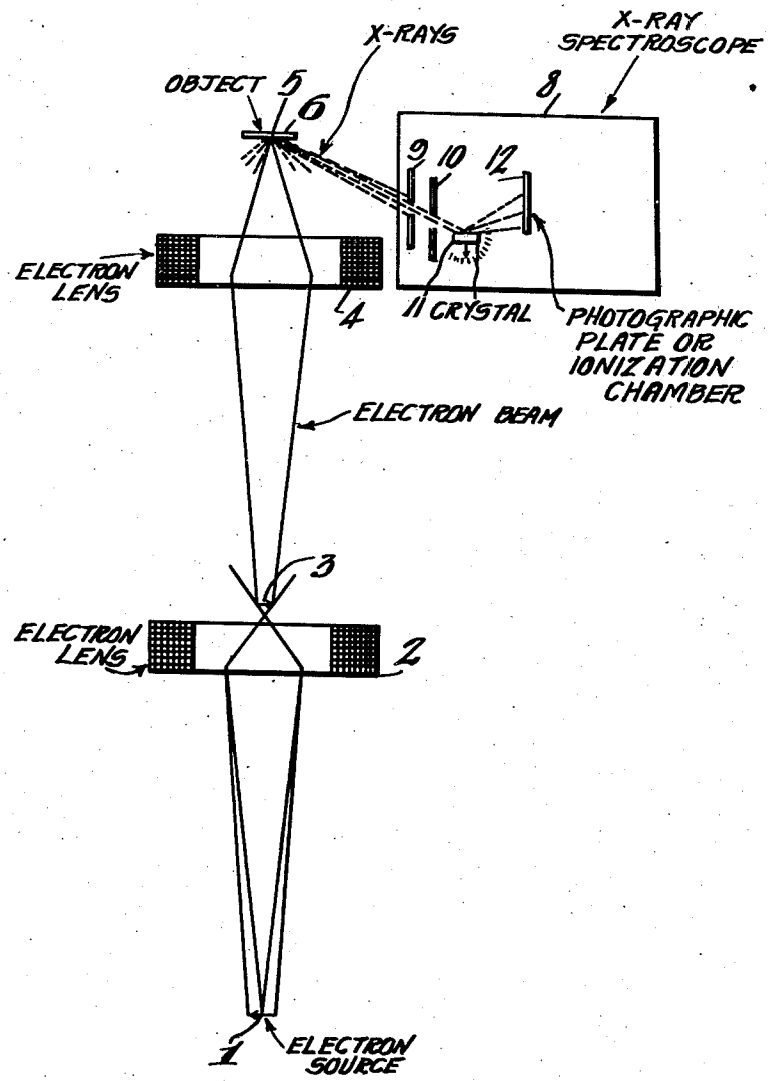
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ELECTRON PROBE ANALYSIS EMPLOYING X-RAY SPECTROGRAPHY

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ELECTRON PROBE ANALYSIS EMPLOYING X-RAY SPECTROGRAPHY

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This invention relates generally to electron optics and more particularly to X-ray spectrographic means for analyzing materials irradiated by an electron beam having minute cross-sectional area.

Investigation of the characteristics of various materials by X-ray analysis is well known. However, the instant invention contemplates a unique improvement upon existing methods of X-ray analysis wherein a minute cross-sectional area of the surface of the material under observation is subjected to irradiation by an extremely fine beam of high velocity electrons. The X-rays generated by the impingement of the high velocity electrons upon the minute electron irradiated material surface area are analyzed by means of any conventional photographic or electrical X-ray spectrographic apparatus. From the wavelengths of the characteristic radiation of the material, the elements thereof may be determined, hence a point analysis of the specimen is desirable.

X-ray spectroscopes of the type described in "X-rays in Theory and Experiment" by Compton and Allison, may be employed to analyze the X-ray radiation derived from the material under observation. The Von Laue type spectrometer, employing a zinc blende crystal for forming a diffraction pattern of the X-ray radiation upon a photographic plate, provides a satisfactory permanent record of the X-ray spectrographic characteristics of the material. Similarly, the Bragg type spectrometer, also described in the reference mentioned heretofore, employs an ionization chamber for indicating the X-ray refraction from a zinc blende crystal the angular relation of which is adjustable with respect to the axis of the derived X-ray radiation. Various other types of X-ray spectroscopes or X-ray spectrometers may be employed to equal advantage.

The instant invention is related to applicant's copending U. S. application, Ser. No. 505,572, filed October 8, 1943, which describes several methods of and means for electron irradiating extremely minute areas of either electron permeable or electron opaque substances. This copending application describes several methods of and means for making a velocity analysis of electrons transmitted by or reflected from said electron irradiated area. The instant invention contemplates means for spectroanalyzing X-ray radiation derived from a minute electron irradiated area of substances which may or may not be substantially opaque to electrons.

