March 18, 1969 J. T. PERRY 3,433,955

X-RAY GENERATOR WITH EMISSION CONTROL ARRANGEMENT WITHIN THE FOCUSING CUP

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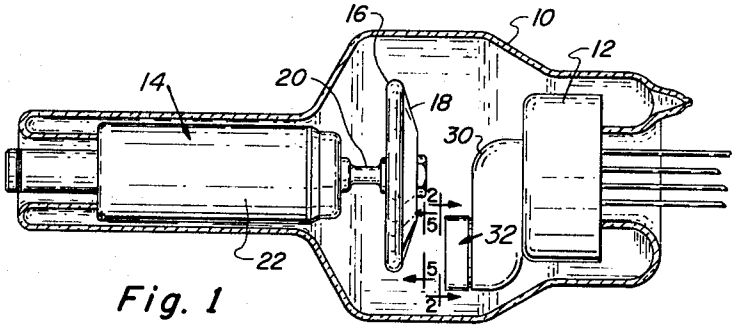


Fig. 1

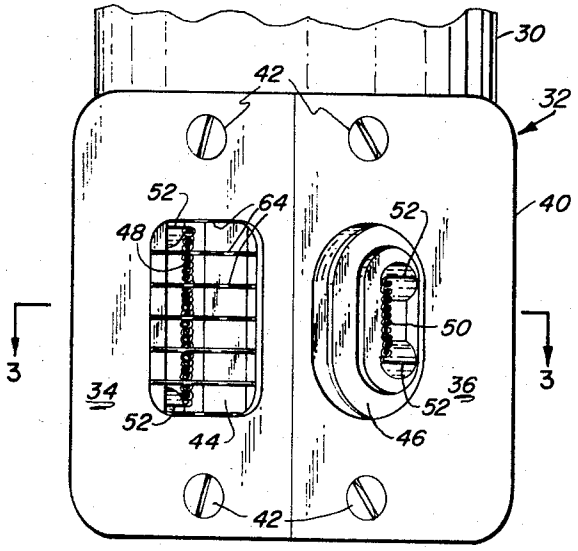


Fig. 2

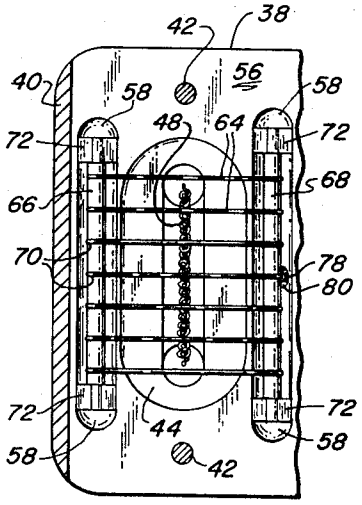


Fig. 4

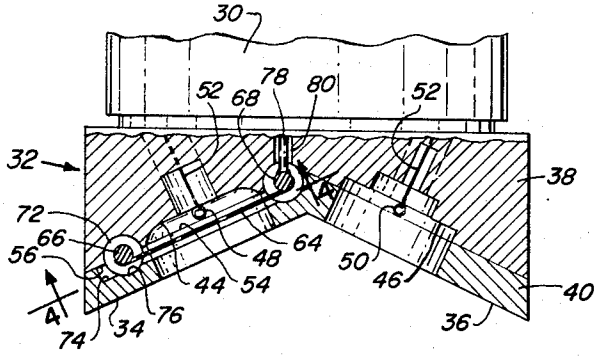


Fig. 3

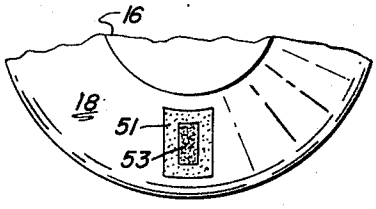


Fig. 5

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X-RAY GENERATOR WITH EMISSION CONTROL ARRANGEMENT WITHIN THE FOCUSING CUP

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Int. Cl. H01j 35/16

ABSTRACT OF THE DISCLOSURE

An X-ray generator is provided with an anode and a cathode, the latter comprising a planar faced metal body with an electron focusing cup formed therein. A parallel wire grid is located in the cup between the face of the cathode body and a filament also located within the cup. The grid is insulated from the cathode and is biased with respect thereto for controlling electron flow without substantially interfering with the electrostatic focusing produced between cathode and anode.

The present invention relates to an X-ray generator and more particularly to an X-ray generator having a new and improved structure for controlling the electron emission of the cathode thereof.

