June 29, 1965 W. B. HOPSON III 3,191,533

GAS DISCHARGE APPARATUS

Filed Jan. 23, 1963

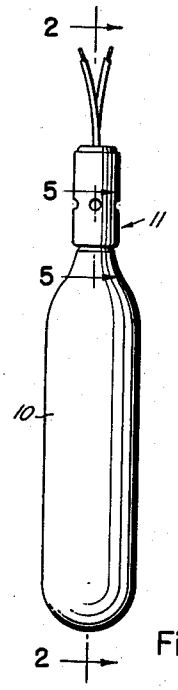


Fig. 1

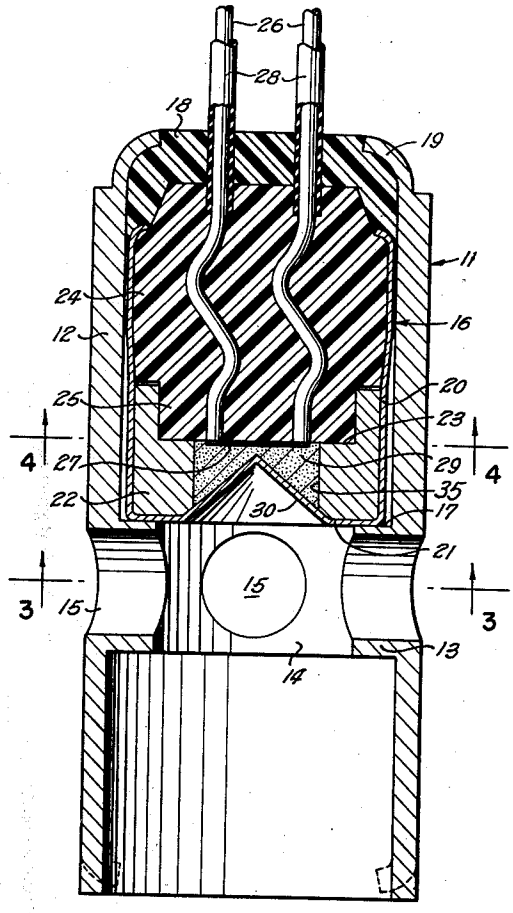


Fig. 2

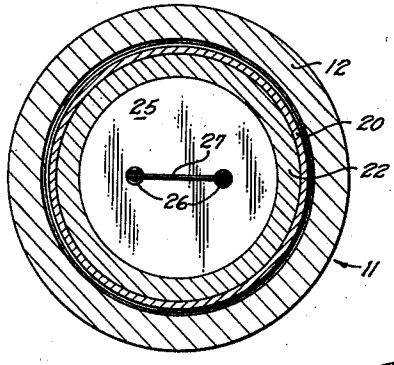


Fig. 4

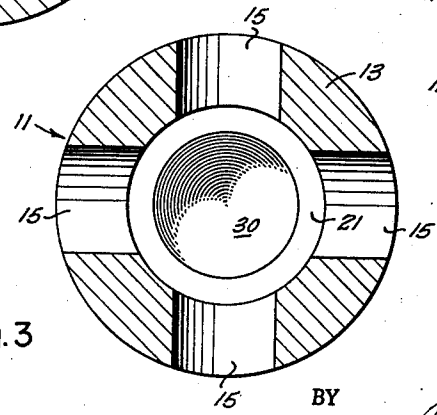


Fig. 3

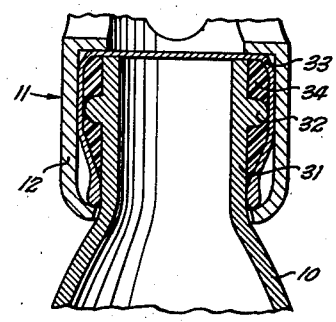


Fig. 5

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GAS DISCHARGE APPARATUS

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This invention relates to an apparatus for holding fluids under high pressure and releasing the same to produce a gas. In its more specific aspects, the invention relates to an apparatus including a shaped charge explosive unit for piercing the seal of a container to release a gas.

There are numerous applications for energy systems which produce a work output by allowing highly compressed gases or fluids to expand to an increased volume at a lower pressure. Stable compressed gases, such as carbon dioxide, have been stored in sealed, pressure-resistant containers for long periods of time and then released to perform useful work functions. The sealed, metal ampoules containing highly compressed carbon dioxide that are commercially available usually require that the ampoule be punctured by a sharp object to release the gas. In some applications, a spring or a small charge of explosive has been used to drive a movable member having a sharp point into the seal of a pressure bottle or ampoule to release the gas. This method of piercing a gas container has not always been satisfactory due to failure of the apparatus to completely pierce the seal on the container, or failure of the sharp-pointed movable member to clear the hole formed in the seal, thus preventing or restricting the escape of gas from the container.

