(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 768 699 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
19.06.2002 Bulletin 2002/25

(51) Int Cl.7: **H01J 35/16**

(21) Application number: **96307066.9**

(22) Date of filing: **27.09.1996**

(54) X-ray tube and barrier means therefor

Röntgenröhre und Barrierevorrichtung dafür

Tube à rayons X et élément barrière associé

(84) Designated Contracting States:
DE GB

(30) Priority: **27.09.1995 GB 9519715**

(43) Date of publication of application:
16.04.1997 Bulletin 1997/16

(73) Proprietor: **Kevex X-Ray Inc.**
Scotts Valley, CA 95066 (US)

(72) Inventor: **Enck,Richard Stark**
San Jose, California 95128 (US)

(74) Representative:
Cross, Rupert Edward Blount et al
BOULT WADE TENNANT,
Verulam Gardens
70 Gray's Inn Road
London WC1X 8BT (GB)

(56) References cited:
EP-A- 0 319 244
WO-A-92/03837
US-A- 2 665 391
US-A- 4 468 802

- **NEUES AUS DER TECHNIK, no. 3, 15 September 1989, page 4 XP000071660 "RONTGENROHRE MIT BERYLLIUMFENSTER"**
- **PATENT ABSTRACTS OF JAPAN vol. 009, no. 251 (E-348), 8 October 1985 & JP 60 101848 A (HITACHI SEISAKUSHO KK), 5 June 1985,**

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to an X-ray tube and barrier means and more specifically to an X-ray tube capable of generating high intensity X-rays without loss of reliability.

[0002] X-ray tubes normally include an electron gun and an anode. A beam of electrons generated by the electron gun is focused to a focal spot on the anode and X-rays are generated by the interaction of the beam of electrons with the atoms of the anode. These X-rays are generated in all directions from the anode in the region surrounding the focal spot. Typically, the anode is substantially surrounded by an evacuated housing in which a window is formed to allow some of the X-rays to pass out of the housing, the window typically comprising a thin foil of a low atomic number metal, such as beryllium or aluminium, having a high transmission coefficient for X-radiation.

[0003] X-ray tubes have a number of applications which involve the treatment or analysis of a sample, for example: industrial imaging, analytical instruments and medical imaging. For such applications it is often desirable to have an X-ray tube which has a long service life, which is capable of forming a small focal spot and which is also capable of generating a high intensity of X-radiation at the sample.

[0004] Increasing the current due to the beam of electrons (the beam current) is an effective method of increasing the power output of an X-ray tube and can also increase the intensity of X-rays at the sample. However, since only a small fraction of the energy of the beam of electrons is converted to X-rays, the majority of electrons are either scattered by the anode or lose their energy to heat in the anode. This generation of heat within the anode can cause the anode to melt, preventing the further use of the X-ray tube without repair.

[0005] There are many factors which can influence the maximum beam current that can be used without melting the anode. For example, the anode material should be chosen to have a high melting point and a high thermal conductivity. However, in order to improve the efficiency of X-ray generation, the anode may be made of a metal of high atomic number. In order to meet this dual requirement the anode is commonly comprised of copper (which has a high thermal conductivity) coated with a layer of tungsten (which has a high atomic number and a high melting point). Enlarging the focal spot, say by reducing the angle α at which the electrons are incident upon the anode, can increase the maximum beam current by enhancing heat dissipation. However, increasing the size of the focal spot can adversely affect the resolution achievable for imaging applications, and decreasing α can result in an increase in the generation of scattered electrons. The problems of scattered electrons and resolution are both discussed below.

[0006] In addition, the anode may be kept cool by rotating it so that the position of the focal spot on the anode is continually changed as the anode rotates. Such rotating anodes have a greater ability to dissipate heat energy than fixed anodes. Finally, anodes are usually cooled by passing a fluid, such as water or oil, through the anode to transport the heat away from the anode.

[0007] A second method of increasing the intensity of the X-rays at the sample is to decrease distance from the focal spot to the window (the exit distance). This is because a small exit distance allows the sample to be positioned closer to the focal spot. Optimising the exit distance, and hence the proximity of the sample to the focal spot, can also improve magnification for the imaging applications mentioned above. Unfortunately, decreasing the exit distance can also increase the number of scattered electrons which are incident upon the window, thus causing heating of the window. Furthermore, decreasing the exit distance exacerbates the effect on the window of heat radiated from the anode. Heating of the window can be a significant source of poor reliability, particularly if the window is comprised of beryllium. Beryllium has a low heat capacity and has a low thermal conductivity so that significant temperature gradients can be formed across a beryllium window which may cause the window to rupture.

