March 3, 1936. H. B. McELRATH 2,032,545

ELECTRON TUBE

Filed Oct. 26, 1931 2 Sheets-Sheet 1

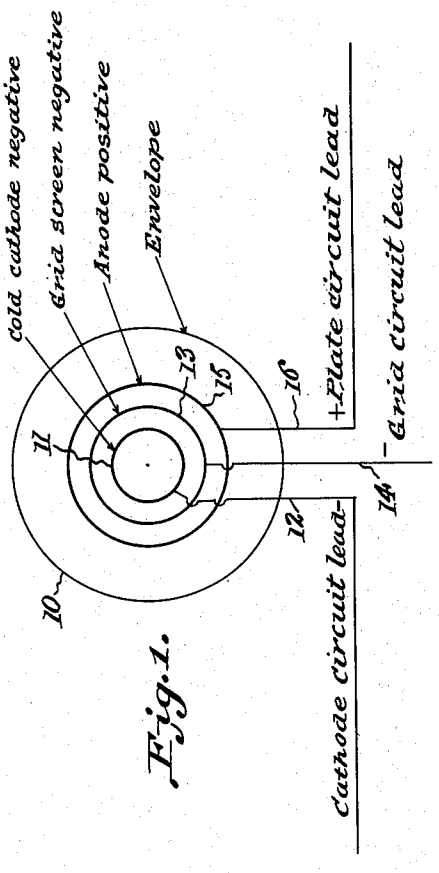


Fig. 1.

