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Zingaro

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[54] **SELECTABLE MULTI-WINDOW X-RAY TUBE**

[76] Inventor: **William P. Zingaro,** 22 Clubway, Hartsdale, N.Y. 10530

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[52] **U.S. Cl.** **313/59**

[51] **Int. Cl.** **H01j 35/18**

[58] **Field of Search** 313/59

[56] **References Cited**

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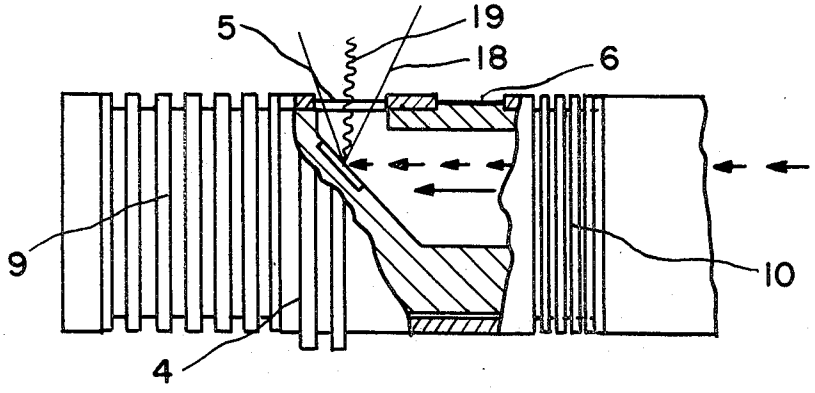
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Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Darwin R. Hostetter
Attorney, Agent, or Firm—Carl P. Steinhauser

[57] **ABSTRACT**

An x-ray tube provides with a plurality of windows mounted in a slide which is hermetically sealed on the exterior of the tube envelope. Movement of the slide which is effected by a bellow at each end of the slide places a window of given thickness and material in the path of x-rays generated within the tube permitting x-rays of different wave-lengths and intensities generated within the tube to be most efficiently and selectively transmitted. The windows may be of different thicknesses and of the same or different material.

7 Claims, 4 Drawing Figures



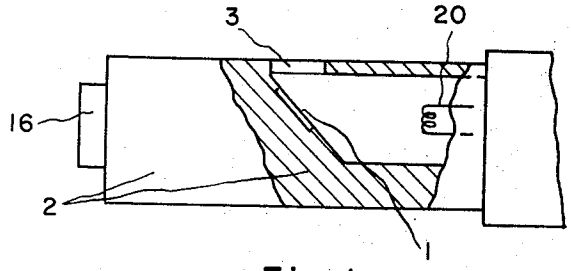


Fig. 1

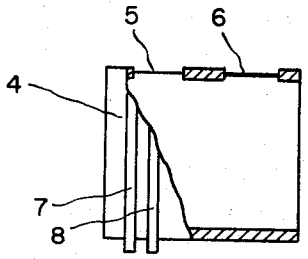


Fig. 2

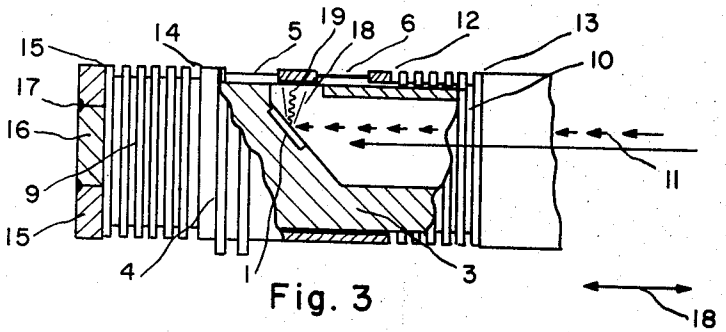


Fig. 3

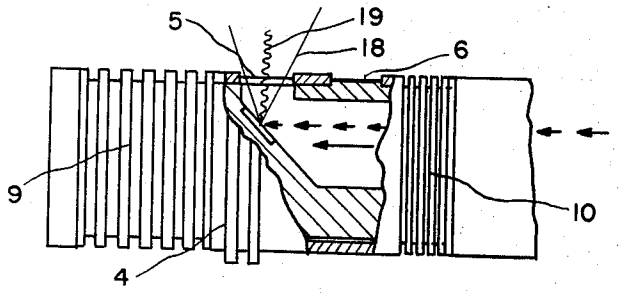


Fig. 4

SELECTABLE MULTI-WINDOW X-RAY TUBE

The invention relates to an x-ray tube having a plurality of windows to permit x-rays of different wave-lengths to be efficiently absorbed or transmitted. More particularly, the invention relates to an x-ray tube having a plurality of windows which may be selected and interposed in the path of x-rays generated within the tube so as to permit the transmission or absorption of x-rays of different wave-lengths from the tube.

It has been customary in this art to provide an x-ray tube with one or more fixed, or stationary windows to permit x-rays generated within the tube to be transmitted and be used outside the tube. Thus, when electrons from a cathode are accelerated by and strike an anode which is at high positive potential three events take place, viz., the production of heat, the production of x-rays, and the deflection of some primary electrons to the interior of the tube structure including the window.

The shortest wave-length of the x-rays generated by electrons striking the target of the tube is dependent upon the accelerating voltage applied to the anode, i.e., the higher the accelerating voltage, the shorter the wave-length. However, with increasing accelerating anode potentials the danger of window damage caused by primary electrons striking the window increases and can cause rupture of the window.

