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Continuation of application Ser. No.
636,706, May 8, 1967, now abandoned.

[56]

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[54] PRESSURE RELIEF IMPACT ABSORBING APPARATUS

10 Claims, 9 Drawing Figs.

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5/347, 137/512.15
 [51] Int. Cl. **F16k 17/36,**
A62b 1/22
 [50] Field of Search **137/560,**
525; 5/347; 182/137, 138

ABSTRACT: Pressure relief apparatus comprising means defining a fluid-receiving chamber and having a flexible wall portion consisting of elongated elastic strands which are interwoven whereby adjacent and intersecting strands cooperate to define interstices that are substantially closed when the fluid pressure in the chamber is below the relief pressure. When the fluid pressure in the chamber is raised above the relief pressure the wall portion is flexed outwardly and the strands stretched in proportion to the pressure to open the interstices thereby defining a cumulative fluid relief flow area that is proportionate to the increase in pressure over the relief pressure.

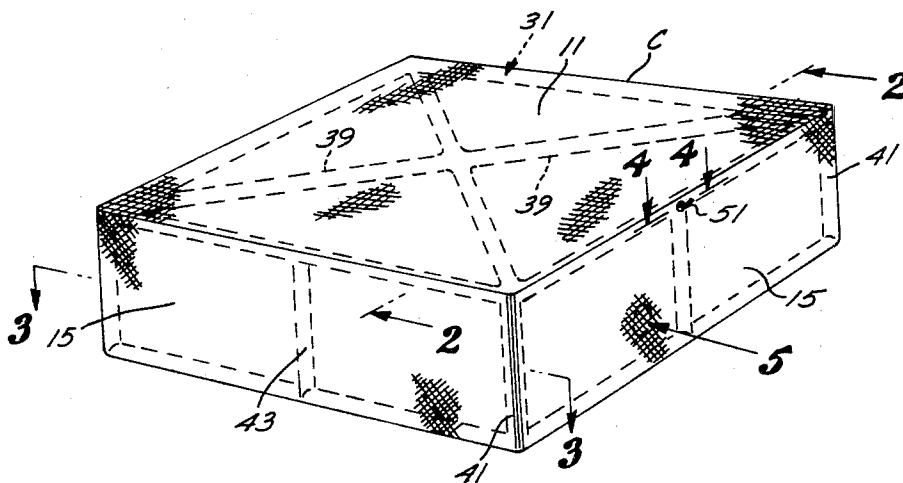


FIG. 1

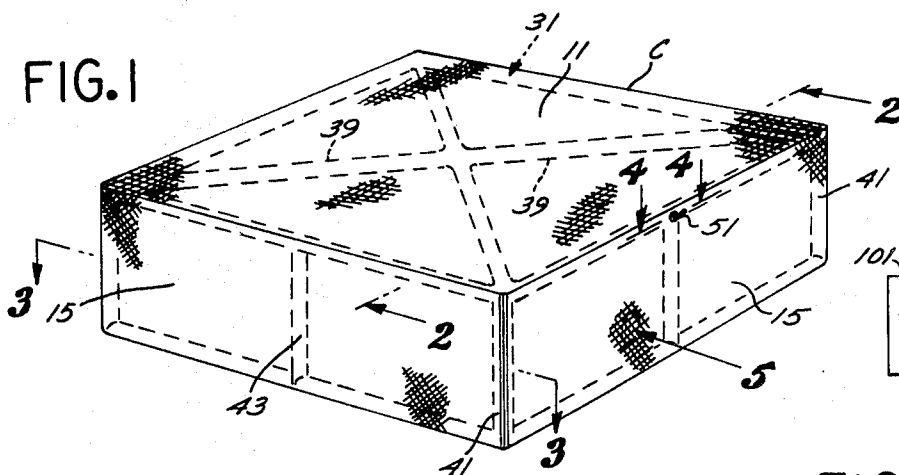


FIG. 7

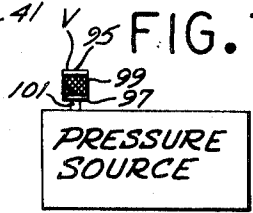


FIG. 2

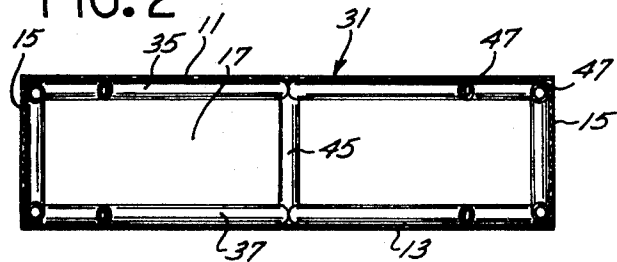


FIG. 4

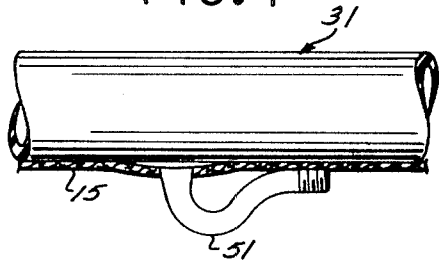


FIG. 3

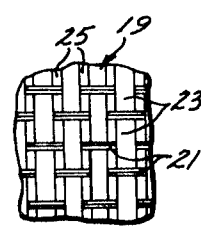
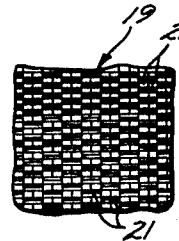
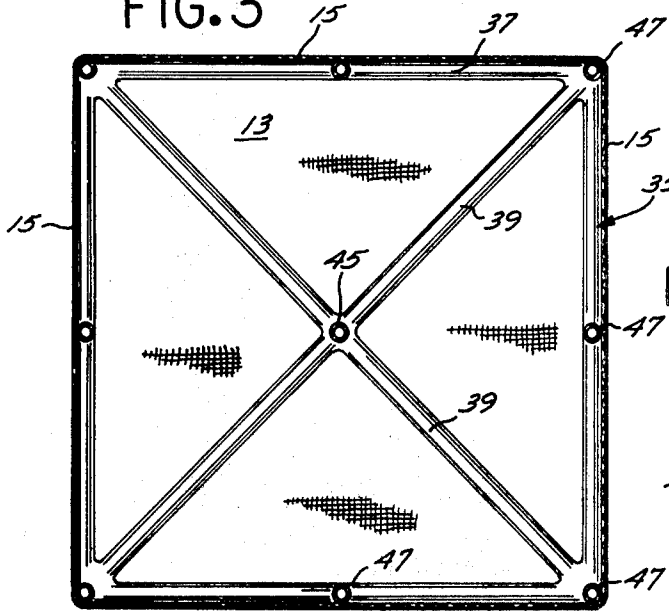


FIG. 5

FIG. 6

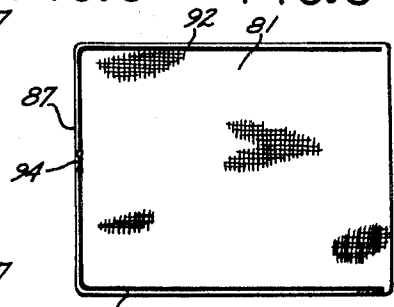


FIG. 9

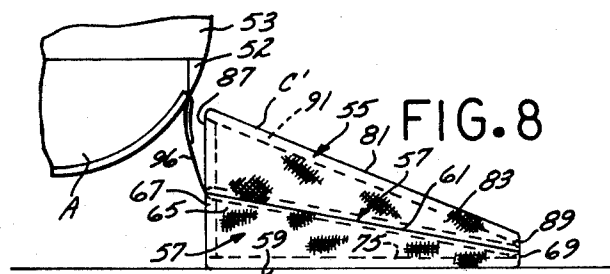


FIG. 8

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PRESSURE RELIEF IMPACT ABSORBING APPARATUS**CROSS REFERENCE TO RELATED APPLICATION**

This application is a continuation of application Ser. No. 636,706, filed May 8, 1967, now abandoned.