[0008] A number of solutions have been adopted to the problem of window heating due to scattered electrons. One approach has been to employ a magnetic field in the region between the anode and the window in order to deflect electrons away from the window. The use of such a magnetic field is described in US 5206895 (equivalent to WO 92/03837). Negatively biasing a metallic mesh placed between the anode and the window can also result in the electrons being deflected away from the window. Such an arrangement is disclosed in "An introduction to X-ray Spectrometry", pp 57 -58 by Ron Jenkins. The use of magnetic or electric fields to deflect electrons away from the window limits the minium value of exit distance that can be employed. If a weak electric or magnetic field is used then the exit distance must be large so that the path of the electrons is sufficiently deflected to prevent damage to the window. If a strong electric or magnetic field is used then the exit distance must also be large to prevent interference with the beam of electrons which are incident upon the anode. The use of magnets or biased electrodes also occupies space between the anode and the window, preventing the exit distance from being reduced. Furthermore the use of an electrode to which a potential is applied will require the provision of insulators and feed throughs, thus increasing complexity. US-A-4468802 discloses a metallic shield between the anode of an X-ray tube and the window of the tube, where the shield is held at a potential which is lower than the anode potential.

[0009] X-rays generated by the electron beam are emitted from the anode in all directions, but usually only X-rays having a limited range of take-off angles β (the angle between an X-ray and the surface of the anode) are used to illuminate the sample under test. The selection of values of β for X-rays used in the treatment or analysis of an object, can be as important as the choice of α. For example the use of X-rays having small values of β can improve resolution for imaging applications, and can also reduce the formation of undesirable penumbra for X-ray lithographic applications. Furthermore X-rays emitted at small values of β can have a higher intensity than those emitted at large values of β though this effect can be offset by absorption in the anode.

[0010] As we have seen, therefore, the parameters of an X-ray tube are interrelated and optimising one parameter may lead to the worsening of another. For example, the use of X-rays having small take-off angles β can improve resolution, but can also lead to a loss of intensity due to absorption by the anode. Also, the use of small α is advantageous in some ways, but can lead to rapid degradation of the window. Furthermore, attempts to optimise α such as those suggested in US 5206895, may lead to an increase in the exit distance and hence to loss of intensity.

[0011] It is an object of the present invention to provide an X-ray tube in which the above mentioned disadvantages are reduced. Particularly it is an object of the present invention to provide an X-ray tube which is capable of generating high intensity X-rays without loss of reliability.

[0012] According to a first aspect of the present invention there is provided an X-ray tube as disclosed in claim 1 comprising:

means for generating a beam of electrons;
an anode, said beam of electrons being focused to be incident upon a focal spot on the anode, said incident beam of electrons impinging upon the anode at an incident angle α substantially between 0° and 25° relative to the anode surface, X-rays and scattered electrons being generated at the anode by said incident beam of electrons; and
a housing which substantially encloses the anode, said housing having a window formed in it through which X-rays may pass,
said X-ray tube is provided with a barrier means in electrical contact with said anode disposed between the focal spot and the window, so that scattered electrons are prevented from reaching the window by the barrier means, at least a portion of said barrier means comprising one or more X-ray permeable wall sections, said X-ray permeable wall sections allowing X-rays to pass through the barrier means towards the window.

[0013] Preferably, said barrier means further includes at least one X-ray impermeable wall section, at least one exit aperture being formed in said X-ray impermeable wall section or sections, the or each said exit aperture being closed by said X-ray permeable wall section or sections.

[0014] Advantageously, the or each said X-ray permeable wall section is made from a material having a high melting point and a high transmission coefficient for X-rays. Preferably said material also has a high thermal conductivity. Further preferably, the said material is diamond.

[0015] Preferably the dimensions and position of the or each said exit aperture are such that only X-rays having take-off angles substantially in the range 0° to 30° relative to the anode surface are able to pass through the or each said exit aperture. Further preferably the dimensions and position of the or each said exit aperture are such that only X-rays having take-off angles substantially in the range 0° to 20° relative to the anode surface are able to pass through the or each said exit aperture.

[0016] Advantageously, the or each said X-ray impermeable wall section comprises a material having a high thermal conductivity. Preferably the or each said X-ray impermeable wall section comprises a material having a high electrical conductivity and/or a high thermal conductivity. Further preferably the or each said X-ray impermeable wall section is formed of copper.

[0017] Advantageously, the incident angle α is substantially between 5° and 15°. Further advantageously, the incident angle α is substantially between 7° and 13°.

[0018] Preferably, the largest dimension of the focal spot is substantially between 1 μm and 100 μm. Further preferably said largest dimension is between 1 μm and 25 μm.

[0019] Typically the window comprises a thin sheet of beryllium foil. Conveniently the distance from the focal spot to the window is in the range 2 to 8 mm.

[0020] According to another aspect as disclosed in claim 16, the invention provides a barrier means for preventing scattered electrons from reaching a window of an X-ray tube, wherein the barrier means is in electrical contact with said anode and comprises:

an X-ray impermeable wall section; and
at least one X-ray permeable wall section for allowing X-rays to pass through said barrier means towards said window, said X-ray impermeable and permeable wall sections being impermeable to electrons.

