Oct. 13, 1942. Z. J. ATLEE 2,298,335

MULTIPLE TARGET ANODE

Filed Sept. 10, 1940

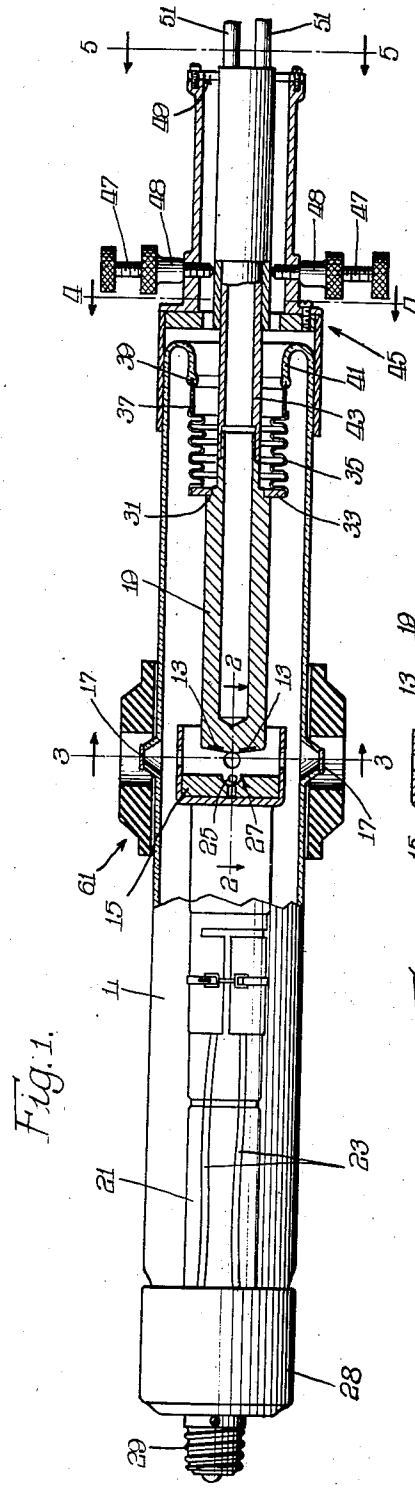

Fig. 1.

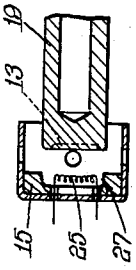

Fig. 2.

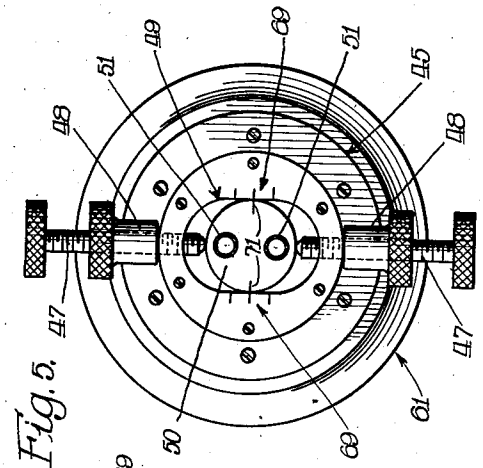

Fig. 5.

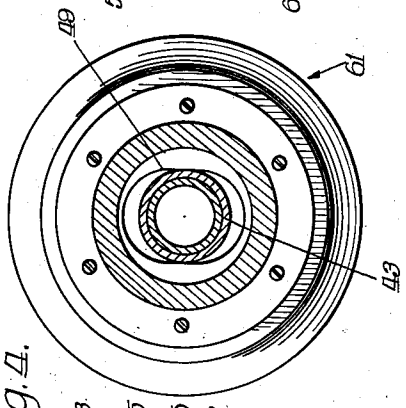

Fig. 4.

