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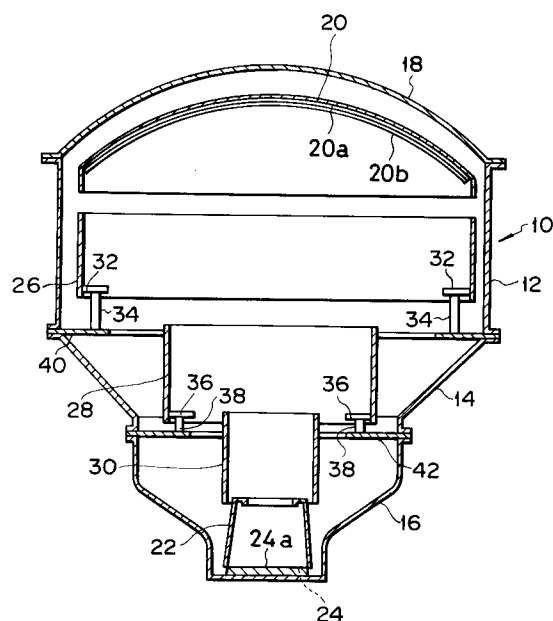
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(54) **X-ray image intensifier and method of manufacturing the same.**

(57) According to the X-ray image intensifier of the present invention, supporting means (40, 42) are provided for the joint portions of envelope elements which constitute a vacuum envelope, thereby increasing the assembly accuracy thereof. Accordingly, the electrostatic electron lens formed of the focusing electrodes (26, 28, 30) fixed on the supporters operates at an improved accuracy. One embodiment of the invention provides disk like metallic supporting means with a center hole sandwiched between neighbouring joint portions of the vacuum envelope (10).

**FIG. 1****EP 0 471 206 A1**

The present invention relates to an X-ray image intensifier and a method of manufacturing the same, and more specifically to those having an improved assembly accuracy.

Conventionally, an X-ray image intensifier includes a metal-made or glass-made hollow vacuum envelope, an input window formed on the side where an X-ray is made incident, an input screen provided close to the input window, an anode designed for accelerating the electron beam converted from an X-ray by the input screen, a plurality of, for example, three hollow-cylindrical focusing electrode, arranged between the input screen and the anode, for focusing electrons, and an output screen made of optical glass material, for converting the electron beam into a visible light image, and for outputting this image to outside.

The operation of such an X-ray image intensifier is as follows:

First, an X-ray which is supplied from an external X-ray source and transmitted through an object, etc. is made incident through the input window onto the input screen and the X-ray image thus obtained is converted into a visible image by the fluorescent (phosphor) screen provided on the input screen. Then, the visible image is made incident onto the photoelectric surface also provided on the input screen, and converted into an electron image. The electrons forming this electron image is concentrated by means of an electron lens consisting of a plurality of focusing electrodes. Further, the electrons are accelerated by the anode, and are made incident on the output screen, which is composed of phosphor material on optical glass, and on which a visible image is formed of the light emitted from the luminescent material when the incident electrons hit thereon. This visible image is further.

In a large X-ray image intensifier of this type, the metal-made or glass-made hollow vacuum envelope is formed of a plurality of envelope elements welded or bonded with each other. This envelope has been evacuated and is maintained at the vacuum state, in which the envelope is pressurized from outside by a force working thereon, which may deform the envelope itself. In connection with this, it should be noted that the joint portions, in particular, welding or bonding the envelope elements with each other are structurally weak. Further, these envelope elements must be arranged accurately in a coaxial manner around the axis of the tube. Meanwhile, the above-mentioned focusing electrodes, made of a metal, are formed into a hollow-cylindrical shape, and must be also placed accurately around the tube axis. Further, since different voltages are applied to these focusing electrodes, the electrodes must be electrically separated from each other. Therefore, convention-

ally, focusing electrodes are fixed by electrode supporters welded to the inner wall of a vacuum envelope.

In this sense, the electrode supporters must be accurately welded to the inner wall of the vacuum envelope; however, with the conventional method, it is not possible to arrange the electrode supporters with a satisfactory accuracy, or even if it is, very expensive jigs are needed. In addition, such an accurate welding process requires very high techniques, and therefore can be performed only by highly skilled technicians.

