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Fischer

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[54] **X-RAY DEVICE HAVING AN ANODE TUBE WITH FILTERING MEANS THEREON**

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[30] **Foreign Application Priority Data**

June 22, 1970 Germany ..... P 20 30 624.5

[52] **U.S. Cl.** **250/503,** 313/55, 250/491, 514, 520

[51] **Int. Cl.** **H01j 35/16,** H01j 5/16

[58] **Field of Search** 250/70, 86, 90; 313/55, 59

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[57] **ABSTRACT**

A device for use in the production of dental X-ray photographs comprises a hollow-anode X-ray tube projecting from a housing with the tube specially mounted to absorb shocks and stresses imposed on the anode tube. The anode tube which projects from the housing is preferably shielded when not in use by a projecting tube slidable relative to the housing. The device may also include a second X-ray tube for intra-oral and extra-oral photography with this second tube emitting X-rays at 90° to the axis of the hollow anode X-ray tube. Prefiltering material may be provided on the head of the anode tube or the head of the anode tube may be specially shaped so that uniform prefiltering of the radiation from the anode tube occurs over the beam angle necessary for full-mouth photography.

7 Claims, 9 Drawing Figures

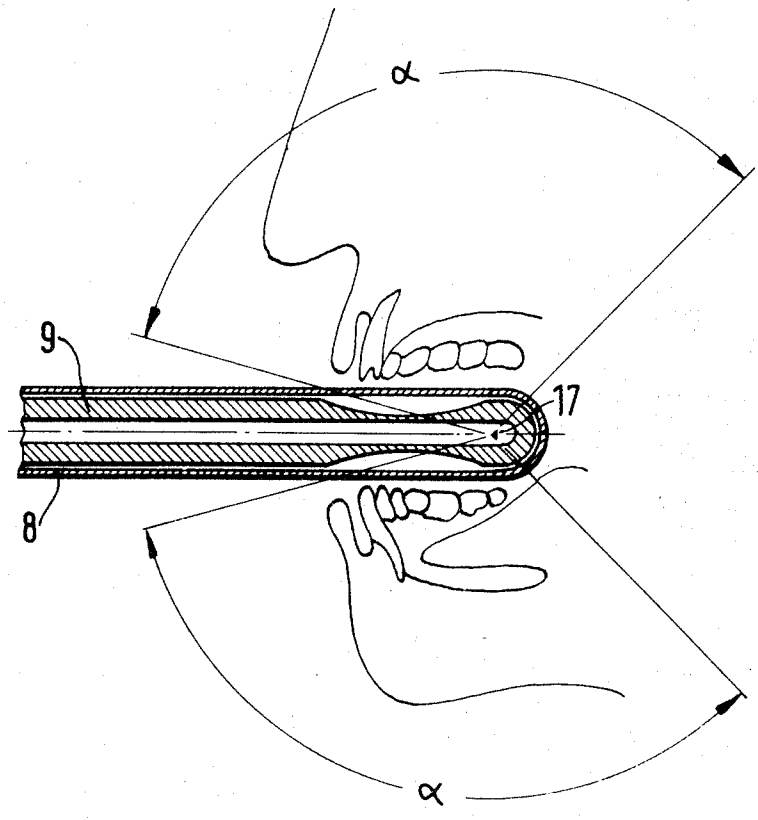


Fig.1

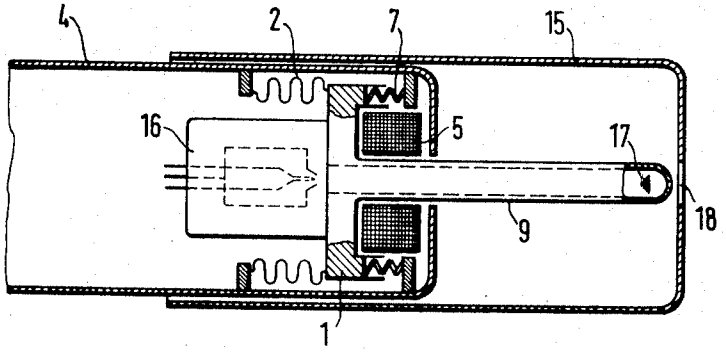


Fig.2

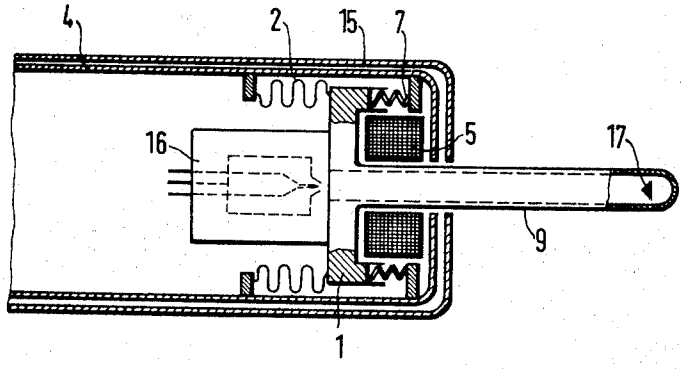


Fig.3

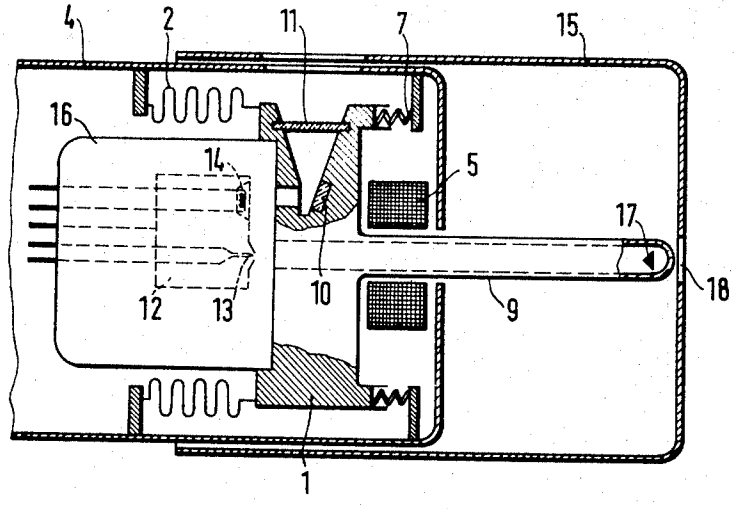


Fig.4

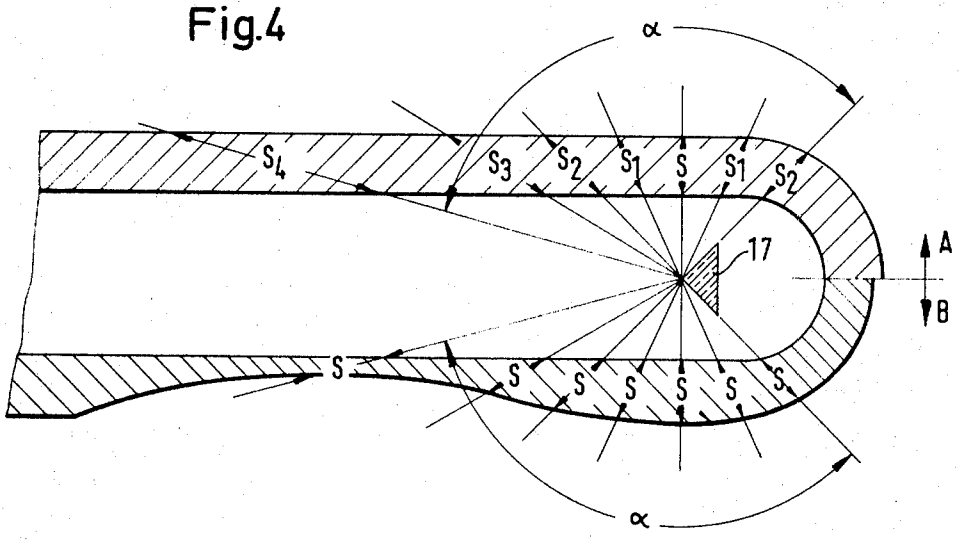


Fig.5

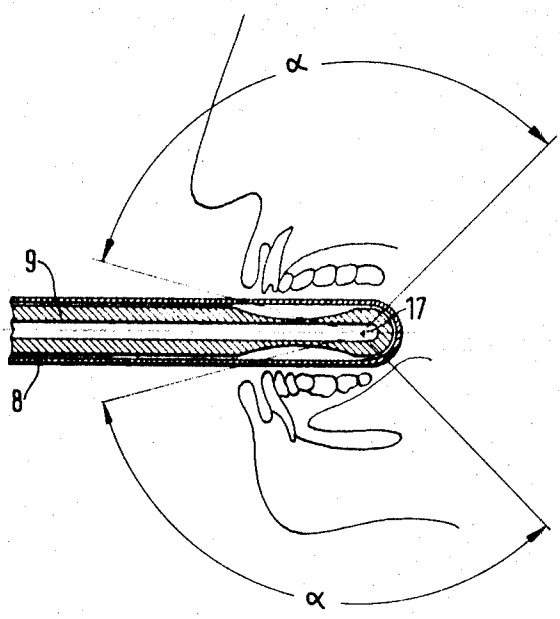


Fig.7

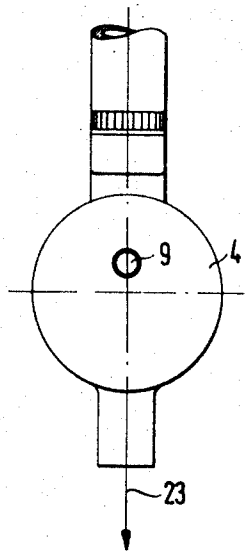
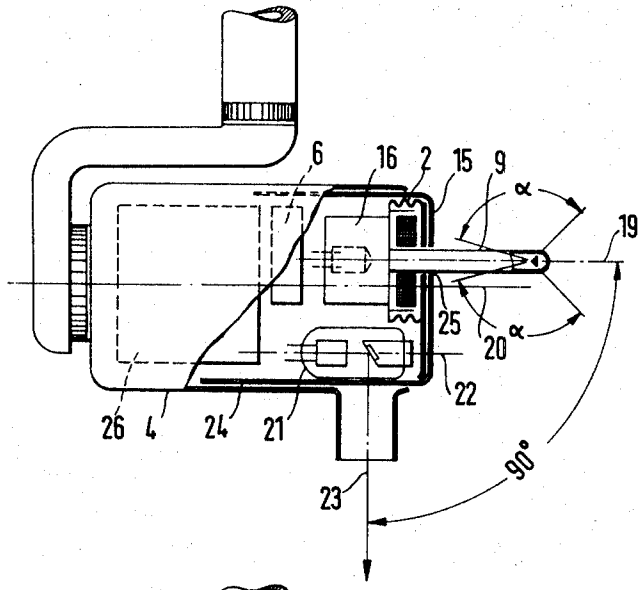


