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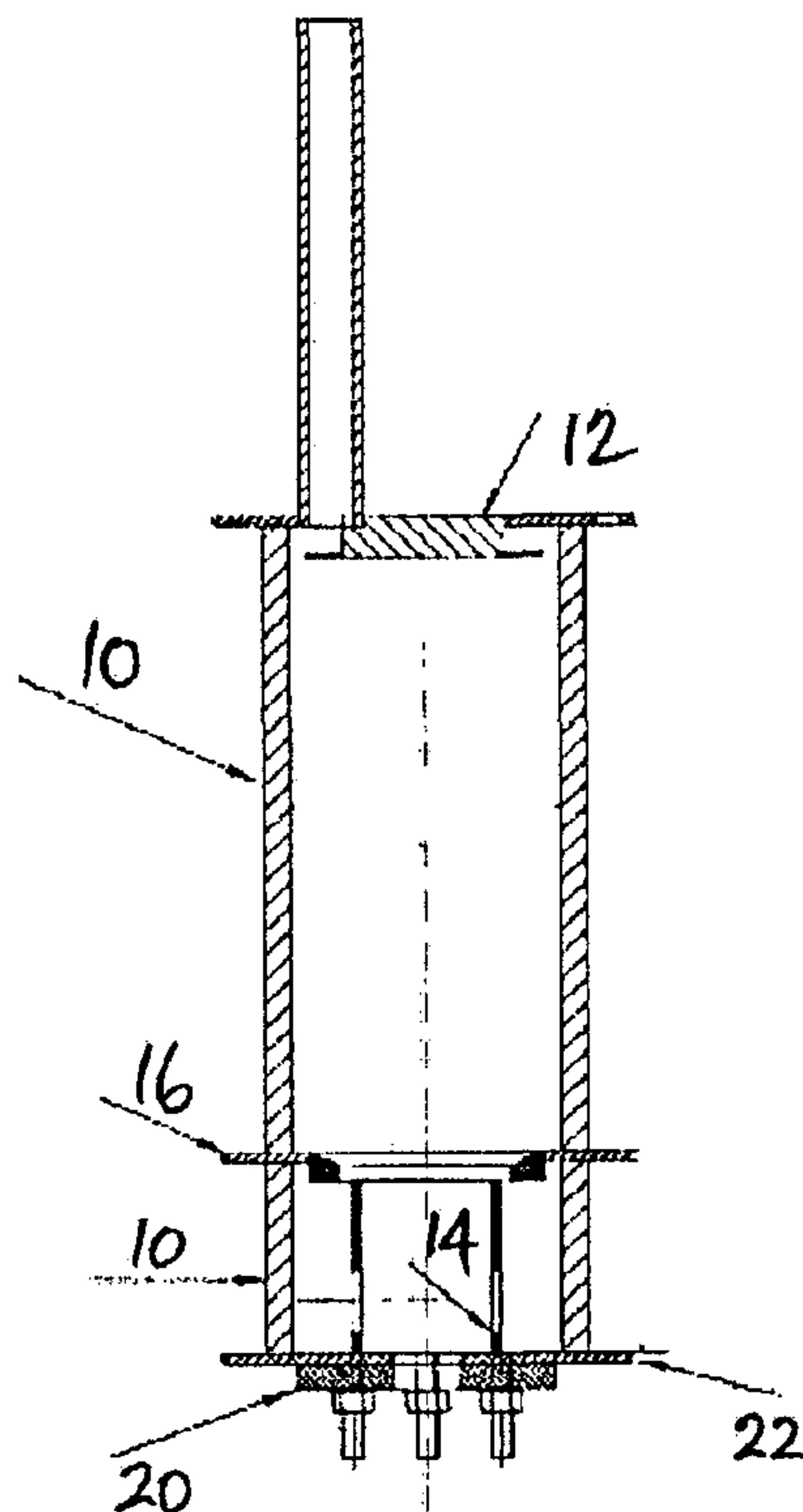
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(54) Title: HIGH ENERGY X-RAY TUBE



(57) Abrégé/Abstract:

A high energy X-ray tube has a cold cathode and anode in opposed relationship for the electron emission X-rays formed by the electron beam to travel directly to the cathode to produce further electron emission. The electron beam is collimated to be concentrated in a spot size on the anode with the result that the resulting X-rays are emitted at 180° to the direction in which the electrons are emitted. A Pierce-type electron gun design is used for the collimation.

