

Nov. 11, 1958

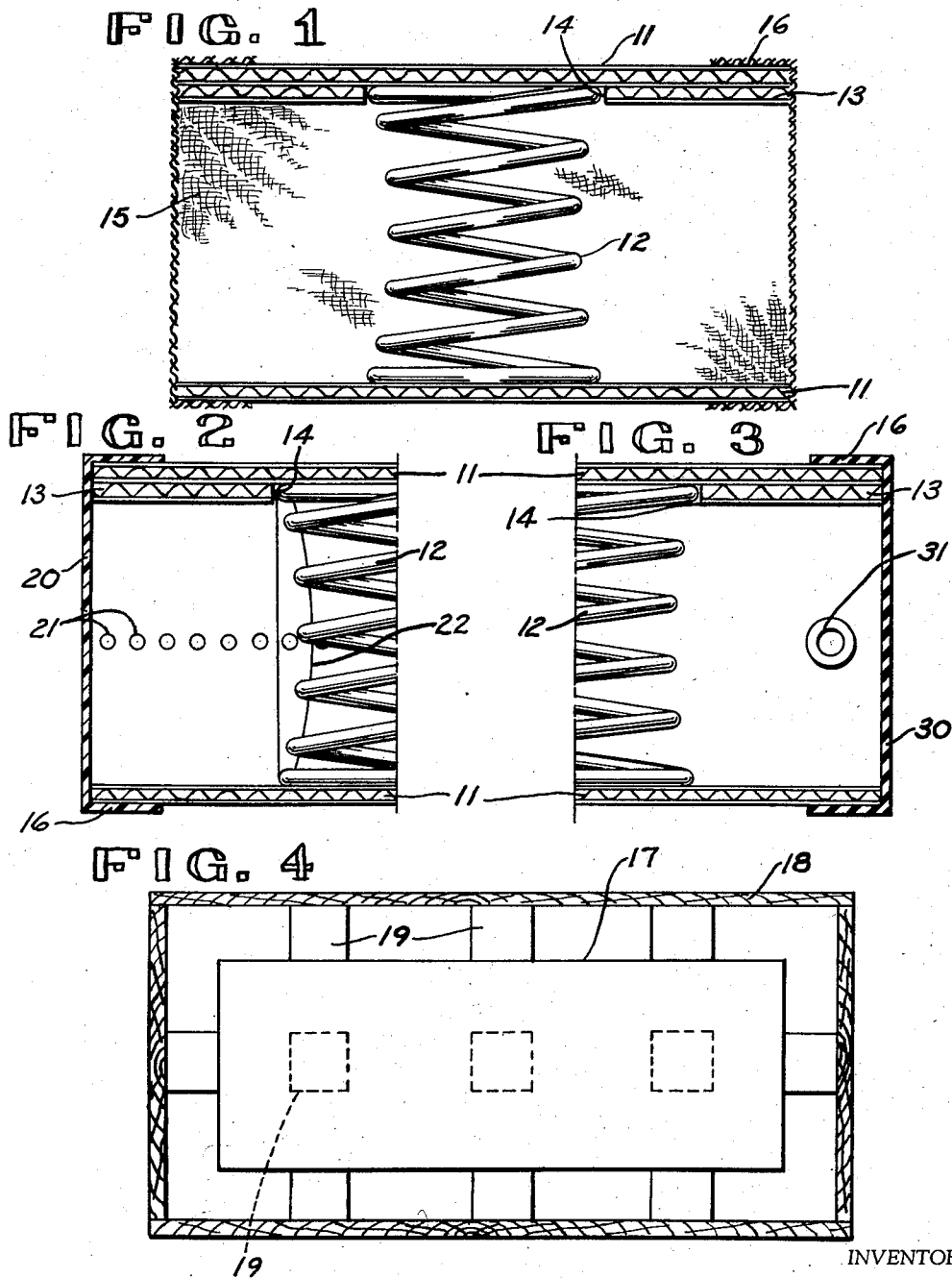
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2,859,959

