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Rogers et al.

[11] **3,820,435**

[45] **June 28, 1974**

[54] **CONFINEMENT SYSTEM FOR HIGH EXPLOSIVE EVENTS**

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[73] Assignee: **The United States of America as represented by the United States Atomic Energy Commission**, Washington, D.C.

[22] Filed: **May 11, 1972**

[21] Appl. No.: **252,171**

[52] **U.S. Cl.** ..... **89/1 R**, 73/35

[51] **Int. Cl.** **G01n 33/22**

[58] **Field of Search** ..... 73/35; 89/1 R

[56] **References Cited**

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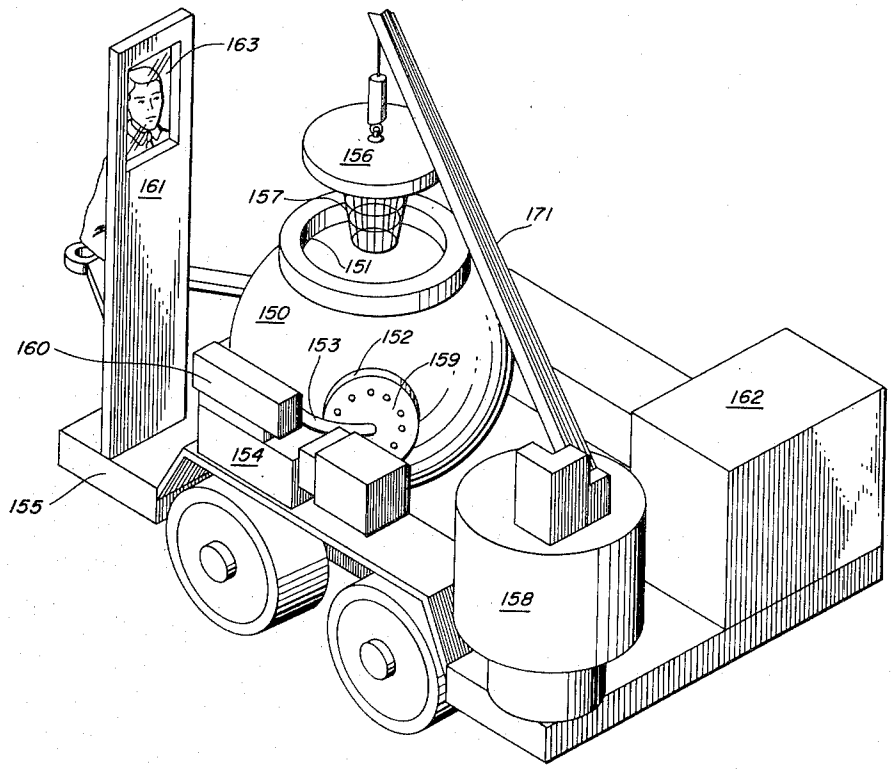
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Primary Examiner—Verlin R. Pendegrass
Attorney, Agent, or Firm—John A. Horan; Edward C. Walterscheid

[57] **ABSTRACT**

A system for completely containing the energy, detonation products, and any other products of an explosive event. In its simplest form, the system comprises a thin-walled confinement vessel, having at least one access port, a closure for the port or ports, a support structure within the vessel for holding the explosive out of direct contact with the vessel wall, and a vacuum system for evacuating the confinement vessel prior to detonation of the explosive. By drawing a 500 micron vacuum within the confinement vessel before detonation, the amount of explosive for which the energy and products can be completely contained is typically doubled over that which can be contained at atmospheric pressure. One embodiment, useful for high-explosive studies, readily allows flash radiography of an event as it occurs. Another embodiment is particularly useful for the containment and disposal of bombs or other infernal devices.

