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Shimizu

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[54] **X-RAY SOURCE FOR GENERATING AN X-RAY BEAM HAVING SELECTABLE SECTIONAL SHAPES**

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July 30, 1970 Japan.....45/66867

[52] **U.S. Cl.**.....**250/90,** 250/49.5 D, 313/57

[51] **Int. Cl.**.....**H01j 37/20**

[58] **Field of Search**.....313/DIG. 3, 57, 83; 250/90, 49.5 C, 49.5 D

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Assistant Examiner—Harold A. Dixon
Attorney—William H. Webb et al.

[57] **ABSTRACT**

This specification discloses an X-ray source comprising an electron gun, an astigmator, a condenser lens and a target. The astigmator comprises four electrodes to which a voltage is supplied, said voltage determining the sectional shape of the electron beam passed through the astigmator. The electron beam passed through the astigmator is focused on the target by the condenser lens, the resultant impingement causing an X-ray to be generated from the target.

4 Claims, 4 Drawing Figures

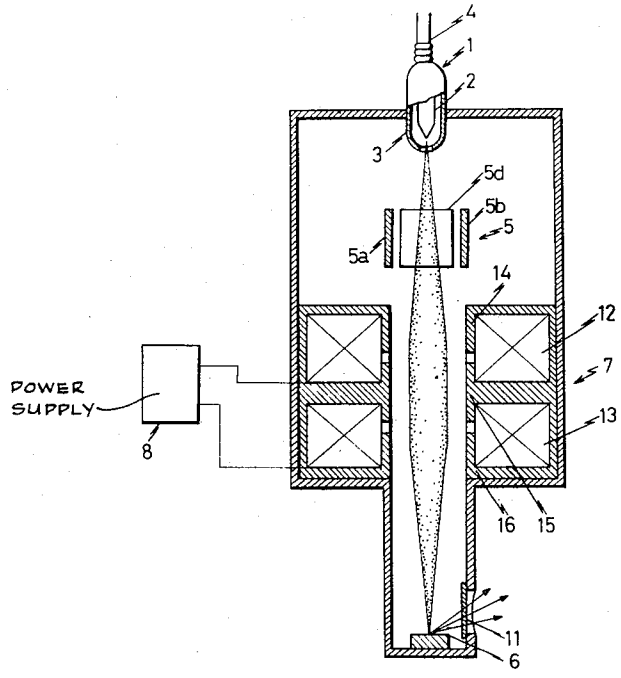


Fig. 1

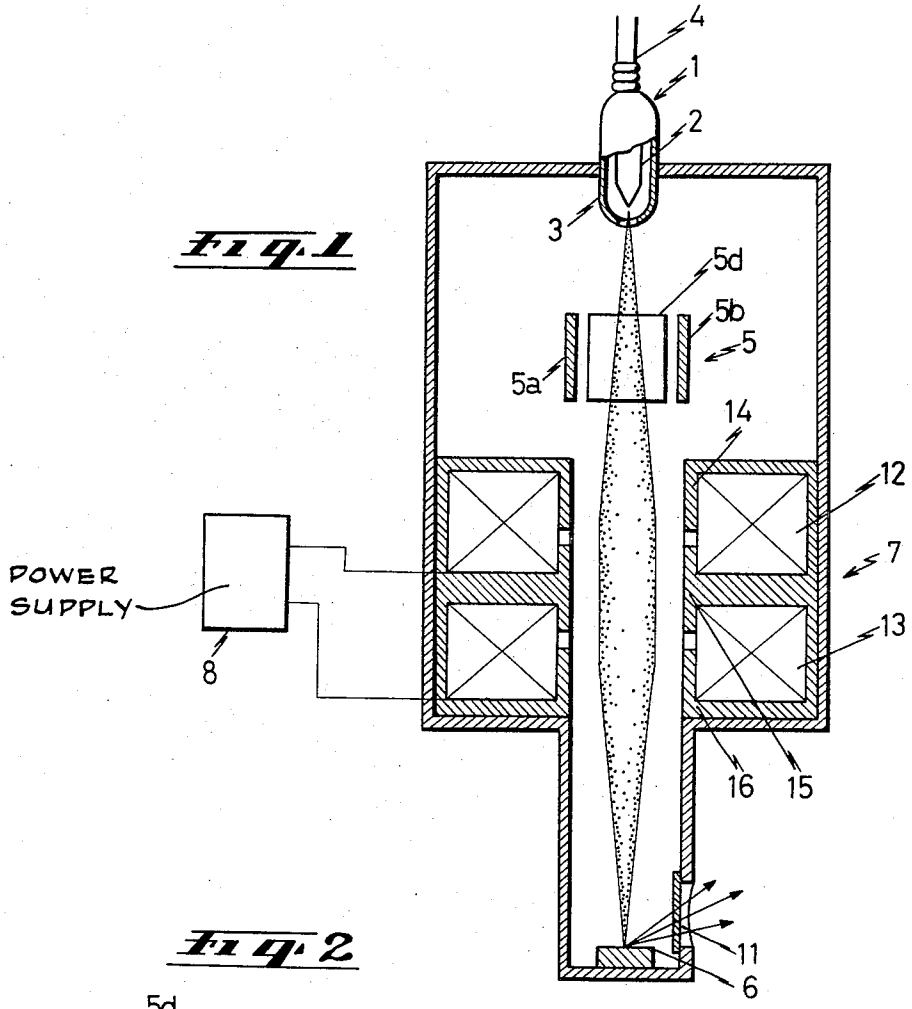


Fig. 2

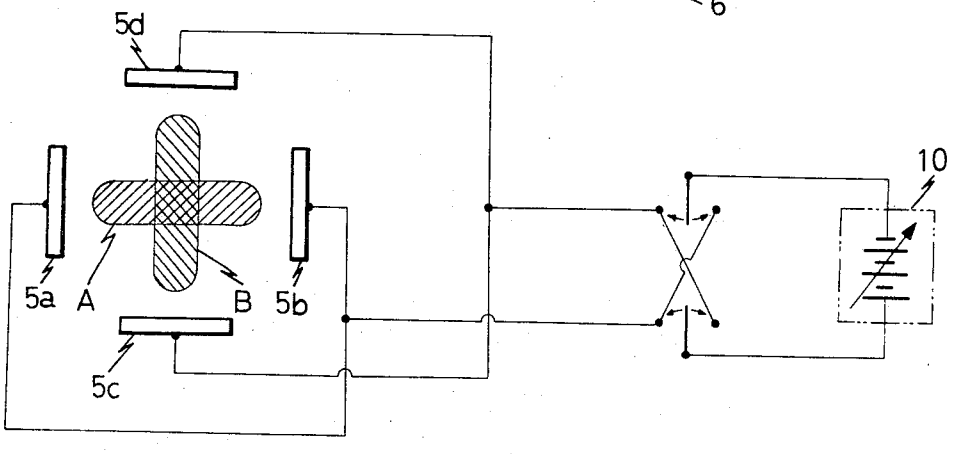
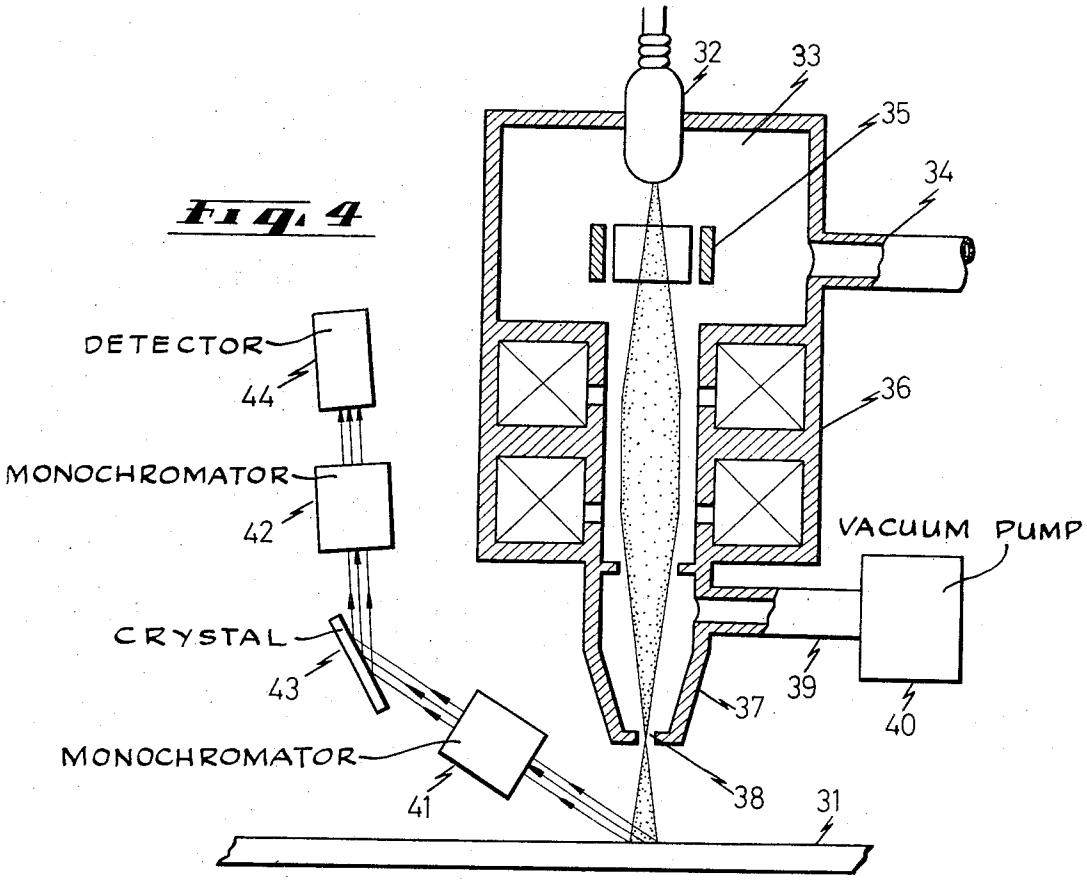


