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(54) Housing for an x-ray emitting assembly and method of making the same

(57) The x-ray emitter assembly of the invention includes an x-ray tube assembly. The emitter assembly further includes a first high voltage connector and a second high voltage connector being operably connected to the x-ray tube assembly. The x-ray tube assembly and the first and second high voltage connectors are selectively operable to generate x-radiation. The emitter assembly further includes a supply of dielectric oil surrounding the x-ray tube assembly. The emitter assembly further includes a housing assembly containing the supply of dielectric oil and surrounding the x-ray tube assembly. The housing assembly is electronically insulated from the first and second high voltage connectors and the x-ray tube assembly and allows for the protrusion of the first and second high voltage connectors. The housing assembly selectively permits emission of x-radiation from the x-ray emitter assembly. The housing assembly includes an composite inner wall. The composite inner wall includes one or more protection layers and a sealing layer. The one or more protection layers has an internal surface and the sealing layer comprises tin and has an external surface. The composite inner wall is integrally formed by cold rolling the external surface of the sealing layer to the internal surface of the one or more protection layers.

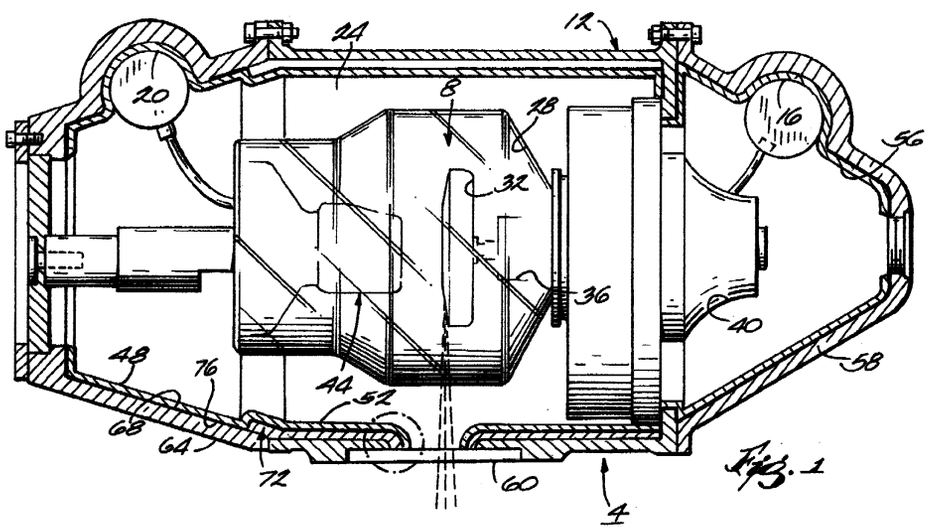

Fig. 1

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Description

BACKGROUND OF THE INVENTION

Technical Field

[0001] The invention relates to x-radiation emitter assemblies and methods of making a housing for x-radiation emitter assemblies.

Related Prior Art

[0002] X-radiation generated by an x-ray apparatus is used in a variety of situations including propagation through a human body for study, An x-ray emitter assembly is the portion of the x-ray apparatus that emits the x-radiation. The emitter assembly typically includes a housing and a vacuum tube located inside the housing, The vacuum tube includes a cathode and an anode that emits x-radiation upon proper voltage biasing. The housing also includes a supply of dielectric oil that surrounds the vacuum tube. The supply of dielectric oil insulates the housing from the energy produced by the vacuum tube during operation of the x-ray emitter.

[0003] Specifically, because production of x-radiation requires large amounts of energy, the vacuum tube generates large amounts of thermal energy. The supply of dielectric oil thermally insulates the housing by dissipating heat from the vacuum tube before reaching the housing. The supply of dielectric oil also serves as an electric insulator between the shielding and the housing. Electric insulation is needed to prevent high voltage discharges from arcing between the vacuum tube and the housing. Such arcing can result due to the high energy potential of the vacuum tube and a low energy potential of the housing. Arcing promotes degradation in the x-ray signal, and can accelerate emitter assembly failure.

[0004] The emitter assembly housing also typically includes a lead shielding which protects the exterior of the emitter assembly from unwanted x-radiation. Using a housing with the proper lead shielding provides a controlled x-radiation beam, or x-rays. Lead shielding can be provided by a housing made of lead or a lead alloy, or by providing the housing with a lining made of lead. When such shielding is provided, it is known to provide a sealant to prevent direct contact between the supply of dielectric oil and the lead shielding because contamination of the oil by the lead will degrade the oil. Oil degradation decreases the oil's capacity to dissipate heat and electrically insulate the housing. It is known to provide such a sealant of the lead by painting or coating the interior surface of the housing with a resistive coating. U.S. Patent No. 5,604,784, which issued on February 18, 1997, discloses an example of such a sealant. Other known methods for providing a sealing on the housing interior include providing an insulating layer provided by plasma spraying material on the interior surfaces.

