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T. O. OLSEN

3,399,407

CUSHION FOR DECELERATING FALLING BODIES

Filed May 3, 1966

2 Sheets-Sheet 1

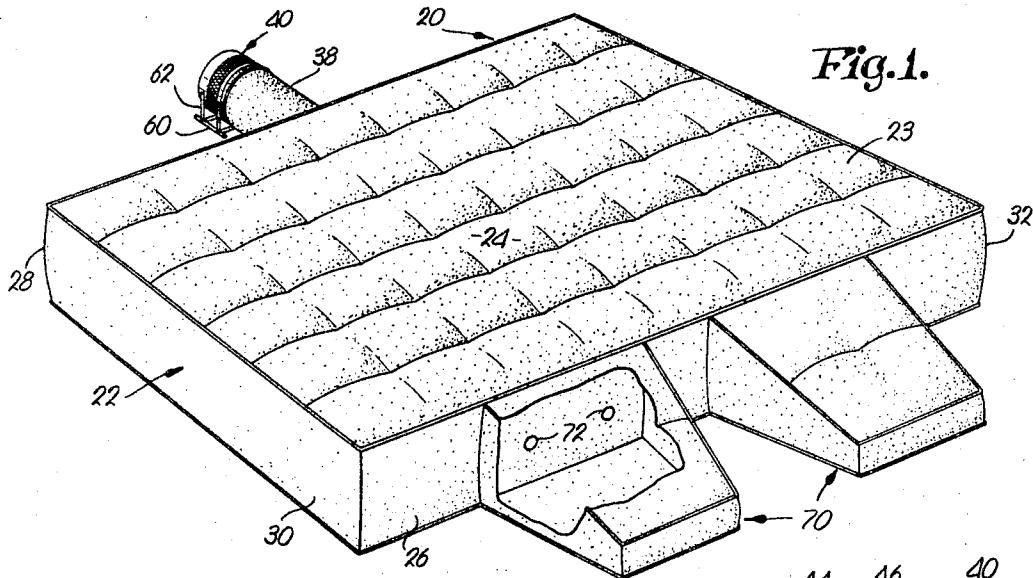


Fig. 1.

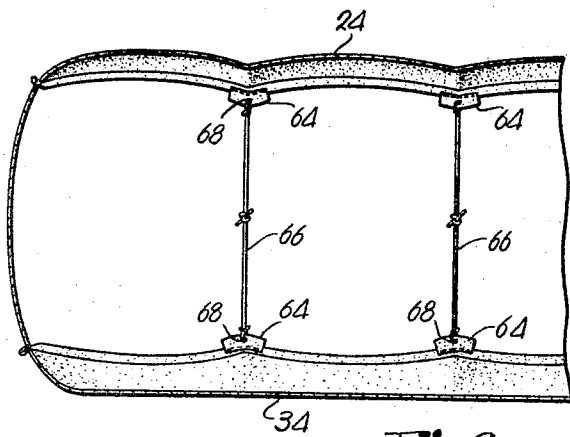


Fig. 3.

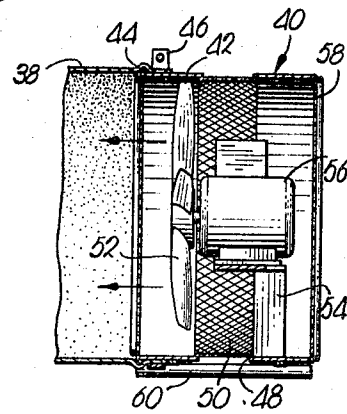


Fig. 4.

Fig. 5.

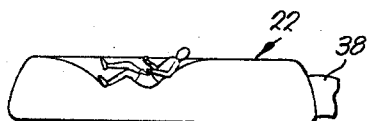
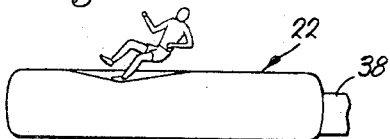


Fig. 6.

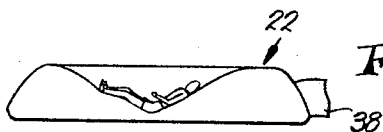


Fig. 7.