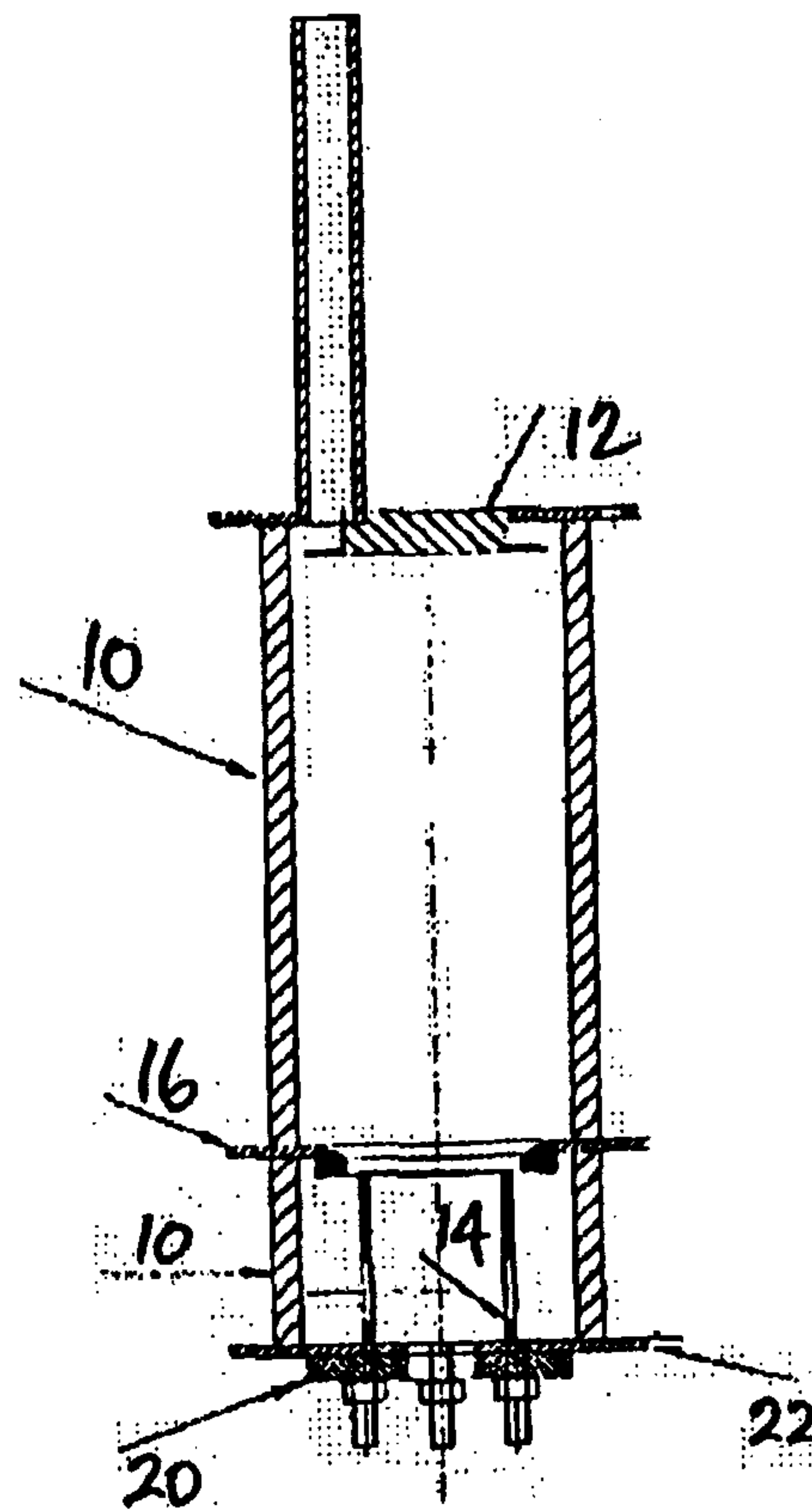
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(54) Title: HIGH ENERGY X-RAY TUBE**(57) Abstract**

