Dec. 11, 1962 T. R. FREDRIKS 3,067,699

LOADING SYSTEM

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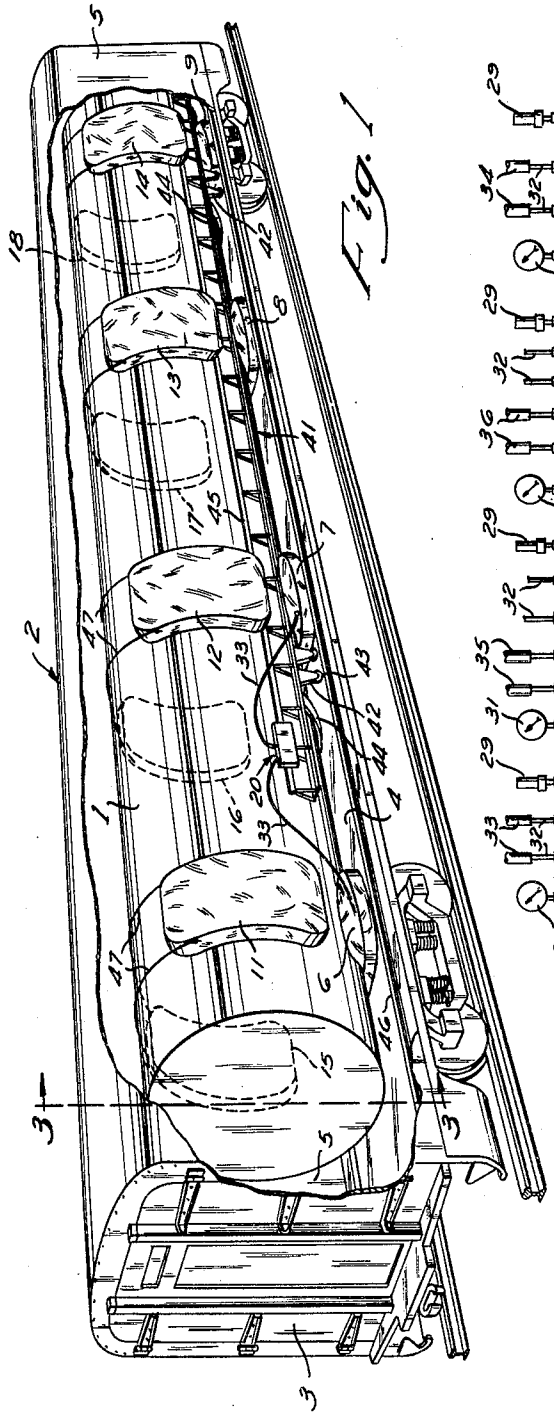


Fig. 1

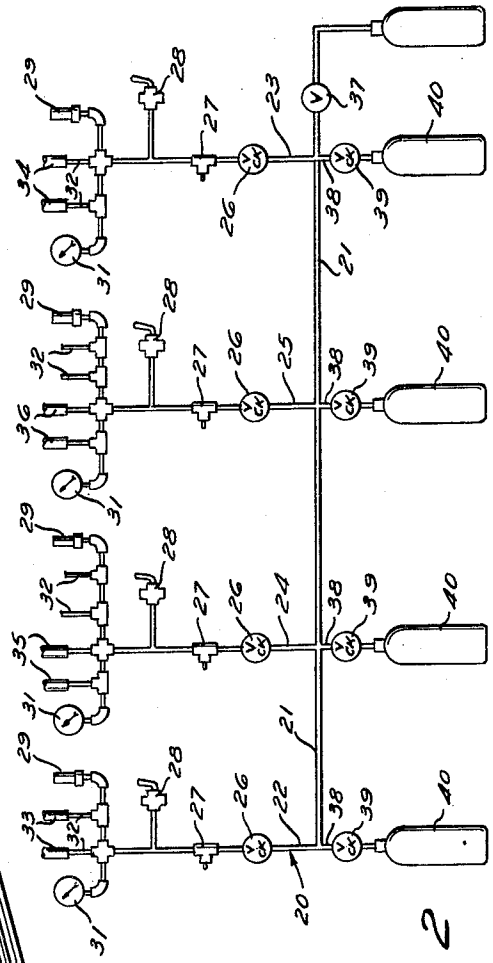


Fig. 2

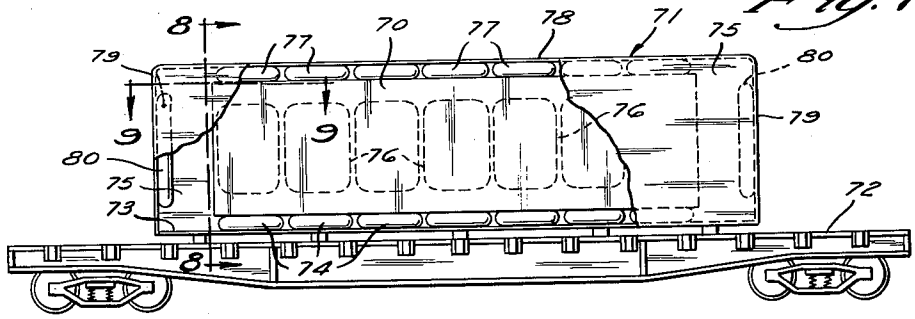
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LOADING SYSTEM