BACKGROUND OF THE INVENTION**1. Field of Invention**

The present invention relates generally to pressure relief apparatus and more specifically to apparatus which includes a flow area for release of fluid, which area increase in size in proportion to increases of the pressure being relieved.

2. Description of Prior Art

Existing pressure relief devices generally include fixed or nonexpansible apertures for relief of fluid.

SUMMARY OF INVENTION

Accordingly, a particular object of the present invention is to provide a pressure relief apparatus including means defining a fluid-receiving chamber and having a flexible wall portion consisting of adjacent elongated members which are interconnected to form interstices. The members are preferably elastic in character to urge the adjacent members together whereby the interstices are diminished in size to restrict fluid flow therethrough. The elastic character of the members further enables them to stretch and bow outwardly upon an increase in fluid pressure in the chamber whereby the interstices are enlarged in size in proportion to the increased pressure whereby flow through such interstices is correspondingly increased. The invention has particular utility for use in impact-absorbing pads for relief of internal pressures developed on impact of a falling body upon the pad, whereby bouncing or rebound of the body is controlled, even to the point of virtual elimination, if desired.

Other objects and advantages of the present invention will become apparent from the following detailed description of a preferred embodiment thereof, when taken in conjunction with the appended drawings.

DESCRIPTION OF DRAWINGS

FIG. 1 is a perspective view of an impact absorbing pad according to the present invention;

FIG. 2 is an elevational sectional view taken along the lines 2-2 of FIG. 1;

FIG. 3 is a horizontal sectional view taken along the lines 3-3 of FIG. 1;

FIG. 4 is a partial horizontal sectional view taken along the lines 4-4 of FIG. 1;

FIG. 5 is a partial front view, in enlarged scale, taken from the bottom circle designated 5 in FIG. 1;

FIG. 6 is similar to FIG. 5, but on a more enlarged scale;

FIG. 7 is a side view of a valve according to the present invention;

FIG. 8 is a front view of a second impact absorbing pad according to the present invention; and

FIG. 9 is a top view, on a smaller scale, of the pad shown in FIG. 8.

DESCRIPTION OF PREFERRED EMBODIMENTS

The impact absorbing pad or body catcher C includes a bag formed by impervious square-shaped top and bottom walls 11 and 13, respectively, which are connected together by vertical walls 15 to define a fluid-receiving chamber 17. Referring to FIGS. 5 and 6, the vertical walls 15 consist of a material, generally designated 19, which is comprised of elongated horizontal and vertical strands or members 21 and 23, respectively, which are interwoven to form an elastic structure characterized by interstices 25. The elasticity of the structure can be a result of the tightly knitted or woven character thereof, but preferably is provided by making the individual fibers of an elastic material. The elastic character of the inter-

woven strands 21 and 23 is then effective to normally urge adjacent strands together thereby maintaining the interstices 25 closed, as shown in FIG. 4, and further to enable outward flexing of the vertical walls 15 when fluid in the chamber 17 is pressurized. On pressurization, stretching and outward bowing of the strands 21 and 23 occur, opening the interstices 25 to a degree determined by the pressure in the chamber 17. The top and bottom walls 11 and 13 are conveniently maintained spaced-apart by a flexible tubular shaping structure, generally designated 31.

To accomplish the foregoing functions, the top and bottom walls 11 and 13 are made of conventional fluid-impervious nylon cloth which is preferably treated with coatings to provide flame resistance or flame retardance. The elastic fibers forming the peripheral walls 15 are so-called "two-way stretch" elastic material such as that sold under the trade name "Lycra" by Du Pont De Nemours & Co., Los Angeles, California. This material in woven form tends to block or offer relatively high resistance to a flow of fluid therethrough in its unstretched or normal condition.

