June 27, 1967 C. T. GRAVES 3,328,496

METHOD OF MAKING HEAT-INSULATED RAILWAY TANK CAR BODIES

Original Filed Nov. 26, 1963 5 Sheets-Sheet 1

FIG. 1

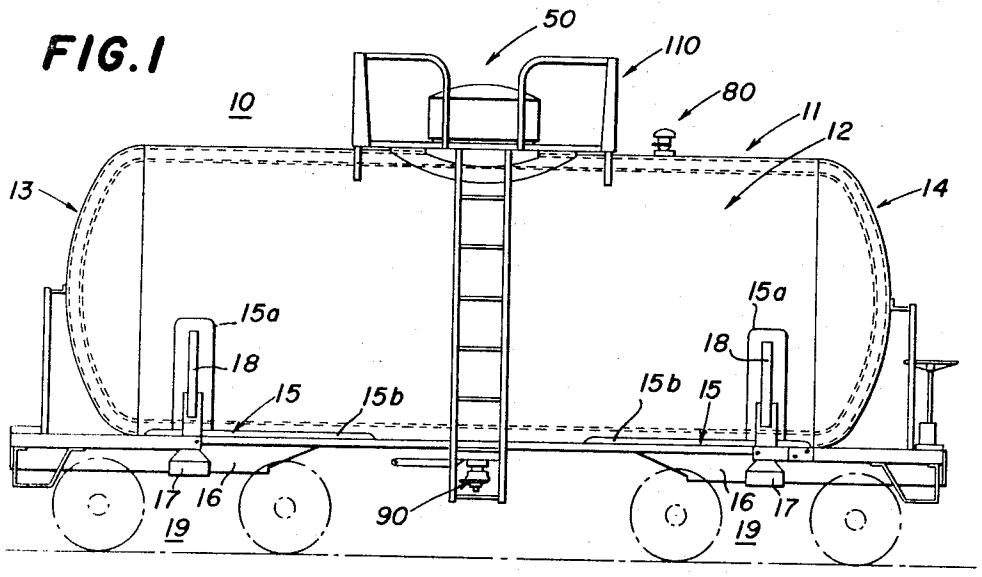
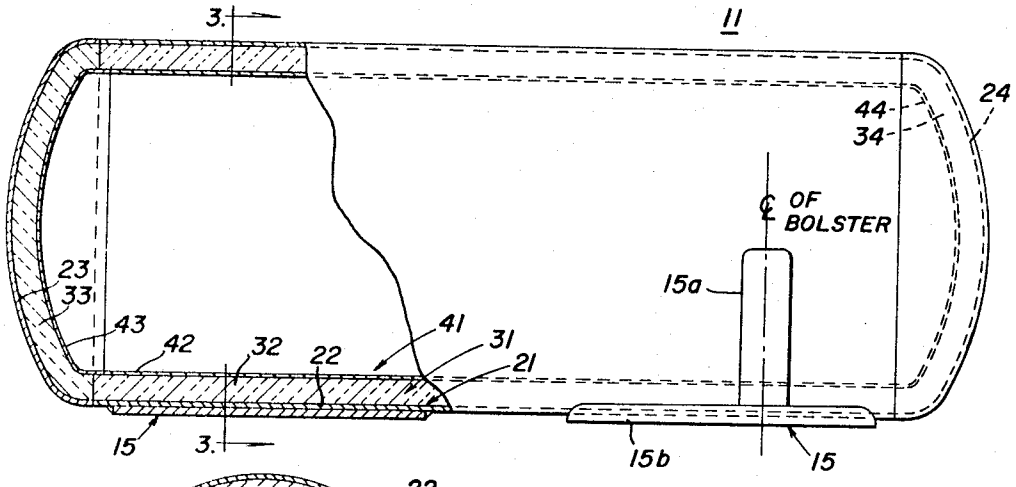


FIG. 2



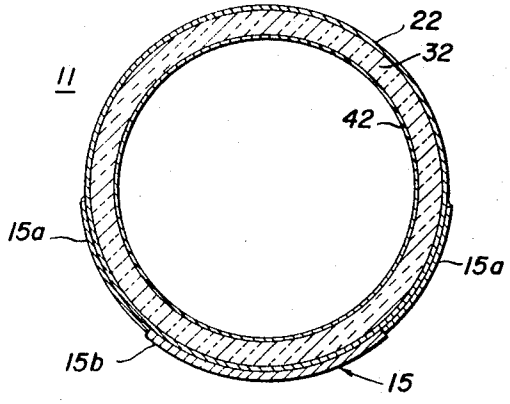


FIG. 3

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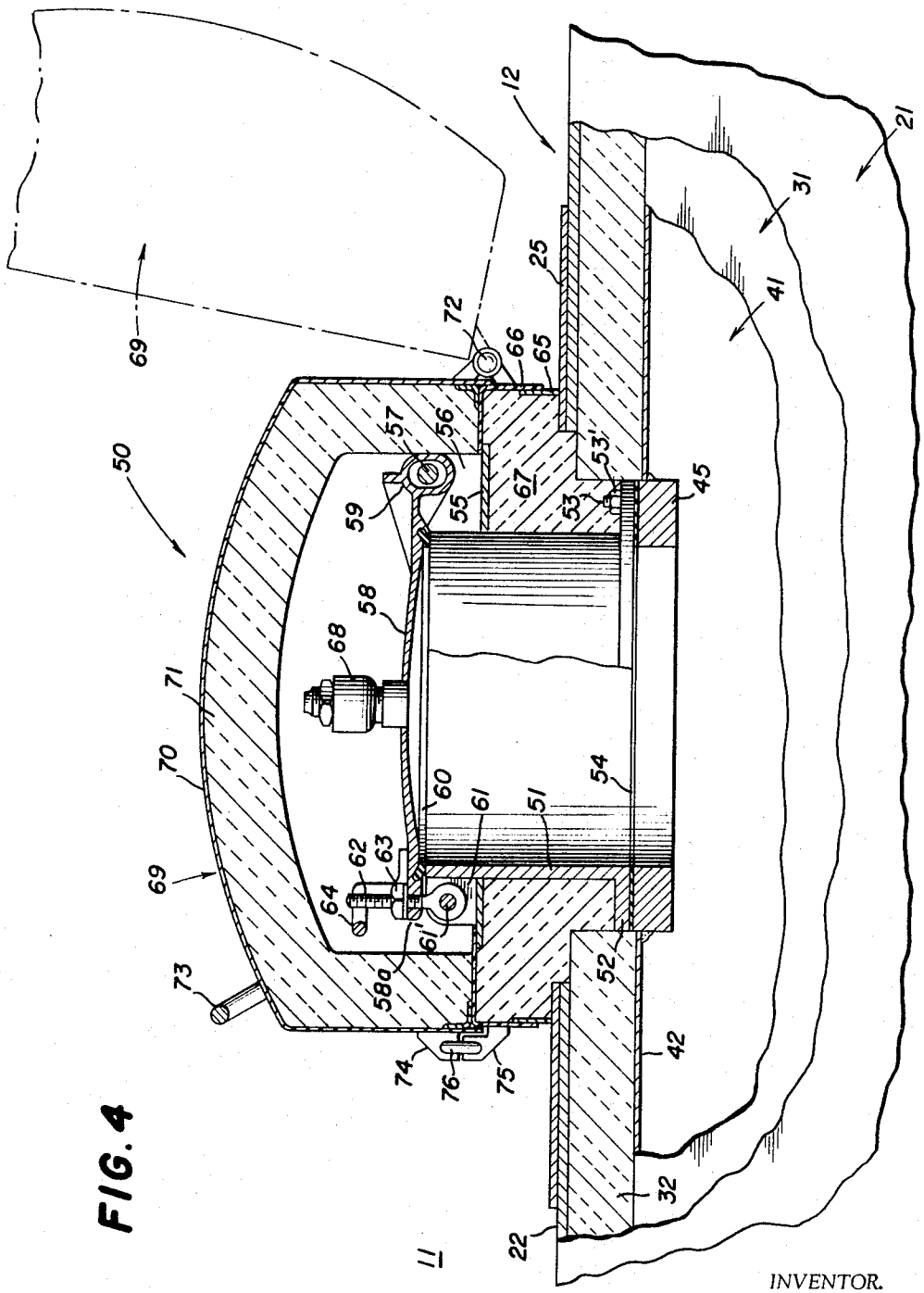