Fig. 4


32
33
35
34
DETECTOR
44
36
MONOCHROMATOR
42
VACUUM PUMP
CRYSTAL
43
39
37
40
MONOCHROMATOR
41
38
31

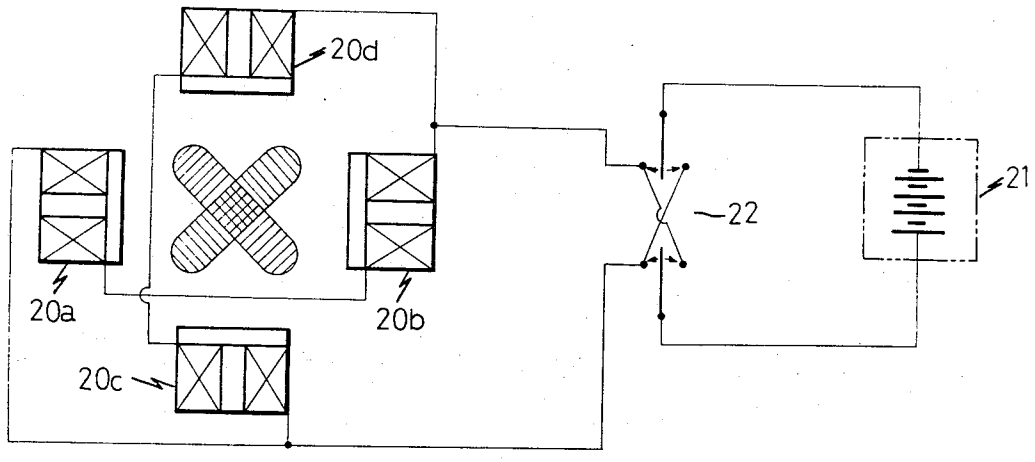

20d
22
21
20a
20b
20c

Fig. 3

X-RAY SOURCE FOR GENERATING AN X-RAY BEAM HAVING SELECTABLE SECTIONAL SHAPES

This invention relates generally to an X-ray source and more particularly to an X-ray source capable of generating X-rays having a plurality of sectional shapes.

In X-ray apparatus for the structural analysis of materials, it is necessary to use various kinds of X-ray source dependent upon the nature of the analysis being carried out. In general, the X-ray source comprises an electron gun, a condenser lens and a target. The electrons emanating from the gun are focused on the target by the condenser lens. The resultant impingement causes an X-ray to be generated from the target. However, when using an X-ray projection pattern camera, for example, a point X-ray source is used. In this case, the incorporated filament is of the hairpin type so as to form a very small circular image of the electron beam on the target. Again, when using a Laue Camera, a line X-ray source is used. In this case, a line filament is incorporated so as to form a long, narrow image of the electron beam on the target.

It will thus be appreciated that a number of X-ray sources are necessary in order to cover a variety of analyses.

Briefly, according to this invention, there is provided a single X-ray source capable of generating a multiplicity of X-rays. This is effected by placing an electrostatic or electromagnetic astigmator between the electron gun and the electromagnetic condenser lens and by varying the voltage or current applied to said astigmator so as to change the shape of the electron image on the target according to the purpose of analysis.

Various other objects and advantages pertaining to this invention will become more readily apparent from the following detailed description read in conjunction with the accompanying drawings in which:

FIG. **1** shows an embodiment of this invention in which an electrostatic astigmator is provided;

FIG. **2** is a diagram of an electrostatic astigmator showing the cross section of the electron beam after passing through the astigmator;

FIG. **3** is a diagram of an electromagnetic astigmator; and,

FIG. **4** shows an apparatus for generating an X-ray according to this invention.