The flexible shaping structure 31 is conveniently made of collapsible plastic tubing arranged to form top and bottom squares 35 and 37, respectively, which are braced by integral diagonal tubular struts 39. Vertical corner tubes 41 interconnect the top and bottom squares 35 and 37 at their respective corners, and vertical side tubes 43 interconnect the sides of the squares intermediate the corners. A central tube 45 interconnects the top and bottom diagonal struts 39 at their intersections. The hollow interior of the tubular shaping structure 31 defines integral and interconnecting pneumatic passages 47 which are inflated through a valve 51 mounted to one side of the top square 35. The valve 51 is preferably a conventional pneumatic tire valve or the like. The catcher C is especially useful for absorbing the impact or kinetic energy of a falling body, such as a person who has jumped or fallen from a considerable height. Operation of the catcher will be described with reference to such exemplary use. In preparing the catcher C for use the shaping structure 31 is inflated through the valve 51 to a pressure sufficient to cause it to assume the boxlike shape shown in FIG. 1. This can be done orally, but is preferably accomplished through the use of a conventional CO₂ cartridge (not shown) of the type used in inflating rubber life rafts.

Upon inflation, the top and bottom walls 11 and 13 are spaced-apart and the vertical walls 15 are distended, thereby forming the chamber 17. If desired, the chamber 17 itself could be pressurized, depending upon the character of the walls 15, that is, their capacity to maintain internal pressures, but in the embodiment shown the chamber 17 is normally at ambient pressure.

When the shaping structure 31 is inflated as described ambient air seeps through the vertical walls 15 and the chamber 17 will assume atmospheric pressure. When the impacting body strikes the top wall 11, the wall will flex downwardly, along with the supporting diagonal tubing 39, thus decreasing the volume of the chamber 17 and thereby tending to increase the pressure of the contained air and compressing it. Such increase in pressure buckles and bows the vertical walls 15 outwardly and stretches the strands 21 and 23, causing the interstices 25 to open and provide for egress therethrough of the contained air.

A particular advantage of the catcher C is that the greater the force of impact the greater the increased pressure within the chamber and accordingly the more the strands 21 and 23 will be stretched thus opening the interstices 25 to a greater extent and allowing egress of a proportionately greater amount of air. Consequently, rather than the kinetic energy absorbed by stopping the impacting body being stored by compression of the air contained in the chamber 17, and the air then expanding rapidly to move the top wall upwardly and impart an upward impulse to the stopped body, this compressed air will at least partially escape through the opened interstices 25, thus releasing the absorbed energy and prevent-

ing undesirable bouncing of the body back up to a height from which the subsequent fall may be injurious unless a controlled amount of bounce is desired.

When the weight of the stopped body has been removed from the catcher C the shaping structure 31 will again distend the top wall 11 and atmospheric air will again seep into the chamber 17, thus preparing the catcher for another impact.

Referring now to FIG. 8 a second catcher C', embodying the present invention, is shown in position for receiving passengers making an emergency exit from the passenger compartment 53 of a passenger airplane A. It is a particular feature of this catcher C', that it can be elevated to two selected heights, a lower height for receiving passengers from an airplane that has its wheels up, and a second, higher position, for receiving passengers from an airplane that has its wheels down. Construction of the catcher C' is similar to that of the catcher C except that it is wedge-shaped and constitutes a composite bag, including independently distendable upper and lower portions, generally designated 55, and 57, respectively.

The lower portion 57 includes a bag formed, in part, by a bottom or base wall 59 and in inclined top wall 61, both of which are made of a conventional fluid-impervious material. The walls 59 and 61 are interconnected by a pair of triangular-shaped opposed sidewalls, one of which is shown at 65, an end wall 67 and 69. The sidewalls 65 and end walls 67 and 69 are also made of a material impervious to fluid flow but obviously could be made entirely or partially of stretch material similar to the above-described material 19 to provide body impact absorption.

Inflatable tubular shaping structure 75, similar to above-described structure 31, is inflatable to distend the walls 59, 61, 67 and 69 to form a wedge-shaped air-receiving compartment similar to compartment 17. Inflation of the structure 75 is through a conventional pneumatic tire valve or the like (not shown). In addition, the pressurized air-receiving compartment is preferably independently inflatable through another such valve (not shown).

