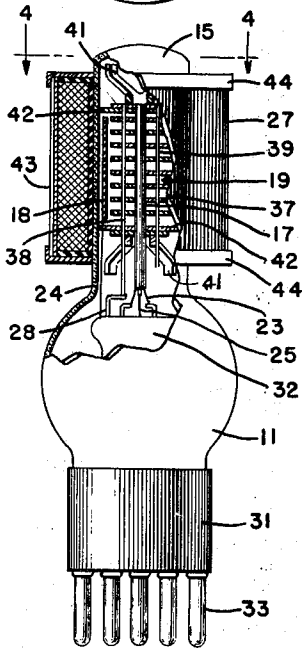


FIG. 3

FIG. 5

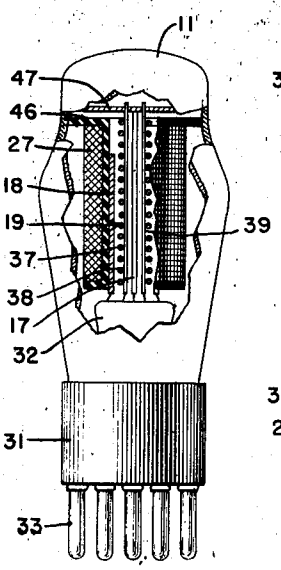
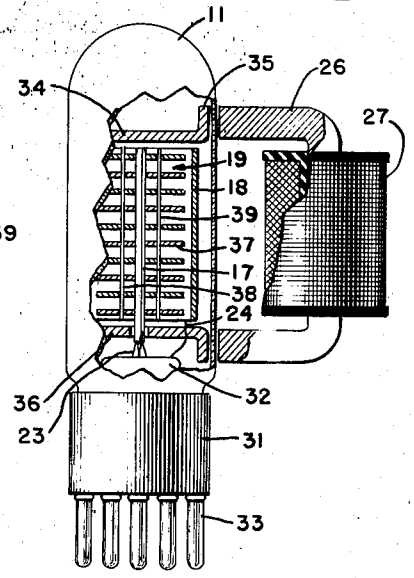


FIG. 2



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ELECTROMAGNETICALLY CONTROLLED THERMIONIC RELAY

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Application June 9, 1941, Serial No. 397,259

21 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to magnetically controlled electron discharge devices.

An object of this invention is to provide a magnetically controlled electron discharge device of improved construction which has increased sensitivity and greater reliability.

The invention features a magnetically controlled electron discharge device in which the reluctance path of the control magnetic circuit is greatly reduced which permits the use of small control currents.

A further feature of this invention resides in the provision of a control magnetic circuit comprising a path of magnetic elements that is completely closed except for a single well defined air gap forming the electron path in the discharge device.

The invention also features an improved magnetic circuit within the discharge device comprising a plurality of spaced magnetic elements that reduce the reluctance of the magnetic path, form a plurality of discharge paths, and improve the control magnetic field.

The improved magnetron device or tube which is the subject of this invention and which is adapted to be employed in repeater circuits, includes in one specific embodiment a yoke external to the tube supporting the control magnet coil and a magnetic structure within the tube which define a control magnetic circuit complete except for a well defined gap within the tube and in the electron path from the cathode to the anode.

In another embodiment of the invention, the magnetic circuit is also interrupted by the tube envelope which supports the yoke externally of the tube. In this embodiment the magnetic circuit within the tube envelope comprises a plurality of washers of magnetic material assembled in stacked relation and spaced with respect to one another. As a modification of this embodiment, the magnet coil is concentric with respect to and supported by the tube envelope.

The magnetic coil in still another embodiment of this invention is supported within the tube envelope and the electrodes are placed concentrically with respect to one another within the bore of the coil.