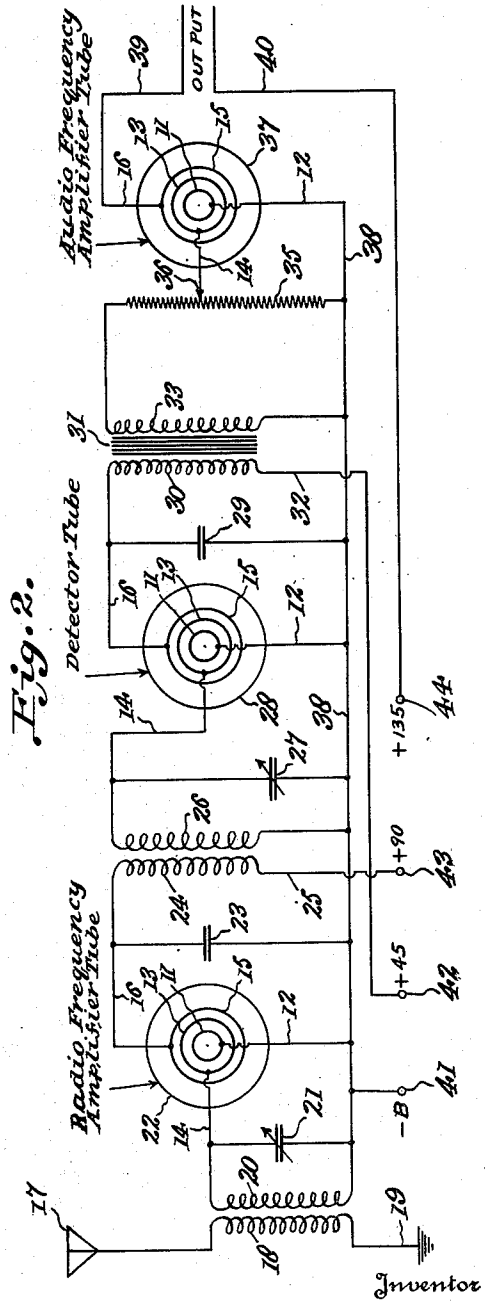


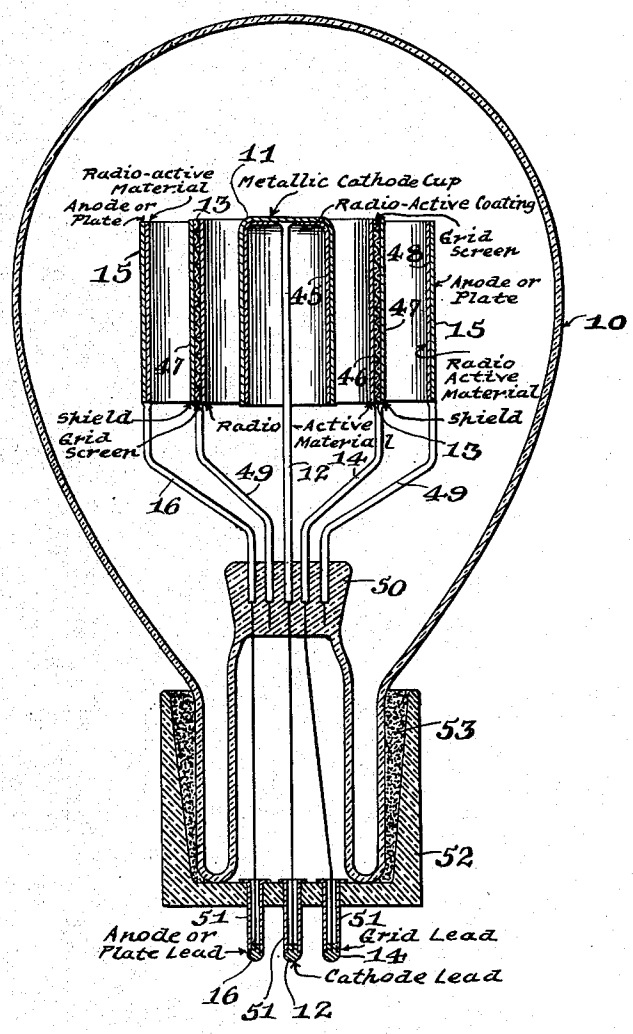
Fig. 2.

March 3, 1936. H. B. McELRATH 2,032,545

ELECTRON TUBE

Filed Oct. 26, 1931 2 Sheets-Sheet 2

Fig. 3.



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ELECTRON TUBE

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5 Claims. (Cl. 250—27.5)

The present invention relates to electron tubes.

An object of the present invention is to provide a cold radio active cathode for emitting negative electrons in lieu of the conventional hot filament with its attendant burnouts, current consumption and other well known disadvantages; to provide in the tube a negative radio active grid by use of which may be eliminated the conventional C current and its attending complications and to provide an inherently self-biased grid action to the exclusion of external complicated circuit layouts; and to provide in the tube a radio active anode for emitting positive active charges and assist the B current in drawing to itself the negative charges emitted by the cold cathode.

With the foregoing and other objects in view, the invention will be more fully described hereinafter, and will be more particularly pointed out in the claims appended hereto.

In the drawings, wherein like symbols refer to like or corresponding parts throughout the several views.

Figure 1 is a diagrammatic view of the improved electron tube employed.

Figure 2 is a diagrammatic view of the improved circuit embodying the potentiometer and the use of a number of the tubes of Figure 1, and

Figure 3 is an enlarged detail sectional view taken through one of the electron tubes.

Referring now to the drawings, 10 designates the envelope or casing of the tube and in which is placed a cold cathode 11 which is shown innermost and connected to a lead 12 which passes to the exterior of the envelope 10 and which may be the cathode circuit lead and is negative. Surrounding the cold cathode 11 is the grid 13 which, in accordance with present usage, is also negative, and which is connected to a lead 14 which constitutes the negative grid circuit lead. Exteriorly about the grid 13 is disposed the anode 15 which is positive and which is connected to a lead 16 extending through the envelope 10 and which constitutes the plus plate circuit lead.

