Aug. 27, 1963 L. C. MATSCH 3,101,862

CONTAINER CONSTRUCTION USING LOAD CARRYING INSULATION

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Fig. 1.

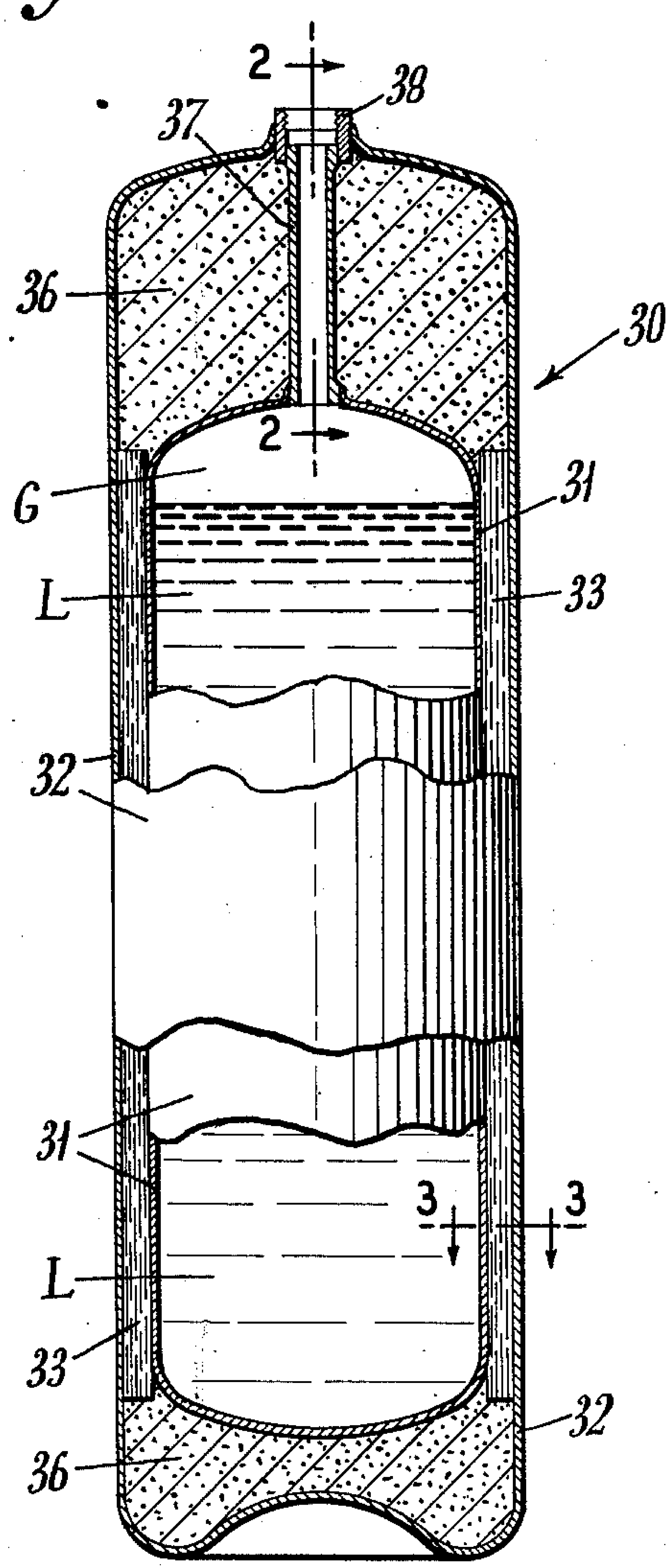
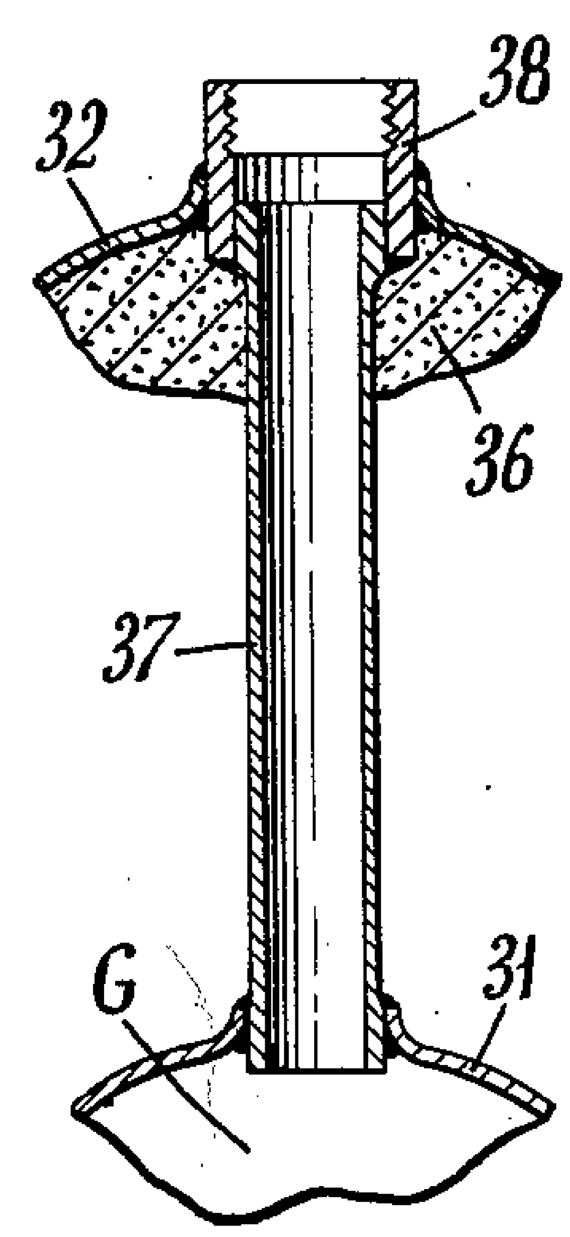


