United States Patent

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[72] Inventor Paul J. Gardner
Davenport, Iowa

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[73] Assignee The Bendix Corporation

[54] **CONTAINER FOR CRYOGENIC FLUIDS**
9 Claims, 6 Drawing Figs.

[52] U.S. Cl. 220/15, 62/54
[51] Int. Cl. B65d 25/00
[50] Field of Search .... 220/9, 9 A, 9 D, 15, 14, 10

[56] **References Cited**

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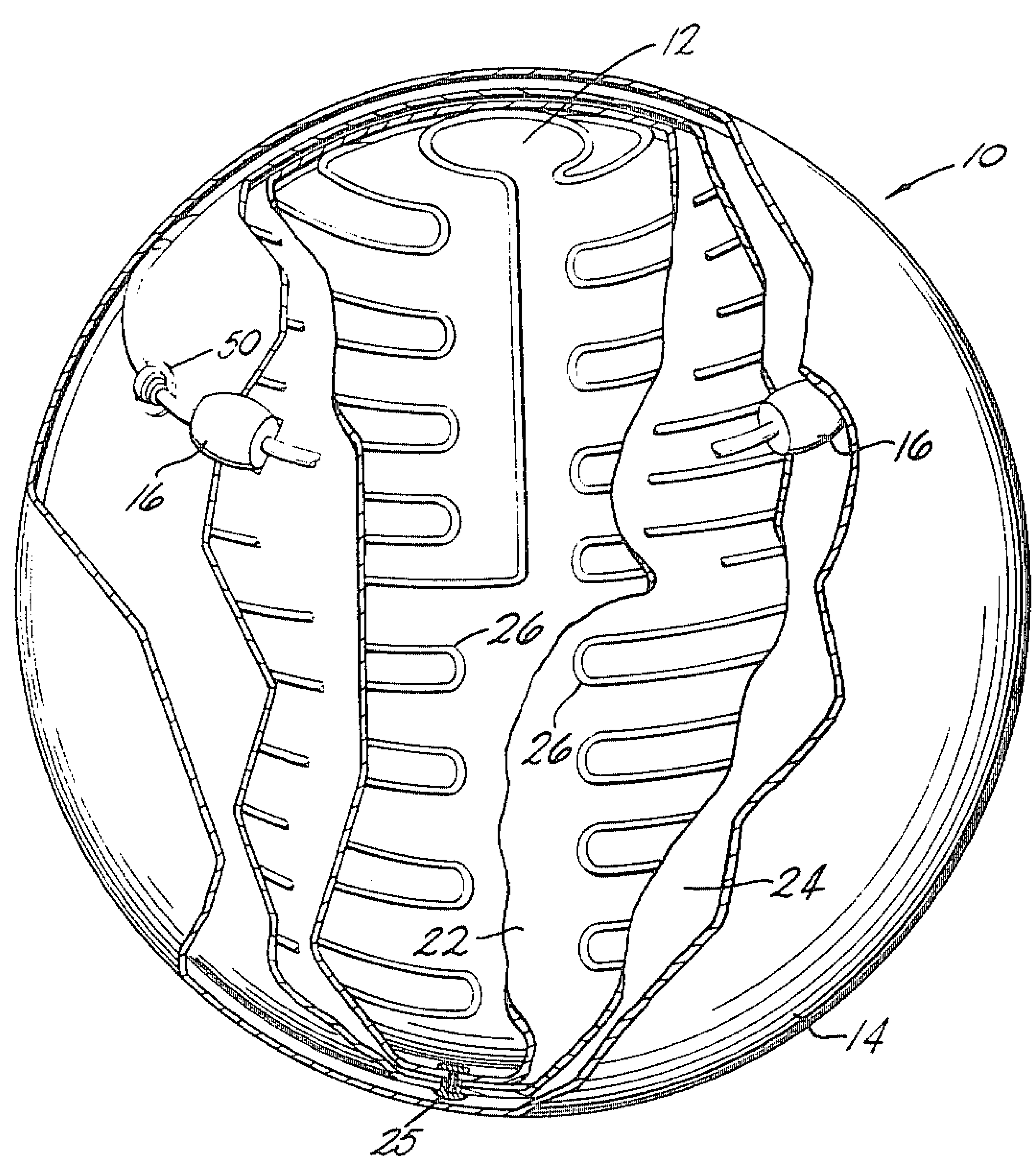
Primary Examiner—Albert W. Davis, Jr.
Attorneys—Plante, Arens, Hartz, Hix and Smith and William N. Antonis

ABSTRACT: A container having an inner and outer vessel for storing cryogenic fluid. The inner vessel is concentrically separated from the outer vessel by bumper members. The bumper members are spaced on a conduit around the inner vessel. A shield member is located in the space between the inner and outer vessel. A mounting member attached to the conduit is secured to the shield member for preventing direct contact between the outer vessel and the shield member and thereby effectively reduce conductive heat transfer to the inner vessel.