FIG. 4

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METHOD OF MAKING HEAT-INSULATED RAILWAY TANK CAR BODIES

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FIG. 5

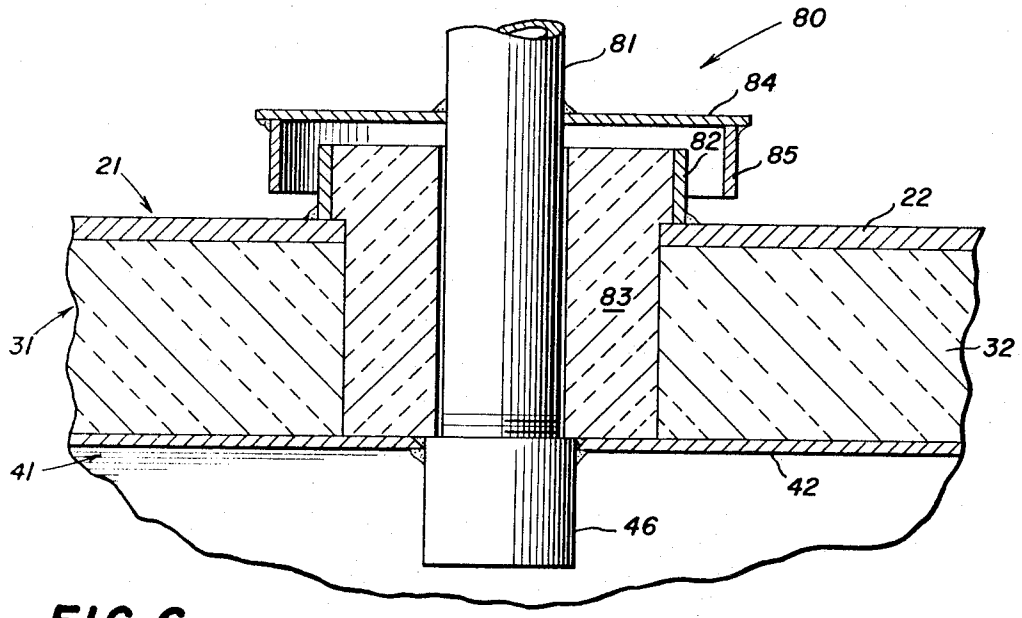
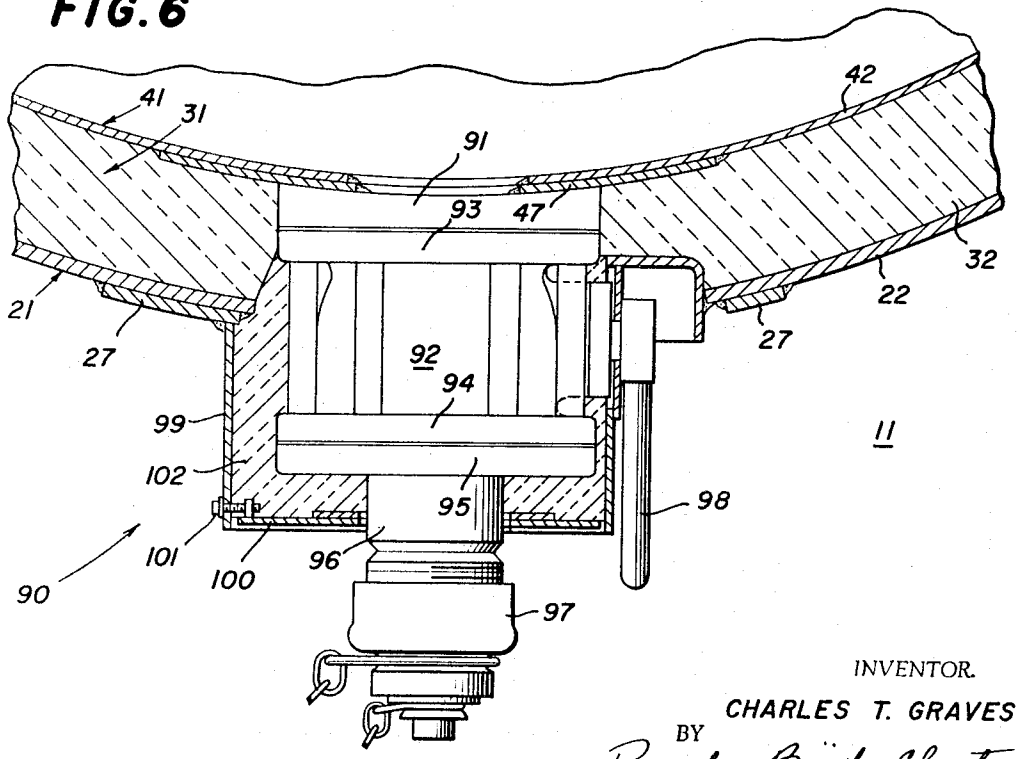


FIG. 6



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METHOD OF MAKING HEAT-INSULATED RAILWAY TANK CAR BODIES

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FIG. 7

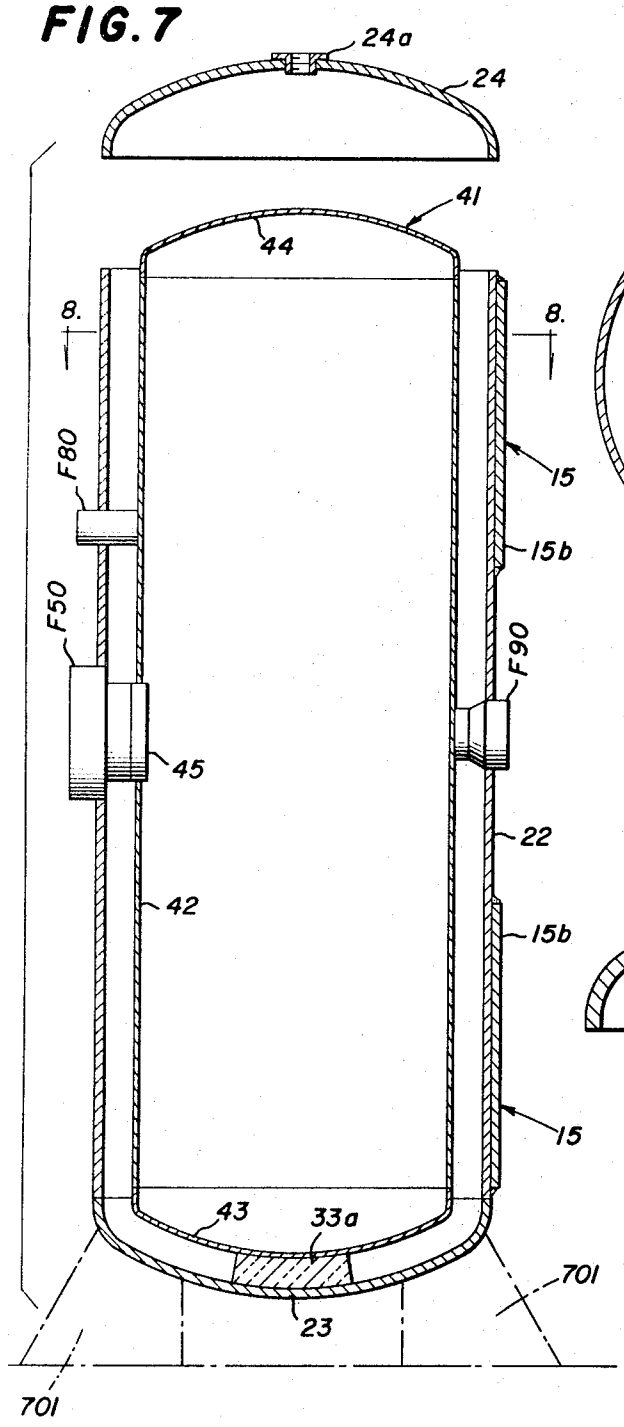


FIG. 8

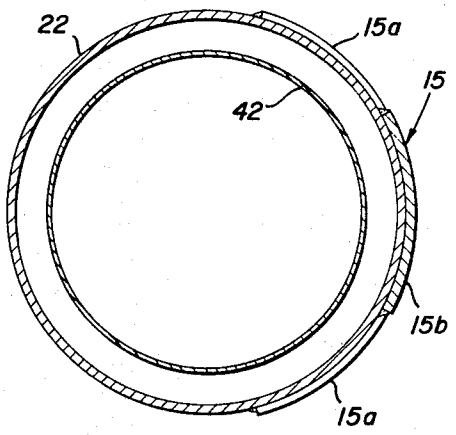
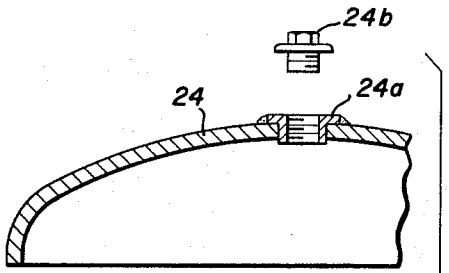