7 Claims, 9 Drawing Figures



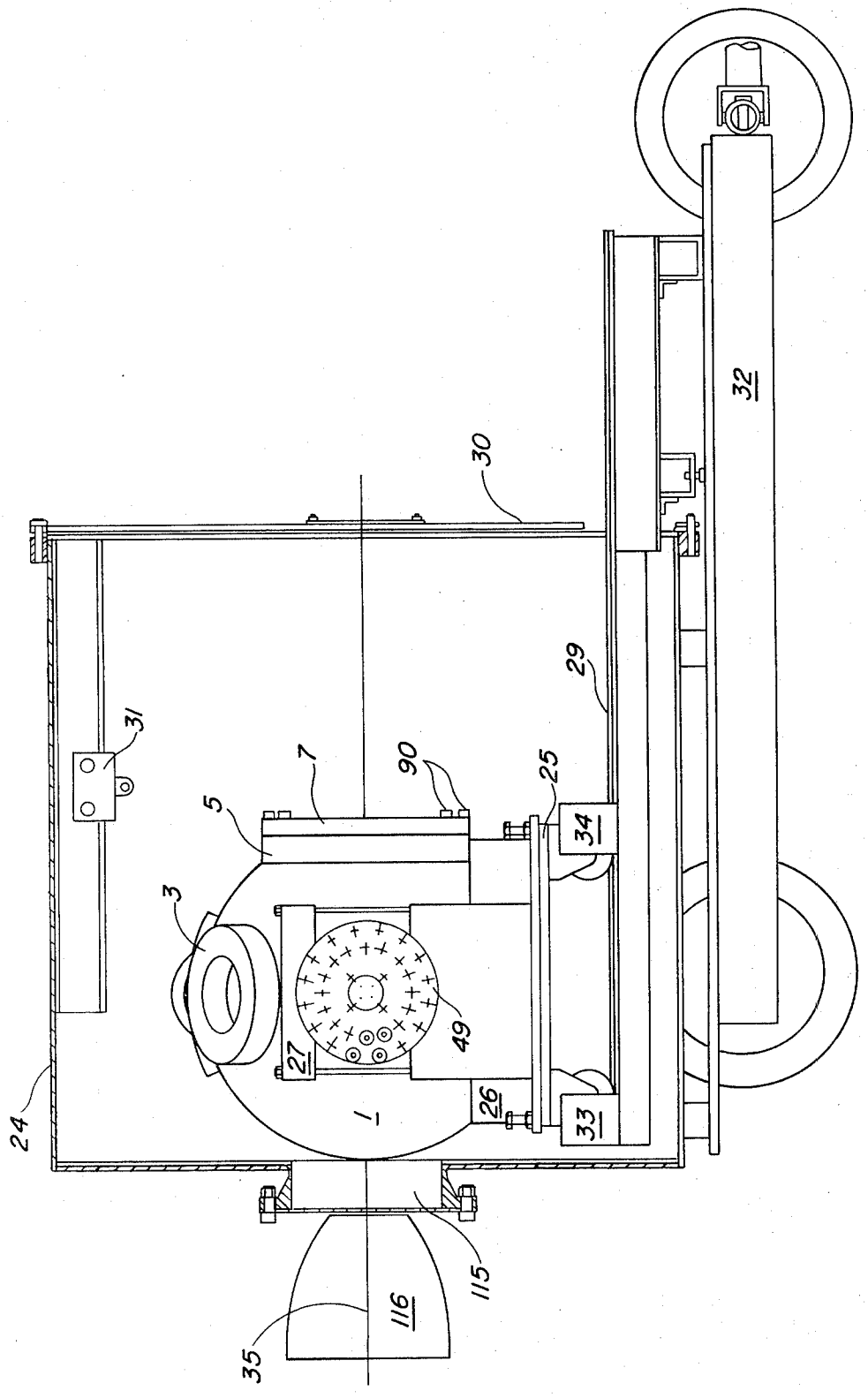


Fig. 1

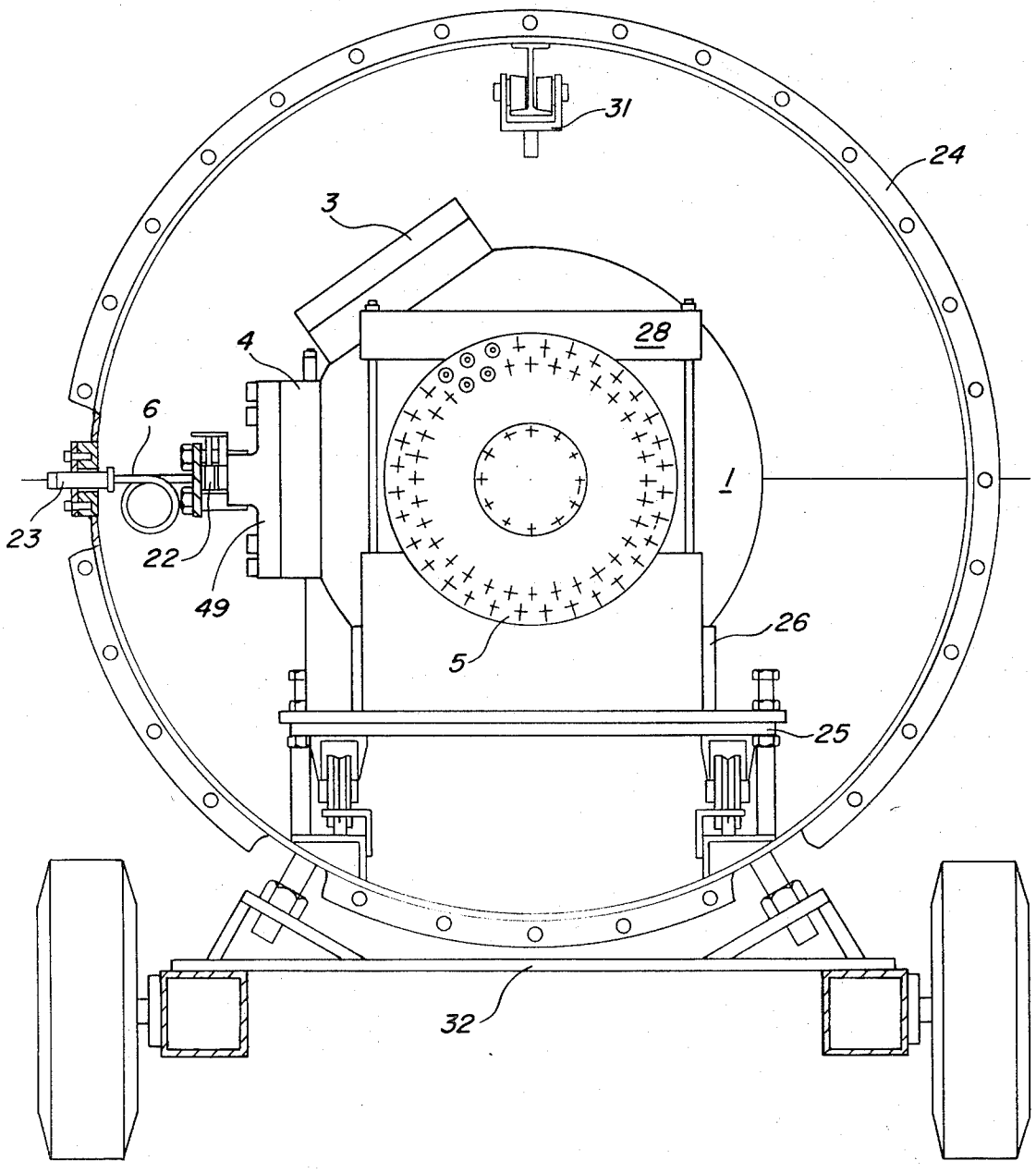


Fig. 2

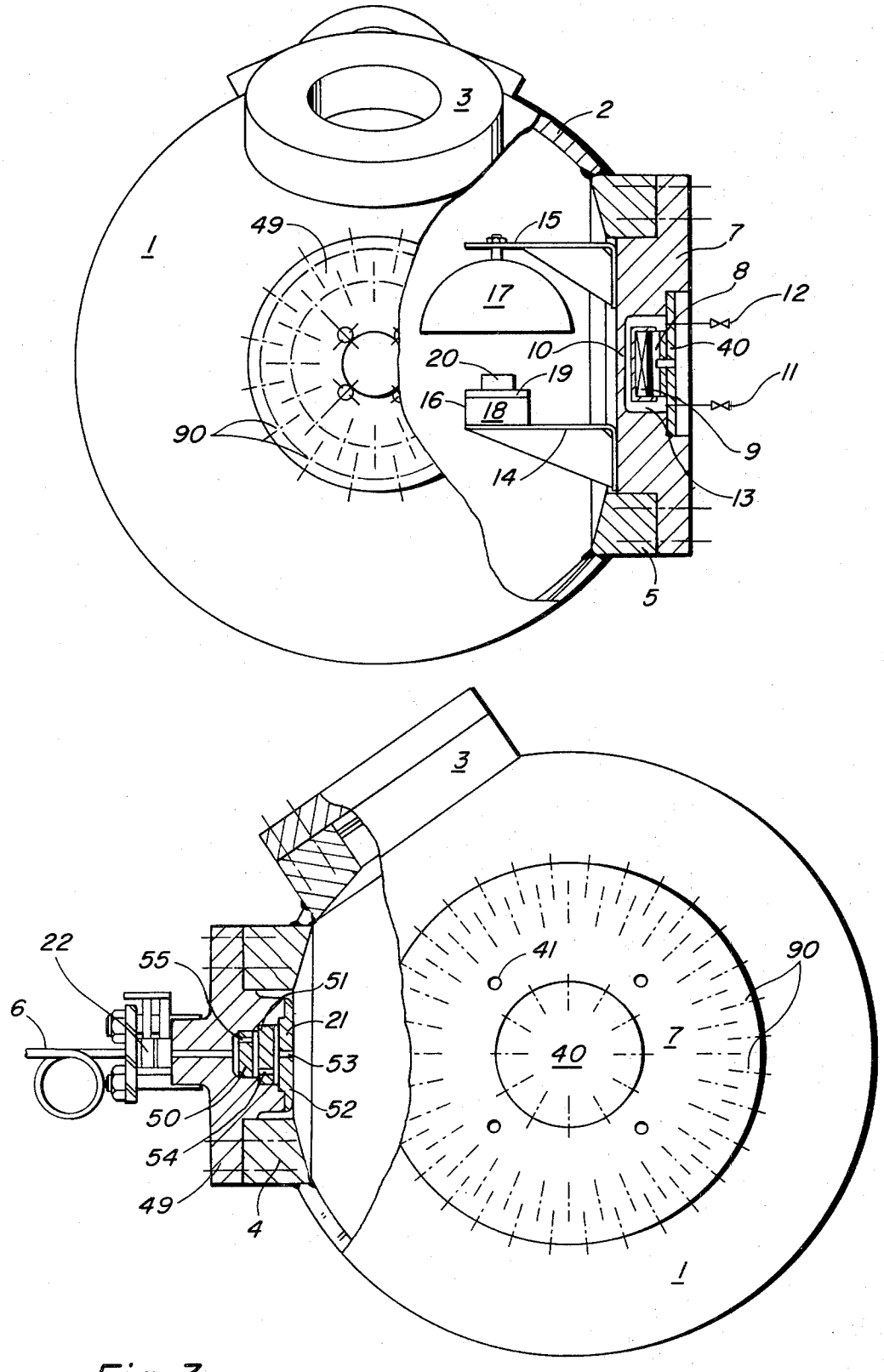

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Fig. 3

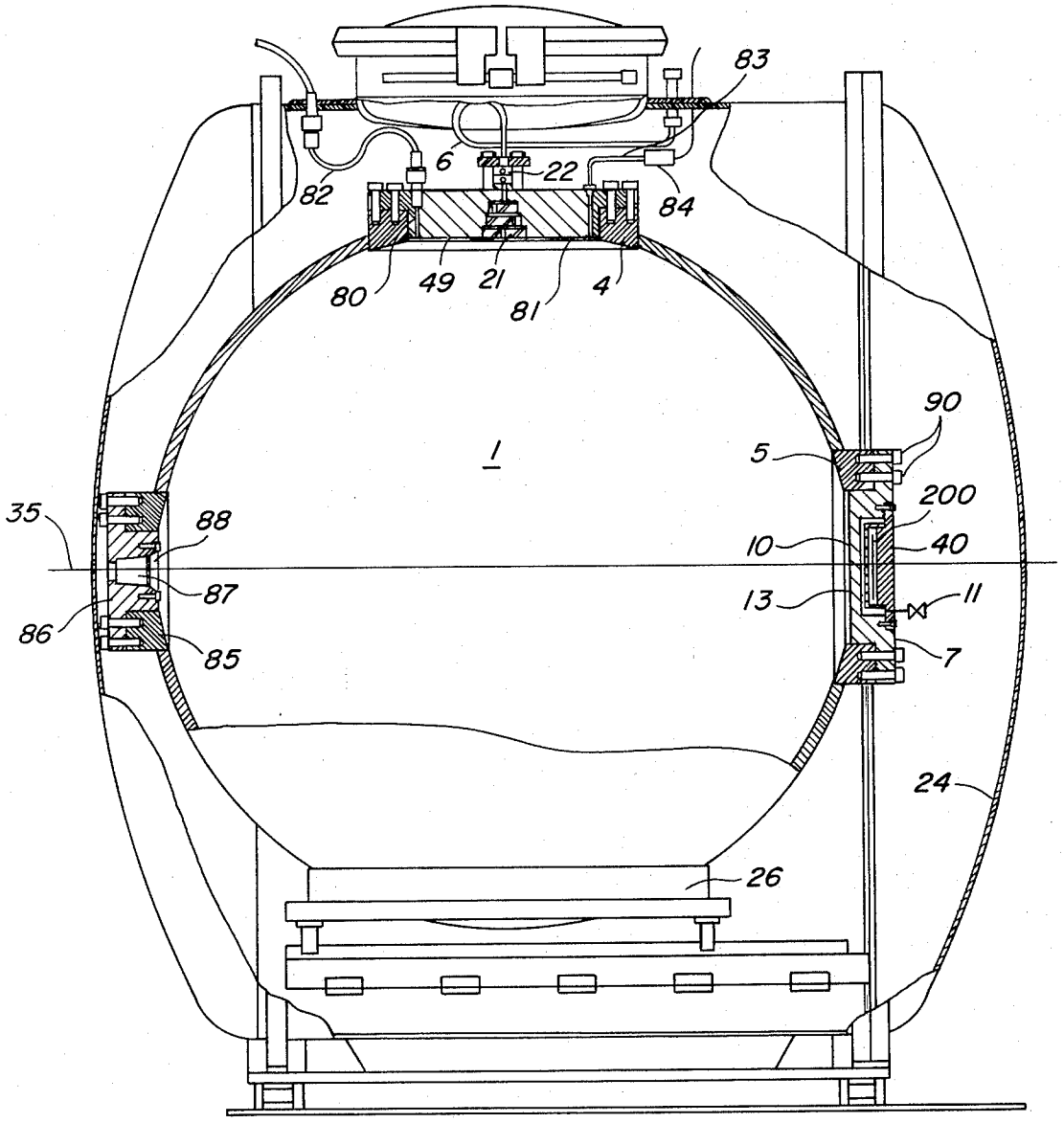


Fig. 4

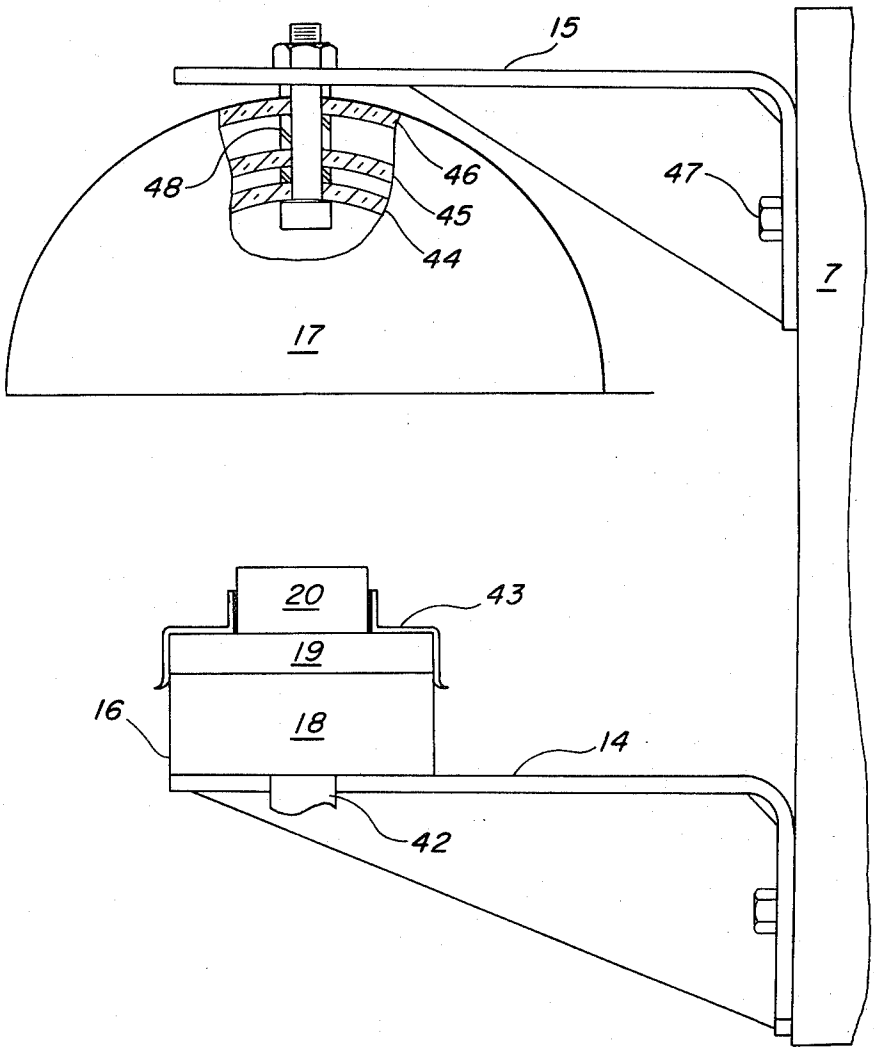


Fig. 5

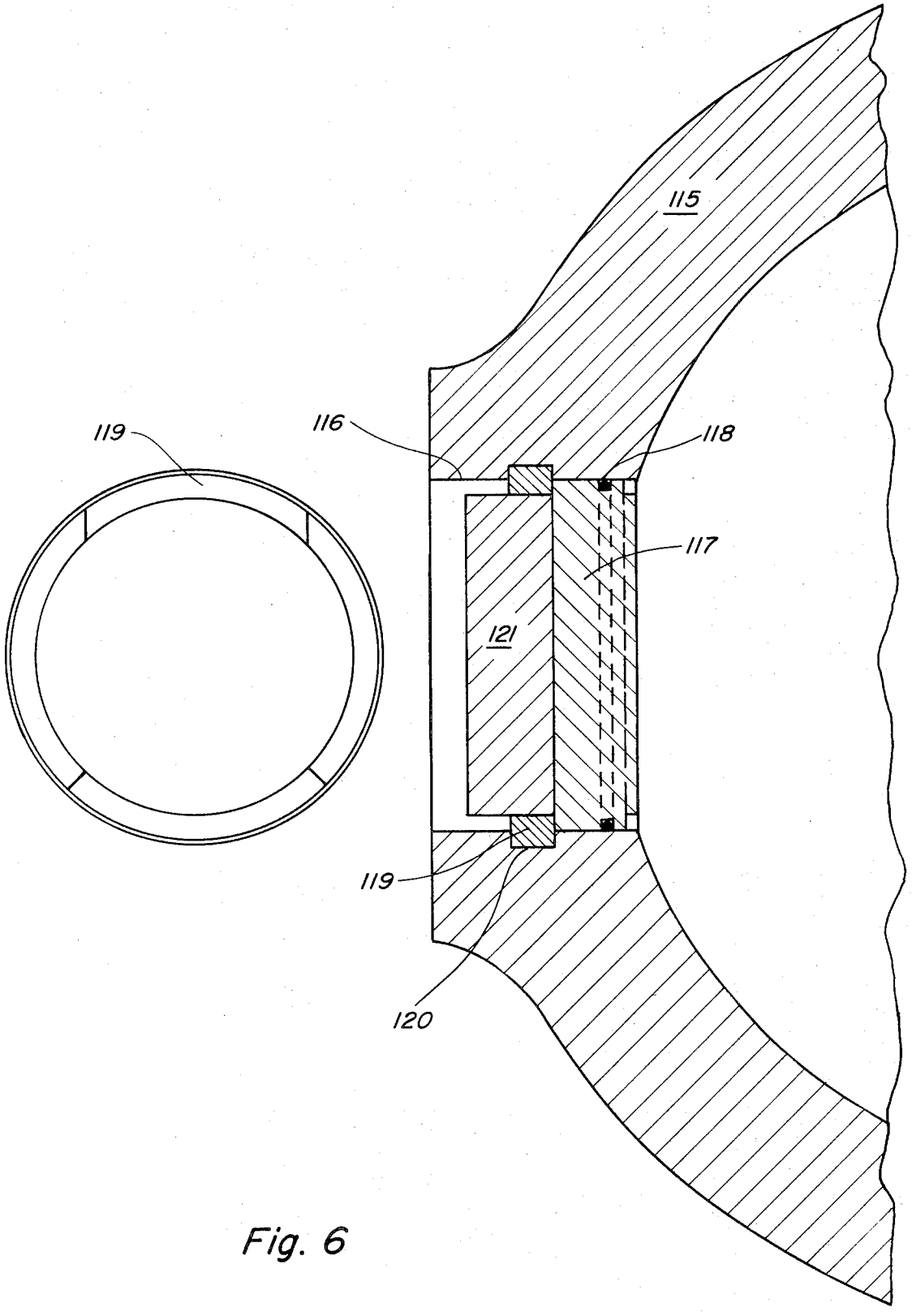


Fig. 6

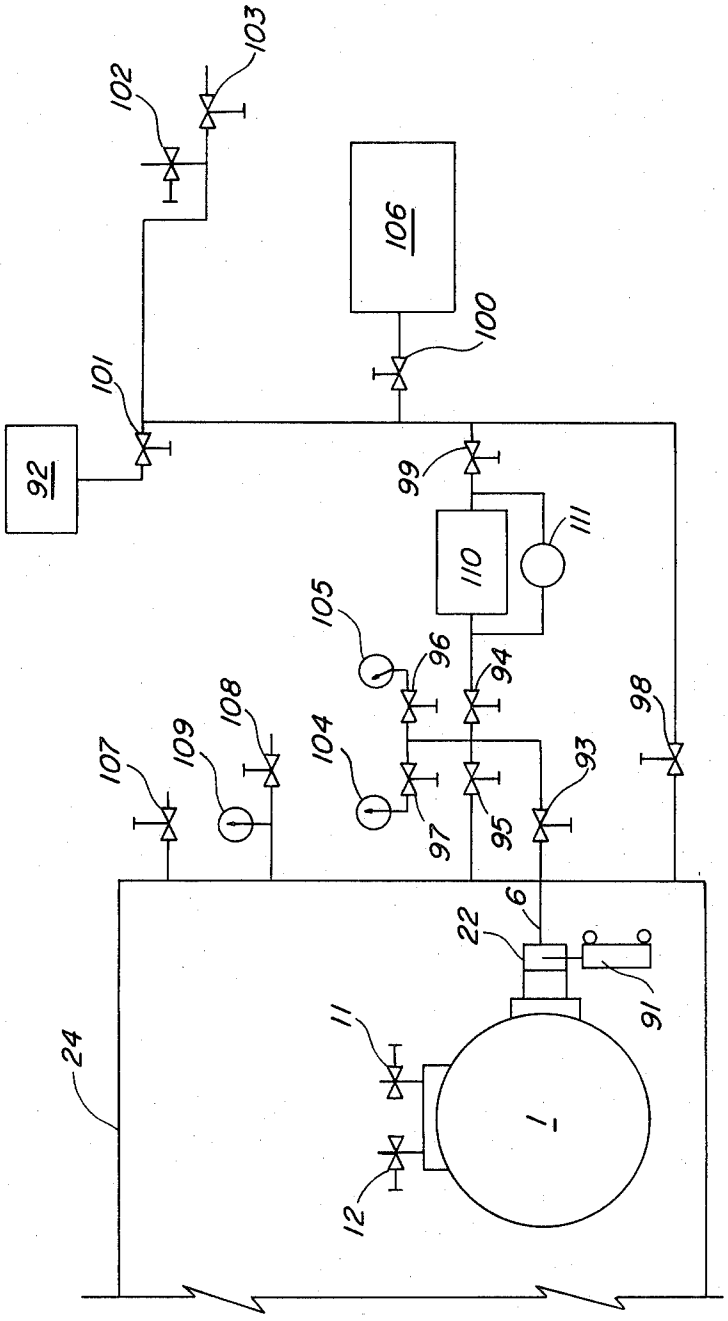

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Fig. 7

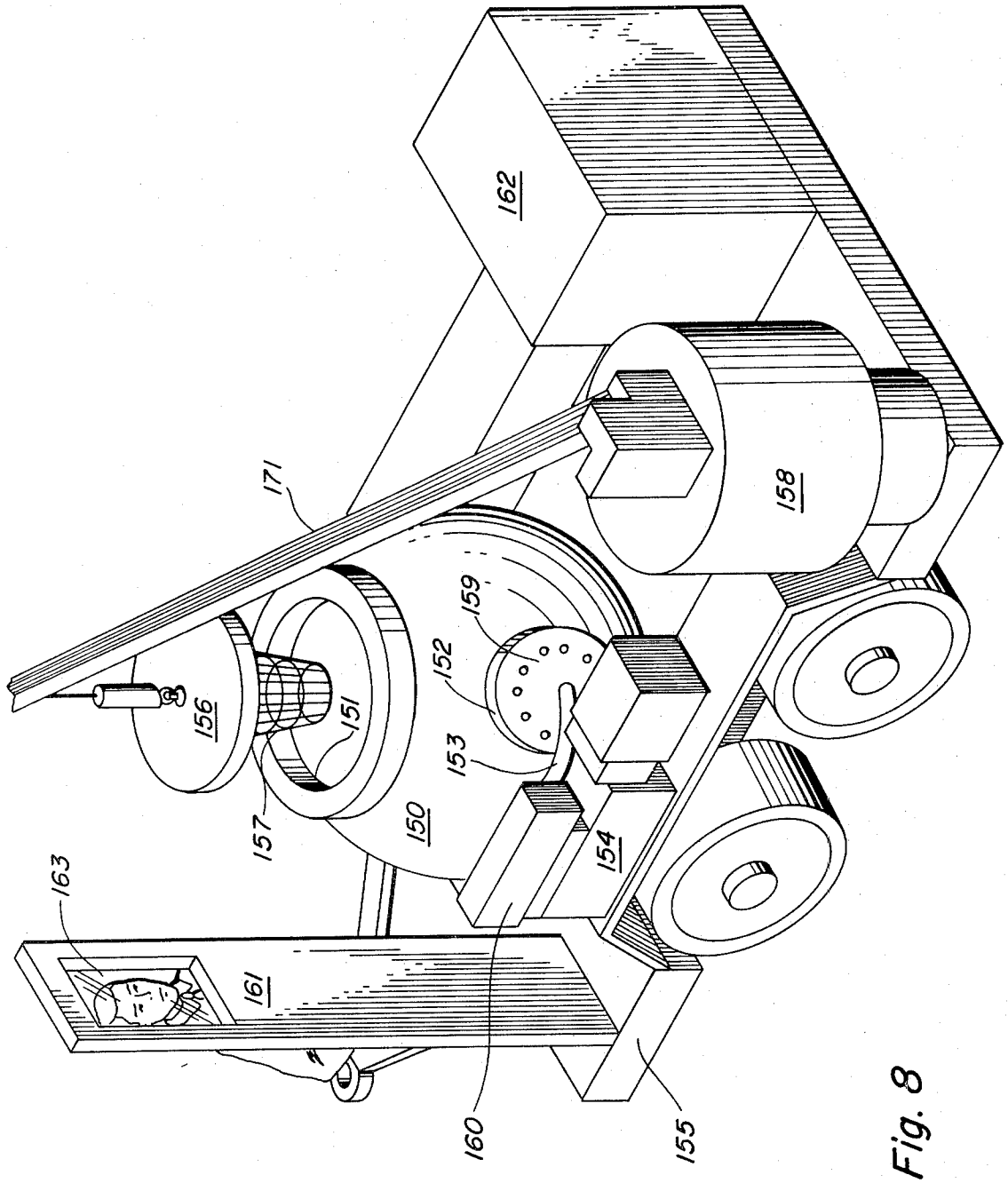


Fig. 8

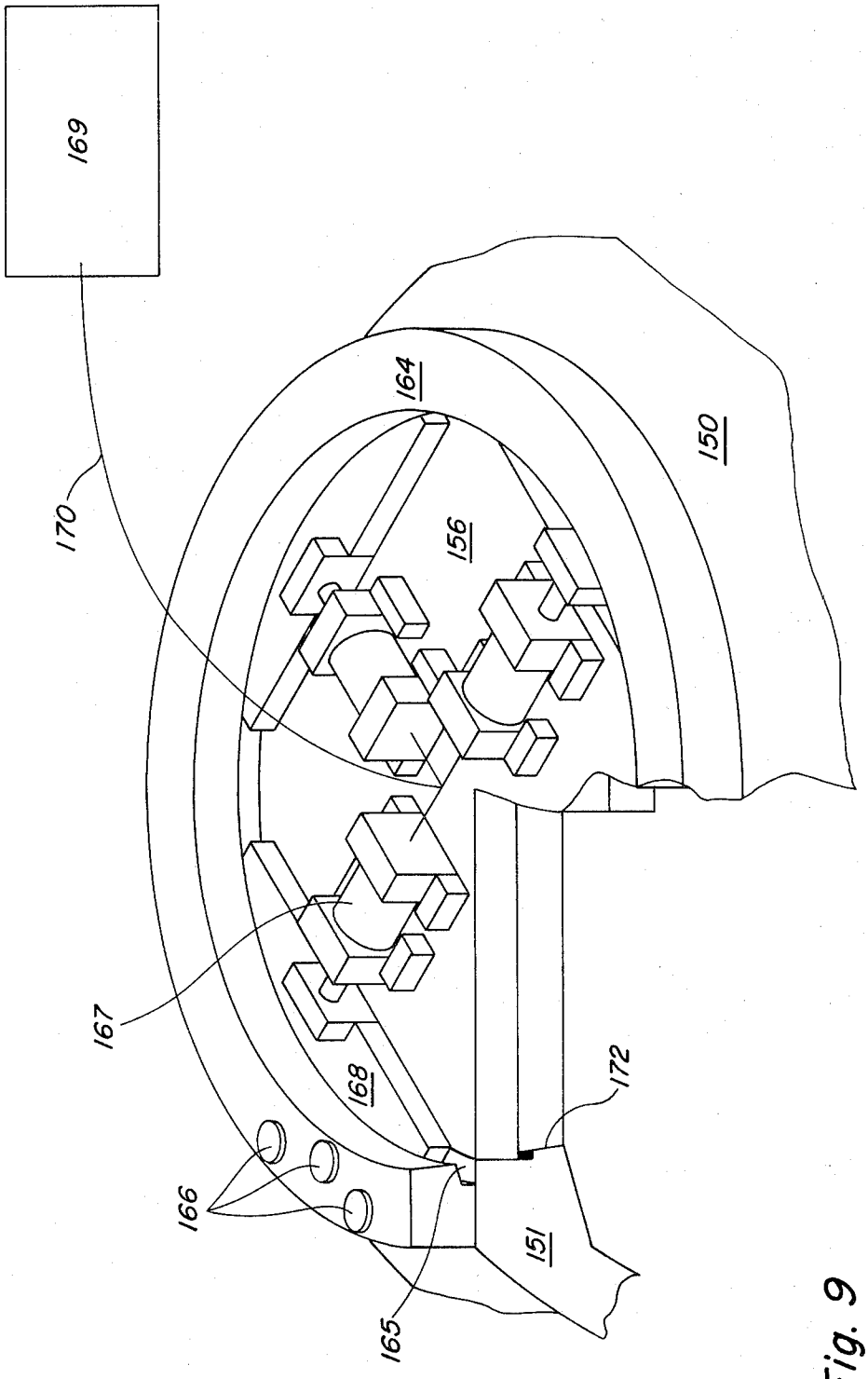


Fig. 9

CONFINEMENT SYSTEM FOR HIGH EXPLOSIVE EVENTS

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of, or under, a contract with the U.S. ATOMIC ENERGY COMMISION. It relates to a system for completely containing the energy, detonation products, and any other products of an explosive event, and more particularly to a system wherein, through evacuation of the confinement vessel, the amount of high explosive whose energy and products can be contained is typically doubled over that containable when the confinement vessel is at atmospheric pressure.