The quantity of X-rays generated at the anode of an X-ray generator is a function both of the electrical potential between the anode and cathode and which accelerates the electrons from the cathode to the anode, and also is a function of the rate at which electrons are emitted by the cathode; thus, by controlling the emission of the electrons from the cathode to the anode the quantity of X-rays generated may be controlled. Control of the quantity of X-rays may be desired, for example, to provide pulses of X-rays of specified predetermined duration, or it may be desired to provide X-rays of varying quantity over predetermined periods.

In the so-called "line focus" type of X-ray generator in which electrons strike the anode in a rectangular area, it is desired that the electrons impinge upon such area as uniformly as possible and that the area be as sharply defined as possible. For the purpose of controlling the emission of electrons from the cathode to the anode in an X-ray generator, it has been proposed heretofore to provide an electrically biased grid between the cathode and the anode. While the prior structures were adequate for generators having a relatively low amount of electron flow between the cathode and the anode, they have inherent limitations where substantial electron flow is desired. For example, in prior structures the focal spot size will vary with the grid bias; grid currents become large when positive bias is applied to the grid, and the plate current is extremely sensitive to changes in the plate voltage. Also, the total emission can be controlled only by changes in filament temperature unless significant changes in positive bias on the grid are used.

Accordingly, it is a principal object of the present invention to provide an X-ray generator having a grid therein to control electron flow from the cathode to the anode but which is not subject to the disadvantages mentioned above.

More particularly, it is an object of the present invention to provide a grid structure in an X-ray generator which can be varied in potential without appreciably changing the focal spot seize.

Another object is to provide a grid structure which will draw a minimum of current at positive potential.

Still another object is to provide an X-ray generator having a grid structure permitting the passage of substantial electron flow.

A further object is to provide an X-ray generator enabling passage of large currents with a minimum value of positive grid bias.

Still further objects and advantages of the invention will become more apparent hereinafter.

In accordance with the present invention an X-ray generator is provided having an anode and a facing cathode means comprising a planar faced metal body having an electron focusing cup formed therein. An electron generating filament is mounted in the cup and a grid comprising a plurality of parallel wires is disposed forwardly of the filament but closely adjacent thereto and rearwardly of the planar face of the cathode.

The grid is insulated from the remainder of the cathode structure and is connected to a source of potential so that an electrical bias may be applied thereto to control the emission of the electrons from the filament to the anode. However, because the grid is positioned within the focusing cup, that is, the focusing cup extends forwardly of the grid towards the anode, the focusing cup structure may exert its electrostatic focusing effect upon the electrons passing through the grid whereupon the dimension of the focal spot upon the anode will not change even though the potential upon the grid may be varied, and because of the close proximity of the grid to the filament control over electron flow may be achieved with a minimum change of grid bias.

For more detailed description of the invention reference is made to the accompanying drawings wherein:

FIG. 1 is a side elevation of an X-ray generator constructed in accordance with the invention;

FIG. 2 is an enlarged end elevation of the cathode taken along line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3; and

FIG. 5 is a fragmentary elevation of the anode target element as viewed along line 5—5 of FIG. 1.

The illustrated generator comprises an envelope **10** having a cathode structure **12** mounted in one end thereof and an anode **14** in the opposite end thereof. The anode is shown as being of the rotating type having the rotating target element **16** preferably formed of tungsten and which is provided with a frusto-conical target surface **18**. The target element **16** is monuted on a stem **20** extending from a rotor **22** suitably supported on the envelope in a conventional manner and which rotor is adapted to be driven by a magnetic field generated by coils (not shown) positioned exteriorally of the envelope **10**.

The cathode structure **12** is of the double focus type and, referring to FIGS 2 and 3, comprises a head **30** including a metal body **32**, which may be formed of nickel or other suitable material, and which body is provided with two planar faces **34**, **36**, disposed at a large obtuse angle with respect to one another. The body **32** is formed of two portions including a base portion **38** and a face defining portion **40**, screws **42**, or other suitable means, being provided to secure the two portions rigidly together.

Formed in the body **32** are a pair of elongated focusing cup recesses **44**, **46**, the recess **44** being longer than the recess **46**. An elongate electron generating filament **48** is mounted in the recess **44** and a similar but shorter filament **50** is mounted in the recess **46**. Suitable leads **52** are provided to connect the filaments **48**, **50** to a source of electrical energy. The recesses **44**, **46** are arranged to focus electrons from the filaments **48**, **50** upon a pair of rectangular anode focal spots **51**, **53**, respectively (FIG.

5). Control of the emission from the smalled filament **50** upon the focal spot **53** is obtained solely by controlling the bias between the cathode and the anode. However, suitable control over the emission from the larger filament **48** upon the focal spot **51** cannot be obtained in such manner, and the improved means of the invention for obtaining such control will now be described.

