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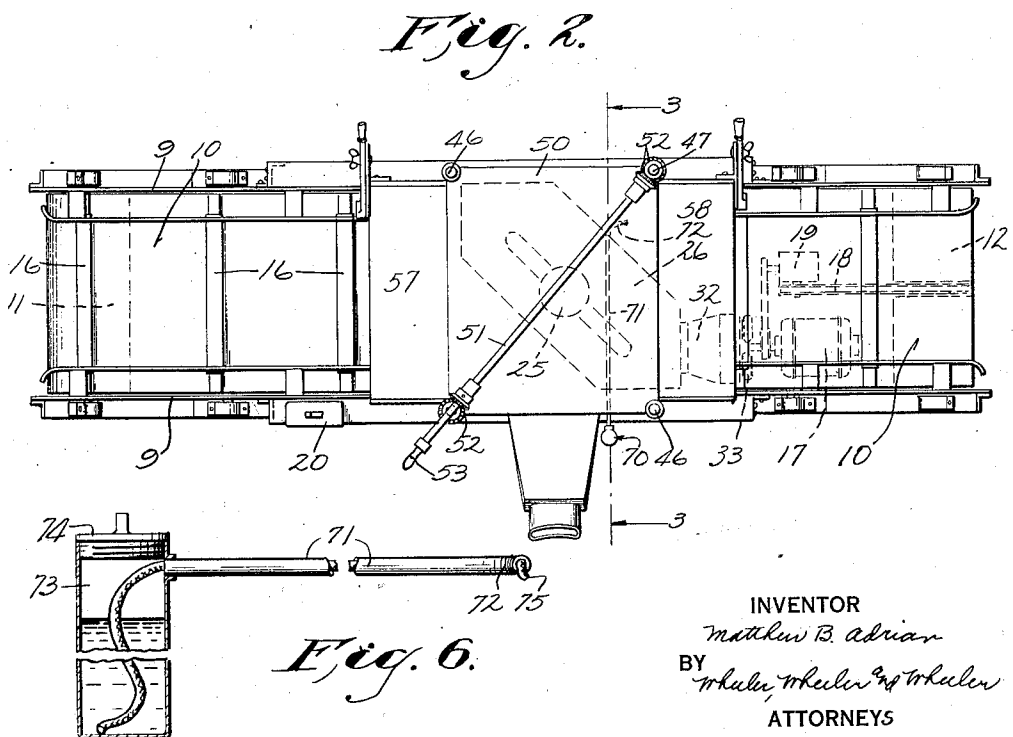
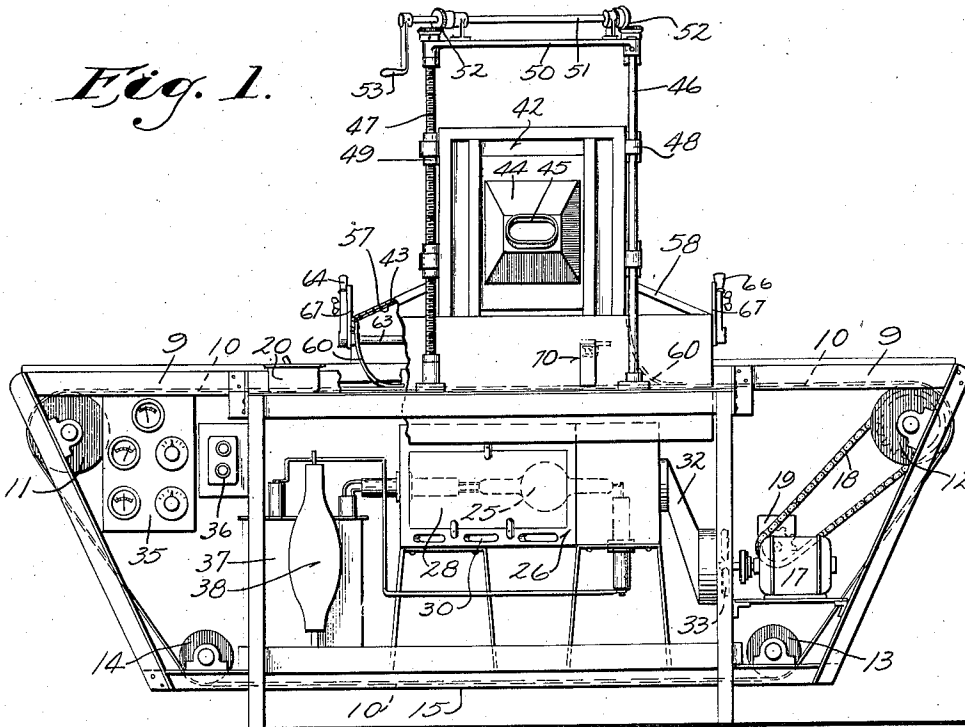
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X-RAY INSPECTION APPARATUS