In the course of research directed at the high-pressure hydrodynamic properties of materials, it is necessary to resort to explosive driven systems to attain the required pressures. From time to time it may also be necessary to examine toxic, noxious, or radioactive materials to complete the study of a given class of materials. Increasingly, considerations of safety, environmental protection, and long-term economics preclude experimental procedures that would allow such materials to be dispersed into the air, onto the earth, or into water.

Aside from experimental consideration, there is also unfortunately an increasing requirement in our society for a means of totally confining the energy and detonation products of bombs and other infernal devices.

The art discloses no system for completely containing both the energy and the products of an explosive event within a reasonably small volume when the size of the explosive detonated exceeds perhaps 1 pound. Although the art reveals various bomb disposal systems for confining partially the energy and products of bombs, there is nothing to indicate the feasibility or even the possibility of confining completely within a reasonably small volume the energy and products of a bomb in the 10 to 25 lb range.

In U.S. Pat. No. 3,165,916, issued Jan. 19, 1965, Loving states that the strength of the wall required to withstand the pressure pulses generated by detonation of an explosive within a structure is a function of the volume of the chamber, the kind of explosive detonated, the weight of explosive detonated, and the yield strength of the material of which the chamber is constructed. According to Loving, the empirical expression

$$P = K\,W/V$$

defines the equivalent hydrostatic pressure generated by detonation of an explosive charge within the chamber. The constant K used in this expression depends not only on the strength of the explosive but also on the completeness of reaction of the explosive under the conditions which prevail in the chamber. Thus, although PETN has a higher available explosive energy per unit weight than does TNT, a higher value of K is used for TNT than for PETN because of the reaction with air of the initial detonation products.

According to U.S. Pat. No. 3,165,916, a 17.44 lb charge of amatol high explosive represents about the maximum charge that can be detonated in a vented 12 ft-diameter sphere having a ¾ inch-thick steel wall without exceeding the permissible strain.

In high-explosive studies involving the use of toxic or radioactive materials, it is often desirable to contain completely (that is, with no venting) the energy and products of the detonation of high-explosive charges in the 15 to 20 lb size range within a confinement vessel substantially smaller than 12 feet in diameter. Further, a bomb containment and disposal system where the energy and products of the detonation of bombs up to 25 pounds in size are completely contained within a reasonably sized confinement vessel would also have widespread utility.

SUMMARY OF THE INVENTION

We have now found that by evacuating the confinement vessel the amount of high explosive for which the energy and detonation products can be completely contained is substantially increased. When the vessel is evacuated to a pressure of about 500 microns, the energy and detonation products of typically twice the amount of explosive are containable than would be possible if the vessel were at atmospheric pressure. Using this discovery, we have developed a system for completely containing within a 6 ft-diameter confinement vessel the energy, detonation products, and any other products of the detonation of more than 30 pounds of high explosive.