SUMMARY OF THE INVENTION

[0005] Known techniques for sealing the interior of an x-ray housing to prevent contamination of the dielectric oil supply by a lead lining sometimes present problems. If the interior of the housing is painted with a sealant, sometimes the sealant can flake off the housing over time into the supply of dielectric oil. If enough flaking occurs, the lead liner will be exposed, thus permitting the lead liner to contact the dielectric oil. When this happens, the dielectric oil can degrade, consequently resulting in stress on the x-ray emitter assembly and promoting failure. Additionally, paint flakes can create an electrically conductive path in the dielectric oil leading to an increased risk of arcing between the housing and the x-ray vacuum tube.

[0006] As to alternative methods of spaying a sealant on the housing interior, such other methods often entail difficulty in manufacturing the housing. For example, when spraying a sealant on the interior of the housing it is often difficult to assure that the sealant has the proper thickness and is uniformly distributed on the surfaces containing the dielectric oil.

[0007] Accordingly, in one embodiment, the invention provides an x-ray emitter assembly including an x-ray tube assembly and a high voltage connector operably connected to the x-ray tube assembly. The emitter assembly also includes a supply of dielectric oil surrounding the x-ray tube assembly. The emitter assembly also includes a housing assembly containing the supply of dielectric oil and enclosing the x-ray tube assembly. The housing assembly includes a composite inner wall including a protection layer providing an internal surface and a sealing layer made at least in part of tin and being integrally formed with the internal surface of the protection layer.

[0008] In another embodiment, the invention provides a housing assembly including an outer wall enclosing an x-ray tube assembly and a supply of dielectric oil The housing assembly also includes a composite inner wall engaged with the outer wall and sealing the outer wall from the oil supply. The composite wall includes a protection layer which prevents the passage of x-radiation and a sealing layer made at least in part of tin and being integrally formed with the protection layer.

[0009] The invention also provides a method for making an x-ray emitter assembly. In one embodiment, the method includes the acts of providing an x-ray tube assembly and integrally forming an composite sheet of protective material. The composite sheet includes at least one protection layer made at least in part of lead and also includes a sealing layer made at least in part of tin. The method also includes the act of providing housing assembly components which, when assembled, surround the x-ray tube assembly, the act of lining the housing assembly components with the composite inner wall; and assembling the housing assembly. The method also includes the step of interjecting a supply of

dielectric oil between the x-ray tube assembly and the housing.

[0010] The invention also provides a method of providing an x-ray emitter assembly. The method includes the acts of forming an integral composite sheet of protective material; the forming step including bonding at least one protection layer made at least in part of lead with a sealing layer made at least in part of tin. The method also includes the step of providing housing assembly components which, when assembled, are adapted to surround an x-ray tube assembly, and lining the housing assembly components with the composite inner sheet. The method also includes the step of providing an x-ray tube assembly, assembling the housing assembly and interjecting a supply of dielectric oil between the x-ray tube assembly and the housing.

[0011] A principal advantage of the invention is bonding one or more layers of lead with a layer made at least in part of tin into a composite sheet of material that is then used to line a x-ray emitter assembly housing. The use of such a composite sheet prevents the lead layer from contacting a supply of dielectric oil. Also, another advantage achieved by the invention is that the sheet is malleable and can be easily formed into a lining for the housing. This plastic characteristic of the protective sheet assures that the protective lining of the housing is sufficiently uniform and thick cold roll one or more layers of lead with a layer comprising of tin.

[0012] It is another advantage of the invention to provide a longer life x-ray emitter assembly by better preventing the lead layer from contacting a supply of dielectric oil.

[0013] It is another advantage of the invention to form, punch, and stamp the cold-rolled layers of lead and tin like a typical lead product..

[0014] It is another advantage of the invention to provide an easier way of applying a scaling layer to the interior of an x-ray emitter assembly housing.

[0015] Other features and advantages of the invention will become apparent to those skilled in the art upon review of the following detailed description, claims and drawings.

DESCRIPTION OF THE DRAWINGS

[0016] Figure 1 is a cross-sectional view of an x-ray emitter assembly embodying the present invention.