SHOCK ISOLATOR

Filed Jan. 31, 1955

2 Sheets-Sheet 1



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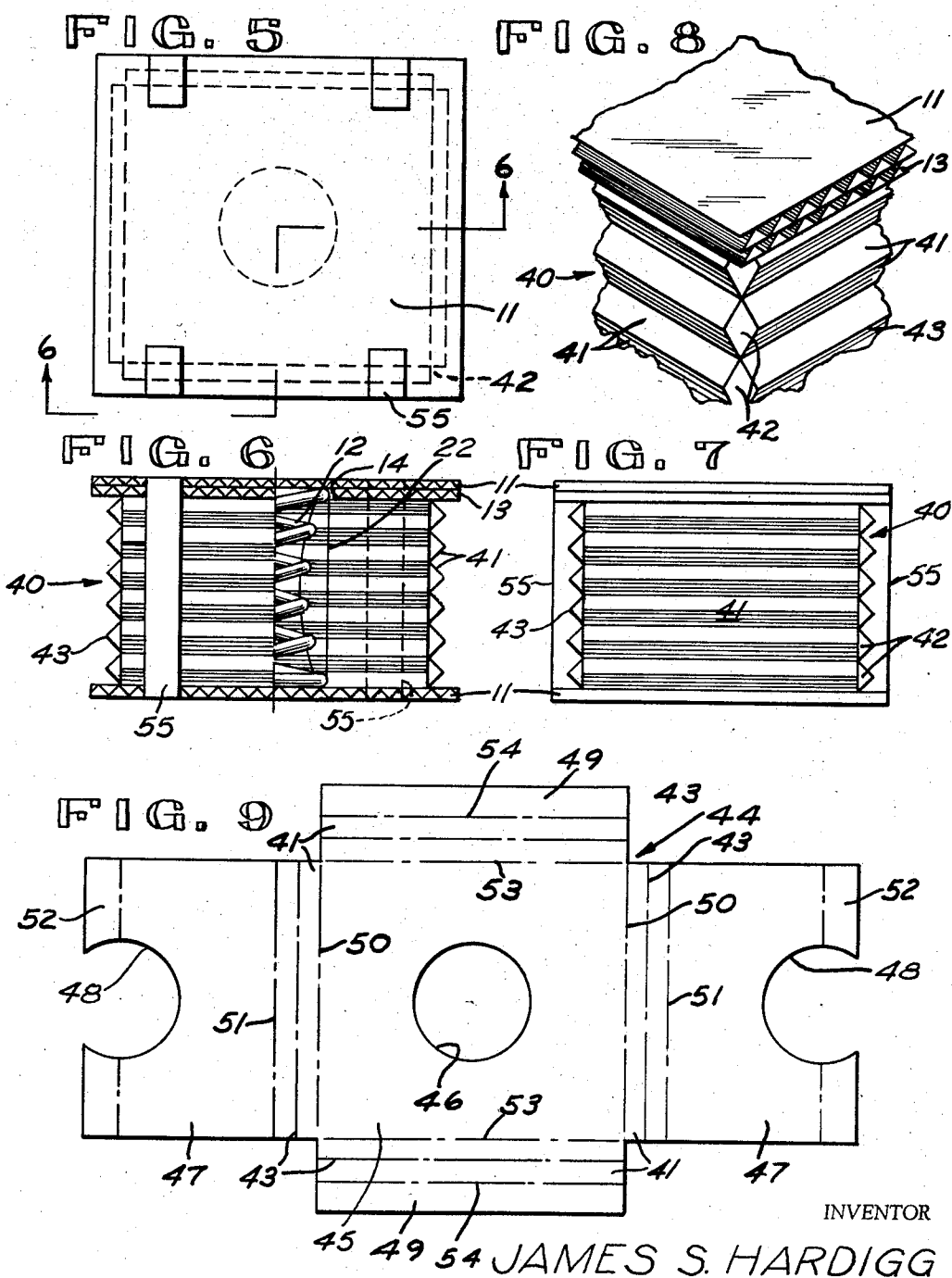
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SHOCK ISOLATOR

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Application January 31, 1955, Serial No. 484,969

10 Claims. (Cl. 267—1)

This invention relates to shock isolators, and in particular to elements adapted to cushion and protect machinery, equipment and the like from damage resulting from shock and/or vibration.