In the meantime, recently, usage of X-ray image intensifier has been widened, and large-sized X-ray image intensifier have been demanded, accordingly. As the sizes of X-ray image intensifier enlarge, a vacuum envelope is no longer formed of a single element, but some envelope elements need to be jointed with each other. The joint portions of the vacuum envelope are relatively weak to the other portions, and therefore it is very difficult to maintain its assembly efficiency. Further, the characteristics of the electrostatic electron lens depend very much on this assembly efficiency, and if the assembly accuracy is low, the electron lens cannot perform its ability to a full extent.

The present invention has been proposed to solve the above-described problem, and a purpose thereof is to provide an X-ray image with a high assembling accuracy.

Another purpose of the present invention is to provide an X-ray image intensifier with an improved quality, which can be achieved by the high assembling efficiency.

An X-ray image intensifier according to the present invention comprises, an X-ray input window, input means including a fluorescent (phosphor) surface for converting the X-ray having passed the input window into electrons, and a photoelectric surface, a vacuum envelope formed of a plurality of envelope elements welded with each other by joint portions thereof, output means including a fluorescent screen for transmitting a signal converted from an X-ray image, supporting means arranged between the joint portions of the envelope elements constituting the vacuum envelope, and a plurality of focusing electrodes supported by the supporting means to concentrating the electrons from the X-ray input window.

Further, according to the present invention, there is proposed a method of manufacturing the X-ray image intensifier comprising the steps of, arranging focusing electrodes on supporting means, and forming a vacuum envelope by sandwiching the supporting means between joint portions of the envelope elements, and then welding the neighboring joint portions of the envelope elements with each other.

Such an X-ray image intensifier has a high assembly efficiency and an improved positioning efficiency of the focusing electrodes, because of the supporting means.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows a cross section of an X-ray image intensifier according to the first embodiment of the present invention;

Fig. 2 shows an enlarged cross section of a joint portion of the vacuum envelope of the X-ray image intensifier according to the first embodiment; and

Fig. 3 shows an enlarged cross section of a joint portion of the vacuum envelope of the X-ray image intensifier according to the second embodiment.

Embodiments of the present invention will now be described in detail with reference to accompanying drawings.

An X-ray image intensifier according to the first embodiment of the present invention includes a vacuum envelope 10 formed of a plurality of steel-made envelope elements 12, 14, and 16, welded with each other, an input window 18 provided on the input side, which has a large diameter, of the vacuum envelope 10, an input screen 20 located close to the input window 18, an anode 22 provided on the output side, which has a small diameter, of the vacuum envelope 10, an output screen 24 for detecting an optical image converted from an X-ray image, and a plurality of, for example, three focusing electrodes 26, 28, and 30 arranged between the input screen 20 and the anode 22.

In the vacuum envelope 10, flat donut-shaped supporters 40 and 42 are welded between each of the joint surfaces of metal-made envelope elements 12, 14, and 16. These supporters 40 and 42 are provided for a reinforcement purpose, and thus the joint portions, which are structurally weak, are strengthened thereby so that the vacuum envelope 10 can withstand the external pressure.

Mount rings 32 and 36 are provided for mounting the focusing electrodes 26 and 28, and are placed on a ceramic ring 34 fixed on the supporter 40 and 42. With these mount rings 32 and 36, the focusing electrodes 26 and 28 are supported in the vacuum envelope 10, as can be seen in Fig. 1.

The input window 18 is made of aluminum (Al), or an aluminum alloy which contains, for a reinforcement purpose, at least one of Si, Cu, Mn and Mg at about 5% or more. The thickness of the input window is 0.5-2.0mm. It should be noted there that the input window 18 is formed into a convex shape in this embodiment, but the shape of the window is not restricted to this, and the window

made of the Ti or Ti-alloy can be formed into, for example, a flat shape or a concave shape. This input window 18 is welded to the first envelope element 12, and the surface of the first envelope element 12 is plated with nickel. The thickness of the Ni plate layer is 100 μm or less, and should preferably be 5-20 μm . The steel alloy-made first envelope element 12 and the aluminum-made input window 18 are heat-pressed and then air-tight jointed with each other.

The input screen 20 is made of aluminum (Al), and a fluorescent (phosphor) layer 20a made of CsI/Nal is evaporated thereon. Further, a photoelectric screen 20b is formed on this fluorescent (phosphor) layer 20a directly or through a conductive layer.

The output screen 24 is formed of a ceramic material, and an output fluorescent (phosphor) screen 24a is coated thereon. And aluminumback layer is formed on the output fluorescent screen.