An obvious solution is to make the window thick enough to withstand the bombardment. However, most of the targets used in x-ray tubes for spectrochemical analysis emit intense K, L and M lines. The K lines are high energy, or hard X-rays of relatively short wave-length. The L and M lines are low energy or soft x-rays of relatively long wave-length. It is important that all lines be used for optimum excitation of the elements in a sample to be analyzed, for example by x-ray spectroscopy.

If a thick window is used for the high energy lines, they are transmitted through the window little attenuation. However, the L and M lines come through with little or no intensity. Conversely, while a thin window will efficiently transmit the L and M lines, the tube must be operated at low power thereby reducing the output of the K lines.

Present practice with Cr target tubes is to introduce a Ti foil over the window in order to attenuate the Cr lines from the target. This reduces the intensities of all wave-lengths since the thick Be and Ti is now the window. The slide can be built with a thin Be window on which is plated Ti of suitable thickness.

It is an object of the invention to provide an x-ray tube which can be operated at high power to produce hard x-rays which are transmitted through a port without rupturing the window.

It is another object of the invention to provide an x-ray tube having a plurality of windows which are selectable to provide different transmissibilities for x-rays of different hardness produced within the tube.

It is still another object of the invention to provide an x-ray tube having a window which is selectable from several without interrupting the vacuum within the tube.

These and further object of the invention will appear as the specification progresses.

In accordance with the invention an x-ray tube is provided with a plurality of windows of different thickness and transmission characteristics which can be inserted serially over a port to permit the escape of x-rays generated within the tube. In order to maintain the vacuum within the tube, and to facilitate the changing of windows, they are mounted in a sleeve which is slideable along the exterior wall of the tube envelope. The sleeve in which the windows are mounted is hermetically sealed to the external wall of the envelope, preferably by bellows which permits the sleeve to move without interrupting the vacuum within the tube.

The invention will be described with reference to the accompanying drawing in which:

FIG. **1** shows an x-ray tube partly in section;

FIG. **2** shows an x-ray tube with two windows;

FIGS. **3** and **4** show an x-ray tube with a slideable sleeve carrying two or more windows.

The x-ray tube shown in FIG. **1** has a cathode **20** and target, or anode **1**, embedded in a housing **2**. X-rays are emitted through a port **2** which has no window.

A sleeve **4** (FIG. **2**) is slideably mounted on the x-ray tube housing **2** and carries two, or more windows **5** and **6** respectively (FIGS. **3** and **4**). Window **5** is relatively thin to permit the passage of the relatively soft x-rays of the L and M series, or longer wave-length K-lines produced when the tube is operated at low power. Window **6** is relatively thick and serves to transmit lines of the K-series produced when the tube is operated at high power. Thus, at low power, the number of primary electrons striking the window is small, and the danger of rupture minimal so that a thin window may be used; at higher power, the thick window is better capable of withstanding rupture due to electron bombardment.

The sleeve **4** is provided with projections **7** and **8** (FIG. **2**) which serve to contact a linkage (not shown) to slide the sleeve on the housing **2**. One end of bellows **10** (FIG. **3**) is welded to the sleeve and at the other end to the housing **2** around its circumference at **12.** The other end of the bellows is welded to housing **2** around its circumference at **13.**

A second bellows **9** is welded to sleeve **4** around its circumference at **14.** The other end of the bellows is welded to a ring **15.** The ring **15** is welded to a stub **16** of housing **2.**

In this way the integrity of the high vacuum required in the tube is maintained as the sleeve is moved in the directions shown by the double headed arrow.

In FIG. **4,** the sleeve has been moved to the right and window **5** is in position to transmit low energy x-rays **19.** Bellows **9** has been expanded while bellows **10** has been contracted. In like manner, movement of the sleeve to the left will place the thick window in transmitting position.

Windows **5** and **6** may also be of different construction. Thus, one of these windows may be mylar or mica and the other of beryllium, and which may be covered by a thin layer of titanium or other absorbing material.

Other features such as ducts for cooling water, electrical connections for a power supply and the like have been omitted for the sake of clarity. The construction of the anode, and the cathode have also been omitted for the sake of clarity.

What I claim is:

1. An x-ray tube comprising an evacuated envelope, cathode and anode electrodes in said envelope for producing x-rays, a port in said envelope for the transmission of the x-rays generated within said tube, a first material relatively more transparent to x-rays of longer

wave-length and a second material relatively less transparent to longer wave-length x-rays but more resistant to electron bombardment, and means for moving and positioning one of said latter materials to cover said port without interrupting the vacuum in said envelope.

2. An x-ray tube as claimed in claim **1** in which each of said materials is positioned in a hermetically sealed sleeve which is slideable over the exterior surface of said envelope.

3. An x-ray tube as claimed in claim **2** in which the slide is attached at each end to a bellows which is hermetically sealed to the envelope.

4. An x-ray tube as claimed in claim **3** in which the window relatively more transparent to x-radiation has a thickness less than that of the window less transparent to x-radiation.

5. An x-ray tube as claimed in claim **3** in which the window includes an element which absorbs unwanted lines produced by excitation of the anode.

6. An x-ray tube as claimed in claim **4** in which the window is beryllium.

7. An x-ray tube as claimed in claim **5** in which the window is beryllium coated with titanium.

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