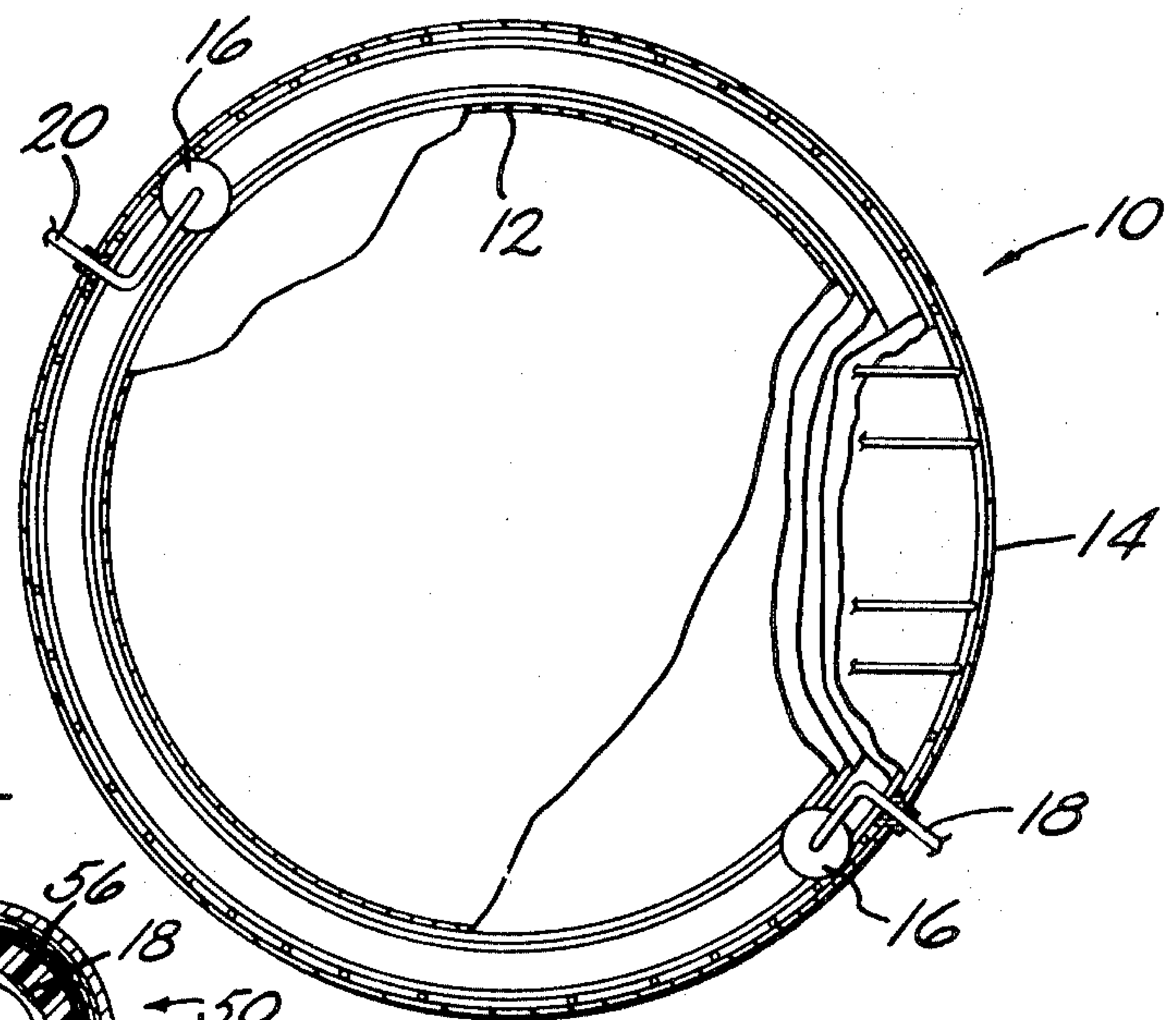


FIG. 1

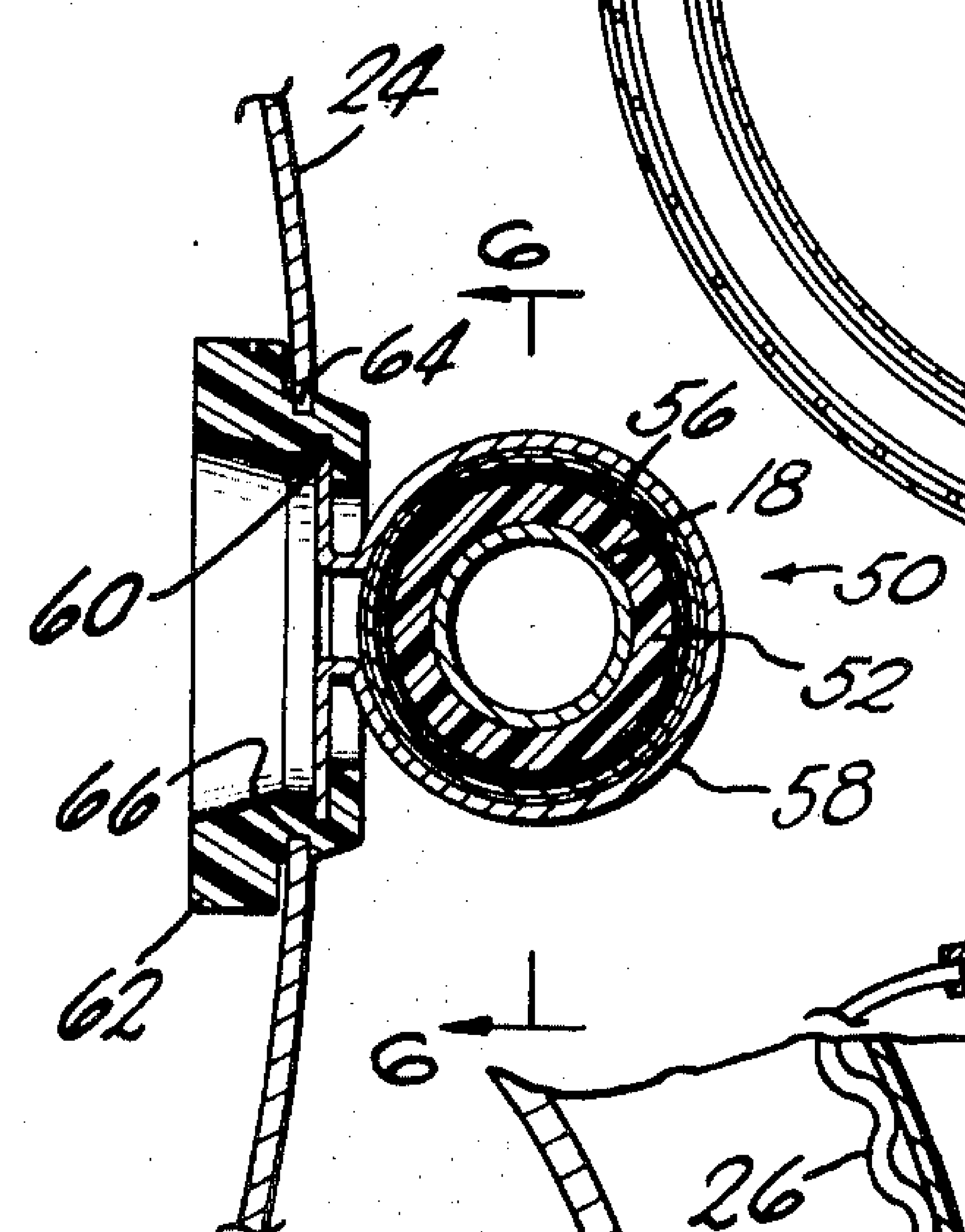


FIG. 5

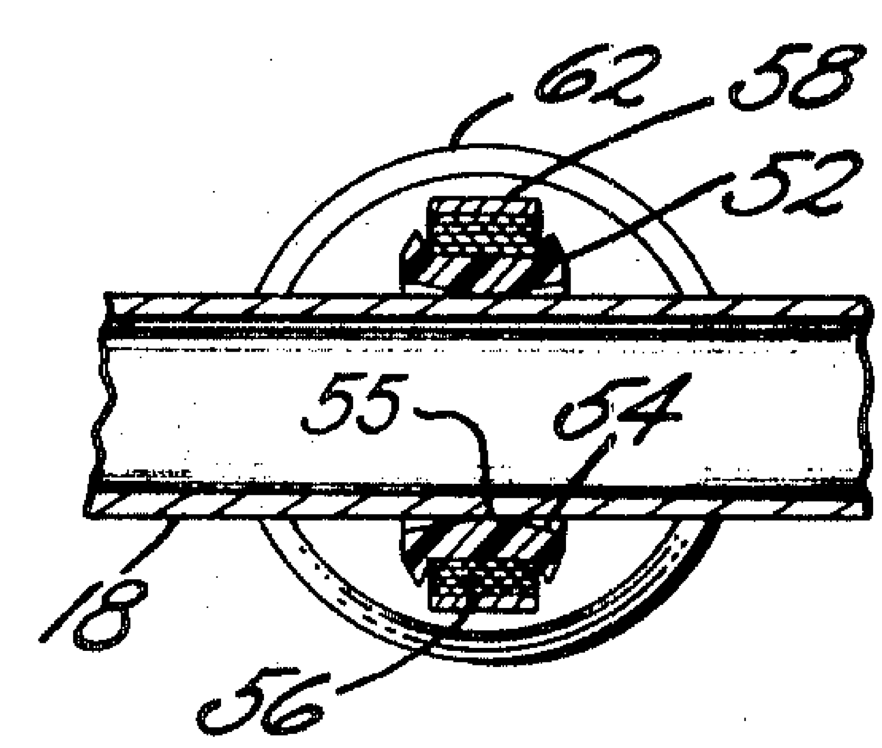


FIG. 6

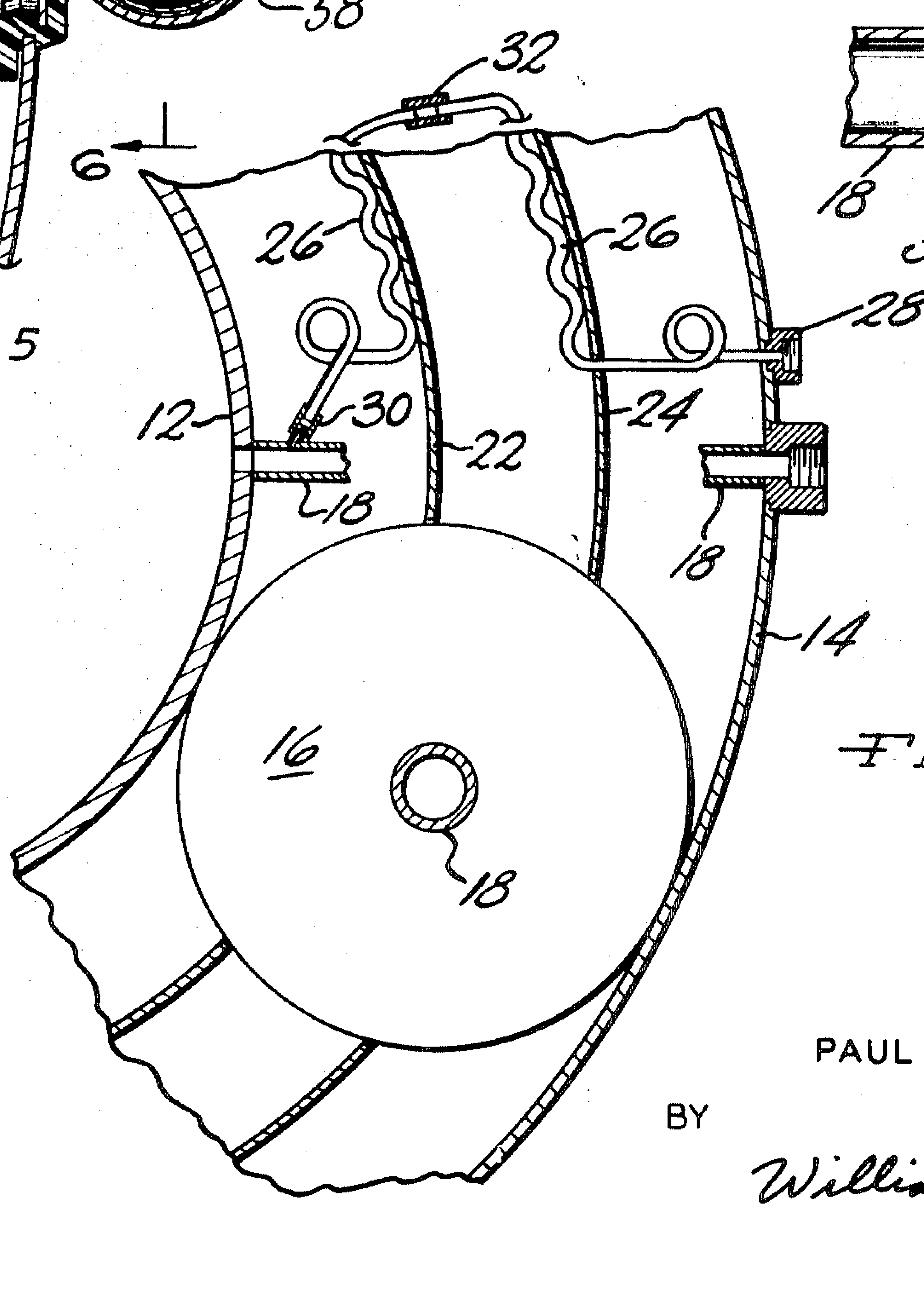


FIG. 2

INVENTOR
PAUL J. GARDNER

BY

William N. Antonis
ATTORNEY

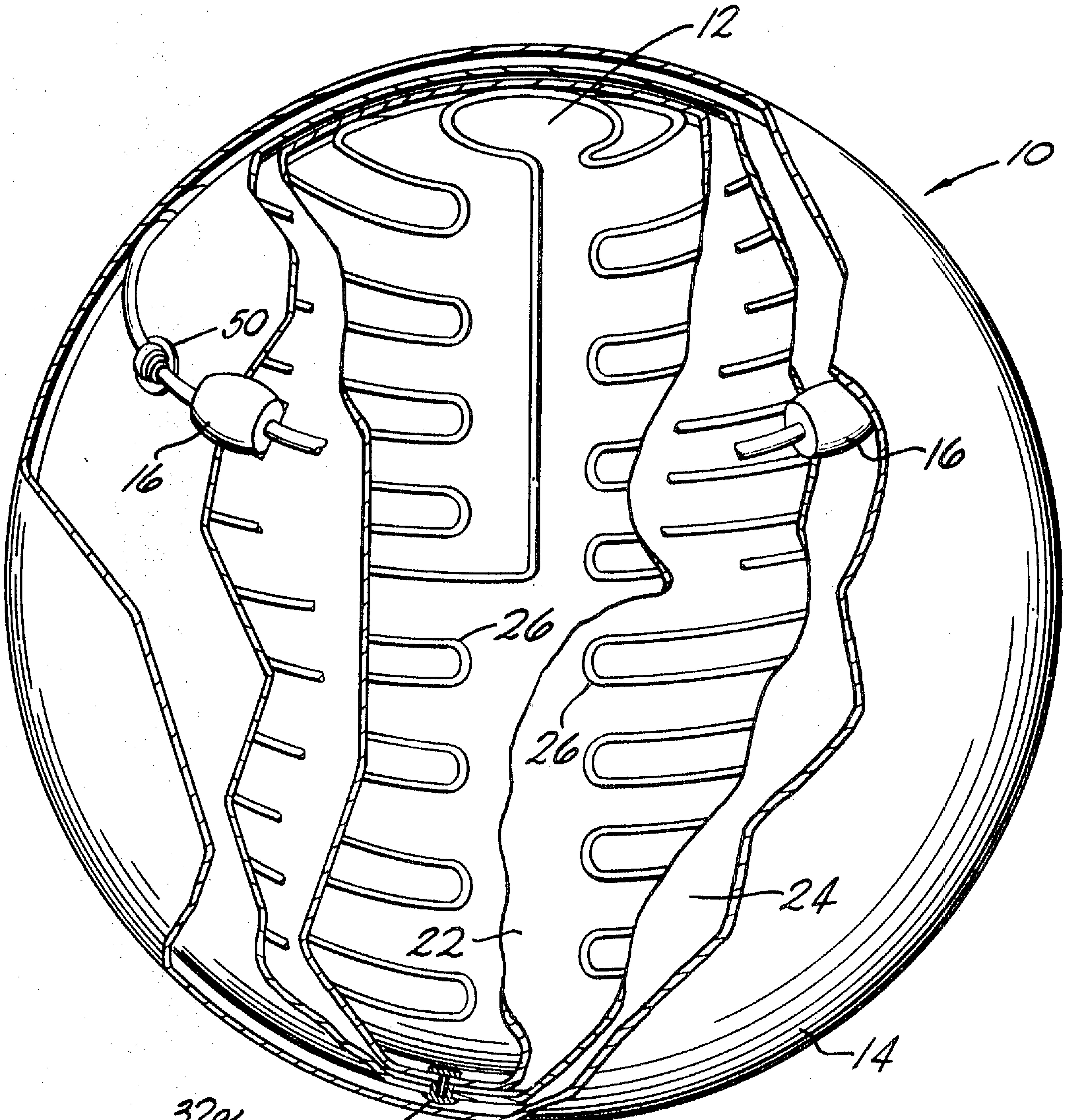


FIG. 3

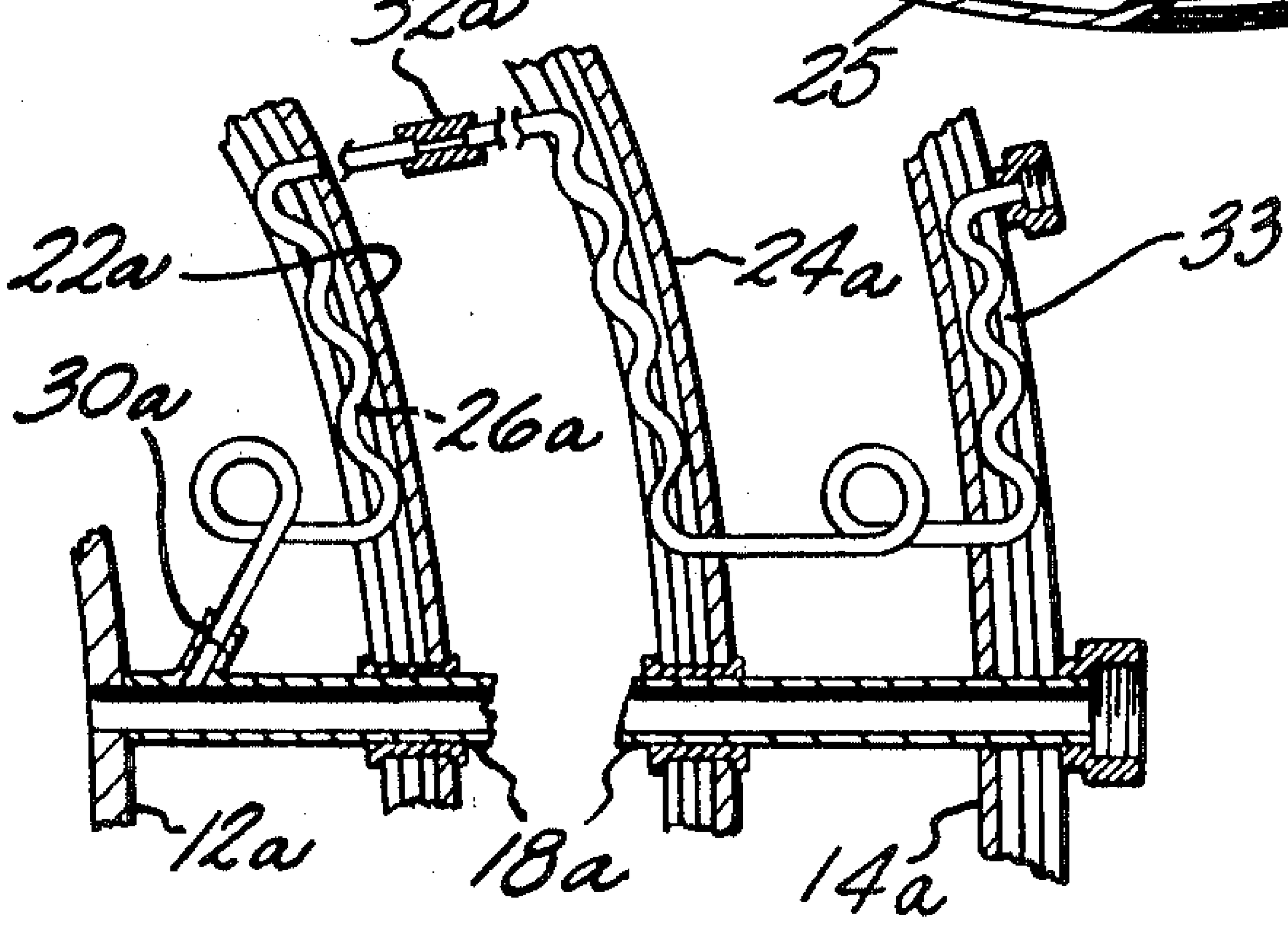


FIG. 4

INVENTOR
PAUL J. GARDNER

BY William N. Antonis
ATTORNEY

CONTAINER FOR CRYOGENIC FLUIDS

BACKGROUND OF THE INVENTION

The present invention relates to a container for cryogenic fluids, and particularly to improvements for reducing heat input to the fluids in such container. The present invention is an improvement over devices of the type disclosed in U.S. Pat. No. 3,043,466, granted July 10, 1962.

It is known when using containers of the type disclosed in U.S. Pat. No. 3,043,466,to employ vacuum insulation, that is, to seal hermetically the inner and outer vessels and to provide a vacuum between the vessels. It is known also to provide other insulation structure between the vessels to supplement the vacuum insulation. For this purpose either a discrete radiation shield or a laminar insulated shield may be employed.