FIG. 9



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METHOD OF MAKING HEAT-INSULATED RAILWAY TANK CAR BODIES

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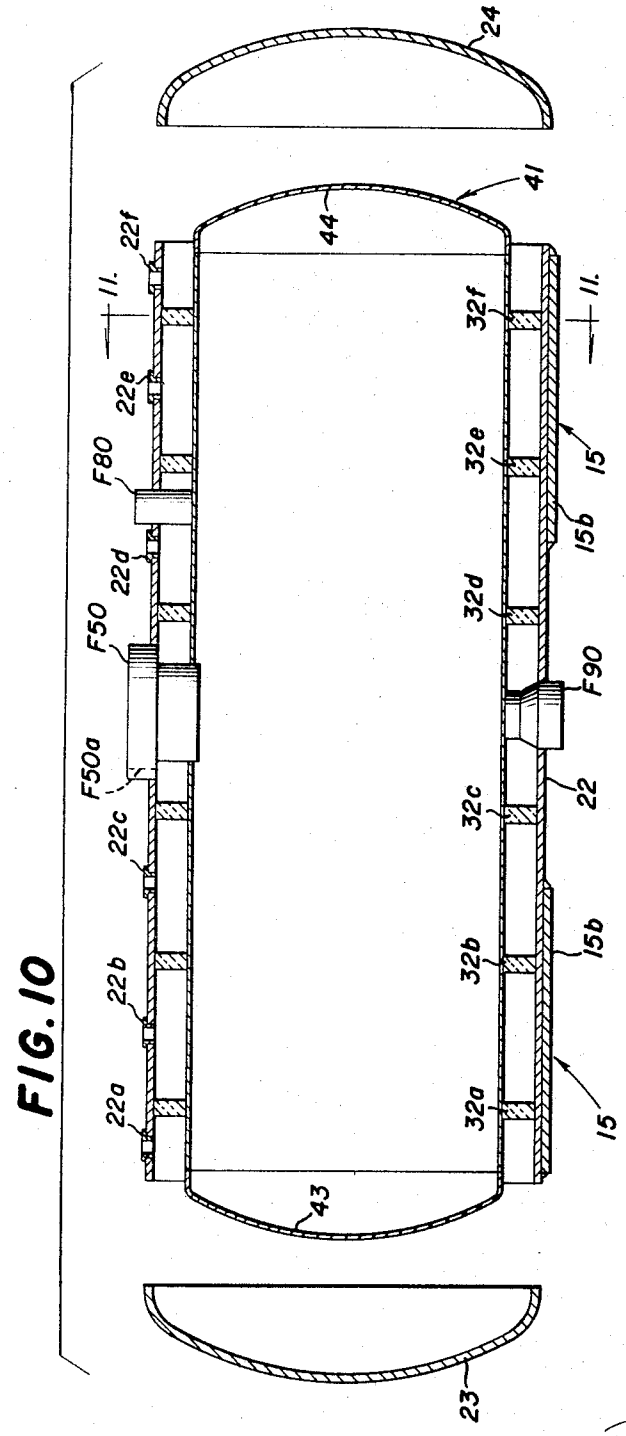


FIG. 10

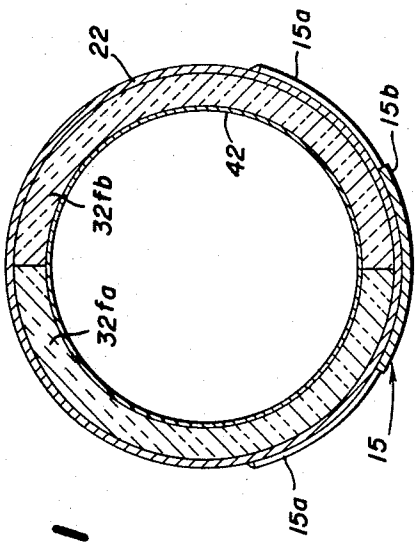


FIG. 11

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United States Patent Office 3,328,496 Patented June 27, 1967

3,328,496

METHODS OF MAKING HEAT-INSULATED RAILWAY TANK CAR BODIES

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Original application Nov. 26, 1963, Ser. No. 325,884. Divided and this application Oct. 19, 1965, Ser. No. 497,664

7 Claims. (Cl. 264—45)

The present invention relates to methods of making railway tank car bodies. This application comprises a division of the copending application of Charles T. Graves, Ser. No. 325,884, filed Nov. 26, 1963.

It is a general object of the invention to provide an improved method of making a railway tank car body of heat-insulated construction and arrangement that is especially adapted to transport a wide variety of hot and cold ladings, with a minimum heat-loss by a hot lading to the cold ambient, and with a minimum heat-gain by a cold lading from the hot ambient.

Another object of the invention is to provide an improved method of making a railway tank car body that comprises an outer shell of string rigid self-supporting metal structure, an intermediate layer of resilient cellular material completely enclosed by the outer shell, and an inner liner of fluid-tight construction completely enclosed by the intermediate layer, wherein the intermediate layer consists essentially of a blown polyester-urethane resin of closed-cell structure entrapping substantial inert gas, and wherein the inert gas consists essentially of a chlorine-fluorine substituted alkane, whereby the intermediate layer has a K-factor at least as low as about 0.15 B.t.u./in./sq. ft./hr./° F. in order to heat-insulate from each other the outer shell and the inner liner, and whereby the intermediate layer is characterized by great chemical and structural stability when the ladings contained in the inner liner have storage temperatures embracing the range from about −50° F. to about +300° F.

Another object of the invention is to provide an improved method of making a railway tank car body that comprises a substantially horizontally disposed body including an outer shell of strong rigid self-supporting metal structure, an intermediate layer of resilient cellular material completely enclosed by the outer shell, and an inner liner of fluid-tight construction completely enclosed by the intermediate layer, wherein the intermediate layer consists essentially of a blown polyester-urethane resin of closed-cell structure entrapping substantial inert gas, wherein the inert gas consists essentially of a chlorine-fluorine substituted alkane, whereby the intermediate layer has an exceeding low K-factor, and wherein the opposite end sections of the intermediate layer have relatively high density and the remainder of the intermediate layer has relatively low density, whereby the opposite end sections of the intermediate layer have higher compressive and tensile yield strengths than the remainder thereof in order to withstand the great longitudinal forces produced by the thermo-dynamic conditions experienced during operation of the tank car.

Another object of the invention is to provide an improved method of making a railway tank car of the character described that involves a minimum number of simple steps which may be carried out in an economical manner.

A further object of the invention is to provide an improved method of making the railway tank car, that permits substantial assembly of the outer shell about the inner liner and in spaced relation therewith prior to the blowing of the polyurethane resin therebetween to produce the intermediate layer.

A still further object of the invention is to provide an

improved method of making the railway tank car, that readily accommodates the blowing of the several sections or portions of the intermediate layer with the uncured ingredients of the polyurethane resin of different density, so as to produce the corresponding sections or portions of the finally cured polyurethane resin of different compressive and tensile yield strengths for the purpose previously noted.

Further features of the invention pertain to the particular arrangement of the steps of the method of making the railway tank car body, whereby the above-outlined and additional operating features thereof are attained.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a side elevational view of a railway tank car provided with a body that may be made in accordance with the present invention;

FIG. 2 is an enlarged side elevational view, partly broken away, of the body of the railway tank car, as shown in FIG. 1;

FIG. 3 is an enlarged vertical sectional view of the body, this view being taken in the direction of the arrows along the line 3—3 in FIG. 2;

FIG. 4 is a greatly enlarged fragmentary longitudinal vertical sectional view of the top central portion of the body, and illustrating the manway provided the inner liner of the body;

FIG. 5 is a greatly enlarged fragmentary longitudinal vertical sectional view of the top portion of the body, taken to one side of the top central portion thereof, and illustrating the inner portion of safety vent and flashing provided the inner liner and intermediate layer of the body;

FIG. 6 is a greatly enlarged fragmentary lateral vertical sectional view of the bottom central portion of the body, and illustrating the outlet valve provided the inner liner of the body;

FIG. 7 is an enlarged exploded longitudinal sectional view of a partial assembly of the body and arranged in a vertical position and involved in the method of making the same in accordance with the present invention;

FIG. 8 is an enlarged lateral sectional view in the partial assembly, this view being taken in the direction of the arrows along the line 8—8 in FIG. 7;

FIG. 9 is a greatly enlarged exploded fragmentary longitudinal sectional view of one end wall of the partial assembly, as shown in FIG. 7;

FIG. 10 is an enlarged exploded longitudinal sectional view of a partial assembly of the body and arranged in a horizontal position and involved in a modified form of the method of making the same in accordance with the present invention; and

FIG. 11 is an enlarged lateral sectional view of the partial assembly, this view being taken in the direction of the arrows along the line 11—11 in FIG. 10.