[0021] An example of the invention will now be described in greater detail with reference to the accompanying drawings, which are provided by means of example only and in which:

Figure 1 is a schematic diagram of an X-ray tube according to the invention; and
Figure 2 is a more detailed diagram of part of the X-ray tube shown in Figure 1.

[0022] Figure 1 illustrates an X-ray tube generally indicated by 7 comprising an anode 8 and a means for generating a beam of electrons, said means comprising an electron gun 1 which is of standard design. The electron gun 1 and the anode 8 are both disposed inside an evacuated housing comprising an end plate 14, a ceramic tube 2, a first weld flange 17, a second weld flange 4, an anode tube 11 and a window assembly 10. The pressure within the evacuated housing is less than 1.333 x 10^{-4} Pa (10^{-6} torr). The electron gun 1 is provided with electrical connectors 5 for the supply of power to the electron gun 1. The electron gun 1 protrudes from and is hermetically sealed to the end plate 14. The end plate 14 is welded to the first weld flange 17 which is in turn brazed to the ceramic tube 2. The ceramic tube 2 is brazed to the second weld flange 4. The ceramic tube 2 insulates the first weld flange 17 from the second weld flange 4, so that the second weld flange 4 can be maintained at ground potential and the first weld flange 17 can be maintained at -50 kV. A stainless steel tube 3 is welded to the second weld flange 4 so that the stainless steel tube 3 is at ground potential.

[0023] One end of the anode tube 11 is formed into a flange 32 which is welded to and is in electrical contact with the second weld flange 4. Anode 8 is brazed to and in electrical contact with the inside of the anode tube 11, so that both the anode tube 11 and anode 8 are at ground potential. The anode 8 is comprised of copper and the anode tube 11 is comprised of stainless steel. The anode 8 is cooled by passing water through a cavity 16 (shown in figure 2 only) formed in the anode tube 11. The water passes into the cavity 16 through an inlet tube 19 which is welded to the anode tube 11. Baffles (not shown) within the cavity 16 restrict the flow of the water so that the water is forced into contact with the anode 8. After flowing against the anode 8 the water passes out of the anode tube 11 through an outlet tube 13 which is welded to the anode tube 11.

[0024] A beam of electrons 6, which is generated by the electron gun 1, has a potential of -50 kV relative to ground on exiting the electron gun 1. The beam current can have a range of values: from a few microamps up to ten milliamps. The beam of electrons 6 is accelerated towards the second weld flange 4 by the potential difference between the weld flange 4 and the electron gun 1, and passes through the entrance aperture 18. The beam of electrons 6 is deflected by a magnetic deflection coil 12 so that it impinges upon the anode 8 an incident angle α (shown in figure 2) of approximately 10°. The beam of electrons 6 forms a focal spot 24 on the anode 8. The anode 8 is coated with a layer of tungsten (not shown) in the area surrounding the focal spot 24 to form a suitable surface from which X-rays 9 may be generated. The X-rays 9 are generated in all directions from the anode 8 in the region surrounding the focal spot 24. The beam of electrons 6 has diameter of approximately 5 μm, but the small incident angle α results in the largest dimension of the focal spot 24 being approximately 25 μm. The focal spot 24 has a larger area than would be the case for a large incident angle and thus the heat generated per unit area is reduced. Those X-rays 9 which have appropriate take-off angles pass through the window assembly 10 shown in more detail in figure 2.

[0025] Figure 2 shows a more detailed representation of the X-ray tube 7 in the region which surrounds the anode 8. An opaque wall portion comprising a copper plate 15, is brazed to and is in electric contact with the anode 8. An exit aperture 34, which is formed in the copper plate 15, is closed by an X-ray permeable wall portion comprising a diamond sheet 20. The diamond sheet 20 is held in place by a retaining ring 21. X-rays 9, which have appropriate take-off angles, pass through the diamond sheet 20 before being transmitted to the exterior of the X-ray tube 7 by a window 31. The spacing between the diamond sheet 20 and the window 31 is approximately 1.5 mm and the spacing between the diamond sheet 20 and the focal spot 24 is approximately 1.5 mm. The window 31 comprises a sheet of beryllium which is brazed to both an upper ring 25 and a lower ring 26, the lower ring 26 having a ring flange 33. The ring flange 33 is welded to a tube flange 28 which is formed from a short section of metal tube 29. The window 31 is mounted on the anode tube 11, which includes an outer tube 23 and an inner tube 22, by inserting the metal tube 29 inside the outer tube 23. A vacuum tight seal is achieved by welding the tube flange 28 to a flange 27 formed from the outer tube 23. The metal tube 29, inner tube 22 and the outer tube 23 are all comprised of stainless steel. The upper ring 25 and lower ring 26 are comprised of Monel (a nickel alloy).

