Aug. 27, 1963 T. J. LORD 3,101,733

EXPLOSIVE VALVE

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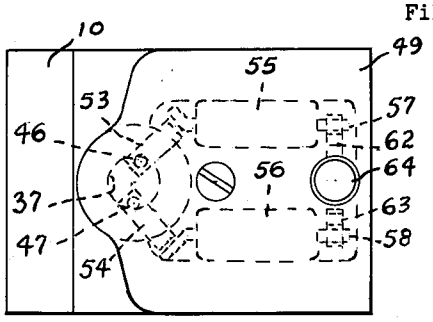

Fig-2

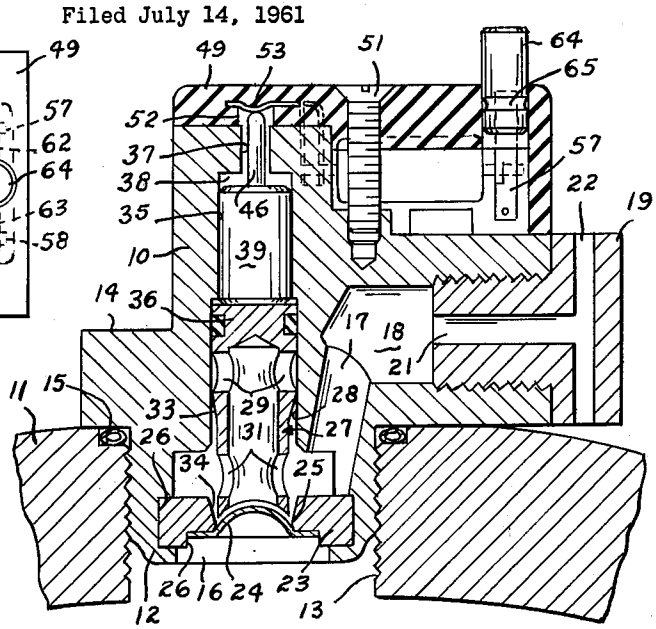

Fig-1

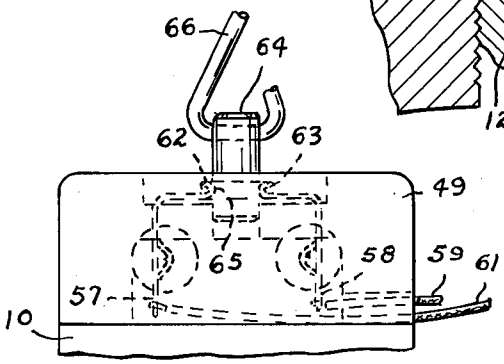

Fig-3

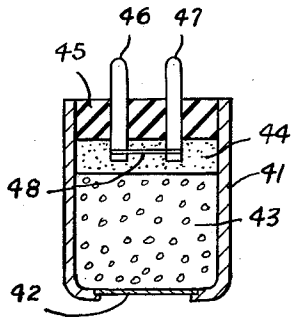

Fig-5

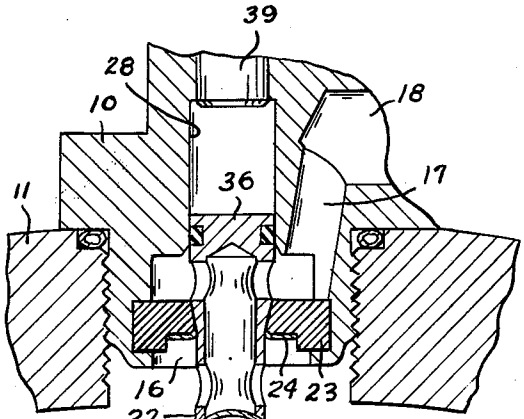

Fig-4

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3,101,733
EXPLOSIVE VALVE

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This invention relates to single action or one-time valves, particularly of the explosive type. Although not so limited the invention has especial application to integrated valve units especially adapted for use on pressure bottles or vessels and selectively energized for release of contained pressure fluids.

An object of the invention is to present a compact, unitary device of the kind described readily applicable to pressure vessels to become an integral part thereof.