Referring now to FIGS. 1 to 3, inclusive, of the drawings, the railway tank car 10 there illustrated, is preferably made in accordance with the present invention; which railway car 10 is of the heat-insulated type and of a construction and arrangement that does not include an underframe. More particularly, the railway tank car 10 comprises an elongated longitudinally extending body 11 including a tubular laminated side wall 12 disposed in a substantially horizontal position and a pair of upstanding laminated end walls 13 and 14 respectively disposed at the opposite ends of the side wall 12. The side wall 12 is substantially cylindrical; and the end walls 13 and 14 are identical, each having a generally outwardly convex or bell-like configuration. The body 11 essentially comprises

an outer shell **21** of strong rigid self-supporting structure, an intermediate layer **31** of resilient cellular material completely enclosed by the outer shell **21**, and an inner liner **41** of fluid-tight construction completely enclosed by the intermediate layer **31**. The general configurations of the elements **21**, **31** and **41** are similar; whereby the outer shell **21** is substantially uniformly spaced by the intermediate layer **31** from the inner liner **41**. Thus: the outer shell **21** includes the substantially cylindrical side wall **22** and the pair of substantially bell-like end walls **23** and **24**; the intermediate layer **31** includes the substantially cylindrical side wall **32** and the pair of substantially bell-like end walls **33** and **34**; and the inner liner **41** includes the substantially cylindrical side wall **42** and the pair of substantially bell-like end walls **43** and **44**.

The outer shell **21** is of welded construction and formed of low carbon steel; the intermediate layer **31** is of blown cellular structure and formed of a particular synthetic organic resin more fully described hereinafter; and the inner layer **41** is of welded construction and formed of low carbon steel provided with an interior plastic coating or of suitable stainless steel for various corrosive ladings, etc. Also, the interior surface of the liner **41**, when formed of stainless steel, is free of all cracks and surface irregularities, and is provided with a smooth, mirror-like finish, so as to provide a surface in contact with the contained lading that may be easily maintained in a clean and sanitary condition, in order to prevent any possible contamination of the contained lading. In the construction, the outer and inner surfaces of the intermediate layer **31** are respectively intimately bonded to the inner surface of the outer shell **21** and to the outer surface of the inner liner **41**. Moreover, the intermediate layer **31** has a substantial thickness, in the general range 4" to 12", in order completely to separate and to isolate the outer shell **21** from the inner liner **41** and resiliently to support the inner liner **41** upon the outer shell **21**.

Further considering the construction of the tank car **10**, it is noted that the opposite lower end portions of the side wall **22** of the outer shell **21** respectively carry two arcuate-shaped saddle plates **15** that are rigidly secured thereto, as by welding. Each of the saddle plates **15** comprises a base section **15***b* disposed directly below the adjacent end of the side wall **22** of the outer shell **21**, and a pair of arm sections **15***a* respectively disposed below the opposite side portions of the adjacent end of the side wall **22** of the outer shell **21**, as best shown in FIGS. 2 and 3. In turn, two longitudinally extending and aligned stub draft sills **16** are respectively disposed below the base sections **15***b* of the saddle plates **15** and rigidly secured thereto, as by welding. In turn, the two stub draft sills **16** respectively carry two laterally extending body bolsters **17** rigidly secured thereto, as by welding; each of the body bolsters **17** carries pair of upstanding pedestals **18** rigidly secured thereto adjacent to the opposite ends thereof, as by welding; and each of the pedestals **18** is rigidly secured to the adjacent arm section **15***a* of the associated saddle plate **15**. Thus, each of the stud draft sills **16** is rigidly secured to the adjacent end portion of the side wall **22** of the outer shell **21** via the adjacent saddle plate **15**, the adjacent body bolster **17** and the adjacent pair of pedestals **18**.

The stub draft sills **6** are arranged in longitudinal alignment with each other and with the center lines thereof disposed in a vertical plane passing through the longitudinal center line of the body **11**. The body bolsters **17** are respectively supported by truck bolsters respectively carried by wheeled trucks **19** respectively disposed therebelow, each of the body bolsters **17** being connected to the adjacent truck bolster by a center pin, not shown, so as to accommodate articulation of the truck **19** with respect to the associated body bolster **17** in a conventional manner. Also the outer ends of the respective stub draft sills **16** are hollow and are adapted respectively to receive conventional draft gears, not shown, in a conventional manner. In view of the foregoing description of the arrangement of the stub draft sills **16** and the associated elements it will be appreciated that the railway tank car **10** does not comprise the usual underframe; whereby the draft and buff forces are applied between the stub draft sills **16** through the side wall **22** of the outer shell **21**, without the provision of an underframe or any other equivalent rigid auxiliary structure interconnecting the stub draft sills **16**.

Further: the top central portion of the body **11** carries manway structure **50**; the top of the body **11** carries, to one side of the manway structure **50**, a safety vent **80**; and the bottom central portion of the body **11** carries an outlet valve **90**. Also, the top central portion of the body **11** carries an annular platform **110** disposed in surrounding relation with the manway structure **50**; which platform **110** is preferably of the construction and arrangement of that disclosed in U.S. Patent No. 3,084,638, granted on Apr. 9, 1963, to Joseph W. Allegretti.

Referring now to FIG. 4, the top central portion of the side wall **42** of the inner liner **41** has a substantially circular opening formed therein, into which a flat substantially annular ring **45** is rigidly secured in place, as by welding. The manway structure **50** comprises an upstanding tubular manway **51** carrying a flat annular ring **52** in surrounding relation with the lower end thereof and rigidly secured thereto, as by welding; which ring **52** is arranged on top of the ring **45** and detachably secured thereto by a plurality of studs **53** carried by the ring **45** and disposed in an annular array and projecting upwardly from the ring **45** through cooperating holes provided in the ring **52** and disposed in a corresponding annular array. A sealing gasket **54** of flat ring like form is arranged between the adjacent surfaces of the rings **45** and **52** for the sealing purpose; and the upper ends of the studs **53** carry corresponding nuts **53'**, so as securely to retain together the rings **45** and **52**. The intermediate portion of the manway **51** projects through aligned holes respectively formed in the top central portions of the side wall **32** of the intermediate layer **31** and the side wall **22** of the outer shell **21**; whereby the upper end of the manway **51** projects well above the top central portion of the laminated side wall **12** of the body **11**. The upper portion of the manway **51** carries a flat annular ring **55** in surrounding relation therewith and rigidly secured thereto as by welding. The top of the ring **55**, at one side thereof, carries a pair of upstanding hinge members **56** that carry a pintle **57** extending therebetween. Also, a cover **58** is operatively associated with the top end of the manway **51**; which cover **58** carries a hinge member **59** that is arranged between the hinge members **56** and operatively connected to the pintle **57**. Thus, the cover **58** is pivotally mounted upon the pintle **57** for movements between open and closed positions with respect to the top end of the manway **51**. A resilient sealing gasket **60** of annular form is arranged in a corresponding annular slot provided in the inner surface of the cover **58**; which gasket **60** seals the adjacent end of the manway **51** and inner surface of the cover **58**, when the cover **58** occupies its closed position. Further, a number of lugs **61** are carried by the top of the ring **55** in circumferentially spaced-apart relation; and a corresponding number of eye bolts **62** are respectively pivotally mounted upon pins **61'** respectively carried by the lugs **61**. A corresponding number of slots **58***a* are formed about the periphery of the cover **58**; which slots **58***a* are adapted respectively to receive the eye bolts **62**, when the eye bolts **62** are pivoted upwardly about the pintles **61'** carried by the lugs **61** and the cover **58** occupies its closed position. The outer ends of the eye bolts **62** respectively carry clamping nuts **63** that are adapted to engage and clamp in place the cover **58**, when the same occupies its closed position and the eye bolts **62** occupy their upwardly pivoted positions. Further, the cover **58** carries

a handle 64 to facilitate pivoting thereof between its open and closed positions.