A discrete radiation shield is a low emissivity radiation barrier placed in the vacuum space and mounted to some support structure. Laminar insulated shields are formed by adding a laminar type low conductivity insulation to the emitting (least critical) side of the discrete shield. In designs requiring light weight, where construction costs permit the processing of high quality vacuum space surfaces, there is limited useful application for laminar insulations because thicknesses of laminar insulation necessary to compete favorably with low emissivity-pure vacuum insulation are too great. Without going into detail, it should be understood that the function of each type of shielding is thus suited to a different temperature region in actual application, and the present invention is concerned primarily with the use of discrete radiation shields. However, as will be apparent, the present invention can also be used in conjunction with laminar insulated shields.

SUMMARY OF THE INVENTION.

According to one form of the present invention, a container for cryogenic fluids is provided comprising inner and outer spaced vessels, and at least one discrete radiation shield is mounted in thermal isolation in spaced relation between the vessels. A cooling conduit is mounted in heat transfer relationship along the inner surface of the shield, and the conduit communicates with the interior of the inner vessel and the exterior of the outer vessel. The conduit has a restricted passageway for limited escape of the cryogenic fluid or cold gas in the inner vessel to effect vapor cooling of the shield. According to another form of the present invention a similar construction and arrangement is provided wherein the shield is laminar insulated, and the cooling conduit extends in heat transfer relationship through the interior of the laminar structure.

It is among the objects of the present invention to provide a cryogenic container having improved insulation characteristics over prior art structures by virtue of the isothermal mounting of at least one radiation shield therein.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawing forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

