United States Patent [19]

Karlan

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[54] **COMBINATION VIBRATION ISOLATOR AND SHOCK ABSORBER**

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[52] **U.S. Cl.** **267/136,** 267/165

[51] **Int. Cl.** **F16f 7/00**

[58] **Field of Search**.....267/136, 165, 151, 267/158, 159, 160, 182

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Attorney—Charles E. Temko

[57] **ABSTRACT**

A combination vibration isolator and shock absorber including a plurality of elongated resilient elements, each of said elements including a plurality of planar segments interconnected by a plurality of C-shaped segments, said plurality of resilient elements being coaxially mutually engaged to provide linear stiffness, each of said resilient elements having first and second aligned free ends, said ends being interconnected by end pieces, each of which have a natural vibrating frequency differing from any of the components of said elongated elements. Said C-shaped segments are provided with additional structure to alter their natural vibration frequency, as compared with the planar segments.

9 Claims, 14 Drawing Figures

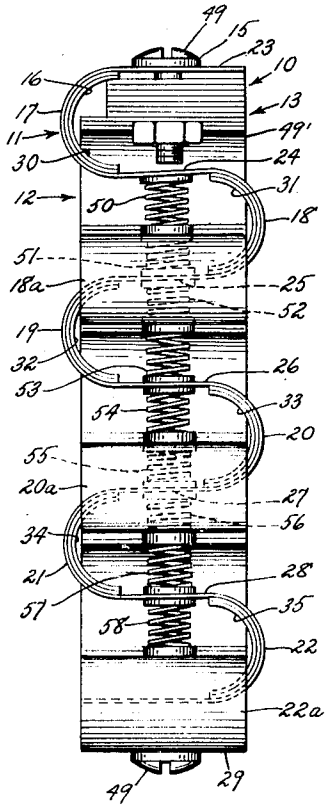


Fig. 1

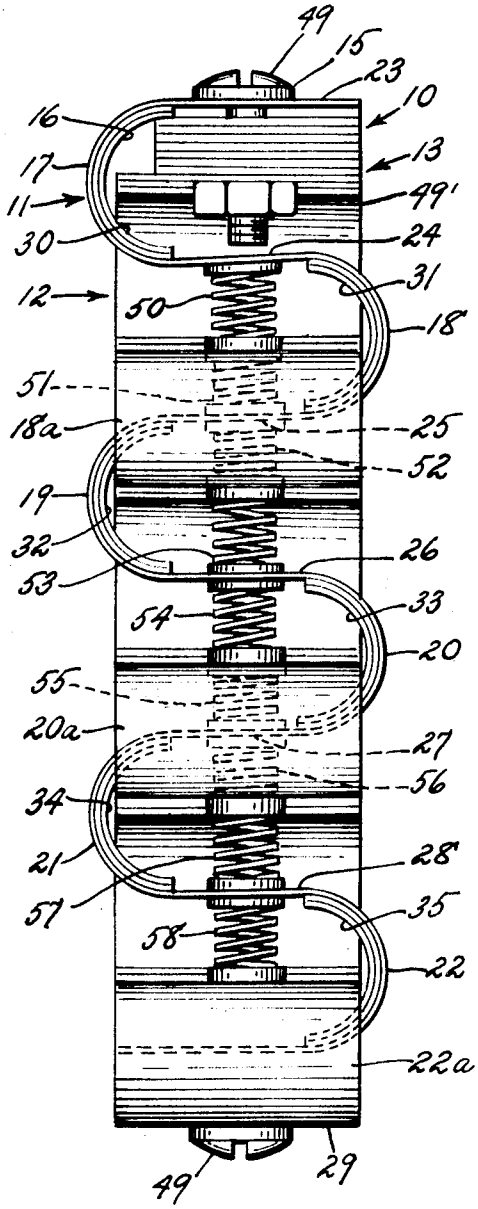
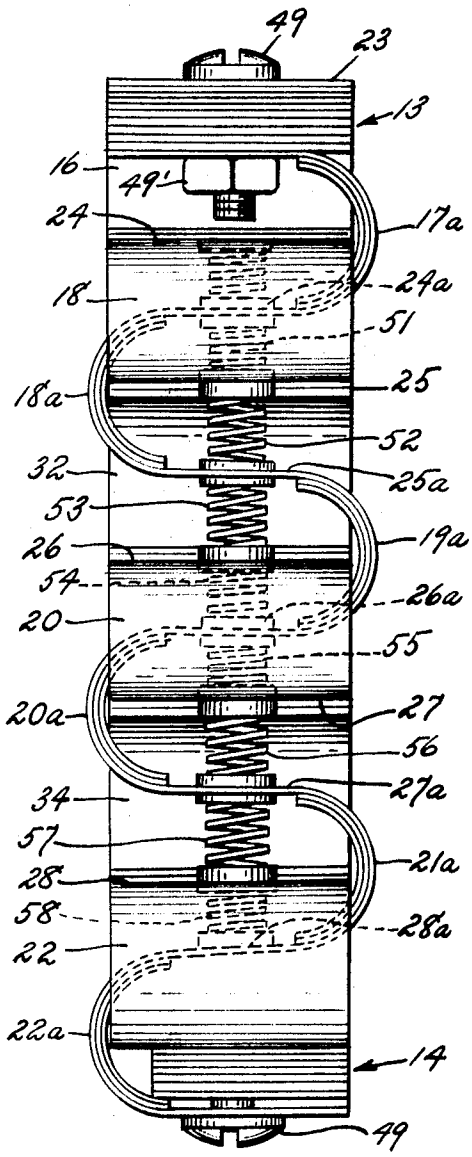