A substantially saddle-shaped ring 25 is carried by the top central potrion of the side wall 22 of the outer shell 21 in surrounding relation with the hole therein through which the upstanding manway 51 projects; which ring 25 is rigidly secured in place, as by welding. In turn a short upstanding tube 65 is rigidly secured to the ring 25 as by welding; which tube 65 surrounds the aligned holes respectively formed in the elements 32, 22 and 25. An annular ring-like member 66, preferably formed of plastic material, and having a substantially L-shaped cross section is carried jointly by the outer peripheral portion of the ring 55 and by the upper end portion of the ring 65, thereby to define a hollow cavity surounding the lower and intermediate portions of the manway 51; and arranged in this cavity is an annular ring 67 of heat-insulating material. The ring 67 closely surrounds the manway 51 and extends into the aligned holes respectively formed in the elements 32, 22 and 25. Preferably, the ring 67 is formed of synthetic organic resin of cellular structure and of the composition of the intermediate layer 31, as explained more fully hereinafter. The top central portion of the cover 58 carries a vacuum relief valve 68 of conventional construction and arrangement.

Operatively associated with the upper end of the manway 51 is a bonnet 69 that is of hollow inverted bucket-like construction and that includes a metal outer shell 70 and an inner layer 71 of heat-insulating material. Preferably, the inner layer 71 is formed of synthetic organic resin of cellular structure and of the composition of the intermediate layer 31, as explained more fully hereinafter. The lower portion of the outer shell 70 is connected to the upper portion of the ring 66 by a hinge device 72, adjacent to the hinge elements 56 and 57; whereby the bonnet 69 is mounted for hinged movements between open and closed positions with respect to the upper end of the manway 51. A handle 73 is carried by the outer shell 70 to facilitate movements of the bonnet 69 between its open and closed positions. When the bonnet 69 occupies its closed positions, it complements the ring 67 to heat-insulate the upper end of the manway 51 from the ambient. Further, the lower portion of the outer shell 70 and the upper portion of the ring 66 carry complementary fastening parts 74 and 75 that are adapted to be fastened together by a removable element 76, thereby to restrain the bonnet 69 in its closed position.

Referring now to FIG. 5, the top portion of the side wall 42 of the inner liner 41 has an opening formed therein, to one side of the manway structure 50, into which a thread fixture 46 is rigidly secured in place, as by welding. The safety vent 80 comprises an upstanding tube 81 having a threaded inner end that projects through aligned holes respectively formed in the side wall 32 of the intermediate layer 31 and in the side wall 22 of the outer shell 21; whereby the threaded inner end of the tube 81 is secured in place in fluid-tight relation with the fixture 46. A short upstanding ring 82 surrounding the tube 81 is carried by the top of the side wall 22 of the outer shell 21 and rigidly secured thereto, as by welding. A ring 83 of heat-insulating material is arranged in surrounding relation with the inner end and the intermediate portion of the tube 81; which ring 83 is disposed within the holes respectively formed in the elements 32 and 22 and within the ring 82. A cap 84 is rigidly secured to the upper portion of the tube 81, as by welding; which cap 84 is disposed above the top of the ring 82 and is provided with a depending annular skirt 85 surrounding the ring 82. Preferably, the ring 83 is formed of synthetic organic resin of cellular structure and of the composition of the intermediate layer 31, as explained more fully hereinafter. Of course, the cap 84 prevents the entry of water into the cavity in which the ring 83 is arranged. The upper end of the tube 81 carries a casing, not shown in FIG. 5, that houses the usual and conventional safety vent. Of course, the device 80 protects the inner liner 41 against abnormally high pressures.

Referring now to FIG. 6, aligned openings are respectively formed in the bottom central portions of the side wall 42 of the inner liner 41, the side wall 32 of the intermediate layer 31, and the side wall 22 of the outer shell 21. A substantially saddle-shaped ring 47 of sheet metal is carried by the outer surface of the side wall 42 and rigidly secured thereto, as by welding; and a substantially saddle-shaped ring 27 of sheet metal is carried by the outer surface of the side wall 22 and rigidly secured thereto, as by welding. A ring 91 is suitably secured to the outer surface of the ring 47, as by welding; and an outlet valve casing 92 is provided that has a top flange 93 that is detachably secured in fluid-tight relation with the ring 91 and that has a bottom flange 94 that is secured in fluid-tight relation with a ring 95. The ring 95 is in turn rigidly secured, as by welding, to a depending tube 96 having a threaded lower end carrying a removable threaded cap 97. The valve casing 92 is arranged in the aligned holes respectively provided in the elements 32 and 22, and projects downwardly through the ring 27 and well below the bottom central portion of the body 11. Also, the valve casing 92 houses valve mechanism, not shown, and selectively operable between open and closed positions by an associated manually operable handle 98. In ivew of the foregoing, it will be understood that after the cap 97 is removed from the threaded lower end of the tube 96, the handle 98 may be operated to actuate the valve mechanism into its open position; whereby the fluid lading contained in the inner liner 41 flows by gravity through the openings in the elements 42, 47 and 91 into the valve casing 92, and therefrom via the element 95 and the tube 96 to the exterior, so as to effect unloading of the fluid lading from the inner liner 41.

A tubular casing 99 is carried by the ring 27 and rigidly secured thereto, as by welding; which casing 99 surrounds the valve casing 92 and projects downwardly to a position disposed below the ring 95 and above the cap 97. An end wall 100 is arranged within the lower end of the casing 99 and disposed in surrounding relation with the intermediate portion of the tube 96 and retained in place by a series of screws 101 carried by the lower end of the casing 99. The casing 99 and the end wall 100 cooperate to define a cavity surrounding the valve casing 92; and this cavity is filled with a mass 102 of heat-insulating material that may take the form of fibrous glass. The mass 102 extends into the aligned holes formed in the elements 32, 22 and 27 and embeds the valve casing 92 and the ring 95, as well as the inner end of the tube 96.

In the operation of the railway tank car 10, the inner liner 41 is adapted to receive cold ladings having temperatures as low as about —50° F.; and it is undesirable to refrigerate the lading during several days of transit of the car 10; and it is required that the temperature rise of the lading be limited to several degrees F. even when the ambient temperature is as high as 100° F. Also, in the operation of the railway tank car 10, the inner liner 41 is adapted to receive hot ladings having temperatures as high as 300° F.; and it is undesirable to heat the lading during several days of transit of the car 10; and it is required that the temperature fall of the lading be limited to several degrees F. even when the ambient temperature is as low as 0° F. In order to meet this difficult specification, it is essential that the resin of the intermediate layer 31 comprises a polyester-urethane resin of closed-cell structure entrapping substantial inert gas selected from the class consisting of a chlorine-fluorine substituted alkane; whereby this resin has a K-factor at least as low as about 0.15 B.t.u./in./sq. ft./hr./° F. in order to heat-insulate from each other the outer shell 21 and the inner liner 41. Likewise, the ring 67 and the inner liner 71 incorporated in the manway structure 50 are formed of the resin specified in order to heat-insulate the manway 51 and the components cooperating therewith from the am-

bient. Similarly, the ring **83** incorporated in the safety vent **80** is formed of the resin specified in order to heat-insulate the inner liner **41** from the ambient.

Reverting to the inert gases specified, this class of compounds comprises $CHClF_2$, $CHCl_2F$, CCl_2F_2, CCl_3F, $C_2Cl_2F_4$ and $C_2Cl_3F_3$; and of these gases CCl_3F and CCl_2F_2 are normally preferred as a matter of efficiency and economy. The utilization of these inert gases as the blowing agent is very important since a typical polyester-urethane resin blown with CCl_3F has a K-factor as low as about 0.122, while a comparable typical polyester-urethane resin blown with CO_2 has a K-factor of about 0.191. For reference purposes it is noted that a comparable cellular polystyrene resin has a K-factor of about 0.220.

The utilization of a polyester-urethane resin, instead of a polyether-urethane resin, is very important, since the chemical stability of the polyester-urethane resin is much greater than the polyether-urethane resin, particularly, when the resin is subject to a temperature higher than about 150° F. In this regard, it is mentioned that at temperatures above about 200° F., the polyester-urethane resin is altogether stable, while the polyether-urethane resin undergoes substantial damage by decomposition.

Again reverting to FIG. 2, it is noted that the end walls **33** and **34** of the intermediate layer **31** have a relatively high density of at least about 4 pounds/cu. ft., while the side wall **32** of the intermediate layer **31** has a relatively low density of about 2 pounds/cu. ft.; whereby the high density resin has a yield strength of about 50 lbs./sq. in., while the low density resin has a yield strength of about 15 lbs./sq. in. This arrangement is very advantageous, since the high density resin of the end walls **33** and **34** of the intermediate layer **31** enable the same to withstand the great forces to which they are subjected by the respective end walls **43** and **44** of the inner liner **41** incident to impact conditions of the lading contained in the inner liner **41**, as a result of coupling of the railway tank car **10** in a train, etc. Also, the utilization of polyester-urethane resin, as distinguished from polyether-urethane resin, is advantageous from the standpoint that the polyester-urethane resin has a higher yield strength than the polyether-urethane resin, employing resins of comparable density.