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Fig. 7



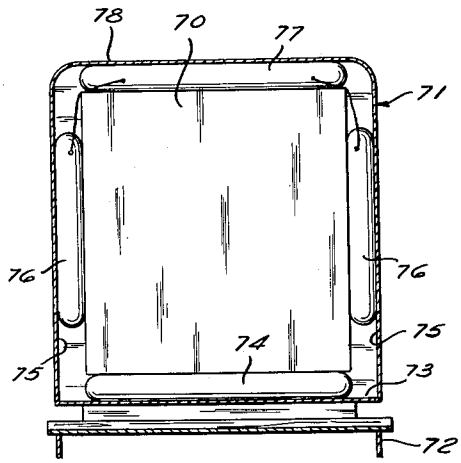


Fig. 8

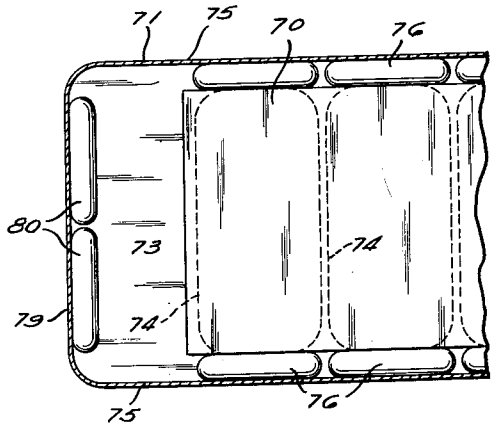


Fig. 9

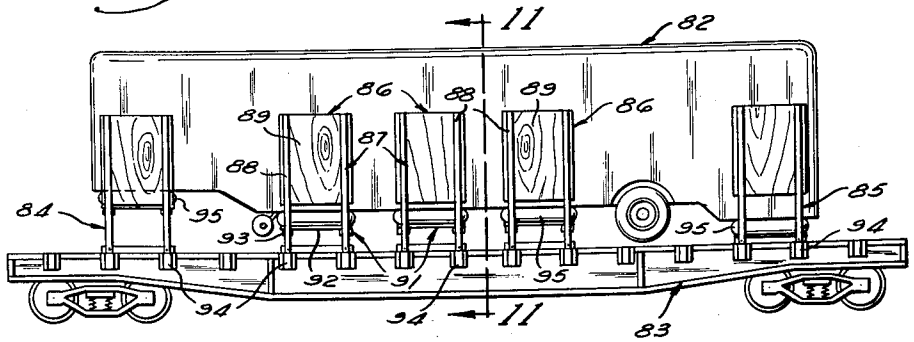


Fig. 10

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LOADING SYSTEM

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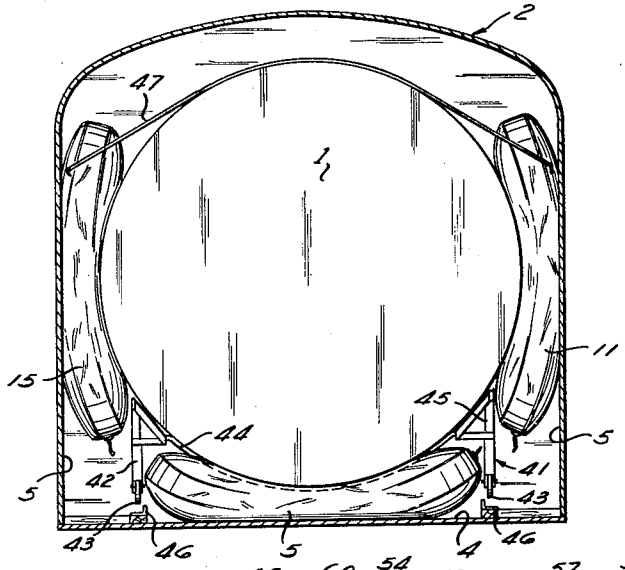


Fig. 3

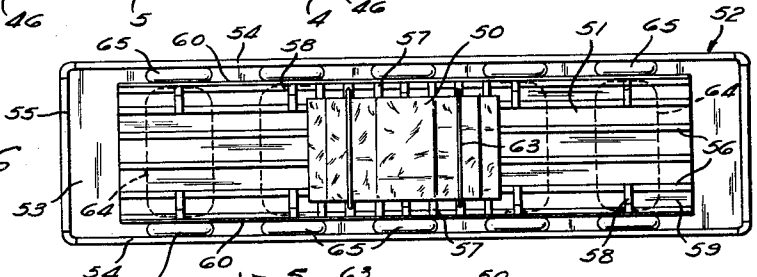


Fig. 6

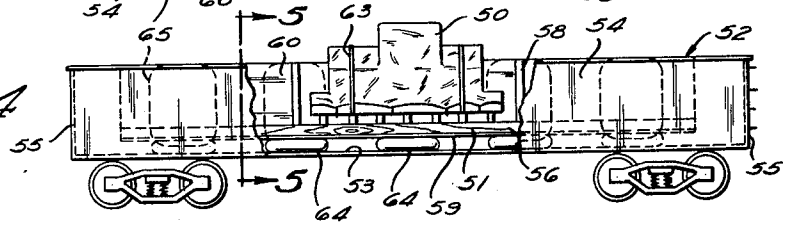


Fig. 4

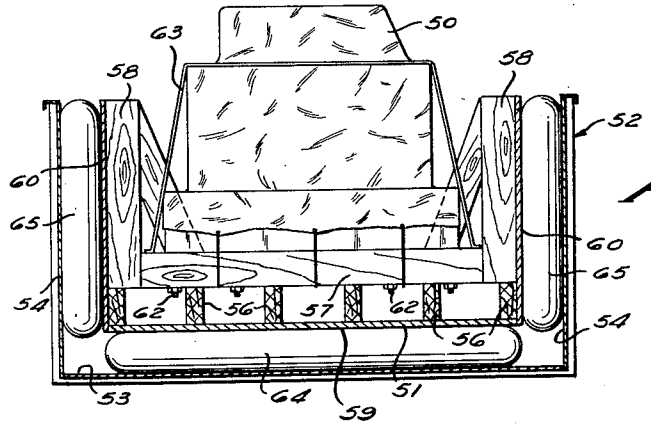


Fig. 5

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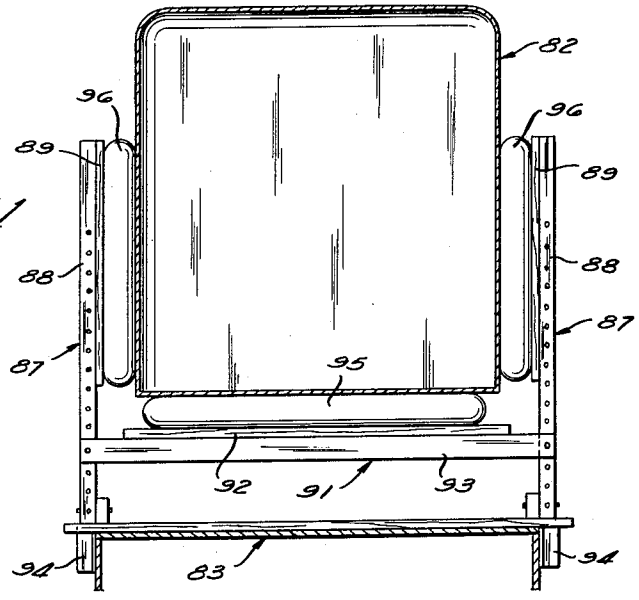


Fig. 11

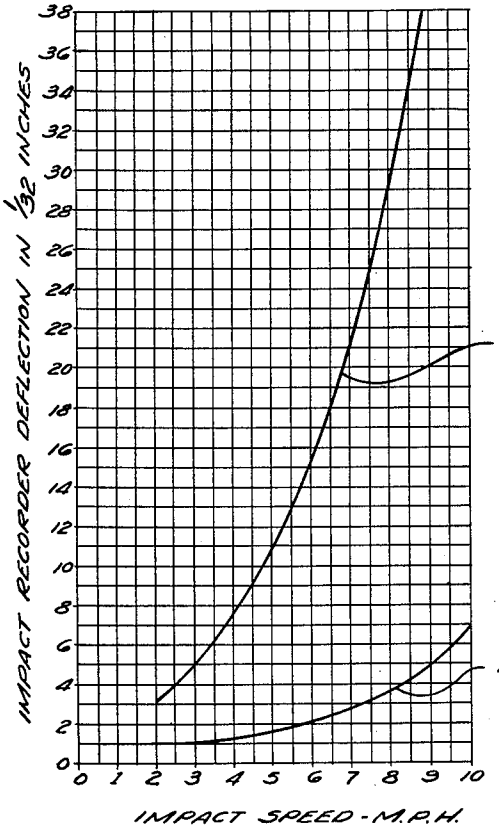


Fig. 12

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United States Patent Office 3,067,699 Patented Dec. 11, 1962

3,067,699

LOADING SYSTEM

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Filed Mar. 21, 1960, Ser. No. 16,445
12 Claims. (Cl. 105—369)

This invention relates to loading systems for freight cars and for other conveyances, and more particularly to protective loading or dunnage systems employing bags or similar flexible enclosures filled with air or other suitable gas. While the invention may be used advantageously to protect loads carried by various types of conveyance, for convenience it will be discussed in connection with railroad cars, in which use it provides particular advantages.

The protection of loads or cargo from damage due to shocks is of vital importance in transportation by railroad cars as well as by other means of transportation. The problem is intensified when the load is fragile in that it is relatively easily damaged by shocks. In railroad transportation, as in other types of transportation, shocks which could damage such a load that is not properly protected can occur from various causes on starting, transit or stopping of the load-carrying conveyance. Thus, on starting a train of railroad cars, the locomotive usually sequentially takes up the slack in the draft gear of each car so that each car is started individually; therefore, in a long train of cars the locomotive may be travelling at a substantial speed when the last cars in the train begin to move; the result is that each of these cars may be started with considerable jerk and shock in a longitudinal direction. During transit, the cars may be subjected to shocks in all directions from vibrations, as well as to substantially transversely directed shocks and substantially vertically directed shocks arising from track and equipment conditions, and to shocks in the direction longitudinally of the car due to "run-ins" and "run-outs" when cars abruptly change speeds relative to adjacent cars with attendant striking or jerking of draft gears. Shocks from these causes during transit may be characterized by high frequencies and magnitudes which can damage fragile loads; for example, vibrations alone can result in shock frequencies of from about 30 to about 100 cycles per second, and in vertically directed shocks of as high as 5 *g*'s (where "*g*" is the acceleration of gravity, or about 32.2 feet per second per second).