A high energy X-ray tube has a cold cathode and anode in opposed relationship for the electron emission X-rays formed by the electron beam to travel directly to the cathode to produce further electron emission. The electron beam is collimated to be concentrated in a spot size on the anode with the result that the resulting X-rays are emitted at 180° to the direction in which the electrons are emitted. A Pierce-type electron gun design is used for the collimation.



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HIGH ENERGY X-RAY TUBE**TECHNICAL FIELD OF THE INVENTION**

This invention relates to a high energy x-ray tube.

BACKGROUND OF THE INVENTION

The conventional x-ray tube includes a target which is at an angle to the electrons emitted from the cathode and the characteristic spectrum of a sample is detected by a detector located in the path of the reflected energy.

The Applicant believes that the efficiency of this could be greatly improved as about 99% of the energy is lost as waste heat.

If it is desired to use high energy it is necessary to provide an ultra-high vacuum in the tube.

It is an object of the present invention to provide a high energy x-ray tube which does not require such high vacuum and which is far more efficient than conventional tubes in that ray scattering from the target is greatly reduced.

PRIOR ART

The closest prior art revealed during the International Search were the following:

US 5 768 337 Anderson describes a x-ray tube having a cathode 32 in face-to-face relationship with a first dynode 40; a second dynode 42 being concentric with and inside the cathode. Electrons from the first anode are directed to the electron-multiplying surface of the second anode and then accelerated to an anode 38 from which they are reflected as shown by reference 48. In the present invention there is no deflection but rather a return of the beam to the cathode for further electron emission.

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US 3 714 486 McCrary describes a x-ray tube in which the anode 15 is curved so that the x-ray beam from the cathode is not collimated as it is in the present invention. The needle 20 is not a Pierce-type electrode. A Pierce-type electrode is a ring electrode that focusses electrons to produce a cylindrical electron beam shape. Thus, the Pierce-type electrode produces a spot size as opposed to the random shape of the beam of McCrary.

JP 60 047355 This describes an arrangement in which x-rays are radiated from the entire outer surface of the container body for uniform radiation. This is virtually the opposite aim having regard to the present invention which has as its object, a collimated beam.

DISCLOSURE OF THE INVENTION

According to the invention a high energy x-ray tube comprising a cold cathode and an anode located in opposed relationship, characterised in that the electron beam is collimated with the assistance of a Pierce-type planar electron gun and concentrated in particular spot size of the produced x-ray beam on the anode so that the resulting x-rays are emitted at 180 degrees to the direction in which the electrons are emitted, the cathode including a window for transmission of the x-rays produced.

The electron beam is preferably collimated so that it is concentrated in a predetermined pattern, for example in a particular spot size of the produced X-ray beam on the anode, the resulting x-rays being thereby emitted at 180° to the direction in which the electrons are emitted.

In a preferred form of the invention the collimation is achieved by means of a Pierce-type electron gun design. When dealing with high electron densities a space charge effect is established which will detract from the efficacy of the X-ray tube of the present invention which relies on the production of an electron flow effect such as the one found in an idealised diode. Pierce's theory of electron beam design comprises the insertion of a unipotential electrode, called the beam forming or focusing electrode which causes fields outside the electron beam to be formed to satisfy the proper boundary conditions in other

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words the electrons still behave as though they were flowing in a complete diode - that is, they pursue rectilinear trajectories.