Fig. 2.



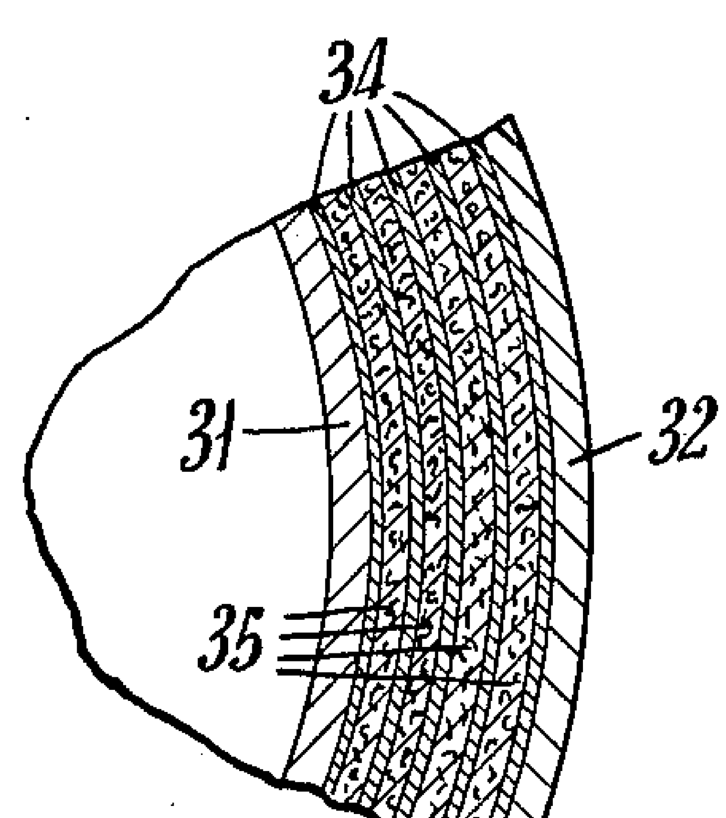


Fig. 3.

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CONTAINER CONSTRUCTION USING LOAD CARRYING INSULATION

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This invention relates to insulated containers characterized by extremely low rates of heat transmission through the walls thereof.

There are many requirements for vessels and containers capable of retaining extreme temperatures for extended periods of time. Such containers are needed; for example, in the storage of low boiling liquefied gases, for the uniform or low temperature storage of highly perishable commodities, and for the storage of liquids at superatmospheric pressure where the maintenance of such pressure is dependent upon close control of the heat content of the liquid. In the case of small portable containers, such storage presents special problems since it is usually not practical to provide an auxiliary source of heat or refrigeration to accompany the vessels in transit. Successful storage then depends largely upon the quality and effectiveness of the thermal insulation which is usually contained between the walls of an inner container and an outer casing.

Substantial improvements in thermal insulations for such vessels have been made. By using small particle materials of low conductivity, heat transmission by solid conduction through the insulant has been reduced to extremely low values. By applying very low absolute pressures on the insulation space; e.g., on the order of 10 microns mercury, and preferably on the order of 1 micron mercury, heat transmission by gaseous conduction has been made almost negligible. By introducing a multiplicity of heat reflective barriers, heat transmission by radiation has been similarly reduced. Such an insulating system is disclosed and described in copending application, Serial No. 599,733, filed by P. E. Loveday and L. A. Bliss on July 24, 1956, now Patent No. 2,951,348. These advances have produced insulations so effective that a major part of the remaining heat transmission across the insulation system is due to the mechanical supports for the inner container.