Fig.6



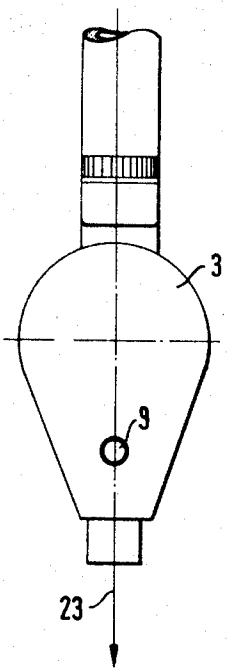


Fig.9

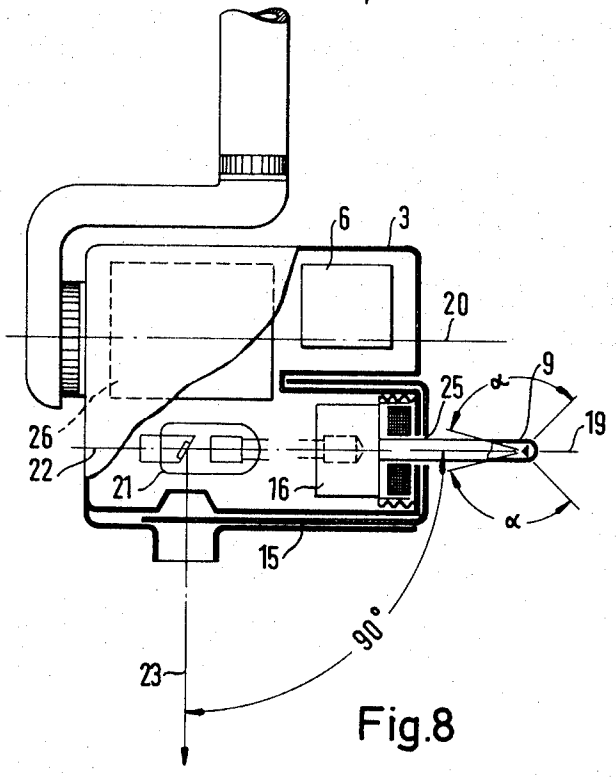


Fig.8

X-RAY DEVICE HAVING AN ANODE TUBE WITH FILTERING MEANS THEREON

BACKGROUND OF THE INVENTION: FIELD OF THE INVENTION

This invention relates to devices for use in producing X-ray photographs, particularly dental X-ray photographs.

The invention is particularly concerned with devices for use in producing dental X-ray photographs which make use of special hollow-anode X-ray tubes which are quite distinct in construction and function from the usual diagnostic X-ray tubes.

BACKGROUND OF THE INVENTION: DESCRIPTION OF THE PRIOR ART

In the presently known tubes of this hollow-anode type, the whole electrode system — comprising a cathode emitting the electrons, a control electrode affecting the focussing, and a usually conical anode arranged in the anode tube with a collecting or focussing coil mounted on the anode tube and also affecting the focussing of the electron stream — is so constructed that it is formed from two or three mechanically completely separate electrode units as far as adjustment of the system is concerned. In these hollow-anode X-ray tubes the focal spot is created at the end of a hollow-anode tube externally of the actual X-ray tube casing and with a conical anode it is at the cone tip pointing towards the cathode.

In the X-ray tubes used in dental medical diagnostic treatment for producing full-mouth or panoramic photographs, in which the anode tube is introduced into the mouth, the focal spot of the tube must be kept very small on account of the comparatively small focal length necessitate by these photographic techniques and on account of the lack of sharpness in the image which would otherwise arise, with the result that the electrode system of such a tube must be extremely accurately focussed and adjusted initially and must then remain so. The danger of the tube becoming out of adjustment is greater the smaller the diameter of the anode tube and the more sensitive the electrode system of the X-ray tube.

Since the wall thickness of the hollow-anode tube, which is barely the size of a finger in diameter, must be kept small and since the electron stream must be very accurately adjusted because of the comparatively small focal spot, the user of such tubes protects the very highly sensitive anode tube, which is formed from very soft annealed copper at those places where in the event of a mechanical stress the greatest bending moment is exerted, by placing a protective cap over the tube housing in the inactive position of the device to protect the anode tube from damage and defocussing. When preparing the instrument for use and when actually using the instrument. the protective cap is removed in all cases.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an X-ray device, comprising a hollow-anode X-ray tube mounted in a housing and provided with an anode tube projecting from the housing, which is resistant to inadvertently applied stresses acting on the device and which is also protected against defocussing and movement out of adjustment.

This is achieved in accordance with one aspect of the invention in that the casing of the hollow-anode X-ray tube is rigidly connected to mounting means to which is connected resilient support means, said support means being secured to the housing and extending between the housing and the casing of the hollow-anode X-ray tube. In this way, in the event of a blow on the anode tube, this tube together with the whole X-ray tube and the focussing means rigidly connected thereto together yield to the blow, and then return to the positions occupied before the blow took place, so that in consequence the adjustment of the focussing is not adversely affected.