In the action of the tube, the electrons leave the surface of the cold cathode 11 and pass through the grid 13 which, like the cathode, is negative. The electrons passing through the negative grid 13 strikes the positive anode 15, and the anode emits positive charges of alpha particles and therefore has a tendency to draw the negative electrons from the negative cathode 11. When the positive terminal of a suitable current is connected to the lead 16, there will be a current of electricity flowing when the negative terminal is connected to the lead 12 and the cold cathode 11. The cold cathode establishes a path for this current across to the anode 15 and the anode assists the cathode and a direct current crosses the space within the tube from the cathode 11 to the anode 15, through the grid 13 in its path. The grid 13, being in the path of this current acts as a valve when an alternating current or a changing potential is impressed upon it. The negative property of the grid 13, due to its radio active properties is very desirable as it places the correct bias which corresponds to the C current. By being inherently biased no external complications are encountered and a relatively simple economical circuit layout is possible. The improved tube therefore embodies an inherently biased tube construction. By making the grid 13 emit negative electrons the effect is the same as introducing a C current in series with the grid return lead, having the C plus terminal connected to the B minus supply and the C minus terminal connected to the grid circuit.

Since all three of the electrodes 11, 13 and 15 are radio active, it follows that each of these electrodes have a charge of an electrical nature; the cathode 11 and the grid 13 carry negative charges and emit electrons or cathode rays, while the anode or plate 15 carries a positive charge and emits protons or opposite electrical charges with respect to the cathode and grid. The radio active nature of these electrodes may be accomplished by any known or suitable method, such as alloying the radio active material with the respective electrodes, using electrodes composed of materials which give off radio activity of their own accord, or using metals or substances that have the property of maintaining induced radio activity or coating the electrodes with suitable radio active substances. The grid 13 and cathode 11 must either use a radio active substance which emits electrons or negative electrical charges, or else use a regular radio active substance emitting the alpha, beta and gamma rays and then shielding the less penetrating alpha rays by a thin sheet of suitable material for example aluminum. The shield will thus shut off the alpha rays and allow the penetrating cathode rays or electrons to continue their course.

Since the cathode 11 and grid 13 must emit negative electrical charges, they must therefore emit or discharge beta rays and this may be accomplished by one of two means. The radio active material must emit beta rays and not alpha rays, or else the material may emit both alpha and beta rays and in this case the alpha rays will have to be shielded off or segregated. Ra-

dium D (Ra-D) gives off beta rays and no alpha rays. Radium (Ra) and radiothorium (Rd-Th) gives off alpha and beta rays. These are the longest life elements in the radio active series. There are others but the above mentioned are considered the best. These substances may be alloyed with the metallic electrodes or they may be coated upon the surfaces of the electrodes.

If a radio active material is used on the cathode 11 and grid 13 which emits both alpha and beta rays, then a thin metallic shield will have to be secured to the outside surfaces of these electrodes so as to cut off the alpha rays and allow the more penetrating beta rays to continue in their path. A metallic covering may be coated or otherwise secured over the radio active material. If the cathode 11 is in the shape of a cup, the inner surface may be coated with a radio active material emitting both alpha and beta rays, and the metal cup will in itself shut off the alpha rays. As it is desirable that the grid 13 be porous, it is found desirable to coat or alloy the grid with a radio active preparation which emits beta rays and not the alpha rays, such as radium D as it may interfere with the porosity if a material or substance is used which emits alpha rays which have to be shielded off.

For shielding off the alpha rays a thin sheet of aluminum .006 cm. thick will effectually shut off the alpha rays, and the thickness of the materials used is to be determined by their density. Lead, for instance, shields better than aluminum for a given thickness. The plate or anode 15 is preferably alloyed or coated with a radio active preparation which emits alpha rays, such as uranium (U), ionium (Io), protoactinium (Pa), or thorium (Th). No shielding is necessary for the anode 15 or plate as the alpha rays are desired. The cathode 11 and the grid 13 will give off the beta rays, and the anode or plate 15 will give off the alpha rays.

The amount of radio activity imparted to each electrode will of course be governed by the requirements of the circuits. In some cases the grid bias will be relatively strong necessitating a higher or larger activity of the grid 13 while the cathode 11 may be only a trifle more radio active than usual. In some cases the anode 15 or plate may require a relatively greater radio activity than in others and in each case the radio activity is predetermined by the circuit requirements which may be controlled by the quantity and quality of the radio active substances employed.

