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(54) IMPROVEMENTS IN OR RELATING TO X-RAY APPARATUS

(71) We, SIEMENS AKTIENGESELLSCHAFT, a German company, of Berlin and Munich, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to an apparatus for producing X-ray radiation.

To produce X-radiation, with a beam of electrons, a target, i.e. a plate of several millimetres thickness consisting of a heavy metal, preferably tungsten, is placed in the electron beam. The thickness of the target represents a compromise. If the target is too thin too few X-ray quanta will be produced. If the target is too thick too much X-radiation will be absorbed in the target itself. Moreover, the maximum of the energy spectrum of the X-rays is then shifted towards the long-wave region. To prevent electrons from passing through the target into the conical beam of X-ray radiation with the target thicknesses customarily used, it is known, to us, to mount an electron absorber directly downbeam of the target in the bore of the target carrier which holds the target. This electron absorber is intended to absorb any electrons which have penetrated the target but to weaken the X-ray radiation produced in the target as little as possible. Hitherto absorption bodies made from copper or another material of a medium atomic number have been used for the absorption of the electrons. However, with this type of electron absorber, there is the disadvantage that additional X-ray quanta are produced by the electrons in the material of the electron absorber itself. These X-ray quanta have a different place of origin from the X-ray quanta produced in the target and thus increase the penumbral region of the shadow cast by the body being X-rayed. These X-rays are also of low energy and undesirable because of skin stress.

According to the present invention, there is provided an apparatus for producing X-ray radiation, comprising a target which in use is exposed to an electron beam so as to produce a conical beam of X-ray radiation; a primary collimator with an opening defining the largest desired angle of the conical beam of X-ray radiation; a first electron absorber made from one or more elements having an atomic number lower than that of copper, mounted downbeam of the target; and a second electron absorber, made from one or more elements having an atomic number lower than that of copper, mounted in the opening in the primary collimator, the dimensions of the second electron absorber being similar to the corresponding dimensions of the opening.

The effective cross-section for producing X-ray deceleration radiation increases with the atomic number and the electron absorption is proportional to the density. The proportion of additional X-ray quanta which arise due to the absorption of the superfluous electrons can thus be considerably reduced if the atomic number of the electron absorber material is reduced. But, because of the reduced electron absorbtion associated with a material of low atomic number, the extent of electron absorption is, in accordance with the invention, correspondingly increased in the beam direction by the use of two electron absorbers.

Preferably, the apparatus according to the invention includes adjustable plate diaphragms disposed downbeam of the primary collimator, and/or an electron accelerator for producing the electron beam to which in use the target is exposed.

Preferably the first electron absorber and/or the second electron absorber are made from aluminium or graphite.

For a better understanding of the present

invention and to show more clearly how the same may be carried into effect reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 shows a partial section of the radiation emitter head of an apparatus for producing X-rays, incorporating an electron absorber of known design;

Figure 2 shows a partial section of an apparatus for producing X-rays, according to the invention; and

Figure 3 shows an enlarged view of the circled area "A" of Figure 2.

Figure 1 shows in a simplified form the construction of radiation emitter head 1 of an X-ray apparatus incorporating an electron accelerator. Directly downbeam of the X-ray window 2 of the evacuated electron beam guidance beam tube 3 is target-carrier 5 in the passage opening 4 of the emitter head 1. Several bores 6, 7 are provided in the target carrier. In one of these bores 6 there is set a heavy metal plate, the target 8, for the production of X-ray deceleration radiation. In the other bores 7 of the target carrier 8 there are fixed scattering foils 9 to scatter the electrons when the electron accelerator is used as an electron beam source. The primary collimator 10 is located in the path of the X-ray radiation downbeam of the target-carrier 5. It has an opening 11 for the X-ray deceleration radiation produced in the target 8, and also a further passage opening 12 for the electrons scattered by a scattering foil 9, when the target carrier 5 is positioned with the foil 9 below the tube 3. In this case the primary collimator 10 should be displaced such that this further passage opening 12 is centred with respect to the electron beam 13. The passage opening 11 for the X-radiation is constructed conically so as to define the maximum possible conical beam. Between adjustable plate diaphragms 14, 15, 16 and the primary collimator 10, there is provided an ionisation chamber 18 for monitoring the radiation issuing from the accelerator. Inside the opening 11 of the primary collimator 10 there is located a compensating body 19 for attenuating the X-ray radiation so as to attain, downbeam of the body 19, uniform radiation over the entire cross-section of the conical beam. In the target-carrier 5 there is in the bore 6 containing the target 8 and directly downbeam of the target 8 an electron absorber 20 made of copper.