Fig. 2



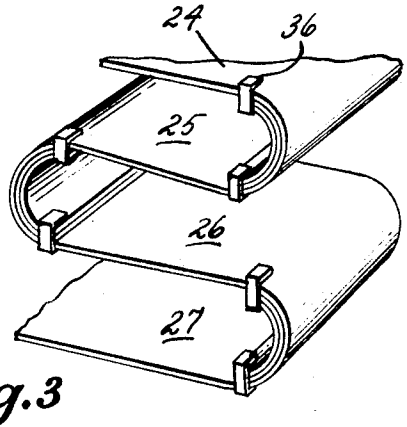


Fig. 3

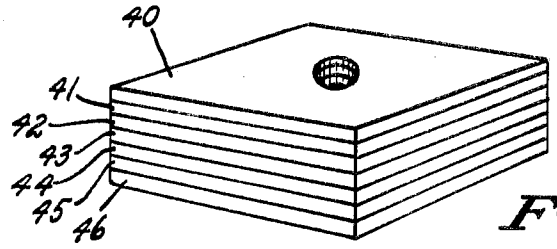


Fig.4

Fig.5

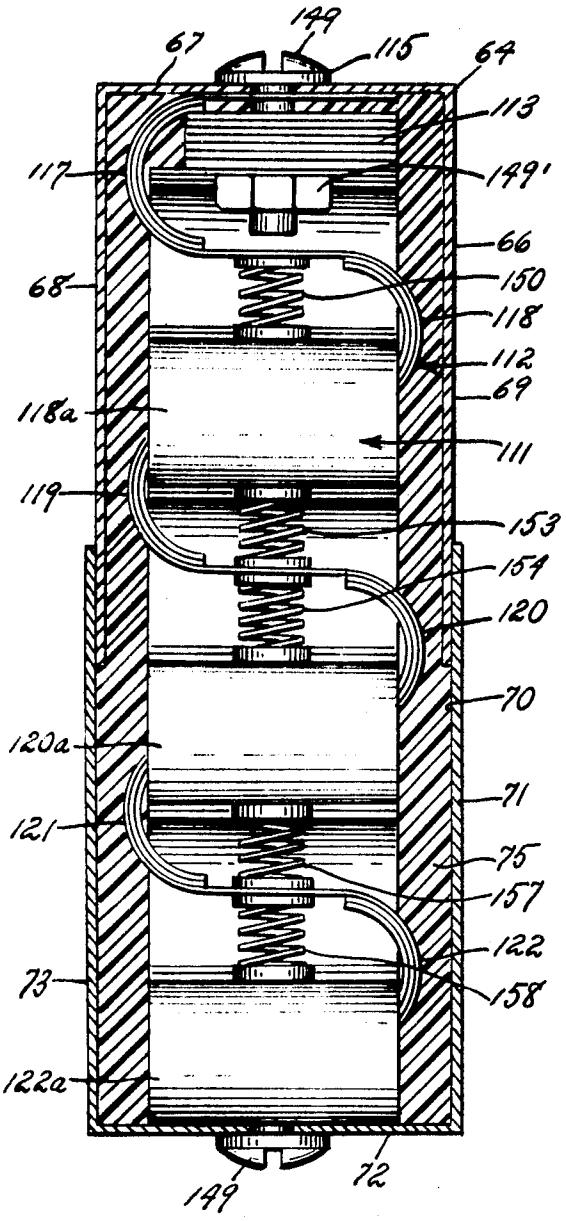
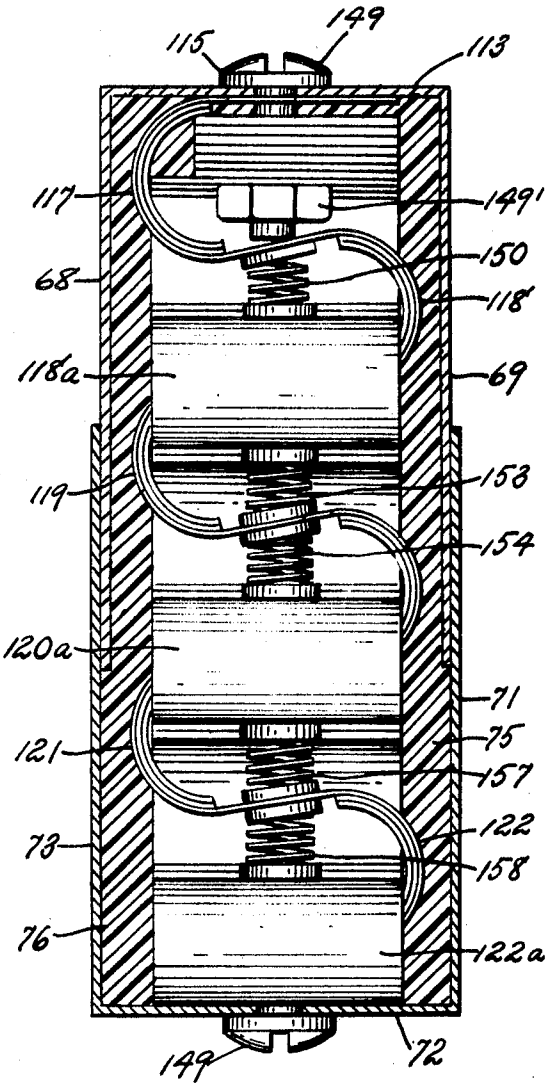


