

EUROPEAN PATENT APPLICATION

Application number: **80104337.3**

Int. Cl.³: **H 01 J 31/50**

Date of filing: **23.07.80**

Priority: **24.07.79 JP 101365/79 U**

date of publication of application:
28.01.81 Bulletin 81/4

Designated Contracting States:
DE FR

Applicant: **TOKYO SHIBAURA DENKI KABUSHIKI KAISHA**
72, Horikawa-cho Saiwai-ku
Kawasaki-shi Kanagawa-ken 210(JP)

Inventor: **Harao, Norio**
1-71, Kozono, Ayase-shi
Kanagawa-ken(JP)

Inventor: **Nishino, Chikae**
408 Kamitsuruma Sagamihara-shi
Kanagawa-ken(JP)

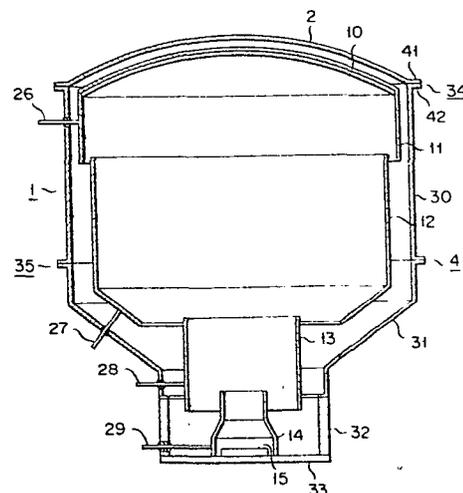
Inventor: **Sugimori, Fumio**
69-17, 2-chome, Futamatagawa
Asahiku, Yokohama-shi(JP)

Representative: **Patentanwälte**
Henkel-Kern-Feiler-Hänzel
Möhlstrasse 37
D-8000 München 80(DE)

X-ray image intensifier.

An X-ray image intensifier is disclosed which has an evacuated envelope (1) and inside it an input screen (10), an output screen (15), and a plurality of electrodes constituting an electron lens system inside said evacuated envelope (1) wherein said evacuated envelope (1) comprises a cylindrical vessel (4) of Al or an Al-based alloy, a metal input window (2) of Al or an Al-based alloy which is hermetically connected to one end of said cylindrical vessel (4), an output container (32) of ceramic or glass which is hermetically connected to the other end of said cylindrical vessel (4), and a glass output window (33) which is hermetically connected to the output end of said output container (32). The construction of the connecting part may be made simple, magnetization may be eliminated, and the X-ray image intensifier may be made compact in size and light in weight.

FIG. 6



- 1 -

X-ray image intensifier

The present invention relates to an X-ray image intensifier which has a metal input window.

5 An X-ray image intensifier (to be referred to as I.I. for brevity hereinafter) has an evacuated envelope which has conventionally been made of glass. It has been recently proposed, however, to manufacture an input window for an I.I. from thin metal in order to improve the characteristics of the I.I., especially the contrast property and resolution. When the input window is made of glass, the thickness of the input window must be 4 - 5 mm in consideration of the pressure. However, X-rays incident on a glass input window of this thickness are scattered, degrading the contrast property and resolution. In contrast with this, when the input window is made of metal, the input window may be made as thin as 0.2 - 1.5 mm. Accordingly, the scattering of the X-rays is less than in the case of the glass input window, and the contrast property and resolution are better.

20 The material to constitute such a metal input window must transmit X-rays and must be resistant to pressure. Materials which have been proposed so far are Al (0.5 - 1.5 mm in thickness), Ti (0.2 - 0.4 mm in thickness), steel (0.2 - 0.4 mm in thickness) and so on. However, the connection between the input window of such

a metal and the cylindrical vessel comprising the main body of the evacuated envelope which must be air-impermeable has presented various problems.