The following example of a polyester-urethane resin of cellular form and of closed-cell structure and blown by an inert gas of the class specified is recommended for the production of the side wall **32** of the intermediate layer **31**, and the elements **67**, **71** and **83**. This resin is produced in a conventional manner employing a well-known machine comprising tanks A and B respectively containing two portions of the ingredients, as noted below. The contents of tank A are maintained at a temperature of about 70° F. and the contents of tank B are maintained at a temperature of about 190° F.; the contents of the two tanks are mixed at a rate of about 5500 r.p.m. and in about equal parts by weight and immediately applied to the mold.

Tank A contains the ingredients in parts by weight:

	Parts
Trichloromonofluoromethane, "Freon-11" (Du-Pont)	27
Tolylene diisocyanate, "70 Nacconate 4040" (Allied Chemical)	71¾
Silicone compound, "L530" (Union Carbide)	1¼

Tank B contains the ingredients in parts by weight:

100 parts chlorinated polyester, "Hetrafoam 250" (Durez Plastics)

In tank A the trichloromonofluoromethane is a propellant and blowing agent, and the silicone compound is an agent for controlling the cell structure of the cured polyester-urethane resin; and in tank B the chlorination of the polyester renders the cured polyester-urethane resin flame self-quenching. This polyester in tank B essentially comprises the basic reaction product of maleic anhydride and phthalic anhydride with propylene glycol; a typical formula comprising 0.5 mole maleic anhydride, 0.5 mole phthalic anhydride, and 1.1 moles of propylene glycol. A small amount of cobalt napthenate, as an accelerator, and a small amount of methyl ethyl ketone peroxide, as a catalyst, may also be added to the basic ingredients named above for the fundamental purpose of controlling the degree of prepolymerization thereof in the production of this linear polyester. Also, the chlorination of this linear polyester is normally carried out subsequent to the prepolymerization mentioned and may be omitted if the flame self-quenching characteristic noted is not desired in the ultimately produced polyester-urethane resin. However, this characteristic is highly desirable, as it increases the safety factor of the resin and contributes to chemical stability thereof when it is subjected to relatively high temperatures.

This blown polyester-urethane resin after curing has a density of about 2 pounds/cu. ft., as previously noted.

Now, in order to produce the blown polyester-urethane resin having a density of about 4 pounds/cu. ft., for the production of the end walls **33** and **34** of the intermediate layer **31**, it is only necessary to decrease the proportion of ingredients taken from tank A in the mixture; whereby the contents of the two tanks A and B are mixed in this case in the ratio of approximately 40%:60% by weight and at a rate of about 5500 r.p.m. and immediately applied to the mold. It is the decreased amount of trichloromonofluoromethane in this mix that produces a decreased porosity in the cured polyester-urethane resin, causing the same to be of higher density and of greater rigidity, with respect to the cured polyester-urethane resin first described.

The foregoing examples of the chemistry of the polyester-urethane resin are well known within themselves and form no part of the present invention; whereby these formulations have been set forth herein only by way of examples, so as positively to insure that the corresponding resins incorporated in the railway tank car **10** possess the desired chemical and physical properties that are required therein, as previously explained in conjunction with the construction and arrangement thereof. Thus, it will be readily apparent that other conventional and well-known chemical formulations of these polyester-urethane resins may be substituted in the railway tank car **10**.

In a constructional example of the railway tank car **10**; the longitudinal distance over the strikers at the extreme outer ends of the stub draft sills **16** is 340½"; the longitudinal distance between the centers of the body bolsters is 209"; the vertical distance between the tops of the rail heads and the longitudinal centerline of the stub draft sills **16** to 34½"; the vertical distance between the tops of the rail heads and the longitudinal center line of the body **11** is 93$\frac{3}{16}$"; the longitudinal distance over the end walls **23** and **24** of the outer shell **21** is 300½"; the longitudinal distance over the end walls **43** and **44** of the inner liner **41** is 292"; the internal diameter of the side wall **22** of the outer shell **21** is 102"; the internal diameter of the side wall **42** of the inner liner **41** is 94"; and the inner liner **41** is spaced substantially uniformly inwardly of the outer shell **21**, so that the intermediate layer **31** has a substantially uniform thickness of approximately 4" in the side wall **32** and in the end walls **33** and **34** thereof. The outer shell **21** is formed of low carbon steel sheet having a thickness of $\frac{7}{16}$" and is of welded construction; and the inner liner **41** is formed of low carbon steel sheet having a thickness of $\frac{3}{16}$" and is of welded construction. Also, the interior surface of the inner liner **41** carries a substantially uniform baked phenolic coating having a thickness in the general range 0.010" to 0.030".

The construction and arrangement of the railway tank car body **10**, as described above, is disclosed and claimed in the previously mentioned copending parent application of Charles T. Graves.

Considering now the method of making the railway tank car body **11** in accordance with the present invention, and referring to FIGS. 7 to 9, inclusive, a subassembly is first produced of the outer shell side wall **22** and the outer shell end wall **23**, together with the saddle plates **15** carried by the opposite lower end portions of the outer casing side wall **22**; whereby one end of the outer shell side wall **22** is closed by the outer shell end wall **23**, and the other end of the outer shell side wall **22** is open, but is adapted to be closed by the outer shell end wall **24**. This subassembly is arranged in a vertical position with the outer shell end wall **23** at the bottom, and is held in such position upon blocks, indicated at **701** in FIG. 7. The inner liner **41** is completely fabricated and fluid-pressure tested to insure that it is of sound fluid-tight construction.

A block **33***a* of polyester-urethane resin is cemented in place upon the central outer surface of the inner liner end wall **43**; which block **33***a* has the approximate composition of the intermediate layer end wall **33** and has a thickness somewhat in excess of 4". The inner liner **41** is then lowered into the open upper end of the outer casing side wall **22** causing the block **33***a* to engage the inner surface of the outer casing end wall **23**. The block **33***a* is compressed to a thickness of approximately 4" by the weight of the inner liner **41**, so as properly to space the inner liner end wall **43** inwardly with respect to the outer shell end wall **23**. Also, the inner liner side wall **42** is arranged substantially concentrically within the outer shell side wall **22** to provide a substantially uniform annular space therebetween. Further, the inner liner **41** is rotated about its longitudinal axis, so that the openings provided in the inner liner side wall **42** register with the corresponding openings provided in the outer shell side wall **22**.

The forms **F50**, **F80** and **F90** are then inserted from the exterior of the outer shell side wall **22** into the corresponding aligned openings in the respective outer shell side wall **22** and inner liner side wall **42**, so as to plug the openings mentioned both to the interior of the inner liner side wall **42** and to the exterior of the outer shell side wall **22**.

The uncured ingredients of the polyester-urethane resin are then foamed into the space to produce the intermediate layer end wall **33** upon setting-up; which ingredients adhere to the block **33***a*, thereby incorporating the same into the intermediate layer end wall **33**. The uncured ingredients mentioned set-up rather quickly at room temperature to produce the intermediate layer end wall **33**.

Thereafter, the uncured ingredients of the polyester-urethane resin are foamed into the space to produce the intermediate layer side wall **32** upon setting-up. This foaming operation should be carried out in a plurality of steps to produce the intermediate layer side wall **32** in a number of sections, each about 3 feet high, with setting-up of each section prior to foaming of the next adjacent section. This procedure is recommended, since a section that is too high does not permit proper escape of the inert blowing agent, as is desirable to obtain a substantially uniform cellular structure in the section undergoing setting-up.

Thereafter, the outer shell end wall **24** is placed upon the adjacent end of the outer shell side wall **22** and welded in place; whereby a space is provided between the inner liner end wall **44** and the outer shell end wall **24** that is adapted to receive the uncured ingredients of the polyester-urethane resin that produce the intermediate layer end wall **34** upon setting-up. The central portion of the outer shell end wall **24** has an opening therein, in which a threaded spud **24***a* is rigidly secured, as by welding; which threaded spud **24***a* is adapted to receive the cooperating threaded plug **24***b*.

The uncured ingredients of the polyester-urethane resin are then foamed in place through the opening in the spud **24***a*; whereby the intermediate layer end wall **34** is produced upon setting-up of the uncured ingredients mentioned; whereupon the plug **24***b* is set in the spud **24***a* to render water-tight the outer casing end wall **24**.

Thereafter, the forms **F50**, **F80** and **F90** are removed from the openings in the outer shell side wall **22**; and the body **11** is placed in an inverted horizontal position. In this position, the stub draft sills **16** are welded to the saddle plates **15**, and the body bolsters **17** are welded to the stub draft sills **16**, and the pedestals **18** are welded both to the body bolsters **17** and to the saddle plates **15**; thereby to finish the principal elements of the draft structure for the railway tank car **10**. At this time, the body **11** carrying the stub draft sills **16**, etc., may be mounted upon the associated wheeled trucks **19**. Ultimately the elements **50**, **80**, **90**, **110**, etc., of the railway tank car **10** are produced in a conventional manner.

