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(54) **MOTOR VEHICLE FUEL TANK AND METHOD**

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **B65D 1/42**
(52) **U.S. Cl.** **220/562**; 220/4.14; 220/4.13
(58) **Field of Search** 220/4.14, 564, 220/562, 4.13

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,611,512	A	*	9/1952	Fashay	220/562
3,912,107	A	*	10/1975	Baumann	220/4.14
4,211,208	A	*	7/1980	Lindner	126/400
4,231,482	A	*	11/1980	Rogan	
4,399,850	A	*	8/1983	Schiemann	150/5
4,526,286	A	*	7/1985	Jung et al.	220/4.14
6,135,306	A	*	10/2000	Clayton et al.	220/562
6,138,859	A	*	10/2000	Aulph et al.	220/4.14

FOREIGN PATENT DOCUMENTS

EP	0 064 310	*	11/1982	220/4.14

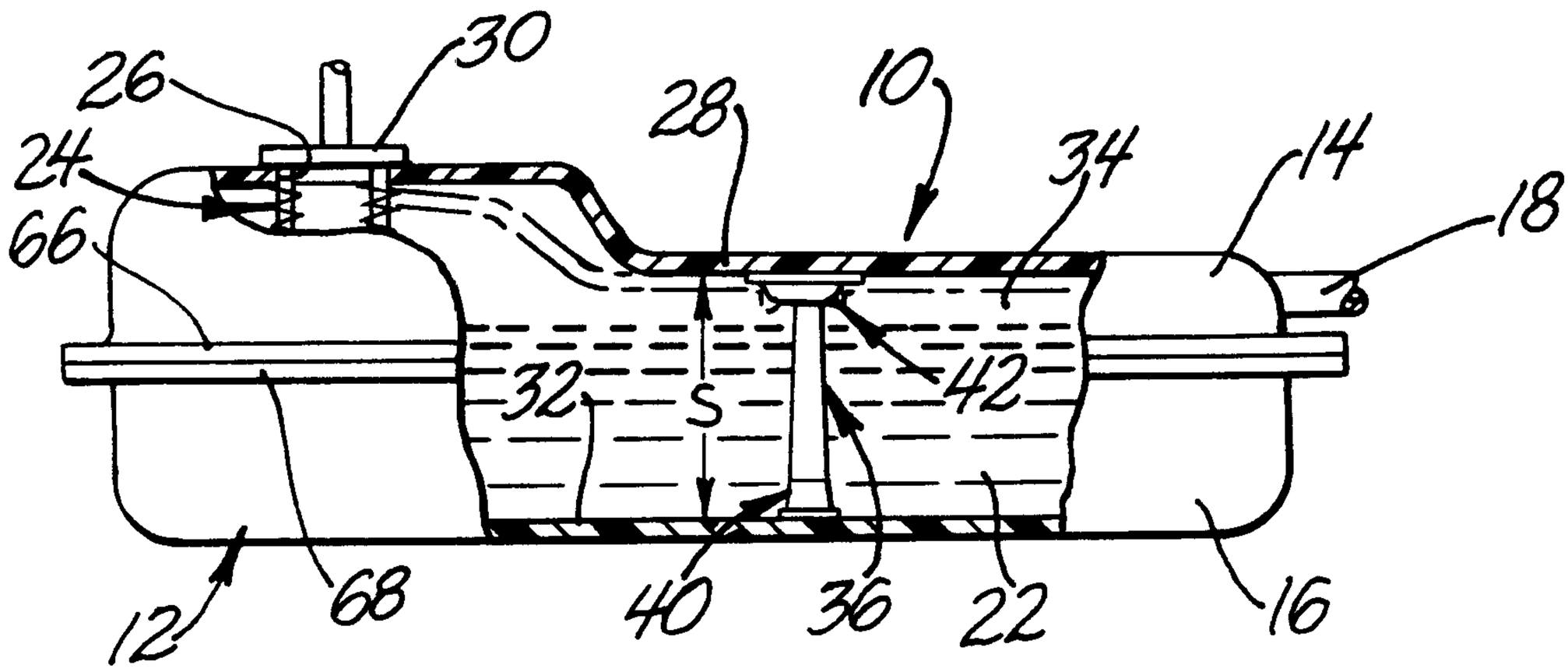
* cited by examiner

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(57) **ABSTRACT**

A plastic fuel tank including a hollow plastic tank body and a variable length plastic strut in the hollow tank body. A pair of flat plastic sheets are vacuum formed at a forming temperature in upper and lower mold cavities to the shape of upper and lower plastic shells. The plastic strut includes an upper foot, a lower foot, and a coupling means operable to support the upper foot on the lower foot for back and forth linear translation against a controlled resistance. With the mold cavities separated, the plastic strut is interposed between the upper and lower shells. The mold cavities are closed to form the hollow tank body by fusion bonding the upper and lower shells at respective attachment flanges on each. When the tank body thereafter cures and shrinks, the plastic strut is squeezed between the upper and lower shells against the controlled resistance of the coupling means to fusion bond the upper and lower feet of the strut to the shells. The strut expands and collapses during pressure and vacuum cycles in the tank body. The coupling means limits linear collapse and expansion of the strut to prevent excessive collapse and expansion of the tank body.