In the meantime, in showed Fig. 2, in order to joint the second and third envelope elements 14 and 16, which constitute a part of the vacuum envelope 10, with each other, a flange 46 of the second envelope element 14, a flange 48 of the third vacuum envelope 16, and the supporter 42 are welded all together by their entire surfaces. More specifically, the supporter 42 is sandwiched between the flanges 46 and 48 such that the ends of all are flush with each other, and these are welded with each other by a welding portion 50 located at the end, thus fixing the supporter 42 between the flanges 46 and 48. It should be pointed out that, for jointing, a regional heating welding technique, for example, the insert gas arc welding, is employed.

The procedure is likewise in jointing the first and second envelope elements 12 and 14, and the supporter 40 is sandwiched therebetween such that the ends are flush with each other, and then welded.

With the above-mentioned structure, even if an external pressure works on the envelope 10 due to a decrease in pressure inside the envelope 10, the envelope 10 can withstand such an external pressure because of the supporter provided for the joint portion 50, and thus the envelope is not deformed very much.

Further, the hollow-cylindrical focusing electrodes 26 and 28 must be arranged coaxially with the center axis of the image intensifier tube. In this embodiment, the supporters 40 and 42 on which the focusing electrodes are fixed, are designed not only to prevent deformation of the vacuum envelope 10, but also to ensure the locations of to-be-welded portions for a successful positioning. When this embodiment is applied, in a 12 inch X-ray image intensifier, the drift of the center axes of the

focusing electrodes 26 and 28 from the tube axis of the vacuum envelope 10 can be suppressed as little as 0.5mm or even less.

In the manufacturing procedure for this X-ray image intensifier, focusing electrodes arranged in a vacuum envelope are once fixed on supporters and then welded to the envelope along with envelope elements. In this way, arrangement of the focusing electrodes is very easily performed unlike in the case where they are directly welded to the inner wall of a vacuum envelope. Since the positioning of the focusing electrodes is completed when the supporter is arranged between the envelope elements, the focusing electrodes can be very accurately welded to the vacuum envelope.

The second embodiment of the present invention will now be explained with the drawings in showed Fig. 3.

It should be first noted that the same reference numerals designate the same items as those of the first embodiment, and difference numerals designate for different items.

The second embodiment has substantially the same structure as that of the first embodiment except for the shape of the joint portions. In the first embodiment, the supporter 42 is sandwiched between the flanges 46 and 48 to joint the second and third envelope elements 14 and 16 with each other by welding. However, in this second embodiment, a cutout 160 is formed in a flange 146 of the second envelope element 114, and a supporter 142 is placed on this cutout 114. With the supporter 142 being placed on the cutout 114, the supporter 142 is sandwiched between the flange 146 of the second envelope element 114 and the flange 148 of the third envelope element 116, and then all of them are welded with each other by a joint portion 160. Since the supporter 142 is already placed at the cutout 160 before the welding, the positioning thereof is rarely missed. In this case, the flanges 146 and 148 are welded with each other by the joint portion 150, whereas the supporter 142 is not welded along with the others, but the end portion of the supporter 142 is set into the cutout 160.

As described, each of the supporters provided at each of the joint portions serves to reinforce the structurally weak portions, and thus the vacuum envelope is not deformed very much. Consequently, the center axis of the focusing electrodes can be set accurately coaxially with the axis of the tube. This will lead to a further advantage that since the external pressure is evenly applied to the envelope, a positioning drift can be suppressed to the minimum degree.

In the second embodiment, the supporters are set to the cutouts, and then the flanges are welded. In other words, when the supporter are set to the cutouts, the positioning of the focusing electrodes

is completed. Therefore, it is only required that the focusing electrodes be accurately located at the supporters, and thus it is very easy to arrange the focusing electrodes accurately in the vacuum envelope. Furthermore, tube characteristic can be good.

In the above-described embodiments, metal-made supporters are employed, but, of course, many types of supporters, for example, ceramic-made, heat-proof-resin-made, and the like, can be also used.

Further, the focusing electrodes are fixed to the supporters by means of various kinds of mount rings, but they can be directly fixed to supporters of, for example, ceramic-made.

To summarize, the X-ray image intensifier according to the present invention has a structure in which each of supporting means is provided for each of joint portions by which envelope electrodes are welded with each other to form a vacuum envelope. With this structure, the vacuum envelope, reinforced by the supporters, can withstand an external pressure. Therefore, the degree of deformation of the envelope can be suppressed to the minimum, and thus the positioning efficiency for the focusing electrodes set on the supporters significantly improves.