Filed Sept. 1, 1934

2 Sheets-Sheet 1



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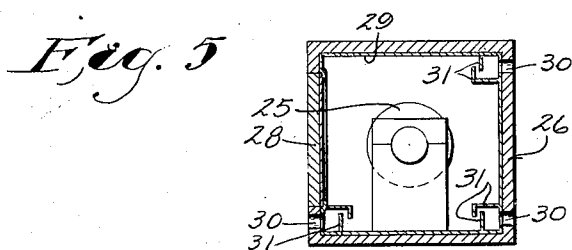
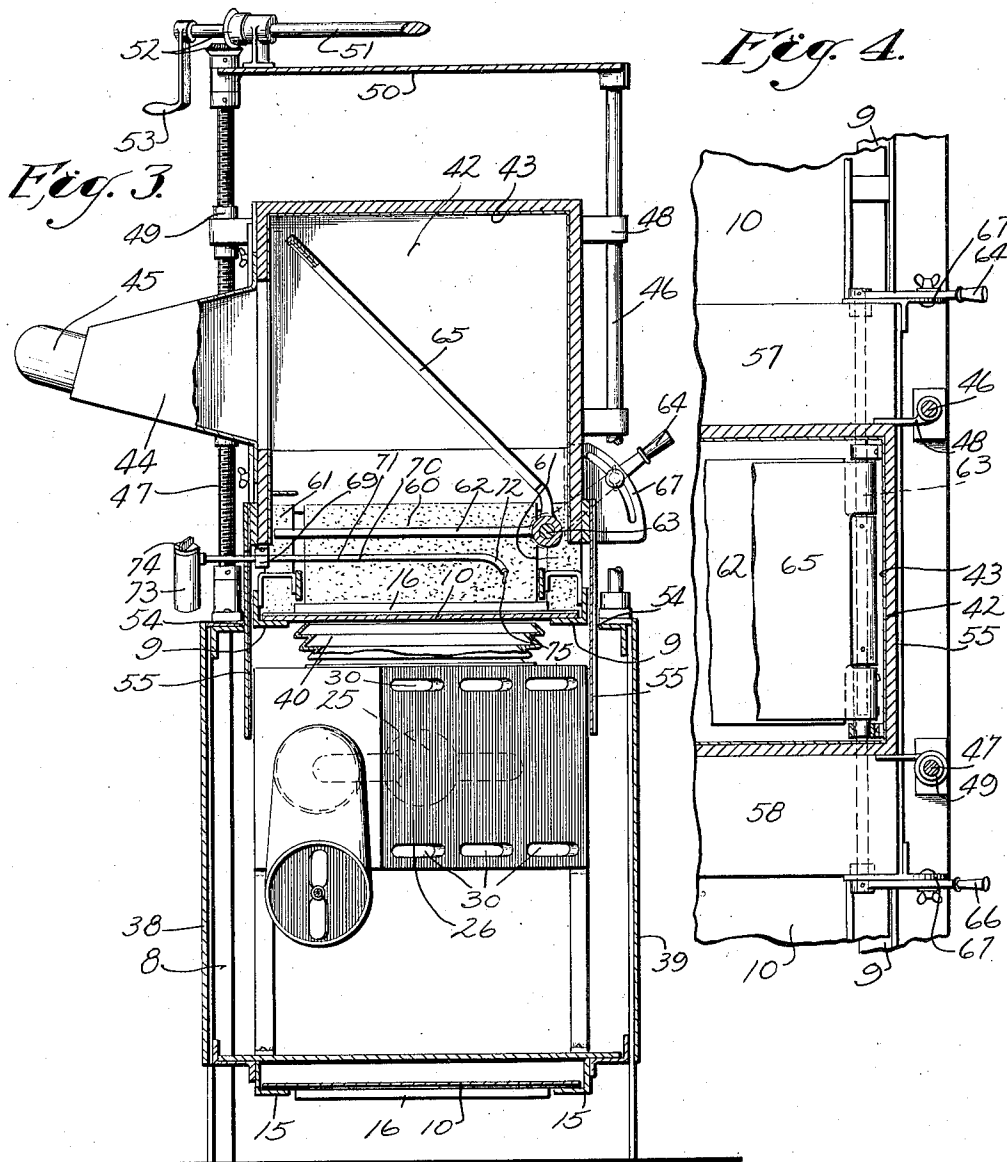
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2 Sheets-Sheet 2



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X-RAY INSPECTION APPARATUS

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Application September 1, 1934, Serial No. 742,439

12 Claims. (Cl. 250—34)

This invention relates to improvements in X-ray inspection apparatus. This is a continuation in part of my application Serial No. 539,226 filed May 22, 1931.

