

United States Patent

Hughes et al.

[15] 3,703,976

[45] Nov. 28, 1972

[54] **HIGH PRESSURE STORAGE VESSEL**

[72] Inventors: **William L. Hughes; Hansel J. Allison; Ramachandra G. Ramakumar**, all of Stillwater, Okla.

[73] Assignee: **Oklahoma State University**, Stillwater, Okla.

[22] Filed: **Oct. 28, 1970**

[21] Appl. No.: **84,771**

[52] U.S. Cl. **220/3, 220/88 R**

[51] Int. Cl. **B65d 25/00**

[58] Field of Search **220/3, 88 R, 63 A**

[56] **References Cited**

UNITED STATES PATENTS

1,080,263 12/1913 Coleman.....220/88 R

3,396,923 8/1968 Windecker.....220/88 R
3,567,536 3/1971 Wickersham, Jr.220/88 R

Primary Examiner—Richard A. Schacher

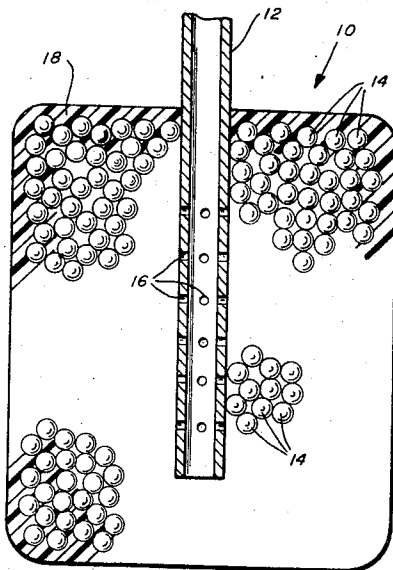
Assistant Examiner—John J. Love

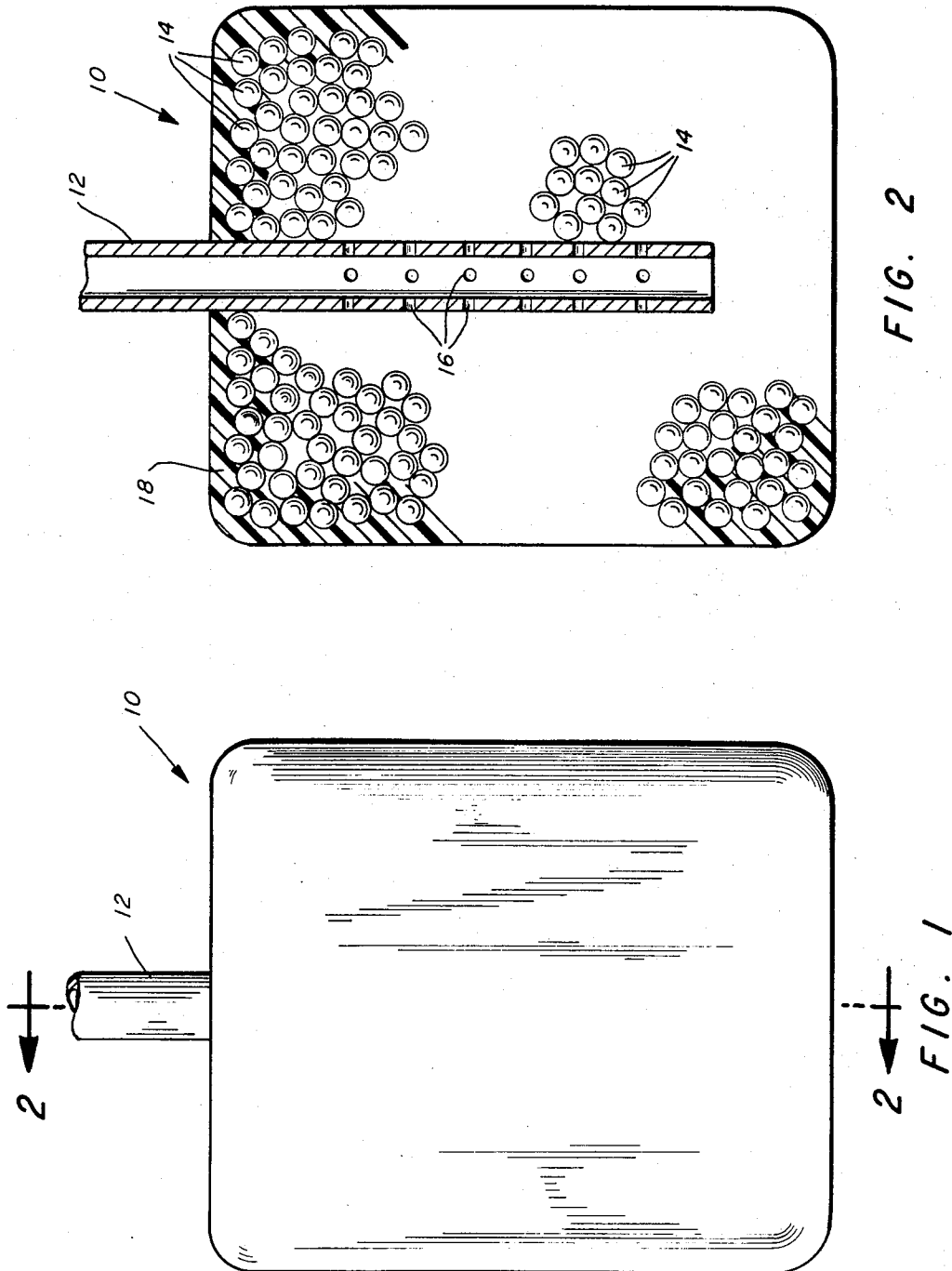
Attorney—Head & Johnson

[57] **ABSTRACT**

A method of manufacture of a high pressure gas storage vessel having a body of particles in the form of a porous solid mass, a conduit having one end within the porous solid body, the conduit extending from the body providing means of conducting gas to and from the body, and an impervious covering encapsulating the body.

5 Claims, 2 Drawing Figures





INVENTORS.
WILLIAM L. HUGHES
HANSEL J. ALLISON
RAMACHANDRA G. RAMAKUMAR
BY *Head & Johnson*
ATTORNEYS

HIGH PRESSURE STORAGE VESSEL

BACKGROUND AND OBJECTS OF THE INVENTION

High pressure gas is typically stored in metal containers, usually in the shape of cylinders or spheres. The stress in the wall of a vessel increases as a ratio of the volume. Thus a vessel designed to store a large volume of gas at high pressures must have thick walls. A major problem with storage of large volumes of gases at high pressures is the danger involved. When a large volume vessel ruptures not only is there danger from the physical effect of such rupture but, in addition, if the gas contained is toxic or explosive other serious hazards exist.