One embodiment, useful for high explosive studies, readily allows flash radiography of an explosive event as it occurs. A spherical, thin-walled confinement vessel is provided which has a plurality of access ports. The plug for one access port is provided with a recess containing a film for recording radiographic data of an event. The plug for a second port contains feedthroughs for electrical cables and a vacuum line. A specimen holder supporting a high explosive charge and materials to be acted on by the detonation of that charge is so aligned within the confinement vessel that the detonation may be recorded by radiography on the film at a time of interest. A specimen catcher consisting of concentric metal hemispheres may be used to dissipate the kinetic energy of metals driven to very high velocities by the explosive event. The confinement vessel is enclosed within a safety vessel, and a vacuum system is provided for maintaining a substantial vacuum within the confinement vessel and a partial vacuum within the safety vessel at the time of firing. The whole system may readily be mounted on a trailer for ease of transportation to and from a firing point.

A second embodiment, useful for bomb containment and disposal, comprises a thin-walled confinement vessel having a first large access port for placing a bomb within the vessel and a second smaller port which provides feedthroughs into the vessel for electrical cables and a vacuum line. A support structure within the vessel holds the bomb away from direct contact with the vessel wall. The large access port has a quick closure device for rapidly sealing the vessel closed once the bomb is inserted. This quick closure device may consist of shear ring segments actuated by hydraulic rams. A vacuum pump is provided for rapidly drawing a substantial vacuum within the confinement vessel, and a high-pressure gas supply is provided for actuating the rams on the quick closure device. Because of the substantial weight of the closure device for the large access port, a crane is provided to move it. All components of the system are remotely operated by an operator lo-

cated behind shielding means. Again the whole system is readily transportable by trailer or truck.

In either embodiment, the presence of a substantial vacuum is used to reduce the shock loading on the confinement vessel. When the high explosive detonated within the confinement vessel is oxygen deficient, the vacuum serves the further purpose of reducing the blast effect because the initial detonation products cannot react with air. Since most bombs are likely to be made from commercially available explosives such as TNT and dynamite, which are oxygen deficient, the method and apparatus of this invention are particularly useful for the containment and disposal of large bombs or other infernal devices.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view partially in cross section and partially cutaway showing the confinement system with a 3 ft diameter confinement vessel as it is utilized for high-explosive studies.

FIG. **2** is a partially cutaway end view of the system of FIG. **1** with the door to the safety vessel removed.

FIG. **3** shows two partially cutaway views of a 3 ft diameter confinement vessel useful with this invention.

FIG. **4** is a partially cutaway end view showing the confinement system with a 6 ft diameter confinement vessel having a beryllium window.

FIG. **5** shows details of a specimen catcher, typical experimental assembly, and support structure as used within the 3 ft diameter confinement vessel of FIG. **1.**

FIG. **6** shows an alternative closure system for the ports of confinement vessels shown in FIGS. **1** through **4** which allows substantial momentum transfer and thus a higher impulse loading on the port closures.

FIG. **7** is a schematic representation of a vacuum and bleeddown system useful with this invention.

FIG. **8** is a perspective view of a confinement system useful for complete containment of the energy, detonation products, and any other products of a bomb or other infernal device.

FIG. **9** is a partial cross-sectional and schematic view of a quick closure device which may be used with the embodiment shown in FIG. **8.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

1. High Explosive Studies

An embodiment of this invention useful for high explosive studies is shown in FIGS. **1** through **4.** The system as it utilizes a 3 ft diameter confinement vessel is shown in FIGS. **1, 2,** and **3,** whereas FIG. **4** shows the system with a 6 ft diameter confinement vessel and a somewhat different configuration.

In FIGS. **1, 2,** and **3** confinement vessel **1** is a spherical steel shell **2** of nominally **1**-inch-thick mild steel (ASTM A516-70*a*, Grade 70 normalized). While the scope of this invention is not limited to spherical or substantially spherical confinement vessels, it will be readily apparent that spherical or substantially spherical configurations are highly desirable in that they have the greatest strength. Vessel **1** has three access ports, **3, 4, 5.** Port **3** is provided for convenience sake for entry into the vessel to clean it or to recover valuable metal that may have been used in an experiment. Port **4** provides access to vessel **1** for vacuum line **6.** Port **5** is the main entry port for placing an experiment within confinement vessel **1.** Plug **7** to port **5** has mounted within it a blast resistant film holder **8** for film packet **9.** Plug **7** thus serves as a radiation window **10** that provides a minimum of structural material between the event and film packet **9.** When toxic or radioactive materials are present in vessel **1** it is necessary to known whether window **10** has been ruptured by the event. Therefore film cavity test ports **11** and **12** are provided through closure **40** to monitor film enclosure area **13** before it is opened. Circumferentially arranged around closure **40** in plug **7** are a plurality of electrical feedthroughs **41** which provide access to vessel **1** for firing cables, diagnostic cables, transducer cables, etc. The number of feedthroughs **41** will vary, depending on the type of diagnostics required from a particular event.

Support structures **14** and **15** for respectively experimental assembly **16** and specimen catcher **17** are mounted on plug **7.** Mounting to plug **7** is readily accomplished by means of bolts **47** (see FIG. **5**). Details of specimen catcher **17** and assembly **16** are given in FIG. **5.** Assembly **16** consists of detonator **42,** plane wave generator **18,** explosive **19,** metal specimen **20** to be driven by the explosive event, and alignment structure **43** to hold specimen **20** at the desired location with regard to explosive **19.** It is essential that any explosive detonated in vessel **1** not be in direct contact with the wall of vessel **1** so as to avoid direct shock coupling with the wall. Specimen catcher **17** is provided so that sufficient momentum transfer occurs between it and specimen **20** to prevent penetration of vessel **1** by metal fragments. As shown in FIG. **5,** catcher **17** consists of a plurality of concentric metal hemispheres **44, 45, 46** separated from one another by spacers **48.** Hemispheres **44, 45, 46** which are typically made from copper form an umbrella configuration to contain any splash or jet that might result from the breakup of specimen **20** as a result of the explosive event. The use of a momentum transfer device such as specimen catcher **17** is not critical to this invention; however, it is desirable when metal is accelerated directionally at any velocity, although velocities in excess of 6,000 ft/sec are quite common in explosive hydrodynamic studies. Metal fragments impinging on the wall of vessel **1** at velocities this high may do substantial damage to the wall of the vessel or—if sufficiently energetic—possibly even penetrate it. On detonation of explosive **19,** metal specimen **20** is driven upward into hemisphere **44,** and energy is dissipated in heating the hemisphere and in some cases in a change of state of one or both materials. The impingement of specimen **20** on hemisphere **44** imparts a considerable velocity to hemisphere **44;** however, substantial energy is lost in the form of heat and the combined mass is perhaps double that of specimen **20** so that the velocity of the combined mass of hemisphere **44** and specimen **20** is reduced by more than a factor of two. This process continues as the combined mass strikes hemispheres **45** and **46** in turn. Energy is dissipated as heat at each new collision, and the velocity of the combined mass decreases as each new hemisphere is contacted. Because the outer hemispheres are larger in size, there is also a reduction in specific momentum as a function of area.

Attached to port **4** is a plug **49** containing a shock attenuator **21** which protects two remotely operated ball valves **22** connected in series. Attenuator **21** consists of three spaced plates **50, 51, 52** having nonaligned paths **53, 54, 55** through them which provide a circuitous

path from the interior of vessel 1 to valves 22. This circuitous path serves to prevent direct shock coupling to valves 22 from the explosive event within vessel 1. Vacuum line 6 loops from valves 22 to a penetration 23 in safety vessel 24 (see FIG. 2). Line 6 then enters the vacuum system shown schematically in FIG. 7.