Fig. 1 shows the construction of an I.I. having a
5 metal input window as proposed in Auslegeschrift
2,619,293. An evacuated envelope 1 of this I.I.
comprises a cylindrical vessel 4 of steel, a metal input
window 2 which is hermetically connected to one end of
this vessel 4 through a joint ring 3, and an output
10 container 5 which is hermetically connected to the other
end of the vessel 4, either directly or through another
metal member. The output end of the output container 5
constitutes a transparent glass output window 6. The
metal input window 2 is of convex shape (outwardly
15 protruding), and on the inside of it is disposed an
input screen 10. Inside the glass output window 6 is
disposed an output screen 15 in opposition to the input
screen 10. Inside the evacuated envelope 1 are further
coaxially disposed a first grid 11, a second grid 12, a
20 third grid 13 an anode 14 constituting an electron lens.

A distinctive feature of such an I.I. is the fact
that Al, which has excellent X-ray transmissivity, may
be used as a material for the metal input window 2.
However, the cylindrical vessel 4 is made of steel.
25 Since the melting point of Al is about 700°C and that of
steel is 1,200 - 1,300°C, it is difficult to weld them
directly. Thus, a special connection method as shown in
Fig. 2 must be adopted. As may be seen from Fig. 2,
according to this method, a Ni-plating layer is formed
30 on the connecting part of the steel joint ring 3 with
the input window 2, and a Ag-plating layer 20 is formed
thereover. The Al input window 2 having the Ni-plating
layer formed at its connecting part with the joint ring
3 is heat welded to the joint ring 3. Since the joint
35 ring 3 and the cylindrical vessel 4 are of the same
material, they may be easily welded by methods such as

arc welding, plasma welding and brazing.

Fig. 3 shows another example of an I.I. which has a metal input window. In this I.I., the metal input window 16 comprises, for example, a Ti plate of 0.25 mm in thickness. The input window 16 of Ti and a joint ring 17 of steel or Kovar (Fe-Ni-Co sealing alloy) are welded by methods such as the resistance heating method or brazing. Fig. 4 is an enlarged view of this connecting part. Referring to Fig. 4, the input window 16 of Ti and the joint ring 17 of steel or Kovar are welded by the resistance heating method. This resistance heating method may be performed by interposing a solder such as Ag between the input window 16 and the joint ring 17, or vacuum soldering may alternatively be performed by similarly using a solder such as Ag. The input window 16 may be steel, a Ni-Fe alloy and so on instead of Ti. However, with any of these the X-ray transmissivity is inferior to that of Al. The input window must be made thin so that it is of concave shape due to the pressure difference between the inside and the outside of the evacuated envelope. The joint ring 17 may be easily welded to the cylindrical vessel 4 which consists of the same material or of a material weldable with the material of the joint ring by methods such as arc welding, plasma welding, brazing and so on.

In the conventional I.I. as described above, since the materials for the metal input window and the cylindrical vessel are different in each case, special care must be taken, making the construction of the connecting part complex. Further, since the material used for the cylindrical vessel is steel, Kovar or the like which is difficult to draw, it is very difficult to form the output side of the cylindrical vessel in a tapered shape. This becomes almost impossible with a large I.I. in which the diameter must be sharply

reduced. Still further, since steel and Kovar are ferromagnetic materials, they are easily magnetized by external magnetic fields and discharge within the tube, resulting in distortion of the image and degradation of the resolution.

The primary object of the present invention is, therefore, to provide an X-ray image intensifier wherein the construction of the connecting part may be made simple, magnetization will not be caused, and the intensifier may be made compact in size and light in weight.

To the above and other ends, the present invention provides an X-ray image intensifier having an evacuated envelope, and inside it an input screen, an output screen, and a plurality of electrodes constituting an electron lens system wherein said evacuated envelope comprises a cylindrical vessel of Al or an Al-based alloy, a metal input window of Al or an Al-based alloy which is hermetically connected to one end of said cylindrical vessel, an output container of ceramic or glass which is hermetically connected to the other end of said cylindrical vessel, and a glass output window which is hermetically sealed to the output end of said output container.

