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(54) Variable-focus X-ray tube.

(57) In an X-ray tube the geometry of a cathode sleeve (5) is such that a comparatively large variation of focus dimensions on the anode is achieved by way of a single potential variation between, for example +0 and +2000 V. Notably a width dimension of a focus can thus be varied between, for example 0.1 and 2.0 mm and with a focus length of 2.0 operation can take place with a line focus of 0.1 x 2.0 mm^2 as well as with a square focus of 2.0 x 2.0 mm^2.

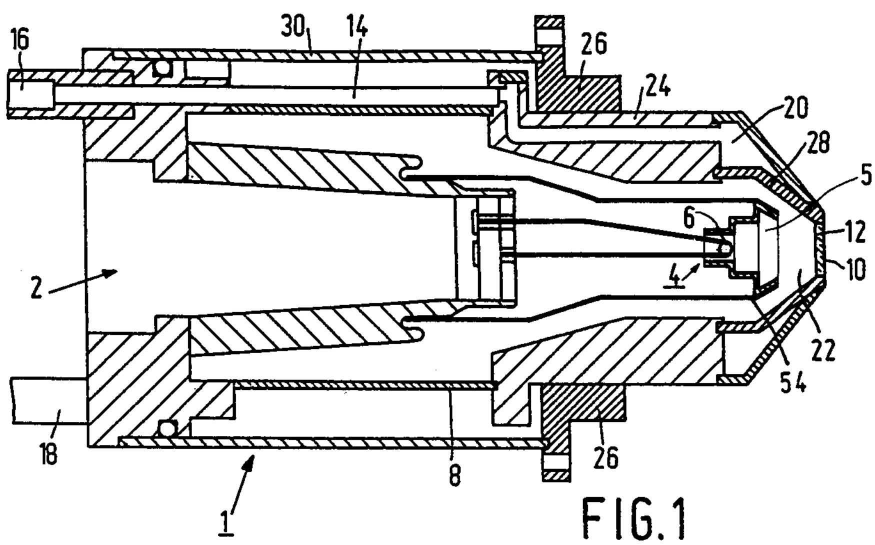

FIG.1

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The invention relates to an X-ray tube, comprising a cathode for generating an electron beam and an anode for generating a X-ray beam in response to impingement of the electron beam.

An X-ray tube of this kind is known from EP 389 326. An X-ray tube described therein comprises a cathode with a cathode sleeve which is provided, at a side facing the anode, with two focusing electrodes which are symmetrically arranged around an electron beam path. The electrodes are electrically insulated from the cathode sleeve and can be connected to mutually different potentials, so that the electron beam is deflected. The position of the electron target spot on the anode can thus be changed. Displacement of the electron target spot across the anode may be of importance in order to optimize the position of the electron spot and hence the focal point of an X-ray beam emanating from the tube. In such a tube it is also possible to use different anode materials which can be alternately irradiated by displacement of the electron spot.

For many examinations, notably for X-ray analysis, it is desirable that the geometry, notably a width dimension of the electron spot or the focus, is variable so that, for example measurement can take place with different resolutions.

It is an object of the invention to achieve the foregoing; to this end, an X-ray tube of the kind set forth in accordance with the invention is characterized in that the cathode comprises an electron emitter and a cathode cap which is arranged so as to be electrically insulated therefrom and which has a geometry and a relative position such that a difference voltage variation between the emitter and the cap of at the most approximately 2000 V enables adjustment of a target spot within a width variation range of up to approximately 2 mm.

As a result of the adapted geometry of the cathode cap and the dimension and position of the electron emitter, the focal width on the anode can be varied by way of a potential variation which can be readily realised and which does not give rise to high-voltage problems. Using a variation of, for example approximately 0.1 mm for realising a focus for high-resolution analysis and, for example approximately 2.0 mm for a focus with a comparatively high energy, the use of a single tube suffices for many analysis methods. The focus width variation is notably reduced to extreme values of approximately 0.4 mm and 2 mm or 0.1 mm and 0.5 mm, so that, for example a potential difference variation can be used which is approximately twice as small, benefiting the controllability of the tube. Analogously, a maximum width value can be adapted. For a similar cathode construction a variation between, for example approximately 0.4 mm and 1.0 mm can be realised by means of a difference voltage variation of approximately 500 V.