Another object of the invention is to present an explosive type valve especially characterized by simplicity and reliability.

Another object of the invention is to obviate the use in valve devices as described of multiple flow passes for pressure fluid supply and for safety blow-off.

Still another object of the invention is to utilize a single valve outlet which in non-operating situations is closed by a shipping plug adapted to negate reaction forces in the event of inadvertent release of pressure.

A still further object of the invention is to utilize a diaphragm-disc assembly both as a rupturable means for a controlled release of pressure and as a safety outlet for obviating an excess pressure build-up in the vessel.

Other objects and structural details of the invention will appear from the following description, when read in connection with the accompanying drawings, wherein:

FIG. 1 is a view in longitudinal section of a valve in accordance with the illustrated embodiment of the invention, the valve being shown installed in a pressure bottle;

FIG. 2 is a top plan view of the valve of FIG. 1, shown at a reduced scale and with the shipping plug removed;

FIG. 3 is a fragmentary view in side elevation of the valve of FIGS. 1 and 2, shown slightly enlarged with respect to FIG. 2;

FIG. 4 is a fragmentary view like FIG. 1, showing the valve after energizing of the explosive charge; and

FIG. 5 is a view, partly diagrammatic and sectional, of a type of explosive charge device useful in the valve of the instant invention.

Referring to the drawing, a valve in accordance with the illustrated embodiment of the invention comprises a body 10 constructed of an aluminum alloy or other material resistant to high internal pressures. The body 10 is adapted to be installed in a pressure bottle 11 or the like to become a unitary yet detachable part thereof, as by being formed with an externally threaded boss 12 adapted to have a threaded reception in an opening 13 in the wall of the bottle 11. A flange 14 on the body confines an O-ring 15 in a complementary groove in the bottle 11 in such manner as to prevent pressure fluid escape around the threads of the boss 12. The bottle 11 conventionally may contain fluid under relatively high pressure, as on the order of 3,000 pounds per square inch, and the valve unit functions positively to confine such pressure within the bottle until such time as the valve is actuated to provide through the body 10 a controlled escape path for the contained pressure.

The boss 12 is recessed to provide a chamber 16 communicating with bottle opening 13 and hence with the interior of the bottle. An interior passage 17 connects the inlet chamber 16 with a transversely extending

chamber 18 opening through the body 10 outside the bottle 11. The wall of chamber 18 is threaded for simplified connection with piping leading to a place of use of the contained pressure. A shipping plug 19 may have a threaded installation in the chamber 18 under non-operating conditions. Serving to prevent the entrance of dirt and foreign materials into the valve, the shipping plug is formed also with a longitudinally extending flow passage 21 and a plurality of communicating radial passages 22. These define an escape path for pressure fluid in the event of an inadvertent release of the contained pressure in a manner tending to negate reaction forces.

Disposed in transverse fashion in the inlet chamber 16 is a rupture disc assembly comprising a relatively rigid ring 23 and a deformable rupturable disc 24. The ring 23 is formed with a through bore 25 and with a counterbore 26. The latter provides a seat for the disc 24 which is caused thereby to assume a position closing bore 25. The ring 23 is stationarily installed in an internal transverse groove 26 in the boss 12 and is so located thereby as to place the ruptured disc assembly intermediate the bottom open end of chamber 16 and passage 17 leading to outlet chamber 18. The disc 24, while held in the ring 23 in any suitable manner and made of any suitable material, is in the illustrated instance a thin, light-weight metallic disc which is brazed to the ring 23 in the bottom of counterbore 26. Presenting normally a continuous, unbroken surface, the disc 24 effectively seals the outlet chamber 18 from the interior of the pressure vessel.