It is the primary object of this invention to provide inspection apparatus for the X-ray examination of all sorts of natural and manufactured objects in a manner that is practical from a commercial production standpoint, and without exposing the operator or his fellow workmen to the X-ray.

The matter of adequate protection is a serious one, but the present invention not only affords such protection but it is nevertheless adaptable to the examination of a number of widely differing objects of various sizes and shapes.

Other objects of the invention include the provision of a novel means for marking a defective article for discard; the provision of an arrangement permitting the adjustment of the apparatus to suit the convenience of inspectors of different heights; the provision of means for adjusting the apparatus for most effective use of articles of different sizes and shapes; the provision of means for cutting off the branching beams and using primarily only the direct beams of the X-ray; the provision of a convenient and compact organization wherein the entire X-ray and motive apparatus is housed between the advancing and returning flights of an endless conveyor; and the provision of means for permitting the ingress of articles to the viewing chamber and their egress therefrom without the escape of X-rays.

In the drawings:

Figure 1 is a view of a device embodying my invention, partially in front elevation and partially exposing the interior mechanism by breaking away and removing the front wall of the housing.

Figure 2 is a plan view of the apparatus shown in Figure 1.

Figure 3 is a vertical section on an enlarged scale, taken in the plane indicated at 3—3 in Figure 2.

Figure 4 is a fragmentary detail in horizontal section on an enlarged scale, showing the mountings upon which the fluoroscopic screen and mirror are individually adjustable.

Figure 5 is a detail view in cross section showing the housing for the X-ray tube.

Figure 6 is a detail view partially in side elevation and partially in section, showing on an enlarged scale the marking device which is a part of the present apparatus.

Like parts are identified by the same reference characters throughout the several views.

The device is conveniently assembled about any suitable frame such as that shown at 8 in Figs. 1 and 3. Suitable guides such as may be made of angle irons 9 support the margins of the wood conveying flight of a conveyor 10 which runs over pulleys 11, 12, 13 and 14. The return flight is carried by suitable angle iron guides 15. Any desired form of conveyor may be used. I have found it convenient to employ a canvas belt conveyor with suitable work propelling lugs in the form of wooden strips 16 fastened to the surface of the belt at short intervals. While any suitable means may be employed for propelling the conveyor, it is very desirable that the conveyor should be at all times under control of the inspector so that he may start the conveyor independently of the X-ray apparatus for the prolonged examination of a given article when necessary. Conveniently, therefore, the conveyor is operated by a motor 17 which drives pulley 12 through a belt 18 and reduction gearing 19, the mode of circuit being subject to control by means of switch 20. The switch is shown to be located at the level of the conveyor with its control lever in easy reach of the operator's left hand.

Directly below the top flight of conveyor 10 at the inspection station is the X-ray tube 25 which, for convenience of mounting and connection, is preferably set diagonally as shown in Fig. 2. The tube is enclosed in a case 26 having pointed ends and provided at 28 with a removable front through which the tube is accessible, the closure 28 and case 26 having a lead sheet or lining 29 throughout to prevent the undesired escape of X-ray emissions from the tube. The case has ventilation openings at 30 shielded by lead baffles 31 for the escape of cooling air which is blown into the case through a conduit 32 by means of a fan 33 carried on the shaft of motor 17. There is, of course, an opening in the lead lining 29 at the top of case 26, toward which the primary emission of tube 25 is directed.

The control panel 35, switch 36, transformer 37, rectifier 38, and suitable connections to the tube 25 are illustrated but are not shown in detail, being well known in the art. All of this apparatus is housed within the closed path of travel of the endless conveyor 10, the front and back sides of the space in which this apparatus is assembled being enclosed, in completed machines, by front and rear panels 38 and 39.

