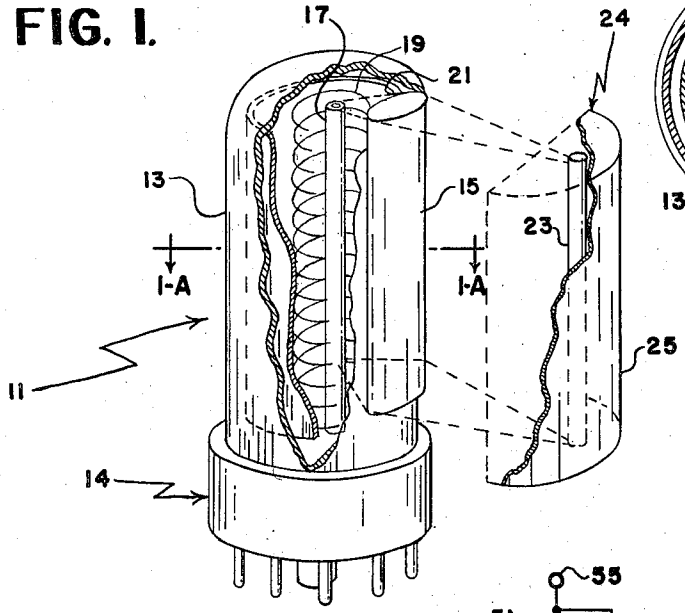
July 29, 1958 C. L. STEC 2,845,558

COLD CATHODE VACUUM TUBE MEANS

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FIG. 1.



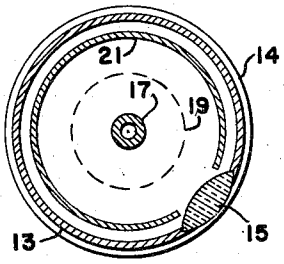
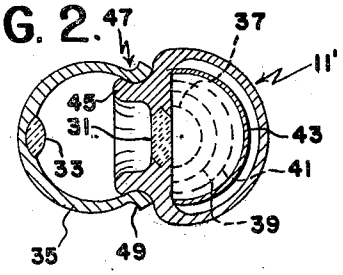


FIG. 1-A.

FIG. 2.



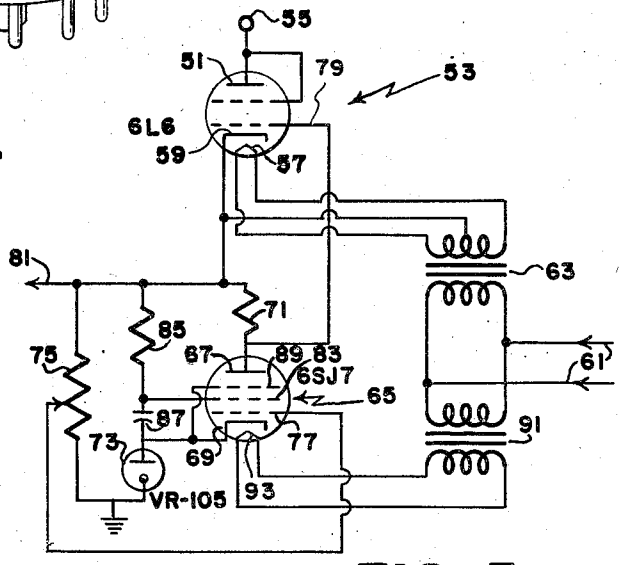


FIG. 3.

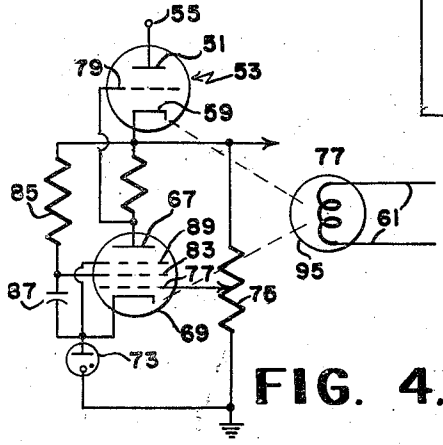


FIG. 4.

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COLD CATHODE VACUUM TUBE MEANS

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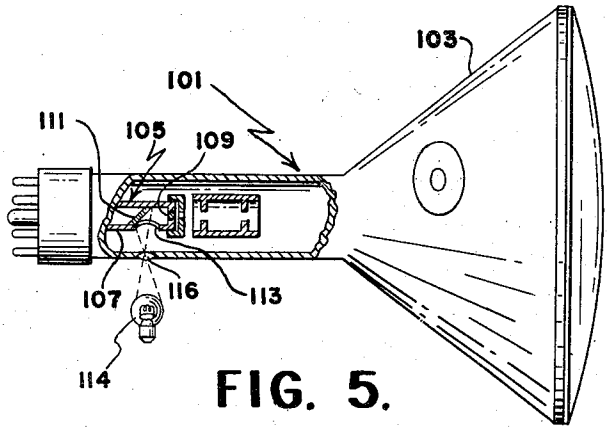


FIG. 5.