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

Fig. 1 is a schematic view of a conventional X-ray image intensifier;

Fig. 2 is a sectional view illustrating the connecting part of the input window of the X-ray image intensifier shown in Fig. 1;

Fig. 3 is a schematic view illustrating another conventional X-ray image intensifier;

Fig. 4 is a sectional view illustrating the connecting part of the input window of the X-ray image

intensifier shown in Fig. 3;

Fig. 5 is a schematic view illustrating the connecting part of the input window of the X-ray image intensifier shown in Fig. 1;

5 Fig. 6 is a sectional view of an X-ray image intensifier in accordance with an embodiment of the present invention;

Fig. 7 is a sectional view illustrating the connecting part between the metal input window and the cylindrical vessel of the X-ray image intensifier shown in Fig. 6;

Fig. 8 is a sectional view illustrating the connecting part between the cylindrical vessel and the output container of the X-ray image intensifier shown in Fig. 6;

Fig. 9 is a sectional view illustrating the connecting part between the cylindrical vessel and the output container of the X-ray image intensifier shown in Fig. 6;

Fig. 10 is a sectional view illustrating the connecting part between the cylindrical vessel and the output container of the X-ray image intensifier shown in Fig. 6; and

Fig. 11 is a sectional view illustrating an X-ray image intensifier of the present invention wherein the input screen is formed directly on the inner surface of the input window.

Detailed Description of the Preferred Embodiments

The embodiments of the present invention will now be described referring to Figs. 6 to 11.

Fig. 6 shows the X-ray image intensifier in accordance with one embodiment of the present invention. An evacuated envelope 1 of this I.I. comprises a cylindrical vessel 4 of aluminum, a metal input window 2 which is hermetically connected to one end of this vessel 4 and an output container 32 which is

hermetically connected to the other end of the vessel 4, either directly or through another metal member. The cylindrical vessel is divided into a first cylindrical vessel 30 and a second cylindrical vessel 31. The
5 output end of the output container 32 constitutes a transparent glass output window 33. The metal input window 2 is of convex shape (outwardly protruding), and on the inside of it is disposed an input screen 10. Inside the glass output window 33 is disposed an output
10 screen 15 in opposition to the input screen 10. Inside the evacuated envelope 1 are further coaxially disposed electrodes comprising a first grid 11, a second grid 12, a third grid 13 and an anode 14. The first grid 11, the second grid 12 and the third grid 13 constitute an
15 electron lens. The electrodes are electrically taken out through outer leads 26, 27, 28 and 29. These leads are insulated from the envelope by insulating material. In the I.I. of Fig. 6, a metal window 2 of 0.5 to 1.5 mm, for example, 1.0 mm in thickness and of Al or
20 an Al-based alloy is jointed by methods such as arc welding, plasma welding, and brazing to the first cylindrical vessel 30 of, for example, 3 mm in thickness and of Al or an Al-based alloy. To enhance the strength and the ease in handling, a joint ring (not shown) of
25 Al or an Al-based alloy may be interposed between the metal input window 2 and the first cylindrical vessel 30. Reference numeral 34 denotes a connecting part between the input window 2 and the first cylindrical vessel 30. Further, the output side of the first
30 cylindrical vessel 30 is welded to the second cylindrical vessel 31 (3 mm in thickness, for example) of Al or an Al-based alloy which has been processed by drawing in a manner similar to the welding of the connecting part 34. Reference numeral 35 denotes this
35 welded connecting part. A welding portion 41 of the metal input window 2 and a welding portion 42 of the

first cylindrical vessel 30 are of substantially the same thickness and are welded together by arc welding. A joint ring of Al may be interposed between the two members for welding. The structure shown in Fig. 7 is the modified example. A brazing filler 43, for example, an Al-based brazing filler (e.g., JIS Z 3263, BA₁ - 0) is interposed between both welding portions. The two members are connected by heating in a vacuum. The connecting structure shown in Fig. 7 may also be adopted for the connecting part 35.