[0026] Figure 2 shows the incident angle α at which the electron beam 6 is incident upon the anode 8 and also shows a take-off angle β at which one of the X-rays 9 is emitted from the anode 8. Those X-rays 9 which are emitted by the X-ray tube 7 have values of β limited by the position and dimensions of the aperture 34 to the approximate range 0° to 20°. The position and dimensions of the aperture 34 enables the use of the X-ray tube 7 for imaging applications in which a high resolution and high X-ray flux is required. The high resolution is achievable because the apparent size of the focal spot 24, when viewed through the exit aperture 34, is much smaller than its real size. Viewed through the centre of the exit aperture 34, the length and width of the focal spot 24 appear to be approximately equal. The interaction of the beam of electrons 6 with the anode 8 results in the formation of scattered electrons (not shown) which are ejected from the anode 8 in a range of directions. The small value of α results in large numbers of scattered electrons being directed towards the window 31. If the diamond sheet 20 were not present, the window 31 would be subject to severe heating as a result of collisions from the scattered electrons. Scattered electrons are also prevented from reaching the window 31 by the copper plate 15. Because the copper plate 15 has a low transmission coefficient for X-rays, unwanted X-rays having values of β greater than 20° are prevented from exiting the window 31.

[0027] The barrier means, which comprises the diamond sheet 20 and copper plate 15, prevents scattered electrons from colliding with the window 31 while allowing some of the X-rays 9 to pass from the anode 8 to the window 31. Diamond has a high melting temperature and thus the diamond sheet 20 is able to withstand the heat generated by impact with the scattered electrons. Diamond and copper are both good thermal conductors, so that heat is conducted away from the window 31 thus preventing damage to the window 31 by radiated heat. The use of the barrier means in conjunction with a small incident angle α results in an X-ray tube 7 which is capable of increased power output without loss of reliability.

Claims

1. An X-ray tube (7) comprising:

means (1) for generating a beam of electrons (6);
an anode (8), said beam of electrons (6) being focused to be incident upon a focal spot (24) on the anode (8), said incident beam of electrons (6) impinging upon the anode (8) at an incident angle α substantially between 0° and 25° relative to the anode surface, X-rays (9) and scattered electrons being generated at the anode (8) by said incident beam of electrons (6); and a housing which substantially encloses the anode (8), said housing having a window (31) formed in it through which X-rays (9) may pass, **characterized in that**:
said X-ray tube (7) is provided with a barrier means in electrical contact with said anode disposed between the focal spot (24) and the window (31), so that scattered electrons are prevented from reaching the window (31) by the barrier means, at least a portion of said barrier means comprising one or more X-ray permeable wall sections (20), said X-ray permeable wall sections (20) allowing X-rays (9) to pass through the barrier means towards the window (31).

2. An X-ray tube as claimed in claim 1, wherein said barrier means further includes at least one X-ray impermeable wall section (15), at least one exit aperture (34) being formed in said X-ray impermeable wall section (15) or sections, the or each said exit aperture (34) being closed by said X-ray permeable wall section (20) or sections.

3. An X-ray tube as claimed in claim 1 or 2, wherein the or each said X-ray permeable wall section (20) is made from a material having a high melting point and a high transmission coefficient for X-rays.

4. An X-ray tube as claimed in any preceding claim, wherein the or each X-ray permeable wall section (20) has a high thermal conductivity.

5. An X-ray tube as claimed in any preceding claim, wherein said X-ray permeable wall section (20) is made from diamond.

6. An X-ray tube as claimed in claim 2 or any of claims 3-5 when dependent on claim 2, wherein the dimensions and position of the or each said exit aperture (34) are such that only X-rays having take-off angles β substantially in the range 0° to 30° relative to the anode surface are able to pass through the or each said exit aperture (34).

7. An X-ray tube as claimed in claim 2 or any of claims 3-5 when dependent on claim 2, wherein the dimensions and position of the or each said exit aperture (34) are such that only X-rays having take-off angles β substantially in the range 0° to 20° relative to the anode surface are able to pass through the or each said exit aperture (34).

8. An X-ray tube as claimed in claim 2 or any of claims 3-7 when dependent on claim 2, wherein the or each said X-ray impermeable wall section (15) comprises a material having a high thermal conductivity.

9. An X-ray tube as claimed in claim 2 or any of claims 3-8 when dependent on claim 2, wherein the or each said X-ray impermeable wall section (15) comprises a material having a high electrical conductivity.

10. An X-ray tube as claimed in claim 2 or any of claims 3-9 when dependent on claim 2, wherein the or each said X-ray impermeable wall section (15) is formed of copper.