In another embodiment, the magnetically controlled electron discharge device comprises a biasing winding tending to render the tube nonconductive and thus transmit a signaling impulse of one nature, a first line coil responsive to received signals of one nature to counteract the control of the biasing winding and render the magnetron conductive to transmit a signaling impulse of a different nature, a locking winding to maintain this condition of the tube, and a second line coil responsive to received signals of a different nature to overcome the locking winding and render the tube nonconductive.

In electron discharge devices comprising a cathode and an anode placed concentrically with respect to one another, the electron travel from the cathode to the anode is generally along a radial line when, due to the cathode temperature and other phenomenon supporting electron discharge, the tube becomes conductive causing an electron flow. However, if a magnetic field is generated parallel to the cathode and intermediate the anode and cathode so that it traverses the normal path of electrons from the cathode to the anode, the path will be converted from a generally radial one to a spiral path, and if the magnetic field is made sufficiently strong, it will impede almost entirely all electron movement from the cathode to the anode. This phenomenon of magnetic control of electron discharge devices is employed in the repeating circuits of the present invention and the magnetic paths are rendered more efficient by reducing their reluctance so that a relatively small control current may be effective to control the operation of the repeaters.

For a more complete understanding of the structural details and mode of operation of this invention, reference may be had to the accompanying specification which is to be interpreted in the light of the accompanying drawing, wherein;

Fig. 1 discloses an electron discharge device embodying the features of this invention in which spaced cylindrical pole pieces included within the tube envelope are connected by means of a magnetic yoke structure external to the tube to complete the magnetic circuit;

Fig. 2 is an embodiment of the invention in which disc type pole pieces are supported within the tube envelope and there is located within the gap between the pole pieces a plurality of spaced magnetic rings assembled in stacked relation;

In Fig. 3 the magnetic coil is concentric of and supported by an extended portion of the tube envelope within which is supported a magnetic structure similar to the magnetic structure illustrated in Fig. 2;

Fig. 4 is a sectional view taken on line 4—4 of Fig. 3;

Fig. 5 represents an electron discharge device

in which the magnetic coil is supported within the tube envelope; and

Fig. 6 is a detailed view illustrating a modified form of pole piece for the device of Fig. 1.

In Fig. 1 there is disclosed one specific embodiment of the invention, including a tube envelope 11 made of glass or any suitable nonmagnetic material and provided with closure or end members 12 of magnetic material to which the envelope is sealed. A sleeve 13 of magnetic material is supported centrally on each closure member and is provided with diametrically opposed, slotted apertures 14 to provide a circulating path for gas confined within the envelope 11. The sleeve members 13 are in alignment with one another and are separated by a gap 16. A cathode 17 extends centrally of the sleeve members 13 and an annular type anode 18 is disposed concentrically with respect to the cathode and the sleeve members and positioned longitudinally in such a manner that the gap 16 is at the approximate center of the anode.

The cathode 17 is supported by means of a glass bead 20 which accommodates an extension of the cathode. The anode 18 is supported from a closure member 12 of the tube by a plurality of mica strips 21 (only one of which is shown) and each mica strip is secured by a metallic member 22 soldered to the closure member 12. Conductors 23 of the cathode heating circuit project through one closure member and are secured in insulators 29 affixed to the end member to insulate the conductors therefrom. From the insulating beads 29 conductors 23 extend into the heating circuit of the cathode through the apertures 14 of the sleeve members 13. Anode and cathode conductors 24 and 25, respectively, also extend through one end member 12 and are supported so as to be insulated therefrom.

The electron discharge tube, as described above, provides a restricted path for the electrons from the cathode to the anode when the tube is discharging, which path includes the gap 16 defined by the extremities of sleeve members 13. In order to control the operation of the tube and electron flow in this path, the sleeve members 13 operate as pole pieces of a magnetic circuit to direct magnetic flux lines across the gap transversely of the electron travel to effect the control in the manner previously set forth. The magnetic circuit within the tube comprises the sleeve members 13 and the metallic closure members 12 which are in surface contact with one another, and is completed externally of the tube by a U-shaped magnetic yoke structure 26 between the end portions of which the tube is positioned with the closure members 12 in contact with the yoke member 26 providing a closed magnetic path therebetween. In other words, the control magnetic circuit including pole pieces 13, magnetic closure elements or cap portions 12, and yoke 26 is a closed circuit, closed except for the gap 16 provided for the purpose of enabling a control magnetic field to traverse the normal electron path.