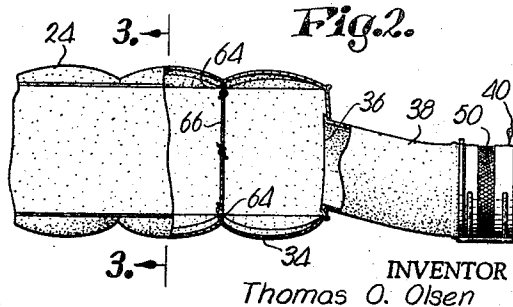


Fig. 2.

INVENTOR
Thomas O. Olsen

BY

Hovey, Schmidt, Johnson & Hovey
ATTORNEYS

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T. O. OLSEN

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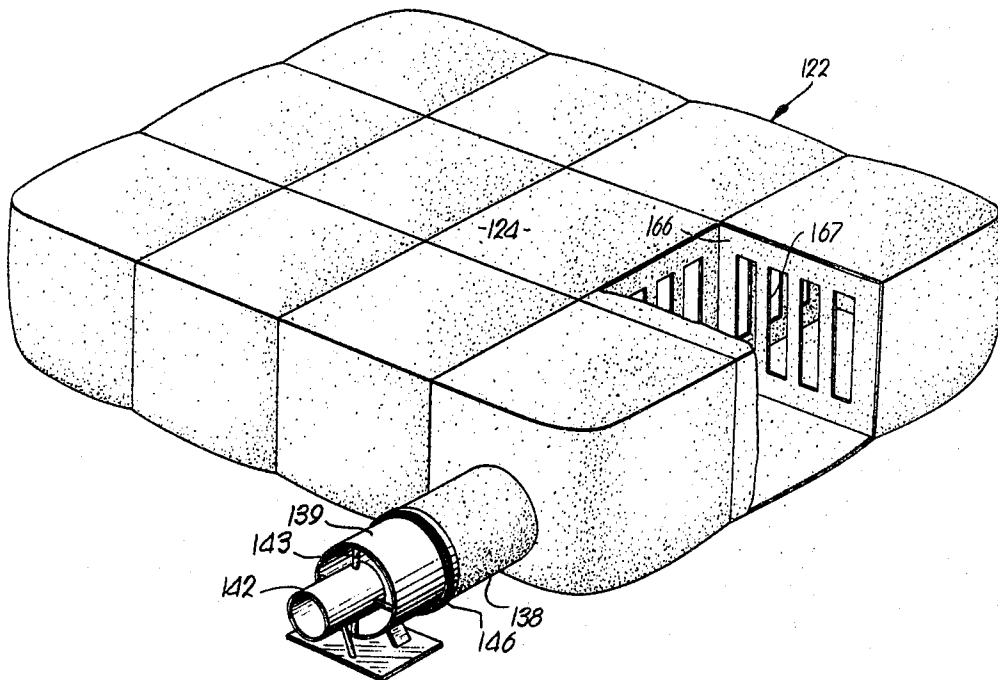


Fig. 9.

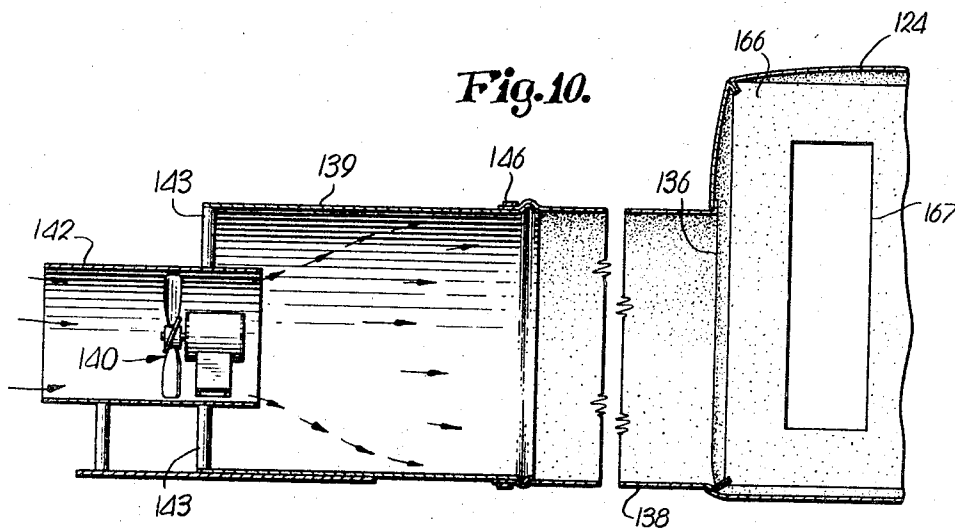


Fig. 10.