Mounted upon the housing 26 for the X-ray tube is a bellows-like cone 40 which extends up-

wardly into substantial contact with the lower surface of the top flight of the conveyor 10. The convolutions in the walls of the generally pyramidal enclosure 40 are not for expansion or contraction, but serve as traps to intercept lateral radiations branching from the principal X-ray beams emitted by the tube. The angles of the convolutions are preferably approximately as illustrated in Fig. 3, so that any reflection of these branching radiations will throw them back into the shielded casing 26 instead of permitting them to reach some point from which they might escape from the machine.

Above that portion of the conveyor 10 through which the X-rays are projected at the viewing station, is a viewing chamber 42 having its top and side wall portions provided with lead sheathing at 43. A forward extension 44 of this chamber carries an eye piece 45 through which the operator may look into the interior of the chamber without being exposed to X-rays passing upwardly therein. The extension 44 may conveniently be made of lead plated or coated metal.

The whole chamber 42 and its appurtenances are guided for vertical movement. As a convenient arrangement I have shown fixed posts 46 at diagonally opposite corners of the chamber 42, and screws 47 at the other two corners. The chamber is provided with apertured arms 48 riding on the posts 46 and with nuts 49 meshing with the screws 47. Upon a crosshead 50 mounted on the posts 46 and provided with bearings for the screws 47, is an operating shaft 51 connected by bevel gearing at 52 with the screws 47 and adapted for rotation by means of crank 53 to turn the screws 47 and thereby to raise and lower the chamber 42. The machine frame is slotted at 54 to receive a lead panel 55 which is connected with chamber 42 and is of such length as to overlap the bellows-like housing 40 in all positions of adjustment of the viewing chamber 42, thereby assuring the protection of the operator from stray rays which might otherwise escape when the chamber was elevated.

Also connected with the viewing chamber are the canopies 57 and 58 comprising a longitudinal enlargement of the chamber along the path of the conveyor 10. These canopies, like the rest of the chamber, are lined with the lead sheathing 43. Their projection is sufficient to ensure against the escape of X-rays from the viewing chamber at the points where articles on the conveyor enter into the viewing chamber.

To permit the ingress and egress of articles to be inspected, the viewing chamber is provided with openings overhung by the canopies 57 and 58. These openings are flexibly closed by a lead coated curtain of rubber or other suitable flexible material, as shown at 60 and 61 in Figs. 1 and 3. These curtains, being somewhat heavy, offer appreciable resistance to the movement of an article on the belt but the wooden lugs 16 on the belt assure the continued movement of the articles carried thereby.

The fluorescent screen 62 is preferably pivoted upon an axis 63 about which it is movable by means of a suitable control lever 64 which may be anchored with reference to a conventional segment. If small articles are being examined the screen may be so adjusted that its forward portion will be very close to the surface of the belt. If large articles, such as hams or other articles of irregular shape, are being examined, the screen may be adjusted to approximate parallelism with

the path followed by the upper surfaces of such articles. The range of adjustment will be such as to give the best X-ray vision of a variety of products within the capacity of the machine. The screen effects a division of the hood or viewing chamber proper which is above the screen, from the enclosure below the screen and within the panels 55 and curtains 60 through which pass the articles to be inspected.

Pivotally adjustable upon the same axis 63 (or upon any other suitable axis), is a mirror 65, the angle of which is adjustable under the control of handle 66, the segment of which is shown at 67. The mirror is of a type which does not intercept or reflect X-rays but does reflect light from the fluorescent screen to the eye piece 45 through which the operator views the articles under examination. The adjustment of the mirror not only compensates for variations in position of the screen, but also compensates for variations in position of the viewing chamber 42 in its vertical adjustment, so that the operator may sit or stand as he desires.

If the operator had to reach into the apparatus for the removal of a defective article found by his X-ray examination, he would not only expose his hand to danger of serious X-ray burns, but he would seriously retard the progress of his work. In order to make any such removal of the defective articles unnecessary, I provide the viewing chamber 42 with a universal mounting at 69 for a marking device located in the enclosure below the screen, the marking device being designated by reference character 70 as shown more particularly in Fig. 6. A tube 71 is reciprocable through an opening in the universal mounting and has its inner end portion 72 bent approximately at right angles in a normally horizontal plane. At the outer end of the tube, the tube communicates with a container 73 for marking fluid, the shape of the container adapting it to serve as a handle for the manipulation of the marking device. A removable closure at 74 permits the renewal of the marking fluid from time to time.