11. An X-ray tube as claimed in any previous claim, wherein the incident angle α is substantially between 5° and 15°

12. An X-ray tube as claimed in any of claims 1 to 10, wherein the incident angle α is substantially between 7° and 13°.

13. An X-ray tube as claimed in any previous claim; wherein the largest dimension of the focal spot (24) is substantially between 1 μm and 100 μm.

14. An X-ray tube as claimed in any of claims 1 to 12, wherein the largest dimension of the focal spot (24) is substantially between 1 μm and 25 μm.

15. An X-ray tube as claimed in any previous claim, wherein the distance from the focal spot (24) to the window (31) is substantially in the range 2 to 8 mm.

Patentansprüche

1. Röntgenröhre (7) umfassend:

   Mittel (1) zum Erzeugen eines Elektronenstrahls (6);
   eine Anode (8), wobei der Elektronenstrahl (6) so fokussiert ist, dass er auf einen Brennpunkt (24) auf der Anode (8) auftrifft, wobei der auftreffende Elektronenstrahl (6) unter einem Auftreffwinkel α, der im Wesentlichen zwischen 0° und 25° in Bezug zu der Anodenoberfläche liegt, auf die Anode (8) auftrifft, wobei durch den auftreffenden Elektronenstrahl (6) Röntgenstrahlen (9) und gestreute Elektronen an der Anode (8) erzeugt werden; und
   ein Gehäuse, das im Wesentlichen die Anode (8) einschließt,
   wobei das Gehäuse ein darin ausgebildetes Fenster (31) aufweist, welches für Röntgenstrahlen durchdringbar ist,

   dadurch gekennzeichnet, dass die Röntgenröhre (7) mit einem mit der Anode in elektrischem Kontakt stehenden Barrieremittel versehen ist, das zwischen dem Brennpunkt (24) und dem Fenster (31) angeordnet ist, so dass gestreute Elektronen durch das Barrieremittel daran gehindert werden, das Fenster (31) zu erreichen, wobei wenigstens ein Abschnitt des Barrieremittels einen oder mehrere Röntgenstrahlen-durchlässige Wandabschnitte (20) umfasst, wobei die Röntgenstrahlen-durchlässigen Wandabschnitte (20) es erlauben, dass Röntgenstrahlen (9) durch das Barrieremittel in Richtung des Fensters (31) durchdringen.

2. Röntgenröhre nach Anspruch 1, wobei das Barrieremittel ferner wenigstens einen Röntgenstrahlen-undurchlässigen Wandabschnitt (15) umfasst sowie wenigstens eine Ausgangsöffnung (34), die in dem Röntgenstrahlen-undurchlässigen Wandabschnitt (15) bzw. den Röntgenstrahlen-undurchlässigen Wandabschnitten ausgebildet ist, wobei die bzw. jede Ausgangsöffnung (34) durch den Röntgenstrahlen-durchlässigen Wandabschnitt (20) bzw. die Röntgenstrahlen-durchlässigen Wandabschnitte verschlossen ist bzw. sind.

3. Röntgenröhre nach Anspruch 1 oder 2, wobei der bzw. jeder Röntgenstrahlen-durchlässige Wandabschnitt (20) aus einem Material, das einen hohen Schmelzpunkt und einen hohen Röntgenstrahlungstransmissionskoeffizient aufweist, hergestellt ist.

4. Röntgenröhre nach einem der vorhergehenden Ansprüche, wobei der bzw. jeder Röntgenstrahlen-durchlässige Wandabschnitt (20) eine hohe Wärmeleitfähigkeit aufweist.

5. Röntgenröhre nach einem der vorhergehenden Ansprüche, wobei der Röntgenstrahlen-durchlässige Wandabschnitt (20) aus Diamant hergestellt ist.

6. Röntgenröhre nach Anspruch 2 oder einem der Ansprüche 3 bis 5, sofern diese von Anspruch 2 abhängen, wobei die Dimensionen und Position der bzw. jeder Ausgangsöffnung (34) so sind, dass nur solche Röntgenstrahlen, die Abstrahlwinkel β im Wesentlichen in dem Bereich zwischen 0° und 30° in Bezug zu der Anodenoberfläche aufweisen, durch die bzw. jede Ausgangsöffnung (34) durchdringen können.

7. Röntgenröhre nach Anspruch 2 oder einem der Ansprüche 3 bis 5, sofern diese von Anspruch 2 abhängen, wobei die Dimensionen und Position der bzw. jeder Ausgangsöffnung (34) so sind, dass nur Röntgenstrahlen, die Abstrahlwinkel β im Wesentlichen in dem Bereich zwischen 0° und 20° in Bezug zu der Anodenoberfläche aufweisen, durch die bzw. jede Ausgangsöffnung (34) durchdringen können.