Referring to FIG. 3 it will be noted that the recess **44** is relatively deep and extends entirely through the face defining portion **40** into the base portion **38**. It will be further noted that the filament **48** is mounted rearwardly with respect to the planar face **34** of the parting plane **54** which extends through the recess **44** between the portions **38, 40.**

Mounted forwardly of the filament **48** but rearwardly of the front face **34** is a grid means comprising a plurality of parallel wires **64** extending latterally of the recess **44** in the direction at right angles to the longitudinal axis of the filament **48.**

The wires **64** are platinum covered molybdenum or other suitable construction and are supported by a pair of support rods **66, 68** mounted one on each of the opposite sides of the recess **44,** the rods having slots **70** for receiving the ends of the wires **64** which are preferably spot welded to the rods. The rods **66, 68** are supported in insulated relation from the cathode body **32,** the opposite ends of the rods being of reduced diameter and encompassed by tubular insulators **72** which are seated within semicircular recesses **58** formed in the face **56** of the body base portion **38.** The wires **64** are spaced a short distance forwardly of the face **56** of the base portion **38** and the rear surface of the base portion **40** is cut away as indicated at **74** so as to provide clearance between the wires **64** and the base portion **40.** The cut away portion **74** is in addition provided with shallow arcuate grooves **76** for receiving the insulators **72.** The rod **68** is connected to a lead **78** extending through an opening **80** in the body **32** and outwardly of the envelope **10** for connection to a suitable source of electrical potential.

The filaments **48, 50** are connected to a conventional control system so that they may be selectively operated. When the shorter filament **50** is operated control of the emission from the cathode to the anode is achieved by biasing the entire cathode structure. However, when the longer filament **48** is operated emission is controlled by applying a bias to the grid **64.** Because the grid is positioned a substantial distance within the focusing cup **44,** electrons passing the grid **64** are subjected to the focusing effect of the electrostatic field within the cup arising from the potential or bias between the anode and cathode and which field is not materially affected by changes in the potential upon the grid. Accordingly, the size of the focal spot **51** produced by electrons emitted from the filament **48** does not change materially as the potential upon the grid changes. Furthermore, because the grid wires are of limited total area, as the grid is swung positive the grid current remains relatively small because of the small collecting area. Another significant advantage of the structure of the invention is that control of the electron emission from the cathode to the anode may be made with relatively small changes in grid voltage while enabling high forward current. For example, in a typical generator having 150 kv. plate voltage cut-off is obtained at −2,500 volts. In the same generator the electron emission expressed as tube current is in excess of 400 milliamperes at 85 kv. with +500 volts bias applied to the grid.

Having illustrated and described a preferred embodiment of the invention it should be apparent to those skilled in the art that it permits modification in arrangement and detail. I claim all such modifications as come within the scope and purview of the appended claims.

I claim:

1. An X-ray generator comprising cooperating spaced apart anode and cathode means,

said cathode means comprising a planar faced metal body having an electron focusing cup formed therein,

means for applying an electrical potential between said anode and cathode means,

an electron generating filament mounted in said cup,

grid means disposed between said filament and said body face and insulated from said body whereby electrons flowing through said grid means are subjected within said focusing cup to electrostatic focusing from the field of the potential between said anode and cathode means after passing said grid means,

and means for connecting said grid means to a source of electrical potential.

2. The X-ray generator of claim **1** wherein said body comprises a base portion and a face portion, said grid means being positioned between said portions.

3. The X-ray generator of claim **1** wherein said focusing cup and said filament are elongated and said grid means comprises a plurality of laterally spaced apart grid wires extending at right angles to the longitudinal axis of said filament.

4. The X-ray generator of claim **2** wherein said grid means comprises grid wires fixedly secured between a pair of parallel rods spaced one on each side of said filament, said rods being rigidly clamped between said body portions but insulated therefrom.

5. The X-ray generator of claim **4** wherein said rods are located within recesses provided between said body portions and outside said electron focusing cup, said grid wires extending into said cup from said rods and across said cup.

6. The X-ray generator of claim **1** wherein said means for connecting said grid means to a source of electrical potential comprises means for connecting said grid means to a controllable source of grid bias potential different from the potential of the cathode means.

7. An X-ray generator comprising cooperating spaced apart anode and cathode means,

said cathode means including a metal body having a pair of elongated, longitudinally parallel electron focusing cup recesses in the surface thereof facing said anode means,

an elongated, filamentary cathode element mounted longitudinally one in each of said cups,

said cups being arranged to focus the electrons emitted by the respective cathode element upon said anode means in longitudinally parallel anode focal spots,

and a grid means disposed within one of said recesses between the filament therein and the opening of said one recess and in insulated relation with respect to said body.

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U.S. Cl. X.R.

250—99; 313—57