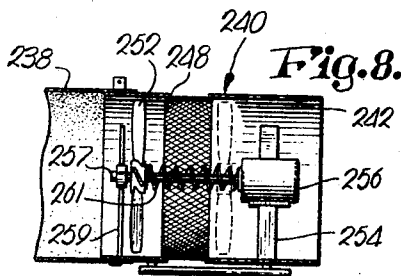


Fig. 8.

INVENTOR
Thomas O. Olsen

BY

Novey, Schmitt, Johnson & Novey
ATTORNEYS

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3,399,407

CUSHION FOR DECELERATING FALLING BODIES

Thomas O. Olsen, 910 S. Santa Fe,
Salina, Kans. 67401

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9 Claims. (Cl. 5—348)

ABSTRACT OF THE DISCLOSURE

A closed flexible bag having a conduit communicating with the bag and a continuously operating fan unit in the conduit for creating artificial currents of air to maintain the pressure in the bag at a predetermined level. Air expelled from the bag upon impact of a falling object on the bag flows in a reverse direction through the fan unit to avoid pressure build up sufficient to damage the object.

This invention relates to a device for decelerating moving objects and, more particularly, to structure in the nature of a flexible, air filled bag adapted to be placed in the path of a moving object to bring the object gently to rest without imparting severe impact and deceleration forces to the object.

Devices constructed pursuant to this invention have been found to be particularly useful for cushioning the fall of pole vaulters and high jumpers in athletic meets wherein it is necessary to bring the bodies of the athletes to rest after the jump and, wherein it is extremely desirable that the athletes not be subjected to shock or injury. The device of this invention not only decelerates the athlete in a manner which substantially eliminates shock, but it also has the additional desirable characteristic of being readily portable, permitting quick and easy removal from the location of use to storage areas.

Heretofore, various materials, such as loose sand, sawdust and foam rubber or the like, have been used to cushion the fall of athletes in vaulting and jumping events. All have the undesirable effect of decelerating the athlete in a manner which causes shock and stresses which can result in discomfort and even injury to the athlete. All of these materials are relatively non-portable. Attempts have been made to utilize a heap of separate pieces of foam rubber in a vaulting pit to minimize the shock of landing experienced by the vaulters. Although heaps of this material were much softer to the vaulter than were bags or mats of foam rubber as had been tried previously, the vaulter still experienced considerable shock upon landing on and compressing the foam rubber, and also huge heaps were required to cushion the fall, especially from substantial heights. Such huge heaps have presented a major problem in installations where the vaulting or jumping pit had to be disassembled after each meet and after each practice session in which the pits were used. Similarly, storage of the foam rubber pieces has also presented substantial problems.

Attempts have heretofore been made to utilize air cushions for this purpose. Some such cushions have even included outlet orifices which permit escape of some of the air from the cushion after the air is compressed to a predetermined pressure. An example of a cushion of this general type is shown and described in U.S. Letters Patent No. 2,975,855, issued Mar. 21, 1961. These devices attempted to relieve air pressure in the cushion by metering the escape of air through relatively small restricted orifices. As a result, compression of the air in the cushion after impact exceeded to such a degree that the vaulter's body was met with substantial resistance, causing the athlete to bounce and imparting considerable shock to his body.

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It is the primary object of this invention to provide a device which will decelerate a moving object with little or no perceptible shock to the object and which will not cause the object to be bounced as it is brought gently to a condition of rest.

Another highly important object of the invention is to provide such a device which is highly portable and can, therefore, be readily moved from place to place by one man.