In the X-ray device of the present invention the X-ray tube casing including the part of the anode tube adjacent to the cathode is preferably formed of a ceramic based material, such as a ceramic oxide for example, since this provides the anode tube with substantially higher resistance to bending stresses than the copper components previously generally used.

Since the thickness of the objects in the whole of the irradiated field of interest for full-mouth photography is approximately the same, it is of great importance that any prefiltering of the radiation within the radiation beam angle should be constant. This is not the case in the presently known hollowanode constructions in which the anode tubes and/or the applicators placed over the tubes have a constant wall thickness in the vicinity of the source of the emitted radiation, with the result that the X-rays follow different length paths in their passage through the wall in dependence on the angle at which they are emitted and are consequently subjected to differential filtering. This disadvantage is overcome in accordance with a preferred feature of the present invention by the provision of prefiltering material on the head of the anode tube containing the anode, the distribution being such that uniform perfiltering of the radiation occurs over the whole beam angle necessary for full-mouth examination. This may be achieved by making the wall at the head of the anode tube of non-uniform thickness such that all X-rays passing through the tube wall at whatever angle traverse equal length paths through the tube wall. Alternatively, it is possible to provide additional prefiltering material on the head of the anode tube in addition to the actual tube material, this additional prefiltering material being provided in such a way that the X-rays which on the basis of their angle of emission traverse a shorter path length through the tube wall pass through a greater mass of prefiltering material than the X-rays which traverse a longer path length.

In photographing the upper jaw it is sometimes necessary in special cases to provide a cut-out in the film strip for the nose of the patient and to photograph the unphotographed nose part in the usual manner, i.e., with the film inside the mouth and with the X-ray tube outside the mouth. The presently known hollow-anode X-ray tubes cannot be used in this way. Photographic views of the whole jaw region are produced with the presently known hollow-anode X-ray tubes when inserted into the mouth for dental X-ray photographs, and these overall pictures obviously give information about the general status of the teeth. However, with these X-ray photographs one takes photographs of the whole of one or both jaws from one focal spot position, which automatically means that individual teeth or whole groups of teeth are shown heavily distorted on

the X-ray film relative to their anatomically correct images or positions in the jaw. Because of this, for specific diagnosis of individual teeth it is necessary to take individual photographs of teeth or groups of teeth by the distortion free intra-oral or extra-oral techniques which are presently known. In order to carry out these two basically different photographic techniques the dental practitioner must have two different X-ray machines respectively adapted for the separate photographic techniques and with which one has to use X-ray tubes which are likewise different and adapted respectively for the different photographic techniques.

It is therefore extremely desirable to provide a device equipped with a hollow-anode X-ray tube which is also such that distortion free photographs of individual objects can be achieved with it as with the known intra-oral and extra-oral photographic techniques. According to the present invention this is achieved by providing a second X-ray tube for intra-oral and extra-oral photographs within the housing of the device and in addition to the hollow-anode X-ray tube, the direction of emission of radiation from the second tube being at an angle of substantially 90° to the longitudinal axis of the hollow-anode X-ray tube. A high voltage transformer for both tubes is preferably also mounted within the housing of the device so that in this case the device can be described as a one-piece instrument.

Instead of having two separate X-ray tubes it is alternatively possible to use a double X-ray tube suitable both for full-mouth photography and also for intra- and extra-oral photography, such as double X-ray tube having two separate cathode filaments in a common casing. This results in a system which can be made extremely compact. On the other hand, a device using two separate X-ray tubes has the possible advantage that the X-ray tubes may be of a simpler and cheaper construction and that in the event of failure of one complete X-ray system or one X-ray tube the other X-ray system is still usable until replacement or repair of the failed system or tube. When using a common tube casing for both X-ray systems the casing may be secured to mounting means which includes an electron reflection target in alignment with the cathode filament for the said second X-ray tube and a side window through which X-rays from the target are beamed.