It is, therefore, an object of the present invention to provide an apparatus for holding fluids under high pressure and then releasing the same to produce a gas.

Another object of the present invention is to provide a device for piercing a sealed container holding a gas-forming fluid under above-atmospheric pressure.

Still another object of the present invention is to provide a shaped charge explosive unit adapted to pierce the seal of a container holding gas-forming fluids under high pressure, or for other purposes.

The present invention, in general, includes apparatus for holding fluid under high pressure and discharging the same to produce a gas. A pressure-resistant container is provided which contains a charge of fluid material at above-atmospheric pressure. Sealing means are provided to close the container against the escape of the fluid material. A shaped charge explosive unit is associated with the container and is adapted upon firing to produce a jet particle stream to pierce the sealing means of the container and permit escape of the fluid material as a gas. Means are provided holding the shaped charge unit adjacent the container at a standoff distance sufficient to allow formation of a jet particle stream capable of penetrating the sealing means upon detonation of the charge unit. The holding means provides at least one escape path for passage of the gas from the container to the atmosphere surrounding the container. Means for detonating the shaped charge unit is provided.

The present invention also includes, in general, a device for piercing the seal of a container holding a gas-forming fluid at above-atmospheric pressure. A case is provided which has a shaped charge explosive unit therein. Means for mounting the case on a gas container is provided. The case is spaced from the mouth of the container with the cavity of the shaped charge explosive unit facing the seal of the mouth of the container and spaced a standoff distance from the seal. The shaped charge explosive unit is adapted upon detonation to produce a jet which pierces the seal to release the gas from the container. The case and the mounting means are adapted to remain substantially in place upon the container after the shaped charge explosive unit has been detonated. Means are provided for venting gas released from the container from the space between the case and the mouth of the container. Means for detonating the shaped charge explosive unit is also provided.

The present invention further includes, in general, a shaped charge explosive unit. The unit includes a ring having an axial hole therethrough. A plug is fitted to one end of the ring closing the hole at said one end. A thin-walled case is fitted over the ring and closes the other end of the hole. The case has a depressed portion extending into the hole in the ring. A charge of detonating explosive fills the hole in the ring and is retained therein by the plug in the case. Means are provided for detonating the explosive.

The foregoing and other objects, features and advantages of the present invention will be apparent from a consideration of the following specification taken in conjunction with the accompanying drawing.

In the drawing:

FIG. 1 is an elevational view of an exemplary pressure-resistant container for a high-pressure gas having a device for piercing the seal on the container attached to the neck of the container;

FIG. 2 is an enlarged, longitudinal, sectional view along line 2—2 of the device shown in FIG. 1 for piercing the seal of the gas container;

FIG. 3 is a cross-sectional view taken on line 3—3 of FIG. 2;

FIG. 4 is a cross-sectional view taken on line 4—4 of FIG. 2; and

FIG. 5 is an enlarged, broken, longitudinal, sectional view, taken along the line 5—5 of FIG. 1, of the upper portion of the gas container with the device for piercing the seal of the container in place.

Referring now to FIG. 1, a pressure-resistant container 10, or storage bottle, holds a charge of gas-forming fluid material (not shown) under above-atmospheric pressure. The container may be constructed of any suitable material capable of withstanding the pressure exerted by the particular gas-forming material selected for use. Metal containers of copper alloy or steel have been found satisfactory. The gas-forming material may be a highly compressed gas such as nitrogen, helium, carbon dioxide or a liquid such as ammonia, methyl chloride, or one of the commercially available Freon refrigerants which are convertible to a gas at ambient temperature. The container 10 has a seal-piercing device, designated generally by the reference numeral 11, attached to the sealed end of the container.

Referring now to FIG. 2, the seal-piercing device 11 includes a tubular housing 12. The tubular housing has an integral, thick-walled, annular section 13 projecting into the interior of the housing adjacent the central portion of the housing. The section 13 may be conveniently formed in the housing 12 by counterboring the housing at each end. The annular section 13 has an axial opening or passage 14 provided therein and a plurality of radially directed openings 15 communicating the axial opening 14 with the atmosphere surrounding the housing exterior. A shaped charge explosive unit, designated generally 16, is received in one of the counterbore portions of the housing and seats on the outwardly-facing annular shoulder 17 of the thick-walled housing section 13. The shaped charge unit is fixedly retained within the housing 12 by a layer of potting compound 18, such as a polymerized epoxy-type resin. A thin ring portion 19 at the end of the housing is bent inwardly to help retain the charge unit in place in the housing.