Still other objects of this invention are to provide such a device which is highly reliable, will not cause objects falling thereon to be pitched off its surface with resultant likelihood of injury, and which returns to a ready condition in a very short period of time subsequent to each use made of the device.

These and other important objects of the invention will be pointed out or will become clear from a study of the drawings, specification and appended claims.

In the drawings:

FIGURE 1 is a front perspective view of the device of this invention, parts being broken away to reveal details of construction;

FIG. 2 is an enlarged, fragmentary, elevational sectional view of the device, a portion of the inflatable bag being broken away and appearing in cross section to reveal details of construction;

FIG. 3 is an enlarged, fragmentary, vertical sectional view taken on line 3—3 of FIG. 2;

FIG. 4 is a fragmentary, vertical sectional view through the fan unit on the same scale as FIG. 3, the fan blade and motor appearing in elevation;

FIG. 5 is a schematic, vertical sectional representation of the bag on a reduced scale and illustrating the condition of the bag immediately after impact of a person on the upper surface of the bag;

FIG. 6 is a view similar to FIG. 5 but illustrating the bag as the person continues his descent by depressing the upper surface of the bag;

FIG. 7 is a view similar to FIGS. 5 and 6 but showing the general configuration of the bag at substantially the time of complete deceleration of the person by the bag;

FIG. 8 is a view similar to FIG. 4 but on a reduced scale and illustrating a modified form of fan unit;

FIG. 9 is a view similar to FIG. 1 but illustrating a modified form of bag and fan unit; and

FIG. 10 is an enlarged, fragmentary, vertical sectional view through the bag and fan unit shown in FIG. 9.

The preferred form of the invention is illustrated in FIGS. 1—4 wherein the device 20 includes an inflatable body in the nature of a hollow, collapsible bag 22 of flexible material. Bag 22 has a top 23 presenting an upper impact surface 24, a front wall 26, a rear wall 28, side walls 30 and 32, and a bottom wall 34.

Bag 22 is constructed from material which is relatively impervious to the flow of air and it has been found that fabric of synthetic material, such as nylon or the like which has been impregnated with rubber, neoprene, plastic or other synthetic material, is well suited for this purpose. The walls of bag 22 may be joined together by any suitable process and, in the preferred construction, the walls are joined by the application of heat and pressure along the seams to provide a "weld" which has been found to be even stronger than stitching. The impregnated fabric material comprising the walls of bag 22 is of relatively thin, highly flexible material and the synthetic fabric provides strength and resistance to deterioration and tearing stresses.

Rear wall 28 is provided with a port 36 which communicates with an elongated conduit 38, the latter having one end secured to the annular rim of port 36 as best illustrated in FIG. 2. Conduit 38 may be of any desired

length, and the opposite end of conduit 38 is secured to a fan unit 40. It will be seen in FIG. 4 of the drawings that unit 40 includes an annular tube 42 of sheet metal or the like. An annular rim 44 is welded to the outer surface of tube 42 adjacent one end of the latter, and the outermost end of conduit 38 is telescoped over the marginal edge of tube 42 and rim 44 where it is clamped to tube 42 by an annular clamp 46. The latter is readily releasable to permit disassembly of unit 40 from conduit 38 when the device is not in use. An annular slot 48 is provided in tube 42 as illustrated best in FIG. 4, and a grill 50 extends in covering relationship over slot 48 to permit ingress and egress of air through grill 50 while preventing foreign objects from encountering a blade 52 forming an integral part of unit 40.

A standard 54 welded to the inner surface of tube 42 provides a base or support for an electric motor 56 which drives blade 52 for a purpose to be described hereinafter. The end 58 of tube 42 remote from conduit 38 is open to permit the flow of air in either direction in tube 42. If desired, a pair of skids 60 may be welded to supporting legs 62 which, in turn, are welded to tube 42 of unit 40 for supporting the latter as illustrated in FIG. 1 of the drawings.

