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(54) Title: VIBRATION ISOLATION AND DAMPING SYSTEM

(57) Abstract: A vibration damping device comprising a shell, a horizontal damping mechanism and a vertical damping mechanism to reduce vibrations transmitted to instruments and equipment. The horizontal damping mechanism has a raceway, one or more ball bearings and, optionally, a spacer horizontal displacement damper. The vertical damping mechanism has a plurality of discrete elastomeric components. The elastomeric components are optimized in up to four configurations of size, shape and number to control vibrations transmitted to a vertical load of up to 100 lbs. The vibration damping device may further comprise any of a connector portion, a mount portion, and/or an equipment support portion.

Figure 2
Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), Published: without international search report and to be republished upon receipt of that report (Rule 48.2(2))
Field Of The Invention

The invention generally relates to devices and assemblies for reducing vibrations transmitted to instruments and equipment. More specifically, this invention relates to a mechanical means of damping and/or isolating vibrations and micro vibrations transmitted to equipment.

Background of the Invention

Vibrations can interfere with the operation of sensitive equipment, create unwanted noise, and are therefore generally undesirable. For example, vibrations can impair operation of instruments and devices such as microscopes, metrology tools, lab balances, computer network racks, computer hard drives, precision machining equipment, marine devices, semiconductor operation, audio equipment, and other electronic devices.

Conventional systems and methods of reducing electronic and mechanical vibration within equipment include various mechanical, elastomeric, active piezoelectric, and air isolation solutions. However, these conventional methods have significant disadvantages.

Conventional mechanical systems and methods utilize springs to create a damping effect. However, springs compress over a range of displacements, causing the isolator system to vary in height when under load. Variation in height requires additional steps to level equipment. Furthermore, spring devices are tall and result in the elevation of equipment above an ergonomically acceptable height.

U.S. Patent No. 6,520,283 entitled "Mechanical Signal Filter" discloses a device for filtering vibrations by mechanical means, utilizing a bearing that is located in cone and floats and rolls in response to vibrations. However, when using this system and method, the equipment will oscillate when touched. This movement can be disconcerting to equipment operators.

Accordingly, what is needed in the art is a device and system capable of vertical and low-profile horizontal isolation and damping of vibrations, which can quickly return the supported equipment to a settled (i.e., motionless) state.
Summary of the Invention

While the way that the present invention overcomes the disadvantages of the known art will be discussed in greater detail below, in general, the present invention is generally any structure capable of damping and/or attenuating the transmission of vibrations to instruments and equipment.

In accordance with various exemplary embodiments, a vibration damping device is provided. A vibration damping device may comprise a shell and a horizontal damping mechanism. In an exemplary embodiment, the horizontal damping mechanism comprises one or more circular raceways and ball bearings. The horizontal damping mechanism may additionally comprise one or more spacers.

A vibration damping device may further comprise a horizontal displacement dampener configured to reduce horizontal movement. In an exemplary embodiment, horizontal displacement dampener comprises silicone material.

In various embodiments, a vibration damping device may comprise a vertical damping mechanism operable to reduce the transmission of vibrations in the vertical plane to equipment supported by a vibration damping device.

In an exemplary embodiment, vertical damping mechanism comprises an elastomer damping material suitable to reduce vibrations transmitted to equipment. Elastomer damping device may comprise rubber and may have a plurality of gripping elements configured to contact a piece of equipment and prevent sliding of the equipment relative to the vibration damping device.

In an embodiment, the vertical damping mechanism comprises a plurality of discrete elastomeric components that are optimized in up to about four configurations of size, shape and number to control vibrations transmitted to a vertical load of up to 100 lbs.

In accordance with various other exemplary embodiments, a vibration damping device may further comprise a connector portion operable to couple the vibration damping device to a piece of equipment, a mount portion operable to support the components, and/or an equipment support portion operable to provide a platform for a piece of equipment supported by the vibration damping device.
Brief Description of the Drawings

A more complete understanding of the invention may be derived by referring to the detailed description and claims when considered in connection with the Figures, wherein like reference numbers refer to similar elements throughout the Figures, and:

Figure 1A illustrates a block diagram of an exemplary embodiment of a vibration damping device;

Figure 1B illustrates an exploded view of an exemplary embodiment of a vibration damping device having three horizontal damping mechanisms;