The upper portion 55 of the composite bag or catcher C' is shaped similarly to portion 57, and includes an inclined fluid-impervious top wall 81, triangular-shaped opposed sidewalls, one being shown at 83, and end walls 87 and 89. The walls 83, 87 and 89 are all made of material like the material 19 previously described, and connect the top wall 81 to the top wall 61 of the lower portion 57.

Inflatable collapsible tubular shaping structure 91, when inflated, distends the walls 81, 83, 87 and 89 away from the wall 61 to form a wedge-shaped air-receiving chamber similar to the compartment 17 of the first embodiment C.

The tubular shaping structure 91 includes a valve (not shown) similar to valve 51 for inflating it independently of the structure 75. The various inflating valves (not shown) may be connected with portable bottles of compressed gas whereby the collapsed catcher C' can be thrown from the airplane A and inflated automatically from such bottles, or, if desired, orally inflated.

To further enhance the usefulness of the catcher C' as a life raft, a pair of zippers 92 and 93 (FIG. 9) are provided for detaching the top wall 81 on three sides to open the interior of the catcher for receiving passengers. The zippers 92 and 93 open from a point 94 intermediate the sidewalls 83 and zip along the end wall 87, turn downwardly along the respective sidewalls 83 thereby leaving the top wall 81 fastened along the end wall 89. The intermediate wall 61 is detachable on the same three sides as the top wall 81 by means of a similar pair of zippers (not shown) which zip along the walls 65 and 67.

In operation, the catcher C' can be used to unload passengers from an airplane that has made an emergency wheels-up landing and is conveniently attached to the plane by means of a flap 96. In this situation, the airplane will be at a lower elevation than that shown in FIG. 8. Therefore, only the bottom portion 57 need have its support structure 76 inflated whereby the passengers can jump directly from the passenger compart-

ment 53 onto the top surface 61 of such portion. On the other hand, when the airplane A has made a wheels-down landing, as shown in FIG. 8, both the upper and lower shaping structures 91 and 75, respectively, are inflated, thereby elevating the impacting surface 81 of the top section 55 for receiving passengers jumping from the compartment 53. It will be clear that with the bottom portion 57 inflated the passengers jumping onto the inclined surface 61 will be directed away from the airplane A, thus assuring that they will be clear of the exit area. This same clearing of the exit area is accomplished when both the top and bottom portions 55 and 57 are inflated and the passengers jump onto the wall 81. Since the walls 59, 61, 65, 67 and 69 of the bottom section 57 are of a nonporous material the inflated catcher C' will float on water and can be utilized as a life raft when the airplane has made an emergency landing in water. By unzipping the zippers 92 and 93 and folding back the top wall 81 and also unzipping the zippers attaching the intermediate wall 61 and folding it back or laying it in the bottom of the catcher, the passengers will be supported directly on the bottom wall 59 thus enhancing the stability of the floating catcher C' and providing weather protection for them by means of the side walls and, if desired, by partial closure of the top wall 81.

The pressure relief structure of the catchers C and C' is also useful in certain valve applications. For example, and with reference to FIG. 7, a valve V embodying such pressure relief structure is shown connected with a fluid pressure source. More particularly, the valve V includes body structure having circular top and bottom walls 95 and 97, respectively, which are connected by a cylindrical wall 99 made of material 19. The bottom wall 97 includes an inlet which is connected to the pressure source by a tube 101. When the pressure from the pressure source increases above the relief pressure of the valve V, the material 19 will be expanded and stretched as described in connection with the catcher C and will permit rapid egress of the fluid through the open interstices 25, thereby relieving such pressure. Again the cumulative flow rate through the interstices 25 will be proportionate to the pressure being relieved.

While the above discussion has been directed to a catcher C or relief valve V to be utilized for relieving internal pressure, it will be clear that the present invention is useful for metering pressure into the internal chamber formed by the body structure and that such type of operation is intended to be comprehended.

