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MONOCHROMATIC X-RAY SOURCE

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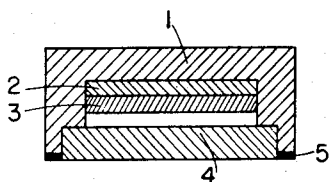


Fig. 1

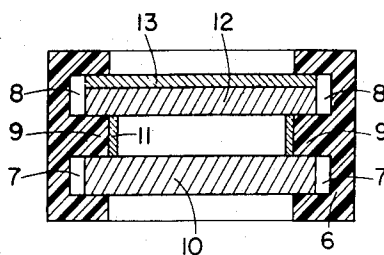


Fig. 2

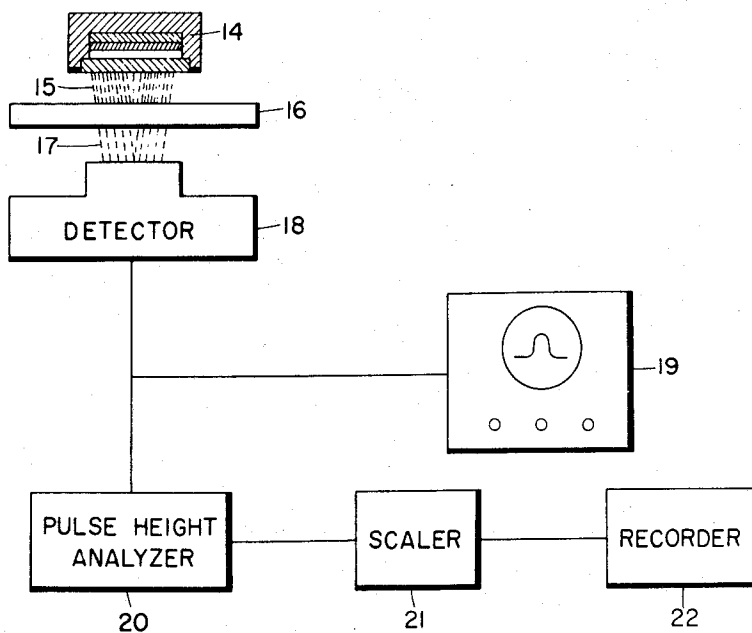


Fig. 3

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MONOCHROMATIC X-RAY SOURCE

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Continuation of application Ser. No. 591,315, June 14, 1956. This application May 14, 1958, Ser. No. 735,264
9 Claims. (Cl. 250—86)

My invention relates to a source of monochromatic X-rays particularly for use in X-ray apparatus such as photometers, spectrometers, and the like.

This application is a continuation of application Serial Number 591,315, filed June 14, 1956, now abandoned.

It is known to generate X-rays by bombarding a suitable target with high speed electrons, e.g. cathode rays in an X-ray tube, or beta rays. The X-ray spectrum produced thereby consists of a continuum of white radiation with a high frequency limit corresponding to the maximum energy of the bombarding electrons. Superposed on this continuum is a characteristic line spectrum of the elements composing the target. For many uses, it is necessary to separate the line spectrum from the white radiation and to utilize only this line spectrum. In the past in order to separate this line spectrum from the white radiation it has been necessary to utilize elaborate systems of filters and reflecting crystals. However, these systems have not proved too satisfactory when an X-ray source free of the white radiation is required.

One method known in the art for producing characteristic X-radiation free of the white continuum is to excite a pure element with polychromatic X-radiation having wave-lengths shorter than the absorption edge of that element (see U.S. Patent 2,449,066, for instance). X-rays so produced are referred to as fluorescent or secondary X-rays since they are generated in the element by primary X-rays having sufficient energy to remove electrons from characteristic levels in the atom just as effectively as cathode rays in an X-ray tube. However, a characteristic X-ray spectrum generated in this manner is far less intense than the X-ray spectrum produced by cathode rays striking a target in an X-ray tube.

A principal object of my invention therefore, is to provide an X-ray source which produces X-rays free of white radiation particularly for use in an X-ray apparatus such as a photometer, spectrometer, or the like.

A further object of my invention is to provide a source of X-radiation which is essentially monochromatic.

These and further objects of my invention will be apparent as the specification progresses.