In general, however, the shocks are most pronounced on stopping. If the car is stopped by braking, the shocks can be of considerable magnitude if the braking is uneven or applied too rapidly. The greatest shocks on stopping, however, usually occur during switching and like operations when the railroad car strikes, or is struck by, one or more other cars. Even at switching speeds that are not considered to be excessive, impacts can occur under some circumstances that result in decelerations of the car at rates greater than 20 *g*'s and in corresponding shocks to a load carried by the car. Deceleration and shock of such magnitude can occur, for example, when a light car, such as one of relatively light construction which is relatively lightly loaded, travelling at substantial speed, strikes a string of heavily loaded cars having their brakes set and draft gear contracted so that they form a substantially immovable object. The resulting type of impact is often referred to as a "stone wall" impact. An impact of this type can result in deceleration of the above order of magnitude even if the switching speed is within the range of 4 to 8 miles per hour established as acceptable practice; however, it is impossible to avoid occasional impacts at speeds as high as 14

miles per hour, with resulting higher decelerations and shocks. Shocks of this order of magnitude are fortunately rare. Nevertheless, shocks are often developed in switching which even though of lesser magnitudes, are sufficient to damage fragile loads in the absence of special precautions. The shocks on stopping are primarily longitudinal, although there may be lesser shocks in the vertical and transverse directions.

From the above, it is apparent that the shocks to which railroad cars are subjected, and which provide the greatest potential for damage to the load, are by far the greatest in directions longitudinally of the car. Protection of the load against shocks in these directions is more important and considerably more difficult than protection against vertical or transverse shocks.

When loads in railroad cars are tied down, blocked or braced in accordance with widely used conventional methods, substantially all shocks imparted to the car are transmitted from the car to the load. In many cases, the loads are of such shock-resistant character that the shock-absorbing capabilities of the draft gear and truck springs of the railroad car are sufficient to prevent damage to the load. However, it is often desired to transport fragile or sensitive loads which cannot be sufficiently protected by the draft gear and springs. For such loads, the loading system should be effective to protect the loads against all shocks likely to be encountered on starting, transit, stopping and switching. Preferably, the system should not require special railroad cars or substantial modification of existing cars, due to the high costs involved in modifying cars and in routing and scheduling specialized equipment. The loading system should be relatively inexpensive and easily installed in existing cars, and should not itself be delicate or susceptible to being damaged or rendered ineffective by shocks to which the car may be subjected.

The various loading systems heretofore proposed or used for protecting fragile loads have been deficient in one or more respects. Most of them have involved the use of special equipment, or have required substantial modification of existing railroad cars, or have been difficult to install. Most of such prior systems have been expensive. Few if any have been as effective as desired. For example, in prior dunnage systems employing air bags, the bags have been used purely as space fillers to assist in wedging or bracing the load in the railroad car. While such bag systems have provided some shock absorption, primarily by removing slack between a load unit and adjacent load units or car walls, they are not capable of adequately protecting fragile loads against shocks of high magnitudes, particularly in the longitudinal and vertical directions, resulting from the various causes dsecribed above.

An object of this invention is to provide a loading system for railroad cars or other conveyances which is effective to protect fragile loads against shocks of substantial magnitude in any direction. Another object is to provide such a loading system which is exceptionally effective in protecting fragile loads against shocks in longitudinal directions; i.e., parallel to the direction of travel of travel of the railroad car or other conveyance. Another object is to provide such a loading system which may be readily installed in existing railroad cars or other conveyances with very little, if any, modification of the cars or conveyances so that at the end of the trip the car or conveyance may be released for general uses. Another object is to provide such a loading system which is inexpensive, simple, and easy to install. A further object of the invention is to provide a loading system in which bags or similar enclosures inflated with air, gas or other suitable fluids support the load and, when the conveyance is subjected to shock in the direction of travel, permit con-

trolled restrained longitudinal movement of the load through substantial distances to absorb or dissipate part of the change in kinetic energy of the load and reduce the rate of acceleration or deceleration of the load to values where shock damage to the load is prevented.

Expressed generally, the invention provides a loading system in which the load (which term as used herein includes a carrier, crate or the like for the actual goods or article being shipped) is carried in a railroad car or other conveyance in such manner that when the conveyance is subjected to a shock parallel to the direction of travel the load can move for a substantial distance parallel to the direction of travel against restraining forces provided by distortion of impermeable bags or similar flexible enclosures inflated at low pressures with air or other suitable gas. Preferably, the bags contact and frictionally engage the conveyance and also the load on the bottom and sides, and if desired or necessary on the top, in such manner that the load is entirely carried by the bags. The bottom bags provide vertical support for the load and, together with the side bags and with the top bags if used, protect the load from substantially vertically directed shocks; the side bags also protect the load from transverse shocks; and the bottom and side bags, and the top bags if used, protect the load from shocks in the longitudinal direction. The protection against longitudinally directed shocks is achieved since the bags are such that they permit the load to move longitudinally with respect to the conveyance for a substantial distance, through clear spaces at the ends of the load, against the restraining forces provided by the bags. Such movement relative to the conveyance against the restraining forces provided by the bags, acts to reduce the rate of acceleration or deceleration of the load, and increases the time during which the kinetic energy of the load is changed by being dissipated on stopping or by being increased on starting of the load; the load is thus protected from substantially longitudinally directed shocks as will be more fully described later. The protection against vertically directed shocks arises not only because of the cushioned support provided by the bottom bags, but also because the side bags permit restrained vertical movement of the load; if top bags are used, they aid in protection against vertical shocks by their cushioning action at the top of the load. The cushioned support of the load and the restrained load movements provided by the bags also effectively dampen and greatly reduce frequencies of vibration and shocks, so that the shock frequency to which the load is exposed is much lower than that to which the conveyance is subjected.

Further advantages, objects and a fuller understanding of my invention will become apparent from the following description of preferred forms thereof, reference being made to the accompanying drawings in which

FIGURE 1 is a perspective elevation, with parts broken away, showing one loading system embodying gas-filled bags according to the present invention, as applied to an elongated cylindrical load carried in a closed baggage car;

FIGURE 2 is a detail elevation, partly diagrammatic, showing a gas supply system for supplying and maintaining gas pressure in the bags of the loading system of FIGURE 1;

FIGURE 3 is a sectional elevation, along line **3—3** of FIGURE 1, showing the bottom and side bags;

FIGURE 4 is a side elevation, with parts broken away, showing another embodiment of the invention as applied to a concentrated load mounted on an auxiliary carrier or cradle supported in a gondola car by a loading system embodying the invention;

FIGURE 5 is a sectional elevation along **5—5** of FIGURE 4;

FIGURE 6 is a plan elevation of the embodiment of FIGURE 4;

FIGURE 7 is a side elevation, with parts broken away, of another embodiment of the invention, comprising a

trailer van with wheels removed, mounted on a flatcar, and having a load carried therein by a loading system embodying the present invention;

FIGURE 8 is a cross-sectional elevation, to an enlarged scale, along line **8—8** of FIGURE 7 showing the load supported in the van;

FIGURE 9 is a plan sectional elevation along line **9—9** of FIGURE 7 and to the same scale as FIGURE 8;

FIGURE 10 is a side elevation of another embodiment of the invention, showing a complete trailer van including its wheels, mounted on a flatcar by a loading system embodying the present invention;

FIGURE 11 is a sectional elevational along line **11—11** of FIGURE 10; and

FIGURE 12 depicts curves of impact recorder deflections plotted against impact speeds for a van mounted on a railcar and for a load supported in the van by a loading system embodying the present invention, and graphically shows the shock protection provided by the present invention.