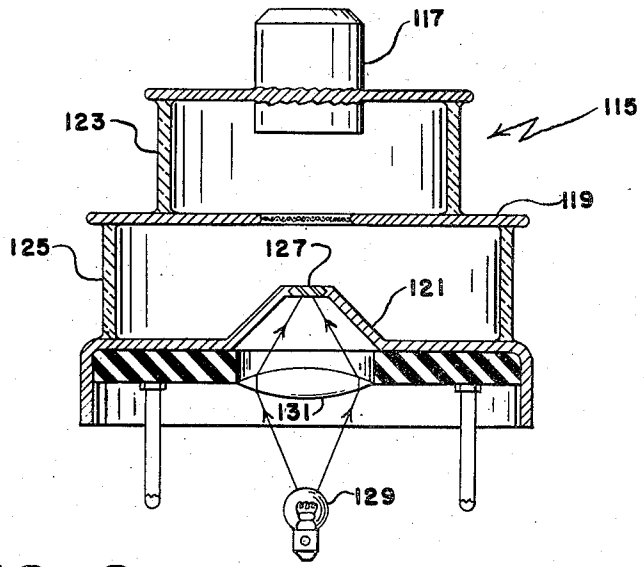


FIG. 6.

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2,845,558

COLD CATHODE VACUUM TUBE MEANS

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Application June 9, 1953, Serial No. 360,618

7 Claims. (Cl. 313—54)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The present invention relates to vacuum tubes and more particularly to a vacuum tube having a cold cathode.

Presently available vacuum tubes employ a filament which emits electrons or a heated cathode surrounding a heating element, and the heating element may be powered by either alternating or direct current. The heat created by the filament or heater within the vacuum tube must be dissipated to the surrounding elements and the envelope of the tube, largely by radiation, and the heat causes uneven expansion of the several parts of the tube. As the tube is normally turned off and on many times, the elements are subjected to alternate expansion and contraction which greatly shortens the useful life of the tube.

The problem of insulating the heater from the surrounding cathode is aggravated by the fact that good electrical insulators are also good heat insulators so that any attempt to provide a high degree of electrical separation between the two results in inadequate heat transfer. As a result, there can be very little insulation between the heater and the cathode, and the allowable voltage difference therebetween is limited to relatively small values. Since both the heater and the cathode operate at elevated temperatures, both emit electrons to some degree and a voltage difference between them creates a flow of current through the cathode and heater circuits. Where the heaters are operated on alternating current, the current flowing between the heater and the cathode is modulated by the alternating current, which current creates a hum in high gain amplifiers which is both annoying and difficult to eliminate.

Furthermore, in special applications, the heat of the tubes have detrimental effects on other components, and frequently a tube dissipating a small fraction of a watt in its anode circuit requires about two watts of heater power. The power consumed by the heaters may be a very large part of the total power consumption of the equipment, so that elimination of such a loss makes possible the production of more compact and lighter equipment.

In the present invention, the filament or heated cathode is entirely eliminated from the vacuum tube, and replaced by a cathode which may be excited by radiant energy from an external source, such as a small lamp or a radiation-emitting substance. By this means, the heating of the several elements to high temperature is eliminated, as is the extraneous conduction path from heater to cathode and the need for insulation therebetween, thus making the tube applicable to a large number of circuits where conventional tubes are not usable.

The present invention reduces the temperatures inside a vacuum tube and thereby reduces the production of ions therein. Since the temperature of the secondary electrodes of the tube is reduced, the tendency of these elements to emit electrons is also reduced.

It is an object of the present invention to provide a grid-controlled vacuum tube having a cold cathode.

It is a further object of the present invention to provide

a grid-controlled vacuum tube having a cathode excited by an external source of radiant energy.

It is another object of the invention to provide a fully grid-controlled vacuum tube in which the cathode is made electron-emitting without the need for passing heating electric current into and out of the tube.

It is still another object of the present invention to provide an electron-emitting cathode within a vacuum tube which does not produce substantial quantities of heat.

Other objects and many of the attendant advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following description when considered in connection with the appended drawings in which:

Fig. 1 is a perspective drawing partially in section of a preferred embodiment of the present invention;

Fig. 1A is a cross-sectional view taken on line 1A—1A of Fig. 1;

Fig. 2 is a cross-sectional view of a further embodiment of the present invention;

Fig. 3 is a schematic diagram showing a conventional regulator circuit;

Fig. 4 is the circuit of Fig. 3 as simplified by the present invention;

Fig. 5 is a view of the present invention applied to a cathode ray tube; and

Fig. 6 is a cross-sectional view of the present invention applied to a co-axial tube of the "lighthouse" type.