The protection of articles in the course of use, transportation and the like is a problem of considerable magnitude, particularly in the case of delicate, sensitive instruments and mechanisms. Shock damage thereto may occur through dropping while handling, and by the sudden stopping and starting of railroad cars, for example. Vibration damage may result from use in or transportation by railroads, trucks, ships or aircraft.

Major damage to delicate mechanisms results most commonly from dropping, in which case the articles are subjected to deceleration forces of great magnitude when they hit. Various cushioning materials and shock isolating devices are commonly employed, particularly in packaging, to prevent such damage. The prior art approaches to the problem involve severe limitations, particularly in the matters of expense and space involved. The use of compression cushioning materials is inefficient, since only a fraction of the basic material's capacity for energy absorption can be utilized. Additionally, the compression cushioning material required for particular applications usually has a weight which is a substantial fraction or more of the weight of the cushioned article, and its volume is frequently greater than that of the protected article. The extra shipping and storage space and weight involved frequently represent a greater expense than the direct cost of the cushioning material itself.

Air cushion shock isolators have been proposed, but are expensive and commonly require the use of elements of relatively great thickness in order to limit the deceleration of the protected article to acceptably low values, or alternatively require considerable space for lateral expansion. Pneumatic shock isolators utilizing air under initial pressure are unreliable due to leakage. Additionally, common air cushions are subject to rebound, which prolongs and multiplies the shock effect. In the case of very fragile articles, both compression cushioning materials and air cushions are inadequate to protect against vibration damage, particularly when the natural frequency of the cushioned article is in the range of vibration frequencies occurring in railroad cars. In such cases, resonance may occur and either the article or the shock isolator or both may be destroyed through fatigue.

It is a principal object of the present invention to provide a shock isolator of outstanding capacity and efficiency, of low weight and small volume, approximating in function and operation an ideal cushion.

Another object of the invention is to provide a shock isolating element utilizing atmospheric air pressure only, relatively unaffected by atmospheric conditions such as temperature, pressure and humidity.

A further object of the invention is to provide a reusable shock isolator, constructed primarily of common, inexpensive materials, including paper and plastic foil or sheets.

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Still another object of the invention is to provide shock isolators suitable for protecting articles from shock and vibration damage in packaging applications, and in the course of transportation, air dropping and under comparably severe conditions.

Another object is to provide shock isolators substantially fully compressible, whereby the entire thickness thereof may be utilized for energy absorption. Yet another object is to provide shock isolators having no rebound.

A specific object of the invention is to provide shock isolators having freely collapsing walls, whereby the device may be compressed without lateral expansion, and stresses on the wall material are confined to tension of a low or moderate order. Further objects will be in part evident, and in part pointed out hereinafter.

The invention and the novel features thereof may best be made clear from the following description and the accompanying drawings, in which:

Figure 1 is a vertical sectional view illustrating a simplified embodiment of the present invention;

Figure 2 is a vertical sectional view of a modified embodiment of the invention, provided with an apertured sheet enclosure;

Figure 3 is a vertical sectional view of another modified embodiment of the invention, provided with a valved sheet enclosure;

Figure 4 is a diagrammatic view illustrating one manner of utilizing the invention to mount and protect an article in an outer container;

Figure 5 is a plan view of a preferred embodiment of the invention;

Figure 6 is a sectional view taken along the line 6—6 of Figure 5;

Figure 7 is an end elevational view of the device of Figure 5;

Figure 8 is a perspective view of the device of Figure 5, on enlarged scale, illustrating the corner configuration and construction thereof, and

Figure 9 is an exemplary sheet layout illustrating an efficient and inexpensive manner of construction of the sheet envelopes employed in the embodiment of Figure 5.

Referring to the drawings in detail, the embodiment illustrated in Figure 1 includes two plate members 11.

Desirably, the plate members possess at least limited rigidity, and may be constructed of common materials such as metal or wood, or of corrugated fiberboard as shown. The plate members are preferably, but not necessarily, planar. The plate members 11 are normally separated and held apart in spaced relationship by resilient means such as the coil spring 12, which, as an important feature of the invention, may be maintained in partially compressed condition. To maintain the spring in desired central position, the upper plate member 11 may have a similar plate member 13 suitably affixed to the inner surface thereof, by means of glue, staples or the like, the plate member 13 being provided with a central recess 14 adapted to receive and retain the upper end of the spring. As will be evident, the upper plate member 11 and the plate member 13 may be integral, and the relative relationship between the spring and the plate member or members may be maintained in other common manner, as by means of staples.

