June 28, 1949. H. FRIEDMAN 2,474,240

FOCUSING X-RAY MONOCHROMATOR

Filed Aug. 8, 1945

FIG. 1

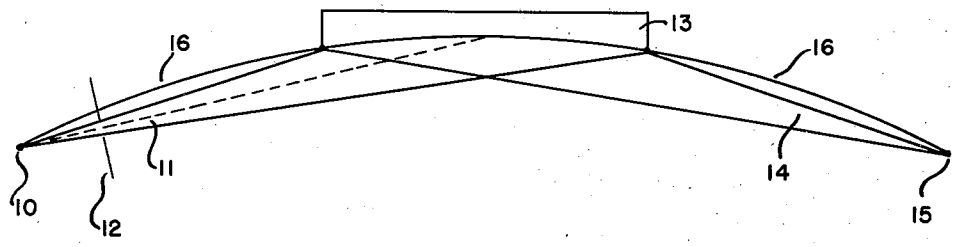


FIG. 2

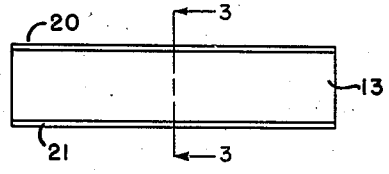
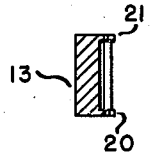


FIG. 3



Inventor

HERBERT FRIEDMAN

By Ralph L. Chappell

Attorney

Patented June 28, 1949 2,474,240

UNITED STATES PATENT OFFICE

2,474,240

FOCUSING X-RAY MONOCHROMATOR

Herbert Friedman, Arlington, Va.

Application August 8, 1945, Serial No. 609,695

9 Claims. (Cl. 250—51)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

My invention relates to a method and apparatus for the production of focused beams of monochromatic X-rays.

In so far as this application discloses subject matter common to my prior-filed applications, Serial Numbers 452,599 and 553,262, filed July 28, 1942, and September 8, 1944, respectively, now Patents 2,386,785 and 2,428,796, respectively, it may be considered a continuation-in-part thereof.

For many purposes in the X-ray study and testing of materials it is desirable to have monochromatic or substantially monochromatic X-rays in the form of a focused beam. Accordingly, it is an object of my invention to provide a simple apparatus and method for the monochromating and focusing of X-rays into a beam.

It is a second object of my invention to show how my apparatus can be used in conventional X-ray spectrometers to produce focused beams of monochromatic X-rays for the production of X-ray diffraction patterns with very little background.

Other objects and advantages of my invention will in part be obvious and in part appear hereinafter in the detailed description of several simple embodiments thereof.

My invention, accordingly, comprises the method of simultaneously monochromating and focusing X-rays and includes the several steps and the relation of one or more such steps with respect to each of the others and the apparatus comprising the X-ray focusing monochromator embodying the features of construction, combination and arrangement of parts adapted to effect such steps, all as exemplified in the detailed disclosure hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature, scope and method of accomplishing the objects of my invention, reference should be had to the following detailed description taken in conjunction with the accompanying drawings in which,

Figure 1 is a diagrammatic illlustration of a monochromator made and mounted in an X-ray spectrometer according to the principle of my invention;

Figure 2 is a view of the face of the monochromator;

Figure 3 is a cross-section taken through the monochromator along the line labeled 3—3.

It is an elementary principle of plane geometry that all angles which can be inscribed in a given arc of a circle are equal. Similarly it is an elementary principle of physics that electromagnetic radiations travel in straight lines. These two principles were first applied to X-ray studies by Sir William Bragg and their embodiment in the Bragg ionization spectrometer appeared many years ago.

2

The bent rock salt crystal monochromator represents a further embodiment of these principles but is limited in its usefulness because of the difficulty of manufacture in that it involves the growth of a large crystal, preparing a reflecting face and bending the plate so produced to a desired radius of curvature.

In Figure 1 I have shown in diagrammatic form the relationship of parts in an X-ray spectrometer employing my monochromator.

In the figure, 10 represents a source of X-rays, which can be the X-ray tube anode sighted according to the method described in my pending application, Serial No. 605,162, filed July 14, 1945, and 11 a divergent beam whose divergence is set by slit 12. Thirteen (13) represents a monochromator, 14 the reflected focused beam of X-rays and 15 the focal spot. By mounting the monochromator 13 in a spectrometer so that X-ray source 10 is on the circumference of the circle, indicated as 16 in the drawing, defined by the radius of curvature of the monochromator, the focused monochromatic beam of X-rays will be found at a point 15 also on the circle so defined. The rays focused at point 15 can be used as a source of monochromatic X-rays for taking diffraction patterns.

Referring to Figure 2, there is there shown a face view of the monochromator 13 to show its structure. As can be seen it comprises a support or backing, preferably of metal, the curved face of which has a pair of slightly raised edges 20 and 21 to define a material-receiving depression.