In order that the invention may be more fully understood a number of embodiments in accordance therewith will now be described by way of example and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view through a part of a first embodiment of device in accordance with the invention, the device comprising a hollow-anode X-ray tube, here shown in its inactive position;

FIG. 2 is a similar cross-sectional view of the device shown in FIG. 1 but with the hollow-anode X-ray tube in its operational position;

FIG. 3 is a similar cross-sectional view through a second embodiment of device in accordance with the invention, this device comprising a double X-ray tube adapted both for panoramic full-mouth photography and also for intra-oral and extra-oral photography, and with the device here shown in its operational position for the last-mentioned photographic technique;

FIG. 4 is a longitudinal sectional view through the head of the anode tube of a hollow-anode X-ray tube, the upper half (A) of the illustrated tube being of known form and the lower half (B) of the illustrated tube being of modified novel form;

FIG. 5 is a longitudinal sectional view through the head of the hollow-anode X-ray tube illustrating the radiation beam-angle necessary for panoramic full-mouth examination and of interest in relation to prefiltering considerations;

FIG. 6 is a schematic longitudinal sectional view through a third embodiment of device in accordance with the invention, the device here comprising two separate X-ray tube systems;

FIG. 7 is a front end elevational view of the device of FIG. 6;

FIG. 8 is a schematic longitudinal sectional view through a fourth embodiment of device in accordance with the invention, again comprising two separate X-ray tube systems; and,

FIG. 9 is a front end elevational view of the device of FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the embodiment of the device shown in FIG. 1 the X-ray tube comprises a casing **16** fitted with an anode tube **9** carrying a conical anode **17**; a mount **1** at anode potential and rigidly connected to the tube casing **16**; and a focussing unit **5** which is fixedly connected to the tube system. The mount **1** is connected to a housing **4** of the device by means of a resilient link **2**, for example in the form of a spring element. A high voltage generator (not shown) for the X-ray tube is mounted in a suitable manner within the housing **4** of the device.

In spite of the provision of a resilient supporting link **2** it is important to provide additional protection for the exposed comparatively slender anode tube **9** in its inactive position. For this purpose a protecting tube **15** is provided which is secured so as to be displaceable in the axial direction over the housing **4** of the device. In FIG. **1**, this protecting tube **15** is shown in its operative protective position enclosing the anode tube **9**. The tube **15** is provided with an aperture **18** in its end face to provide for passage of the anode tube **9** therethrough.

Additional springs **7** are provided between the housing **4** and the mount **1** on the tube casing **16** in order to adjust the flexibility and resiliency of the link **2** so that it will absorb forces arising as a result of impacts or pressures on the anode tube **9** and will return the tube system to its original setting as soon as such foreign external forces no longer act on the anode tube.

In the illustration shown in FIG. **2** the protecting tube **15** has been withdrawn back over the housing **4** of the device so that the anode tube **9** is located in its operational position in which it can be inserted into the mouth if panoramic photography of the whole of a patient's mouth is to be carried out.

The embodiment of the invention which is shown in FIG. **3** comprises a double X-ray tube by means of which it is possible to use both the hollow-anode technique for panoramic full-mouth photography and also intra-oral and extra-oral photographic techniques for examination of individual teeth. In this embodiment a tube side window **11** with an electron target disc **10** arranged adjacent thereto are provided in the mount **1** as a part of the tube casing **16**, in addition to the anode tube **9** which has the anode **17** as an electron target

point. A filament arrangement **13** acting as the cathode associated with the anode **17** and a filament arrangement **14** acting as the cathode associated with the electron target disc **10** are provided within the tube casing **16.** The mount **1** is at anode potential.

In this embodiment the cathode filaments **13** and **14** which are necessary for the two electrode systems are mounted on a cathode support **12** and can be selectively switched on individually according to the desired type of photographic examination to be effected with the device.