Electromagnetic coils 27 are suitably supported by yoke 26 to energize the magnetic circuit and control the operation of the tube. A bias potential indicated 28 in Fig. 1, and more completely shown in Fig. 6 is applied to the yoke member 26 and supplies a corresponding bias to the sleeve members 13 to prevent those members from operating as free electrodes which might generate a space charge effect within envelope 11.

The device of Fig. 1 may, if desired, include the modified pole pieces 13', shown in Fig. 6, which are not provided with apertures corresponding to apertures 14 of Fig. 1. With this construction, the pole pieces effectively partition the interior of envelope 11 into two compartments joined solely by gap 16. In one compartment, the cathode 17 is located while anode 18 is in the other and the magnetic gap 16 provides the only discharge path from the cathode to the anode so that the control effect of the magnetic field established across the gap is increased.

The tube illustrated in Fig. 2 comprises the nonmagnetic envelope 11 which is closed at its upper extremity and which is supported at its lower extremity upon a base member 31 of Bakelite or any suitable nonmagnetic material and within the envelope the cathode 17, anode 18 and compound grid 19 are supported. Their associated conductors are directed through an insulated terminal and supporting member 32 within the base 31 and terminate in a contact 33, one individual for each conductor within the envelope. Cathode 17 is disposed along the axis of envelope 11 and suitably supported from member 32, and anode 18 which is cylindrical in form is disposed concentrically with respect to cathode 17.

A disc type pole piece 34 of magnetic material provided with an upturned flange 35 is sealed to envelope 11 transversely of and spaced slightly from the upper extremity of anode 18 while a similar pole piece 36 apertured centrally to permit the cathode 17 to project therethrough, is sealed to tube envelope 11 and disposed transversely of and spaced from the lower extremity of anode 18. A plurality of magnetic washers 37 is positioned longitudinally of the tube envelope between the pole pieces 34 and 36 to reduce the reluctance between the pole pieces and to direct the magnetic field between the pole pieces in a manner parallel to the cathode and anode elements. The magnetic washers are spaced from one another and supported transversely of the envelope 11 upon nonmagnetic supporting elements 38 and 39 which may be secured to the lower pole piece 36. The cathode 17 is disposed through the bore of the stacked assembly of washers. For convenience, the anode 18 may also be supported from either or both pole pieces by means of nonmagnetic and nonconducting supporting strips of mica. The flange portions 35 of the discs 34 and 36 are approximately of the same dimension as the transverse dimension of the magnetic yoke 26 which is also sealed to and supported by the envelope 11 and which carries the magnetic coil 27. The magnetic yoke 26 may be secured to the envelope 11 in any convenient manner so long as the extremities of the yoke are in substantial alignment with the flange portions of pole pieces 34 and 36.

The circuit conductors comprising the heating circuit for the cathode and the anode-cathode circuit of the tube and grid bias bear the same numerics as in Fig. 1. This tube operates substantially the same as the tube illustrated in Fig. 1 in that the electron flow, when the tube discharges, is from cathode 17 along a plurality of paths defined by the magnetic washers to anode 18 and this flow is controlled by means of a magnetic circuit including the pole pieces 34 and 36 and magnetic yoke 26 which directs a magnetic field parallelly of and intermediate the principal electrodes of the tube. The magnetic washer elements of the control grid 19 serve to strengthen and direct the magnetic field between the pole pieces to provide a more efficient

control of electron flow under the influence of the control magnetic circuit.