In accordance with a feature of the instant invention, the rupture disc assembly is used both for burst safety control and as a part of the means to bring about the selective, controlled release of the contained pressure. For greater predictability of the burst pressure, the disc is prestressed by exposing the unsupported mid-portion thereof to a pressure approaching the value of the burst pressure, or that pressure at which it is desired to relieve the contained pressure as a safety precaution. As a result of such prestressing, the mid-portion of the disc assumes a hemispherical shape, substantially as indicated, in which a part of the disc is projected into the bore 25 and assumes therein a concavo-convex configuration. A rise in the contained pressure to a value significantly higher than that used in the prestressing of the disc accordingly will cause disc 24 to rupture or to break whereupon pressure fluid from the vessel 11 may escape through bore 25 to the rear of inlet chamber 16 and thence to outlet chamber 18 by way of passage 17 where it is discharged to atmosphere under the reaction inhibiting control of shipping plug 19.

Bursting of the disc 24 as described is a safety function of the valve. To perform its intended control or selective pressure release function the valve is provided with selectively operable means to rupture disc 24. This means, in the illustrated instance, includes a tubular projectile 27 is adapted to be received within the bore 25 of inlet chamber 16 above or to the rear of the rupture disc assembly. The projectile 27 extends into inlet chamber 16 with its inner end in nearby relation to the concavo-convex portion of disc 24. Such outer end of the projectile has a concave shape complementing the convexly presented surface of disc 24, with the outer peripheral edge of such end being given a knife-like edge. Th projectile 27 is adapted to be received within the bore 25 of ring 23 and if forcibly thrust downward or outward from the position shown in FIG. 1 will pass through and beyond the bore 25, and, in the process cut out a segment of the disc 24. The disc is thus ruptured and opened for pressure fluid escape.

The tubular projectile is formed with longitudinally

spaced apart sets of radial ports 29 and 31 utilized in the out-thrust position of the projectile to assure communication between the interior of the vessel 11 and inlet chamber 16 to the rear of the rupture disc assembly. Thus, and as shown in FIG. 4, when the projectile has been thrust outwardly to rupture disc 24 it assumes approximately the position shown in FIG. 4 wherein the ports 31 are projected beyond the rupture disc assembly and are open for pressure fluid flow from the interior of the vessel 11. Having access through the body of the projectile to the ports 29 the pressure fluid is discharged thereby into the inlet chamber 16 to the rear of the rupture disc assembly and flows by way of passage 17 to outlet chamber 18. The latter, as heretofore noted, is under operating or installed conditions suitably connected to a place of use of the pressure fluid. In order to limit the outwardly thrusting motion of the projectile 27, and accurately to place the ports 29 and 31 on opposite sides of the rupture disc assembly, the exterior of the projectile and the inner end of bore 25 in ring 23 are formed with complementary taper formations 33 and 34. When in its extended or out-thrust position, therefore, the projectile 27 seats in the ring 23 limiting and positioning the projectile as described.

The bore 28 which receives the projectile 27 is longitudinally aligned with inlet chamber 16. At what may be considered its inner end it merges with an aligned reduced diameter bore 35. The projectile 27 is formed at its inner end with a solid portion 36 presented as a piston to the inner end of bore 35. The opposite end of bore 35 is closed except for a reduced diameter opening 36 extending through the outer surface of the body 10. The bore 35 and piston portion 36 of projectile 37 accordingly define a chamber 38. Received in such chamber in relatively close fitting relation to the sides thereof is a pyrotechnic actuator 39 having the characteristics of a propellant cartridge. When ignited, actuator 39 generates a powerful expansion force which, in this instance, is directed toward the piston portion 36 of the projectile 27 in a manner to deliver an outward thrust to the projectile, driving it forcibly from the position shown in FIG. 1 to the position shown in FIG. 4.

While any known form of pyrotechnic actuator may be used, in the illustrated instance the device 39 comprises an outer metal case 41. At one end thereof the case 41 is turned inwardly to provide a mount for a thin metal or plastic disc 42. Inside the case 41, immediately adjacent to the disc 42, is a charge 43 of propellant material 43. Contiguous to the charge 43, toward the opposite end of the case 41, is a layer of pyrotechnic or ignitor material 44. In overlying relation to the material 44, and in closing relation to the said opposite end of the case 41, is a plug 45 of a plastic or like material. A pair of electrically conductive posts 46 and 47 are mounted in the plug 45 to project through the plug, within and without the case 41. The inwardly projecting ends of the posts terminate within the layer 44 of ignitor material and are there connected by an electrically conductive bridge wire 48. The outer ends of the posts project through and beyond the reduced diameter bore 37 and terminate outside the body 10.