As far as the Applicant is aware, such an electron gun arrangement has not been used in X-ray tubes, nor in conjunction with a cold cathode. A further discussion of this aspect of the invention will be found in the description of the embodiment of the invention below.

In a preferred form of the invention the cathode includes a window for transmission of the x-rays produced.

The geometry of the tube is arranged to prevent arcing across the vacuum or across the material of the tube and the electrodes, and at the same time to achieve optimum focusing of the emitted electrons so that they can strike the anode surface at a right angle and hence produce x-rays whose maximum intensity is orientated at 180° to the electron beam.

The cathode may be a cold photocathode made from earth alkali oxides on a metallic base, for example Ni-based MgO due to the fact that a self-sustained electron emission from cold magnesium oxide films applied to a metal sleeve or mesh can be achieved by applying a minimum of 300V to the anode. A positive charge is developed on the magnesium oxide layer producing a high electrical field of the order of 54 kV/cm inside the layer. Electrons which are liberated in the magnesium oxide coating are multiplied by an avalanche effect to gain sufficient energy to leave the surface. This emission current can be controlled by varying the voltage of the anode and/or of the ring electrode so that currents of several tens of milliamperes can be achieved over a period of several thousand hours without any decrease in emission.

The cathode may comprise a thin and porous magnesium oxide layer which is applied to the nickel mesh.

The tube may be of joined ceramic and metal or glass and metal.

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BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention is described below with reference to the accompanying drawings, in which

Figure 1 is a sectional side view of an X-ray tube according to the invention;

Figure 2 is a diagrammatic representation of a Pierce-type planar electron gun adapted for use for the X-ray tube of the invention;

And

Figure 3 is a graph of the equipotential lines external to the planar space charge limited electron beam at differing distances from the edge of the beam and from the cathode.

DESCRIPTION OF MODES OF THE INVENTION

In Figure 1 a ceramic sleeve 10 encloses an anode 12 and a cathode indicated by reference 14. A focusing lens 16 for the X-rays emitted by the anode is located above the cathode. An X-ray window 20 and a cathode and X-ray window structure 22 are also provided at the base of the tube. The cathode is made from an alkaline earth oxide on a metallic base, such as magnesium oxide on a nickel base. The anode may be W-Cu and is parallel with the cathode.

In general, the operation of the tube relies on the establishment of an electron path, which strike the anode at right angles. Some of the X-rays pass through the window 20 for analyses while those that do not pass through the window strike the cathode and cause further electrons to be emitted therefrom.

As indicated above a Pierce-type electron gun arrangement is provided and this is illustrated in Figure 2 where the cathode 30 is surrounded by a focusing electrode 32 which diverts random electrons back to the desired electron path between cathode and anode 34.

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CLAIMS:

1. A high energy x-ray tube comprising a cold cathode and an anode located in opposed relationship, characterised in that the electron beam is collimated with the assistance of a Pierce-type planar electron gun and concentrated in particular spot size of the produced x-ray beam on the anode so that the resulting x-rays are emitted at 180 degrees to the direction in which the electrons are emitted, such x-rays causing further electron emission from the cold cathode significantly to contribute to the operation of the x-ray source, the cathode including a window for transmission of the x-rays produced.
2. The x-ray tube according to any of the above claims characterised in that the geometry of the tube is arranged to prevent arcing across the vacuum or across the material of the tube and the electrodes, and at the same time to achieve optimum focusing of the emitted electrons so that they can strike the anode surface at a right angle and hence produce x-rays orientated at 180° to the electron beam.
3. The x-ray tube according to any of the above claims characterised in that the cathode is a cold photo cathode made from a metal-based alkaline earth oxide.
4. The x-ray tube according to claim 3 characterised in that the cathode comprises a thin and porous magnesium oxide layer applied to a nickel mesh.
5. The x-ray tube according to any of the above claims characterised in that the tube is of joined ceramic and metal or glass and metal.