An object of this invention, therefore, is the provision of a double-walled, insulated vessel characterized by compactness, portability, and a high resistance to heat transfer across the insulation system.

Another object of the invention is to provide a double-walled container in which a high quality insulation is provided which not only serves to limit heat flow between the walls, but also serves to provide lateral support for the inner vessel, thereby eliminating the need for heat-conducting, solid stabilizing supports.

These and other objects, features, and advantages of the present invention will become apparent in the following detailed description of the accompanying drawings in which:

FIGURE 1 is a transverse vertical section, partly in elevation showing a container embodying the present invention;

FIGURE 2 is a cross section of the neck tube of the container; and

FIGURE 3 is an enlarged fragmentary cross section through the container insulation taken along line 3—3 in FIGURE 1.

According to this invention, the heat insulation system of a small portable container can be still further improved by the use of an elastic or resilient insulant which fills the vacuum space and acts as a lateral support for the inner container. Such an insulant is disclosed and described in copending application, Serial No. 597,947, filed by Ladislas C. Matsch on July 16, 1956, now Patent No. 3,007,596. This insulant is a fixed-in-place type, as contrasted with powders which tend to flow when compressed. The use of a resilient insulant for lateral support of the container permits a reduction in the number and cross section area of high conductive supports required for the inner container. At the same time, lateral loads are evenly distributed over the entire side surface of the container, and the high accelerations caused by horizontal impact loads have a much reduced effect on the container.

With reference now to FIGURE 1, there is shown a double-walled container, indicated generally at **30**, which is made up of a pressure-tight casing **32** which surrounds an inner pressure-tight vessel **31** in outwardly spaced relation so as to define therewith an intervening space for receiving thermal insulation. Elongated cylindrical containers are preferred, but are not essential. The inner vessel **31** has a normal liquid space L and a gas space G thereabove. The insulation space around the side wall of vessel **31** is filled with a multiple layer insulation, indicated at **33**, which encircles the side wall of the inner vessel and consists essentially (see FIGURE 3) of heat-reflecting foils **34** extending vertically and in spaced parallel relation in the space between the casing **32** and the inner vessel **31** and of a plurality of vertical sheets **35** of fibrous material disposed in alternation with the foils. The fibrous material must be of low thermal conductivity and of low apparent density. This wrapped insulation is of the type disclosed and described in said copending application, Serial No. 597,947, filed by Ladislas C. Matsch on July 16, 1956, now Patent No. 3,007,596. The end spaces between the arcuate ends of vessel **31** and the ends of casing **32** may be insulated with the same multiple layer insulation overlapped or formed to the contour of the heads. Alternatively, the ends may be filled with a powder-type insulation, such as for example and preferably, an opacified powder-in-vacuum insulation **36** of the type disclosed in copending application, Serial No. 580,897, filed by L. C. Matsch and A. W. Francis on April 26, 1956, now Patent No. 2,967,152. This latter insulation may be briefly described as a finely-divided powder made up of particles of low conductivity, such as Santocel, having dispersed and intermixed therewith small heat-reflecting or heat-absorbing bodies.

The foil and fiber wrapping may be wound under moderate tension about the inner vessel **31** as a multiple layer insulation of any predetermined number of layers depending on the desired degree of insulation, the thickness of the individual layers and the dimensional limits of the insulation space. The multiple layer insulation fills the space between the inner vessel **31** and the casing **32** and is elastically deformable to a substantial degree without objectionably or permanently affecting the heat-insulating effectiveness of the insulation. Consequently, it yieldably supports compression loads and can thereby serve to support the inner vessel laterally within the casing.

Winding or wrapping the container with the foil and fiber layers under tension imparts an initial compression to the insulation. The container is best wrapped with the insulation before assembly into the casing, and a sufficient number of layers are applied to completely fill the annular insulation space and still not interfere with the assembly of the container into the casing. Mats of very fine glass fibers on the order of 0.35 micron may have an uncompressed density of perhaps one pound per cubic foot. Best results are achieved by precompressing the multiple layer insulation as described above during installation to a density of about 3 to 4 pounds per cubic foot. This degree of compression assures that large void spaces will not exist in the insulation and that the interstitial voids between fibers will be properly reduced in dimension to below the mean free path of residual gas molecules. Such precompression also exerts a gentle, yet firm pressure of the insulation on the walls of the vacuum space and provides a positive support for the inner container. Precompression of the very fine fiber material to a substantially greater degree is to be avoided because many of the interstitial voids will be closed, the number of solid fiber-to-fiber contact points will be increased, and heat transmission by solid conduction through the insulant will be greater.