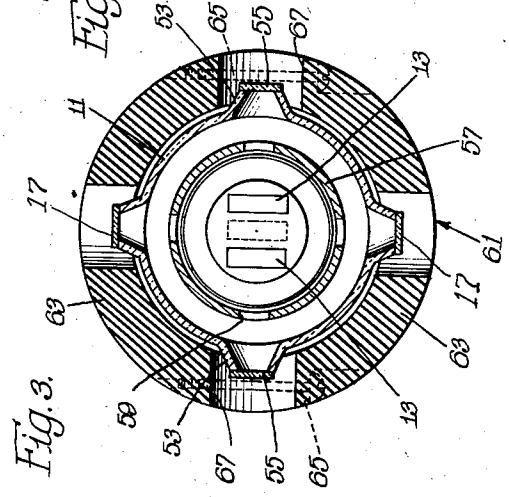

Fig. 3.

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MULTIPLE TARGET ANODE

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6 Claims. (Cl. 250—144)

My invention relates in general to Roentgenology and has more particular reference to an X-ray tube having an anode providing a plurality of targets for producing X-rays of predetermined character at each target, whereby the X-ray tube is adaptable to produce a plurality of rays having characteristics corresponding each with the target material.

An important object of the present invention resides in providing, particularly in an X-ray tube, an anode having a plurality of targets, each of which, when energized, produces corresponding X-rays having characteristics different from the rays produced at the other targets.

Another important object is to provide an X-ray tube particularly well adapted for analysis of materials by X-ray diffraction.

Another important object resides in providing an X-ray tube having an anode formed with a plurality of targets of unlike material, including an adjustable mounting for the anode, whereby a selected target may be positioned in focal operating position with respect to the cathode of the tube, so that the tube may be conditioned to emit X-rays generated by electron impingement upon any selected one of a plurality of targets.

The foregoing and numerous other important objects, advantages and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawing, discloses a preferred embodiment of the invention.

Referring to the drawing:

Figure 1 is a side view, partially sectionalized, of an X-ray tube embodying my present invention; and

Figures 2, 3, 4 and 5 are sectional views taken substantially along the lines 2—2, 3—3, 4—4 and 5—5 in Figure 1.

Analysis of materials may be accomplished by exposing the material to be analyzed to X-rays and observing the X-ray diffraction characteristics of the material as by recording the same on a sensitive film.

The choice of a proper target material for X-ray diffraction analysis depends to a great extent upon the type of specimen being examined, the particular technique to be used, and the kind of information sought.

The radiation from an X-ray tube consists of a continuous, or "white," spectrum, the wave length and intensity distribution of which depends largely upon the potential employed, and a characteristic sharp "line" spectrum comprising a relatively few lines, each of which has a specific wave length, depending only upon the type of X-ray target material employed in producing the X-rays. This "line" spectrum is entirely independent of the operating potential above a minimum voltage, which minimum voltage also is characteristic of the target material. Any suitable target material may, of course, be employed for X-ray diffraction analysis, provided, of course, the material of the target and hence its "line" spectrum is known. Otherwise the lines caused by the target material in the spectrograph of the material being examined may be mistaken for lines supposedly caused by the material being examined. It will be obvious also that various materials to be examined by diffraction may best be examined by using different targets.

In order to facilitate examination of materials by X-ray diffraction, I have provided an X-ray tube 11 having a plurality of targets 13 of unlike material so that, by aligning either of the targets in operating position with respect to the cathode 15, X-rays having the "line" spectrum corresponding with the material of either target may be produced at will and projected through the windows 17 for application in diffraction analysis.

The targets 13 may comprise any preferred target material, such as tungsten, molybdenum, copper, nickel, cobalt, iron, chromium, or other desired target material, and, as shown, the targets 13 comprise rectangular buttons set in the end of a target support comprising the anode 19. This support 19 preferably comprises a hollow copper cylinder which is closed at the target end; and if it is desired to produce X-rays having the "line" spectrum characteristic of a copper target, the anode may be aligned to receive electron impingement directly upon the cupreous material of the member 19 at the target end thereof as between the spaced buttons 13.