A wick 75 has its end within the container 73 and extends through the tube 70 to project from the end 72 thereof. Not only does the wick carry the marking fluid through the open end 72 of the tube by capillarity, but, since the container 73 serves as a handle, it will be obvious that every time the handle is oscillated to turn downwardly the curved end 72 of the tube, the liquid contents of the container 73 will to some degree be discharged along the wick into the tube toward the end from which the wick projects.

Obviously, the operator is able to use this marking device to place a spot of marking fluid upon each defective article passing through the inspecting station. The articles so marked can be removed separately from the conveyor by some other person and discarded, thus leaving the inspector unharmed in his continuous observation of the articles carried by the conveyor 10.

Articles such as shoes may conveniently be inspected to determine whether nails used temporarily for lasting purposes have inadvertently been allowed to remain in the shoe. Objects such as oranges may be inspected to determine whether or not they are juicy or pulpy. Objects such as hams may be inspected to determine whether or not the marrow is sound or spoiled. Those articles specifically mentioned are chosen to illustrate the wide range or shapes of mate-

rials which may be examined in this single piece of apparatus.

In all examinations the inspector is fully protected from the menace of the X-ray tube. Not only is his body shielded from direct emanations, but it will be observed that he even views the fluoroscopic screen through a mirror so that emanations passing the screen cannot reach his eyes. The arrangement is such that the articles enter and leave the viewing chamber without permitting the escape of rays.

The disposition of the X-ray and mode of mechanism between the conveyor flights has the advantage that the upper surface of the conveyor is fully exposed at both ends of the apparatus for the mounting and removal of the articles requiring inspection. The X-rays do not have to pass through more than one flight of the conveyor and the tube is located in the best position with reference to the articles on the conveyor.

The X-ray tube is sufficiently close to the path of movement of the articles to be inspected so that the emanations of the tube pass through the articles at a wide variety of angles. Assuming the articles to be moving from left to right in Fig. 1, at the time when the article first appears beneath the fluoroscopic screen within the path of the rays, the rays will penetrate the article upon a line upwardly inclined toward the left. When the article passes directly above the tube the rays will penetrate it vertically, and before the article leaves the area of the fluoroscopic screen the rays will penetrate the article upon a line inclined upwardly and to the right. Since the image on the screen accurately portrays the structure of the article as it appears in the direction of movement of the rays at any given moment, the operator is able to see each article, in effect, from a constantly changing viewpoint in the course of its travel through the machine, the effect being the same as if the articles were held above the tube and turned from side to side.

While a conventional belt conveyor has been illustrated for the purpose of exemplifying the present invention, it will be obvious to those skilled in the art that such articles as oranges, and many other articles requiring inspection, are capable of propelling themselves by gravity along a conveyor which comprises a mere trough for the guidance of such articles. Many other changes may be made without departure from the spirit of the invention which is merely exemplified by the apparatus herein described.

I claim:

1. X-ray inspection apparatus comprising the combination with a conveyor for propelling in a predetermined path the articles requiring inspection, and means for actuating said conveyor during inspection of articles thereon, of an X-ray tube arranged to discharge immediately across said path, an X-ray sensitive screen operatively disposed opposite said tube adjacent said path, a viewing chamber enclosing said screen for the exclusion of extraneous light and provided with inlet and outlet openings through which said articles move, and ray confining means at said inlet and outlet through which said conveyor and articles are freely movable.

2. X-ray inspection apparatus comprising the combination with an endless conveyor having widely spaced work supporting and return flights, of X-ray apparatus assembled between said flights and including an X-ray tube having its discharge portion operatively directed immedi-

ately at said work supporting flight, and an X-ray sensitive screen operatively positioned at the other side of said flight to intercept rays traversing work thereon, means substantially impervious to X-rays enclosing said tube and extending to said work supporting conveyor flight about the path of discharge of said tube, shielding means extending from said screen to said conveyor flight and provided with means for the ingress and egress of work thereon, and means for actuating said conveyor for the advance of work between said tube and screen during inspection thereof.

3. X-ray inspection apparatus comprising the combination with a work propelling conveyor flight, of an X-ray tube therebeneath arranged to discharge upwardly across the path of an article propelled by said flight, an X-ray sensitive screen disposed above said path in a position to intercept rays from said tube, a mirror extending angularly above said screen and arranged to reflect laterally the light emanating from the screen, and means for shielding the inspector from X-rays, said means including a viewing chamber enclosing said screen and the path of work exposed to said X-rays and provided with a lateral sight opening through which the image of said screen in said mirror is visible, said conveyor flight being provided with means for the continuous propulsion of work through said chamber.