[0017] Figure 2 is an enlarged view of a portion of the assembly shown in Fig. 1.

[0018] Before one embodiment of the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangements of components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] The drawings illustrate an x-ray emitter assembly 4 which embodies the invention and which is adapted for use with an x-ray apparatus (not shown). With reference to Fig. 1, the emitter assembly 4 includes an x-ray tube assembly 8, a housing assembly 12, a first high voltage connector 16, a second high voltage connector 20, and a supply of dielectric oil 24. The housing assembly 12 encloses the tube assembly 8 and contains the supply of dielectric oil 24 which surrounds the tube assembly 8. The first and second high voltage connectors 16 and 20 are operably connected to the tube assembly 8 and extend through the supply of dielectric oil 24 and the housing assembly 12.

[0020] The tube assembly 8 includes an outer glass envelope 28, a disc shaped anode 32, a rotor 36, a motor 40 and a cathode assembly 44. The outer glass envelope 28 provides a vacuum tube surrounding the cathode assembly 44, the anode 32, and the rotor 36. The cathode assembly 44 includes a conventional thermionic emissive cathode (not shown) and a filament (not shown) which heats the cathode to a temperature which will emit electrons when properly biased. The anode 32 is fabricated of conventional material that emits x-radiation upon electron bombardment. The anode 32 is attached to the motor 40 by way of rotor 36. When current is applied to the motor 40 the rotor 36 and the anode 32 spin. Upon bombardment of electrons from the cathode assembly 44 to the spinning anode 32, x-radiation is emitted from the tube assembly 8.

[0021] The first and second high voltage connectors 16 and 20 extend through and are electrically insulated from the housing assembly 12. The first and second high voltage connectors 16 and 20 are connected to a power supply (not shown). The first high voltage connector 16 is adapted to receive a high positive bias potential and is connected to the anode 32 via the motor 40. The second high voltage connector 20 is adapted to receive a high negative bias potential and is connected to the cathode assembly 44. When the high voltage connectors 16 and 20 are energized, the tube assembly 8 emits x-radiation.

[0022] Upon emission of x-radiation from the tube assembly 8, the x-radiation propagates through the supply of dielectric oil 24, The dielectric oil 24 can be any dielectric oil known in the art. There are at least two reasons for the use of the supply of dielectric oil 24. First, due to the high amount of power needed to produce x-radiation, the tube assembly 8 radiates large amounts of thermal energy. The supply of dielectric oil 24 helps cool the housing assembly 12 by dissipating a portion of the thermal energy before it reaches the housing assembly 12. Second, the supply of dielectric oil 24 serves as an electrical insulator between the tube assembly 8, the hous-

ing assembly 12, and the first and second high voltage connectors 16 and 20. Acting as an electrical insulator, the supply of dielectric oil 24 helps prevent arcing between the tube assembly 8 and the housing assembly 12.

[0023] The housing assembly 12 includes three interconnected components: a cupped-shaped cathode end segment 48, a tubular center segment 52, and a cupped-shaped anode end segment 56. The three segments 48, 52 and 56 are fixed together to form a continuous shield or wall 58 which, with the window 60, extends around and envelops the tube assembly 8 to prevent unwanted leakage of x-radiation from the emitter assembly 4. The center segment 52 extends around the majority of the tube assembly 8 and has a window 60 through which x-radiation may pass. The cathode end segment 48 is fixed to the center segment 52 by bolts and is adjacent the cathode assembly 44. The anode end segment 56 is fixed to the center segment 52 by bolts and is adjacent the motor 40. While the preferred embodiment of the housing assembly 12 includes three segments or components, it will be readily understood that any suitable configuration and combination of segments can be used to provide the housing assembly 12. The housing assembly 12 thus provides a substantially continuous wall 58 surrounding the tube assembly 8 and containing the oil supply 24.

[0024] More particularly, and with reference to Fig. 2, the housing assembly wall 58 includes an outer wall 64 having an inner surface 68 and an composite inner wall 72 having an outer surface 76. The outer surface 76 of the composite inner wall 72 directly contacts the inner surface 68 of the outer wall 64. The outer wall 64 is typically comprised of aluminum and is generally thicker than the composite inner wall 72. It should be understood that the outer wall 64 can be made of materials other than aluminum and that its thickness may vary. The outer wall 64 defines the cavity in which the tube assembly 8 and the supply of dielectric oil 24 reside. Furthermore, the outer wall 64 allows for the placement of the window 60 and two high voltage connectors 16 and 20. For example, Fig. 1 shows the window 60 affixed to the tubular center segment, the first high voltage connector 16 protruding through the anode end segment 56 and the second high voltage connector 20 protruding through the cathode end segment 48.