Fig.6



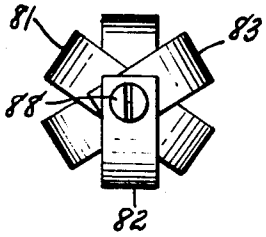


Fig. 10

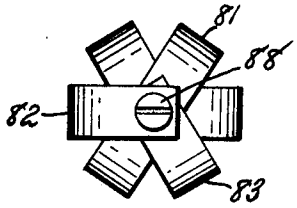


Fig. 11

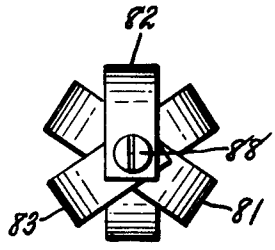


Fig. 12

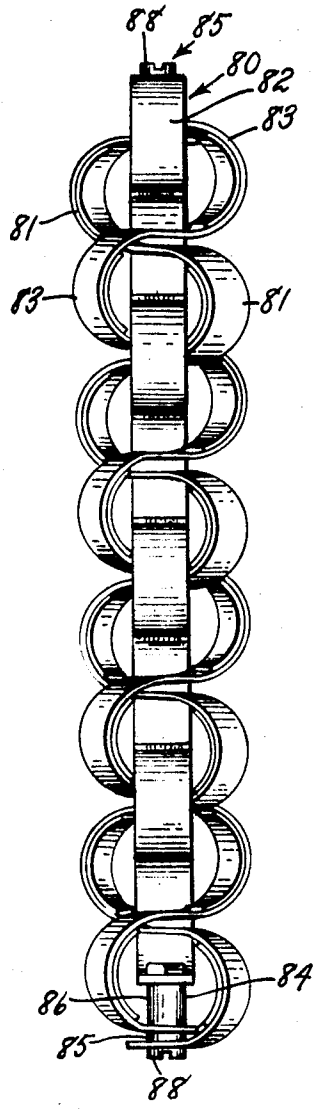


Fig. 7

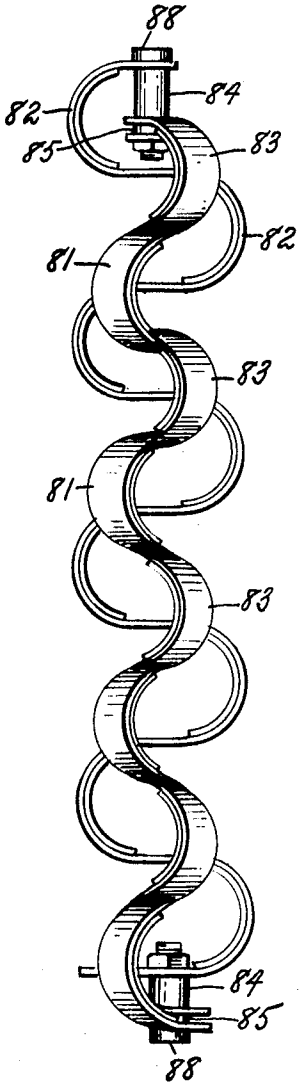


Fig. 8

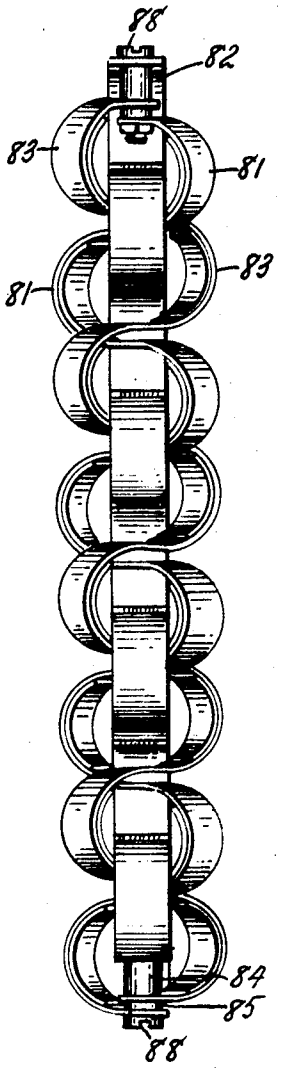


Fig. 9

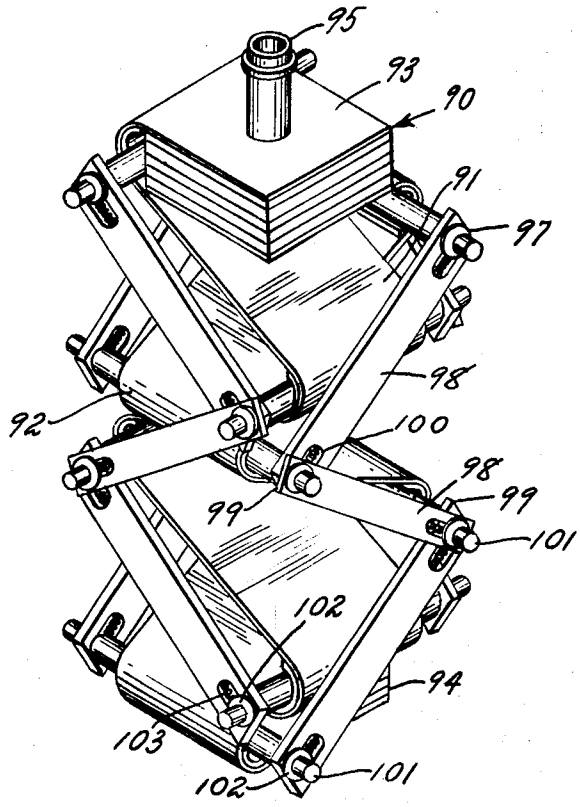

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Fig. 13

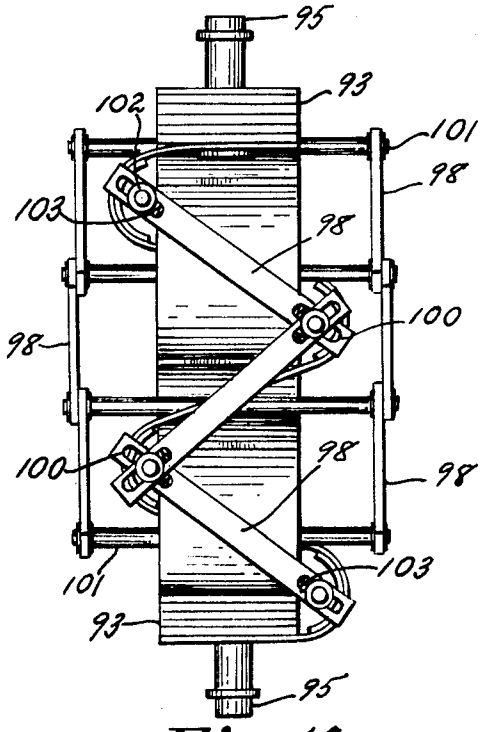
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Fig. 14

COMBINATION VIBRATION ISOLATOR AND SHOCK ABSORBER

This invention relates generally to the field of resilient damping devices, and more particularly to an improved shock absorber and vibration isolator adapted for a wide variety of loadings.

It is among the principal objects of the present invention to provide an improved form of shock absorber and vibration isolator which may be conveniently and cheaply fabricated using techniques already known and existing in the art, and which will readily perform the functions of more expensive devices already known in the art.

Another object of the invention lies in the provision of a combination vibration isolator and shock absorber in which the resilient components are of accordion configuration, and are formed or shaped in interconnected condition at the time the same are bent to operative configuration, whereby the means necessary for maintaining the resilient components in fixed relative mutual association may be minimized.

A further object of the invention lies in the provision of a single device which may simultaneously perform the functions of a shock absorber and a vibration isolator.

Still another object of the invention lies in the provision of simplified heat-dissipation means which may have a rapid energy dissipation and rapid recover.