Figure 2 illustrates an exploded view of an exemplary embodiment of a vibration damping device having four discrete elastomeric components;

Figures 3A & 3B illustrate exemplary embodiments of a bottom plate of a vibration damping device;

Figure 4 illustrates another exemplary embodiment of a vibration damping device;

Figures 5A & 5B illustrate square-shaped vibration damping devices;

Figure 6 illustrates an exploded view of an exemplary embodiment of a vibration damping device having a top, middle and bottom plate;

Figure 7 illustrates an exemplary embodiment of a bottom plate of a vibration damping device;

Figures 8A & 8B illustrate exemplary embodiments of spacer components;

Figure 9 illustrates a cross-sectional view of an exemplary embodiment of a vibration damping device;

Figure 10 illustrates an exemplary embodiment of a horizontal displacement damper;

Figure 11A illustrates an exemplary embodiment of a vibration damping mechanism having surrounding damping material;

Figure 11B illustrates an exemplary embodiment of a vibration damping mechanism having an elastomeric damping material;

Figures 12 A & 12B illustrate exemplary embodiments of the top and bottom surfaces of a top plate of a vibration damping device;

Figures 13A & 13B illustrate exemplary embodiments of the bottom and top surfaces of a middle plate of a vibration damping device;

Figures 14A & 14 B illustrate cross-sectional views of exemplary embodiments of a vibration damping device having a top, middle and bottom plate;
Figures 15A-15D illustrate exemplary embodiments of vibration damping devices having different numbers of discrete elastomeric components;

Figures 16A-16D illustrate exemplary embodiments of vibration damping devices having different sizes of discrete elastomeric components;

Figure 17 illustrates various exemplary shapes of discrete elastomeric components; and

Figures 18A-18C illustrate exemplary embodiments of vibration damping devices having connector portions, mount portions and equipment support portions.

**Detailed Description**

The description that follows is not intended to limit the scope, applicability, or configuration of the invention in any way; rather, it is intended to provide a convenient illustration for implementing various embodiments of the invention. As will become apparent, various changes may be made in the function and arrangement of the elements described in these embodiments without departing from the scope of the invention. It should be appreciated that the description herein may be adapted in any number of ways and still fall within the scope of the present invention. Furthermore, different materials, structures, compositions, and the like may be employed in the vibration damping device disclosed herein without departing from the scope of the present invention. Moreover, the various parts and systems herein disclosed may be configured in different arrangements than disclosed while remaining within the scope of the present invention. Thus, the detailed description herein is presented for the purpose of illustration only and not of limitation. References to singular include plural, and references to plural include singular.

In accordance with various exemplary embodiments of the present invention, and with reference to Figure IA, vibration damping device 100 is provided. A vibration damping device may be any structure or apparatus capable of damping and/or attenuating the transmission of vibrations to equipment. In an exemplary embodiment, a vibration damping device comprises shell 102 and one or more horizontal damping mechanisms 130.

The shell may generally be any structure suitable to form a cavity for containing various components of a vibration damping device. In one exemplary embodiment, the shell may comprise bottom plate 110 and top plate 115. For example, Figures 1B and 2 illustrate embodiments of vibration damping device 100/200 having a shell comprising bottom plate 110/210 and top plate 115/215. In various embodiments, the shell of the vibration damping
device may comprise additional plates. For example, Figures 2 and 6 illustrate exemplary embodiments of vibration damping devices 200/600 comprising bottom plate 210/610, middle plate 250/650, and top plate 215/615. That said, it will be understood that the device may comprise any number of plates.

The plates may comprise any desired size, shape and configuration. For example, as illustrated in Figures 5A & 5B, top plate 515 and bottom plate 510 of vibration damping device 500 may be square-shaped and, when assembled, form a minimized vertical profile 512. In an exemplary embodiment, the sides e.g., side 514 of vibration damping device 500 are about 4-6 inches in length. However, it will be understood the vibration damping device may comprise any desired length, size and/or shape (such as circular, polygonal, and/or the like). For example, in the embodiments illustrated in Figures 2 and 6, bottom plate 210/610 and top plate 215/615 are substantially circular.