The electron absorber 20 absorbs the electrons downbeam of the target. At the same time, however, X-ray deceleration radiation is also produced in the material of the electron absorber. Because the point of origin of these X-rays is spaced apart from the location of the X-rays from the target, these X-rays cannot be limited with the adjustable plate diaphragms 14, 15, 16 to exactly the same field as the X-radiation produced in the target itself. The X-radiation produced in the electron absorber 20 thus contributes to the formation of penumbral areas.

As in the emitter head 1 of Figure 1, the emitter head 1′ constructed in accordance with the invention and illustrated in Figure 2, has scattering foils 26 and a target 27 in bores 21, 22 of the target-carrier 25 disposed in the direction of radiation directly downbeam of the X-ray window 23 of the beam guidance tube 24. The electron absorber 28 inserted in the target carrier 25 directly downbeam of the target 27 does not consist of copper, however, but of a material of a lower atomic number than copper. In this exemplified embodiment, the electron absorber 28 is formed from graphite. Because of the reduced absorption coefficients in comparison with an electron absorber made of copper, a further additional electron absorber 29 is disposed in the opening 30 of the primary collimator 31 which is downbeam of the target carrier 25 in the direction of radiation. This additional absorber 29 is also formed of a material of a lower atomic number than copper; in the exemplified embodiment aluminium has been used because of facilitated processing. That section of the opening 30 of the primary collimator 31 which is not occupied by the compensating body 32 is available for this additional electron absorber 29. This section is long enough to enable the atomic number of the material of the additional absorber 29 to be as low as 6. The arrangement of the remaining structural elements such as ionisation chamber 33, the adjustable plate diaphragms 34, 35, 36 and the further opening 37 for electron radiation in the primary collimator 31, remains unchanged.

Figure 3 shows the mounting of the additional electron absorber 29 in the opening 30 of the primary collimator 31. For this purpose the passage opening of the primary collimator which tapers conically towards the target 27, is bored out cylindrically at its narrowest point and provided with an encircling inwardly projecting rim. The outer dimensions of the additional electron absorber 29 are matched to the inner dimensions of the opening 30 of the primary collimator 31, such that it can be inserted into the opening 30 and fully abut the inner wall of the primary collimator 31 up to the inner section of the protruding rim in the conical section. The end of the additional electron absorber 29 nearest the target 27 is provided with an encircling annular groove 39 into which a spring ring 40 can be inserted. The spring ring 40 bears on the protruding rim edging 38 of the primary collimator 31 and thus anchors the additional electron absorber securely in the primary collimator 31.

If the electron accelerator for the production of X-ray deceleration radiation is operated with the target 27 in the electron beam 41, the electrons are no longer fully absorbed in the electron absorber 28, which is disposed on the target carrier 25 downbeam of the target 27 in the direction of radiation due to the low atomic number of the material used for the electron absorber, unless the thickness of the electron absorber and thus of the emitter head 1' is considerably increased. By installing the additional electron absorber 29 in the opening 30 of the primary collimator 31, but upbeam of the compensating body 32, a path sufficient for complete absorption of the electrons can be obtained in the material of the two successively arranged electron absorbers 28 and 29, without the atomic number of the material of the electron absorber having to be greater than the atomic number of aluminium. As a result of this atomic number being significantly reduced as compared with previous absorbers, no additional X-radiation is produced in the material of the electron absorbers 28 and 29. Consequently the collimation achieved with the adjustable plate diaphragms 34, 35, 36 is sharper and the maximum of the energy spectrum of the X-radiation is shifted into the longer wave region to a somewhat lesser extent.

By disposing a part of the electron absorber in the primary collimator 31, the primary collimator 31 also participates in the head dissipation from the electron absorber 29. Thus, target carrier 25 does not have to dissipate so much heat. Surprisingly, as a result of the insertion of an additional electron absorber into the passage opening of the primary collimator, the otherwise customary dose magnification at the edge region of the maximum adjustable beam field may be decreased.