A feature of the invention lies in the provision of resilient components which tend to distribute shock throughout the entire length of the device, and effectively damp vibration and shock impulses over an extended frequency range.

Another feature of the invention lies in the ready adaptability of a single basic structure to a wide variety of shock absorber and vibration isolator requirements, over a wide range of loadings, severe applications of shock and vibration, extreme conditions of frequency and wide ambient environments.

These objects and features, as well as other incidental ends and advantages, will more fully appear in the progress of the following disclosure, and be pointed out in the appended claims.

In the drawing, to which reference will be made in the specification, similar reference characters have been employed to designate corresponding parts throughout the several views.

FIG. 1 is a side elevational view of one embodiment of the invention.

FIG. 2 is a second side elevational view as seen from the right-hand portion of FIG. 1.

FIG. 3 is a fragmentary view in perspective of a single resilient element comprising a part of the embodiment.

FIG. 4 is a view in perspective showing one of two end pices comprising parts of the embodiment.

FIG. 5 is a central longitudinal sectional view of a second embodiment of the invention.

FIG. 6 is a similar sectional view showing the device in stressed condition under load.

FIG. 7 is a view in elevation of a third embodiment of the invention.

FIG. 8 is a second view in elevation of the third embodiment.

FIG. 9 is a third view in elevation of the third embodiment.

FIG. 10 is a top plan view as seen from the upper portion of FIG. 7.

FIG. 11 is a top plan view as seen from the upper portion of FIG. 8.

FIG. 12 is a top plan view as seen from the upper portion of FIG. 9.

FIG. 13 is a perspective view of a fourth embodiment.

FIG. 14 is a side elevational view of the fourth embodiment.