6 Claims, 2 Drawing Sheets



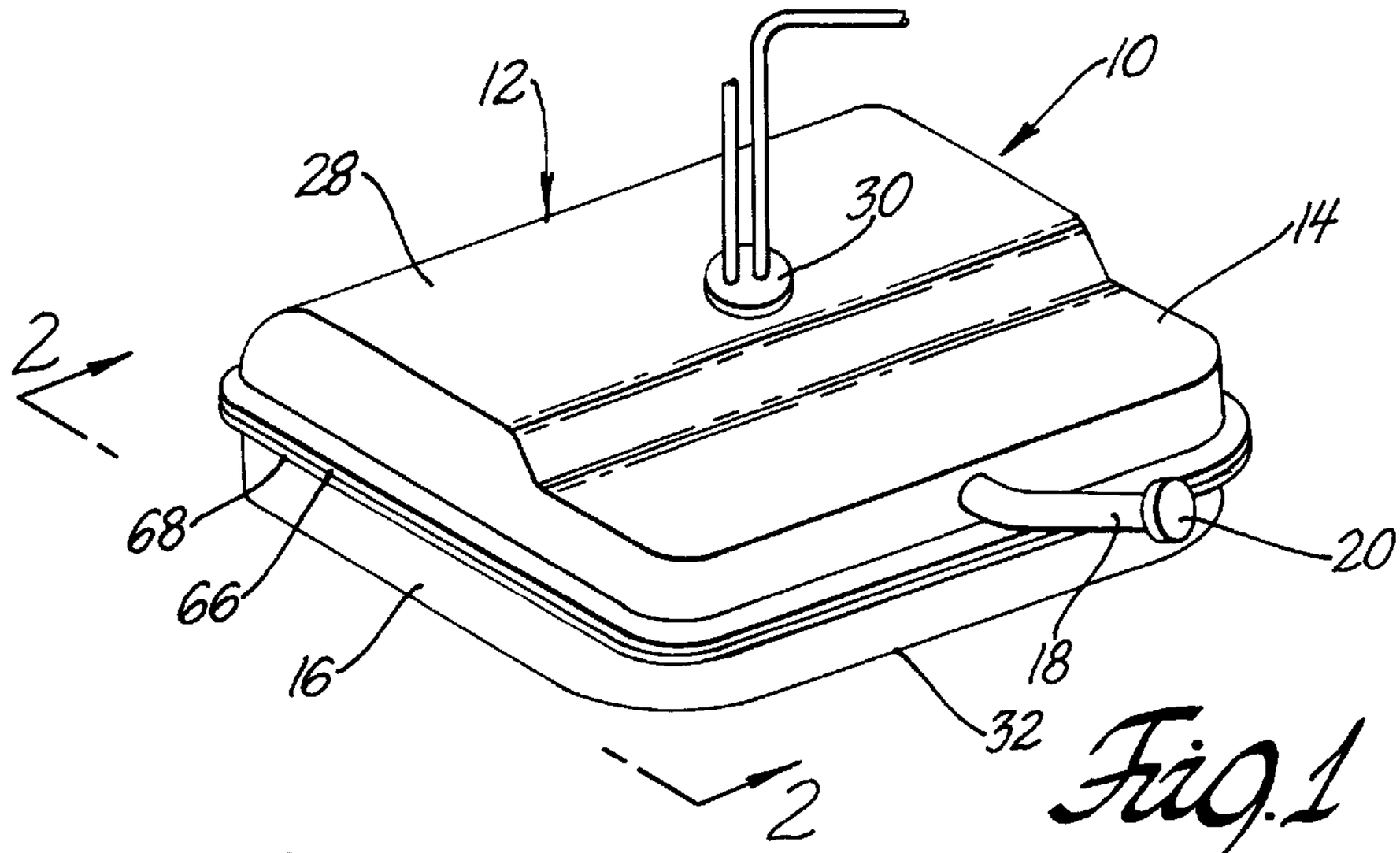


Fig. 1

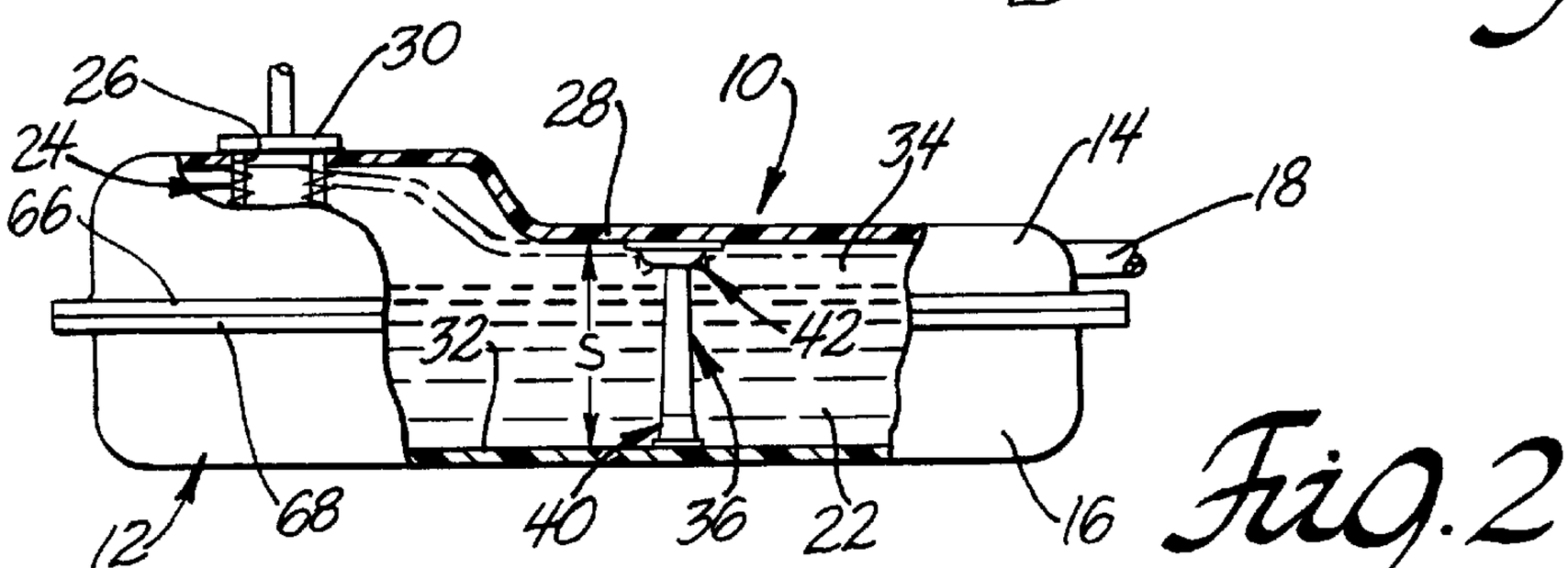


Fig. 2

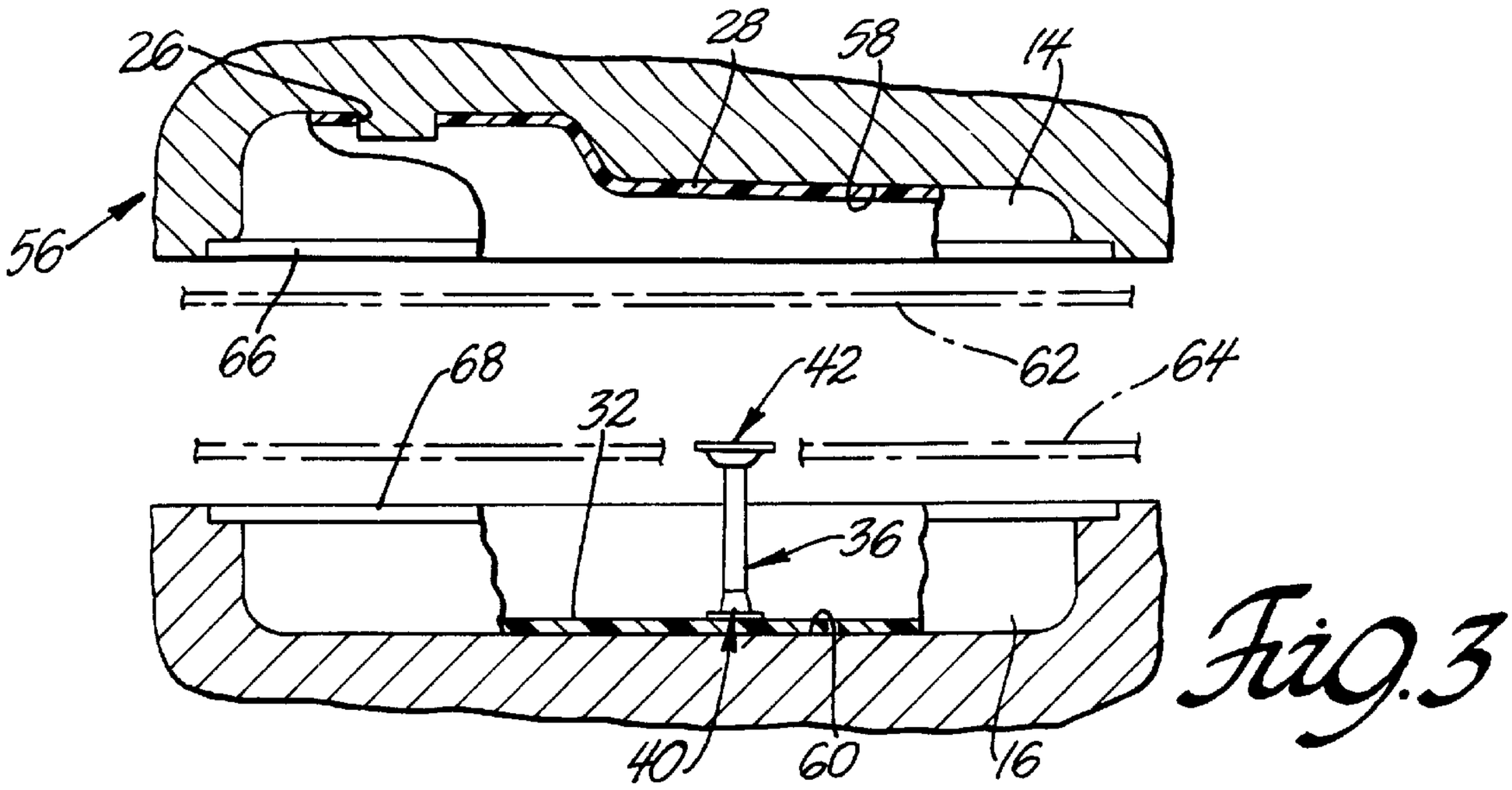


Fig. 3

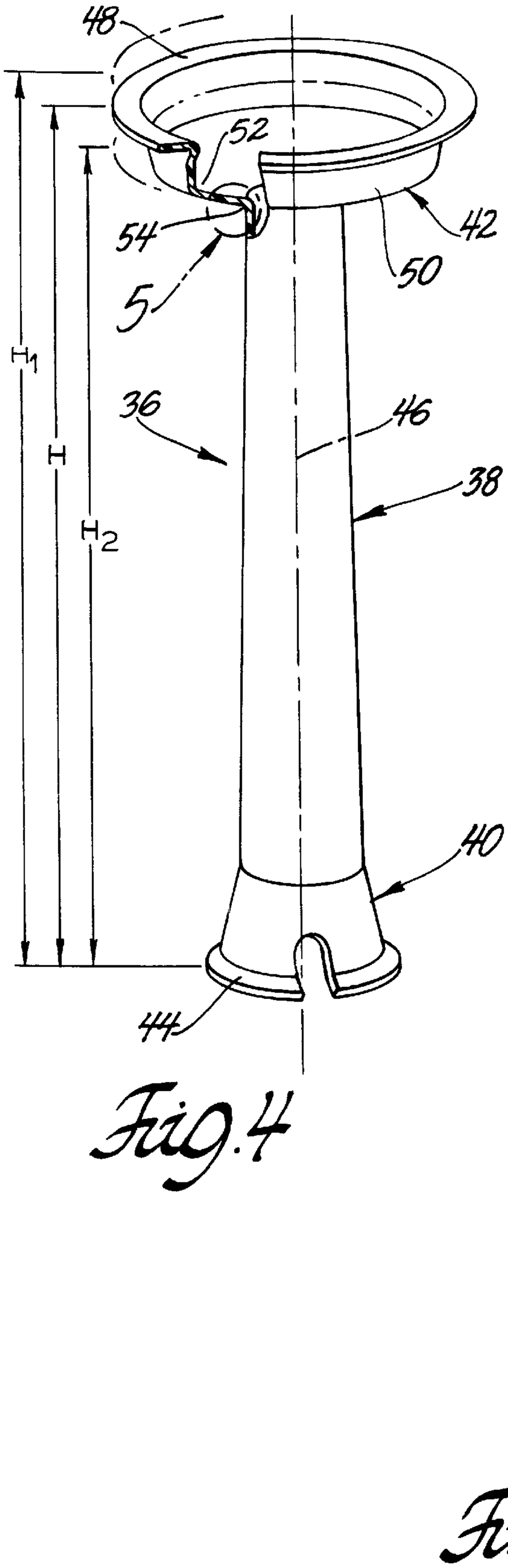


Fig.4

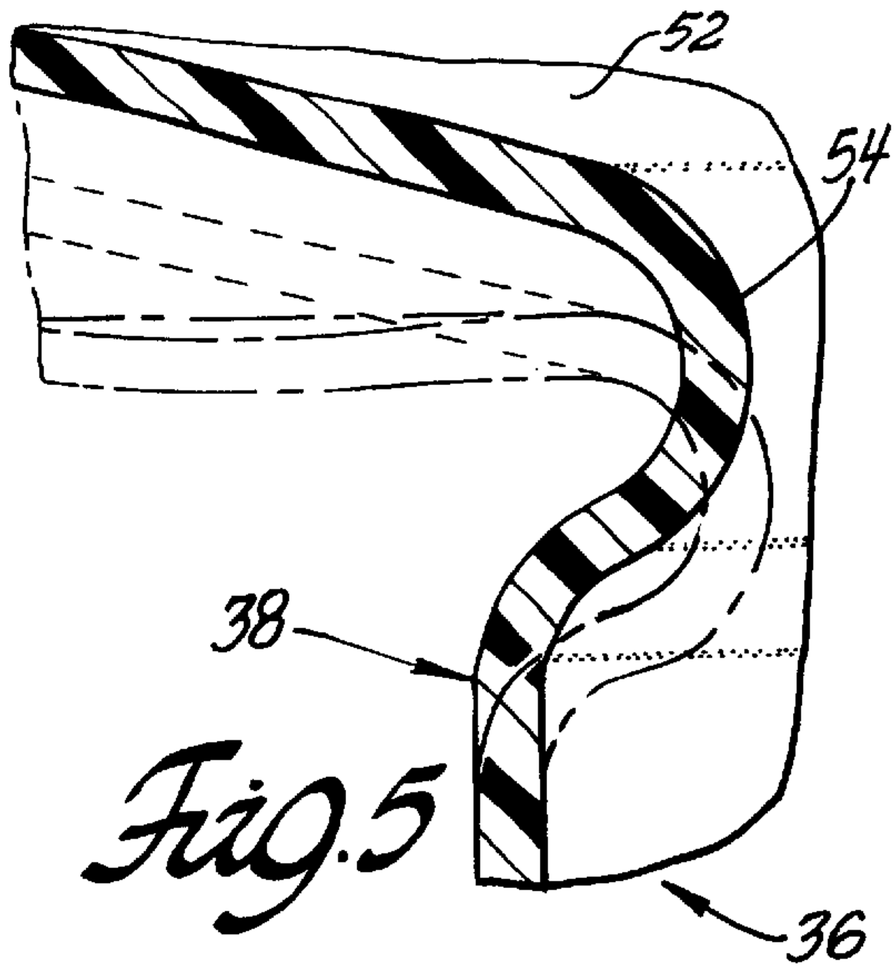


Fig.5

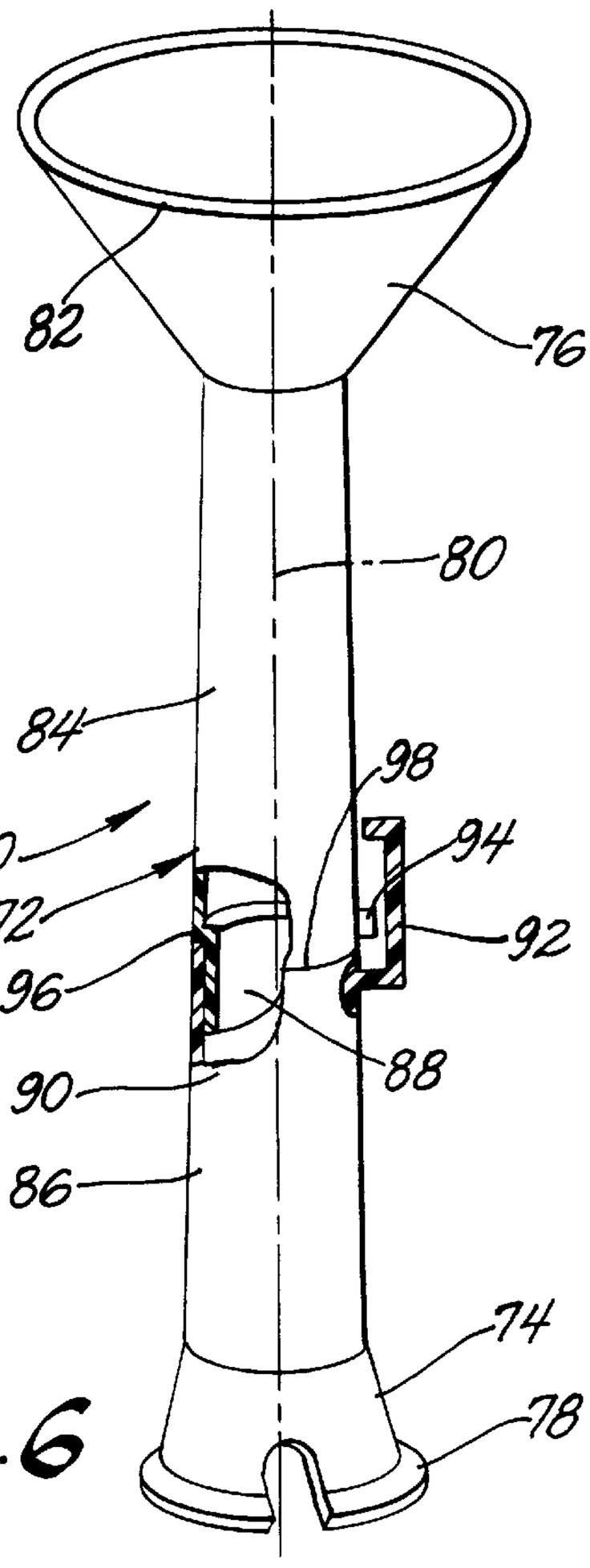


Fig.6

MOTOR VEHICLE FUEL TANK AND METHOD

RELATED PATENT APPLICATION

This application claims the benefit of U.S. Provisional Patent Application No. 60/138036, filed Jun. 8, 1999.

TECHNICAL FIELD

This invention relates to a motor vehicle fuel tank and method of making a motor vehicle fuel tank.

BACKGROUND OF THE INVENTION