Considering now a modified form of the method of making the railway tank car body **11** in accordance with the present invention, and referring to FIGS. 10 and 11, a subassembly is first produced of the outer shell side wall **22**, together with the saddle plates **15**; whereby both ends of the outer shell side wall **22** are open; which subassembly is suitably mounted in a horizontal position. In this case the top of the outer shell side wall **22** carries a series of threaded spuds, indicated at **22***a*, **22***b*, **22***c*, **22***d*, **22***e* and **22***f*. The inner liner **41** is completely fabricated and fluid-pressure tested to insure that it is of sound fluid-tight construction.

A series of rings **32***a*, **32***b*, **32***c*, **32***d*, **32***e*, and **32***f*, each formed of polyester-urethane resin, are cemented in place, in longitudinally spaced-apart relation, upon the outer surface of the liner **41**; each of the rings **32***f*, etc., is assembled in complimentary halves, as indicated at **32***fa* and **32***fb* in FIG. 11. Each of the rings **32***a*, etc., has the approximate composition of the intermediate layer side wall **32**, and a radial thickness between the inner and outer circumferences thereof of about 4". The inner liner **41** is then slid in place horizontally into the outer shell side wall **22**; whereby it is supported by the rings **32***a*, etc., in a position wherein the inner liner side wall **42** is disposed substantially concentrically within the outer shell side wall **22** and with the inner liner end walls **43** and **44** projecting substantially equally from the opposite open ends of the outer shell side wall **22**. Further, the inner liner **41** is rotated about its longitudinal axis, so that the openings provided in the inner liner side wall **42** register with the corresponding openings provided in the outer shell side wall **22**.

The forms **F50**, **F80** and **F90** are then inserted from the exterior of the outer shell side wall **22** into the corresponding aligned openings in the respective outer shell side wall **22** and inner liner side wall **42**, so as to plug the openings mentioned both to the interior of the inner liner side wall **42** and to the exterior of the outer shell side wall **22**. In this case, the rings **32***a*, **32***b*, etc., cooperate with each other and with the inner liner side wall **42** and the outer shell side wall **22** to define a plurality of longitudinally spaced-apart ring-shaped voids respectively accessible from the exterior via the spuds **22***b*, **22***c*, etc., and disposed in surrounding relation with the inner liner side wall **42**.

Thereafter, the uncured ingredients of the polyester-urethane resin are foamed through the spuds **22***b*, **22***c*, **22***d*, and **22***e* and through a slot **F50***a* provided in the side of the form **F50** into the voids mentioned, so as to produce the intermediate layer side wall **32** upon setting-up. As illustrated, five of the voids mentioned are thus filled, whereby the rings **32***a*, **32***b*, **32***c*, **32***d*, **32***e* and **32***f* are thus integrated into the composite intermediate layer side wall **32** upon setting-up of the uncured ingredients mentioned.

Thereafter, the outer shell end walls **23** and **24** are placed upon the adjacent ends of the outer shell side wall **32** and welded in place; whereby two spaces are provided between the inner liner end walls **43** and **44** and the respective outer shell end walls **23** and **24**.

Thereafter, the uncured ingredients of the polyester-urethane resin are formed through the spuds **22***a* and **22***f* into the two spaces mentioned; thereby to produce the two intermediate layer end walls **33** and **34** upon setting-up.

Thereafter, the forms **F50**, **F80** and **F90** are removed from the openings in the outer shell side wall **22**; the spuds **22***a*, **22***b*, **22***c*, **22***d*, **22***e* and **22***f* are closed by associated plugs, now shown; and the body **11** is placed in an inverted horizontal position. In this position, the stub draft sills **16** are welded to the saddle plates **15**; and thereafter, the railway car **10** is finished, in the manner previously described.

The formulation of the intermediate layer **31** of polyester-urethane is also very advantageous with respect to the method of making the railway tank car **10**, since it is most desirable to foam the intermediate layer **31** in place prior to welding in place the stub draft sills **16**, etc. Now, while the saddle plates **15** offer some protection to the intermediate layer **31** against the heat developed incident to the welding in place of the stub draft sills **16**, nevertheless hot spots are developed in the intermediate layer **31** at this time. However, these hot spots do not have temperatures in excess of about 300° F. and this high temperature is maintained only during a short time interval; whereby there is no damage to the intermediate layer **31**, since it is formed of polyester-urethane. Again, it is noted that this would not be the case, if the intermediate layer **31** were formed of other types of polyurethane resins, such, for example, as polyether-urethane; whereby the polyester-urethane resin as the material of which the intermediate layer **31** is formed represents a significant and important feature of construction of the railway car **10**. Also, it is reiterated that the polyester-urethane resin of the intermediate resin layer **31** must be blown with a chlorine-fluorine substituted alkane in order to obtain the desirable low K-factor that is essential to satisfactory operation of the railway tank car **10**, since the same may be employed for cold ladings or hot ladings in accordance with a feature of construction thereof. Also, it is a feature of construction of the railway tank car **10** that the same comprises neither auxiliary refrigerating apparatus nor auxiliary heating apparatus; whereby a cold lading must be precooled before it is loaded into the inner liner **41** and a hot lading must be preheated before it is loaded into the inner liner **41**. Although it is not essential, it is highly advantageous to precool the inner liner **41**, prior to loading a cold lading thereinto, by blowing a stream of cold air therethrough, and to preheat the inner liner **41**, prior to loading a hot lading thereinto, by blowing a stream of hot air therethrough. This procedure prevents thermal shock to liner **41** and avoids changing the temperature of the lading in the loading step.

In the operation of the railway tank car **10**, it is contemplated that the inner liner **41** will be loaded through the manway structure **50** and will be unloaded through the outlet valve structure **90**. The vacuum relief valve **68** protects the inner liner **41** against undesirable low pressures, and the safety vent **80** protects the inner liner **41** against undesirable high pressures. Also, it is noted that the intermediate layer **31** is quite resilient, thereby to protect the inner liner **41** against the transmission of vibration and shock thereto incident to operation of the railway tank car **10**. Not only do the end walls **33** and **34** of the intermediate layer **31** offer protection to the inner liner **41** against undue longitudinal shifting within the outer shell **21**, but the side wall **32** of the intermediate layer **31** also offers such protection to the inner liner **41**, since the side wall **32** of the intermediate layer **31** is subjected to shear stresses incident to such longitudinal shifting of the inner liner **41**, so that the same resiliency opposes such shifting. This effect is produced by virtue of the intimate boding of the intermediate layer **31** throughout the internal surface thereof to the adjacent external surface of the inner liner **41** and the intimate bonding of the intermediate layer **31** throughout the external surface thereof to the adjacent internal surface of the outer shell **21**. Specifically, the side wall **32** of the intermediate layer **31** of the composition heretofore specified has an ultimate shear strength of about 25 p.s.i., and an ultimate tensile strength of about 30 p.s.i.; whereby the inner liner **41** is capable of carrying safely quite dense ladings without danger of pulling the inner liner **41** loose from the intermediate layer **31** or pulling the intermediate layer loose from the outer shell **21**, particular at the top surfaces thereof that are subjected to tensile stresses, when the inner liner **41** is loaded.

In view of the foregoing, it is apparent that there has been provided an improved method of making a railway tank car of the heat-insulated type that may be carried out in a simple and economical manner.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications that fall within the true spirit and scope of the invention.

What is claimed is:

1. The method of making a railway car body including a metal outer shell and a metal inner liner and an intermediate layer of resilient cellular material intimately bonded to the inner surface of said outer shell and to the outer surface of said inner liner, wherein each of said outer shell and said inner liner and said intermediate layer includes an elongated tubular side wall and a pair of end walls respectively joining the opposite ends of the side wall thereof; said method comprising producing an assembly of said outer shell and said inner liner with said inner liner side wall spaced radially inwardly substantially concentrically with respect to said outer shell side wall and with said inner liner end walls spaced inwardly substantially equally with respect to the respectively adjacent ones of said outer shell end walls, foaming with inert gas first uncured ingredients of a polyurethane resin into the space between said outer shell side wall and said inner liner side wall, wherein said first ingredients are characterized by setting-up to produce a first body of cellular resin having a relatively low density and providing with closed cells entrapping a substantial amount of the inert gas, foaming with an inert gas second uncured ingredients of a polyurethane resin into the space between one of said outer shell end walls and the adjacent one of said inner liner end walls, wherein said second ingredients are characterized by setting-up to produce a second body of cellular polyurethane resin having a relatively high density and provided with closed cells entrapping a substantial amount of the inert gas, and foaming with an inert gas third uncured ingredients of a polyurethane resin into the space between the other of said outer shell end walls and the adjacent other of said inner liner end walls, wherein said third ingredients are characterized by setting-up to produce a third body of cellular polyurethane resin having a relatively high density and provided with closed cells entrapping a substantial amount of the inert gas, wherein the inert gas employed in said foaming steps consists essentially of a chlorine-fluorine substituted alkane, whereby each of said bodies named of cellular polyurethane resin has a K-factor at least as low as about 0.15 B.t.u./in./sq. ft./hr./° F. in order to heat-insulate from each other said outer shell and said inner liner in the resulting railway tank car body.