Referring now to the drawings in which like or corresponding parts are indicated by the same symbol, there is shown in Fig. 1 a vacuum tube **11** having an envelope **13** of impervious-to-gas material. The envelope **13** is fitted with a port **15** for the admission of radiant energy which is directed toward the cathode **17** from the source **24**.

It will be understood by those skilled in the art that the form of tube shown in the drawings in no way limits the invention, since either a glass or a metal envelope may be employed. While it is usually convenient to employ a plug-in base for tube such as is illustrated in Fig. 1 by the reference numeral **14**, such bases may also be eliminated, especially since the life of the tube is greatly extended by elimination of the internal heater. As illustrated, the base **14** may be similar to the conventional tube base.

The external source of radiant energy **24** may be of any type which will excite a suitable cathode material to emit electrons. Examples of suitable sources and corresponding cathode materials include selenium or compounds thereof such as SeAgO actuated by light, compounds actuated by infrared such as PbS and PbTe, and the alkaline halide group actuated by a source of atomic radiation, such as radium-bearing materials used for watch crystals and radio-active cobalt. Other combinations will be apparent to those skilled in the art.

As illustrated in Fig. 1, the envelope **13** may be constructed of glass equipped with a cylindrical lens comprising a transparency or port **15**, by transparency meaning that the appropriate radiant energy can pass therethrough. The lens focuses or directs light onto the cylindrical cathode **17** of selenium or other photo-electric materials. Surrounding the cathode **17** is a control grid **19** which may consist of helically wound wire adjacent to but spaced from the cathode **17**, and a plate **21** arcuately disposed about the control grid **19**. It is apparent that the plate **21** should contain a slit or port through which light may reach the cathode **17**.

The source of radiant energy **24** may consist of an electric lamp **23** provided with a reflector **25**. It will be readily apparent that different types of light sources may be readily employed, and that if desired a single light

source may be used to excite several tubes arranged around it.

In Fig. 2, a modification of the present invention is shown in which a cathode **31** of an alkaline halide compound is sealed into the envelope **11'**, and the cathode is excited by a source of radiation **33**, such as radio-active cobalt secured within the radiation shield **35** of lead or other metal. The quantity of the radio-active substance required to excite the cathode **31** is very small, so that very little shielding is required, and the danger to personnel from such a source is negligible.

The modification illustrated in Fig. 2 is a design for a pentode tube and includes the crystal cathode **31**, the control grid **37**, the screen grid **39**, the suppressor grid **41**, and the anode or plate **43**. The exterior face of the envelope **11'** is extended to form the male portion **45** of a snap-on latch **47**, over which the edges **49** of the radiation shield **35** engage. Because of the long half-life of radio-active cobalt, the same radiation shield **35** has a life of several tubes.

The present invention is applicable to cathode ray tubes as illustrated in Fig. 5. The envelope **103** of the cathode ray tube **101** is of conventional shape having a flared end, a neck, and a base carrying a plug. The neck of the envelope contains an electron gun having the usual anodes and control grid. The cathode **105** may be co-axial with the electron gun, and comprises a tube **107** containing an insert of radiation-sensitive material **109** and an inclined mirror **111**, an opening **113** in the wall of the cathode serving to admit radiation.

As illustrated herein, the cathode ray tube **101** is excited by light generated by the lamp **114** positioned exterior of the envelope **103**. While its use is not essential to the operation of the device if light of sufficient intensity is otherwise available, I prefer to provide a lens **116** sealed into the envelope **103** to concentrate the lamp from the lamp **114** on the radiation-sensitive material **109**, the mirror **111** serving to deflect the light in the proper direction.

The present invention is also applicable to co-axial tubes such as the "lighthouse" tube **115** shown in Fig. 6, which comprised an anode **117**, a grid **119**, and a cathode **121**, which elements are sealed to glass cylinders **123** and **125** to form an impervious-to-gas envelope. The cathode **121** is provided with an insert of radiation-sensitive material **127**, which is excited by radiant energy from a source, such as a lamp **129**, the light from the lamp being focused onto the cathode by means of the lens **131**.