A plurality of flaps 64 are secured at spaced intervals to the underside of top 23 and to the upper surface of bottom 34. It may be seen from FIGS. 2 and 3 of the drawings that the flaps 64 for top 23 are located immediately above the corresponding flaps 64 for bottom 34 so that cords 66 may be tied to grommets 68 in the respective flaps 64 to extend vertically between a pair of corresponding flaps 64. Thus, cords 66 provide spacers to maintain the shape of bag 22 substantially as shown in the drawings when the latter is inflated with air. The spacing of the flaps 64 may provide a somewhat tufted appearance to upper surface 24 of bag 22, but the latter is maintained as a generally flat surface adapted to receive thereon an object in motion for the purpose of cushioning and decelerating the object.

It has been found that substantially inelastic cords 66 are preferable to elastic members for the purpose of maintaining the generally rectangular configuration of bag 22 inasmuch as elastic members have a tendency to yield and impart a motion to surface 24 after impact which causes bouncing of the object which impinges upon bag 22. Further, for ease in manufacturing, it has been found desirable to utilize two cord segments for construction of the cords 66, the segments being tied together with a suitable knot. Manifestly, the adjustability afforded with the use of the cord segments eliminates the necessity for close tolerances in manufacture and permits adjustment of the lengths of cords 66 after assembly as may be necessary to insure that upper surface 24 of bag 22 is essentially flat and presents a reasonably level surface to receive the object in motion without tending to cause the latter to bounce after impact.

In the embodiment illustrated in FIGS. 1-4, a pair of auxiliary wedge-shaped cushions 70 are secured to front wall 26 in mutually spaced relationship, and each cushion 70 communicates with the interior of bag 22 through relatively restricted orifices 72 in wall 26 as shown. Manifestly, the ends of the walls of cushions 72 proximal wall 26 are secured to the latter in fluid-tight relationship by any suitable means.

The device chosen for illustration in FIGS. 1-4 is particularly suited as a landing cushion for use in pole vaulting events wherein the upright standards (not shown) for supporting the vaulting crossbar are adapted to be disposed immediately adjacent front wall 26 of bag 22. Thus, the cushions 70 extend forwardly from the device and on the side of the vaulting crossbar from which the vaulter will make his running approach during the jump. The vaulting box (not shown) is disposed immediately between the cushions 70.

Fan blade 52 is placed in motion by energizing motor

56 to impart artificial currents of air which are drawn through grill 50 and end 58 of unit 40, and are forced through conduit 38 into bag 22. The diameter of conduit 38 and port 36 is relatively large in relationship to the volumetric capacity of bag 22 so that the latter is inflated by operation of fan unit 40 in a relatively short period of time. Blade 52 is preferably of the "no overload" type as will be well understood by those familiar with the art, whereby the currents of air are forced into bag 22 until the air within the bag reaches a predetermined pressure, after which no further compression of the air in the bag is accomplished even though blade 52 continues to rotate. Unit 40 does not compress the air within bag 22 beyond a relatively low value intended primarily to be sufficient merely to inflate the bag so that the latter is filled with a quantity of air at this low pressure. It has been found that a fan capable of compressing the air in bag 22 to a value of approximately .25 inch of H₂O column is entirely adequate, and that compression to higher pressures is undesirable.

The air in bag 22 flows through orifices 72 to inflate the cushions 70. Thus, cushions 70 contain air at substantially the same pressure as the air in bag 22.

After the vaulter makes his jump, his body accelerates as he falls toward upper surface 24 of bag 22. Thus, the body of the vaulter attains a considerable amount of momentum by the time that initial contact is made with surface 24. The vaulter is met with little resistance on initial impact against surface 24 because of the extremely low pressure of the air within bag 22. However, as the vaulter strikes surface 24, the movement of his body depresses top 23 of the bag against the elastic quantity of air in the bag to begin cushioning the fall and deceleration of the vaulter. It is to be emphasized that the initial impact is very gentle upon the vaulter's body and may be almost imperceptible because of the low pressure of the quantity of air in the bag.