With the present invention, expensive jigs as well as a highly-skilled technique, conventionally required in a welding, are no longer necessary, and therefore the quality of products, and the productivity are significantly improved.

Claims

1. An X-ray image intensifier comprising:
 - an X-ray input window (18);
 - input means (20) including a fluorescent screen, for converting X-rays transmitted through said X-ray entrance into electrons, and a photoelectric screen;
 - a vacuum envelope (10) formed by welding joint portions of a plurality of envelope elements (12, 14, 16);
 - output (24) means including a fluorescent screen for guiding a signal converted from an X-ray image to outside;
 - characterized by comprising:
 - supporting means (40, 42) sandwiched between the neighboring joint portions of the envelope elements constituting said vacuum envelope; and
 - a plurality of focusing electrodes (26, 28), supported by said supporting means, for concentrating the electrons from said X-ray input window.
2. An X-ray image intensifier according to claim

1, characterized in that each of said supporting means is metal-made.

3. An X-ray image intensifier according to claim 1, characterized in that each of said supporting means is formed into a disk-like shape with a center hole. 5
4. An X-ray image intensifier according to claim 1, characterized in that a cutout is formed on each of said joint portions of said envelope elements, and each of said supporting means is provided at each of the cutouts. 10
5. An X-ray image intensifier according to claim 1, characterized in that each of the supporting means has ring means, with which each of the supporting means can support a plurality of focusing electrodes. 15
6. An X-ray image intensifier according to claim 1, characterized in that said plurality of focusing electrodes have a hollow cylindrical shape. 20
7. An X-ray image intensifier according to claim 1, characterized in that there are at least three focusing electrodes. 25
8. An X-ray image intensifier according to claim 1, characterized in that there are at least three envelope elements which constitute the vacuum envelope. 30
9. A method of manufacturing an X-ray image intensifier including: 35
 - a vacuum envelope (10) formed of a plurality of envelope elements (12, 14, 16) whose joint portions are welded together;
 - supporting means (40, 42) each sandwiched between joint portions of envelope elements of said envelope elements; and 40
 - a plurality of focusing electrodes (26, 28), each supported by one of said supporting means;
 - characterized by comprising the steps of, 45
 - arranging the focusing electrodes on said supporting means; and
 - forming the vacuum envelope by sandwiching the supporting means between joint portions of the envelope elements, and welding the joint portions of the envelope elements the each other. 50

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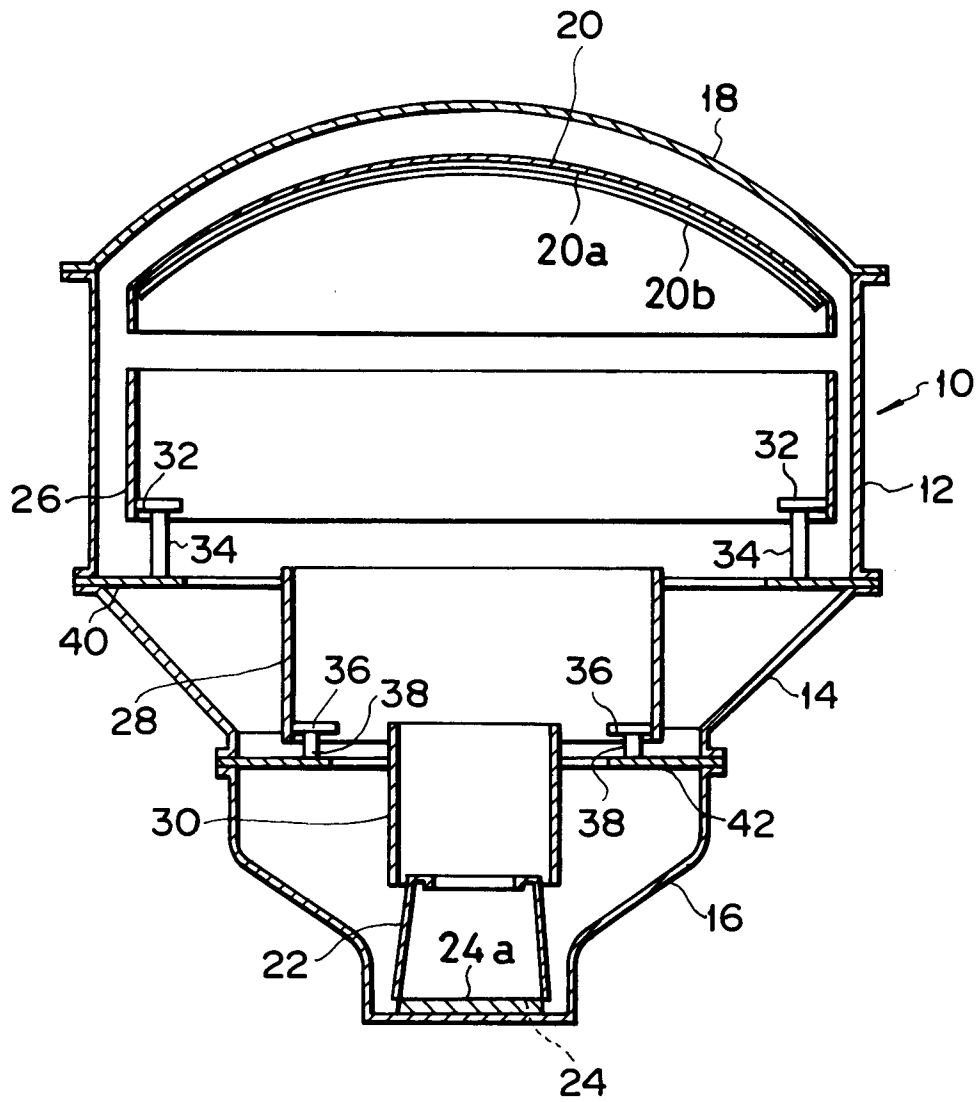