4. X-ray inspection apparatus comprising the combination with a work propelling conveyor flight, of an X-ray discharge tube immediately therebeneath, a fluoroscopic screen spaced above said flight, a viewing chamber enclosing said screen, means for adjusting said chamber and screen to and from said flight, and shielding means extending continuously between said flight and said chamber and operative to confine the emission from said tube in all adjustments of said chamber.

5. X-ray inspection apparatus comprising the combination with a work propelling conveyor flight, of an X-ray discharge tube disposed immediately therebeneath with its discharge directed upwardly across the path of materials propelled by said flight, a fluoroscopic screen spaced above said path, a viewing chamber projecting above said screen and extending about said screen to said flight, a mirror adjustable as to angle disposed in said viewing chamber for the lateral reflection of the image of said screen, and a lateral extension of said viewing chamber provided with an inspection opening.

6. The combination with a conveyor flight for the continuous propulsion of material to be inspected, and means for effecting continuous propulsion of work on said flight, of an X-ray tube at one side of said flight, a screen at the other side of the flight and an enclosure substantially opaque to X-rays between said screen and said flight provided with openings for the ingress and egress of material propelled by said flight and means at said openings for intercepting X-rays and preventing their escape from said enclosure during the passage of such material into and out of the enclosure.

7. The combination with a conveyor flight for the propulsion of material to be inspected, and means for propelling material on said flight during inspection, of an X-ray tube at one side of said flight, a screen at the other and an enclosure substantially opaque to X-rays between said screen and said flight provided with openings for

the ingress and egress of material propelled on said flight, said openings having X-ray obstructing closures movable under pressure of said material in entering and leaving said enclosure.

5 8. X-ray inspection apparatus comprising the combination with a conveyor, of an X-ray tube arranged to discharge across the path of materials thereon, a screen operatively positioned across said path from said tube and immediately adjacent said path, means for adjusting
10 said screen angularly with respect to said path, and a viewing chamber enclosing said screen and provided with a mirror and a sight opening through which the image of said screen is visible
15 in the mirror.

9. X-ray inspection apparatus comprising the combination with a conveyor, of an X-ray tube arranged to discharge across the path of articles on the conveyor, a fluorescent screen operatively
20 positioned across said path from said tube, a viewing chamber enclosing said screen and bodily movable to and from said path, and means extending the wall portions of said viewing chamber to said conveyor and provided with shielding
25 effective in all positions of said chamber to enclose the space between said conveyor and screen.

10. X-ray inspection apparatus comprising the combination with a conveyor, of an X-ray tube arranged to discharge across the path of articles
30 on the conveyor, a fluorescent screen operatively positioned across said path from said tube, a viewing chamber enclosing said screen and bodily movable to and from said path, and means extending the wall portions of said viewing chamber to said conveyor and provided with shielding
35 effective in all positions of said chamber to enclose the space between said conveyor and screen, said means including lead treated curtains in the path of articles entering and leaving said means.

40 11. X-ray inspecting mechanism comprising the combination with a shielded and apertured

enclosing means, of a conveyor flight arranged to pass articles into and out of said means through the apertures thereof, means for the continuous actuation of the conveyor flight during inspection, X-ray trapping means associated
5 with each of said apertures for permitting the continuous movement of articles on the conveyor flight into and out of the enclosing means while affording substantially continuous protection against the escape of X-rays therefrom, an
10 X-ray tube at one side of the path of articles through said means, and a viewing screen at the other side of the path of articles through said enclosing means, said tube and screen being within said enclosing means, and said enclosing
15 means being extended about said screen to intercept direct rays of extraneous light and provided with an opening for the use of an operator through which said screen is visible for the inspection of the images thereon of successive
20 articles advanced by said conveyor flight.

12. X-ray inspection apparatus comprising the combination with a continuously movable conveyor and means for the continuous actuation thereof during inspection, said conveyor being
25 adapted for the propulsion of material requiring inspection, of an X-ray tube arranged to discharge immediately across the path of the material to be inspected as such material moves upon the conveyor, a screen sensitive to X-rays
30 operatively disposed opposite the tube adjacent said path, a viewing chamber enclosing the screen for the exclusion of extraneous light and including X-ray shielding means enclosing the path of material moving with said conveyor between the X-ray tube and screen, said shielding
35 means having inlet and outlet portions through which said conveyor and the materials propelled thereby are freely movable during the continuous operation of the conveyor.

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