As further indentation is made in the bag by movement of the vaulter's body against surface 24, an increasingly greater area of the latter is depressed. This is schematically illustrated in FIGS. 5 and 6 of the drawings. The pressing of top 23 downwardly into the bag causes an elevation of the pressure of the air within the bag. This elevated pressure further retards movement of the vaulter and decelerates his body. At the same time, the elevated pressure very quickly causes the volume of air initially in bag 22 to flow outwardly through the substantially large diameter conduit 38 past the continuously operating fan blade 52. The almost instantaneous dumping of a large volume of air within bag 22, through port 36 and conduit 38, prevents the rise of air pressure within bag 22 to a value which would cause shock and impactive stresses to the vaulter's body.

Further, the compression of air within bag 22 does not reach a pressure value which results in bounce of the body. Rather, the body is lowered continuously and gently toward bottom 34 of the bag. It has been found that a bag about 15' x 20' (exclusive of cushions 70) with a depth ranging from 3' to 4' and having a port 2' in diameter, will lose air at a sufficient rate following the impact of an average size vaulter in a fall from approximately 16' so that the pressure within bag 22 never exceeds approximately 2" of H₂O column while bringing the vaulter to rest. This maximum pressure which is achieved when the vaulter's body has traversed approximately one-half the depth of bag 22, is not sufficient to cause more than mild stresses in the vaulter's body, whereby the vaulter continues to receive the sensation of a very gentle and soft deceleration.

It will be apparent that a bag of somewhat smaller dimensions may be utilized for high jumping purposes. In such event, the size of port 36 may be selectively varied to accommodate for objects having less momentum partially as a result of the fall from a lower height, main-

taining the proportion necessary to achieve pressures substantially as described above.

The rate of evacuation of the air as the latter is squeezed from bag 22 continues to be sufficient as the velocity and momentum of the vaulter decrease to avoid further pressure buildup and actually to lower the pressure of the air in bag 22 until the pressure again reaches approximately .25 inch H₂O column as the body comes to rest or is completely decelerated and gravitates at a uniform rate toward bottom wall 34 of the bag. The pressure of .25 inch H₂O column is constantly maintained by the continuous operation of unit 40 and insures that the vaulter's body is always resisted by air pressure and cannot proceed to impact with bottom 34 with sufficient velocity to shock or injure the vaulter. It will be understood that the egress of air through conduit 38 is always resisted by the continuously operating fan, but the no-overload characteristics of the latter insure that egress past the fan is possible at a rate to provide the enhanced damping of the momentum of the falling body as described above.

The position of the body of the vaulter after deceleration is schematically illustrated in FIG. 7 where it may be seen that a substantial portion of the inner surface of bag 22 is caused to impinge upon the elastic air within the bag as the body approaches complete deceleration, whereby the force of even the low pressure air is sufficient to counteract the weight of the body on the crumpled and partially deflated bag. Thus, the forces of the air counterbalance the weight of the vaulter and tend to prevent complete movement of the latter into contact with wall 34 of bag 22.

It has been found that the generally upright walls 26, 28, 30 and 32 of bag 22 enhance the operation of the latter for decelerating objects striking the surface 24 without a tendency to pitch the objects from the surface where they could be injured by striking the ground. Further, the restraining cords 66 also limit any tendency of the device to pitch the objects from the surface 24 after impact.

The cushions 70 are provided for breaking the fall of any vaulter who might land short of the impacting surface 24 through the abortive vault, broken pole or the like. These projecting cushions contain a quantity of low pressure air and, should the vaulter's body hurl against either of the cushions, the escape of air from the cushion through the orifices 72 is calculated to be of such a slow rate that the vaulter would be uninjured because of elasticity of the air partially entrapped in the cushion.

For cushions 70 containing approximately 48 cubic feet of air when inflated, two 3" diameter orifices 72 for each cushion have been found satisfactory. The gentle deceleration characteristics described in connection with bag 22 are not intended for short landings made on, or partially on, cushions 70. Rather, the bounce available from the trapped air is desirable in such emergency situations so that there is a tendency for the vaulter to be thrown or pitched toward the soft bag 22 for further gentle deceleration. The partially trapped air in cushions 70 operates as a barrier at the forward portion of the device which tends to prevent collapse of bag 22 and particularly front wall 26, thereby urging the vaulter's body rearwardly toward the soft landing portion of the bag. Yet, orifices 72 do permit metered escape of air to soften the landing in a manner to prevent injury to the vaulter as a result of landing short of the optimum location on bag 22.