The cathode 15 preferably comprises a suitable head which may be supported and sealed upon a re-entrant envelope portion comprising a hollow stem 21. Conductors 23 for energizing the electron producing filament 25 may extend through the stem 21. The cathode end of the tube may be fitted with a ferrule 28 carrying a base 29 for connecting the conductors 23 with a suitable external source of power for energizing the filament 25 for electron emission.

It will be noted that the filament is of elongated character and is supported in a groove 27 formed in the cathode head, whereby electrons emitted

by the filament, when energized, will be focused substantially along a line parallel to the longitudinal axis of the filament on the target end of the anode. This line focus of electrons makes it possible to bring either of the targets 13 into focal position or to position the anode so that the copper material thereof, extending between the spaced rectangular buttons 13, is positioned to receive focused electrons impinging thereon. To this end, the anode 19 is mounted for tilting movement in the tube envelope so that it may be aligned with either of the buttons 13 or the copper material of the anode intermediate the buttons in electron receiving position. The anode near its target remote end is formed with a shoulder 31 to which is sealed an annular washer 33 forming a sealed anchorage for one end of a flexible, preferably metallic, bellows or Sylphon 35, the other end of which is sealed to a cylindrical ring 37. This ring, in turn, has an annular edge forming a glass-to-metal seal 39 with the re-entrant portion 41 of the envelope of the tube at the anode end thereof. In this fashion, the anode 19 is sealed, yet shiftably mounted on the envelope.

Within the Sylphon 35, the open end of the hollow anode member 19 is fitted with an extension tube 43 which projects outwardly of the end of the envelope through the annular re-entrant portion 41. The anode end of the envelope carries a yoke structure 45 loosely surrounding the projecting end of the extension tube 43, the yoke structure carrying diametrically opposed adjusting screws 47 having knurled operating heads in position outwardly of the yoke for manipulation, the screws, inwardly of the yoke, bearing on the opposite sides of the anode extension and being provided with lock nuts 48 for securing the same in adjusted position. The outermost end of the anode extension 43 preferably extends in an elongated slot 49 so that the extension is movable diametrally in one direction only, that is to say, in the direction of the axes of the adjusting screws 47. The outer end of the anode extension which projects from the yoke assembly 45 is closed and fitted preferably with conduits 51, by means of which a cooling fluid may be circulated into and out of the hollow anode 19.

It will be seen from the foregoing that the anode member 19 is tiltably mounted in the end of the envelope by virtue of the flexible mounting afforded by the Sylphon 35. By adjusting the members 47, the anode 19 may be shifted to bring either of the buttons 13 in position to receive the focused electrons emitted by the filament 25. If adjusted to the position illustrated in the drawing, the anode will be in position to receive focused electrons on the copper area shown in dotted lines in Figure 3 of the drawing intermediate the rectangular buttons 13.

The envelope 11 preferably, though not essentially, comprises lead glass and is formed with conical embossments 53 which are truncated and fitted with preferably lime glass window-panes 55 in position to project, outwardly of the envelope, X-rays emanating from the target end of the anode, Fig. 3. The cathode head 15 also is preferably provided with an annular shell 57 encircling the target end of the anode and formed with openings 59 for the transmission of useful X-ray beams from the anode to the window panes 55. The tube also is preferably enclosed in an annular sleeve 61 preferably comprising the split parts 63 suitably clamped together around the windowed portion of the envelope by means of the screws 65, the sleeve 61 being provided with openings 67 for receiving the conical window projections 53. The sleeve, if desired, may be formed of material opaque to X-rays for the purpose of confining all except desired useful X-rays which emanate from the anode through the openings 59, the window-pane 55, and the openings 67 in the sleeve.

It will be seen from the foregoing that I have provided an extremely useful X-ray generator for producing X-rays at will by electron impingement upon any selected one of a variety of targets. In spectograph analyses, it is a simple matter to condition the tube for the production of X-rays by the excitation of any desired one of the several target materials embodied in the unit, the change from one target to another being merely a matter of adjusting the members 47 and clamping them in place. To facilitate adjustment, I provide gauge marks 69 on the end of the yoke assembly 45 at the edges of the slot 49 and index marks 71 on the closed end 50 of the anode extension 43. By operating the members 47 to bring the index 71 opposite the desired gauge mark 69, the alignment of the anode may be instantly determined.