[0025] The composite inner wall 72 shields the exterior of the emitter assembly from x-radiation, Preferably, the composite inner wall 72 covers the entire inner surface 68 of the outer wall 64. Referring to Fig. 2, the composite inner wall 72 includes one or more protection layers 80 having an internal surface 84 and a sealing layer 88. The sealing layer 88 is bonded to the internal surface 84 of the protection layers 80 at an outer surface or interface 92.

[0026] The protection layers 80 are preferably made of lead, are preferably a thickness of 1/32 inches to 1/4 inches and may comprise multiple layers. The required thickness and the number of layers of the layers 80 varies depending on the energy level of the tube assembly 8 and the location of the one or more protection layers 80 within the housing assembly 12. Thicker layers are generally required in areas with higher energy levels. For example, in the preferred embodiment shown in the figures, a second protection layer has been added to the center segment 52, which provides extra protection from unwanted emissions of x-radiation.

[0027] The sealing layer 88 is preferably formed of a composition that is made at least in part tin, and can be made entirely of tin. The sealing layer is typically 0.5 mils to 10 mils in thickness. The required thickness of the sealing layer 88 varies depending on the energy level of the tube assembly 8 and the location of the sealing layer 88 within the housing assembly 12. For example, thicker layers are generally required in areas with higher energy levels. Preferably, the sealing layer is made of pure tin, but other embodiments of the sealing layer 88 may be made of a tin alloy. Suitable tin alloys include lead/tin alloys, bismuth/tin alloys, or silver/tin alloys. If the alloy is a lead /tin alloy, the preferable tin content is at least 60%.

[0028] The composite inner wall 72 is preferably formed by cold rolling sheets of materials for the protection layers 80 and the sealing layer 88 so that the resultant product is a single, composite material having a lead base and a non-lead surface. The composite sheet can then be formed and applied to the interior of the outer wall 64. The variations in the thickness and the number of the protection and sealing layers 80 and 82 can be taken into account when cold rolling the composite inner wall 72. The tin or tin alloy in the sealing layer 88 bonds to the lead in the one or more protection layers 80 during the cold rolling process. The bonded layers allow the composite inner wall 72 to be formed, punched, or stamped like a typical lead product.

[0029] When the composite inner wall 72 is formed, punched, or stamped, an edge of lead may be exposed. In this event, tin solder should be applied to the exposed lead edges so that when those formed portions of the composite sheet are used as the protective, sealing lining of the housing, the lead is sealed from contact with the dielectric oil supply 24.

[0030] The composite inner wall 72 is arranged next to the outer wall 64. The arrangement may be accomplished by either fixedly attaching the composite inner wall 72 to the outer wall 64 by an adhesive or by folding the composite inner wall 72 into engagement with the outer wall 64. In general, when the composite inner wall 72 is placed next to the outer wall 64, the supply of dielectric oil 24 will provide sufficient pressure against the composite inner wall 72 to adequately hold the composite inner wall 72 into place.

[0031] Accordingly, the x-ray emitter assembly can be formed by performing the following acts: the forming an integral composite sheet of protective material; the forming step including bonding at least one protection

layer made at least in part of lead with a sealing layer made at least in part of tin. The method of forming the x-ray emitter assembly also includes the step of providing housing assembly components which, when assembled, are adapted to surround an x-ray tube assembly, and lining the interior surfaces of the housing assembly components with portions of the composite inner sheet formed to mate with or engage the components. The method also includes the step of providing an x-ray tube assembly, assembling the housing assembly and interjecting a supply of dielectric oil between the x-ray tube assembly and the housing.

[0032] Cold rolling the one or more protection layers 80 to the sealing layer 88 provides an improved way to seal the one or more protection layers 80 from contacting the supply of dielectric oil 24. Cold rolling the protection layers 80 to the sealing layer 88 allows for an improved way of applying a sealing layer since it can be formed, punched or stamped like a typical lead product. More importantly, the cold rolled sealing layer 88 does not flake off of the one or more protection layers 80 like the painted sealing layer. Thus, the improved housing assembly is easier to produce and lasts longer than the prior art.