8. Röntgenröhre nach Anspruch 2 oder einem der Ansprüche 3 bis 7, sofern diese von Anspruch 2 abhängen, wobei der bzw. jeder Röntgenstrahlen-undurchlässige Wandabschnitt (15) ein Material umfasst, das eine hohe Wärmeleitfähigkeit aufweist.

9. Röntgenröhre nach Anspruch 2 oder einem der Ansprüche 3 bis 8, sofern diese von Anspruch 2 abhängen, wobei der bzw. jeder Röntgenstrahlen-undurchlässige Wandabschnitt (15) ein Material umfasst, das eine hohe elektrische Leitfähigkeit aufweist.

10. Röntgenröhre nach Anspruch 2 oder einem der Ansprüche 3 bis 9, sofern diese von Anspruch 2 abhängen, wobei der bzw. jeder Röntgenstrahlen-undurchlässige Wandabschnitt (15) aus Kupfer gebildet ist.

11. Röntgenröhre nach einem der vorangehenden Ansprüche, wobei der Auftreffwinkel α im Wesentlichen zwischen 5° und 15° liegt.

12. Röntgenröhre nach einem der Ansprüche 1 bis 10, wobei der Auftreffwinkel α im Wesentlichen zwischen 7° und 13° liegt.

13. Röntgenröhre nach einem der vorangehenden Ansprüche, wobei die größte Dimension des Brennpunktes (24) im Wesentlichen zwischen 1 μm und

100 μm liegt.

14. Röntgenröhre nach einem der Ansprüche 1 bis 12, wobei die größte Dimension des Brennpunktes (24) im Wesentlichen zwischen 1 μm und 25 μm liegt.

15. Röntgenröhre nach einem der vorangehenden Ansprüche, wobei der Abstand zwischen dem Brennpunkt (24) und dem Fenster (31) im Wesentlichen in dem Bereich zwischen 2 und 8 mm liegt.

Revendications

1. Tube (7) à rayons X comportant :

un moyen (1) destiné à générer un faisceau d'électrons (6) ;
une anode (8), ledit faisceau d'électrons étant focalisé de façon à être incident sur un point focal (24) sur l'anode (8), ledit faisceau incident d'électrons (6) tombant sur l'anode (8) sous un angle d'incidence α sensiblement compris entre 0° et 25° par rapport à la surface de l'anode, des rayons X (9) et des électrons dispersés étant générés à l'anode (8) par ledit faisceau incident d'électrons (6) ; et
un boîtier qui renferme sensiblement l'anode (8), ledit boîtier ayant une fenêtre (31) formée dans celui-ci, à travers laquelle les rayons X (9) peuvent passer, **caractérisé en ce que** :

ledit tube (7) à rayons X est pourvu d'un moyen formant barrière en contact électrique avec ladite anode, disposé entre le point focal (24) et la fenêtre (31), afin que le moyen formant barrière empêche des électrons dispersés d'atteindre la fenêtre (31), au moins une partie dudit moyen formant barrière comportant une ou plusieurs sections de parois (20) perméables aux rayons X, lesdites sections de parois (20) perméables aux rayons X permettant à des rayons X (9) de passer à travers le moyen formant barrière vers la fenêtre (31).

2. Tube à rayons X selon la revendication 1, dans lequel ledit moyen formant barrière comprend en outre au moins une section de paroi (15) imperméable aux rayons X, au moins une ouverture de sortie (34) étant formée dans ladite section de paroi (15) ou lesdites sections de parois (15) imperméables aux rayons X, la ou chaque ouverture de sortie (34) étant fermée par ladite section ou lesdites sections (20) de parois perméables aux rayons X.

3. Tube à rayons X selon la revendication 1 ou 2, dans lequel la ou chaque section de paroi (20) perméable aux rayons X est formée d'une matière à haut point de fusion et à haut coefficient de transmission des rayons X.

4. Tube à rayons X selon l'une quelconque des revendications précédentes, dans lequel la ou chaque section de paroi (20) perméable aux rayons X présente une conductivité thermique élevée.

5. Tube à rayons X selon l'une quelconque des revendications précédentes, dans lequel ladite section de paroi (20) perméable aux rayons X est constituée de diamant.

6. Tube à rayons X selon la revendication 2 ou l'une quelconque des revendications 3 à 5 lorsqu'elle dépend de la revendication 2, dans lequel les dimensions et la position de la ou chaque ouverture de sortie (34) sont telles que seuls des rayons X ayant des angles de décollage β sensiblement compris dans la plage de 0° à 30° par rapport à la surface de l'anode peuvent passer à travers la ou chaque ouverture de sortie (34).

7. Tube à rayons X selon la revendication 2 ou l'une quelconque des revendications 3 à 5 lorsqu'elle dépend de la revendication 2, dans lequel les dimensions et la position de la ou chaque ouverture de sortie (34) sont telles que seuls des rayons X ayant des angles de décollage β sensiblement compris dans la plage de 0° à 20° par rapport à la surface de l'anode peuvent passer à travers la ou chaque ouverture de sortie (34).