It is thought that the invention and its numerous attendant advantages will be fully understoood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. An X-ray tube comprising a cathode and an anode, said cathode comprising an elongated electron-emitting filament disposed in position to emit an electron beam of elongated sectional shape toward said anode, said anode being adjustable laterally of said filament whereby to cause impingement of said electron beam upon a selected one of several adjacent elongated target zones in said anode, said zones comprising target material of unlike character whereby resulting X-rays of a desired character corresponding with the target material of the selected zone may be produced.

2. An X-ray tube comprising a cathode and an anode, said cathode comprising a head formed with a focusing groove and an elongated electron-emitting filament disposed in said groove in position to emit a line focused beam of electrons toward said anode, said anode being adjustable laterally of said elongated filament whereby to cause impingement of said focused electrons upon a selected one of several adjacent elongated target zones in said anode, said zones comprising target material of unlike character whereby resulting X-rays of a desired character corresponding with the target material of the selected zone may be produced.

3. An X-ray tube comprising an envelope, a cathode and an anode in facing relationship in said envelope, said anode having a plurality of adjacent target zones comprising unlike target material and said cathode comprising means operable to emit a focused beam of electrons upon said anode, resilient means sealing said anode on said envelope, said resilient means being adapted to flex and permit the anode to be moved within the envelope, and adjusting means

operable outwardly of the envelope to so move the anode in order to present a selected one of said target zones in alignment with said beam whereby to constitute the selected target zone as a source of X-rays through activation thereof by bombardment of focused electrons emanating from said cathode.

4. An X-ray tube comprising an envelope, a cathode and an anode in facing relationship in said envelope, said anode having a plurality of adjacent target zones comprising unlike target material and said cathode comprising means operable to emit a focused beam of electrons upon said anode, resilient means sealing said anode on said envelope, said resilient means being adapted to flex and permit the anode to be moved within the envelope, and adjusting means operable outwardly of the envelope to so move the anode in order to present a selected one of said target zones in alignment with said beam whereby to constitute the selected target zone as a source of X-rays through activation thereof by bombardment of focused electrons emanting from said cathode, said adjusting means comprising a mounting on said envelope, and threaded means adjustable on said mounting and drivingly connected with said anode for adjustably shifting the same within the envelope.

5. An X-ray tube comprising an envelope, a cathode and an anode in facing relationship in said envelope, said anode having a plurality of adjacent target zones comprising unlike target material and said cathode comprising means operable to emit a focused beam of electrons upon said anode, resilient means sealing said anode on said envelope, said resilient means being adapted to flex and permit the anode to be moved within the envelope, and adjusting means operable outwardly of the envelope to so move the anode in order to present a selected one of said target zones in alignment with said beam whereby to constitute the selected target zone as a source of X-rays through activation thereof by bombardment of focused electrons emanating from said cathode, said adjusting means comprising a mounting on said envelope forming a guideway, said anode having a portion extending outwardly of said envelope in said guideway, and means on said mounting for adjustably shifting said anode portion in said guideway.

6. An X-ray tube comprising an envelope, a cathode and an anode in facing relationship in said envelope, said anode having a plurality of adjacent target zones comprising unlike target material and said cathode comprising means operable to emit a focused beam of electrons upon said anode, resilient means sealing said anode on said envelope, said resilient means being adapted to flex and permit the anode to be moved within the envelope, and adjusting means operable outwardly of the envelope to so move the anode in order to present a selected one of said target zones in alignment with said beam whereby to constitute the selected target zone as a source of X-rays through activation thereof by bombardment of focused electrons emanating from said cathode, said adjusting means comprising a mounting on said envelope forming a guideway, said anode having a portion extending outwardly of said envelope in said guideway, means on said mounting for adjustably shifting said anode portion in said guideway, and co-operating gauge marks on said outwardly extending anode portion and on said guideway for indicating the adjusted position of the anode within the envelope.

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