There is disclosed in Fig. 3 another embodiment of the invention in which the tube envelope 11 is provided with a tubular projection 15 within which are enclosed the anode, cathode and grid which elements, as well as those remaining elements of the tubes which are common to the disclosures in Figs. 1 and 2, bear the aforementioned numerics. The magnetic structure within the envelope which also serves as the compound grid 19 comprises a plurality of stacked magnetic washers, similar to the disclosure of Fig. 2, which are supported on corresponding nonmagnetic supporting structures 38 and 39. A spider 41 comprises a plurality of arms extending radially outward from a hub portion and is secured to or made integral with the extreme washers of the magnetic structure and the radially extending arm members of the spider extend as close as is feasible into engagement with the tube extension 15 so as to render the intervening air gap as small as possible. A mica washer 42 extends across each extremity of the annular type anode 18 to insulate the anode electrically from the grid structure 19. The anode should preferably be of nonmagnetic material.

The energizing coil 27 of the control magnetic circuit surrounds the tubular extension 15 of the tube envelope and preferably is supported thereby. The coil is contained within a magnetic shell 43 and enclosed by magnetic end members or closure elements 44 defining a closed magnetic circuit external to the tube envelope. The arms of the spiders 41 may, if desired, be secured to the tube extension 15 and preferably are located as near as possible to the external magnetic structure so as to continue the magnetic circuit internally of the tube.

In the embodiment of the invention illustrated in Fig. 5 wherein the elements corresponding to equivalent elements in the previously described figures bear the same reference numerals, the energizing coil 27 for the control magnetic field is located within the glass envelope of the electron discharge device. The anode, cathode and control grid are located within the bore of the spool supporting the energizing coil 27 and this spool is provided with an enlarged flange 46 extending into engagement with the tube envelope for the purpose of support. Located above the flange 46 is a nonmagnetic supporting member 47 which supports the cathode and supporting elements of the compound grid. The grid 19 may be constructed of spaced magnetic elements to provide an improved magnetic path within the tube envelope. The energizing coil 27 may, if desired, be encased within a magnetic casing similar to that disclosed in Fig. 3 in order to provide an improved magnetic circuit within the tube envelope.

Although specific embodiments and modes of operation of this invention have been disclosed and described, it is to be understood that the invention is not limited to such embodiments and disclosure but is subject to modifications and rearrangements. The scope of the invention is to be determined by the appended claims.

What is claimed is:

1. An electron discharge device comprising an anode, a cathode, an envelope enclosing said anode and cathode, a magnetic structure within said envelope extending intermediate said anode and cathode and provided with a gap defining part of an electron path from said cathode to said anode, a magnetic structure external to said envelope in contact with said first mentioned magnetic structure and defining a magnetic circuit therewith, and an energizing coil linking said magnetic circuit.

2. A magnetically controlled discharge device comprising an envelope, a pair of spaced magnetic elements within said envelope separating the interior of said envelope into two compartments joined by the space between said elements, a cathode in one compartment and an anode in the other compartment having an electronic discharge path including the space between said magnetic elements, and means comprising a control coil to generate a magnetic field between said magnetic elements to control the discharge between said anode and said cathode, said control coil being electrically disconnected from the electronic discharge path through said space.

3. A magnetically controlled electron valve including a plurality of electrodes, a cylinder enclosing said electrodes, magnetic closure members closing said cylinder, a magnetic structure within said cylinder extending intermediate of said electrodes and having a gap defining an electron path between said electrodes, a magnetic structure external to said cylinder defining with said closure members and said first mentioned magnetic structure a closed magnetic circuit, and coil means to energize said circuit and control electron flow between said electrodes.

4. A magnetically controlled electron discharge apparatus including a plurality of electrodes, an envelope enclosing said electrodes, a pair of magnetic elements within said envelope, certain of said electrodes extending through said elements, other of said electrodes surrounding said elements, said elements spaced to define a gap within the electron path between said electrodes, magnetic closure members closing said envelope, a magnetic yoke member connecting said closure members externally of said envelope completing a magnetic circuit with said elements and members for controlling electron flow between said electrodes, and an energizing coil linking said magnetic circuit.