8. Tube à rayons X selon la revendication 2 ou l'une quelconque des revendications 3 à 7 lorsqu'elle dépend de la revendication 2, dans lequel la ou chaque section de paroi (15) imperméable aux rayons X comprend une matière à haute conductivité thermique.

9. Tube à rayons X selon la revendication 2 ou l'une quelconque des revendications 3 à 8 lorsqu'elle dépend de la revendication 2, dans lequel la ou chaque section de paroi (15) imperméable aux rayons X comprend une matière à haute conductivité électrique.

10. Tube à rayons X selon la revendication 2 ou l'une quelconque des revendications 3 à 9 lorsqu'elle dépend de la revendication 2, dans lequel la ou chaque section de paroi (15) imperméable aux rayons X est formée de cuivre.

11. Tube à rayons X selon l'une quelconque des revendications précédentes, dans lequel l'angle d'incidence α est sensiblement compris entre 5° et 15°.

12. Tube à rayons X selon l'une quelconque des revendications 1 à 10, dans lequel l'angle d'incidence α est sensiblement compris entre 7° et 13°.

13. Tube à rayons X selon l'une quelconque des revendications précédentes, dans lequel la plus grande dimension du point focal (24) est sensiblement comprise entre 1 µm et 100 µm.

14. Tube à rayons X selon l'une quelconque des revendications 1 à 12, dans lequel la plus grande dimension du point focal (24) est sensiblement comprise entre 1 µm et 25 µm.

15. Tube à rayons X selon l'une quelconque des revendications précédentes, dans lequel la distance du point focal (24) à la fenêtre (31) est sensiblement comprise dans la plage de 2 à 8 mm.