WHAT WE CLAIM IS:-

1. An apparatus for producing X-ray radiation, comprising a target which in use is exposed to an electron beam so as to produce a conical beam of X-ray radiation; a primary collimator with an opening defining the largest desired angle of the conical beam of X-ray ratiation; a first electron absorber made from one or more elements having an atomic number lower than that of copper, mounted downbeam of the target; and a second electron absorber, made from one or more elements having an atomic number lower than that of copper, mounted in the opening in the primary collimator, the dimensions of the second electron absorber being similar to the corresponding dimensions of the opening.

2. An apparatus as claimed in claim 1, including adjustable plate diaphragms disposed downbeam of the primary collimator.

3. An apparatus as claimed in claim 1 or 2, including an electron accelerator for producing the electron beam to which in use the target is exposed.

4. An apparatus as claimed in any of claims 1 to 3, wherein the first electron absorber is made from aluminium.

5. An apparatus as claimed in any of claims 1 to 3, wherein the first electron absorber is made from graphite.

6. An apparatus as claimed in any of claims 1 to 5, wherein the second electron absorber is made from aluminium.

7. An apparatus as claimed in any of claims 1 to 5, wherein the second electron absorber is made from graphite.

8. An apparatus as claimed in any of claims 1 to 7, wherein the opening in the primary collimator is formed as a frustrum, the end of small diameter being nearest to the target.

9. An apparatus as claimed in claim 8, wherein the end of small diameter is widened and is provided with an annular rim which supports the second electron absorber but which does not interfere with the largest possible conical beam of X-ray radiation.

10. An apparatus as claimed in claim 9, wherein a spring ring is located in an annular groove in the second electron absorber, the spring ring bearing on the annular rim to support the second electron absorber.

11. An apparatus for producing X-ray radiation, substantially as hereinbefore described with reference to and as shown in Figures 2 and 3 of the accompanying drawing.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

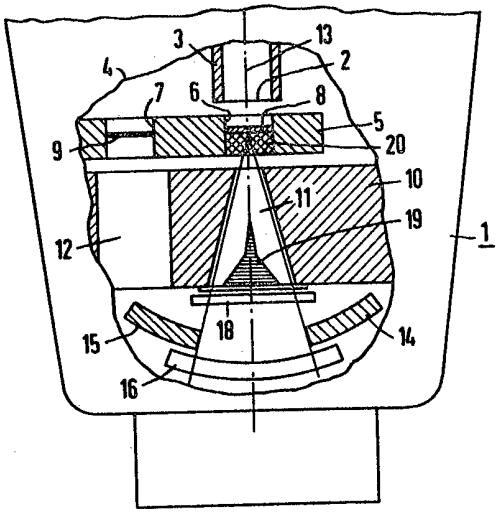

Fig. 1

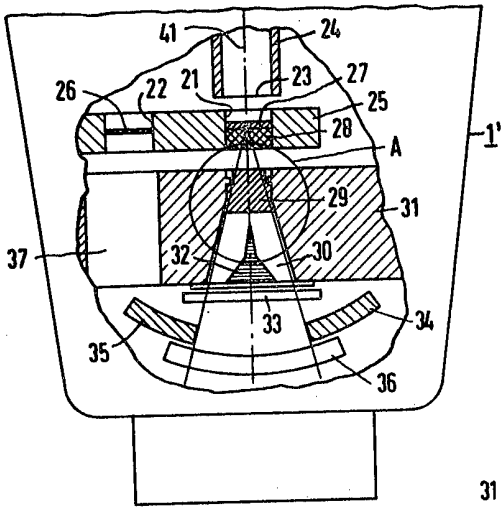

Fig. 2

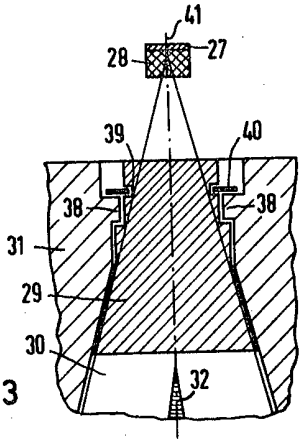

Fig. 3