In this embodiment, apertures are provided in the housing **4** and in the axially displaceable protecting tube **15** for the passage of the X-rays emitted through the tube side window **11.** These apertures are so arranged that when the device is used for hollow-anode photographic examination the protecting tube **15** masks the aperture in the housing **4** in front of the side window **11** and uncovers the free end of the anode tube **9,** while when the device is used for intra-oral or extraoral photographic examination the protecting tube **15** encloses the free end of the anode tube **9** and unmasks the side window **11.**

The upper half of FIG. **4** of the drawings, designated as A, shows the head of a known form of hollow-anode X-ray tube in which the anode tube **9** is cylindrical and of uniform wall thickness in the radiating region. In such circumstances the X-rays coming from the anode **17** within a beam angle α and which do not pass through the wall of the anode tube at right-angles along the line S, for example rays passing along the lines S1 to S4, must penetrate larger amounts of the material of the anode tube. These rays are therefore prefiltered differentially and this has an extremely unfavourable effect on the quality of the image on the X-ray photograph.

In the lower half of FIG. **4,** designated as B, there is there shown how this differential prefiltering of the X-rays is avoided by the use of a special configuration for the wall thickness of the head of the anode tube **9.** With the wall thickness made non-uniform as shown the same length of path S is traversed by all radiation from the anode **17** throughout the whole beam angle which is of interest.

FIG. **5** shows, in relation to an anode tube **9** with a conical anode **17** and fitted with an applicator **8** over the anode tube, the tube and applicator being shown inserted into a patient's mouth, that the beam angle α shown in FIG. **4** is in fact necessary for full-mouth photographic examination.

Alternatively, it is possible to provide additional prefiltering material on the head of the anode tube **9,** preferably on its external surface, with such a distribution or gradation that the X-rays within the beam angle α which follow a shorter path through the wall of the head of the tube traverse a greater mass of prefiltering material than the X-rays which follow a longer path. In this case, the cylindrical wall of the anode tube, as is shown in the upper part A of FIG. **4,** may have its thickness unchanged. Alternatively, this additional prefiltering material may be provided on the applicator **8** which is slidable over the anode tube **9,** or it may be provided partially on this applicator and partially on the anode tube itself. By these means one can ensure in a simple manner that all the X-rays coming from the anode **17** are prefiltered to the same extent irrespective of their direction, and preferably to a degree equivalent to the case of the rays taking the longest path S4.

The X-ray tube casing, including the part of the anode tube adjacent to the cathode, is preferably made from a ceramic-based material having high resistance to bending stresses. Among the best materials are ceramic oxides, particularly beryllium oxide, which can absorb large bending moments and which at the same time are permeable to the magnetic field necessary for focussing the electron stream.

In each of the embodiments described above in which the mounting of the X-ray tube within the housing of the device is accomplished by means of an intermediate element such as the resilient link **2,** this resilient supporting link need not necessarily consist of a spring element, but for example can alternatively be in the form of resilient membranes, or in the form of ball and socket joints in association with individual springs spaced on a circle around the tube. In each case the arrangement is such that the reaction to bending stresses of the resilient link due to forces acting from externally on the anode tube **9** is smaller than the reaction to deformation of the anode tube **9** due to the external forces acting thereon.

Focussing unit **5** shown in FIGS. **1** to **3** may be an electromagnetic unit or a permanent magnet system. It will further be appreciated that an electrostatic focussing unit could alternatively be used.

In the embodiment shown in FIGS. **6** and **7** there is provided a hollow-anode X-ray tube suitable for full-mouth or panoral photographic examination and comprising the X-ray tube casing **16,** the anode tube **9,** and an associated transformer **6** mounted on an axis **19** which is parallel to but displaced upwardly relative to the longitudinal axis **20** of the housing **4** of the device. Parallel to this tube **9, 16** is provided an intra-oral tube **21** having its longitudinal axis **22** displaced downwardly relative to the longitudinal axis **20** of the housing **4** of the device. The direction **23** of the emitted radiation from the intra-oral X-ray tube **21** is at 90° to the longitudinal axis **19** of the hollow-anode X-ray tube **9, 16.**

In this embodiment the hollow-anode X-ray tube **9, 16** is resiliently mounted in the housing **4** by means of springs or a spring bellows or a membrane **2.** A protecting tube **15** is provided to protect the anode tube **9.** The protecting tube **15** is displaceable along the axis of the X-ray tube such that its cylindrical wall is displaceably positioned within the housing **4** and only its forward end wall portion provided with an aperture **25** for the anode tube **9** lies outside the housing **4.** A window **24** for the passage of radiation from the intra-oral tube **21** is provided in the cylindrical wall portion of the protecting tube **15.** This window **24** is only aligned with the output from the intra-oral tube **21** when the hollow-anode X-ray tube **9, 16** is not operational and is enclosed by the protecting tube **15.** However, the window **24** is not in alignment with the axis **23** of the radiation from the tube **21** when the protecting tube **15** is displaced inwardly and the hollow-anode X-ray tube **9** extends in its operative position.