The output end of the second cylindrical vessel 31 is connected to a ceramic output container 32 as shown in Fig. 8. A Mo-plating layer 49 and Ni-plating layer 44 is formed on the connecting surface of the output container 32. A brazing filler 45 (e.g., an Al-based brazing filler) is interposed between the Ni-plating layer 44 and the output end of the second cylindrical vessel 31 for connecting upon heating. A transparent glass output window 33 is attached to the output end of the output container 32 by using fritted glass.

As described above, in the X-ray image intensifier of the present invention, the input window and the cylindrical vessel are made of Al or an Al-based alloy. Thus, since the input window and the cylindrical vessel are of similar materials, the melting points of these materials are close and welding of these two parts is easy. In addition to this, by forming the cylindrical vessel of Al or an Al-based alloy, the output side may be easily drawn and the construction of the I.I. may be made simple, resulting in lightness and compactness of the X-ray image intensifier. And, since the diameter of the cylindrical vessel at the output end may be made smaller than the maximum diameter of the I.I. by the drawing, the connecting pressure per unit area may be advantageously made great. Since a ferromagnetic material such as Kovar is not used, there is no

magnetization which might otherwise be caused by the influence of an external magnetic field or a discharge within the tube. Consequently, the accompanying distortion of the image and degradation of the resolution are eliminated.

As mentioned above, the cylindrical vessel of an image intensifier having a diameter of, for example, 6 to 12 inches is made of aluminum according to this invention. In practice, this made it possible to connect the cylindrical vessel to an output container made of glass or ceramic. This effect was an unexpected one, which can drastically improve the structure of an image intensifier.

Fig. 9 shows the modified example of a connecting part wherein the output container 32 is not made of ceramic as shown in Fig. 8 but is made of glass. An Al ring 46 is interposed between the connecting surfaces of the output container 32 and the second cylindrical vessel 31 for welding by hot-pressing. The welding by hot-pressing using an Al ring may be accomplished, for example, by exerting a pressure of 340 kg/cm^2 on the members to be connected at 430°C for 30 minutes.

Fig. 10 shows another example of a connecting structure of the output end of the second cylindrical vessel 31 and the output container 32. The ceramic output container 32 and a joint ring 47 of Al or an Al-based alloy are hot-pressed with an Al ring 48 interposed therebetween. Then the joint ring 47 and the second cylindrical vessel 31 are arc-welded. The output container 32 and the joint ring 47 may be connected by another method. A transparent glass output window 33 is attached to the output end of the output container 32 by using fritted glass. The output container 32 is of preferably cylindrical shape so as to withstand the pressure exerted during hot-pressing.

Fig. 11 shows an example wherein an input screen 50

is formed directly inside the metal input window 2. The input screen 10 of the I.I. shown in Fig. 6 is generally formed by vacuum-depositing Na-activated CsI phosphor to a thickness of about 200 μm on the recessed side of a spherical Al substrate of about 0.5 mm in thickness; forming a protective film of Al_2O_3 or the like of about 400 \AA in thickness thereover, and finally forming a photoconductive layer of Cs-Sb or the like while evacuating the I.I. However, in the construction shown in Fig. 11, the Na-activated CsI phosphor layer, the protective film, and the photoconductive layer are formed in the order mentioned directly on the inner surface of the metal input window 2 of Al or an Al-based alloy. Thus, in the construction shown in Fig. 11, the X-ray transmissivity is improved, and the scattering of the X-rays is made less since the Al substrate is unnecessary. Thus, an I.I. of excellent performance may be obtained.

Although the cylindrical vessel is divided into two parts in the embodiments described above, it may be formed in unitary form, especially in the case of a small I.I. However, if the input phosphor screen is disposed directly inside the input window, it is advantageous to divide the cylindrical vessel into two parts since then the input phosphor screen may be disposed after connecting the input window to the first cylindrical vessel, and the thermal degradation of the input phosphor screen due to the welding heat is eliminated. An input phosphor screen of excellent characteristics can thus be obtained.