5. A magnetically controlled electron discharge apparatus including a container, a plurality of electrodes within said container, magnetic circuit elements to control electron flow between said electrodes, said magnetic circuit elements comprising spaced pole pieces, certain of said electrodes extending through said pole pieces, other of said electrodes surrounding said pole pieces disposed intermediate of and parallel to said electrodes to facilitate the generation of a magnetic field in said space to provide a magnetic shutter for controlling the electron flow between said electrodes, a closed path of magnetic material external to said container connecting said pole pieces to complete a magnetic circuit, and means to energize said magnetic circuit to produce the shutter effect.

6. An electron discharge apparatus comprising a container, a pair of spaced cylindrical pole pieces in alignment within said container, a cathode extending through the bores of said pole pieces, an anode surrounding said pole pieces, said pole pieces spaced to facilitate the generation of a magnetic field therebetween to provide a magnetic shutter for controlling the electron flow between said cathode and said anode, a magnetic structure external to said container completing a magnetic circuit to said pole pieces, and an electromagnetic coil supported by said

structure to energize the magnetic circuit to produce the shutter effect.

7. A magnetically controlled electron discharge apparatus including an envelope of nonmagnetic material, spaced magnetic pole pieces within said envelope, a plurality of spaced magnetic elements intermediate said pole pieces, supporting means for said elements, means for creating a magnetic field between said pole pieces and through said magnetic elements to define a magnetic circuit therewith, and an energizing coil linking said magnetic circuit.

8. A magnetically controlled electron discharge device comprising a magnetic circuit including a pair of spaced pole pieces within the device, said pole pieces comprising peripherally flanged discs extending across said device, a magnetic structure external to said device completing a magnetic circuit between said pole pieces, and an energizing coil linking said magnetic circuit.

9. A magnetically controlled electron discharge device comprising an anode, a cathode, spaced magnetic elements surrounding said cathode and surrounded by said anode, an envelope including said anode and cathode, and a magnetic circuit including an energizing coil within said envelope to create a controlling magnetic field across a magnetic space between said elements according to received current and no current signal conditions to vary the flow of electrons from said cathode to said anode, said energizing coil linking said magnetic circuit.

10. A magnetically controlled electron discharge device comprising a control magnetic circuit including a pair of spaced pole pieces within the device, said pole pieces comprising peripherally flanged discs extending across said device, a magnetic structure completing said magnetic circuit between said pole pieces, and an energizing coil linking said magnetic circuit.

11. A magnetically controlled discharge device comprising an envelope, a cathode and an anode within said envelope, two spaced pole pieces within said envelope, said cathode extending through said pole pieces, said anode surrounding said pole pieces, said pole pieces spaced to form a gap defining part of a discharge path between said anode and cathode, extensions of magnetic material on said pole pieces extending through said envelope, an external circuit of magnetic material in magnetic contact with said extensions to generate a control magnetic field across said gap to provide a magnetic shutter for controlling the electron flow between said cathode and said anode, and an energizing coil linking said circuit.

12. A magnetically controlled discharge device comprising an envelope, a control magnetic circuit extending through said envelope, said circuit including spaced magnetic elements providing a gap within said envelope, a cathode extending through said elements, an anode surrounding said elements, and a winding linked with magnetic structure external of the envelope to facilitate the generation of a magnetic field in said gap to provide a magnetic shutter for controlling the electron flow between said cathode and said anode.

13. A magnetically controlled electronic device comprising an envelope, an anode and a cathode within said envelope, a magnetic structure comprising means to produce a magnetic field between said cathode and said anode to control electron discharge therebetween, elements of magnetic material within the magnetic field defining a plurality of electron discharge paths in the magnetic field, and an energizing coil linked with said magnetic structure.