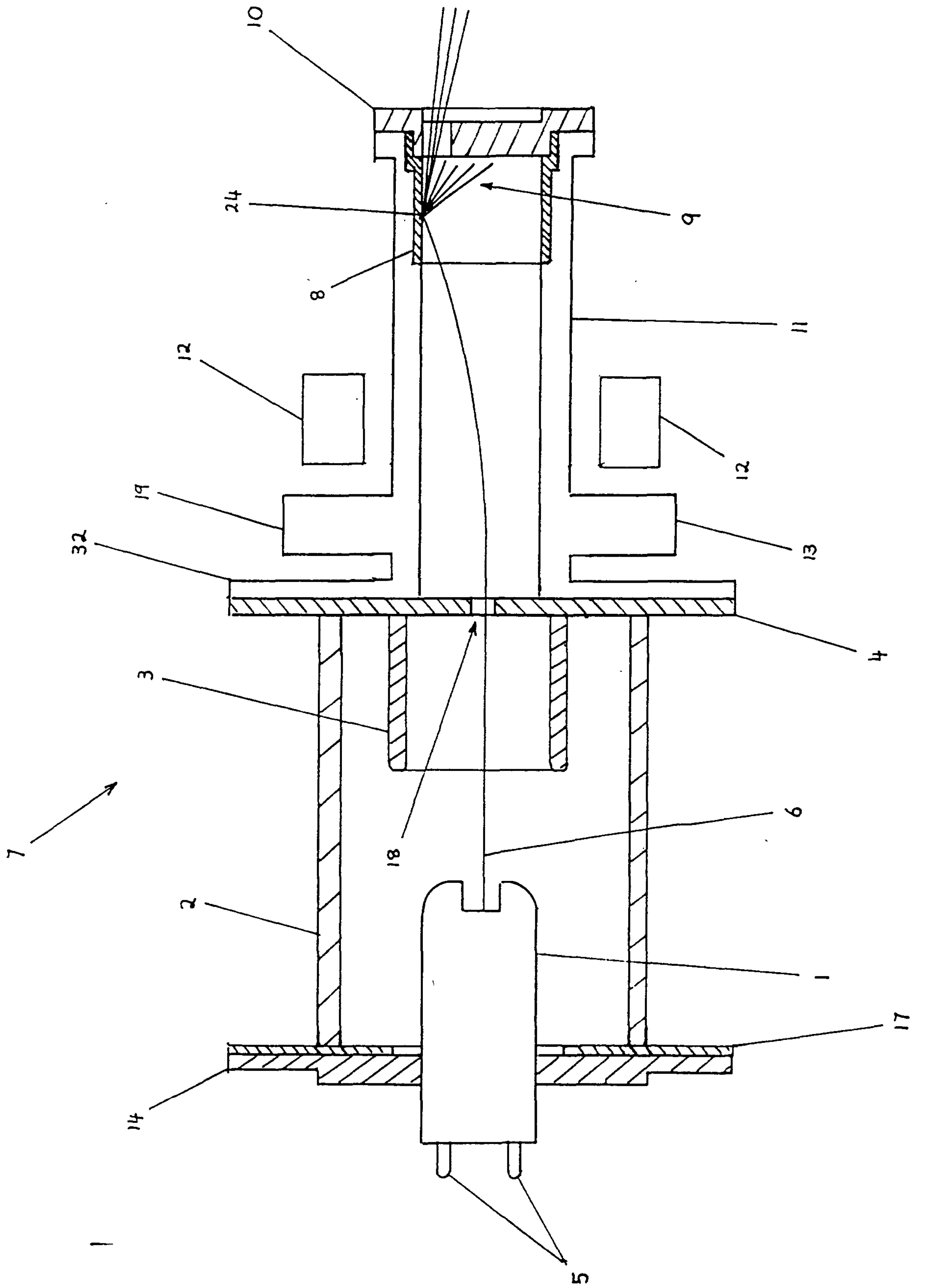

Figure 1

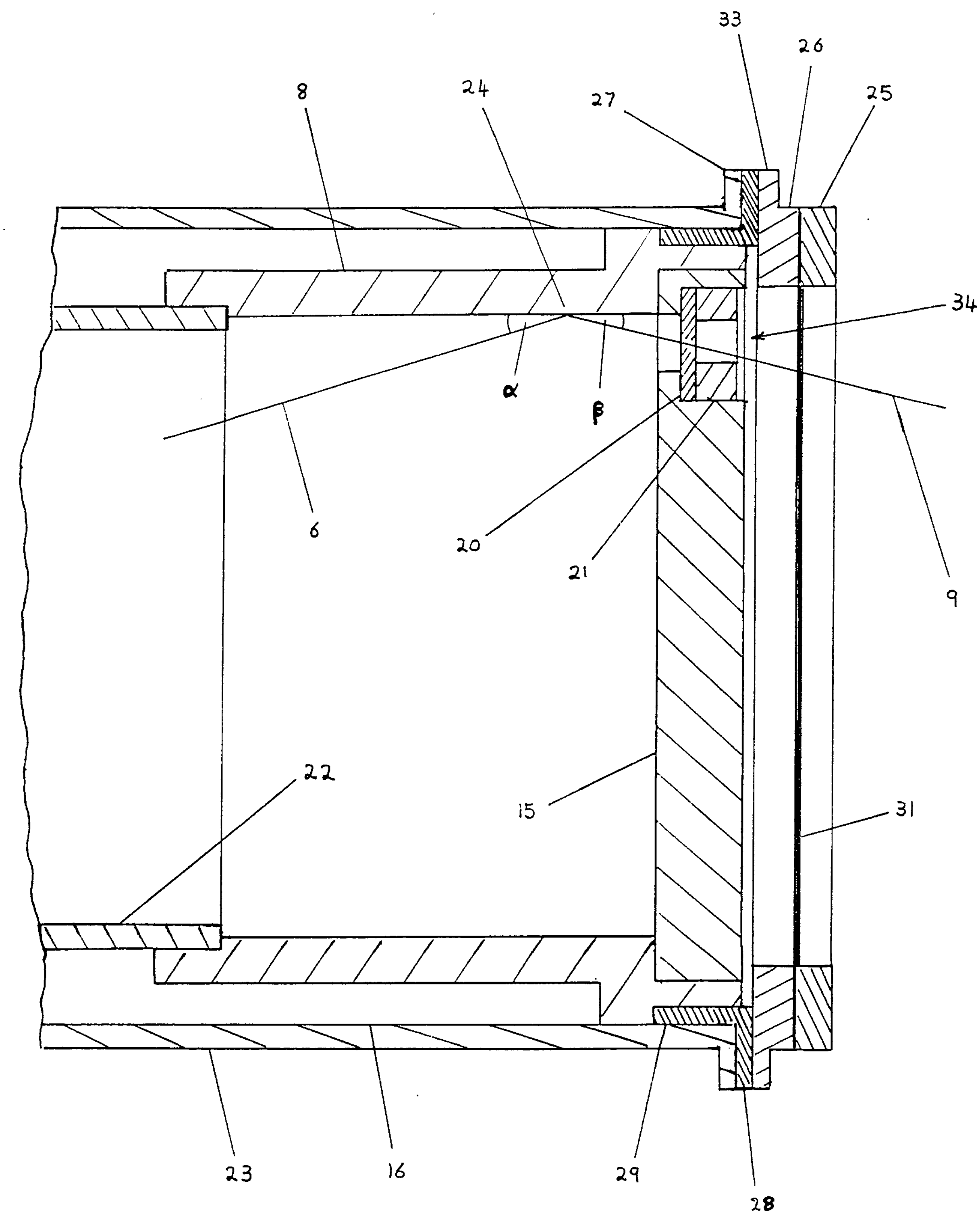

Figure 2