In FIGURES 1, 2 and 3, the load **1** is carried in the railroad car **2**. The railroad car is a standard baggage car approximately 70 feet long and 8 feet wide inside, having at one end doors **3** which when open provide a doorway approximately 8′ wide and 8′ high.

The illustrated load is of elongated cylindrical shape and is approximately 6½′ in diameter, 64′ long and weighs approximately 16,000 lbs. It is supported from the floor **4** of the car and the sides **5** by means of air bags in accordance with the present invention, with approximately 3 feet of clear space at each end of the car. In the illustrated loading system there are four air bags **6**, **7**, **8** and **9** between the bottom portion of the cylndrical load **1** and the floor **4** of the car, four air bags **11**, **12**, **13** and **14** between one side **5** of the car and the load, and four similar air bags **15**, **16**, **17** and **18** between the other side **5** of the car and the load. While the air bags may be of various types, those illustrated are commercially available flexible, non-elastic air bags comprising an outer casing made of nylon or similar fabric and a synthetic rubber such as neoprene, containing a bladder of butyl or other suitable rubber designed for a 10 lb. per square inch maximum working pressure and a 28 lb. per square inch bursting pressure. Preferably, each of these bags when uninflated has approximately the form of a rectangle and is about 2 feet thick when inflated to the range of pressures used and not under load. The supporting bags at the bottom of the load are preferably nominally 4′ x 7′ with the long length extending transversely of the load while the side bags are nominally 4′ x 5′ and are disposed with the longer length extending substantially vertically. The bags are shown as spaced equidistantly along the length of the load for satisfactory distribution of forces. While, as will be explained later, any one of various gases in a range of pressures may be used in the bags, in the illustrated embodiment the bottom bags **6** to **9**, inclusive, are filled with air at a pressure of approximately 3 lbs. per square inch, and the side bags are filled with air at a pressure of approximately 1 lb. per square inch, all pressures being above atmospheric.

To facilitate the inflation of the bags and to automatically supply gas to maintain substantially constant static pressure in the bags in the event of leakage or pressure changes from other causes during long trips, a supplemental gas supply system is provided. This system comprises a control center identified generally by reference numeral **20**, shown in FIGURE 1 and to an enlarged scale in FIGURE 2. The control center comprises a main supply manifold **21** to which are connected four vertically disposed secondary supply manifolds **22**, **23** and **24** and **25**, each comprising a check valve **26**, a pressure regulating valve **27**, a bleed cock **28**, a relief valve **29**, a pressure gauge **31** and the required number of outlets **32** to the bags. Secondary manifold **22** has two outlets **32** which are connected by suitable tubes **33** to the bottom bags at the

left of FIGURE 1; these two tubes 33 are shown in FIGURE 1, the remaining tubes described below being omitted so as not to encumber the drawing. Similarly, secondary manifold 23 has two outlets 32 connected through tubes 34 to the two air bags at the bottom of the load at the right of FIGURE 1. The four outlets 32 of secondary manifold 24 are connected through tubes 35 to the four side bags 11 to 14, inclusive, on the near side of FIGURE 1, while the four outlets 32 of the secondary manifold 25 are connected through tubes 36 to the four side bags 15 to 18, inclusive, on the far side of FIGURE 1. The main supply manifold 21 is provided with a suitable valve 37 to which an air supply from a station line, portable compressor or car train line can be connected to fill the bags initially. The gas supply system also comprises a plurality of connections 38 to the main supply manifold 21, each being equipped with suitable check valve 39, which are connected to suitable tanks 40 of air or bottled gas such as carbon dioxide under pressure; this supplemental gas supply is for the purpose of maintaining pressure in the bags during an extended trip.

In FIGURES 1 and 3, the load 1 is shown as mounted in an auxiliary carrier or cradle generally indicated by 41 by means of which the load may be moved into or out of the car through doors 3. The cradle illustrated comprises two dollies 42 each having one or more pairs of rollers 43, a transverse member 44 connecting the dollies on opposite sides of the load, and longitudinal truss members 45 on each side of the load forming parts of the dollies.

On loading or unloading of the cylindrical load 1 from the car, the rollers travel on tracks 46 temporarily fastened to the floor 5 of the car. By this means the load may be moved into or out of the car when the air bags are not inflated or are not present. When the air bags are in position and inflated, the rollers 43 are lifted above the tracks 46 and do not engage them, as shown in FIGURE 3.

While the frictional engagement of the air bags with the load and the inner surfaces of the car will hold the bags in place after the bags are inflated, it is preferable to use elastic cords 47 to support the bags while uninflated during loading and unloading, and to position them during and after inflation.

FIGURES 4, 5 and 6 illustrate the invention as applied to the transportation of an article being shipped, shown at 50, which is of irregular shape, of considerable weight, and has a relatively small base area. It is rigidly supported on an auxiliary supporting carrier 51 by suitable conventional bracing or tie-down means; carrier 51 is supported in the gondola car 52 by a loading system embodying the present invention. The carrier 51 and the article 50 thus constitute the load. The gondola car 52 shown is a standard open-topped type having a flat bottom 53, vertical side walls 54, and vertical end walls 55. The carrier 51 may be of any suitable design which provides the necessary strength to carry the article being shipped and the necessary bottom and side surface area for engaging bottom and side bags according to the present invention. The illustrated carrier member is a non-permanent structure formed of lumber, comprising longitudinal bottom framing members 56, cross framing members 57 and side framing members 58. The longitudinal bottom framing members 56 are surfaced with panel members to provide a substantially smooth continuous bottom 59 of considerable area; the side framing members 58 are similarly provided with panels to form substantially smooth continuous sides 60 of considerable area. While the carrier 51 is of considerable length in the embodiment shown there are several feet of clearance between each end of the carrier and the car end. The load 50 is shown as rigidly fixed to the cradle 51 in a conventional manner by means of bolts 62 and strapping 63.

A plurality of air bags 64 are located between the bottom 59 of the carrier 51 and the bottom 53 of the gondola car. Between each side 60 of the carrier 51 and the corresponding side wall 54 of the gondola car are disposed a plurality of side air bags 65. The air bags may be of a similar type to those previously described; the number and sizes are dependent largely on the weight of the load 50 and are selected according to the principles discussed later so that the load is not only supported against vertical and transverse shocks, but is also protected against longitudinal shocks, since the load is permitted to move longitudinally for a substantial distance against the restraining forces of the bottom and side air bags.

The air bags 64 and 65 of this embodiment may also be provided with a supplemental gas supply system, similar to that described above, to facilitate filling of the bags with air and to maintain pressure during long trips; they may also be secured by cords, as described previously.

FIGURES 7, 8 and 9 show an arrangement in which a load 70 is supported in a truck trailer van 71 mounted on a flatcar 72 by an air bag loading system embodying the invention. The van 71 has had its wheels removed and is supported on and fixed to the flatcar by suitable means, not shown. In accordance with known practice, the van, with wheels attached, may be loaded, driven to the flatcar, loaded on the car with its wheels removed, transported to the destination, have wheels attached, and driven to the point of unloading. This practice and the means for making it possible form no part of the present invention.