Referring to FIG. **1**, an electron gun **1** comprises a hairpin filament **2** and an anode **3**. Filament heating current and high voltage for energizing the anode are applied to the gun from a power supply source (not shown) via a high tension cable **4**. The accelerated electrons pass through an electrostatic astigmator **5** comprising four electrodes **5***a*, **5***b*, **5***c* and **5***d*, and are focused on a target **6** such as Fe or Mo by a condenser lens **7** suitably energized by a power supply source **8**. In this arrangement, a control voltage is supplied to the astigmator **5** from a power supply source **10** (see FIG. **2**). Electrodes **5***a* and **5***b* are maintained at a positive potential and electrodes **5***c* and **5***d* at a negative potential. Thus, the electrons passing through the astigmator are attracted towards electrodes **5***a* and **5***b* and repelled from electrodes **5***c* and **5***d*, a phenomenon which causes the electron beam to become elongated as shown by the cross section A in FIG. **2**. Consequently, an electron beam of similar shape, that is to say, long and narrow, impinges on the target **6** forming a replica image and the resultant generated X-ray passes through an Al or Be window **11**.

By reversing the polarity of the astigmator electrodes, cross section A becomes orientated as shown by cross section B. Further, when the voltage applied to the four electrodes is zero, the electron beam cross section remains unchanged and the X-ray source functions as a point source.

In this embodiment, the condenser lens **7** comprises two coils **12** and **13** and three pole pieces **14**, **15** and **16**. In order to prevent the lens from rotating the electron beam and to facilitate spot size adjustment, the polarities of pole pieces **14** and **16** are arranged so as to be opposite that of pole piece **15**.

In the above embodiment, an electrostatic astigmator is used for adjusting the sectional shape of the electron beam. However, it is possible to use an electromagnetic astigmator in lieu as shown in FIG. **3**. In this case, four electromagnets **20***a*, **20***b*, **20***c* and **20***d* replace the four electrodes **5***a*, **5***b*, **5***c* and **5***d* shown in FIG. **2**. The magnets are energized by a power supply **21** via a switch **22**, in order to produce a magnetic field, said field serving to control the shape of the electron beam.

In the apparatus shown in FIG. **4**, an electron beam irradiates a specimen **31** placed in the atmosphere so as to cause the specimen to generate an X-ray. The electron beam is produced by an electron gun **32** positioned in a chamber **33** which is connected to a vacuum pump (not shown) via a tube **34**. The beam passes through an electrostatic astigmator **35**, a nonrotating electromagnetic condenser lens **36** and a nozzle **37** having a small opening **38**. The air entering the nozzle **36** through the opening **38** is exhausted by a vacuum pump **40** via a tube **39**. The sectional shape of the beam is adjusted by the astigmator **35** and then focused in the neighborhood of the opening **38** by the condenser lens **36**. By so doing, it is possible to reduce the diameter of the opening to an extent whereby the air entering the nozzle through the opening is decreased. The electron beam passed through the opening **38** is irradiated on the specimen **31**, the resultant impingement causing an X-ray to be generated from the specimen. The generated X-ray is dispersed according to its wavelength and detected by a monochromator comprising slits **41** and **42**, a crystal **43** and a detector **44**. As a result, the specimen is quantitatively and qualitatively analyzed.

Having thus described the invention with the detail and particularity as required by the Patent Laws, what is desired protected by Letters Patent is set forth in the following claims.

I claim:

1. An X-ray source for generating an X-ray pattern having a plurality of selectable sectional shapes comprising:

A. an electron gun for producing an electron beam;

B. a condenser lens comprising two coils, first, second and third pole pieces, the polarities of said first and third pole pieces being arranged opposite that of the second, such that the electron beam is not substantially rotated passing through the lens;

C. means including an astigmator lens placed between said gun and condenser lens for shaping the electron beam into at least two distinct shapes;

D. a target on which said beam is focused by said condenser lens, such that a shaped X-ray beam emits therefrom relating to the shape of the electron beam impinging thereon.

2. An X-ray source according to claim 1 wherein said astigmator comprises four electrodes connected to a power supply source.

3. An X-ray source according to claim 1 wherein said astigmator comprises four electromagnets connected to a power supply source.

4. An apparatus for generating an X-ray pattern having a plurality of selectable sectional shapes comprising:

A. a vacuum chamber;

B. a nozzle, having a minute opening, said nozzle being connected to said chamber;

C. a vacuum pump for exhausting the air entering the opening of said nozzle;

D. an electron gun for producing an electron beam;

E. a condenser lens for focusing said beam so as to pass through the opening of said nozzle, comprising two coils, first, second and third pole pieces, the polarity of said first and third pole pieces being arranged opposite that of the second such that the electron beam is not substantially rotated; and,

F. means including an astigmator lens placed between said gun and said lens, for varying the sectional shape of the electron beam passed through the opening of said nozzle, such that said beam may irradiate a specimen to generate an X-ray relating to the shape of the electron beam.

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