In accordance with the first embodiment of the invention, the device, generally indicated by reference character **10**, comprises broadly: a first resilient element **11**, a second resilient element **12**, first and second end piece elements **13** and **14**, respectively, mounting means **15**, and a plurality of auxiliary resilient elements **16**.

The first resilient element **11** is formed from an elongated strip of spring steel folded in accordion fashion, and tempered to retain a resilient set. As best seen in FIG. **1** in the drawing, the element **11** includes first, second, third, fourth, fifth and sixth C-shaped segments, **17,18, 19, 20, 21** and **22**, respectively. The segments **17–22** are interconnected by a first upper planar portion **23**, a second planar portion **24**, a third planar portion **25**, a fourth planar portion **26**, a fifth planar portion **27**, a sixth planar portion **28**, and a seventh lowermost planar portion **29**. Disposed within the concave portions of the C-shaped segments **17–22** are correspondingly C-shaped resilient inserts **30, 31, 32,33,34,** and **35**, being secured in interconnected relation by tab-like extensions generally indicated by reference character **36**. It will be observed that the transverse edges of the inserts **30–35** are inwardly curved, so as to avoid any frictional rubbing effect with respect to the inner surfaces of the C-shaped segments **17–22**. During flexing, a degree of relative movement will occur between the inserts **30–35** and the segments **17–22** with which they are associated, this movement resulting in the development of frictional heat which is dissipated locally as it travels through the segments **17–22** and the planar portions **23–29** to the end piece elements **13** and **14**, where the same are further absorbed and slowly dissipated to the ambient atmosphere.

The second resilient element **12** is substantially identical with the first resilient element **11**, and is shaped simultaneously so as to lie in permanent interconnection therewith. To avoid needless description of the above-described parts, those parts corresponding to those of the first resilient element have been designated by similar reference characters with the additional suffix "*a*." It will be observed that the second resilient element **12** is longitudinal offset with respect to the first element **11** by a distance equivalent to the thickness of the end piece elements **13** and **14**.

The end piece elements **13** and **14** are identical, and accordingly a description of one of such elements will serve to describe the other. Each element **13–14** is made up of a plurality of rectangularly-shaped plates, having a centrally disposed bore therein, as will be best seen in FIG. **4** in the drawing. These plates or laminae include a first plate **40** made of silicon rubber, second and third lead plates **41** and **42**, a fourth rubber plate **43**, fifth and sixth lead plates **44** and **45**, and a seventh rubber plate **46**. The centrally disposed orifice **47** is continuous through each of the above plates **40–46**, and permits the engagement of screw means. The end piece elements **13–14** are preferably formed by first

shaping the lead plates 41–42 and 44–45, and placing them in stacked relation with respect to rubber plates 40, 43 and 46.

The mounting means 15 is illustrated in the drawing as including bolts 49 engaged by nuts 49′ which serve the purpose of maintaining the spaced relationship between the elements 11 and 12, and maintain the end piece elements 13 and 14 in interconnected relation. The precise mounting brackets (not shown) will depend upon the nature of the device being supported thereupon, and, as is well-known in the art, such brackets will include openings (now shown) through which the screws 49 may project to provide interconnection.

The auxiliary resilient elements 16 are in the form of coil springs 50, 51, 52, 53, 54, 55, 56, 57 and 58, which are mounted in suitable fixtures on the planar surfaces of the planar portions 23–29, and are of a natural frequency differing from that of the resilient elements 11 and 12, so that an impluse will tend to set up anti-resonances within the overall device and reduce impact accelerations.

Turning now to the second embodiment of the invention, generally indicated by reference character 62, parts corresponding to those of the principal embodiment have been designated *b* similar reference characters with the additional prefix "1."

In the second embodiment, the resilient elements 111 and 112 and end piece elements 113 and 114 are disposed within a telescoping casing element 64, which provides a sealed chamber of variable volume. The volume unoccupied by these elements is filled with a suitable shock-absorbing medium, such as a silicon foam into which a substantial quantity of silicon fluid has been injected. This provides a prestressed condition to the planar segments.

The silicon foam is formed in situ. By injecting the silicon fluid both the solid portion of the foam as well as the air gaps in the foam increase in size. This prestresses the planar portions of the accordion spring. If an excess of fluid is introduced which is not absorbed by the silicon solid, it remains as a liquid and upon the introduction under normal operation of an impulse, this liquid transfers internally (intracellularly) and in so doing absorbs energy.