Among the objects of the invention are to provide an improved method of and means for microscopically analyzing materials. Another object of the invention is to provide an improved method of and means for microscopically analyzing materials substantially opaque to irradiating electrons. A further object of the invention is to provide an improved method of and means for microscopically analyzing materials by subjecting minute areas of said materials to high velocity electron irradiation, and spectroanalyzing X-rays generated in the vicinity of said electronic irradiation.

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Further objects of the invention include improved means for electron irradiating minute areas of a substance to generate X-rays therefrom and photographic X-ray spectrographic means for providing a permanent record of the X-ray spectrographic characteristics of the said material. An additional object of the invention is to provide an improved means for electron irradiating a minute area of a material to generate X-rays therefrom and electrical means for spectroanalyzing said X-ray radiation.

The invention will be further described by reference to the accompanying drawing of which the single figure is a schematic diagram of a typical embodiment thereof.

Referring to the drawing, an electron source 1, which may comprise, for example, a thermionic cathode and an apertured anode having high electron accelerating potentials therebetween, is focused by a conventional electron lens 2 to form a greatly reduced image 3 of the electron source 1. The image 3 is further focused by means of a second electron lens 4 to form substantially a point image of the electron source 1 at the point 5 on the surface of a material 6 to be spectroanalyzed. It should be understood that the first and second electron lenses 2, 4, respectively, may be of either the conventional electromagnetic or electrostatic types employed in electron microscopes and similar apparatus. The electron lenses may be energized by any means known in the art.

The electron irradiation of the point 5 on the surface of the electron opaque material 6 provides X-ray radiation in the vicinity of the point 5 due to the energy released by the high velocity electrons comprising the electron beam. A portion of this X-ray radiation is intercepted by an X-ray spectroscope 8 of any known type which will provide the desired X-ray spectroanalysis.

For the purpose of illustration, the X-ray spectroscope 8 shown in the drawing, comprises a pair of lead collimating apertures 9, 10 for selecting an extremely minute X-ray beam for

spectroanalysis. The selected X-ray radiation is applied to a crystal 11, which may be composed, for example, of zinc blende. The crystal 11 is arranged to be oriented with respect to the X-ray beam, in order that the X-rays may either be transmitted by the crystal or reflected therefrom. The velocity of the X-rays impinging upon the crystals 11 will determine the refraction of the X-rays derived from the crystal. The X-ray radiation derived from the crystal may be applied to a photographic plate 12, to obtain a spectroscopic pattern characteristic of the material under observation. When employing a photographic plate in an X-ray spectroscope, of the type described, it is customary to orient the crystal so that it transmits the applied X-rays to the photographic plate.

However, if electrical indication of the X-ray characteristics is desired, an ionization chamber, not shown in the drawing, is substituted for the photographic plate 12. The X-rays are reflected from the crystal 11, and the current derived from the ionization chamber is indicated in terms of the angular orientation of the crystal with respect to the axis of the applied X-rays.

Thus the invention described comprises a novel method of and means for spectroanalyzing extremely minute surface areas of materials by focusing a high velocity electron beam upon a minute area of the material surface, and spectroscopically analyzing X-rays generated by said electron bombardment.

I claim as my invention:

1. The method of microscopically analyzing the atomic composition of a material comprising electron irradiating a minute cross-sectional area of said material, generating X-rays in the vicinity of said area in response to said irradiation, and spectroanalyzing said generated X-rays.

2. The method of microscopically analyzing the atomic composition of a material comprising generating an electron probe of minute cross-sectional area, electron irradiating said material by said electron probe, generating X-rays in the vicinity of said area in respons to said irradiation, and spectroanalyzing said generated X-rays.

3. A spectroscope for analyzing the atomic composition of a material including means for supporting said material, means for electron irradiating a predetermined minute cross-sectional surface area of said material to generate X-rays in the vicinity of said irradiation, and means for spectroanalyzing said generated X-rays.

4. A spectroscope including means for generating an electron probe of minute cross-sectional area, means for supporting an object, means for irradiating substantially only a minute surface area of said object by said electron probe to generate X-rays in the vicinity of said electron irradiation, and means for spectroanalyzing said generated X-rays.

5. A spectroscope including means for generating an electron probe of minute cross-sectional area, means for supporting an object, means for irradiating substantially only a minute surface area of said object by said electron probe to generate X-rays in the vicinity of said electron irradiation, and photographic means for spectroanalyzing said generated X-rays.

6. A spectroscope including means for generating an electron probe of minute cross-sectional area, means for supporting an object, means for irradiating said object by said electron probe to generate X-rays in the vicinity of said electron irradiation, and photographic means and an X-ray refracting crystal disposed intermediate said object and said photographic means for spectroanalyzing said generated X-rays.

7. A spectrometer for analyzing the atomic composition of a material including means for supporting said material, means for electron irradiating substantially only a predetermined minute cross-sectional surface area of said material to generate X-rays in the vicinity of said irradiation, and electrical means for spectroanalyzing said generated X-rays.

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