According to my invention, a source of X-radiation which is free of the white continuum, and which contains only the characteristic radiation of a target material, i.e., only the line radiation of the target material, is provided by a novel assembly comprising a base member consisting of one or more elements adapted upon appropriate irradiation to produce the desired characteristic radiation, a body of material which is capable of exciting this base member to provide this X-radiation, and a cover member enclosing the exposed surface of the exciting body member, said cover member being transparent to X-radiation and relatively opaque to alpha particles.

In one embodiment of my invention an alpha particle emitting material covers the surface of a target whose characteristic X-radiation is desired and the exposed surface of the alpha particle emitting material is covered by a layer of a material which is transparent to X-radiation but which is relatively opaque to alpha particles.

According to another embodiment of my invention, a characteristic X-radiation source comprises a source of alpha particles physically separated from a plate member adapted to produce the desired X-radiation, and a filter

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element for selectively transmitting the X-radiation of this plate member while suppressing the transmission of the α particles.

In a preferred embodiment of my invention I hermetically seal the alpha particle emitting material in the former embodiment.

Another feature of the invention is that the target need not consist of a pure element in which case, a filter is provided to obtain essentially monochromatic X-radiation. More particularly, each element in the periodic system when suitably excited, generates a characteristic spectrum which may comprise one or more lines depending upon the number of electron shells in the atom of that element and the energy level of the exciting radiation. Thus, if the atom contains the K, L, M, and N shells, e.g. iron, a characteristic spectra corresponding to each of those shells will be produced if the level of excitation is sufficient to remove an electron from that shell. If the target includes more than one element, characteristic spectra of each of the elements will thus be produced.

Accordingly, if FeK α radiation is desired, from an iron containing target, it is desirable to place a manganese filter about 0.0075 mm. thick in front of the target. If AgK α radiation is desired from a silver containing target, a palladium filter about 0.03 mm. thick should be used. In some cases, the filter may also serve to suppress the transmission of α particles. Thus, SeK α rays from a selenium containing target will be transmitted by a beryllium plate which will also suppress the α particles.

My invention will now be described in greater detail with reference to the accompanying drawing in which:

FIG. 1 is a cross-sectional view of the preferred embodiment of my invention;

FIG. 2 is a cross-sectional view of another embodiment of my invention; and

FIG. 3 is a schematic diagram illustrating an X-ray photometer utilizing the preferred embodiment of my invention.

The device shown in FIG. 1 comprises a metal container 1 in the form of a hollow cup. Within the container 1 is a base member 2 consisting of a material from which it is desired to generate its characteristic X-radiation. The base member 2 may consist for example, of a metal such as gold, silver, iron, copper, titanium, aluminum, potassium or sodium, an alloy such as steel, bronze or brass, a solid compound such as sodium chloride, potassium chloride, zinc chloride and lead chloride. The base member may be in the form of a solid body or a sintered or pressed powder.

In those instances in which the base 2 consists of a metal or alloy it may be formed as part of the container in which case the container 1 is made of such metal or alloy.

For irradiating the base 2, thereby to provide the desired X-radiation, a layer 3 is provided which consists essentially of an alpha ray source such as Po^{209} , Pu^{239} , Pa^{227} , Sm^{147} , Bi^{197} or At^{217} .

In the preferred arrangement of the invention the layer 3 is formed as a coating or electroplating on the surface of the base 2.

For selectively attenuating the α particles and transmitting solely the X-radiation produced by the base 2, a filter 4 is provided consisting for example of a layer of beryllium, aluminum, mica or plastic such as methyl methacrylate.

The container 1 may be hermetically sealed by brazing the filter layer 4 to the container, for example as shown at 5. The layer 4 in this instance thereby serves as a cover for the container 1.

If the base 2 consists of substantially pure selenium, and is coated with a layer of Po^{209} , the characteristic Se

spectrum will be produced free of the white continuum or general background radiation. The filter 4, in this case, should consist of a beryllium plate to suppress unwanted α particles and to transmit only the $\text{SeK } \alpha$ rays.

The embodiment shown in FIG 2 comprises a frame member 6 the opposite walls of which are provided with longitudinal grooves 7—7 and 8—8 between which are formed inwardly projecting abutments 9—9 and a base portion. The frame member 6 preferably consists of a plastic such as methyl methacrylate. However, as later to be more fully pointed out the frame member 6 may consist of a metal.