Claims

1. An x-ray emitter assembly comprising:

an x-ray tube assembly;
a high voltage connector operably connected to the x-ray tube assembly,
a supply of dielectric oil surrounding the x-ray tube assembly; and
a housing assembly containing the supply of dielectric oil and enclosing the x-ray tube assembly, the housing assembly including a composite inner wall including a protection layer providing an internal surface and a sealing layer made at least in part of tin and being integrally formed with the internal surface of the protection layer.

2. The emitter assembly as set forth in claim 1, wherein the composite inner wall has an outer surface and the housing assembly further comprises an outer wall having an inner surface, the outer surface of the composite inner wall is arranged next to the inner surface of the outer wall.

3. The emitter assembly as set forth in claim 2, wherein the outer surface of the composite inner wall is arranged next to the inner surface of the outer wall by fixedly attaching the outer surface of the composite inner wall next to the inner surface of the outer wall.

4. The emitter assembly as set forth in claim 2, wherein the outer surface of the composite inner wall is arranged next to the inner surface of the outer wall by placing the outer surface of the composite inner wall next to the inner surface of the outer wall.

5. The emitter assembly as set forth in claim 2, wherein the composite inner wall is thinner than the outer wall.

6. The emitter assembly as set forth in claim 2, wherein the outer wall composite comprises aluminum.

7. The emitter assembly as set forth in claim 1, wherein the one or more protection layers comprises lead.

8. The emitter assembly as set forth in claim 1, wherein the sealing layer is pure tin.

9. The emitter assembly as set forth in claim 1, wherein the sealing layer comprises a tin alloy.

10. The method of providing an x-ray emitter assembly comprising the acts of:

providing an x-ray tube assembly;
integrally forming an composite sheet of protective material, the composite sheet including at least one protection layers made at least in part of lead and including a sealing layer made at least in part of tin;
providing housing assembly components which, when assembled, surround the x-ray tube assembly,
lining the housing assembly components with the composite inner wall;
assembling the housing assembly and
interjecting a supply of dielectric oil between the x-ray tube assembly and the housing.

11. The method as set forth in claim 10, wherein the bonding act further includes the act of cold rolling the protection layer with the sealing layer.

12. The method as set forth in claim 10, wherein the lining act includes the act of fixing the composite sheet to the housing.

13. The method as set forth in claim 10, wherein the outer wall is made of aluminum.

14. An x-ray emitter assembly comprising:

an x-ray tube assembly;
a first high voltage connector and a second high voltage connector, the first and second high voltage connectors being operably connected to the x-ray tube assembly, the x-ray tube as-

sembly and the first and second high voltage connectors being selectively operable to generate x-radiation;
a supply of dielectric oil surrounding the x-ray tube assembly; and
a housing assembly containing the supply of dielectric oil and surrounding the x-ray tube assembly, the housing assembly being electronically insulated from the first and second high voltage connectors and the x-ray tube assembly and allowing for protrusion of the first and second high voltage connectors, the housing assembly selectively permits emission of x-radiation from the x-ray emitter assembly, the housing assembly including

an outer wall, the outer wall being made of aluminum and having an inner surface, and an composite inner wall, the composite inner wall is thinner than the outer wall and having an outer surface, the outer surface of the composite inner wall is arranged next to the inner surface of the outer wall, the composite inner wall further including

one or more protection layers, the one or more protection layers comprising lead having a thickness of 0.03125 inches to 0.25 inches and having an internal surface, and
a sealing layer, the sealing layer comprising tin having a thickness of 0.0005 inches to 0.01 inches and having an external surface, the composite inner wall is integrally formed by cold rolling the external surface of the sealing layer to the internal surface of the one or more protection layers.

15. The emitter assembly as set forth in claim 14 wherein the outer surface of the composite inner wall is arranged next to the inner surface of the outer wall by fixedly attaching the outer surface of the composite inner wall next to the inner surface of the outer wall.

16. The emitter assembly as set forth in claim 14, wherein the outer surface of the composite inner wall is arranged next to the inner surface of the outer wall by placing the outer surface of the composite inner wall next to the inner surface of the outer wall.

17. The method of providing an x-ray emitter assembly comprising the acts of:

providing an x-ray tube assembly;
integrally forming an composite inner wall, the integrally forming act including the act of bonding one or more protection layers with a sealing layer, the bonding act further including the act of cold rolling the internal surface of the one or more protection layers with the external surface of the sealing layer;
integrally forming a housing assembly to surround the x-ray tube assembly the integrally forming act including the act of arranging an outer surface of the composite inner wall to an inner surface of an outer wall, the outer wall being made of aluminum and is thicker than the composite inner wall;
surrounding the x-ray tube assembly with the housing; and
interjecting a supply of dielectric oil between the x-ray tube assembly and the housing.