That side of the body 10 through which the posts 46 and 47 project has an auxiliary body 49 secured thereto, as by means of a screw 51. The auxiliary body 49 overlies the body 10 and is made of a molded plastic or like material which is electrically nonconductive. The auxiliary body 49 has a recess 52 receiving the posts 46 and 47. Formed in the body is a pair of leaf contacts 53 and 54 which, near their one ends, contact respective posts 46 and 47. At their other ends the leaf members 53 and 54 are connected through resistors 55 and 56 to respective electrically conductive bars 57 and 58 also molded within or otherwise carried by the auxiliary body 49. The bars 57 and 58 are connected by flexible conductors 59 and 61 to a source of electricity.

In accordance with the mode of operation of the pyrotechnic actuator and its controls, the circuit to the actuator by way of the conductors 59 and 61 normally is open. Upon closing of such circuit, electrical current flows to and through one of the posts 46 or 47, across the bridge wire 48 to the other post and then back to the source. Wire 48 is heated thereby and quickly ignites pyrotechnic material 44. This acts as a fuse, touching off the propellant charge 43. Powerful expanding gases eject or rupture the disc 42 and are so directed against the piston portion 36 of the projectile 27, with the results heretofore described.

Upwardly and inwardly bent extensions on the bars 57 and 58 terminate in spaced apart spring contact arms 62 and 63. These are selectively joined by an insert pin 64 adapted to be pressed in place between the contact arms and resiliently held by engagement of the arms in a peripheral groove 65 in the pin. When positioned as described, and as shown in FIG. 3, the pin 64 provides a short circuit for electric current flow, obviating its passage through the actuator 39. It is hence a safety device by which actuation of the valve may be prevented should the circuit across conductors 59 and 61 be closed prematurely or by mistake. Prior to a planned "firing" of the valve the shorting pin 64 is withdrawn from its insert position, as by pulling on an attached lanyard 66. The valve is in this manner prepared or armed for use.

The illustrated form of the invention contemplates use of a tubular projectile as disclosed. It will be evident, however, that other forms of rupture producing means may be used. A simple punch, for example, might be formed on the end of a projectile to pierce the disc or diaphram 24. Escaping pressure from the vessel 11 would then deform the disc to define a full open area through the rupture disc assembly.

The mating surfaces 33 and 34, on projectile 27 and in bore 25, provide for a wedging engagement of the projectile with ring 23, after firing. As a result the projectile tends to maintain its outthrust position against opposing pressures from within vessel 11. In the event positive retention is desirable, snap ring or like means may be suitably disposed between the projectile and body 10.

What is claimed is:

1. A valve adapted for mounting on a pressure vessel or the like and selectively operable for pressure release, including a body formed with a through fluid flow passage having an inlet end adapted to communicate with the pressure source, a mount installed in said body in said passage and having a through opening therein, a side wall of said opening tapering from one diameter on one side of said mount to a larger diameter on the other side thereof, a rupturable disc having a peripheral portion seated on said one side of the mount and a concavo-convex central portion received in said opening, a projectile slidable in said body in aligned relation to said mount on the said other side thereof, said projectile being tubular and having longitudinally spaced apart radial openings and a tip facing the convex surface of said disc, means for driving said projectile into and through said opening in said mount to rupture said disc in the process, and means on the exterior of said projectile complementing the taper in said opening engageable therewith to limit thrust of said projectile into and through said opening and to position said projectile with said longitudinally spaced apart openings therein on respectively opposite sides of said mount.

2. A valve according to claim 1, characterized in that said mount and said disc comprise a unitary assembly separably installed in said valve body, the installation of said assembly presenting the concave surface of said disc to confined pressure, the shape of said disc producing a prestressing of said disc for accurate burst pressure predictability.

3. A valve according to claim 1, characterized in that the tip of said projectile is open with its edge having a

concave shape complementing the convexly presented surface of said disc and terminating at its extremity in a knife-like edge.

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