The shaped charge explosive unit 16 has a thin-walled, generally cylindrical case 20 with an integral end wall

21 closing one end thereof. The case may be made by drawing from a metal such as copper, aluminum, gilding metal, or steel. A thick-walled ring member 22 is seated against a portion of the interior surface of end wall 21 at the bottom of the case. The axial opening or bore 35 provided in the ring member is enlarged on the side facing the open end of the case, as by counterboring, to provide an annular shoulder 23 inside the ring member. A plug 24 is force-fitted in the upper portion of the case. The plug has a cylindrical boss 25 on the lower end thereof which is tightly fitted in the enlarged portion of the axial opening in ring member 22 and seats firmly against shoulder 23 provided inside the ring member. The maximum diameter of the plug is slightly greater than the inside diameter of the case 20 so that the upper portion of the case is expanded when the plug is forced into the case. A pair of lead wires 26 extend longitudinally through the plug and have their inner ends terminating flush with the plane surface of the boss 25. As may be more clearly seen in FIG. 4, the inner ends of the pair of lead wires 26 are connected by a fusible bridge wire 27. The portion of the lead wires extending from the outer end of the plug are covered by suitable insulation material 28. The plug 24 is desirably made by curing a phenolic resin or other suitable polymerizable plastic material around the wires 26 in a suitable mold. A charge of compressed detonating explosive material 29, such as PETN or Cyclonite, is contained within the space defined by the axial openings in the ring member below the shoulder 23. A central portion of the end wall 21 of the case is provided with a conically-shaped depression which extends into the explosive material 29 contained within the ring member. The depressed portion of the end wall of the case provides an outwardly-facing cavity in the explosive material and a metal liner 30 for the cavity.

Referring now to FIG. 5, the container 10 is provided with a cylindrical neck portion 31 which has an integrally-formed annular bead 32 adjacent the upper end thereof. The open mouth of the neck is sealed by cap 33 which is crimped over the neck portion of the container into sealing engagement with the bead 32. The space between the neck of the container and the cap is filled with a plastic gasket material 34 to insure that a gas-tight seal is provided between the cap and the bottle neck. The seal-piercing device 11 has the lower end of the housing 12 crimped tightly to the neck of the container immediately below the bottom of the cap to hold the device on the container when the shaped charge unit is fired.

As is well known in the shaped charge explosive art, it is desirable to provide an open space between the hollow end of the charge and the object to be penetrated to permit the formation of an effective jet particle stream. This spacing is commonly referred to as standoff or standoff distance. In the device of the present invention for piercing the seal of a gas container, the standoff distance between the hollow end of the shaped charge unit and the sealed end of the gas container is determined by the depth of the thick-walled annular section 13 of the housing. The optimum standoff distance for any particular size shaped charge unit and gas container seal thickness can be readily determined by experimentation, and then the depth of the annular section 13 of the housing can be sized accordingly.

In operation, the seal-piercing device 11 is attached to the neck of the gas container 10 by crimping or by other suitable means and the assembled gas discharge apparatus is placed in, or connected by a suitable conduit to, the mechanism which it is desired to operate by expanding a gas. Such a mechanism may be a piston and cylinder arrangement which opens or closes a flow control valve, or throws an electrical switch; or the gas may be used to inflate a flexible gas-holding bag to raise an object to the surface of a body of water, or to lift an object into the air. The lead wires 26 are connected to a source of electrical energy (not shown) sufficiently powerful to fuse the bridge wire 27 and cause detonation of the explosive material 29. Whenever it is desired to energize the gas-operated mechanism, a switch (not shown) is closed by manual or remote means, causing the explosive material in the shaped charge unit to detonate. This detonation produces a jet particle stream which cleanly pierces the top of the cap 33 and allows the gas-forming fluid in the container 10 to escape through the four radial openings 15 (see FIG. 3) provided in the thick-walled section 13 of housing 12.

By way of example and without restricting the invention, in a specific embodiment of the device for piercing the seal of a gas container constructed in accordance with FIG. 2 of the drawing, the length of the tubular housing (before crimping the ends) is 0.787". The housing is made from stainless steel tubing. The counterbored end portion of the housing which receives the shaped charge unit is 0.412" deep and has an I.D. of 0.280". The counterbored end portion of the housing which receives the neck of the gas storage container is 0.250" deep and has an I.D. of 0.300". The thick-walled annular ring portion of the housing is 0.125" deep and the axial opening therethrough is 0.200" in diameter. The four symmetrically spaced radial openings in the case are 0.300" in diameter. The case for the shaped charge unit is made of drawn aluminum and is 0.410" high and has an I.D. of 0.255" with a side wall thickness of 0.008". The end wall thickness is 0.004" and the conical depression is 0.050" deep. The thick-walled ring in the charge unit has an O.D. of 0.250" and is 0.125" deep with an axial opening having a 0.125" diameter. The plug has a 0.266" diameter at the portion of maximum thickness and is 0.240" high. The boss on the end of the plug is 0.050" deep and has a diameter of 0.191". PETN is used for the detonating explosive material.