In Figure 3 there is shown a section of the monochromator taken along the line 2—2 of Figure 2.

Any material which can be prepared in the form of small perfect crystallites which form a highly orienting powder can be used to coat the curved focusing surface of the monochromator to give a strong reflection of monochromatic X-rays at a given angle. I have found that heavy metal acetates such as silver acetate, which grows spinel crystals and gives very intense reflection from powder crystal samples at a Bragg angle of 10°, can be used to coat the focusing surface of the monochromator. The action of the device thus prepared is relatively simply explained. Referring to Figure 1, X-rays originating at source 10 are directed onto the focusing surface of monochromator 13 which is coated with silver acetate. The silver acetate selectively reflects X-rays incident at a Bragg angle of 10° and of a single wave length. The curved backing surface which defines an arc of a circle causes the crystallites to focus the reflected rays at a point on the circle. The result is that at point 15 focused monochromatic X-rays are obtained which originated at source 10.

For convenience in the preparation of the

monochromator, I have found that the curved surface should be accurately milled to a desired convenient radius of curvature. By leaving the edges slightly raised, the surface can be made to define a specimen-receiving depression which is coated with a layer of very fine, perfect, self-orienting crystallites.

For convenience in coating I have found that the crystallites can be suspended in some sort of non-crystalline binding material such as a solution of methyl cellulose, collodion, styrene solutions, or polyvinyl alcohol to make a paste which is smeared onto the monochromator surface.

The crystallite which is to be used as a reflecting medium should be one which forms small perfect crystals which have one long axis and are, consequently, self-orienting when applied to a surface. The crystals are dispersed in the binding agent to form a paste of the crystallites which is subsequently coated on the curved surface. I have found that heavy metal acetates, especially silver and mercuric acetates, are particularly good in that the reflection occurs at a low angle. This permits the sighting of the X-ray source at a low angle and thereby makes possible the use of beam of only slight divergence.

From the foregoing, the various embodiments of my invention will be fully understood, but it is to be understood further that the invention is not restricted to the present disclosure to any extent otherwise than by the manner in which such invention is claimed.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

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

1. An X-ray monochromating and focusing system comprising, a source of non-monochromatic X-ray radiation, and a support having a concave cylindrical surface having bound thereon with a non-crystalline binding material a coating of a finely divided material consisting essentially of selectively reflective crystallites having one axis longer than the other two respective axes, said X-ray source being disposed on the circle defined by said concave cylindrical surface.

2. A focusing X-ray monochromator comprising, a support defining a concave cylindrical surface and having bound thereon by means of a non-crystalline binding material a coating of finely divided selectively reflective crystallites of silver acetate.

3. A focusing X-ray monochromator comprising, a support defining a concave cylindrical surface and having bound thereon by means of a non-crystalline binding material a coating of finely divided selectively reflective crystallites of mercury acetate.

4. A focusing X-ray monochromator comprising, a support defining a concave cylindrical surface and having bound thereon by means of a non-crystalline binding material a coating of finely divided selectively reflective crystallites having one axis longer than the other two axes and with one of the shorter axes perpendicular to said surface.

5. A focusing X-ray monochromator comprising, a support defining a concave cylindrical surface and having bound thereon by means of a non-crystalline binding material a coating of particle material whose particle size with respect to the radius of curvature of said surface is such as to permit the coating to adapt itself substantially to the contour of said curvature, said particle material consisting essentially of selectively reflective crystallites having one axis longer than the other two respective axes and with one of the shorter axes perpendicular to said surface.

6. A focusing monochromator comprising, a support defining a concave cylindrical surface having bound thereon by means of a non-crystalline binding material a coating of particle material consisting essentially of selectively reflective crystallites oriented randomly with respect to the area dimensions of said surface and fixedly with respect to the normal thereto dimension.

7. A focusing monochromator comprising, a support defining a concave cylindrical surface having bound thereon by means of a non-crystalline binding material a coating of particle material consisting essentially of non-equiaxed selectively reflective crystallites oriented randomly with respect to the area dimensions of said surface and fixedly with respect to the normal thereto dimension.

8. In an X-ray monochromating and focusing system, a focusing monochromator of the type defined in claim 7, and a source of non-monochromatic X-rays disposed in the plane of the circle defined by said concave cylindrical surface.

9. An X-ray monochromating system comprising, a source of non-monochromatic X-ray radiation, and a support defining a concave cylindrical surface having bound thereon with a non-crystalline binding material a coating of particle material whose particle size with respect to the radius of curvature of said surface permits the contour of said coating to conform substantially with the contour of said curvature, said particle material consisting essentially of non-equiaxed selectively reflective crystallites, and said X-ray source being disposed in the plane of the circle defined by said concave cylindrical surface.

HERBERT FRIEDMAN.

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