Plastic fuel tanks for motor vehicles are typically manufactured by processes identified as "blow molding" and "twin sheet thermoforming". In the blow molding process, a mass of liquid plastic at elevated temperature is expanded in a mold by injecting gas under pressure into the plastic mass. In the twin sheet thermoforming process, a pair of flat plastic sheets are vacuum formed in mold cavities at an elevated forming temperature to the shape of upper and lower shells each having an attachment flange around an open end thereof. When the mold cavities are closed, the attachment flanges are squeezed together to fusion bond the shells and thereby form a hollow plastic tank body. Plastic fuel tanks manufactured by both processes are subject to pressure and vacuum cycles attributable to differences between atmospheric pressure around the tank body and the pressure of a gaseous mixture of air and fuel vapor in the tank body. In a pressure cycle, gas pressure in the tank body exceeds atmospheric pressure and the top of the tank body expands away from the bottom of the tank body. In a vacuum cycle, atmospheric pressure exceeds the gas pressure in the tank body and the top of the tank body collapses toward the bottom of the tank body. To reinforce a blow molded plastic tank fuel tank against such pressure and vacuum cycles, it is known to install rigid structural supports through an access port in the top of the tank body. Such rigid supports may not be adequate, however, because of their location only in the immediate vicinity of the access port. To reinforce a twin sheet thermoformed plastic fuel tank, it is known to interpose a rigid structural support between the vacuum formed shells before the mold cavities are closed so that after the attachment flanges are fusion bonded, shrinkage during curing of the tank body fusion bonds the ends of the structural support to the top and bottom of the tank body. Such rigid structural supports, however, may compromise the integrity of the tank body by piercing the top and/or bottom thereof as the tank body shrinks.