In the loading system inside the van which embodies the invention, the load 70 is shown as having the shape of, or being contained in, a suitable container or carrier having the shape of a parallelepiped. Between the bottom of the load and the floor 73 of the van are disposed a plurality of inflated air bags 74. Between each side of the load 70 and the adjacent side 75 of the van there are disposed a number of air bags 76. Furthermore, a plurality of air bags 77 are shown as disposed between the top surface of the load and the top 78 of the van.

There is a space of approximately 30 inches between the end of the load and each end 79 of the van; as shown one or more auxiliary air bags 80 may be disposed in the space adjacent each end of the van; these bags ordinarily do not contact the ends of the load but serve as emergency buffers in the event that shocks more severe than those for which the system is designed should cause the load to travel longitudinally more than the calculated distance. However, under ordinary circumstances it is not necessary to employ the air bags 80.

The air bags may be similar to those described in connection with FIGURES 1 to 3, inclusive. In the embodiment of FIGURES 7, 8 and 9, however, for a load 70 of approximately 20 tons and spaces approximately 6" wide between the top, bottom and sides of the load and the van, seven bottom air bags 74, which are approximately 4' wide and 6' long, are disposed with their longer dimensions extending transversely of the trailer van, each bag being inflated with air to a pressure of approximately 3 lbs. per square inch; at each side, seven approximately 4' x 5' air bags 76 are located with the longer dimension vertically, each of these bags having an air pressure of approximately 1 lb. per square inch; and at the top of the load, there are six air bags 77, which are approximately 4' x 7' in size, disposed with the long dimension extending transversely, each bag having an air pressure of approximately 1 lb. per square inch. The two air bags 80 shown at each end for emergency buffering are approximately 4' x 7' and are inflated to a predetermined thickness.

It is obvious that the above or similar loading systems embodying the invention may be used in truck trailer vans having their wheels attached which are mounted on railroad flatcars in accordance with conventional "piggyback" practices.

FIGURES 10 and 11 show another embodiment comprising a complete trailer van 82, including its wheels, mounted on a flatcar 83 by air bags according to the loading system in the present invention. In this arrangement,

the trailer van **82** constitutes the load; the cargo inside the van may also, if desired, be supported by a system embodying the invention. The van **82** is supported on flatcar **83** by means of end saddle members **84** and **85** and intermediate saddle members **86**. Each of these saddle members comprises two side units **87** formed of two vertical framing members **88** fixed to a vertically and longitudinally extending panel member **89**, and a bottom unit **91** extending transversely of the car and comprising a horizontally extending panel member **92** fixed to spaced cross frame members **93** which are connected to vertical framing members **88**. Each of the saddle members is rigidly but non-permanently fixed to the car **83** by insertion of the lower ends of vertical framing members **88** into the stake pockets **94** at the sides of the car. The bottom unit is designed so it may be adjustably connected a any desired height to side units **87**.

In each saddle member, an air bag **95** is disposed between the horizontal bottom panel member **92** of the saddle member, and the bottom of the trailer van, while a vertically disposed air bag **96** is disposed between each vertical panel member **89** of each saddle member and the adjacent side portion of the trailer van. Suitable cords or ropes may be used to tie or otherwise hold the air bags in place. In the illustrated arrangement the load represented by the van is approximately 24 tons; the bottom air bags **95** are approximately 4′ wide and 7′ long and are disposed transversely of the trailer van, while the side air bags are approximately 4′ wide and 5′ long and are disposed substantially vertically with their long dimensions vertically of the trailer van. The bags under load are approximately 8″ thick; the bottom bags have an air pressure of approximately 4 lbs. per square inch and the side bags have an air pressure of approximately 2 lbs. per square inch.

In each of the loading systems described above, the load is fully supported by inflated air bags. One group of air bags, shown in the examples as located at the bottom of the load, supports the load vertically and aids in protecting it against vertically directed shocks; another group of air bags, shown as located at the sides of the load, supports the load laterally and aids in protecting it against laterally and vertically directed shocks. The air bags in these bottom and side groups contact and frictionally engage in non-slipping relation surfaces of substantial area fixed to the conveyance and surfaces of substantial area fixed to the load, these latter surfaces being either surfaces of the article itself which is being shipped, or of an intermediate carrier on or in which the article is mounted.

The bags of the two groups, and if desired the bags of an additional group which contact surfaces of substantial areas attached to the load and to the vehicle such as the top bags shown in FIGURES 7 and 8, also act to protect the load against shocks directed longitudinally of the conveyance; as was indicated above, these shocks normally are by far the greatest to which the conveyance is subjected. Such protection is effected because the air bags permit the load to move in the direction of the shock, which is parallel to the direction of movement of the conveyance, against restraining forces provided by the bags. The frictional engagement between the bags and the above-mentioned surfaces of the vehicle and load are such that the bags do not slip or slide appreciably, if at all, relatively to such surfaces while the bags undergo shear-type deformation due to such movement of the load. Generally, the load oscillates or reciprocates in directions parallel to the direction of the shock, usually to and from positions on each side of the normal position of the load at rest. In any event, after completion of such oscillatory movement, the load returns to the original position it occupied before the movement.

Considered from one aspect, the shock protection arises because the movement of the load through a substantial distance against the restraining force provided by the bags requires work which dissipates the kinetic energy of, or imparts kinetic energy to the load. Considering the simplest but the most frequently occurring shock-producing situation, in which the motion of the load changes from the velocity of the conveyance to a state of rest, or vice-versa, the following equation applies:

$$Fd=\frac{mv^2}{2} \quad (1)$$

where "F" is the restraining force provided by the bags, "*d*" is the distance through which the load moves against the restraining force of the bags, "*m*" is the mass of the load and "*v*" is the velocity of the load. When the load is on a moving vehicle such as a railroad car striking a fixed object such as a string of loaded cars with a "stone wall" impact as previously described, the velocity "*v*" is that of the vehicle immediately before the impact; when the load is on a stationary vehicle such as a railroad car which is rapidly started, as by being struck by another car or jerked on starting of a train the velocity "*v*" is the ultimate velocity reached on such sudden starting. Ordinarily, the velocity "*v*" is a speed in the accepted range of 4 to 8 miles per hour, but may be as high as 14 miles per hour.

Considered from another aspect, the loading system of the invention protects the load against the shocks by greatly reducing the acceleration to which the load is subjected; this is accomplished because the longitudinal movement of the load due to air bag deformation increases the time during which the velocity of the load is changed. Again, taking the simplest, but most frequent occurring shock-producing situation, during which the load is brought from a velocity to a state of rest or vice-versa, the following equation applies:

$$a=\frac{v}{t} \quad (2)$$

in which "*v*" is the velocity of the load, "*t*" is the time in which the load is brought from a velocity to a state of rest or vice-versa, and "*a*" is the acceleration to which the load is subjected, acceleration being the rate of change of velocity, whether the velocity is increasing or decreasing. It is obvious that the greater the time "*t*," the smaller is the acceleration "*a*."

The restraining force "F" required to perform the above indicated function of shock protection is dependent on the mass "*m*" of the load and the acceleration of the load as defined above, in accordance with the equation:

$$F=ma \quad (3)$$

Therefore, given the load and the maximum acceleration "*a*" to which the load can be subjected without damage, it is possible to determine the required restraining force "F."