Vessel 1 is securely positioned on dolly 25 by means of support structure 26 and clamps 27, 28. Dolly 25 is movable on track 29 located within cylindrical safety vessel 24. Access to safety vessel 24 is by means of door 30. Safety vessel 24 can be partially evacuated by means of the vacuum system shown schematically in FIG. 7. When partially evacuated, safety vessel 24 serves to prevent the release to atmosphere of toxic or radioactive materials should vessel 1 vent as a result of the explosive event. Safety vessel 24 is intended only to prevent atmospheric contamination if vessel 1 is breached. It is not intended to contain vessel 1 if it is blown apart by the explosive event. Trolley 31 is located within safety vessel 24 as a means of providing support to plug 7 as it is inserted or withdrawn from port 5. Safety vessel 24 is mounted on trailer 32 for ease of transportation.

FIG. 4 shows a cross-sectional view of the system as adapted to the use of a spherical 6 ft diameter confinement vessel. The configuration shown in FIG. 4 is substantially similar to that shown in FIGS. 1 through 3, with the following exceptions. Plug 49 has feedthroughs 80, 81 for electrical cable 82 and transducer tubing 83 for transducer 84. Feedthroughs 80, 81 serve essentially the same purpose in plug 49 as do feedthroughs 41 in plug 7. In addition, vessel 1 of FIG. 4 is fitted with an additional port 85 whose plug 86 contains a beryllium window 87 held in place by closure 88. Because of its low Z number beryllium attenuates an xray beam substantially less than does mild steel. Port 85 is aligned with port 5 on a common axis such that an x-ray beam 35 entering through window 87 passes through the explosive event of interest and then impinges on a film packet 200 (see FIG. 4) in film enclosure area 13. An experimental assembly may readily be aligned within vessel 1 so that x-ray beam 35 passes through the explosive event at a desired point. This alignment can easily be accomplished by suspending the assembly by means of a support structure from plug 49. The beryllium window assembly shown in FIG. 4 is not limited to use with 6 ft diameter confinement vessels but may as readily be used with the 3 ft diameter confinement vessel shown in FIGS. 1 through 3.

In FIGS. 1 through 4 all plugs are secured in their ports by means of socket head cap screws 90. In the preferred embodiment, cap screws 90 are made of high-tensile steel (grade 5 or better) having eight threads to the inch and conforming to A.S.A. specification B18.3-1961. Although each port is shown with a double row of these screws, the number of screws 90 shown in FIGS. 1 through 4 is not critical to this invention. It will be understood that substantially fewer screws might be used, depending on the size of the explosive to be detonated in the confinement vessel. For ease of drawing, only the centerlines of many of the screws 90 are shown in FIGS. 1 through 4.

Although cap screws 90 are suitable for securing plugs within their ports in most applications, FIG. 6 shows an alternative fastening means used to secure a closure of a vessel or other containment device when said closure is subjected to a high level impulsive loading. The fastening means comprises a plug to produce the closure, a shear ring to hold the plug in place, and a slug adjacent to the shear ring and in intimate contact with the plug. When the plug and shear ring are subjected to a high impulsive loading, momentum transfer occurs between the plug and the slug, the slug flies off, and the strain on the shear ring is substantially reduced.

FIG. 6 shows the closure device incorporated into a port 116 of a vessel 115 similar to confinement vessel 1 of FIGS. 1 through 4 used to contain the detonation of high explosive charges. Actual closure is accomplished by means of plug 117 having an O-ring seal 118. Plug 117 may be constructed with a slight taper to make it easier to insert into the port 116 to be closed and also to limit the insertion depth. Other means of accomplishing such objectives will be obvious, however, to one skilled in the mechanical arts. Plug 117 is secured against the force of explosive or other impulse loading by segmental shear ring 119. Shear ring 119 is assembled into groove 120 into port 116 such that to break free plug 117 must first shear ring 119. In the embodiment shown in FIG. 6, a shear ring is specified but it is intended that any shearing means may be used to restrain plug 117 including but not limited to cam-like segments that swing into a shear-ring-like configuration, plates that slide into the port groove, sprag-like struts that rotate into a shearing configuration, and similar means that may be manually or power activated.

In the embodiment of FIG. 6 shear ring 119 is held in place by a loosely fitting slug 121 held in intimate contact with plug 117. This contact may be obtained by gravity if port 116 is vertical or by other light restraint means obvious to those conversant with the mechanical arts for other orientations. In an alternate embodiment the shear ring means may be restrained by a ring machined from rigid polystyrene foam that also supports a slug of reduced diameter.

When an explosive charge is detonated in vessel 115 the mass of the explosive is converted into a mass of gas that expands with a characteristic velocity. A portion of this mass of gas impinges on plug 117. A momentum exchange takes place and plug 117 acquires a kinetic energy. If slug 121 is not introduced into the assembly the kinetic energy of plug 117 is transferred to port 116 through shear ring 119. The kinetic energy of plug 117 appears for a time as strain energy in shear ring 119. Shear ring 119 may be able to absorb this energy in the elastic mode; however, under the abuse of blast loading it may go plastic and deform to such an extent that the closure may be broken or the closure means rendered unsuitable for future use. With slug 121 in place there is an additional momentum exchange between it and plug 117. Slug 121 flies off and carries a portion of the incident energy with it; impulse is thus "trapped" and does not appear as strain energy in shear ring 119. Experimental studies demonstrate that 34 to 41 percent of the incident impulse may be trapped with a fairly primitive embodiment such as that shown in FIG. 6.

FIG. 7 is a schematic representation of the system used to produce the required vacuum in confinement vessel 1 and safety vessel 24 and also to bleed pressure from confinement vessel 1 (and safety vessel 24, if required) after an explosive event has occurred. The system may be used with either 3 or 6 ft diameter confinement vessels. Vacuum pump 92 is used to evacuate both confinement vessel 1 and safety vessel 24. To

evacuate confinement vessel **1**, ball valves **22** are opened through actuator **91** controlled by means of an electrical solenoid external to safety vessel **24**. Valves **93, 94, 99,** and **101** are opened while valves **95, 96, 97, 98, 100, 102,** and **103** are closed. Pump **92** is then used to evacuate confinement vessel **1** to a desired pressure. Leakage in vessel **1** may be periodically determined by opening valve **100** to leak detector **106**. In the preferred embodiment leak detector **106** is a mass spectrometer. When the desired pressure is reached in vessel **1**, actuator **91** is used to close valves **22**, valve **99** is closed, and valve **98** opened to commence evacuation of safety vessel **24**. When the desired pressure is reached in vessel **24**, valve **98** is closed and pump **92** is shut off to await firing of the explosive event in vessel **1**.

Valves **107** and **108** and low pressure gauge **109** are provided to monitor the atmosphere within safety vessel **24** after an explosive event. Low pressure gauge **104** and high pressure gauge **105** are provided to monitor the bleeddown of confinement vessel **1** (and safety vessel **24**, if required). Bleeddown of vessel **1** is accomplished by closing valve **101** and opening valves **93, 94, 99,** and **103** and valves **22**. Gases from vessel **1** pass through filter **110** where toxic or radioactive components are removed. The flow of gas through filter **110** is monitored by flow indicator **11**. Prior to commencement of bleeddown through valve **103**, which is to atmosphere, a sample of the gas coming through filter **110** may be monitored through sampling valve **102**. If monitoring of safety vessel **24** shows that confinement vessel **1** has vented into it, bleeddown and flushing of vessel **24** is accomplished by closing valve **93** and opening valve **95**. To flush safety vessel **24**, additional positive pressure may be added through valve **107**.