The space between the plate members 11 is enclosed by a flexible sheet 15 having limited permeability to air. In one simple form, the sheet 15 may be constructed of textile fabric as shown, the physical characteristics of the textile fabric being selected to give the desired air permeability for specific applications. To secure sheet 15 to the plate members 11, the sheet may be provided with outwardly extending flaps or skirt portions 16. In the exemplary embodiment illustrated, the skirt portions

16 of the sheet 15 are folded over the outer surfaces of the plate members 11, and secured thereto in any conventional fashion, as by stapling or gluing. If desired the sheet 15 may be affixed to the edges or the inner surfaces of the plate members, it being necessary only that the sheet 15 enclose the space between the plate members in substantially air tight fashion. The effective area of the plate members may be square, round, rectangular or of other shape, the enclosing sheet 15 merely following the peripheral contour of the plate members.

The free, unattached length of the enclosing sheet 15 serves, in this embodiment, to maintain the pre-compression of spring 12 at the desired value, in that it limits the spacing between the plate members and thereby the degree to which the spring may extend. The spring 12 serves to keep the device fully open or extended, by maintaining the spacing between the plate members at the maximum permitted by sheet 15, and the sheet cooperates with the spring to maintain the sheet members normally in substantial parallelism.

In an obvious application, the shock isolating device of Figure 1 may be interposed between an article to be protected and an outer crate or container. Such relationship is illustrated in Figure 4, wherein an article 17 is mounted in outer crate 18, the article being separated from the outer crate by a plurality of shock isolator elements 19, each constructed in accordance with Figure 1, which are interposed between the article and the crate on all sides of the article, thereby protecting the article from shock in any direction. As will be evident, the elements 19 may be provided in special applications to protect against shock in a single direction only, or in two or more directions.

In such relationship, in the event the package is dropped in the direction of the spring axis of one or more elements 19, when the package hits the article 17 will exert great compressive force against the device or devices involved, depending upon the weight of the article, the height of the drop and other factors, tending to compress the elements in axial direction. The elements of the invention are well adapted to absorb the impact energy of the article, initially primarily by reason of compression of air inside the sheet 15. While the sheet 15 is air permeable, the initial compression of the air therewithin is at such a high rate that leakage of air therethrough in the initial compression period is inconsiderable. Further, the initial air pressure in the device is atmospheric, whereby the average pressure during the initial compression period is relatively low.

As the pressure within the device rises, the article 17 is accordingly decelerated, and the rate of compression, that is the rate of reduction of volume of the air inside the sheet 15, decreases. Concurrently, the device is progressively compressed, the sheet material wall collapsing without substantial lateral extension. Simultaneously, the leakage or flow of air through the interstices of the sheet fabric increases, until a balance is achieved, whereafter the pressure within the device remains substantially constant as the device is further compressed. The decelerating action of the device, accordingly, builds up smoothly to a predetermined maximum, and thereafter remains level at that value. As will appear, the device may be substantially fully compressed, to a point whereat the space between the plate members is substantially zero. To this end, it is desirable that the coils of the spring be of varying pitch diameter, to permit them to nest within each other under extreme compression. A conical spring may be readily provided, for example, which when fully compressed will fit entirely within the recess 14.

As previously indicated, the precompressed spring 12 maintains the device always fully extended, and ready to absorb shock energy. Additionally, preloading of the spring may be utilized to support the static weight of the article 17. In many applications the preloading of the

spring is desirably adequate to support the static weight of the article resting thereon, and further to resist the maximum anticipated vibration forces. Railroad car vibrations, for example, produce a maximum acceleration of about 1.1 g., or 1.1 times the weight of the article. Thus a spring force of 2.1 g., or slightly more than twice the weight of the article, will be sufficient to support the article without compression of the shock isolating device, and to prevent relative movement between the article and the container due to vibration. It may be demonstrated that the volume of spring material is least when the spring exerts the required initial force in the device at a pre-compression of one half of its free length. At this degree of pre-compression, the impact energy which may be absorbed by a spring exerting initially a force equal to twice the weight of the article, is equal to four times the weight of the article multiplied by the precompressed length of the spring. Utilizing a shock isolator of relatively small thickness, then, while the spring therein may be designed to support the static weight of the article and resist vibration forces, the fraction of the impact energy which may be absorbed by the spring is small compared to the total energy absorbed by the entire device in cushioning shock.