From Equation 1, the restraining force "F" can also be calculated:

$$F=\frac{mv^2}{2d} \quad (4)$$

where "*m*," "*v*" and "*d*" are defined as above. From Equations 3 and 4 above, the acceleration "*a*" can also be determined to be:

$$a=\frac{v^2}{2d} \quad (5)$$

If it is desired to determine the distance through which the load would move, this can be calculated from the following equations, which are respectively based on Equations 4 and 5:

$$d=\frac{mv^2}{2F} \quad (6)$$

$$d=\frac{v^2}{2a} \quad (7)$$

By use of the proper equations set forth above, in appropriate units, it is possible to design a loading system

embodying the invention; in general Equation 4 is the most helpful. The load is usually known, which establishes the mass "*m*." The velocity "*v*" which will produce, or result from, the maximum shock to be guarded against is also usually known or can be readily established. The distance "*d*" through which the load moves against the restraining force provided by the bags, according to the present invention should be between about 8" to 30" and preferably from about 15" to 23". These distances are the minimum clearance distances which should be provided at the end of the vehicle such as the railcar to permit longitudinal restrained movement of the load according to the invention. It has been found that when the distance "*d*" exceeds about 30", the deformations of the bags are excessive and the bags may slip relatively to the load or vehicle; at distances below about 8" the total resistance force to be provided by the bags becomes excessive. Optimum action in load restraint and shock absorption is obtained when the distance is between about 15" to about 23".

From either Equation 3 or 4, it is possible to determine the total restraining force "F" which the bags must provide in order to achieve the results of the invention for a given load, distance "*d*," and velocity "*v*" or acceleration "*a*." By means of Equation 5 it is also possible to determine if the maximum acceleration to which the load can be subjected without damage will be exceeded, if it is the criterion of protection against shocks.

While various types of bags may be employed, it has been found advantageous to use commercially available air bags such as those previously described, ranging in size from approximately 22" to 48" in width, and from about 3' to 9' in length; in general the maximum distance "*d*" should be no more than about two thirds of the bag width. Preferably, each of the bags is of approximately the shape of a rectangle when uninflated, and of a thickness considerably less than, and preferably no more than about a half of, its width when inflated and not under load; each bag preferably is located with its width and its longest dimension transversely of the direction of travel and preferably substantially at right angles to such direction. The bags supporting the load from its bottom should be of such size and number that their total projected area contacting the load, multiplied by the pressure used in the bags, provides a total force sufficient to offset the weight of the load and the force provided by any top bags used, and to support the load clear of the floor of the conveyance while providing a bottom bag thickness within the range outlined below. Such total area of these bags should result in a bag pressure falling within the preferred range of from approximately 1 lb. to 5 lbs. per square inch; and preferably the pressure should be as low as possible within the range consistent with the provision of the necessary support and clearance of the load from the floor. Pressures of from about ½ lb. to 3 lbs. per square inch are preferably used in air bags, located at the sides or tops of the load or elsewhere, which primarily provide longitudinal restraining forces. In general, in loading systems embodying the present invention, the thickness of the inflated air bag after it is mounted between the surface fixed to the load and the surface fixed to the vehicle should be between about 4 to about 12 inches; exceptional advantages in providing maximum holding power and satisfactory operation during the shear-type deformation are provided when the bags are between approximately 6 and approximately 10 inches in thickness when in place.

In general, according to the present invention, best results are obtained when each of the bags is of such type that when inflated as described above to a pressure of from about ½ to about 5 lbs. per square inch, it provides a restraining force of from about 500 to about 1800 pounds when deformed by displacement of its sides approximately 15" transversely, and preferably substantially at right angles, to the length and thickness of the bag. The number of bags and their air pressures to be used may thus be readily determined from the total required restraining force "F," determined as described above.

FIGURE 12 is a graphical showing of results of impact tests of a railroad car carrying a load supported by a loading system embodying the present invention. The tests were carried out with a loading system similar to that illustrated in FIGURES 7, 8 and 9. Two vans were mounted on the flatcar, the total weight of the loaded car being approximately 161,000 lbs. One van had a gross loaded weight of approximately 47,000 lbs.; the other 36' long van on which tests were conducted had an approximate gross weight of 52,000 lbs., of which approximately 46,000 lbs., was a load supported in the van by a loading system similar to that described in connection with FIGURES 7, 8 and 9. In this van, the load was supported at the bottom by seven air bags of approximately 4' x 6' in dimension inflated to a pressure of about 3 lbs. per square inch. On each side of the load there were seven nominal 4' x 5' air bags and on the top of the load there were six nominal 4' x 7' air bags, the side and top air bags being inflated to a pressure of approximately 1 lb. per square inch. At each end of the load there was a clear space of approximately 30". The clearance between the load and between the bottom, sides and top of the van was approximately 6", which therefore was the thickness of the air bags in place. Mounted on the van and on the load were impact recorder devices, rated at 1 "*g*" per 4/32" of reading.

The loaded car was caused to strike three loaded gondola cars having a gross weight of approximately 140,000 lbs. each; several tests were made with the loaded flatcar moving at speeds of approximately 4, 6 and 8.5 miles per hour immediately prior to impact. During the impacts the load reciprocated back and forth on the air bags; during the higher impact speeds the maximum movement in one direction was nearly 30". As shown in FIGURE 12, the impact recorder showed much less shock on the load than on the car. Thus, at an impact speed of approximately 8.5 miles per hour, the impact recorder reading on the load was approximately 4/32" or 1 *g* and on the van was approximately 34/32" or 8.5 *g*'s indicating that the shock to the load was reduced by more than 85%.

Test runs of railroad cars carrying fragile loads supported according to the present invention have been made, some of them involving transcontinental trips. In these cases the shocks to which the loads themselves were subjected in transit were extremely small as compared to the shocks to which the cars were subjected, and the loads were transported in undamaged condition. For example, a loading system embodying the invention reduced to less than ¾ *g* on the load shocks of as high as 5 *g*'s imparted to the car by vibration, and reduced vibrational shock frequency to less than 3 cycles per second on the load from 30 to 100 cycles per second on the car.

From the above, it is apparent that the present invention provides a loading system which is simple of installation, inexpensive and highly effective to protect loads against heavy shocks, even exceeding those to be normally expected in rail or other vehicular transportation. While air bags have been described as the means for supporting the load and restraining it while permitting longitudinal movement, bags or similar enclosures filled with suitable fluids other than air may be employed. Although the invention has been described in connection with the transportation of loads in railroad cars, it is obvious that the loading systems embodying the system may be employed in other types of vehicles such as trucks and airplanes. Supplemental gas supply means or bag-securing cords may be employed in each of the embodiments where not shown, and means for these purposes different from those specifically described may be employed in any of the illustrated embodiments.

Furthermore, while various specific types of loading systems have been described in the disclosed embodiments, those skilled in the art will appreciate that the invention may be employed in loading systems other than those specifically disclosed herein and that various changes and modifications other than those indicated above can be made in the invention without departing from the spirit and scope thereof. The essential characteristics of the invention are defined in the appended claims.

I claim:

1. A loading system for protecting a load against shocks comprising a longitudinally extending conveyance comprising a longitudinally extending floor surface and other longitudinally extending surfaces of substantial areas, a load having associated with it bottom and other longitudinally extending surfaces of substantial areas, inflated bags located between and contacting in essentially frictional essentially non-slipping relation said bottom and floor surfaces of said load and said conveyance, and other inflated bags located between and contacting in essentially frictional essentially non-slipping relation adjacent longitudinally extending surfaces of said load and said conveyance, the load being carried by said conveyance so that there is a substantial clear distance at each end of the load through which it can move against restraining force provided by shear-type deformation of said bags when the conveyance is subjected to longitudinally directed shocks, the loading system being such that it substantially complies with the equation

$$F=ma$$

in appropriate units, in which "F" is the total restraining force provided by the bags, "*m*" is the mass of the load, and "*a*" is the maximum acceleration to which the load can be subjected without damage thereto, each of the bags being such that when inflated to a pressure between ½ to 5 lbs. per square inch and when deformed so its surfaces which contact the surfaces of the load and conveyance are relatively displaced in shear-type deformation for approximately 15" it provides a restraining force of from about 500 to about 1800 pounds, the total number of said bags being such as to provide the total restraining force "F" and deformation of said bags provides essentialy all protection for the load against longitudinally directed shocks.