The electron emitter in a preferred embodiment is line-shaped, so that an elongate focus can be comparatively simply realised, notably the width of said focus being variable by way of an adapted voltage variation.

The electron emitter in a further preferred embodiment is formed by a flat cathode, for example a post-delivery cathode. An emissive surface of such a cathode can be varied by variation of the difference voltage, so that an additional means for varying the electron target spot is obtained.

The cathode cap in a further preferred embodiment is not constructed to be rotationally symmetrical. The cathode cap is notably constructed to be elliptical, enabling a change-over from, for example a substantially round target spot having a diameter of, for example from 1 to 2 mm, to an elongate target spot having a dimension of, for example $0.4 \times 2.0\ mm^2$. Such non-rotational symmetry in the electron-optical system can be supplemented by an elongate electron emitter again.

In a preferred embodiment, the cathode cap comprises two successive tapered portions in the direction opposing the direction of the electron beam, the electron emitter being arranged approximately at the area of the last tapered portion. Notably an axis of an emitter which is substantially round in the direction transversely of the emission direction is situated in the plane of the last tapered portion. The last tapered portion notably has a diameter ratio or axis ratio, of approximately 1 to 4 to 1 to 6 in the case of an elliptical cathode cap.

In a further preferred embodiment, the cathode cap is subdivided into several, notably two, mutually electrically insulated portions, so that focus displacement can be realised by deflection of the electron beam.

In a further preferred embodiment, a power supply system for the cathode cap voltage can be controlled in steps, the potential of each step adjusting a focus desired for a given analysis mode.

Some preferred embodiments in accordance with the invention will be described in detail hereinafter with reference to the drawing. Therein:

Fig. 1 shows an X-ray tube in accordance with the invention in the form of a target transmission tube, and

Fig. 2 is a more detailed representation of an appropriate cathode sleeve/anode geometry.

An X-ray tube as shown in Fig. 1 comprises an envelope 1 with a conical, ceramic base 2, a cathode 4 with an emissive element in the form of a filament 6, and a cathode sleeve 5, a cylindrical wall 8 and an exit window 10. In the present embodiment an anode 12 is deposited as a layer of anode material on an inner side of the exit window. The anode is made of, for example chromium, rhodium, scandium or another anode material. The thickness of the layer is adapted to the desired radiation, to the radiation absorption properties of the material, but notably to the electron absorption thereof, and to the desired high voltage for the tube. A chromium layer and a scandium layer have a thickness of, for example approximately 2.5 μm and a rhodium layer has a thickness of 1 μm. The anode preferably operates substantially at ground potential, so that no problems are encountered in respect of the electrical insulation of the comparatively thin beryllium window.

In the present embodiment a cooling duct 14, having an inlet 16, an outlet 18 and a flow duct 20 which surrounds the exit window, is provided in the envelope.

A high-voltage connector which is preferably made of rubber can be inserted into the base 2. Such a high-voltage connector is connected to a high-voltage cable, to supply leads for the filament and to supply leads for any further electrodes to be arranged in a cathode-anode space 22. Around the envelope there is provided a mounting sleeve 24 which comprises a mounting flange 26 and an additional radiation shield 28 which also bounds the flow duct 20. Around the tube there is also provided a thin-walled mounting sleeve 30 which accommodates the cooling ducts and which also has a temperature-equalizing effect.

A cathode sleeve as shown in Fig. 2 comprises an end sleeve 40, a second tapered portion 41, an intermediate sleeve 42, a first tapered portion 43, and a first sleeve 44. Electron-optical properties of the sleeve in respect of electrons to be emitted by the emitter 6 are determined mainly by: the diameter E of the first sleeve 44, the diameter C of the intermediate sleeve 42, the length B of the intermediate sleeve 42, the length A of the end sleeve 40, the diameter D of the emitter 6, and the position of the emitter in the cathode sleeve, expressed as its distance F from the tapered portion 43. The term "diameter" is used in the foregoing, but the geometry of the sleeves is not necessarily rotationally symmetrical. This also holds for the emitter 6. An electron beam 50 emanating from the emitter 6 is focused more or less on the anode 12 by variation of the potential across the sleeve. In a model for the geometry, subject to secondary conditions such as reasonable possibility of mounting in the X-ray tube and possibility of performing comparatively simply potential variations, for example up to approximately 2000 V, an optimum configuration can be calculated for a desired focus width. The drawing shows, by way of solid lines and dashed lines, two focus conditions, for example for 500 V and 1500 V, respectively.