This construction affords a special advantage not only in providing a much better insulation than that obtained without such wrapping, but also in minimizing solid conduction through supports to the inner container, for only a single tension member is then required for supporting the inner vessel from the outer vessel. For example, in the preferred embodiment illustrated, the neck tube **37** affords access to the inner vessel and also suspends the inner vessel **31** from a head assembly **38** that is mounted on the casing **32**. The neck tube can be made exceptionally long, thin-walled, and slender—this being permitted by the elastic characteristic of the multiple layer insulation which provides lateral support for the container and which thereby reduces the ruggedness requirements of the neck tube. Length, thinness, and slenderness in the neck tube are characteristics which tend to minimize heat transmission along the tube, and which contribute to maximum flexibility. Flexibility is desirable to avoid high stresses in the neck tube while permitting sufficient lateral movement of the inner container against the elastic insulation to absorb shock loads imposed on the casing. Thus, it is necessary to design the neck tube for strength in tension only, and additional side or bottom solid supports are not necessary. Preferred materials for the neck tube are an austenitic-type alloy of nickel, iron and molybdenum made up to about 26 to 30 percent molybdenum, 4 to 7 percent iron, up to 2.5 percent cobalt, up to 1 percent chromium, about 1 percent silicon, up to 1 percent manganese, up to .05 percent carbon, .2 to .6 percent vanadium, up to .04 percent phosphorus, and up to .03 percent sulphur and the balance nickel and the austenitic stainless steels. Hastelloy was found to combine high strength, high impact at low temperatures, and low thermal conductivity. Austenitic stainless steels exhibit similar characteristics when cold worked as by rolling or stretching, and the central portion may be so strengthened while the ends remain in the annealed, weldable condition.

A vessel as shown in FIGURE 1 having a water capacity of 69 pounds may be effectively insulated on its side walls by a thickness of only ⅜ inch of foil and fiber insulation wrapped at 80 layers per inch (30 layers total) and on its ends by opacified powder, both in an absolute pressure of 1 micron or less. A cold worked stainless steel neck tube comprising the sole vertical support for the container may be about 8 inches long, ½ inch inside diameter, and .016 inch thick between the end sections. An insulation system so constructed will limit heat inflow to the inner vessel containing liquid oxygen to .0002 B.t.u. per hour per °F. per pound water capacity. If the liquid oxygen is uniformly in equilibrium with a vapor pressure of 65 p.s.i.g. and is sealed with relief devices (not shown) set at 235 p.s.i.g. a holding period of at least 72 hours may be obtained without loss of contents due to evaporation. The actual holding time observed will depend in part upon the amount of liquid present in the vessel, and the 72-hour period represents the minimum no-loss holding time characteristic of a near-empty container. With greater amounts of liquid present to absorb heat inleak, no-loss holding periods of 120 hours have been observed. The insulation space of the vessel described is equal to only about 47.5 percent of the liquid container volume and provides a portable vessel of exceptionally low bulk.

Ruggedness tests conducted on a liquid-filled vessel such as described above indicate that high resistance to internal damage can be achieved without the use of numerous highly heat conductive supports for the inner container. A vessel provided with a slender neck tube for vertical support plus multi-layer insulation for lateral support was found to be capable of withstanding vertical drop tests from heights up to 8 inches and severe horizontal impact caused by allowing the vessel to fall over from the upright position. The combination allows the successful design of small double-walled containers having extremely effective thermal insulation, yet sufficiently rugged to be transported and handled in a normal manner without suffering internal damage. By designing the vessel so that a resilient thermal insulation serves also as the lateral support for the inner container, the restraining members spanning between the two walls are required to lend support for the vessel in one direction only. Thus, the supports need not be designed for strength in bending and may have minimum cross section area or maximum slenderness consistent with axial load requirements.

The arrangement described above in which a fluid connection to the inner container serves also as a vertical support is the preferred arrangement. However, other arrangements are possible and would be highly beneficial. For example, a short, low-conductive compression member may be employed at the bottom of the container as the sole vertical support. Alternatively, the inner container may be suspended entirely by means of a single fine, high-strength wire. In either case, the fluid connections to the top of the container may be much longer for lower heat transmission and may be looped around within the insulation space. As in the preferred arrangement, the resilient insulation slightly compressed between the vertical walls serves as the principal or sole lateral support for the container.