Referring now to Figure 3, the metallic cathode cup 11 is provided on its inner side with a coating 45 of radio active material having a characteristic as above outlined. The grid 13 is provided upon its inner side, toward the cathode cup 11, with a coating of radioactive material 46, and the outer side of the grid 13 is provided with a protecting shield 47 of aluminum, or the like. In a like manner, the anode plate 15 is provided upon its inner side with a coating of radio active material 48. While Figure 3 shows the radio active material in the form of coating or layers upon the respective electrodes, it is of course understood that this radio active material may be incorporated or embedded in the material or substances of which the various electrodes are formed.

In order to mount the electrodes, the radio active material and the shield of the present invention in a conventional manner within the tube or envelope 10, the leads or wires which extend from the respective electrodes, as shown at 12, 14, and 16, may be supplemented by supporting wires 49, or the like, which may have a general configuration corresponding to that of the actual leads so as to produce a symmetrical structure to lend the necessary support to the various sides of the electrodes. These wires and supports may be molded or suitably secured in the anchor stem 50 of the tube which is usually of glass as shown, or leads may be used being carried down through the anchor stem and soldered or otherwise suitably secured to the prongs or stems 51 which extend through the cap 52 of the tube in the usual manner. These prongs or stems 51 may be arranged in triangular or any other suitable manner which may be conventional so that the tube may be mounted in an ordinary socket. The envelope 10 is of any practical construction and is shown as secured in the cap 52 by a sealing compound 53 in the ordinary manner. Of course the present invention admits of various different constructions to adapt the tube for any desired number of electrodes, leads and variations in the shape and construction of the envelope and the cap.

It will of course be understood that when a radioactive material 46 is added to the grid screen 13 and which is capable of emitting beta rays to the exclusion of alpha rays, such as radium D, Ra-D, for instance, the shield 47 around the grid 13 is unnecessary so that in this case the shield 47 would be omitted. In the present illustration of an electron tube 3 electrodes are shown, and of course these operate satisfactorily and constitute the essential elements of a tube. There are used electron tubes having a greater number of electrodes therein, the essential electrodes, however, comprise the cathode, the grid and the plate. According to this invention three radio active electrodes may be used irrespective of the number of electrodes with which the tube is equipped. This adapts the invention to not only the screen grid tube, but also the pentode and the hi-mu types.

This improved electron tube may be used in radio receiving circuits as a radio frequency amplifier, a detector, a power detector and an audio frequency amplifier or power amplifier. The improved tube eliminates the grid leak and grid condenser used in the detector circuits of some systems as the grid is inherently biased. In the radio and audio frequency circuits the tube eliminates all biased connections and the C current systems. The improved tube may also be used in radio transmitting circuits where oscillating and amplifying tubes are required as the tube will operate satisfactorily as a detector, amplifier or oscillator. In telegraphic and telephonic communication the improved tube may be used wherever electronic transmission is employed.

Referring now to Figure 2 there is shown an improved circuit embodying a number of tubes as above described and which are arranged in the various stages of the circuit. In Figure 2, 17 is an antenna connected through a primary winding 18 and ground 19. The secondary winding 20 of the coupling has shunted across its ends a variable condenser 21 which constitutes the first tuning condenser. At 22 is a radio frequency amplifier tube which is of the above described construction. Within the tube 22 is mounted the negative grid 13, the negative cathode 11 and the radio positive plate or anode 15. 23 is a bypass condenser shunted across the plate-cathode circuit of the tube 22. 24 designates the primary winding of the radio frequency transformer and

is connected between the plate 15 of the tube 22 and the B current supply wire 25 which may be connected to the plus 90 volt terminal thereof.