Claims

1. An X-ray tube, comprising a cathode for generating an electron beam and an anode for generating X-rays in response to impingement of the electron beam, characterized in that the cathode is provided with an electron emitter and a cathode cap which is arranged to be electrically insulated therefrom and which has a geometry and relative position such that a target spot can be adjusted within a width variation range of up to approximately 2.0 mm by a difference voltage variation of at the most approximately 2000 V between the emitter and the cathode cap.

2. An X-ray tube as claimed in Claim 1, characterized in that a focus width variation by approximately a factor 5 can be adjusted by way of a difference voltage variation of at the most approximately 1000 V.

3. An X-ray tube as claimed in Claim 1 or 2, characterized in that a difference voltage variation of at the most approximately 500 V enables a focus width variation of between approximately 0.4 mm and 1.0 mm.

4. An X-ray tube as claimed in Claim 1,2 or 3, characterized in that the electron emitter is a linearly arranged filament.

5. An X-ray source as claimed in Claim 1,2 or 3, characterized in that the electron emitter is a flat post-delivery cathode.

6. An X-ray tube as claimed in any one of the preceding Claims, characterized in that in order to produce an elongate focus, the electron emitter, the cathode cap or both are not rotationally symmetrical.

7. An X-ray tube as claimed in any one of the preceding Claims, characterized in that the cathode cap comprises two successive tapered portions, viewed in the direction opposing the direction of electron emission, the electron emitter being arranged approximately at the area of the last tapered portion.

8. An X-ray tube as claimed in Claim 7, characterized in that the axis of a substantially round emitter is situated at least substantially in the plane of the last tapered portion.

9. An X-ray tube as claimed in Claim 7 or 8, characterized in that the last tapered portion has a diameter ratio of between approximately

1 to 4 and 1 to 6.

10. An X-ray tube as claimed in any one of the preceding Claims, characterized in that the cathode cap consists of several parts in order to displace or change the shape of the focus.

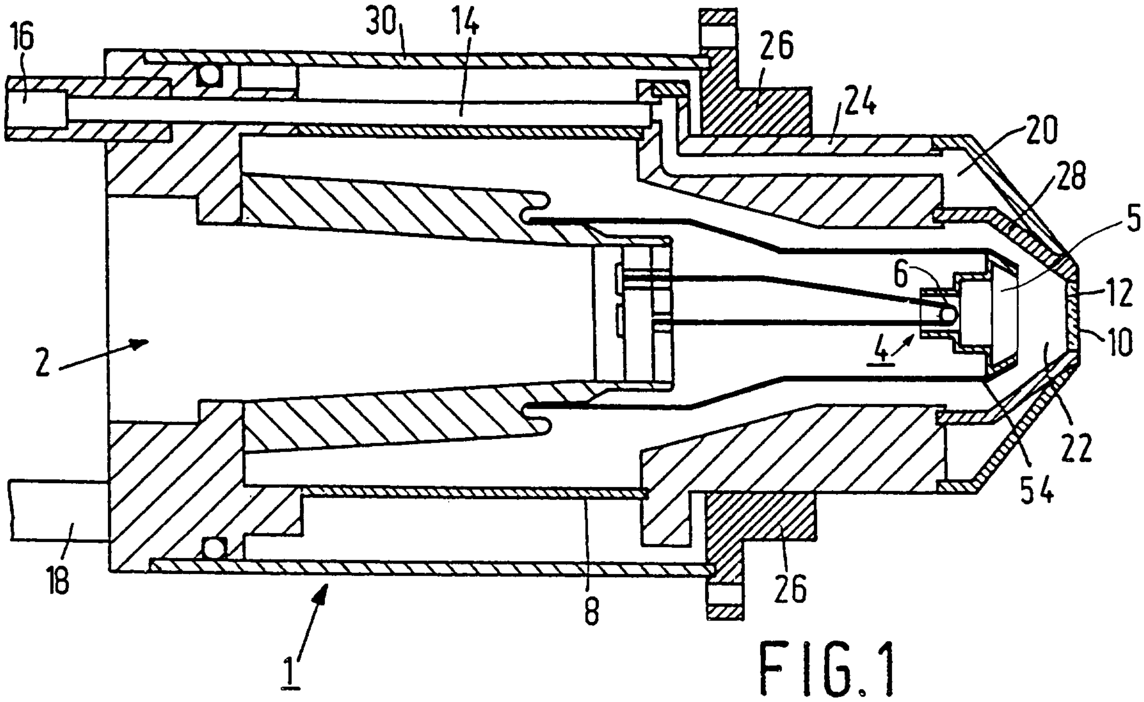
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FIG.1