Bottom plate and top plate may be joined using any suitable attachment mechanism including, for example, rubber dowels, binding barrels, and/or shoulder assembly screws, or other like mechanisms. In Figure 1B, bottom plate 110 and top plate 115 are coupled together using drive caps 116 and binding barrels 118. In the embodiment illustrated in Figure 4, rubber dowels 417 are located between bottom plate 410 and top plate 415 so as to operably join the two halves together. With momentary reference to Figures 3A & 3B, bottom plate 310 may comprise a substantially flat surface and recessed opening 311 for insertion of an attachment mechanism.

In an exemplary embodiment, the top plate and bottom plate are decoupled by one or more components of the device. For example, as illustrated in Figure 4, bottom plate 410 and top plate 415 are decoupled by the presence of ball bearing 420 rolling on conical raceway 425. In other embodiments, the top and bottom plate may be monolithic.

The shell and other components of the vibration damping device may be made of any suitable material, including rigid materials such as steel and other metals, and/or a material suitable for providing a damping effect, such as rubber and polymeric materials.

As mentioned above, vibration damping device 100 may further comprise horizontal damping mechanism 130. A horizontal damping mechanism is a structure that attenuates, reduces or otherwise lessens the transmission of vibrations in the horizontal plane to equipment supported by the vibration damping device.

In an exemplary embodiment, horizontal damping mechanism 130 comprises one or more circular raceways and ball bearings, which allow equipment supported on the vibration
damping device to float and/or roll in response to vibrations. For example, Figure 6 illustrates vibration damping device 600 comprising one or more horizontal damping mechanisms 630 having circular raceway 625 and bearings 620. As shown, bearings 620 are separated by spacer 636 (discussed below). Figure 7 illustrates another embodiment of vibration damping device 700 in which bottom plate 710 comprises the lower portion of raceway 725.

In accordance with an exemplary embodiment, vibrations in the two horizontal directions (e.g., perpendicular to gravity) cause the ball bearings located within the raceway to displace from the lowest settling point, thereby increasing their potential energy and reducing the kinetic energy that otherwise would have been transmitted to the equipment supported by the vibration damping device. Gravity then returns the ball bearings to their resting point and the lowest state of potential energy. In this manner, a reduced amount of energy is transmitted to the supported device as vibrations. Similarly, as the bearing moves in the raceway, friction dissipates the energy that has been transmitted to the vibration damping device.

In another exemplary embodiment, a horizontal damping mechanism may additionally comprise a spacer. A spacer is any structure suitable for retaining the ball bearings and separating the ball bearings at a predetermined distance. For example, Figure 8A illustrates an embodiment of spacer 836 comprising ball bearing openings 837 that are operable to keep the bearings separated at 120 degrees when moving within the raceway. Figure 8B illustrates an embodiment of spacer 836 comprising six ball bearing openings 837 operable to keep the ball bearings separated at approximately 30 degrees. However, it will be understood that the spacer may comprise any number of ball bearing openings.

The raceway may be formed of two concave surfaces opposing each other to form a recess. For example, Figure 9 illustrates a cross-sectional view of vibration damping device 900 comprising a horizontal damping mechanism having lower raceway 925 and upper raceway 926 separated by spacer 936 and ball bearing 920.

Figure 4 illustrates another exemplary embodiment of a raceway wherein vibration damping device 400 comprises bottom plate 410 and top plate 415 joined to form raceway 425. Raceway 425 comprises ball bearing 420 which is gravity restoring and is operable to provide horizontal damping.

Figures 2 and 6 illustrate horizontal damping mechanism 230/630 comprising circular raceway 225/625, a plurality of ball bearings 220/620, and spacer 236/636 contained
between bottom plate 210/610 and middle plate 250/650. Middle plate 250/650 and bottom plate 210/610 each comprise a groove to form circular raceway 225/625. Figure 13A illustrates an exemplary embodiment of middle plate 1350 having raceway 1325 and openings 1365 for attachment mechanism. Moreover, Figure 3A illustrates the top surface of bottom plate 310 having raceway 325 and opening 311 for insertion of an attachment mechanism, such as a shoulder screw.

In an exemplary embodiment, the raceway has a width of about 0.6 inches. In another embodiment, the width of the raceway is about 0.4 inches. The raceway may be located around the outer perimeter of a vibration damping device having a diameter of about 1.7 to about 2.2 inches, but could be smaller or larger or anything in-between.