The embodiment illustrated in FIGS. **8** and **9** only differs from that shown in FIGS. **6** and **7** in that the two X-ray tubes **9, 16** and **21** are not arranged one below the other but are positioned on a common axis **22** one behind the other within the housing **3.** In this embodiment the housing **3** is not cylindrical but has an inverted teardrop shape cross-section. The hollow-anode

X-ray tube is mounted within the housing **3** in almost the same way as in the embodiment shown in FIGS. **6** and **7** but below the pivot axis **20** of the housing, while the second X-ray tube **21** lies on the axis **22** behind the hollow-anode X-ray tube **9, 16.** The two transformers **6** and **17** of these two X-ray systems are provided as a one-piece unit positioned within the upper portion of the housing which is of larger cross-section.

In both the embodiments shown in FIGS. **6** to **9** the direction **23** of the emitted radiation from the intra-oral tube **21** makes an angle of 90° with the longitudinal axis **19** of the hollow-anode X-ray tube **9, 16.**

The casing of the intra-oral or extra-oral X-ray tube **21** preferably consists of a ceramic oxide with the tube side window being formed from sintered beryllium oxide.

Since certain other obvious changes may be made in the device without departing from the scope thereof it is intended that the above description of certain embodiments of the invention be interpreted in an illustrative and not a limiting sense.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In an X-ray device for use in producing dental X-ray radiographs,

a. a tube housing;

b. anode tube means projecting from said tube housing, said tube means having a longitudinal axis;

c. an anode mounted in said anode tube means adjacent the end of said anode tube means opposite said tube housing, said anode, when bombarded by electrons, emitting X-rays over a beam angle that extends both radially and longitudinally of said anode tube means to produce a full-mouth radiograph when said anode tube means is correctly positioned within a patient's mouth; the improvement

d. wherein said anode tube means comprises filtering means, said filtering means having a variable thickness along the longitudinal axis of said tube means such that the X-rays pass through substantially equal thicknesses of filtering material irrespective of the emission angle relative to the longitudinal axis of said anode tube means whereby the X-rays are uniformly filtered over the entire beam angle.

2. The X-ray device as set forth in claim **1** wherein the thickness of said anode tube means varies such that all X-ray radiation emitted within said beam angle travels a path of equal length through the wall of said anode tube means.

3. The device as set forth in claim **2** wherein said filtering means comprises a first portion of filtering material of uniform thickness forming said anode tube means and a second portion of filtering material of varying thickness covering preselected areas of said first portion of filtering material wherein said second portion of filtering material provides additional filtering to said X-ray radiation such that said X-ray radiation travels equal path lengths within said filtering means.

4. The apparatus as set forth in claim **3** wherein said anode tube means comprises:

a. an anode tube of cylindrical cross sectioning having walls of uniform thickness wherein said walls comprise said first portion of said filtering means; and

b. an applicator tube for covering at least a portion of said anode tube means, surrounding said at least a portion of said anode tube, wherein said second portion of said filtering means is affixed to said applicator tube.

5. The device as set forth in claim **2** wherein said anode tube means comprises:

a. an anode tube including said filtering means; and

b. an applicator surrounding said anode tube.

6. The device as set forth in claim **2** wherein said anode tube means comprises:

a. an anode tube;

b. an applicator surrounding said anode tube; and

c. wherein said filtering means comprises a first portion disposed of said anode tube and a second portion disposed on said applicator.

7. The apparatus as set forth in claim **1** wherein said anode tube means is formed from a ceramic based material such as a ceramic oxide.

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