As seen in FIG. 5, the casing element 64 includes a first upper member 66 including an end wall 67 and side walls 68, the outer surface 69 of which forms a sliding fit with the inner surface 70 of a lower member 71 having a corresponding end wall 72 and side walls 73. The silicon foam material 75 may be blown into the casing 64 and cured in situ, following which a quantity of the silicon fluid 76 is introduced and the casing sealed. The amount of fluid 76 provided is such that when the device is in relatively unstressed condition as shown in FIG. 5, all of the fluid will be disposed within the foam, whereas when in a relatively compressed state as seen in FIG. 6, a quantity of the fluid will be transferred between the pores of the foam material.

It is to be understood that when the device 62 is in the condition shown in FIG. 5, a degree of pre-stressing is present owing to the fact that the silicon fluid 76 causes the foam material 75 to expand approximately 20 to 30 percent, this resilient effect working against the resilient elements 111 and 112.

Not only can the thickness of the spring material, its temper, and width of the C-shaped segments be controlled to produce a particular effect, but within the same casing, springs can be placed in juxtaposition so as to effect reactions at certain frequencies and dampenings of particular shock waves. In addition, the end piece elements, the silicon foam, and the amount of fluid can be varied for specific end purposes.

For example, some of the springs may be of thin metal and others of heavier metal; the thin metal resilient elements may have relatively thick C-shaped inserts, while the heavier resilient elements thin C-shaped inserts. This combination may be effective for both heavy and moderate shock waves, and will isolate vibrations over a very broad spectrum.

An ideal vibration isolator has:

a. low natural frequency. (In practice this cannot occur, for a vibration isolator must also provide support to the mass that it is isolating. If the mass is zero, there is no problem, for the spring will have a natural frequency of less than unity. In a practical sense, the mass is finite. Therefore the spring must be designed to carry the load, minimally. In practice, the spring is designed to withstand impact loadings greater than the static mass loadings, or else the spring would fracture in a very short time. The only way a coil spring can be overdesigned to conform to the above is to make the coil diameter larger, and in so doing, the natural frequency is increased, thus defeating the condition of an ideal vibration isolator.)

b. high reactive capability. This translates to practical terms in indicating a very small excursions and high natural frequency.

c. Zero damping characteristics.

d. good structural integrity.

e. capability of transferring heat energy quickly to surroundings.

f. high fatigue limits.

g. broad temperature characteristics.

By contrast, an ideal shock absorber has:

a. low natural frequency.

b. low reactive capacity.

c. critical damping characteristics.

d. limited structural integrity.

e. slow transference of heat energy to surroundings.

f. high fatigue limits.

g. broad temperature characteristics.

Because of the divergence of the first five characteristics of the ideal isolator as compared with those of an ideal shock absorber, it has heretofore been impossible to incorporate within a single device the duality of operation of a shock absorber with a vibration isolator. The accordion spring with reinforcing C segments at the points of maximum stress and minimum strength satisfies the conditions of both devices for structural integrity, low natural frequency (a flat, thin plate has low natural frequency), high reactive capability for the spring, yet low reactive capability for the absorbers; zero damping characteristics of the spring; and capability of energy transference.

When this spring complex is encased in a silicon-foam envelope, it performs all of the functions of a perfect energy (shock) absorber. A flat spring is the only geometry that will compress a large volume of foam. Thus critical damping is obtained.

Coincidentally, the coil springs 50 to 57, inclusive, may be made with extremely low natural frequency, since they are not structural bearing members. Alternatively, these coil springs can have the accordion design

with all of the geometrical advantages of this concept.

Turning now to the third embodiment (FIGS. 7 to 12), inclusive, this embodiment differs from the first embodiment principally in the provision of three resilient elements which are arranged mutually at angles of 120°. Thus, the device, generally indicated by reference character **80**, includes resilient elements **81, 82** and **83** and end elements **84** and **85** interconnecting the same at the extremities thereof. The end elements are of relatively simplified construction, including a tubular sleeve **86** and spacing washer **87** interconnected by nut and bot means **88**, axially more rigid than two members at right angles.