Ball bearings may comprise any suitably durable material including metals such as stainless steel, ceramics, and elastomers such as rubber. In an exemplary embodiment, the raceway may be dimple machined, stamped and/or pressed into the ball bearing.

Figure 1B illustrates a vibration damping device 100 comprising three horizontal damping mechanisms 130. However, it will be understood that any number of horizontal damping mechanisms may be utilized.

In accordance with an exemplary embodiment, vibration damping device 100 may further comprise a horizontal displacement dampener 139 operable to reduce the amount of horizontal movement of the vibration damping device in response to vibrational stimuli. For example, Figure 10 illustrates an exemplary embodiment of horizontal displacement dampener 1039.

The horizontal displacement dampener may be operable to contact the top and bottom portion of the vibration damping device in order to limit horizontal movement. For example, Figure 1B shows vibration damping device 100 comprising horizontal displacement dampener 139 contacting top plate 125 and bottom plate 110. However, it will be understood by one skilled in the art that any device suitable for limiting the amount of horizontal movement in response to vibration may be used. In an exemplary embodiment, the horizontal displacement as a result of vibrations of equipment placed on the vibration damping device is less than about ½ inches.


In various exemplary embodiments, a vibration damping device may further comprise a vertical damping mechanism. A vertical damping mechanism is any structure that attenuates, reduces or otherwise lessens the transmission of vibrations in the vertical plane to equipment supported by a vibration damping device.

In an embodiment, a vertical damping mechanism comprises a damping material. The damping material may be any material suitable for further lessening vibrations, thereby shorting settling time of vertical displacement. For example, damping material may be an elastomeric material such as rubber, neoprene, polypropylene, silicone, high-damping rubber or other polymers.

In the exemplary embodiment illustrated in Figure 1B, vertical damping mechanism 145 comprises a sheet of elastomeric material (e.g., rubber) recessed within top plate 115 and bottom plate 110 so as to dampen vibrations in the vertical plane. Figures 4, 11A and 11B illustrate exemplary embodiments of vibration damping device 400/1 100 having surrounding shell 432/1 132 comprising an elastomeric damping material. In Figure 11B, elastomeric shell 1132 surrounds and is operable to at least partially restrict movement horizontal components, such as top plate 1115 and bottom plate 1110. Elastomeric shell 1132 may be bonded to the metallic components (e.g., top plate 1115 and bottom plate 1110) using any suitable composition or structure.

However, the elastomeric material may be located anywhere on the vibration damping device to facilitate damping of vibrations in the vertical plane.

In an exemplary embodiment, the vertical damping mechanism comprises a plurality of discrete vibration-absorbing components. The vibration-absorbing components may be made of any suitable material, including elastomeric materials such as rubber or other polymers. In an embodiment, the vibration absorbing components may be substantially compressible or substantially incompressible.

Figures 2 and 6 illustrate exemplary embodiments of vibration damping devices 200/600 comprising vibration absorbing components that include discrete elastomeric components 255/655 contained between top plate 215/615 and middle plate 250/650. As shown, top plate 215/615 and/or middle plate 250/650 may comprise recesses 260/660 to house the discrete elastomeric components. Figure 12B also illustrates the bottom surface of top plate 1210 having recesses 1260 at least partially contain the discrete elastomeric
components as well as recesses 1265 at least partially contain the dowels and/or other attachment mechanism.

In various embodiments, the surface of the middle plate and/or top plate may be flat to allow the discrete elastomeric components to sit on the surface. For example, Figure 13B illustrates middle plate 1350 having a flat surface and openings 1365 for insertion of one or more dowels or other attachment mechanism.

Although Figure 2 illustrates four discrete elastomeric components and three ball bearings, any desired number of elastomeric components and ball bearings may be used. Moreover, any known or hereinafter devised attachment mechanism such as dowels, screws, washers, and rods may be used to couple the components of the vibration damping device.

Figures 14A and 14B illustrate cross sectional views of an exemplary embodiment of an assembled vibration damping device 1400. As shown, top plate 1415 is coupled to middle plate 1450 via shoulder screws 1416 to constrain rotational and horizontal movement (in the x/y-plane) of the device while allowing vertical movement (in the z-plane). Bottom plate 1410 is coupled to middle plate 1450 via shoulder screw 1417 to constrain vertical movement (in the z-plane) while allowing for both rotation and horizontal movement (in the x/y plane).