Typically, this confinement system is operated as follows. Trailer **32** is positioned such that region **115** of safety vessel **24** abuts truncated metal cone **116** which serves as a blast shield for a source of intense x-rays and is not a part of this invention. Vessel **1** is positioned inside safety vessel **24** such that x-ray beam **35** will pass through the region of the explosive event to be studied. The required experimental arrangement is made within vessel **1**, all ports are sealed, film packet **9** is inserted in plug **7**, and vessel **1** is then evacuated through line **6** to a pressure of about **500** microns. Safety vessel **24** is then evacuated to a soft vacuum, i.e., about **12** inches mercury gauge. Evacuation of vessel **1** is a critical feature in that the substantial absence of air avoids the formation of strong shocks by the explosive event. The absence of such shocks makes it possible to typically contain the detonation of twice as much explosive as is possible with the same vessel at atmospheric pressure. Safety vessel **24** is partially evacuated so that in the event of accidental venting of vessel **1** toxic or radioactive materials will not be released to the atmosphere. When the system has been suitably aligned and evacuated, a timing sequence is started wherein the explosive event is detonated and a pulse of intense x-rays transmitted through the region of interest at the appropriate time. In some cases the x-ray beam **35** is directed through the wall of vessel **1** is as shown in FIG. **1**. In many instances, however, a beryllium window is used to admit the beam. Such a window **87** is shown in FIG. **4** for use with a **6** ft diameter confinement vessel.

The bursting charge of confinement vessels evacuated in the foregoing manner has been determined by detonating successive charges of Composition B-3 in single **3** ft and **6** ft-diameter vessels. Proceeding in this manner punishes the vessel unduly, but the estimated bursting load thus determined for a given geometry is probably conservative. A shot summary is presented below showing the history to failure of two vessels tested to destruction.

Three-Foot Geometry Load (lb)	Six-Foot Geometry Load (lb)
2	5
3	5
5	5
3	10
6	15
7	20
8	26
10	32
12*	36*

*Failure

2. Bomb Containment

An embodiment of this invention useful for complete containment of the energy, detonation products, and any other products of a bomb or other infernal device is shown in FIG. **8**. FIG. **9** is a partial cross-sectional and schematic view of a quick closure device which may be used with the embodiment shown in FIG. **8**. In FIGS. **8** and **9**, confinement vessel **150** is a 6 ft diameter spherical steel shell of nominally **1** inch thick mild steel (ASTM A516-70*a*, Grade 70 normalized). While vessel **150** need not be spherical or substantially spherical, it will again be understood that spherical or substantially spherical confinement vessels are desired in that they have the greatest strength. Vessel **150** has access ports **151, 152**. Large port **151** is the main entry port for placing a bomb or other infernal device in vessel **150**. Port **151** is of sufficient size that a bomb 2 ft by 2 ft by 2 ft may readily be inserted in vessel **150**. Smaller port **152** provides access to vessel **150** for vacuum line **153** from vacuum pump **154**. Vessel **150** is mounted vertically on trailer **155** so that in the event a bomb should detonate before closure **156** can be sealed in port **151**, the force of the blast will be directed upward. Typically, the bomb or other infernal device is placed in a netting **157** suspended within vessel **150** such that the bomb does not come into contact with the wall of vessel **150**. Netting **157** may be attached to a supporting structure located within vessel **150** proper, or it may preferably be attached directly to closure **156**. Crane **158** is provided for inserting and removing closure **156** in port **151**. Plug **159** to port **152** is provided with a shock attenuator and valves similar to shock attenuator **21** and valves **22** shown in FIG. **3**. The shock attenuator serves to protect against a direct shock to the valves and other components of vacuum system **160** in the event that a bomb is detonated in vessel **150**. Plug **159** may also be fitted with electrical feed-throughs. Such feedthroughs may be used for an electrical firing circuit to a small shaped charge located within vessel **150** and so directed as to dismantle or otherwise disrupt a bomb or other infernal device when the shaped charge is detonated. Trailer **155** is provided with a power supply **162** for operating the various mechanical and electrical systems associated with crane **158**, vacuum system **160**, etc. Trailer **155** may further be provided with shielding means **161** behind which an operator controlling the

various equipment on trailer **155** may stand. Alternatively, shielding means **161** may be located on a truck or other vehicle used to transport trailer **155.** Although shielding means **161** is shown with a blast window **163** allowing an operator direct visual observation of vessel **150** and crane **158,** shielding means **161** may as well be fitted with periscope means for indirect observation. Shielding means **161** is fitted with control means for operating the equipment mounted on trailer **155.**

It will be readily understood that a primary interest of a bomb disposal squad will be the transfer of the bomb to within vessel **150** and the sealing of closure **156** as rapidly and as safely as possible. With this end in mind, it is highly desirable that closure **156** to port **151** be fitted with quick closing means. One type of quick closing means amenable for use with this embodiment of the invention is shown in FIG. **9.** Port **151** has attached a circular flange **164** having recess **165** located along the bottom portion of its inner edge. Flange **164** may be attached to port **151** by means of bolts or screws **166** similar to the socket head cap screws **90** shown in FIGS. **1** through **4.** Mounted on the outer face of closure **156** are a plurality of hydraulic rams **167** by which a plurality of wedges **168** may be rapidly driven into recess **165** thus sealing closure **156** into port **151.** Rams **167** are operated by means of gas pressure supplied from source **169** through flexible line **170.** Source **170** may readily be a high-pressure gas bottle stored on trailer **155.**

A suggested operational sequence for bomb disposal is as follows. Boom **171** of crane **158** is rotated to the side of trailer **155** and lowered to a heighth wherein net **157** is readily accessible for receiving a bomb from a bomb disposal officer standing alongside trailer **155.** Because it is imperative from a safety standpoint that bombs and other infernal devices be jarred as little as possible, a set of safety interlocks is incorporated into crane **158** wherein boom **171** must be elevated at a sufficient angle to ensure an adequate clearance between the bottom of loaded net **157** and the top of port **151** before boom **171** can be rotated over vessel **151.** The safety interlock system operates to halt the rotation of boom **171** when closure **156** is centered over port **151.** As shown in FIG. **9,** the bottom portion of closure **156** and the inner lower portion of port **151** are tapered **172,** so that should a slight mismatch between closure **156** and port **151** exist, there will be an automatic tendency for them to line up as closure **156** is lowered into port **151.** During the time that closure **156** is being lowered into port **151,** thus inserting the bomb or other infernal device into vessel **150,** it is preferred that vacuum system **160** be operating. It is critical to this invention that a substantial vacuum be drawn in vessel **150** once port **151** is sealed with closure **156.** When closure **156** is fully inserted into port **151,** a quick closure means such as that illustrated in FIG. **9** is used to seal port **151** closed. Trailer **155** may then be transported to an appropriate bomb disposal area for disposition of the bomb contained within vessel **150.**

It will be apparent that numerous components of the several embodiments of this invention disclosed herein are interchangeable. It will be further apparent that the confinement vessel utilized with this invention need not be made of mild steel nor have a wall thickness of 1 inch. Those knowledgeable in the art will be aware of other wall materials and thicknesses that may be used with this invention. Finally, it will be apparent that the manner in which a shaped charge may be used to disrupt or dismantle a bomb or other infernal device can clearly be inferred from the disclosure herein made and the illustration of FIGS. **3** and **5.**

What we claim is:

1. An apparatus for completely containing the energy, detonation products, and any other products of an explosive event which comprises a confinement vessel, access means to the interior of said vessel, closure means for said access means, support means within said vessel for holding an explosive to be detonated, said explosive having no direct contact with the walls of said vessel, and means for producing a substantial vacuum within said vessel.

2. The apparatus of claim **1** wherein said confinement vessel is spherical and said access means is a plurality of access ports.

3. The apparatus of claim **1** wherein said support means for said explosive is mounted to said closure means.

4. The apparatus of claim **1** wherein said vessel contains means for rapidly reducing the kinetic energy of metal driven to high velocity by said explosive event.

5. The apparatus of claim **4** wherein said means for rapidly reducing the kinetic energy of said metal comprises in combination in spaced relationship a plurality of concentric metal hemispheres, said hemispheres being so oriented in relation to said metal that when said metal is driven to high velocity it impinges upon the innermost of said hemispheres.

6. The apparatus of claim **1** wherein said closure means is a quick closure device.

7. The apparatus of claim **1** having a safety vessel surrounding and encompassing said confinement vessel and means for producing a soft vacuum within said safety vessel.

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