The form of the invention illustrated in FIGS. 9 and 10 is similar to that described above and includes a flexible bag 122 which may be of the same material as that of bag 22. Bag 122, however, is provided with compartmentalizing walls 166 at spaced intervals on the inside of bag 122, and intersecting as illustrated. The walls 166 are provided with a plurality of slots 167 to permit substantially uninhibited flow of air within the interior of bag 122, yet the walls 166 maintain the desired inflated shape of bag

122 to present a substantially flat impactive surface 124. Further, the walls serve to provide the substantially vertical, outer edges of bag 122 to eliminate any tendency of an object to be pitched from the surface 124 after impact.

A flexible conduit 138 communicates through a port 136 with the interior of bag 122 similar to the construction of bag 22 as described above. However, conduit 138 communicates with an annular, rigid conduit 139 of sheet metal or the like and of substantially the same diameter as conduit 138. The latter is clamped by a clamp 146 in telescoped relationship with conduit 139 as illustrated in FIG. 10. A cylindrical tube 142 is partially telescoped in concentric relationship into the outer end of conduit 139 and is maintained by radially extending, rigid spacers 143 in axial alignment with conduit 139.

A fan unit, broadly designated 140, mounted within tube 142 provides artificial currents of air to inflate bag 122 through port 136, as will be understood. Unit 140 operates continuously and at a speed to maintain the pressure within bag 122 at a value in the range of the pressure described with respect to device 20. As the air emanates from the inner end of tube 146, it follows a path generally as illustrated by the arrows in FIG. 10. Thus, as the air fans out, it moves toward the inner surface of conduit 139 and provides a moving air seal to prevent egress of slightly pressurized air from bag 122. However, when an object impacts upon surface 124, this moving air seal is readily overcome to permit egress of air out the open end of conduit 139 and around the outer surface of tube 142. Thus, it is not necessary for the air to pass in a reverse direction by the rotating blade of unit 140. Rather, the air is provided with an auxiliary opening between the outer surface of tube 142 and the inner surface of conduit 139 for egress from the bag.

It will be noted that no auxiliary cushions are illustrated in connection with bag 122. Obviously, if the latter were to be utilized for pole-vaulting purposes, such cushions would be desirable and could be provided substantially identical to cushions 70 as illustrated in connection with bag 22. On the other hand, if these devices are to be used for cushioning the fall of high jumpers, it is preferable that no cushions be provided. It will be understood that device 20 could be constructed without the provision of cushions 70 and orifices 72 for this purpose.

Referring now to FIG. 8, a still further modified form of unit 240 for providing artificial currents of air to the flexible bags is illustrated. Thus, unit 240 includes an elongated, rigid tube 242 in which is mounted an electric motor 256 having an elongated, axially extending, splined motor shaft 257. A standard 254 supports motor 256 in tube 242 and radially extending spacer rods 259 support the end of shaft 257 proximal the flexible conduit 238 as shown. A spring 261 between motor 256 and blades 252 normally urges the blade into the position illustrated in full lines in FIG. 8 forwardly of an annular slot 248 in tube 242. When the pressure within the flexible bag connected to conduit 238 reaches a maximum value, it acts against blade 252 to cause the latter to shift against the bias of spring 261 along splined shaft 258 to the position illustrated in dashed lines in FIG. 8. It will be noted that this position is on the side of slot 248 remote from conduit 238 and its connected flexible bag, whereby relatively unobstructed egress of large volumes of air is permitted through slot 248 without interference by blade 252. When the pressure within the bag is again lowered to a value below that achieved during maximum pressure buildup, blade 252 is urged back into its normal position by spring 261 for maintaining the substantially low air pressure within the flexible bag.

One significant feature of all of the embodiments of this invention is the rapid rate of recovery of the bags to their normal inflated conditions following each use of the device for decelerating moving objects. It has been found that for a bag of the dimensions described above utilizing

a fan unit capable of achieving the pressures mentioned, the bag can be filled with air to such pressure in approximately 30 seconds time. Thus, after each vault or jump there is no appreciable delay until the subsequent vault or jump may take place. Further, after the device has been utilized, the fan unit can be disconnected from its source of electrical energy. The bag can be quickly and easily disconnected from the fan unit by means of the releasable clamp following which the bag unit can be immediately folded or rolled into a highly compressed condition. This permits one man to carry the deflated bag with one arm and the fan unit with the other for ready transportation to storage facilities. Manifestly, re-assembly of the unit for use can be quickly and easily accomplished.