Turning now to the fourth embodiment of the invention, the device, generally indicated by reference character **90** comprises broadly: first and second resilient elongated elements **91** and **92**, respectively, first and second end piece elements **93** and **94**, respectively, and mounting means **95** and **96**, which correspond in function as in the first embodiment.

Associated with each element **91-22** are auxiliary resilient linkages **97**, each including a plurality of elongated link members **98**, having end portions **99** which are provided with elongated slots **100** having a principal axis congruant with the principal axis of the member **98** itself. The elongated slots **100** of adjoining link members are disposed in abutted relationship, and are interconnected by pintles **101** and maintained in position by locking members **102** thereon. Small springs **103** are positioned within the slots or openings **100**, and bear against the pintles **101**, tending to move them toward the outer ends of said slots.

From a consideration of FIG. **14**, it will be apparent that when the device is compressed, and the C-shaped segments are flexed, the link members **78** will be moved toward each other, compressing the springs **103** to the compressive limit thereof, following which the rigidity of the link members transmits force to the pintles to impart a stretching effect upon the C-shaped segments to rapidly increase the effective spring modulus of the device. Upon release of the load, the springs **103** again expand, to help restore the device to a static condition.

I wish it to be understood that I do not consider the invention limited to the precise details of structure shown and set forth in this specification, for obvious modifications will occur to those skilled in the art to which the invention pertains.

I claim:

1. A combination vibration isolator and shock absorber comprising: first and second elongated resilient elements, each of said elements including a plurality of C-shaped segments interconnected by a plurality of relatively planar segments, said first and second elements each having a principal axis and being coaxially mutually engaged, each of said resilient elements having first and second free ends, and first and second end piece elements interconnecting, respectively, said first ends and said second ends of each of said first and second resilient elements; a plurality of auxiliary resilient elements disposed between and interconnected to said planar segments, said auxiliary resilient elements having a frequency differing from that of said first and second resilient elements.

2. Structure in accordance with claim **1**, including a telescoping casing element including first and second mutually cooperating members defining a chamber of variable volume, said first and second resilient elements being disposed within said chamber, the remaining volume of said chamber being substantially filled with a porous compressible shock absorbing medium.

3. Structure in accordance with claim **2**, in which the last mentioned shock absorbing medium is silicon foam.

4. Structure in accordance with claim **3**, including a silicon fluid filling the pores of said foam, whereby compressive forces exerted upon said casing may serve to force said fluid outwardly of said pores.

5. Structure in accordance with claim **1**, including a pair of elongated resilient linkages, one associated with each of said first and second resilient elements; each linkage element including a plurality of elongated link members having first and second ends, and elongated openings extending through the plane thereof at said ends, and having a principal axis parallel to that of said links; a plurality of elongated pintles, each engaged with a pair of abutting openings in said link members to provide pivotal interconnection therebetween, each pintles including a medial portion lying within a C-shaped segment; whereby when said first and second resilient elements are compressed, said interconnected links are pivoted toward each other to exert additional tension upon said C-shaped segments to momentarily increase the effective spring modulus.

6. Structure in accordance with claim **5**, including compressible resilient means disposed axially within the principal axis of said openings to assist in returning said linkage to static condition.

7. A combination vibration isolator and shock absorber comprising: first and second elongated resilient elements, each of said elements including a plurality of C-shaped segments interconnected by a plurality of relatively planar segments, said first and second elements each having a principal axis and being coaxially mutually engaged, each of said resilient elements having first and second free ends, and first and second end piece elements interconnecting, respectively, said first and second ends of each of said first and second resilient elements; a telescoping casing element including first and second mutually cooperating members defining a chamber of variable volume, said first and second resilient elements being disposed within said chamber, the remaining volume of said chamber being substantially filled with a porous compressible shock absorbing medium.

8. Structure in accordance with claim **7**, in which the last mentioned shock absorbing medium is silicon foam.

9. Structure in accordance with claim **7**, including a silicon fluid filling the pores of said foam, whereby compressive forces exerted upon said casing may serve to force said fluid outwardly of said pores.

* * * * *