FIG. 1 is a view in side elevation, partly in section of a container embodying one form of the present invention wherein vapor cooling of two shields is provided;

FIG. 2 is an enlarged fragmentary sectional view through the container illustrating the cooling conduit or circuit that is employed in conjunction with the embodiment illustrated in FIG. 1;

FIG. 3 is a perspective view of a container of this invention, with some parts broken away and other parts shown in section for the purpose of clarity;

FIG. 4 is a fragmentary sectional view, similar to that of FIG. 2 but illustrating another embodiment of the invention wherein vapor cooling of two laminar insulated shields is provided;

FIG. 5 is a sectional view of a shield mounting assembly in the container of this invention; and

FIG. 6 is another sectional view of the shield mounting assembly as seen from substantially the line 6—6 in FIG. 5.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

In the embodiment of the invention illustrated in FIGS. 1—3, 5 and 6, the cryogenic container 10 includes an inner pressure vessel 12 fabricated of a suitable metal such as stainless steel, and an outer vessel 14 which is in spaced relation to the inner vessel 12 and is preferably fabricated of an aluminum alloy. In the illustrated embodiment of the container 10, the vessels 12 and 14 are spherical in shape and are concentrically arranged. The inner vessel 12 is supported within the outer vessel 14 by an arrangement which provides minimum thermal conductivity. This is accomplished by a plurality of bumpers 16, only two of which are shown, but normally it is contemplated that six or more such bumpers will be employed. These bumpers and the manner in which they are constructed and arranged form no part of the present invention, and attention is directed to the aforementioned Letters U.S. Pat. No. 3,043,466 for a more detailed description. The vessels 12 and 14 are hermetically sealed and are typically spherical in shape so as to permit the outer vessel to withstand loads imposed thereon because of the high vacuum insulation that is provided between the vessels.