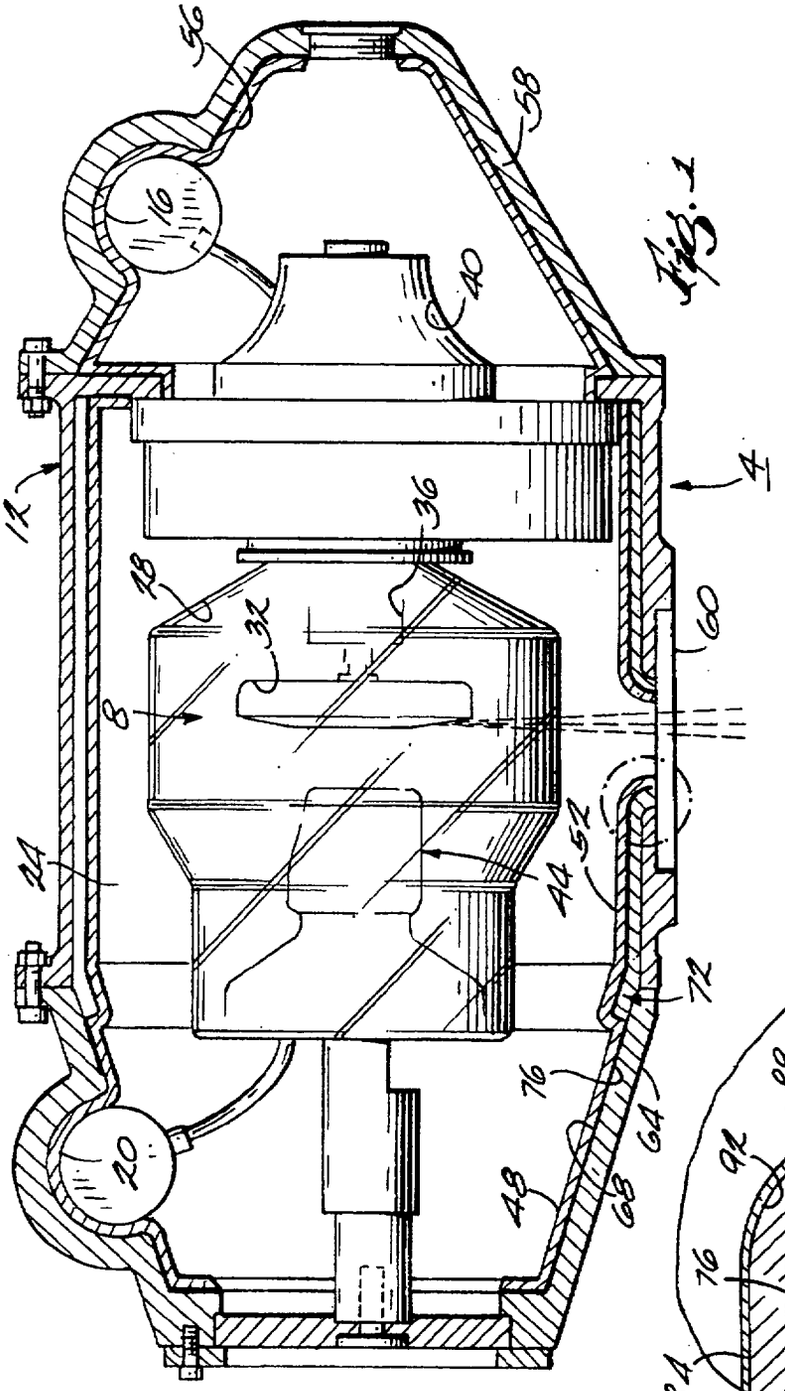
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Fig. 1

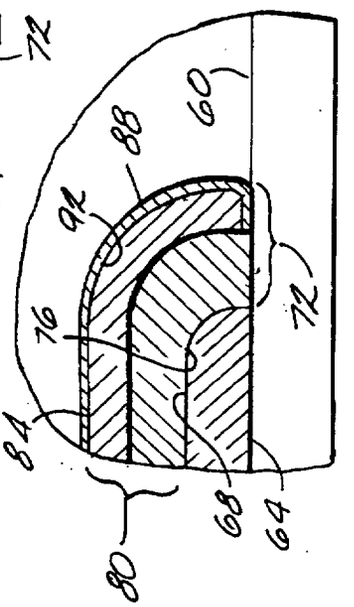
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Fig. 2