It is to be emphasized that the theory of operation of the devices of this invention is to be distinguished from conventional cushions which rely upon the ever increasing compression of the captive air in a flexible bag to accomplish deceleration of an object. Such devices have a tendency to achieve compression of the air to an amount which causes shock to the object and pitch or bounce which can injure a vaulter.

Further, devices of this kind which rely on limited metering of the air through an orifice to avoid excessive buildup of pressure, are highly susceptible to destruction through inadvertent puncture of the flexible material. On the other hand, it is not really important with the devices of this invention that the material be absolutely impervious to the flow of air. So long as the punctures which do occur to the flexible bags are not sufficiently great that the air pressure cannot achieve a value which will distend the bag to its inflated condition, it will still operate satisfactorily for gently cushioning the fall of moving objects. Thus, vaulters or jumpers may use spiked shoes and the punctures which might be created from such use have a negligible effect inasmuch as the fan units are capable of producing whatever air flow may be required for distending the bags.

It will also be appreciated that the devices of this invention do not necessarily have to be utilized in horizontal positions for decelerating falling objects. On the contrary, the principles of the invention are equally applicable for decelerating moving objects which impinge upon the surface of the bag as by throwing or the like, even though the bag may not be in a horizontal position.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A device for decelerating an object in motion comprising:

a hollow, flexible, inflatable body having a conduit placing the same into communication with the atmosphere for flow of air into and out of the body, said body having an impact surface for disposition within the path of travel of said object, said surface being movable inwardly of the body in response to the force of said object thereagainst; and fan means in said conduit rotatable continuously in a direction for holding said body normally inflated with air from the atmosphere at a constant pressure for damping said motion without shock to the object striking said surface, said conduit and said fan means being adapted for escape of the air from the body while the fan means continue to rotate in said direction in response to said inward movement of the impact surface,

the air flow capacity of said conduit and said fan means being proportioned to the mass and to the velocity of said object for discharge of air from the body solely through said conduit at a rate to rapidly relieve the body of pressure build-up resulting from initial impact and thereby preclude rebound, yet restrict the egress of said air from the body through said conduit to cushion said object through the elasticity of the air in the body until the object comes to rest.

2. The invention of claim 1, said fan means having a no overload type blade whereby currents of air are forced into said body until said pressure is attained with no further compression of the air in the body.

3. The invention of claim 1, one end of said conduit subjacent the body being open to the atmosphere, said fan means being between the body and said one end of the conduit, said conduit being elongated and of uniform cross-sectional area throughout its length.

4. The invention of claim 1, said fan means having blade means rotatable about an axis parallel with the longitudinal axis of the conduit and within a plane normal to said axis of the conduit, presenting a barrier normally preventing escape of air from the body and yieldable to exhaust of air from the body in response to said pressure build-up.

5. The invention of claim 1, said fan means having a blade reciprocable toward and away from said body; and means yieldably holding the blade biased toward the body,

said conduit having an auxiliary opening between the ends of the path of reciprocation of the blade for augmenting the flow of air into and out of the body,

6. The invention of claim 2, a tube telescoped in said conduit at that end of the latter remote from the body, said unit being housed in the tube, said conduit having a larger diameter than that of the tube, presenting an auxiliary opening between the tube and the conduit to augment the flow of air through the tube.

7. The invention of claim 3, said conduit having an auxiliary opening to augment the flow of air through said one end thereof.

8. The invention of claim 7, said auxiliary opening surrounding the conduit between said one end of the conduit and said fan means adjacent the latter.

9. The invention of claim 3, said blade being shiftable toward and away from said one end of the conduit; and means yieldably holding the blade biased toward the body.

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BOBBY R. GAY, *Primary Examiner*.

A. CALVERT, *Assistant Examiner*.