Since the internal pressure inside the device builds up smoothly to a maximum of moderate proportions, and is thereafter substantially constant, the compression forces exerted against the sheet 15 are but moderate, and the sheet is stressed in tension only. As the device compresses, the sheet necessarily forms into transverse folds or convolutions, and contracts in length in the manner of a bellows or accordion. Since the tension forces exerted against the fabric are but moderate, common fabrics such as broadcloth or burlap are entirely suitable.

A modified form of the invention is illustrated in Figure 2, wherein the device is constructed with plate members 11 and 13 and a spring 12 corresponding in all respects to those employed in the Figure 1 modification. In this embodiment, however, a flexible sheet 20 is employed, constructed of organic plastic film material such as regenerated cellulose, Pliofilm, Saran or Mylar. The plastic film material being normally relatively impenetrable to air, the sheet 20 is provided with a plurality of apertures 21. The size and number of the apertures 21 are selected for particular applications, to effect the desired air permeability. So constructed, the device will function in all respects in the manner of the embodiment previously described. In the initial compression of the device, the volume of air passing outwardly through the apertures 21 will be negligible, but the air leakage will increase with the pressure inside the sheet 20 until it attains a maximum value, whereafter it will decrease due to construction of the apertures. As a further modification, particularly useful when the precompression of the spring 12 is high, the extension of the spring may be limited by a plurality of clips or ties 22, extending between the end convolutions of the spring and adapted to absorb at least the major portion of the extending force thereof. By this expedient, the sheet 20 is relieved of a substantial part or all of the spring force, and serves when the device is in normal extended position primarily to maintain the plate members 11 parallel.

Another variation of the invention is illustrated in Figure 3, where a device corresponding to that of Figure 1 is constructed with a flexible sheet 30 of rubber or equivalent elastomeric material. In the sheet 30 is provided one or more valve elements 31, adapted to pass air outwardly therethrough when the pressure in the interior of the sheet 30 reaches a predetermined value. The valve 31 may include a spring pressed ball, or similar conventional pressure relief valve means. In this embodiment, in the initial compression of the device, the sheet 30 may bulge outwardly to some degree, a consequence not detrimental if lateral clearance is available. The outward bulging of the sheet 30 may be limited, if desired, and the sheet

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reinforced by a net of cords extending about the sheet. When the pressure inside the shock isolator reaches the predetermined value the valve 31 will open, and air may then escape from the interior of the device at a rate determined largely by the area of the valve passage. Additionally, means may be provided to readmit air to the interior of sheet 30 when the device returns to normal extended position.

It can be demonstrated that an air cushion functioning with air discharge operates in ideal fashion if there is no discharge of air during initial compression, until maximum working pressure is attained. The discharge area should then be effective at a maximum value, which should diminish in linear fashion as the cushion is thereafter compressed to bottom position. As a practical matter, this ideal function is approximated by each of the embodiments described above. A modification of the invention functioning in a manner approaching this ideal even more closely is illustrated in Figures 5 to 9.

Referring to these figures, a preferred embodiment of the invention comprises the customary plate members 11, maintained in spaced relationship by the precompressed coil spring 12, the extension of which may be limited by a plurality of ties 22. In this embodiment, the space between the plate members is enclosed by a plurality of flat sheet envelopes 40, each substantially coextensive in area with the plate members. Each sheet envelope 40 comprises peripheral wall portions 41, separated from corresponding wall portions of the same envelope by slits 42, which extend, as will be evident, in direction generally normal to the sheet members. Each respective wall portion 41 is transversely creased at 43, whereby the wall portions resemble and function in compression of the device as pleats or folds.