2. A loading system for protecting a load against shocks comprising a longitudinally extending conveyance comprising a longitudinally extending floor surface and other longitudinally extending surfaces of substantial areas, a load having associated with it bottom and other longitudinally extending surfaces of substantial areas, inflated bags located between and contacting in essentially frictional essentially non-slipping relation said bottom and floor surfaces of said load and said conveyance, and other inflated bags located between and contacting in essentially frictional essentially non-slipping relation adjacent longitudinally extending surfaces of said load and said conveyance, the load being carried by said conveyance so that there is a substantial clear distance at each end of the load through which it can move against restraining forces provided by shear-type deformation of said bags when the conveyance is subjected to longitudinally directed shocks, the loading system being such that it substantially complies with the equation

$$F=\frac{mv^2}{2d}$$

in appropriate units, in which "F" is the total restraining force provided by the bags, "*m*" is the mass of the load, "*v*" is the velocity of the conveyance immediately prior to impact against a substantially immovable object such velocity being in the range of from about 4 to about 14 miles per hour, and "*d*" is the longitudinal distance through which the load moves against the restraining force "F" of the bags and is in the range of from about 8" to about 30", each of the bags being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when deformed so its surfaces which contact the surfaces of the load and conveyance are relatively displaced in shear-type deformation for approximately 15" it provides a restraining force of from about 500 to about 1800 pounds, the total number of said bags being such as to provide the total restraining force "F" and deformation of said bags provides essentially all protection for the load against longitudinally directed shocks.

3. A loading system for protecting a load against shocks comprising a longitudinally extending conveyance comprising a longitudinally extending floor surface and other longitudinally extending surfaces of substantial areas, a load having associated with it bottom and other longitudinally extending surfaces of substantial areas, inflated bags located between and contacting in essentially frictional essentially non-slipping relation said bottom and floor surfaces of said load and said conveyance, and other inflated bags located between and contacting in essentially frictional essentially non-slipping relation adjacent longitudinally extending surfaces of said load and said conveyance, the load being carried by said conveyance so that there is a substantial clear distance at each end of the load through which it can move against restraining forces provided by shear-type deformation of said bags when the conveyance is subjected to longitudinally directed shocks, the loading system being such that it substantially complies with the equation

$$F=ma$$

in appropriate units, in which "F" is the total restraining force provided by the bags, "*m*" is the mass of the load and "*a*" is the maximum acceleration to which the load can be subjected without damage thereto, each of said bags having approximately the form of a rectangle when uninflated and being disposed in the loading system with its longest dimension and thickness extending transversely of the longitudinal direction of the conveyance, each of said bags also being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and deformed transversely of the length and thickness of the bag in shear-type deformation for approximately 15" it provides a restraining force of from about 500 to about 1800 pounds, the total number of said bags being such as to provide the total restraining force "F" and deformation of said bags provides essentially all protection for the load against longitudinally directed shocks.

4. A loading system for protecting a load against shocks comprising a longitudinally extending conveyance comprising a longitudinally extending floor surface and other longitudinally extending surfaces of substantial areas, a load having associated with it bottom and other longitudinally extending surfaces of substantial areas, inflated bags located between and contacting in essentially frictional essentially non-slipping relation said bottom and floor surfaces of said load and said conveyance, and other inflated bags located between and contacting in essentially frictional essentially non-slipping relation adjacent longitudinally extending surfaces of said load and said conveyance, the load being carried by said conveyance so that there is a substantial clear distance at each end of the load through which it can move against restraining forces provided by shear-type deformation of said bags when the conveyance is subjected to longitudinally directed shocks, the loading system being such that it substantially complies with the equation

$$F=\frac{mv^2}{2d}$$

in appropriate units, where "F" is the total restraining force provided by the bags, "*m*" is the mass of the load, "*v*" is the velocity of the conveyance immediately prior to impact against a substantially immovable object such velocity being in the range of from about 4 to about 14

miles per hour, and "*d*" is the longitudinal distance through which the load moves against the restraining force "F" of the bags and is in the range of from about 8" to about 30", each of said bags having approximately the form of a rectangle when uninflated and being disposed in the loading system with its longest dimension and thickness extending transversely of the longitudinal direction of the conveyance, each of said bags also being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when deformed transversely of the length and thickness of the bag in shear-type deformation for approximately 15" it provides a restraining force of from about 500 to about 1800 pounds, the total number of said bags being such as to provide the total restraining force "F" and deformation of said bags provides essentially all protection for the load against longitudinally directed shocks.

5. A loading system for protecting a load against shocks comprising a longitudinally extending conveyance having a floor and side surfaces of substantial areas, a load having bottom and side surfaces of substantial areas, inflated bags located between and contacting in essentially frictional essentially non-slipping relation the bottom and floor surfaces of said load and said conveyance, and other inflated bags located between and contacting in essentially frictional essentially non-slipping relation each side surface of said load and the adjacent side surface of said conveyance, the load being carried by said conveyance so that there is a substantial clear distance at each end of the load through which it can move against restraining force provided by shear-type deformation of said bags when the conveyance is subjected to longitudinally directed shocks, the loading system being such that it substantially complies with the equation

$$F=ma$$

in appropriate units, in which "F" is the total restraining force provided by the bags, "*m*" is the mass of the load, and "*a*" is the maximum acceleration to which the load can be subjected without damage thereto, each of said bags having approximately the form of a rectangle when inflated and being disposed in the loading system with its longest dimension and thickness extending transversely of the longitudinal direction of the conveyance, each of said bags also being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when deformed transversely of the length and thickness of the bag in shear-type deformation for approximately 15" it provides a restraining force of from about 500 to about 1800 pounds, the total number of said bags being such as to provide the total restraining force "F," and of said number of bags there being sufficient bags between the bottom and floor surfaces of the load and conveyance to support the load clear of said floor surface of the conveyance, and deformation of said bags provides essentially protection for the load against longitudinally directed shocks.

6. A loading system for protecting a load against shocks comprising a longitudinally extending conveyance having a floor and side surfaces of substantial areas, a load having bottom and side surfaces of substantial areas, inflated bags located between and contacting in essentially frictional essentially non-slipping relation said bottom and floor surfaces of said load and said conveyance, and other inflated bags located between and contacting in essentially frictional essentially non-slipping relation each side surface of said load and the adjacent side surface of the conveyance, the load being carried by said conveyance so that there is a substantial clear distance at each end of the load through which it can move against restraining force provided by shear-type deformation of said bags when the conveyance is subjected to longitudinally directed shocks, the loading system being such that it substantially complies with the equation

$$F=\frac{mv^2}{2d}$$

in appropriate units, where "F" is the total restraining force provided by the bags, "*m*" is the mass of the load, "*v*" is the velocity of the conveyance immediately prior to impact against a substantially immovable object such velocity being in the range of from about 4 to about 14 miles per hour, and "*d*" is the longitudinal distance through which the load moves against the restraining force "F" of the bags and lies in the range of from about 8" to about which the load moves against the restraining force "F" of 30", each of said bags having approximately the form of a rectangle when uninflated and being disposed in the loading system with its longest dimension and thickness extending transversely of the longitudinal direction of the conveyance, each of said bags also being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when deformed transversely of the length and thickness of the bag in shear-type deformations for approximately 15" it provides a restraining force of from about 500 to about 1800 pounds, the total number of said bags being such as to provide the total restraining force "F" and of said number of bags there being sufficient bags between the bottom and floor surfaces of the load and conveyance to support the load clear of the floor surface of the conveyance, and deformation of said bags provides essentially all protection for the load against longitudinally directed shocks.