In various exemplary embodiments, the number, shape, size and/or other parameters of the discrete elastomeric components (alone or in combination) may be varied to accommodate the load capacity of equipment resting on the vibration damping device. For example, in accordance with one aspect of the invention, four or less elastomeric configurations are used to maintain a natural frequency of between about 7 to about 15 Hz for a load range of between about 0 to about 100 pounds.

As mentioned above, the number of discrete elastomeric components may be varied to accommodate a range of vertical load capacities. For example, Figures 15A-D illustrate four configurations of vibration damping devices 1500 operable to accommodate a vertical load capacity of up to about 100 lbs. Namely, Figure 15A illustrates four discrete elastomeric components 1555 and is operable to accommodate up to about 25 lbs, Figure 15B illustrates eight discrete elastomeric components 1555 and is operable to accommodate between about 25-50 lbs, Figure 15C illustrates twelve discrete elastomeric components and is operable to accommodate between about 50-75 lbs, and Figure 15D illustrates 16 discrete elastomeric components 1555 and between about 75-100 lbs.
In various embodiments, the size of the elastomeric components may be varied to accommodate a range of vertical load capacities. In accordance with an aspect of the invention, a load range of about 0-100 lbs may be accommodated using four or less configurations of elastomeric components. For example, Figures 16A-D illustrate four configurations of vibration damping devices 1600 operable to accommodate a vertical load capacity of up to about 100 lbs. Figure 16A illustrates discrete elastomeric components 1655 having a diameter of about 0.125" to about 0.375" operable to accommodate up to about 25 lbs. Figure 16B illustrates discrete elastomeric components 1655 having a diameter of about 0.125" to about 0.5" operable to accommodate between about 25 - 50 lbs, Figure 16C illustrates discrete elastomeric components 1655 having a diameter of about 0.375" to about 0.675" operable to accommodate between about 50 to about 75 lbs, and Figure 16D illustrates discrete elastomeric components 1655 having a diameter of about 0.5" to about 0.75" operable to accommodate between about 75-100 lbs.

In accordance with an exemplary embodiment, the ratio of length to effective diameter (L/D_{eff}) of the elastomeric components may be in the range of about 1 to about 2. In an embodiment, L/D_{eff} of the elastomeric components is about 1.5.

In various embodiments, the shape of the elastomeric components may be varied to accommodate a range of vertical load capacities and optimize the effective spring rate. For example, Figure 17 illustrates a plurality of different shapes of elastomeric components such as cylindrical (vertical or laterally-loaded), cone, square, barrel, inverted barrel and hexagon. However, it will be understood that any desired shape may be used. Moreover, the elastomeric components may be hollow or solid.

In an exemplary embodiment, the vertical damping mechanism may comprise one or more gripping elements. A gripping element may be any structure suitable for contacting a surface and preventing sliding and other movement. For example, Figure 1B illustrates gripping elements 183 that are operable to contact and prevent movement of equipment supported by vibration damping device 100. Figure 5A further illustrates vertical damping mechanism 545 and gripping elements 583. Moreover, as shown in Figure 11A, vertical damping mechanism 1132 may be formed around bottom plate and top plate 115 to increase vibrational damping effect.

In accordance with an exemplary embodiment, a vibration damping device may further comprise a connector portion. A connector portion may be any structure suitable for coupling a vibration damping device to a piece of equipment, such as a rod, dowel, and/or
the like. For example, as shown in the exemplary embodiments in Figures 9, vibration damping device 900 comprises connector device 970 attached to top plate 915. Figure 2 illustrates connector device 270 having a threaded insert for removably coupling to a piece of equipment. Figure 12A illustrates top plate 1215 having openings 1272 for insertion of one or more connectors.

In accordance with an exemplary embodiment, vibration damping device may further comprise a mount portion and/or an equipment support portion. A mount portion may be any structure suitable for providing a bottom to support the components of the vibration damping device. An equipment support portion may be any structure or device suitable for providing a platform for supporting a piece of equipment or instrument. For example, Figures 18A-18C vibration damping device 1800 comprises a mount portion 1875. Connector device 1870 is coupled to equipment support portion 1880 so as to suitably provide a platform for a piece of equipment.