The secondary winding 26 of the transformer is provided with a variable condenser 27 shunted across its leads. This condenser comprises another tuning condenser. A detector tube 28, of the same construction as above set forth, is connected to the radio frequency transformer. A bypass condenser 29 is shunted across the plate-cathode circuit of the tube 28 and has one side connected to the primary winding 30 of an audio frequency transformer having a laminated core 31, and the other side connected to common return 38. The other end of the primary winding 30 is connected to the plus 45 lead wire 32 connected to the terminal of the B current circuit. Connected in parallel with the secondary winding 33 is a high resistance element 35 shunted across the secondary winding 33 and which has a movable contact 36 for varying the volume of current or voltage of the grid 13 of an audio frequency amplifier tube 37 having the grid thereof connected directly to the movable contact 36. The resistance 35 and the movable contact 36 provide what is commercially known as a potentiometer and the mounting of this resistance control element in its operation of the circuit is deemed to be an important feature of the present invention. The cathode 11 of the tube 37 is connected to the common return B minus wire 38 and to the adjacent branch wires leading from the resistance 35, and the secondary winding 33 of the audio frequency transformer. The anode or plate 15 is connected to one of the output wires 39, the other wire or side of the output is returned to the plus 135 volt terminal 44 of the B current through the wire 40.

The B current has its negative terminal 41 connected to all of the cathodes in the circuit through the wire 38, and all of the secondary windings and all of the condensers are also connected to the wire 38. The detector tube 28 uses the plus 45 volt terminal 42 and the radio frequency amplifier tube 22 uses the plus 90 volt terminal 43 while the audio frequency amplifier tube uses the maximum voltage or plus 135 volts through the output wire 39.

Though not shown in the drawings, it is clear and understood that these electrodes or systems may be enclosed in vacuum tubes or envelopes or in tubes or envelopes containing a rarefied gaseous atmosphere, as is done in certain electron tubes.

It is obvious that various changes and modifications may be made in the details of construction and design of the above specifically described embodiment of this invention without departing from the spirit thereof, such changes and modifications being restricted only by the scope of the following claims.

I claim as my invention:

1. An electron tube comprising a partially evacuated envelope, a multiplicity of electrodes in the envelope, at least one of said electrodes having a porous shield substantially providing a supplemental electrode in said envelope, one of said first electrodes comprising a cathode, a second of said electrodes comprising a grid, said porous shield mounted in the path of the electron stream and having electrical connection with said grid, a third electrode comprising an anode, said cathode and grid cooperating to establish a difference of potential with respect to said porous supplemental shield, said anode adapted to augment the process of ionization to produce a conductive path for the current flow.

2. An electron tube comprising an envelope adapted to contain a rarefied gas, a plurality of electrodes mounted in the envelope, a porous shield mounted in the envelope, one of said electrodes comprising a cathode including a radio active substance, another electrode comprising a grid including a radio active substance, another electrode comprising an anode including a radio active substance, said shield being mounted to absorb a preponderance of one kind of radio active emission and utilize said absorbed emission to assist the functioning of the radio active grid.

3. An electrical device comprising an envelope containing a low pressure gas and a cold radio active cathode emitting beta rays mounted in said envelope and a radio active grid emitting beta rays mounted in said envelope, said grid having a porous shield providing an auxiliary electrode mounted in said envelope and having an electrical connection with said radio active grid, and a radio active anode mounted in said envelope and the said radio active cathode, radio active grid and radio active anode having leads emerging from said low pressure envelope for connection to an external circuit.

4. An electron tube comprising an envelope, a plurality of radio active electrodes mounted in said envelope at least one of the electrodes having a porous shield providing a supplementary electrode mounted in said envelope and having electrical connection with the said radio active electrode, and said porous supplementary electrode functioning to assist one of the said radio active electrodes, at least two of the said radio active electrodes emitting beta rays and at least one of the said radio active electrodes emitting alpha rays.

5. An electron tube comprising an envelope, an electrode having a porous supplementary shield mounted in said envelope, a cold radio active cathode mounted in said envelope, a radio active grid mounted in said envelope and a radio active anode mounted in said envelope, the said cold radio active cathode and radio active grid establishing a difference of potential with respect to said porous shield.

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