FIG. 1

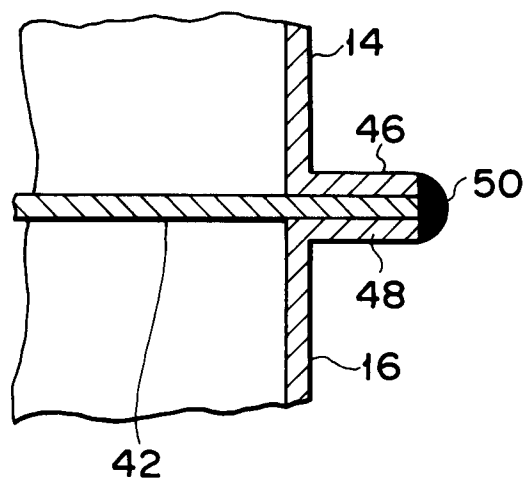


FIG. 2

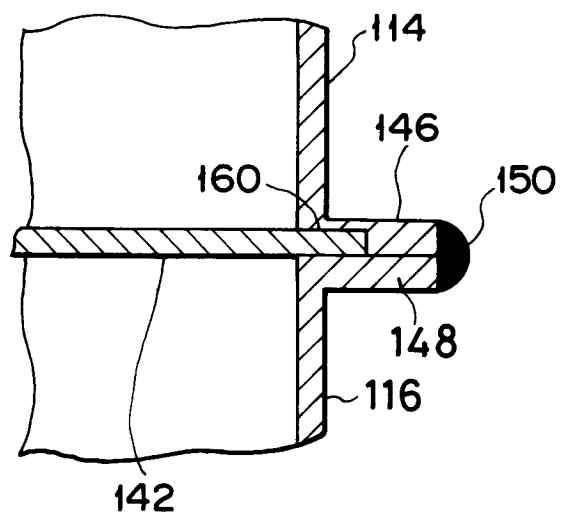


FIG. 3



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Application Number

EP 91 11 2129

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 258 940 (N.V. PHILIP'S GLOEILAMPEN-FABRIEKEN) * abstract; figures * * * column 3, line 19 - column 6, line 48 * * - - -	1-3,5,6,8,9	H 01 J 31/50 H 01 J 29/02
A	US-A-4 870 473 (FUMIO SUGIMORI) - - -	1,2,5,9	
A	US-A-4 870 473 (* abstract; figure 2 *) * column 4, line 67 - column 6, line 24 * * - - -		
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 95 (E-892)(4038) 21 February 1990 & JP-A-1 302 643 (TOSHIBA CORPORATION) 6 December 1989 * abstract * *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 164 (E-410)(2220) 11 June 1986 & JP-A-61 016 436 (MITSUBISHI DENKI K.K.) 24 January 1986 * abstract * *	4	
A	US-A-3 356 851 (ROLAND W. CARLSON) * column 2, line 50 - column 2, line 59; figure 1 * * - - - - -	7	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
Place of search			Examiner
The Hague			CLARKE N.S.
CATEGORY OF CITED DOCUMENTS			E : earlier patent document, but published on, or after the filing date
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