It should be apparent that various details of construction can be changed without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A container for storing and thermally insulating material including a pressure-tight casing, a vessel supported vertically within and from said casing, said vessel being spaced inwardly from the casing to define therewith an intervening space surrounding the vessel, said space being gas-tight and under an absolute pressure of ten (10) microns or less of mercury, heat-insulating, elastically yieldable means in said space, at least between the side wall of the vessel and the side wall of the casing, such means comprising a multiple layer insulation of alternating layers of heat-reflecting foils and sheets of fibrous material and providing the principal lateral support for said vessel within said casing.

2. A container for storing and thermally insulating material, including a pressure-tight casing, a vessel supported vertically within said casing by a single connection extending between one end of the vessel and said casing, said vessel being spaced inwardly from the casing to define therewith an intervening space surrounding the vessel, said space being gas-tight and under a high degree of vacuum, and heat-insulating elastically yieldable means in said space, at least between the side wall of the vessel and the side wall of the casing, such means comprising a multiple layer insulation consisting of essentially alternating layers of heat-reflecting foils and sheets of fibrous material of low thermal conductivity and low apparent density and serving to support the vessel laterally within the casing.

3. A container for storing and thermally insulating material including a pressure-tight casing, a vessel sup-

ported vertically within and from said casing, said vessel being spaced inwardly from the casing to define therewith an intervening space surrounding the vessel, means within said intervening space to provide the principal lateral support for the vessel within the casing, said means comprising a multiple layer insulation at least around the side wall of the vessel consisting essentially of alternating layers of heat-reflecting foils and sheets of fibrous material of low thermal conductivity and low apparent density, said space being gas-tight and evacuated to a combined gas and vapor pressure of ten (10) microns or less of mercury absolute, and said insulation being wrapped around said vessel in sufficient number of layers and tightly enough to be elastically yieldable and so provide said lateral support.

4. A container for storing low-boiling liquefied gas material, including a pressure-tight casing, a vessel suspended at its upper end vertically within and from said casing, said vessel being spaced inwardly from the casing to define therewith an intervening space, said intervening space containing around the side wall of the vessel a multiple layer insulation consisting essentially of alternating layers of heat-reflecting foils and sheets of fibrous material of low thermal conductivity and low apparent density, the ends of said space containing an opacified powder insulation, said space being evacuated to a combined gas and vapor pressure of ten (10) microns or less of mercury absolute, and said insulation being wrapped around said vessel in sufficient number of layers and tightly enough to provide an elastic support for yieldingly resisting lateral movement of the inner vessel.

5. A double-walled container for the storage and thermal insulation of materials, including a pressure tight casing, a vessel supported vertically within and from said casing by a single support member extending between the casing and vessel and along the longitudinal axis of said vessel, said vessel being spaced inwardly from the casing to define therewith an intervening space, said intervening space being gas-tight and under an absolute pressure of ten (10) microns or less of mercury, and means within the space to provide the principal lateral support for the vessel within the casing, said means comprising an elastically yieldable insulation extending between the walls of said space and covering at least the major portion of the vertical surface of said vessel, said insulation being wrapped around the vessel in sufficient number of layers and tightly enough to be elastically yieldable so as to thereby provide said lateral support.

6. A double-walled container for the storage and thermal insulation of materials, including a pressure-tight casing, a vessel suspended vertically within and from said casing by a single tubular connection extending between the upper end of the vessel and said casing, said vessel being spaced inwardly from the casing to define therewith an intervening space, said intervening space being gas-tight and under an absolute pressure of ten (10) microns or less or mercury, and means within the space to provide the principal lateral support for the vessel within the casing, said means comprising a multiple layer insulation at least around the vertical wall of the vessel consisting essentially of alternating layers of heat reflecting foils and sheets of fibrous material of low thermal conductivity and low apparent density, said insulation being wrapped around the vessel in sufficient number of layers and tightly enough to be elastically yieldable so as to thereby provide said lateral support.

7. A double-walled container in accordance with claim 6 for storing low-boiling liquefied gas material in which said tubular connection is made from an alloy composed of 26 to 30 percent molybdenum, 4 to 7 percent iron, up to 2.5 percent cobalt, up to 1 percent chromium, about 1 percent silicon, up to 1 percent manganese, up to .05 percent carbon, from .2 to .6 percent vanadium, up to .04 percent phosphorus, up to .03 percent sulphur and the balance nickel.

8. A double-walled container in accordance with claim 6 for storing low-boiling liquefied gas material in which said tubular connection is composed of austenitic stainless steel and is cold worked to a high strength condition for at least a portion of its length between annealed end sections.

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