The envelopes 40 may be constructed of any suitable sheet material, wet strength kraft paper being entirely suitable and preferred. A simple manner of forming the individual envelopes may be readily understood by consideration of the blank 44 illustrated in Fig. 9. The blank 44, inexpensively cut from a flat sheet of paper, comprises a rectangular central section 45, centrally apertured at 46 to clear the spring 12. On opposite sides, the central section 45 is adjoined by wall portions 41, which in turn are adjoined by cover sections 47. The cover sections are each partially apertured at 48, to form together a clearance hole for the spring corresponding to aperture 46. The remaining edges of the central section 45 are adjoined by wall portions 41, which in turn are adjoined by flaps 49. An individual envelope may be assembled from the blank 44 by folding wall portions 41 inwardly along crease lines 50, and folding the cover sections 47 into overlapping relationship along the crease lines 51. The cover sections may then be secured to each other by means of the adhesive strips 52, to together form a section corresponding to central section 45. Thereafter, the wall portions 41 may be folded inwardly along crease lines 53, and the flaps 49 folded inwardly along crease lines 54 into contact with the joined cover sections, and affixed thereto as by gluing. In this manner, an individual envelope is quickly and conveniently assembled.

The individual envelopes may be joined to each other in aligned stack relationship by gluing or otherwise, and the upper and lower surfaces of the stack may be adhesively or similarly secured to the inner surfaces of the plate members 11, or to the inner surface of the plate member 13, if one is provided. The assembly of the individual envelopes effects the corner slits 42. These slits are an outstanding feature of this embodiment, in that they constitute openings the area of which is variable in accordance with the spacing between the central section and cover sections of the envelope. That is, when the envelope is opened to full extent and the wall portions 41 thereof are substantially planar, the slits 42 are substantially closed. As the envelope is progressively com-

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pressed or collapsed, the slits open progressively until an opening of maximum area is effected, whereafter further compression of the envelopes effects a decrease in the area of the slit opening, which reaches substantially zero when the envelope is fully compressed.

In the normal or extended condition of the device, the envelopes 40 may be fully extended or slightly collapsed. To insure the initial desired degree of opening of the envelope slits, the spring ties 22 may be suitably adjusted, and a plurality of flexible straps 55, which may be made of paper, may be provided extending between the plate members. The straps 55 function not only to limit the spacing between the plate members, but also to maintain them normally parallel, relieving the envelope wall portions of stress which might otherwise be set up therein in case the device is compressed at one edge only.

The number of individual envelopes employed in a particular case depends upon the over-all thickness of the device, the plan configuration thereof, and the total maximum air opening desired. For any given over-all thickness, the maximum possible total air opening decreases as the number of individual sheet envelopes is increased, two half inch slits for example having a total maximum gap opening less than that which is characteristic of a single slit one inch long.

As will be understood, the plate members 11 and envelopes 40 may be of any desired plan configuration. Square or rectangular shape is preferred as simplifying the envelope construction, but the device may be round, triangular, hexagonal, or of other polygonal or other shape. The polygonal shape is preferred because it permits the slits to be disposed at the envelope corners, precluding stress concentrations at these points. In particular applications, the corner slits may be supplemented by additional vertical slits in the envelope wall portions 41, preferably by diamond shaped openings disposed with long axes normal to the plate members.

In operation, the device of Figures 5 to 8 functions in near ideal manner. In the initial compression of this shock isolator, if the envelopes thereof are fully extended or nearly so, the slit openings provided for the escape of air are substantially closed. The internal pressure in the device builds up smoothly and quickly, until when the device is compressed to approximately one half its normal or original thickness, the slits attain maximum opening area, a natural and inherent consequence of the accordion or pleat folding action of the wall portions 41. As the device is further compressed, the area of the slit openings progressively decreases, down to zero when the device is fully compressed. Inherently, then, the action of the device corresponds to a remarkable degree to the function and operation of an ideal air cushion with air discharge. Other advantages of this embodiment, including the low cost of material and manufacture, will be obvious.

In such applications, it is desirable that the envelopes be initially partly collapsed. In such case initial tension in the envelope wall portions 41 is entirely avoided. Further, when the device is compressed under load, the resulting internal pressure tends to bulge or round out the envelope wall portions at an early stage of the compression, thereby avoiding stresses tending to delaminate or separate the envelopes. The envelope wall portions and webs are stressed in tension only, the tension resulting substantially entirely from the internal air pressure.