From the foregoing, it will be apparent that the pressure relief apparatus of this invention can be conveniently utilized in a body catcher C and C' that will effectively and efficiently absorb the kinetic energy of the impacting body but which will not induce the body to bounce from the catcher after the impact force has been absorbed. Clearly, if limited bounce were desired, the type of material 19 selected would provide for a lesser amount of air escape to correspond with the desired bounce. The catchers C and C' are efficient to manufacture and use and can be collapsed and easily stored in a relatively small space. They can also be rapidly inflated and readied for use and such inflation can be accomplished automatically by connecting the valves associated with the shaping structure directly to a bottle containing compressed gas. Moreover, the pressure relief apparatus can be used in valves, such as the valve V, to effect pressure regulation in any of the various systems utilizing fluid under pressure.

Various modifications and changes may be made with regard to the foregoing detailed description without departing from the spirit of the invention.

I claim:

1. Pressure relief or metering apparatus for releasing fluid when a predetermined pressure is attained, said apparatus comprising:

a container formed with a fluid-receiving chamber having a flexible wall portion consisting of adjacent elastic members extending in longitudinal and transverse directions, and interconnected to form interstices, the elastic

character of said members and the interconnection thereof tending to draw said members together, both longitudinally and transversely, to maintain said interstices substantially closed when the pressure in said chamber is below said predetermined pressure, the elastic character and interconnection of said members further enabling said members to stretch when the fluid pressure increases above said predetermined pressure to move adjacent ones of said members apart to open said interstices and cause them to expand in size in direct proportion to said fluid pressure to enable said fluid to escape at a rate which increases progressively with the increase of said pressure above said predetermined pressure.

2. Pressure relief apparatus as set forth in claim 1 wherein: said flexible wall portion is unconstrained to enable it to expand in overall area and cause said elastic members to diminish in cross section as they are stretched to thereby enhance the enlargement of said interstices to increase the rate of discharge of said fluid.

3. Pressure relief or metering apparatus as set forth in claim 1 wherein:

said elastic members are interconnected by weaving to enable said respective longitudinal and transverse members to shift with respect to one another.

4. Energy-absorbing apparatus for absorbing the energy of an impacting body of a predetermined weight and comprising: a flexible container for interposition between said body and an impacting surface, said container being formed with a fluid chamber of sufficient size to receive a predetermined volume of a selected fluid, said chamber including a flexible wall portion consisting of adjacent elongated flexible members interconnected to form interstices, said interstices in the normal state of said members being diminished in size to restrict fluid flow therethrough and the flexible character of said elongated members being sufficient to cause said interstices to be enlarged sufficiently, by the pressure differential across said wall por-

tion resulting from said impacting body flexing the walls of said container and reducing the volume of said chamber, to meter said fluid through the enlarged interstices at a rate sufficient to enable said container to gradually collapse and absorb the kinetic energy of said body.

5. Energy-absorbing apparatus as set forth in claim 4 that includes:

flexible shaping structures for normally urging said container to an uncollapsed configuration and sufficiently flexible to be collapsed by the impact of said body.

6. Energy-absorbing apparatus as set forth in claim 5 wherein:

said flexible shaping structure is formed by fluid inflatable collapsible tubing.

7. Energy-absorbing apparatus as set forth in claim 4 wherein:

said elongated members are of sufficiently flexible character to enable said interstices to become sufficiently enlarged by said pressure increase to provide absorption of substantially all of said kinetic energy of said impacting body whereby there is substantially no rebound of said body.

8. Energy-absorbing apparatus as set forth in claim 4 wherein:

said container is formed with a base wall and an oppositely disposed impacting wall.

9. Energy-absorbing apparatus as set forth in claim 8 wherein:

said base wall and impacting wall are relatively airtight and said impacting wall is sloped relative to said base wall.

10. Energy-absorbing apparatus as set forth in claim 4 that includes:

an inflatable container disposed beneath said flexible container for elevating it.

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