This invention provides a means for constructing a high pressure gas storage vessel which overcomes some of the problems with the existing type vessel. Particularly, this invention provides a high pressure gas storage vessel which has a safety factor much greater than existing type high pressure gas storage vessels.

It is therefore an object of this invention to provide an improved high pressure gas storage vessel and a method of constructing such vessel.

More particularly, an object of this invention is to provide a method of constructing a high pressure gas storage vessel formed of a body of particles fused into a porous solid mass in which the high pressure gas is stored in the pores.

These general objects as well as other objects of the invention will be fulfilled by the method of manufacturing a high pressure storage vessel and the high pressure storage apparatus set forth in the following description and claims, taken in conjunction with the attached drawings.

DESCRIPTION OF VIEWS

FIG. 1 is an external appearance of a high pressure gas storage vessel manufactured according to the method of this invention.

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1.

DETAILED DESCRIPTION

Referring to the drawings, a high pressure vessel manufactured according to the invention is shown. The vessel, appearing in external view of FIG. 1, includes a body 10 having a conduit 12 extending therefrom. Gas is conducted into and away from the vessel body 10 by conduit 12.

Referring to FIG. 2 the construction of the vessel is best shown. The vessel body is formed of particles 14 which are formed into a porous solid mass. The solid particles 14 are shown to be spherical although this configuration is not essential to the invention. The particles 14 may be shot, crystals, or the like formed of metal or plastic. Particles 14 are formed into a solid mass such as by sintering or crystalization into a porous structure. Received within the fused solid mass of particles 14 is one end of tubing 12. The tubing is preferably provided with apertures 16 to afford improved communication between the pores of the fused body and the interior of the conduit 12.