Normally the inner and outer vessels 12 and 14 will have two apertures with fittings for accommodating a fill line or conduit 18 and a vent line or conduit 20, which are shown in FIG. 1 but do not appear in FIG. 3. These lines are supported by the bumpers 16 in the manner illustrated and described in the aforesaid patent.

Two discrete radiation shields 22 and 24 are isothermally mounted in spaced relationship between the inner and outer vessels 12 and 14. Connectors 25, only one of which is shown (FIG. 3) provide for the support of one shield on the other. These discrete shields are used to reduce the radiant heat input to the cryogen which normally will be stored within the vessel 12. In the illustrated embodiment, the shields are preferably formed from aluminum with a 0.015 wall thickness.

The shields 22 and 24 are mounted in the container 10 of this invention so that they are thermally isolated from the vessels 12 and 14. This is accomplished by utilizing materials having low heat conductivity characteristics for supporting the shields 22 and 24 and by designing interfaces into the shield mounting structures. In the illustrated embodiment of the invention, this is accomplished by mounting each of the shields 22 and 24 on a plurality of identical shield hanger assemblies 50, only one of which appears in FIG. 3. A shield hanger assembly 50 is described in detail herein with reference to the support of a shield on a fill conduit 18, although it is to be understood that the assembly 50 can also be assembled with other structure in the container 10 such as the usual electrical leads and cables which are found therein but which are not illustrated in the drawing.

As shown in FIGS. 5 and 6, the hanger assembly 50 includes a substantially tubular spool member 52, formed of a material having low heat conductivity characteristics such as Teflon. The spool 52 is of a progressively increasing diameter, on the inner surface 54 thereof, so that substantially midway between its ends it has an annular edge 55 which is disposed in a supporting relation with the tube 18. A thin stainless tape 56 is wound about the external surface of the spool 52 and is tack-welded thereto so that there is very poor thermal conductivity between the tape 56 and the spool 52. A clip 58 is disposed in a supporting relationship with the tape 56 and is in turn supported at its ends in an internal groove 60 formed in an annular body 62 which is also formed of a material having poor heat conductivity characteristics such as Teflon. The body 62 is extended through an opening 66 in the shield 24 until the shield 24 at the edge of the opening 66 snaps into an external retainer groove 64 formed in the body 62.

It can thus be seen that the assembly 50 includes the spool 52 and the body 62 of low heat conductivity materials and the tape 56 and the clip 58 form interfaces therebetween for mimimizing heat conductivity between shields 22 and 24 and vessels 12 and 14.

The function of the shields 22 and 24 to prevent heat transfer between the vessels 12 and 14 is further enhanced by the provision of a vapor cooling coil or conduit 26 (FIGS. 2 and 3) located in the space between the inner vessel 12 and the outer vessel 14. The coil 26 is very long and is of the serpentine shape shown in FIG. 3, and is illustrated in FIG. 2 as being of irregular shape only for purposes of clarity to distinguish it from the shields 22 and 24. The coil 26 also has a low thermal conductivity relationship between the shields 22 and 24 and the pressure vessel 12 and the shields and the outer vessel 14. The inner end of the cooling coil 26 communicates with the inner end of the fill conduit 18, as shown in FIG. 2, so as to be in communication with the interior of the inner vessel 12, and the cooling coil 26 has its outer end attached to an external fitting 28 on the outer wall of the outer vessel 14 so as to be in communication with the exterior of the outer shell 14. The cooling coil 26 extends along the inner surface of the inner shield 22 and along the inner surface of the outer shield 24 in heat transfer relationship with respect to both such shields.

The passageway within the coil 26 is restricted so as to permit a flow situation to prevail whereby the cold cryogenic fluid or cold gas from the inner vessel 12 can leak or escape through the coil 26 to cool the shields 22 and 24. This is called vapor cooling or vapor expansion cooling depending upon whether fluid expansion subcooling is employed. It is contemplated that an expansion orifice 30 can be located between the inner tank 12 and the inner shield 22, and a second expansion orifice 32 can be located between the inner shield 22 and the outer shield 24. The object of the conduit or coil 26 is to cool each shield emitting surface to a temperature below the static heat transfer equilibrium temperature by absorbing shield heat into the cold flowing fluid. It is recognized that as the shield temperature is reduced, there is an increase in outer wall heat radiation to the shield due to the larger temperature differential; however, heat absorbed from the shield by conduction to the colder exiting fluid causes a net reduction of heat input to the internal cryogen vessel. Thus, by virtue of the illustrated arrangement, the heat input to the inner vessel 12 is minimized. By virtue of the length of the coil 26, heat conductivity between the vessels 12 and 14 and the shields 22 and 24 is minimized.