SUMMARY OF THE INVENTION

This invention is a new and improved twin sheet thermoformed plastic fuel tank including a hollow plastic tank body and a variable length plastic strut in the hollow tank body. A pair of flat plastic sheets are vacuum formed at an elevated forming temperature in upper and lower mold cavities of a molding apparatus to the shape of upper and lower plastic shells. The plastic strut includes an upper foot, a lower foot, and a coupling means operable to support the upper foot on the lower foot for back and forth linear translation in the direction of a longitudinal centerline of the strut against a controlled resistance. With the mold cavities separated, the plastic strut is interposed between the upper and lower shells. Then, the mold cavities are closed together to form the hollow tank body by fusion bonding the upper and lower shells at respective attachment flanges on each. When the tank body thereafter cures and shrinks, the plastic strut is squeezed between the upper and lower shells against the controlled resistance of the coupling means to fusion bond the upper and lower feet of the strut to the shells. The strut then expands and collapses with the hollow tank body during pressure and vacuum cycles therein The coupling means also limits linear collapse and expansion of the strut to prevent collapse and expansion of the tank body which could negatively affect the structural integrity thereof. In a first embodiment of the plastic fuel tank according to this invention, a resilient flexible lobe of the plastic strut constitutes the coupling means. In a second embodiment of the plastic fuel tank according to this invention, a pilot on an upper shank portion of the strut, a guide on a lower shank portion of the strut for the pilot, and end stops on the upper and lower shank portions constitute the coupling means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a plastic motor vehicle fuel tank according to this invention;

FIG. **2** is a partially broken-away elevational view taken generally along the plane indicated by lines **2—2** in FIG. **1**;

FIG. **3** is similar to FIG. **2** but showing an upper shell, a lower shell, and a plastic strut of the plastic motor vehicle fuel tank according this invention in different relative positions;

FIG. **4** is a partially broken-away, enlarged perspective view of the strut of the plastic motor vehicle fuel tank according to this invention;

FIG. **5** is an enlarged view of the portion of FIG. **4** identified by reference circle **5** in FIG. **4**; and

FIG. **6** is a partially broken-away perspective view of the strut of a modified plastic motor vehicle fuel tank according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. **1–2**, a plastic fuel tank **10** according to this invention includes a hollow tank body **12** consisting of an upper shell **14** and a lower shell **16**. A fill pipe **18** on the tank body has an outboard end **20** through which liquid fuel is dispensed into the fuel tank from a filling station pump nozzle, not shown, to form a pool **22** of liquid fuel in the tank body. A fragmentarily illustrated fuel sender **24** is installed in the tank body **12** through an access port **26** in a top **28** of the upper shell constituting the top of the tank body. The fuel sender includes a cover **30** over the access port and a fuel pump, not shown, thrust against a bottom **32** of the lower shell constituting the bottom of the tank body. The fuel sender pumps liquid fuel from the pool **22** in the tank body to a fuel injection system, not shown, of the motor vehicle.

A vapor dome **34** in the tank body **12** above the pool **22** of liquid fuel contains a gaseous mixture of air and fuel vapor. The tank body experiences vacuum and pressure cycles as the temperature in the vapor dome changes. In a vacuum cycle, atmospheric pressure exceeds the pressure of the gaseous mixture in the vapor dome so that the top **28** of the tank body collapses toward the bottom **32** of the tank body. Conversely, in a pressure cycle, the pressure of the gaseous mixture in the vapor dome exceeds atmospheric pressure so that the top of the tank body expands away from the bottom of the tank body.

As seen best in FIGS. **2,4** and **5**, a vertical plastic strut **36** in the tank body remote from the access port **26** includes a

tubular shank **38** having a flared lower base **40** and a cup-shaped upper base **42**. The lower base **40** terminates at an annular flange constituting a lower foot **44** of the strut fusion bonded to the bottom **32** of the tank body in a plane perpendicular to a longitudinal centerline **46** of the strut. The upper base **42** terminates at an annular flange constituting an upper foot **48** of the strut fusion bonded to the top **28** of the tank body in a plane perpendicular to the longitudinal centerline **46** of the strut.

The upper base **42** is cupshaped and includes a cylindrical side wall **50** integral with the upper foot **48** and an annular bottom wall **52** integral with the side wall An annular flexible lobe **54** integral with each of the shank **38** and the bottom wall **52** of the upper base constitutes a coupling means supporting the upper foot **48** on the lower foot **44** for back and forth linear translation in the direction of the longitudinal centerline **46** of the strut. The plastic from which the strut **36** is molded is resilient when flexed within its elastic limit. The lobe **54** thus constitutes a spring in the coupling means. In the absence of tension or compression applied to the strut at the upper and lower feet **48**,**44** thereof, the strut assumes a height "H", FIG. **4**.