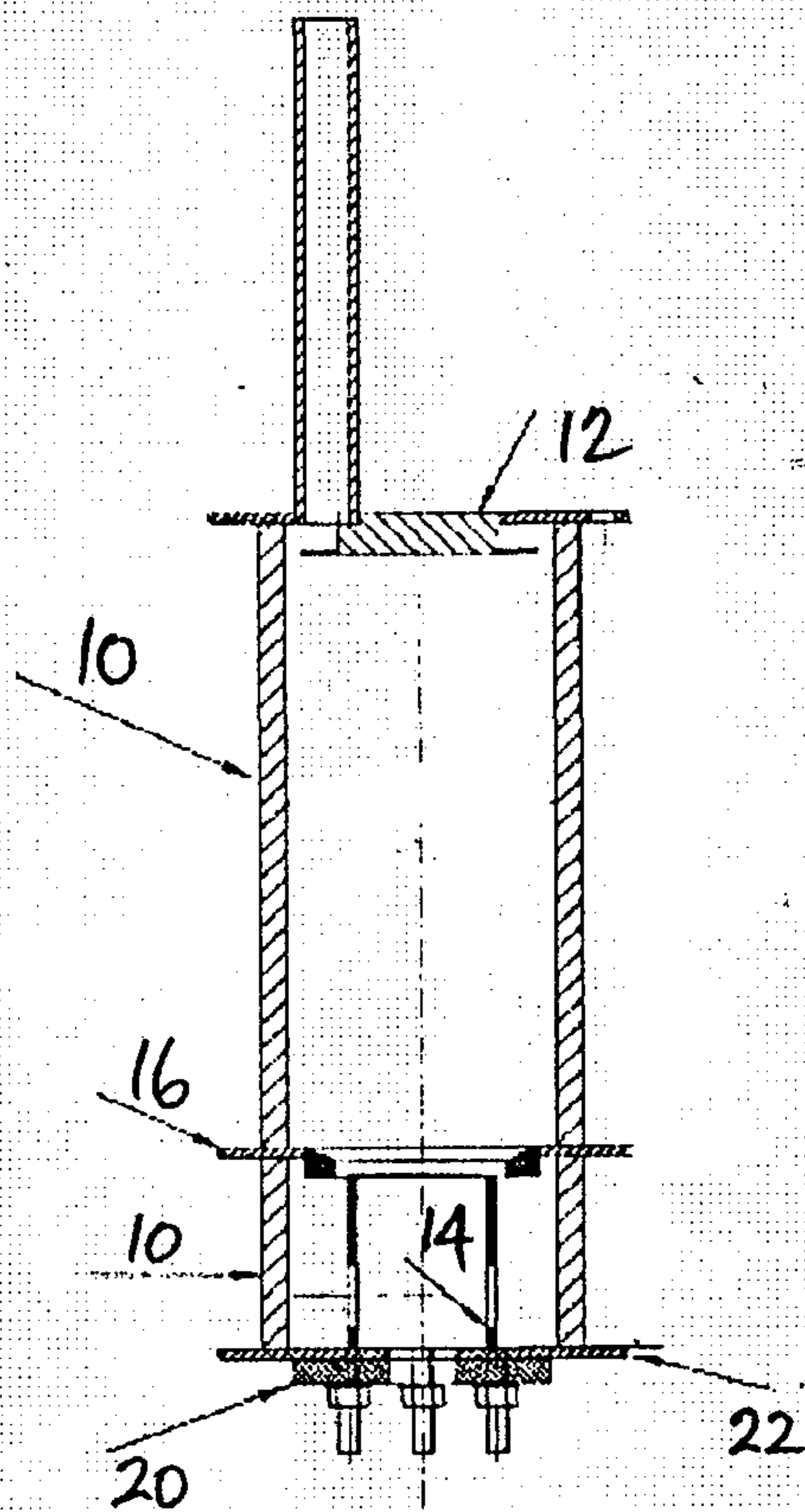


FIG 1