In the embodiment illustrated in FIG. 4, essentially the same construction as that shown in FIGS. 1–3, 5 and 6 is illustrated, except that in this embodiment inner and outer laminar insulated shields 22*a*and 24*a*are employed, and it will be observed that the cooling coil 26*a*extends through the interior of the laminar structure. The cooling coil 26*a*again is in communication with the inner vessel 12*a*via the conduit 18*a*and with the exterior of the outer vessel 14*a*, and it has an expansion orifice 30*a*between the inner laminar insulated shield 22*a*and the inner vessel 12 *a*and an expansion orifice 32*a*between the shields 22*a*and 24*a*. Thus, this arrangement provides an opportunity of employing a vapor cooling coil as a heat transfer barrier so that a reasonably high temperature differential can be maintained across the shield 22*a*, and a similar temperature differential can be maintained across the outer shield 24*a*and thus, low temperature will be maintained at the emitting surfaces of the shields.

Also, changes in atmospheric temperature and high temperature environment can be reduced by the addition of insulation, such as the laminar type insulation shown at 33 in FIG. 4, to the exterior of the outer vessel 14*a*. Furthermore, the outer vessel 14*a*can be cooled by the flow of cold gas through the vapor cooling line 26*a*by extending the line 26*a*through the insulation 33, as shown in FIG. 4. This arrangement utilizes the unused heat absorbing capacity of the escaping gas so that it exits to the atmosphere at a temperature as nearly equal to that of the environment as possible and in the process cools the outer vessel 14*a*. This reduces heat transfer from the outer shell 14*a*to the inner vessel 12*a*.

From the above description it is seen that this invention provides a container 10 for cryogenic fluids in which the inner vessel is effectively insulated by the isothermally mounted discrete shields 22 and 24. By virtue of the isothermal mounting of the shields 22 and 24, they are thermally isolated from the vessels 12 and 14 and the conduits 18 on which they are hung. Under "no flow" conditions, only a radiation mode heat transfer exists in the container 10 and a high performance is obtained from the shields 22 and 24 to limit this transfer. Under "flow" conditions, the isothermally mounted shields conserve the refrigerative capability of the cryogen in the vessel 12 by eliminating or minimizing the conductive mode heat transfer. Since for a given vessel size the peripheral surface area is constant, maximum efficiency would occur with all conductive or all radiant heat transfer. In the applicable temperature range of 0° F. to −400° F. a radiation mode heat transfer is most effective since the heat transfer varies according to the fourth power difference between the temperatures of two surfaces, namely, the shield and pressure vessel surfaces; whereas, with a conductive mode heat transfer, the heat transfer varies directly as the temperature difference. In the container 10, conductive mode transfer to the shields is practically eliminated and the shields effectively reduce radiation mode heat transfer. The vapor cooling coil 26 reduces the temperature differential between adjacent vessel and shield surfaces to reduce radiation mode heat transfer, and the coil 26 is of a length such that heat conductivity between adjacent surfaces is negligible.

It will be understood that the container for cryogenic fluids which is herein disclosed and described is presented for purposes of explanation and illustration and is not intended in indicate limits of the invention, the scope of which is defined by the following claims.

1. In a container for storing cryogenic fluids having an inner vessel and an outer vessel separated by bumper members spaced on a conduit surrounding the inner vessel, means for isothermally isolating the inner vessel from the transfer of thermal energy from the outer vessel, said means comprising:

a shield member surrounding said inner vessel, said shield member dispersing radiant energy away from said inner vessel and toward said outer vessel; and

means for mounting said shield member on said conduit for preventing direct contact between said outer vessel and said shield member to thereby reduce conductive heat transfer from said outer vessel to said inner vessel.

2. In the container, as recited in claim 1, wherein said shield member includes:

a first radiation shield surrounding said inner vessel at a predetermined distance; and

a second radiation shield concentrically spaced from said first radiation shield by low thermal conductive connector members and attached to said mounting means.

3. In the container, as recited in claim 2 wherein said mounting means includes:

tubular means surrounding said conduit having a progressively increasing interior diameter from a midpoint contact with said conduit for reducing the thermal conductive surface between said conduit and said mounting means.

4. In the container, as recited in claim 3, wherein said mounting means further includes:

clip members surrounding said tubular means having tab members; and

body members extending through opening in said second radiation shield, each of said body members having an internal groove for retaining said tab members of the clip member for securing said second radiation shield to said conduit.

5. In the container, as recited in claim 4 wherein said tubular means is in the form of a spool constructed of a low thermal conductive material.

6. In the container, as recited in claim 5 wherein said second radiation shield will flex in the area of the edge of said openings to permit said body members to pass through said opening until said edge snaps into an external groove in each of said body members.

7. In a container for storing cryogenic fluids having an inner vessel and an outer vessel separated by bumper members spaced on a conduit operatively connected to and interposed between the inner and outer vessels, means for isothermally isolating the inner vessel from the transfer of thermal energy from the outer vessel, said means comprising:

a shield member surrounding said inner vessel, said shield member dispersing radiant energy away from said inner vessel and toward said outer vessel; and

means for mounting said shield member on said conduit for preventing direct contact between said outer vessel and said shield member to thereby reduce conductive heat transfer from said outer vessel to said inner vessel.

8. A container for cryogenic fluids according to claim 7, wherein said inner and outer vessels are hermetically sealed and the space therebetween is evacuated to provide a vacuum insulation.

9. A container for cryogenic fluids according to claim 7 further including an insulation layer on the outer surface of said outer shell so as to further reduce heat transfer into said inner vessel.