Carried within the groove 7—7 is a plate member 10 consisting of a metal adapted to produce the desired X-radiation as pointed out above. For exciting the plate 10 to produce the desired X-radiation, a layer 11 of one of the α particle sources noted above is provided, said layer being in the form of a coating on the abutments 9—9. For attenuating the α particle radiation and selectively transmitting the X-radiation produced there is provided a filter plate member 12. If a pure monochromatic source is desired, an additional filter plate 13 is provided to transmit only a particular characteristic line, such as the $\text{K } \alpha$ line, of the entire characteristic spectrum which is produced. Filters 12 and 13 may consist of any of the materials pointed out in connection with FIG. 1.

When the device of FIG. 2 is to be used as a source of only a single type of X-radiation, the frame member 6 may consist of the same material as the plate member 10.

It will be noted that the plates 10, 12 and 13 are removable from frame member 6 and may be substituted for by other plates whereby X-radiation of different wave lengths may be formed as desired.

In FIG. 3 the source illustrated by FIG. 1 is positioned so that its X-rays 15 irradiate the surface of a thin specimen 16 such as an aluminum strip. The emergent beam 17 which contains in this case the unabsorbed aluminum X-radiation then enters a detector 18 such as a proportional counter which conventionally comprises a chamber having a thin window through which the radiation can pass (in this case a thin window of beryllium), a pair of electrodes and an ionizable medium. A suitable potential is applied between the electrodes so that the entering radiation ionizes the medium and causes conduction proportional to the intensity of the radiation. The output of the detector may be monitored directly by means of cathode ray oscilloscope 19. Preferably, however, the output of the detector is coupled to a multi-channel pulse height analyzer 20 which separates pulses of different amplitudes into groups having definite amplitude intervals. By means of appropriate but conventional scaling circuits 21, the number of pulses per unit time in each amplitude interval are separately counted and recorded, on a strip-chart recorder 22.

Since the attenuation of the X-radiation by the sample is proportional to its thickness comparison of the intensity of the radiation passing through the sample with the intensity of the radiation of the same wave length that passes through a layer of known thickness enables the determination of the thickness of the sample. For this purpose, a single determination on a layer of known thickness for comparison purposes is sufficient.

While I have described my invention in connection with specific embodiments and applications, other modi-

fications thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A source of X-radiation free of the white continuum comprising a base containing at least one element adapted to be excited by alpha particles into producing its characteristic X-radiation, a layer of material relatively opaque to alpha particle radiation and transparent to X-radiation and an alpha particle emitting material interposed between the base and said first layer of material.
2. A source of X-radiation free of the white continuum comprising a base containing at least one element adapted to be excited by alpha particles into producing its characteristic X-radiation, a first plate relatively opaque to alpha particle radiation and transparent to X-radiation, and a second plate containing an alpha particle emitter interposed between the base and said first plate.
3. A source of X-radiation free of the white continuum comprising a base containing at least one element adapted to be excited by alpha particles into producing its characteristic X-radiation, a layer of an alpha particle emitter deposited on said base for exciting said element, and a second layer relatively opaque to alpha particle radiation and transparent to X-radiation completely covering the exposed surface of the alpha particle emitter.
4. A source of X-radiation free of the white continuum comprising a container having wall portions, a base portion containing at least one element adapted to be excited by alpha particles into producing its characteristic X-radiation arranged within said container, a layer of an alpha particle emitter arranged over said base portion and supported by said wall for exciting said base portion and a second layer relatively opaque to alpha particle radiation and transparent to X-radiation, secured to said wall portions and hermetically sealing said container.
5. As a source of monochromatic X-radiation the source of claim 1 in combination with at least one suitable filter transparent only to the desired monochromatic X-radiation.
6. The source of claim 5 in which the filter transparent to the desired monochromatic X-radiation is other than the layer of material opaque to the alpha particle radiation.
7. The source of claim 5 in which the alpha particle emitter is Po^{209} .
8. The source of claim 5 in which the alpha particle emitter is Pu^{239} .
9. A source of X-radiation as defined in claim 3, comprising a base containing aluminum, a hermetically sealed layer of polonium deposited on said base and a layer of beryllium relatively opaque to alpha particle radiation and transparent to X-radiation, completely covering the exposed surface of the polonium layer.

References Cited in the file of this patent

UNITED STATES PATENTS

2,679,609	Meloy	May 25, 1954
2,797,333	Reiffel	June 25, 1957

OTHER REFERENCES

Reiffel: "Beta Ray Excited Low Energy X-ray Sources," article in *Nucleonics*, March 1955, pp. 22 to 24.