2. The method set forth in claim **1**, wherein a subassembly is first produced of said outer shell side wall and one of said outer shell end walls and said complete inner liner, whereby in said subassembly one end of said outer shell side wall is closed by said one outer shell end wall and the other end of said outer shell side wall is open, wherein said first and second bodies of polyurethane resin are then produced, wherein a complete assembly of said outer shell is then produced by securing the other of said

outer shell end walls to the other end of said outer shell side wall, and wherein said third body of polyurethane resin is then produced.

3. The method set forth in claim 1, wherein a subassembly is first produced of said outer shell side wall and said complete inner liner, whereby in said subassembly both ends of said outer shell side wall are open, wherein said first body of polyurethane resin is then produced, wherein a complete assembly of said outer shell is then produced by securing the pair of outer shell end walls to the opposite ends of said outer shell side wall, and wherein said second and third bodies of polyurethane resin are then produced.

4. The method of making a railway tank car body comprising producing an outer shell subassembly including an elongated tubular metal outer shell side wall and one metal outer shell end wall rigidly secured to one end of said outer shell side wall to close the one end thereof, whereby the other end of said outer shell side wall is open in said subassembly, providing another metal outer shell end wall adapted to be rigidly secured to the other end of said outer shell side wall to close the other end thereof, producing a complete inner liner of fluid-tight construction and including an elongated tubular metal inner liner side wall and a pair of metal inner liner end walls respectively closing the opposite ends of said inner liner side wall, producing an assembly of said outer shell subassembly and said complete inner liner, wherein said assembly is arranged in an upstanding position with said one outer shell end wall at the bottom thereof and with said complete inner liner disposed within said outer shell subassembly and with said inner liner side wall spaced radially inwardly substantially concentrically with respect to said outer shell side wall and with said one outer shell end wall spaced below the adjacent one of said inner liner end walls, foaming with an inert gas first uncured ingredients of a polyurethane resin into the space between said one outer shell end wall and said one inner liner end wall, wherein said first ingredients are characterized by setting-up to produce a first body of cellular polyurethane resin having a relatively high density and provided with closed cells entrapping a substantial amount of the inert gas, then foaming with inert gas second uncured ingredients of a polyurethane resin into the spaced between said outer shell side wall and said inner liner side wall, wherein said second ingredients are characterized by setting-up to produce a second body of cellular resin having a relatively low density and provided with closed cells entrapping a substantial amount of the inert gas, rigidly securing said other outer shell end wall to the other end of said outer shell side wall to close the other end thereof and with said other outer shell end wall spaced above the adjacent other of said inner liner end walls, and then foaming with inert gas third uncured ingredients of a polyurethane resin into the space between said other outer shell end wall and said other inner liner end wall, wherein said third ingredients are characterized by setting-up to produce a third body of cellular polyurethane resin having a relatively high density and provided with closed cells entrapping a substantial amount of the inert gas, wherein the inert gas employed in said foaming steps consists essentially of a chlorine-fluorine substituted alkane, whereby each of said bodies named of cellular polyurethane resin has a K-factor at least as low as about 0.15 B.t.u./in./sq. ft./hr./° F. in order to heat-insulate from each other said outer shell and said inner liner in the resulting railway tank car body.

5. The method of making a railway tank car body comprising producing an outer shell subassembly including an elongated tubular metal outer shell side wall, whereby the opposite outer ends of said outer shell sidewall are open in said subassembly, providing two metal outer shell end walls adapted to be rigidly secured to the opposite outer ends of said outer shell side wall to close the respective ends thereof, producing a complete inner liner of fluid-tight construction and including an elongated tubular metal inner liner side wall and a pair of metal inner liner end walls respectively closing the opposite ends of said inner liner side wall, securing a plurality of longitudinally spaced-apart rings of polyurethane resin to the outer surface of said inner liner side wall, producing an assembly of said outer shell subassembly and said complete inner liner carrying said rings, wherein said assembly is arranged in a generally horizontal position with said complete inner liner disposed within said outer shell subassembly and with said inner liner side wall spaced radially inwardly substantially concentrically with respect to said outer shell side wall by said rings and with said inner liner end walls disposed adjacent to the respective ends of said outer shell side wall, foaming with inert gas first uncured ingredients of a polyurethane resin into the space between said outer shell side wall and said inner liner side wall, wherein said first ingredients are characterized by setting-up to produce a first body of cellular resin having a relatively low density and provided with closed cells entrapping a substantial amount of the inert gas, rigidly securing said outer shell end walls to the opposite outer ends of said outer shell side wall to close the repective ends thereof and with said outer shell end walls spaced outwardly with respect to the respectively adjacent ones of said inner liner end walls, then foaming with an inert gas second uncured ingredients of a polyurethane resin into the space between one of said outer shell end walls and the adjacent one of said inner liner end walls, wherein said second ingredients are characterized by setting-up to produce a second body of cellular polyurethane resin having a relatively high density and provided with closed cells entrapping a susbtantial amount of the inert gas, and then foaming with an inert gas third uncured ingredients of a polyurethane resin into the space between the other of said outer shell end walls and the adjacent other of said inner liner end walls, wherein said third ingredients are characterized by setting-up to produce a third body of cellular polyurethane resin having a relatively high density and provided with closed cells entrapping a substantial amount of the inert gas, wherein the inert gas employed in said foaming steps consists essentially of a chlorine-fluorine substituted alkane, whereby each of said bodies named of cellular polyurethane resin has a K-factor at least as low as about 0.15 B.t.u./in./sq. ft./hr./° F. in order to heat-insulate from each other said outer shell and said inner liner in the resulting railway tank car body.

6. The method of making a railway tank car comprising an elongated longitudinally extending tubular body disposed in a substantially horizontal position, said body including an outer shell of strong rigid self-supporting steel structure, a pair of longitudinally extending and aligned stub draft sills each formed of steel and respectively disposed below the opposite ends of said outer shell and welded thereto, whereby draft and buff forces are applied between said stub draft sills through said outer shell, a pair of longitudinally spaced-apart and laterally extending body bolsters respectively rigidly secure to said stub draft sills, and a pair of wheeled trucks respectively disposed below and in supporting relation with said body bolsters, said body also including an intermediate layer of resilient cellular material completely enclosed by said shell, said body further including an inner liner of fluid-tight construction completely enclosed, by said intermediate layer, the outer and inner surfaces of said intermediate layer being respectively intimately bonded to the inner surface of said outer shell and to the outer surface of said inner liner, said intermediate layer having a substantial thickness in order completely to separate and to isolate said outer shell from said inner liner and resiliently to support said inner liner upon said outer shell; said method comprising producing said intermediate layer in situ between said outer shell and said inner liner prior to securing said stub draft sills in place at the opposite ends

of said outer shell, said last-mentioned step consisting essentially of foaming into place with an inert gas uncured ingredients of a polyurethane resin so that said intermediate layer is produced by setting-up of said uncured ingredients and is of blown closed-cell structure entrapping a substantial amount of said inert gas, wherein said inert gas consists essentially of a chlorine-fluorine substituted alkane, whereby said intermediate layer has a K- factor at least as low as about 0.15 B.t.u./in./sq. ft./hr./° F. in order to heat-insulate from each other said outer shell and said inner liner, and then following setting-up of said intermediate layer placing said stub draft sills in proper positions at the opposite ends of said outer shell and rigidly securing said stub draft sills to said outer shell by welding, wherein said polyurethane resin is characterized by chemical and structural stability at temperatures at least as high as about 300° F. during a short time interval, whereby the areas of said intermediate layer respectively disposed immediately adjacent to said stub draft sills are not damaged by heat produced incident to the welding in place of said stub draft sills at the adjacent ends of said outer shell.

7. The method set forth in claim 6, wherein said uncured ingredients are those of a polyester-urethane resin.

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