Claims:

1. An X-ray image intensifier having an evacuated envelope and inside it an input screen, an output screen, and a plurality of electrodes constituting an electron lens system, characterized in that said evacuated envelope comprises a cylindrical vessel of Al or an Al-based alloy, a metal input window of Al or an Al-based alloy which is hermetically connected to one end of said cylindrical vessel, an output container of ceramic or glass which is hermetically connected to the other end of said cylindrical vessel, and a glass output window which is hermetically sealed to the output end of said output container.

2. An X-ray image intensifier as claimed in claim 1, characterized in that said output container is of cylindrical shape.

3. An X-ray image intensifier as claimed in claim 1 or 2, characterized in that the diameter at one end of said cylindrical vessel is greater than the diameter at the other end thereof.

4. An X-ray image intensifier as claimed in claim 1, 2 or 3, characterized in that said cylindrical vessel comprises a first cylindrical vessel and a second cylindrical vessel.

5. An X-ray image intensifier as claimed in claim 1 or 2, characterized in that said output container is made of ceramic and is hermetically connected to the other end of said cylindrical vessel by brazing.

6. An X-ray image intensifier as claimed in claim 1 or 2, characterized in that said output container is made of ceramic and is hermetically connected to the other end of said cylindrical vessel by hot-pressing.

7. An X-ray image intensifier as claimed in

- 2 -

claim 4, characterized in that a Ni-plating layer is formed between connecting surfaces of said output container and said cylindrical vessel.

5 8. An X-ray image intensifier as claimed in claim 1, characterized in that said output container is made of glass and is hermetically connected to the other end of said cylindrical vessel by hot-pressing.

10 9. An X-ray image intensifier as claimed in claim 1, characterized in that said output container is made of ceramic or glass and is hermetically connected to the other end of said cylindrical vessel through the intermediary of a joint ring of Al or an Al-based alloy.

15 10. An X-ray image intensifier as claimed in claim 3, characterized in that an input phosphor screen is arranged directly inside the inner surface of said metal input window.