It will be apparent that no internal heating element is required on the present invention as is usually employed. There is shown in Fig. 3 a conventional voltage regulator circuit in which the anode **51** of the tube **53** is operated at the voltage of the power source connected to terminal **55** which is usually of the order of three or four hundred volts. The tube **53** is a conventional beam power amplifier tube such as the type 6L6 having its anode and screen grid elements connected together to operate as a triode, the maximum allowable voltage between the heater **57** and the cathode **59** is approximately 175 volts. One side of the usual power source **61** is grounded, so that the insulation of the filament transformer **63** is stressed by several hundred volts, since the heater **57** must be operated at substantially the same potential as the cathode **59**, and other tubes cannot be operated from the same transformer because of its elevated voltage with respect to ground.

An amplifying tube **65** such as the sharp cut-off pentode type 6SJ7 has its anode **67** connected to the cathode **59** of tube **53** through a load resistance **71**; and its cathode **69** connected to ground through the gaseous voltage regulator tube **73**, which regulator tube maintains the cathode **69** at a constant potential. The voltage between the cathode **59** of tube **53** and ground is impressed on the potentiometer **75** and a proportionate part thereof is impressed on the control grid **77** of the tube **65** to control conduction therethrough and hence produce a voltage across the resistance **71** in its anode circuit which varies with changes in output voltage of the system. This voltage is impressed on the control grid **79** of tube **53** to control its conduction and hence its effective resistance. The load supplied from the regulator is connected between terminal **81** and ground, and the screen grid **83** of tube **65** is supplied with voltage through resistance **85** and capacitor **87**. The suppressor grid **89** is connected to the cathode **69** in the usual manner.

A second filament transformer **91** is required to supply heater current to the heater **93** of tube **65**. Thus the circuit requires two filament transformers to supply heater current to the tubes, which transformers are expensive and bulky. However, the equivalent circuit employing the present invention requires no filament transformers, as shown in Fig. 4 and no consideration need be given for insulation of the cathode from the heater of tube **53**. In the figure, cathode excitation is supplied through the lamp **95** which is both inexpensive and compact.

It will be apparent to those skilled in the art that many changes and modifications may be readily made in the present invention without departing from the spirit thereof, and that the examples described herein are purely illustrative of the principles thereof. It is therefore intended to cover all modifications of the invention within the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a vacuum tube means, a cold cathode composed of an alkaline halide emitting electrons when actuated by radio-active particles, an anode for attracting said electrons from said cathode, a control grid interposed between said cathode and said anode, an impervious-to-gas evacuated envelope surrounding said anode, said control grid, and at least part of said cathode, a source of radio-active particles positioned exterior of said envelope and adjacent said cathode for radiating thereon, and a radiative shield positioned about said source of radio-active particles and mounted on the exterior side of said envelope adjacent said cathode.

2. An electronic tube means comprising, in combination, an impervious-to-gas, evacuated envelope, a cathode element composed of an electron-emitting material when subjected to radiation embedded in the wall of said envelope, said cathode element having portions thereof exposed to the inner and outer areas of said envelope, a grid and plate element in said envelope in spaced relation to said cathode element and to each other, a radiation shield, means for securing said radiation shield on said envelope adjacent said cathode element, and a self-contained source of radiation carried on the inner surface of said shield in open communication with said cathode element.

3. In an apparatus as defined in claim 2 but further characterized by said source of radiation comprising a radioactive particle.

4. An electronic tube means comprising, in combination, an impervious-to-gas, evacuated envelope, a cathode element composed of an alkaline halide material mounted in the wall of said envelope, said cathode element having portions thereof exposed to the inner and outer areas of said envelope, a plate element in said envelope in spaced relation to said cathode element, a radiation shield releasably secured to said envelope in confining relation to said cathode element, and a source of radio-active particles carried on the inner surface of said shield in open communication with said cathode element.

5. In an apparatus as defined in claim 4 but further characterized by said envelope having an integral male extension circumscribing said cathode element, and said

radiation shield having a female portion operative to interfit said male extension to form a releasable joint.

6. An electronic tube means comprising, in combination, an impervious-to-gas, evacuated envelope, a cathode element embedded in one side of said envelope and having portions thereof exposed to the inner and outer areas of said envelope, a grid and a plate element separated from each other and from said cathode element, said grid and plate elements having an electrical connection passing through said envelope and to said base member, an integral male flange formed on the outer side of said envelope and circumscribing said cathode element, a radiation shield having an open end portion fitting over said male flange for releasably securing said shield to said envelope, and a self-contained radiation source mounted on the inner surface of said radiation shield in open communication with said portion of the cathode element exposed to the outer areas of said envelope.

7. An electronic tube means comprising, in combination, an impervious-to-gas evacuated envelope, a cold cathode element composed of a material that emits electrons when subjected to radiation, said element being on the inside of a wall of said envelope, a grid and plate in said envelope in spaced relation to said cathode element and to each other, a self-contained source of radiation disposed outside said envelope but in proximity to said cathode so as to radiate to a side of said cathode element, said grid and plate element being on the other side of said cathode element.

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