14. A magnetically controlled space discharge device including an anode, a cathode, and an envelope housing said anode and said cathode, said envelope comprising a tubular portion of nonmagnetic material having cap portions of magnetic material sealed thereto, a magnetic circuit for controlling electron flow from said cathode to said anode, said magnetic circuit including said cap portions and comprising a magnetic structure within said envelope and disposed in parallel relationship with respect to said anode and said cathode, said magnetic structure comprising a pair of spaced pole pieces surrounding said cathode and surrounded by said anode, and coil means to energize said magnetic circuit to control said device.

15. An electron discharge device comprising an anode, a cathode, an envelope enclosing said anode and said cathode, said envelope comprising a tubular portion of nonmagnetic material and cap portions of magnetic material, a magnetic structure within said envelope including said cap portions and extending intermediate said anode and cathode and provided with a gap defining an electron path from said cathode to said anode, a magnetic structure external to said envelope in contact with said cap portions of said first-mentioned magnetic structure and defining a magnetic circuit therewith, and an energizing coil linking said magnetic circuit.

16. An electronic relay comprising a gas filled container, an anode and a cathode within said container, spaced elements of magnetic material surrounding said cathode and surrounded by said anode, and a control coil to vary the magnetic lines of force through the elements and across a magnetic space between said elements according to received current and no current signal conditions to vary the flow of electrons between the anode and cathode through said space, said control coil being electrically disconnected from the electrical circuit through said space.

17. An electronic relay comprising a gas filled container, an anode and a cathode within said container, elements of magnetic material surrounding said cathode and surrounded by said anode, a magnetic space between the elements, other elements together with said elements of magnetic material completing a magnetic circuit, a control coil comprising an electromagnetic means linked with said other elements to energize said magnetic circuit to vary the magnetic lines of force through the first-mentioned elements and across the space to vary the flow of electrons between the anode and cathode through the space, said control coil being electrically disconnected from the electrical circuit through the space.

18. A magnetically controlled space discharge device including a single anode, a single cathode, an envelope enclosing said anode and cathode, spaced magnetic elements within said envelope surrounding said cathode and surrounded by said anode, a magnetic structure defining a magnetic circuit with said elements to facilitate the generation of a magnetic field between said elements whereby a magnetic shutter is provided for controlling the electron flow between said cathode and said anode, and an energizing coil linked with said magnetic structure and electrically disconnected from the electrical circuit through

said magnetic field to energize said magnetic circuit to produce the shutter effect.

19. A magnetically controlled discharge device comprising an envelope, a single cathode and a single anode within said envelope, spaced magnetic elements within said envelope surrounding said cathode and surrounded by said anode, a magnetic circuit comprising with said magnetic elements a loop of magnetic material having a magnetic space within said envelope forming a discharge path for an electrical circuit between said anode and said cathode, and signal responsive means linked with said circuit and electrically disconnected from the electrical circuit through said magnetic space, said means effective through said magnetic material to generate a magnetic field within said magnetic space whereby a magnetic shutter is provided to permit or prevent electron travel through said magnetic space in accordance with the effect of received signals on said means.

20. A magnetically controlled space discharge device comprising an envelope, spaced magnetic elements in said envelope, a cathode extending through said magnetic elements, an anode surrounding said elements, a magnetic structure defining a magnetic circuit with said elements to facilitate the generation of a magnetic field between said elements whereby a magnetic shutter is provided for controlling the electron flow between said cathode and said anode, and an energizing coil linked with said magnetic structure and electrically disconnected from the electrical circuit through said field to energize said magnetic circuit to produce the shutter effect.

21. An electron discharge apparatus comprising a container, spaced tubular pole pieces in said container, a cathode extending through the opening of each of said tubular pole pieces, an anode surrounding said pole pieces, said pole pieces spaced to facilitate the generation of a magnetic field therebetween to provide a magnetic shutter for controlling the electron flow between said cathode and said anode, a magnetic structure adjacent said container for completing a magnetic circuit to said pole pieces, and an electromagnetic coil supported by said structure to energize the magnetic circuit to produce the shutter effect.

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