FIG. 1

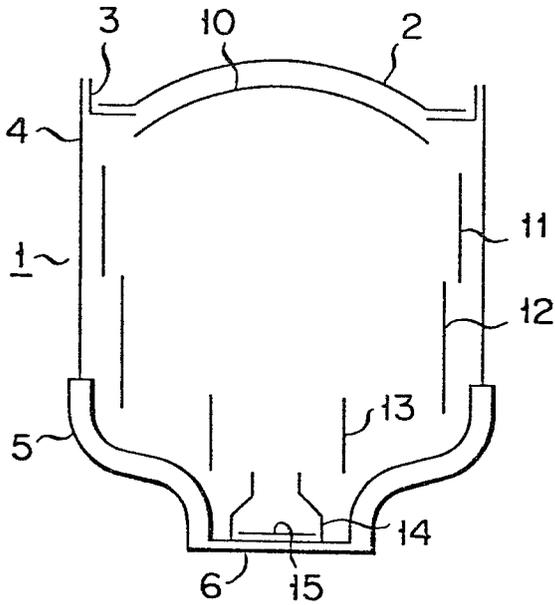


FIG. 2

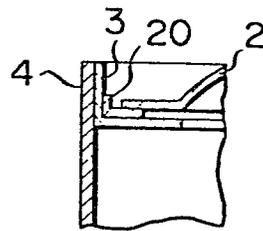


FIG. 4

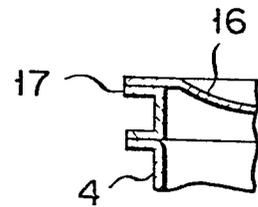


FIG. 3

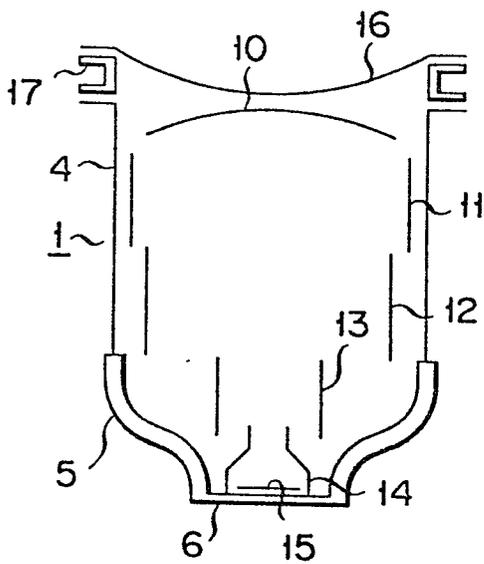


FIG. 5

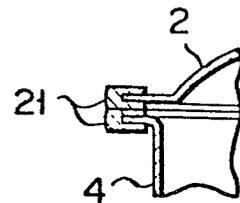


FIG. 6

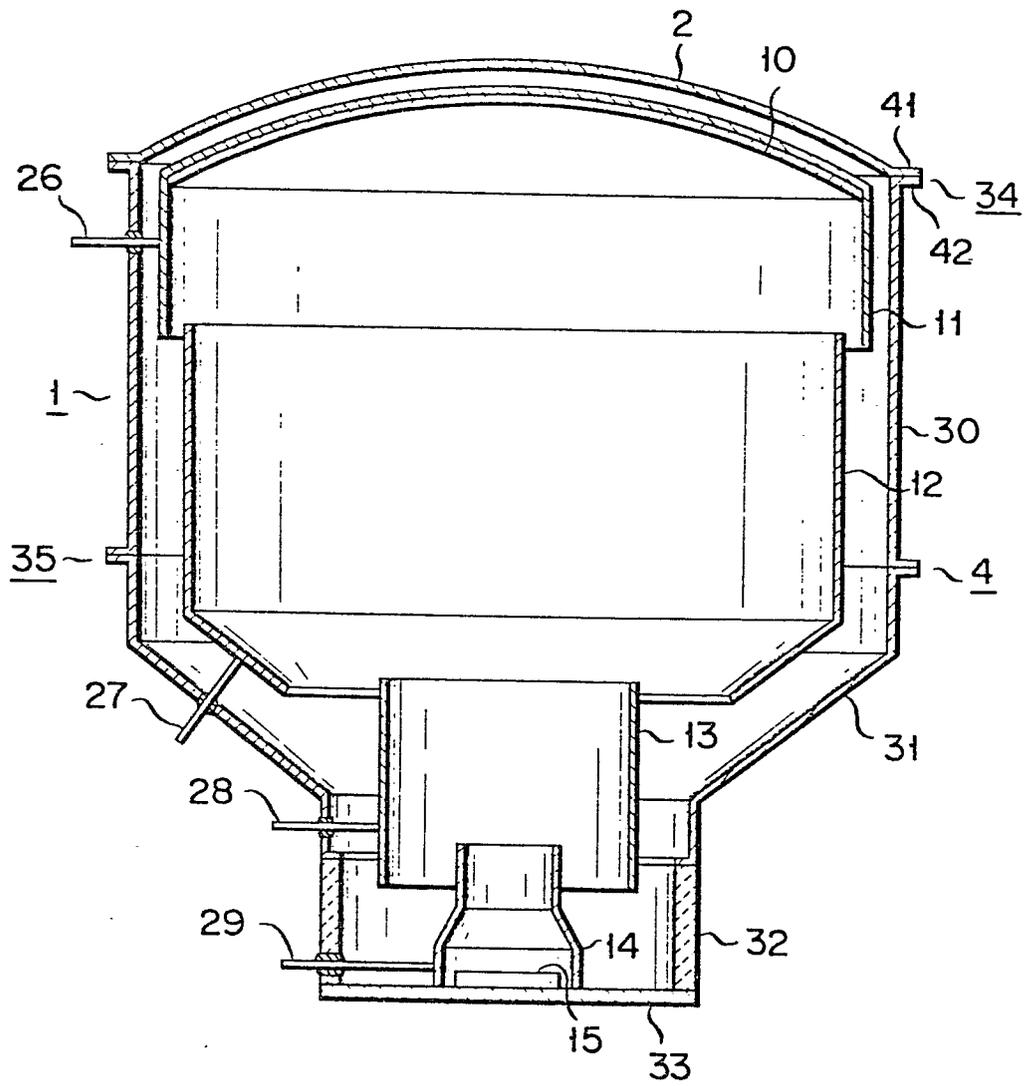


FIG. 7

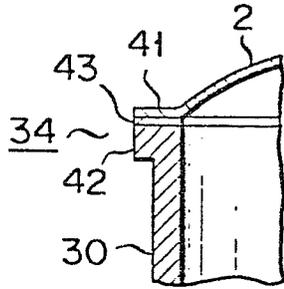


FIG. 8

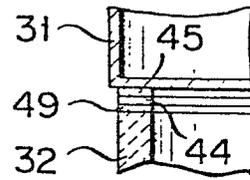


FIG. 9

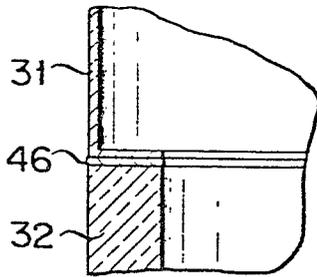


FIG. 10

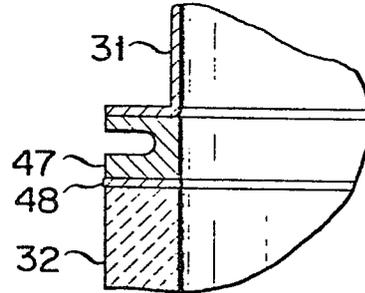
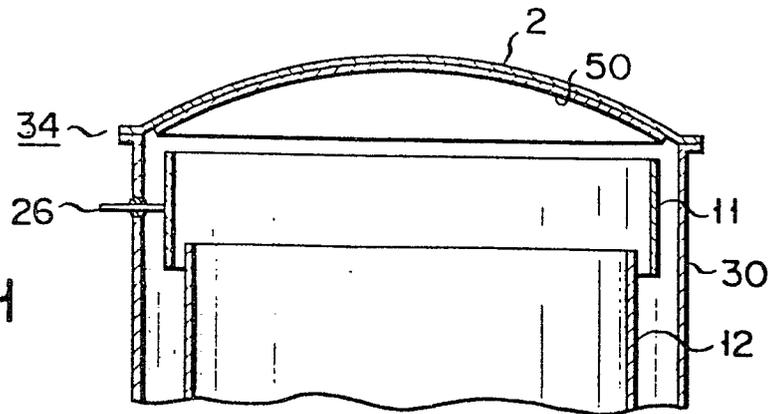


FIG. 11





DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
D,A	DE - A1 - 2 750 132 (DIAGNOSTIC) + Page 9, lines 17-21; page 10, lines 10-12; page 19, lines 14-18; page 20, lines 4-8; page 23, lines 9-11; page 25, lines 23-25; page 26, lines 20-27; fig. 2 + --	1	H 01 J 31/50
	DE - B - 2 331 210 (SIEMENS) + Column 2, lines 31-36, 66-68; column 3, lines 1,18-21, 49-64; column 4, lines 9-16; fig. 1,2 + --	1,3	
	US - A - 4 045 700 (SIEMENS) + Column 2, lines 35-50; column 3, lines 4-9, 29-34; fig. 1,2 + --	1-5	H 01 J 31/00 H 01 J 35/00 H 01 J 1/00 H 05 G 1/00
	DE - A1 - 2 423 935 (SIEMENS) + Page 3, lines 10-27; fig. 1,2 + --	1-5	
	DE - A1 - 2 505 991 (SIEMENS) + Totality + --	1-5	
	DE - A1 - 2 619 293 (SIEMENS) + Totality + ----		
X The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl. 3) CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons &: member of the same patent family, corresponding document
Place of search	Date of completion of the search	Examiner	
VIENNA	29-10-1980	DIMITROW	