Benefits, other advantages, and solutions to problems have been described herein with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any elements that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as critical, required, or essential features or elements of the invention. The scope of the invention is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." Moreover, where a phrase similar to "at least one of A, B, or C" is used in the claims, it is intended that the phrase be interpreted to mean that A alone may be present in an embodiment, B alone may be present in an embodiment, C alone may be present in an embodiment, or that any combination of the elements A, B and C may be present in a single embodiment; for example, A and B, A and C, B and C, or A and B and C. Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims. No claim element herein is to be construed under the provisions of 35 U.S.C. 112, sixth paragraph, unless the element is expressly recited using the phrase "means for."

As used herein, the terms "comprises", "comprising", or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may
include other elements not expressly listed or inherent to such process, method, article, or apparatus.
I claim:

1. A vibration damping device comprising:
   a shell comprising a top plate and a bottom plate, the bottom plate having a first groove;
   a vertical damping mechanism contacting the top plate;
   a horizontal damping mechanism contacting the vertical damping mechanism, the horizontal damping mechanism comprising:
      a middle plate contacting the vertical damping mechanism, a bottom side of the middle plate comprising a second groove; and
   a spacer component positioned between the middle plate and the bottom plate, the spacer component having an opening containing a ball bearing, wherein the ball bearing is at least partially positioned within the first groove and the second groove.

2. The device of claim 1, the vertical damping mechanism comprising a plurality of discrete elastomeric components.

3. The device of claim 2, wherein the plurality of discrete elastomeric components comprise rubber.

4. The device of claim 2, wherein the vertical load capacity of the device is dependent upon the number of discrete elastomeric components.

5. The device of claim 4, wherein the device has a vertical load capacity of less than 25 pounds-force and up to about four discrete elastomeric components.

6. The device of claim 4, wherein the device has a vertical load capacity of between about 25-50 pounds-force and between about four and about eight discrete elastomeric components.

7. The device of claim 4, wherein the device has a vertical load capacity of between about 50-75 pounds-force and between about eight and about twelve discrete elastomeric components.

8. The device of claim 4, wherein the device has a vertical load capacity of between about 75-100 pounds-force and between about twelve and about sixteen discrete elastomeric components.

9. The device of claim 1 comprising 3-6 ball bearings.

10. The device of claim 1, wherein the ball bearing comprises one of stainless steel and an elastomeric material.
11. An apparatus for damping vibrations to a frequency of about 7 to 15 hertz comprising:
   a shell comprising a top plate and a bottom plate;
   a plurality of discrete elastomeric components contacting the top plate, the elastomeric components operable to provide vertical vibration damping;
   a middle plate contacting the elastomeric components, the bottom side of the middle plate comprising a first circular raceway;
   a spacer component positioned between the middle plate and the bottom plate, the spacer component having an opening containing a ball bearing, the ball bearing partially housed within the first circular raceway; and
   the bottom plate comprising a second circular raceway, the ball bearing partially housed within the second circular raceway,
   wherein the apparatus comprises a vertical load capacity of between about 0 to about 100 pounds-force.

12. The apparatus of claim 11, wherein the shape of the plurality of discrete elastomeric components is selected based upon the vertical load capacity of the apparatus.

13. The apparatus of claim 12, wherein the plurality elastomeric components comprise a shape selected from a group consisting of a cylinder, a cone, a square, a barrel, an inverted barrel and a hexagon.

14. The apparatus of claim 13, wherein the plurality of elastomeric components each comprise a \( 1/d_{\text{eff}} \) ratio of 1.5.

15. The apparatus of claim 13, wherein the plurality of discrete elastomeric components are substantially solid.

16. A vibration damping apparatus comprising:
   a shell comprising a top plate and a bottom plate;
   a horizontal damping device contained within the shell, the horizontal damping device comprising a circular raceway, a ball bearing, and a spacer.

17. The apparatus of claim 16, wherein rubber dowels connect the top portion and the bottom portion of the shell.

18. The apparatus of claim 16, further comprising an vertical damping device positioned on the top surface of the shell.

19. The apparatus of claim 18, wherein the elastomeric vertical damping device is a sheet of rubber.
20. The apparatus of claim 16, further comprising at least one of a connector device, a mount portion and an equipment support portion.
Figure 10