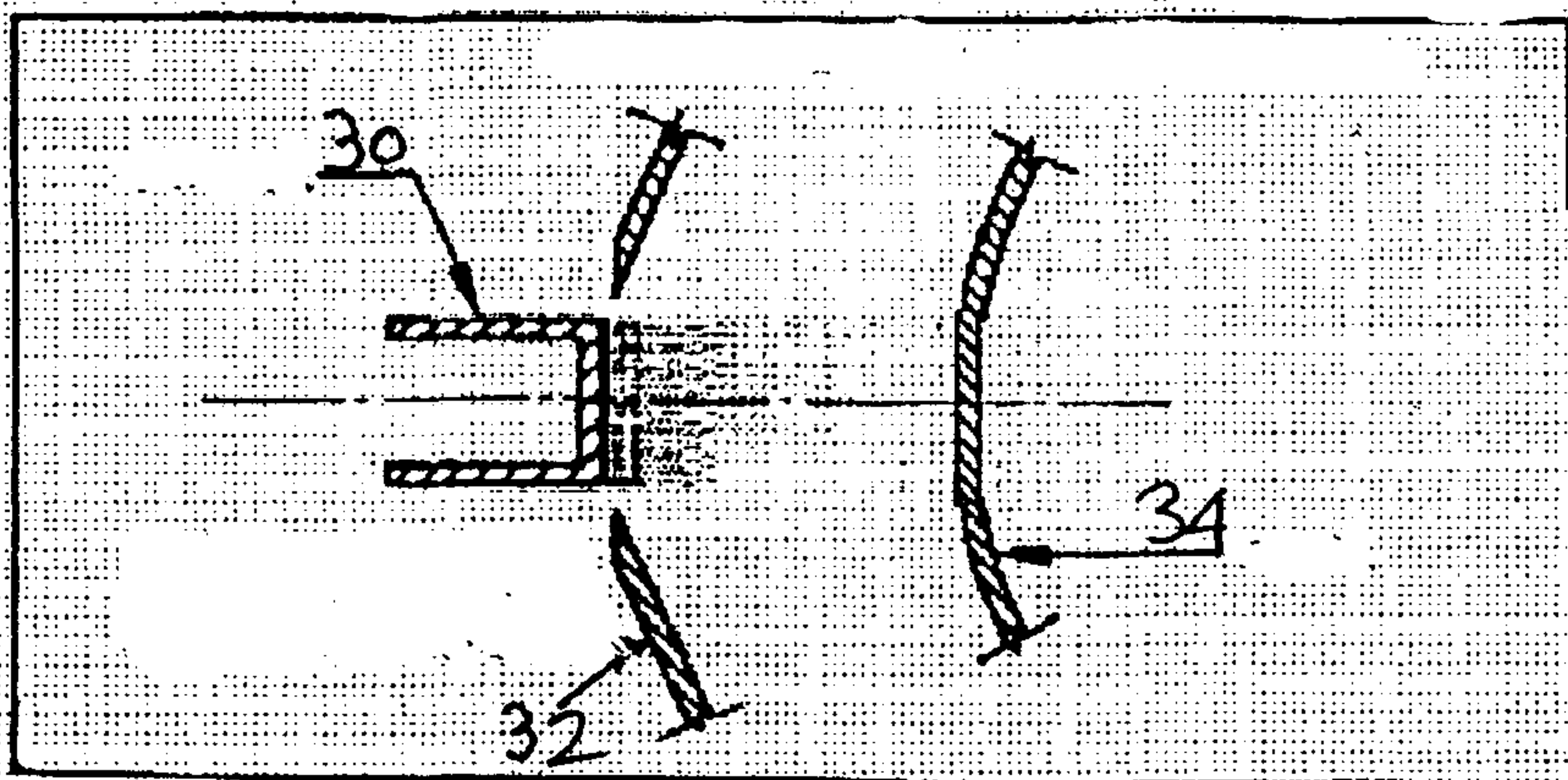


Fig 2