By way of specific example, a rectangular shock isolator was constructed in accordance with Figures 5 to 8, measuring nine by eleven inches and having an over-all extended thickness of two and seven eighths inches, utilizing five sheet envelopes constructed of thirty pound kraft paper each having an initial thickness or opening of one half inch when assembled, and a maximum thickness of five-eighths inch when fully extended. The total weight of the device, including corrugated fiberboard, paper and spring was eleven ounces. The device was tested re-

peatedly in cushioning the impact shock of various weights dropped free from various heights. Using twenty pound weights dropped from a height of sixty inches, the maximum deceleration of the weight was found to be forty-four g. After twenty-five tests of comparable severity, the device was found to be substantially undamaged, and capable of further usage.

Shock isolating devices according to the invention have great energy absorption capacity, and are capable of suitably cushioning impact shocks of the nature of those encountered in air drops, with or without parachutes. In air drops, the spring employed need be strong enough only to forcibly separate the plate members, so that prior to dropping the cushion may be completely compressed under the static weight of the associated article, or otherwise, and accordingly occupy substantially no space. In the course of a free drop, the spring will be capable of extending the device and maintaining it in normally open, operative condition.

In the majority of common packaging applications, for optimum operation the maximum opening of the slits or other apertures provided, that is the total open area of the slits at the point of maximum opening, will be within the range of from 0.5 to 5.0 percent of the plan area. For applications of unusual severity, such as may be encountered in air drops, total open area ranging up to 9 or 10 percent of the plan area may be utilized.

In particular cases, the resilient element may be replaced by non-resilient means collapsible under pressure. A crushable column member, for example, capable only of maintaining the device in normal extended position and supporting any static load, may be utilized in place of a spring, such member preferably being adapted to collapse completely under impact, so as not to interfere with full compression of the device.

It will thus be seen that there has been provided by this invention a structure in which the various objects hereinbefore set forth, together with many practical advantages, are successfully achieved. As various possible embodiments may be made of the mechanical features of the above invention, all without departing from the scope thereof, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative, and not in a limiting sense.

I claim:

1. A shock isolator comprising two spaced plate members normally disposed in substantial parallelism, resilient means disposed between and normally separating said plate members, and a plurality of flat sheet envelopes substantially coextensive with said plate members disposed therebetween, each of said envelopes being peripherally slit in direction normal to the planes of said plate members.

2. A shock isolator comprising two spaced plate members normally disposed in substantial parallelism, a pre-compressed coil spring disposed between and normally

separating said plate members, a recess in one of said plate members adapted to maintain the relative position of said spring and receive said spring when said plate members are contiguous, a plurality of flat sheet envelopes substantially coextensive in area with said plate members together enclosing the space between said plate members, each of said envelopes having a plurality of peripheral slits extending in direction generally normal to said plate members, and a plurality of flexible straps extending between said plate members to limit the spacing therebetween to a predetermined maximum.

3. A shock isolator as defined in claim 2, wherein said plate members are polygonal, and said slits are located at the corners of said envelopes.

4. A shock isolator as defined in claim 2, including means limiting the extension of said spring.

5. A shock isolator comprising two spaced plate members normally disposed in substantial parallelism, and a flexible sheet enclosing the space between said plate members, said sheet being peripherally slit in direction normal to the planes of said plate members.

6. A shock isolator as defined in claim 5, wherein said plate members are polygonal, and said slits are located at the corners of said sheet.

7. A shock isolator comprising two spaced plate members normally disposed in substantial parallelism, means maintaining said plate members normally separated, and a flexible sheet enclosing the space between said plate members, said sheet being peripherally slit in direction normal to the planes of said plate members.

8. A shock isolator comprising two spaced plate members normally disposed in substantial parallelism, means maintaining said plate members normally separated, and a plurality of flat sheet envelopes substantially coextensive with said plate members disposed therebetween, each of said envelopes being peripherally slit in direction normal to the planes of said plate members.

9. A shock isolator comprising two spaced plate members, and a flexible sheet enclosing the space between said plate members, said sheet having a plurality of openings therein, the effective areas of said openings being variable and increasing progressively to a maximum as the spacing between said plate members is decreased, and then decreasing from said maximum as the spacing between said plate members is further decreased.

10. A shock isolator as defined in claim 9, including resilient means normally separating said plate members.

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