The third portion of the vessel is an impervious covering 18 which encapsulates and seals the body 10.

The covering 18 is a homogenous material, such as plastic or metal, which extends inwardly into the interstices between the particles 14 to a selected depth of penetration of the total exterior surface of the vessel.

METHOD OF MANUFACTURING

The high pressure gas storage vessel is manufactured by the following steps:

1. A mass of particles 14 is molded about one end of conduit or tubing 12 into the desired configuration and size of the vessel desired. Such molding may preferably be done in a crucible or other heat resistant container having an interior shape of the desired external configuration of the vessel.

2. The molded mass of particles is sintered at a temperature and under conditions such that the particles fuse at their contact points into a monolithic porous structure. Sintering temperatures, durations, and conditions depend primarily upon the material utilized. For instance, if the vessel is formed of lead powder or lead shots the sintering temperature and duration will be that just sufficient to bring the lead powder or shots to a temperature wherein the powder elements or shots fuse to each other without totally melting. If steel powder, pellets or shot is utilized, rather than lead, then obviously higher temperatures will be required. If plastic material is utilized, a lower temperature will be required. The sintering may take place in an inert environment if desired. To insure that the gas surrounding the individual particles is the desired inert gas the mold bearing the mass of particles may be subjected to evacuation prior to introduction of the desired inert gas so that all interstices are filled with the inert gas during the sintering process.

When the particles are crystalline the fusing step may include soaking the mass of particles at a temperature a few degrees below sintering temperature for a relatively long period so that the whole mass bonds into a single porous crystalline structure.

3. After the sintering process during which the molded mass of particles is fused into a homogenous porous structure, the covering 18 is applied. The covering may be of a variety of materials, an example being uncured epoxy. The epoxy preferably is forced to penetrate into the porous structure for a given depth of penetration surrounding the entire mass. This may be accomplished by subjecting the fused porous mass to a pressurized bath of such uncured epoxy wherein the uncured epoxy is forced into the porous structure for a given depth. Another means of forcing the covering material 18 to penetrate the exterior of the porous structure includes subjecting tubing 12 to a vacuum to pull the covering material into the porous structure. The combination of exterior pressure with vacuum applied to the tubing 12 may also be used. Liquid metal may be utilized in the same way to form covering 18.

4. The covering 18 is then permitted to solidify. Where the covering is uncured epoxy the final step is the curing of the epoxy to form a solid impervious covering.

The method of manufacturing the high pressure gas storage vessel and the vessel so manufactured described herein fulfills the objectives above set forth. It can be seen that many alternate embodiments of the invention may be employed. The shape of the vessel so

manufactured may vary considerably. If the high pressure gas is utilized in conjunction with a vehicle or other type of machinery the vessel may take the form of a part of the structure of such machinery or vehicle, thus serving a dual function.

While the invention has been described with a certain degree of particularity it is manifest that many other changes may be made without departing from the spirit and scope of this disclosure. It is understood that the invention is not limited to the specific embodiment or the specific steps which have been described for purposes of exemplifying the invention but the invention is to be limited only by the scope of the attached claim or claims, including the full range of equivalency to which each element or step thereof is entitled.

What is claimed is:

1. A high pressure gas storage vessel comprising:
a solid porous body of sintered particles;

a conduit having one end received within said porous solid body, the conduit extending from the body and providing means of conducting gas to and from said body; and

5 an impervious covering encapsulating and penetrating said porous body to a selected depth.

2. A high pressure gas storage vessel according to claim 14 in which said body is of sintered discrete particles.

- 10 3. A high pressure gas storage vessel according to claim 1 in which said body is of fused crystals, the body thereby being of porous crystalline structure.

- 15 4. A high pressure gas storage vessel according to claim 1 in which said impervious covering is epoxy.

5. A high pressure gas storage vessel according to claim 1 in which said impervious covering is metal.

* * * * *

20

25

30

35

40

45

50

55

60

65