With the upper and lower feet **48**,**44** fusion bonded to the top and bottom **28**,**32** of the tank body **12**, the strut **36** expands and collapses with changes in a vertical span "S", FIG. **2**, between the top and the bottom of the tank body. In a pressure cycle, the top **28** of the tank body expands away from the bottom **32** of the tank body causing the upper foot **48** to translate linearly away from the lower foot **44** against a restoring force attributable to resilient flexure of the lobe **54**. Similarly, in a vacuum cycle, the top of the tank body collapses toward the bottom of the tank body causing the upper foot **48** to translate linearly toward the lower foot **44** against a restoring force attributable to opposite resilient flexure of the lobe **54**.

At an expanded height "H_1", FIG. **4**, of the strut **36** in a pressure cycle, the restoring force of the lobe **54** equals the pressure force on the top **28** of the tank body urging expansion so that the strut becomes effectively rigid in tension and prevents excessive expansion of the top of the tank body relative to the bottom of the tank body. Conversely, at a collapsed height "H_2" of the strut in a vacuum cycle, the restoring force of the lobe **54** equals the pressure force on the top of the tank body urging collapse so that the strut becomes effectively rigid in compression and prevents excessive collapse of the top relative to the bottom. The coupling means in the strut **36** thus permits expansion and collapse of the top of the tank body relative to the bottom of the tank body but stops excessive expansion and collapse of the tank body which could compromise the structural integrity of the tank body.

The method by which the plastic fuel tank **10** is made is an important feature of this invention and includes forming each of the upper and lower shells **14**,**16** of the tank body by twin sheet thermoforming process steps. Referring to FIG. **3**, a schematically represented twin sheet thermoforming apparatus **56** includes an upper mold cavity **58** shaped like the upper shell **14** and a lower mold cavity **60** shaped like the lower shell **16** which are opened and closed relative to each other. With the mold cavities open, a first flat plastic sheet **62** is located over the upper mold cavity **58** and a second flat plastic sheet **64** is located over the lower mold cavity **60**. The first and second plastic sheets **62**,**64** are heated to a forming temperature at which the plastic sheets are soft and pliable. A vacuum is then drawn in each of the upper and lower mold cavities **58**,**60** which causes the heated flat plastic sheets to assume the shapes of the upper and lower shells **14**,**16** including an annular flange **66** around an open end of the upper shell and an annular flange **68** around an open end of the lower shell.

With the upper and lower mold cavities **58**,**60** still open relative to each other and with the vacuum formed upper and lower shells still at the aforesaid forming temperature, the plastic strut **36** is interposed between the shells, FIG. **3**, with the upper and lower feet **48**,**44** heated to the forming temperature. When the mold cavities are then closed, the annular flanges **66**,**68** on the upper and the lower shells are squeezed together and fusion bonded to seal closed the interface between the shells and form the hollow tank body **12**. At the same time, the upper foot **48** is squeezed against the top **28** of the upper shell and the lower foot **44** is squeezed against the bottom **32** of the lower shell. When the tank body is then permitted to cool and cure, plastic shrinkage collapses the strut linearly and initiates flexure of the lobe **54**. The flexure of the lobe **54** is calculated to squeeze the upper and lower feet **48**,**44** against the top and bottom of the upper and lower shells with sufficient compression to fusion bond the feet to the top and bottom without piercing the top and bottom. Importantly, because the strut is interposed between the upper and lower shells when the mold cavities **58**,**60** are open, it is located for optimum structural integrity of the tank body independent of the location of the access port **26**.

Referring to FIG. **6**, a modified plastic fuel tank according to this invention, not shown, is identical to the plastic fuel tank **10** except that the modified tank includes a modified plastic strut **70** instead of the plastic strut **36** described above. The modified plastic strut **70** includes a tubular shank **72** having a flared lower base **74** and a flared upper base **76**. The lower base terminates at an annular flange constituting a lower foot **78** of the modified strut fusion bonded to the bottom of the tank body in a plane perpendicular to a longitudinal centerline **80** of the modified strut. The upper base **76** terminates at an annular end constituting an upper foot **82** of the strut fusion bonded to the top of the tank body in a plane perpendicular to the longitudinal centerline **80** of the modified strut.

The shank **72** of the modified strut **70** is divided into a tubular upper shank portion **84** integral with the upper base **76** and a tubular lower shank portion **86** integral with the lower base **74**. A reduced diameter cylindrical pilot **88** on the end of the upper shank portion opposite the upper base **76** telescopes into a tubular guide **90** in the end of the lower shank portion opposite the lower base **74** with a mild interference fit which induces friction between the guide and the pilot without foreclosing relative linear translation therebetween The pilot and the guide constitute a coupling means supporting the upper foot **82** on the lower foot **78** for back and forth linear translation in the direction of the longitudinal centerline **80** of the modified strut against a resisting force attributable to friction between the pilot and the guide.