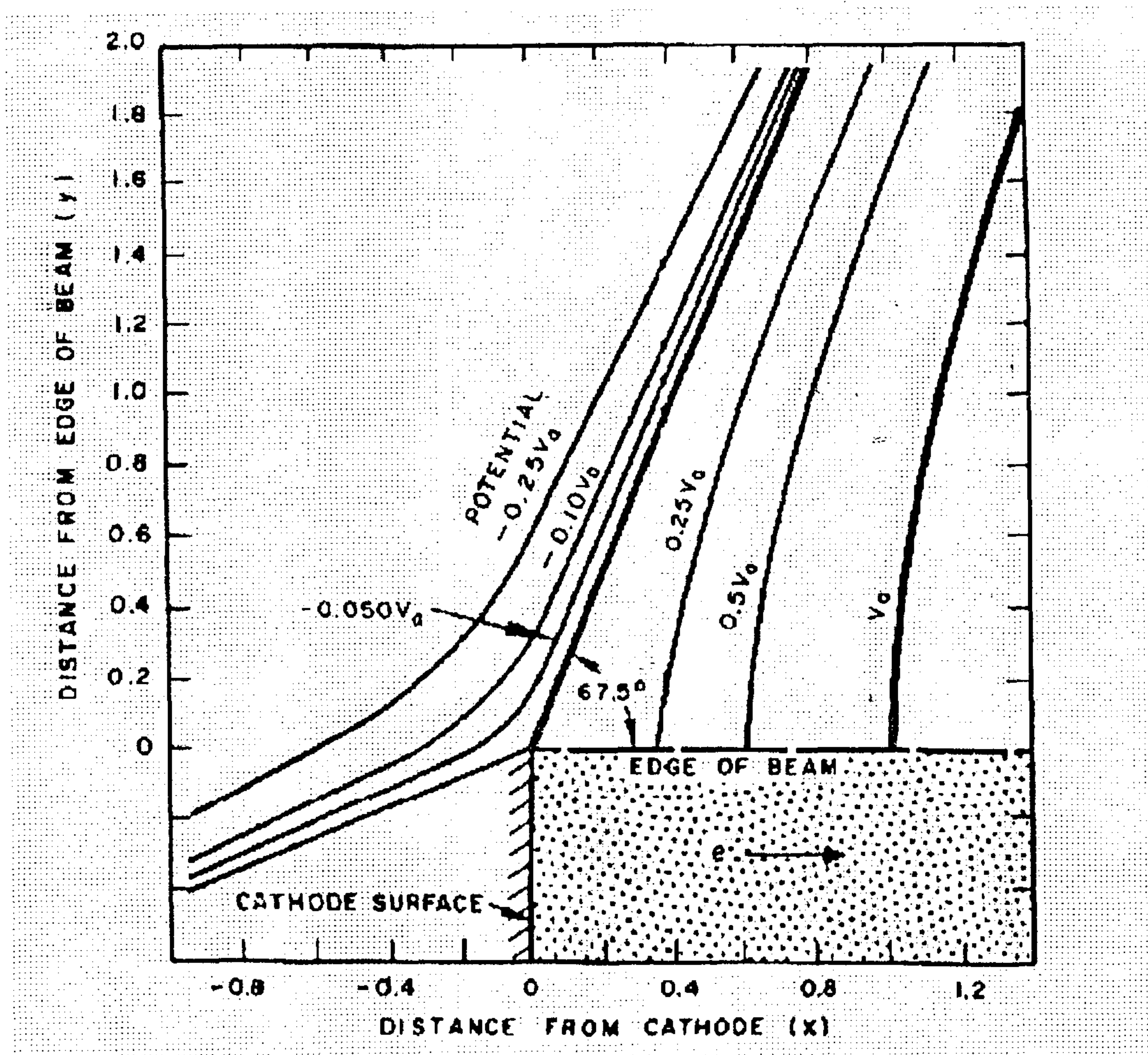


Fig.2;