While there has been described what is at present considered a preferred embodiment of the present invention, it will be apparent to those skilled in the art that various modifications and changes may be made without departing from the essence of the invention. It is intended to cover herein all such modifications and changes as come within the true scope and spirit of the following claims.

I claim:

1. A shaped explosive charge unit comprising:
(a) a thick-walled ring having a top face and a bottom-face, said ring having an axial bore therethrough;
(b) a generally cylindrical plug having a bottom face and a top face, said plug being fitted to said ring with the bottom face of said plug closing said bore at its upper end;
(c) a generally cylindrical, thin-walled case having a bottom wall closing the lower end of said case, the top of said case being open, said case containing said ring and at least the lower portion of said plug with the bottom wall of said case closely fitted to the bottom face of said ring to close said bore at its lower end, and with the side walls of said case closely fitted to the periphery of said ring and to the lower portion of the sides of said plug;
(d) means securing said case to said plug;
(e) a charge of detonating explosive material in said bore;
(f) said bottom wall of said case having an axially symmetrical indentation extending into said charge of explosive material to provide a downwardly facing, lined cavity in said material; and
(g) means to detonate said explosive material.

2. A shaped explosive charge unit comprising:
(a) a thick-walled ring having a top face and a bottom face, said ring having an axial bore therethrough and having an axial counterbore in said top face to provide an annular shoulder inside said ring;

(b) a generally cylindrical plug having a bottom face and a top face, said plug being fitted to said ring with the bottom face of said plug abutting the top face of said ring, said plug having a cylindrical boss extending into the counterbore of said ring and being seated against said annular shoulder to close said bore at its upper end;

(c) a generally cylindrical, thin-walled case having a bottom wall closing the lower end of said case, the top of said case being open, said case containing said ring and at least the lower portion of said plug with the bottom wall of said case closely fitted to the bottom face of said ring to close said bore at its lower end, and with the side walls of said case closely fitted to the periphery of said ring and to the lower portion of the sides of said plug;

(d) means securing said case to said plug;

(e) a charge of detonating explosive material in said bore;

(f) said bottom wall of said case having an axially symmetrical indentation extending into said charge of explosive material to provide a downwardly facing, lined cavity in said material; and

(g) means to detonate said explosive material including a bridge wire in said bore in detonating relation to said charge of explosive material and a pair of lead wires connected to said bridge wire and extending through said plug to the exterior.

3. A shaped explosive charge unit for piercing a diaphragm sealing the neck of a pressure fluid container, said unit comprising:

(a) a tubular housing having a lower axial opening in one end for reception of the neck of the container,

(b) means whereby the housing may be secured to the neck of the container,

(c) the housing having an upper axial opening and having an annular section interposed between said axial openings, the annular section having a central axial passage of smaller size than said upper axial opening to define a shoulder,

(d) said annular section having radial outlet ports communicating with said central passage,

(e) a ring having an axial bore therethrough,

(f) a means closing said bore at its upper end,

(g) a case received within said upper axial opening and having a bottom wall closing the lower end of the case, the case containing said ring, the bottom wall of the case having a portion contacting said ring and contacting said shoulder,

(h) a charge of detonating explosive material in said bore;

(i) said bottom wall of said case having an axially symmetrical indentation extending into said explosive material to provide a downwardly facing, lined cavity in said material defining the upper end of said axial passage; and

(j) means to detonate said explosive material.

4. A shaped explosive charge unit for piercing a diaphragm sealing the neck of a pressure fluid container, said unit comprising:

(a) a tubular housing having a lower axial opening in one end for reception of the neck of the container,

(b) means whereby the housing may be secured to the neck of the container,

(c) the housing having an upper axial opening and having an annular section interposed between said axial openings, the annular section having a central axial passage of smaller size than said upper axial opening to define a shoulder,

(d) said annular section having radial outlet ports communicating with said central passage,

(e) a thick-walled ring having an axial bore therethrough,

(f) a plug closing said bore at its upper end,

(g) a case received within said upper axial opening and having a bottom wall closing the lower end of the case, the case containing said ring and at least the lower portion of said plug, the bottom wall of the case having a portion contacting said ring and contacting said shoulder,

(h) means securing said case to said plug,

(i) a charge of detonating explosive material in said bore;

(j) said bottom wall of said case having an axially symmetrical indentation extending into said explosive material to provide a downwardly facing, lined cavity in said material defining the upper end of said axial passage; and

(k) means to detonate said explosive material.

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