With the upper and lower feet **82**,**78** of the modified strut fusion bonded to the top and bottom of the tank body, the modified strut expands and collapses with changes in the vertical span between the top and the bottom of the tank body. Linear expansion of the modified strut **70** is limited by a schematically represented cage **92** on the lower shank portion **86** which intercepts a schematically represented pin **94** on the upper shank portion **84**. Linear collapse of the modified strut is limited by a shoulder **96** constituting an abutment on the upper shank portion **84** which seats on an end **98** of the lower shank portion **86** constituting an abutment on the lower shank portion. The modified strut

thus expands and collapses with the tank body except at the limits defined by the cage and pin **92,94** and by the shoulder **96** and the end **98** of the lower shank portion where the modified strut becomes rigid in expansion and collapse to prevent excessive expansion and collapse of the tank body which could compromise the structural the integrity thereof

The modified plastic fuel tank is made by the process described above for the plastic fuel tank **10**. With the upper and lower mold cavities open relative to each other and with the vacuum formed upper and lower shells at the aforesaid forming temperature, the modified plastic strut **70** is interposed between the shells with the upper and lower feet **82,78** heated to the forming temperature. When the mold cavities are then closed, the annular flanges on the upper and the lower shells are squeezed together and fusion bonded to seal closed the interface between the shells and form the hollow tank body. At the same time, the upper foot **82** on the modified strut is squeezed against the top of the upper shell and the lower foot **78** is squeezed against the bottom of the lower shell. When the tank body is then permitted to cool and cure, plastic shrinkage collapses the strut linearly against the friction between the pilot **88** and the guide **90** which induces sufficient compression between the upper and lower feet and the top and bottom of the upper and lower shells to fusion bond the feet to the top and bottom of the shells without piercing either. As before, because the modified strut **70** is interposed between the upper and lower shells when the mold cavities are open, it is located for optimum structural integrity of the tank body independent of any access ports in the shells.

Having thus described the invention, what is claimed is:

1. A plastic fuel tank for a motor vehicle comprising:

a hollow plastic tank body having a bottom and a top which expands and collapses relative to the bottom in respective ones of a pressure cycle and a vacuum cycle in the tank body,

a plastic strut in the hollow tank body having an upper foot fusion bonded to the top of the tank body and a lower foot fusion bonded to the bottom of the tank body, and

a coupling means on the plastic strut operable to support the upper foot on the lower foot for relative linear translation parallel to a longitudinal centerline of the plastic strut in an expansion direction from a height (H) of the strut and in an opposite collapse direction from the height (H) of the strut against a resisting force in each direction and to effectively stop translation of the upper foot relative to the lower foot in the expansion direction at an expanded height (H_1) of the strut and in the collapse direction at a collapsed height (H_2) of the strut so that the plastic strut resists expansion and collapse of the top of tank body relative to the bottom of the tank body above and below the height (H) of the strut and reinforces the top of tank body against further expansion and further collapse relative to the bottom of the tank body at respective ones of its expanded height (H_1) and collapsed height (H_2).

2. The plastic fuel tank for a motor vehicle recited in claim **1** wherein the plastic strut comprises:

a tubular plastic shank,

a lower plastic base integral with the tubular plastic shank having an annular flange thereon in a plane perpendicular to the longitudinal centerline of the plastic strut constituting the lower foot of the plastic strut, and

an upper plastic base integral with the tubular plastic shank having an annular flange thereon in a plane perpendicular to the longitudinal centerline of the plastic strut constituting the upper foot of the plastic strut.

3. The plastic fuel tank for a motor vehicle recited in claim **2** wherein the coupling means comprises:

a resiliently flexible plastic lobe integral with each of the tubular plastic shank and the upper plastic base of the plastic strut.

4. The plastic fuel tank for a motor vehicle recited in claim **1** wherein the plastic strut comprises:

a tubular plastic shank having an upper shank portion and a separate lower shank portion,

a lower plastic base integral with the lower shank portion of the tubular plastic shank having an annular flange thereon in a plane perpendicular to the longitudinal centerline of the plastic strut constituting the lower foot of the plastic strut, and

an upper plastic base integral with the upper shank portion of the tubular plastic shank having an annular surface thereon in a plane perpendicular to the longitudinal centerline of the plastic strut constituting the upper foot of the plastic strut.

5. The plastic fuel tank for a motor vehicle recited in claim **4** wherein the coupling means comprises:

a cylindrical pilot on an end of a first one of the upper shank portion and the lower shank portion,

a tubular guide on an end of a second one of the upper shank portion and the lower shank portion slidably receiving the cylindrical pilot with an interference fit therebetween so that friction between the cylindrical pilot and the guide resists relative linear translation between the upper foot and the lower foot in the expansion direction and in the collapse direction, and

a stop means operable to stop sliding movement of the pilot relative to the guide at the expanded height of the plastic strut and at the collapsed height of the plastic strut.

6. The plastic fuel tank for a motor vehicle recited in claim **5** wherein the stop means comprises:

a pin rigidly connected to a first one of the pilot and the guide,

a cage rigidly connected to a second one of the pilot and the guide operable to intercept the pin at the expanded height of the plastic strut,

a first abutment rigidly connected to the pilot, and

a second abutment rigidly connected to the guide operable to intercept the first abutment at the collapsed height of the plastic strut.

* * * * *