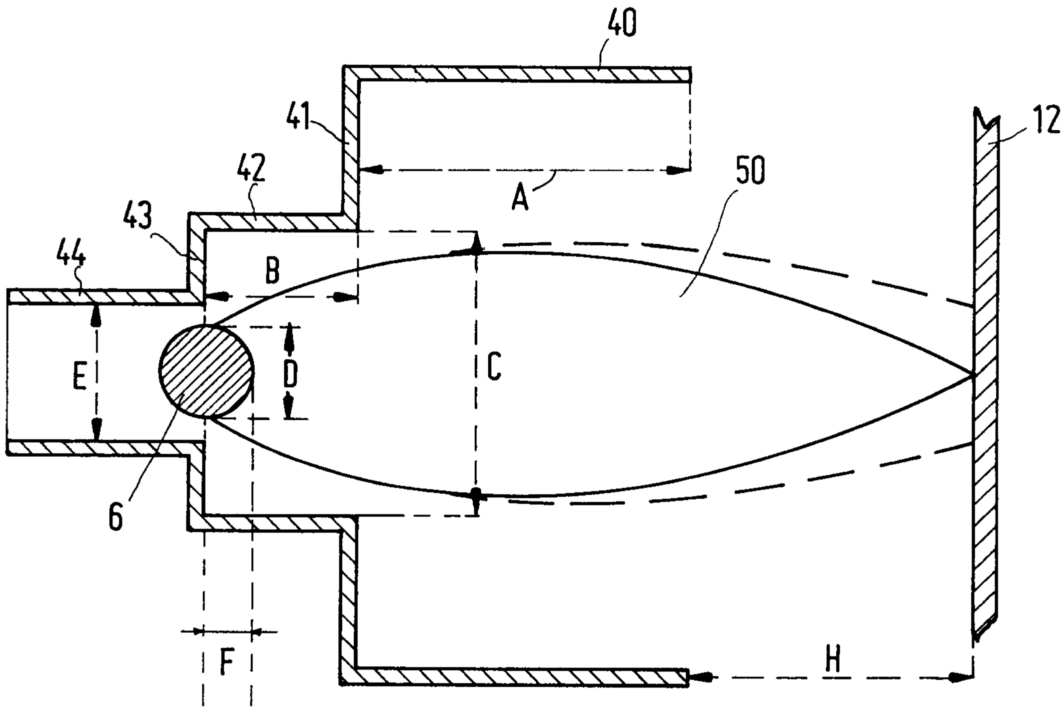
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FIG.2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 20 0136

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 349 388 (GENERAL ELECTRIC) * the whole document * ---	1	H01J35/06 H01J35/30
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 209 (E-268)22 September 1984 & JP-A-59 094 348 (HITACHI) 31 May 1984 * abstract * ---	1	
A	EP-A-0 283 039 (LITTON SYSTEMS) * Abstract * * claim 1 * * figures 4-8 * ---	1	
A	US-A-4 344 011 (T.HAYASHI ET AL.) * the whole document * ---	1	
D,A	EP-A-0 389 326 (GENERAL ELECTRIC) * the whole document * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	05 MARCH 1993	DAMAN M.A.

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