7. A loading system according to claim 3 in which said bags are inflated with gas and which comprises supplemental gas supply means for automatically supplying gas to each inflated bag to maintain substantially constant static pressure therein over an extended period of time.

8. A railroad car loading system comprising a railroad car having a floor, and walls and side walls, and having at one end a doorway opening substantially the entire end of the car; guide tracks fixed to the floor of the car; an elongated load, of a length sufficiently less than the length of the car so as to provide a substantial clear distance at each end of the car, said load being carried on rollers fixed to said load near each end thereof and adapted to engage said guide rails and provide guided rolling support for said load during loading and unloading of said car; a plurality of inflated bags disposed between the floor of said car and said load, said bags being adapted when inflated to support the load with its rollers clear of said floor and said guide rails; and a plurality of inflated bags disposed between each side of the car and said load, all said bags engaging said car and said load over substantial areas in essentially frictional essentially non-slipping realtion and permitting said load to move longitudinally of said car against restraining forces provided by shear-type deformation of said bags to protect the load against shocks imparted to the car longitudinally thereof, each of said bags having approximately the form of a rectangle when uninflated and being disposed with its longest dimension and thickness extending transversely of said railroad car, each of said bags being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when subjected to shear-type deformations for approximately 15" transversely of the length and thickness of the bag it provides a restraining force of substantially 500 to 1800 pounds, said bags being employed in sufficient number below and at the sides of said load to support said load and to permit longitudinal movement thereof through the clear space at an end of the car for a distance between about 8" to about 30" when the car is subjected to an impact equivalent to that resulting from striking a substantially immovable object at a speed between about 4 and about 14 miles per hour and shear-type deformation of said bags provides essentially all protection for the load against shocks imparted to the car longitudinally thereof.

9. A railroad car loading system comprising a railroad car carrying members providing horizontally disposed surfaces; a truck trailer van supported on said car, having bottom and side surfaces of substantial areas; a plurality of inflated bags disposed between the horizontally disposed surfaces of said car and the bottom surfaces of said van and supporting said van so all portions thereof clear said car; a plurality of side members fixed to said car and providing side surfaces of substantial areas disposed adjacent to but spaced from said side surfaces of said van; a plurality of inflated bags disposed between each side surface of each side member and the adjacent side surface of said van, all said bags contacting said surfaces of said car and said van in essentially frictional essentially non-slipping relation and permitting said van to move longitudinally of said car against restraining forces provided by shear-type deformation of said bags to protect the van against shocks imparted to the car longitudinally thereof, each of said bags having approximately the form of a rectangle when uninflated and being disposed with its longest dimension and thickness extending transversely of said railroad car, each of said bags being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when subjected to shear-type deformation for approximately 15" transversely of the length and thickness of the bag it provides a restraining force of substantially 500 to 1800 pounds, said bags being employed in sufficient number below and at the sides of the van to support it and permit longitudinal movement thereof for a distance between about 8" to about 30" when the car is subjected to an impact equivalent to that resulting from striking a substantially immovable object at a speed between about 4 and about 14 miles per hour, said bags providing essentially all protection for the van against shocks imparted to the car longitudinally thereof.

10. A railroad car loading system comprising a railroad flatcar; a truck trailer van mounted on and attached to said flatcar, said van having a floor and inwardly facing side wall surfaces of substantial areas; a load supported in said van, said load having bottom and side surfaces of substantial areas, said side surfaces being disposed closely adjacent those of said van, said load being of a length substantially less than that of the interior of said van so as to provide a substantial clear distance at each end of the load; a plurality of inflated bags disposed between the floor of said van and the bottom surface of said load; a plurality of inflated bags disposed between each side surface of said van and the adjacent side surface of said load, all of said bags contacting said surfaces of said van and said load in essentially frictional essentially non-slipping relation and permitting said load to move longitudinally of said van against restraining forces provided by shear-type deformation of said bags to protect the load against shocks imparted to the van longitudinally thereof, each of said bags having approximately the form of a rectangle when uninflated and being disposed with its longest dimension and thickness extending transversely of said van, each of said bags being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when subjected to shear-type deformation for approximately 15" transversely of the length and thickness of the bag it provides a restraining force of about 500 to about 1800 pounds, said bags being employed in sufficient number below and at the sides of said load to support the load in the van and permit longitudinal movement thereof through the clear space at an end of the load for a distance between about 8" to about 30" when the van is subjected to an impact equivalent to that resulting from the railroad car striking a substantially immovable object at a speed between about 4 and about 14 miles per hour, said bags providing essentially all protection for the van against shocks imparted to the car longitudinally thereof.

11. A railroad car loading system comprising an elongated railroad car body having a floor and inwardly facing side surfaces of substantial areas, an elongated load supported by said car body, the length of said load being sufficiently less than the length of said car body so as to provide a substantial clear distance at each end of the load, said load having a bottom surface and outwardly facing side surfaces of substantial areas; a plurality of inflated bags disposed between said floor surface of said car body and said bottom surface of said load; a plurality of inflated bags disposed between each side surface of said car body and the adjacent side surface of said load, all said bags engaging said car body surfaces and said load surfaces in essentially frictional essentially non-slipping relation and permitting said load to move longitudinally of said car body against restraining forces provided by shear-type deformation of said bags to protect the load against shocks imparted to the car body longitudinally thereof, each of said bags having approximately the form of a rectangle when uninflated and being disposed with its longest dimension and thickness extending transversely of said railroad car, each of said bags being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when subjected to shear-type deformation for approximately 15" transversely of the length and thickness of the bag it provides a restraining force of substantially 500 to 1800 pounds, said bags being employed in sufficient number below and at the sides of said load to support said load and to permit longitudinal movement thereof through the clear space at the end of the load for a distance between about 8" to about 30" when the railroad car is subjected to an impact equivalent to that resulting from striking a substantially movable object at a speed between about 4 and about 14 miles per hour, and shear-type deformation of said bags provides essentially all protection for the load against shocks imparted to the car body longitudinally thereof.

12. A vehicle loading system comprising an elongated vehicle having a floor and inwardly facing side surfaces of substantial areas, an elongated load-carrier supported by said vehicle, the length of said carrier being sufficiently less than the length of said vehicle so as to provide a substantial clear distance at each end of the vehicle, said carrier having a bottom surface and outwardly facing side surfaces of substantial areas; a load supported by said carrier; a plurality of inflated bags disposed between said floor surface of said vehicle and said bottom surface of said carrier; a plurality of inflated bags disposed between each side surface of said vehicle and the adjacent side surface of said carrier, all said bags engaging said vehicle surfaces and said carrier surfaces in essentially frictional essentially non-slipping relation and permitting said carrier supporting said load to move longitudinally of said vehicle against restraining forces provided by shear-type deformation of said bags to protect the load against shocks imparted to the vehicle longitudinally thereof, each of said bags having approximately the form of a rectangle when uninflated and being disposed with its longest dimension and thickness extending transversely of said vehicle, each of said bags being such that when inflated to a pressure between about ½ to about 5 lbs. per square inch and when subjected to shear-type deformation for approximately 15" transversely of the length and thickness of the bag it provides a restraining force of substantially 500 to 1800 pounds, said bags being employed in sufficient number below and at the sides of said carrier to support said carrier and to permit longitudinal movement thereof through the clear space at the end of the vehicle for a distance between about 8" to about 30" when the vehicle is subjected to an impact equivalent to that resulting from striking a substantially movable object at a speed between about 4 to about 14 miles per hour, and shear-type deformation of said bags provides essentially all protection for the load against shocks imparted to the vehicle longitudinally thereof.

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