



US 20090126289A1

(19) **United States**(12) **Patent Application Publication****Jee et al.**(10) **Pub. No.: US 2009/0126289 A1**(43) **Pub. Date: May 21, 2009**(54) **DAMPING STRUCTURE****Publication Classification**(76) Inventors: **Kwang-Koo Jee**, Seoul (KR);
Yoon-Bae Kim, Seoul (KR);
Jun-Hyun Han, Seoul (KR)(51) **Int. Cl.**
E04B 1/98 (2006.01)(52) **U.S. Cl.** **52/167.2**

Correspondence Address:

OSTROLENK FABER GERB & SOFFEN
1180 AVENUE OF THE AMERICAS
NEW YORK, NY 100368403(57) **ABSTRACT**

The present invention relates to a damping structure which is capable effectively damping vibration of a structure. The damping structure includes a vibration controlling medium fixed at a structure and vibrating with an amplitude greater than that of the structure upon vibration and a damper vibrating separately from the vibration controlling medium as a result of being loosely fitted into the vibration controlling medium or a damper supporter extended therefrom, and thus having a vibration frequency different from that of the vibration controlling medium.

(21) Appl. No.: **12/264,378**(22) Filed: **Nov. 4, 2008**(30) **Foreign Application Priority Data**

Nov. 8, 2007 (KR) 10-2007-0113848

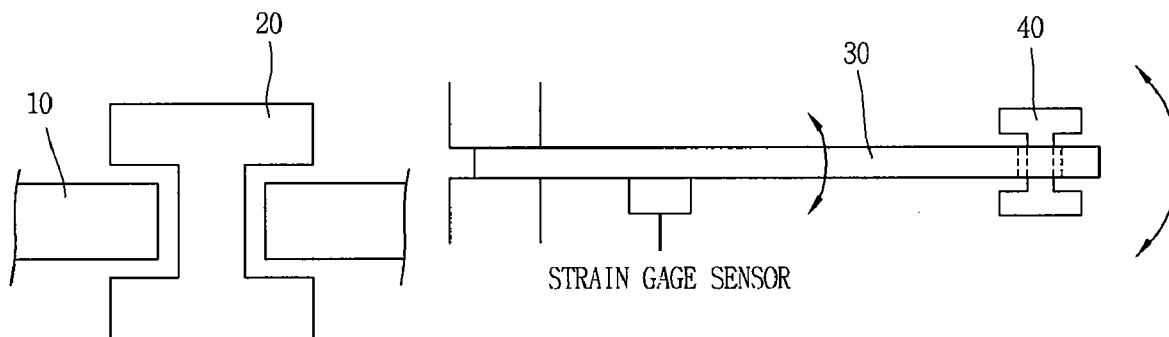


FIG. 1

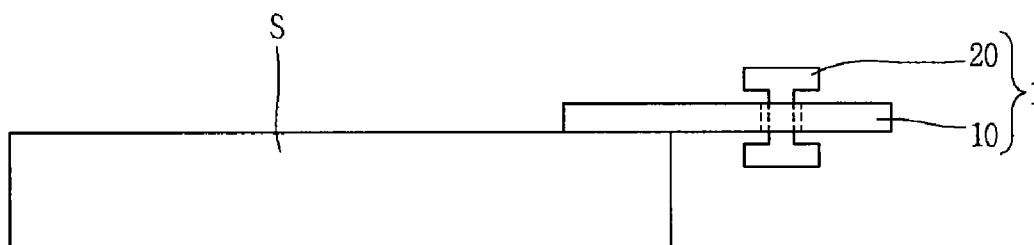


FIG. 2

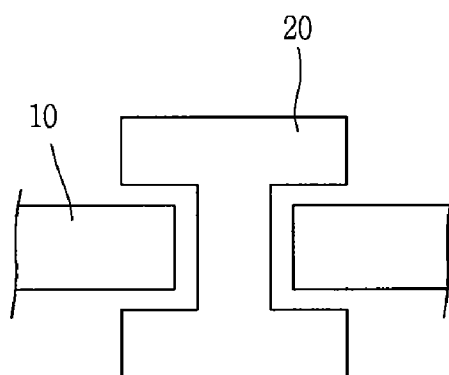


FIG. 3

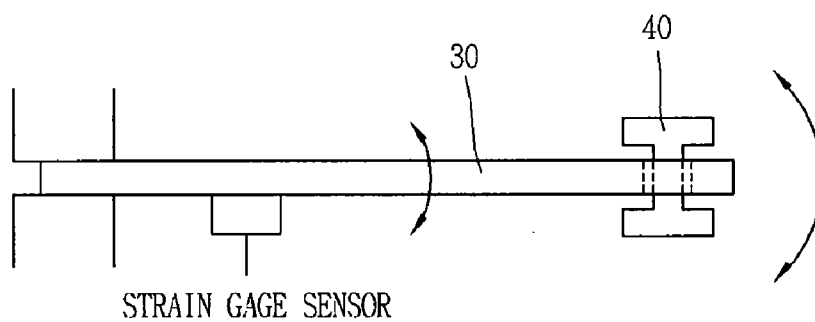


FIG. 4

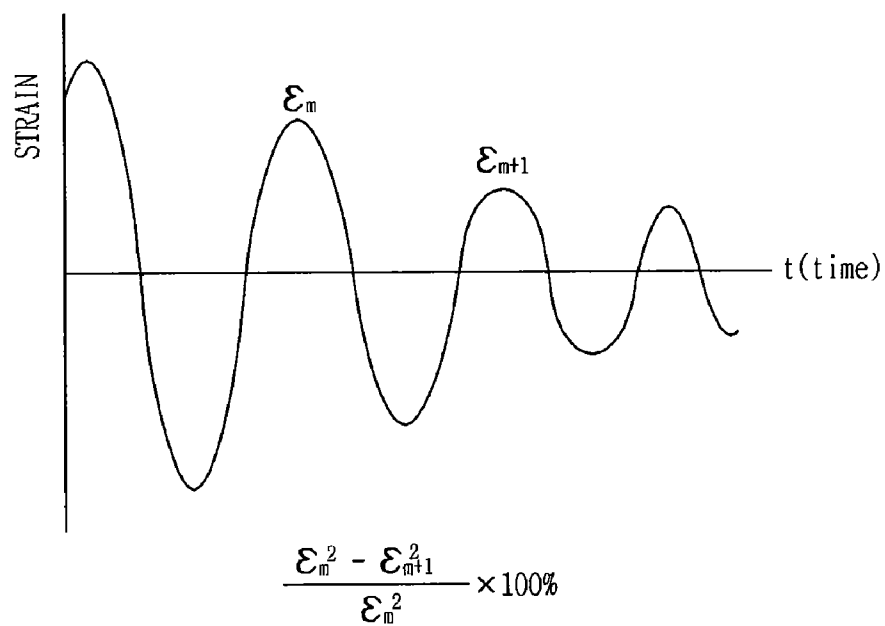


FIG. 5

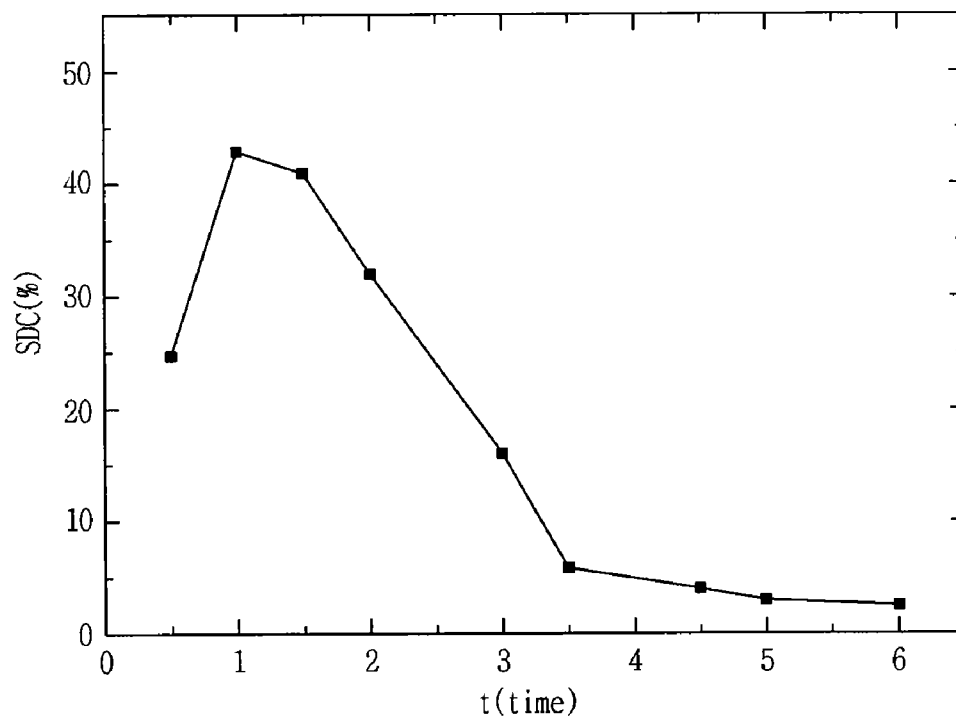


FIG. 6

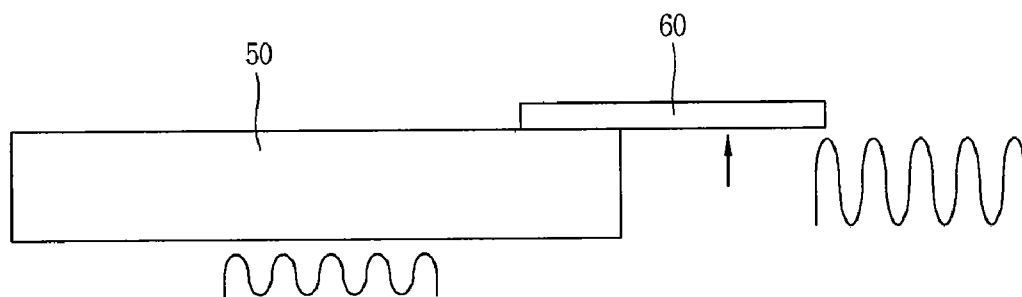


FIG. 7

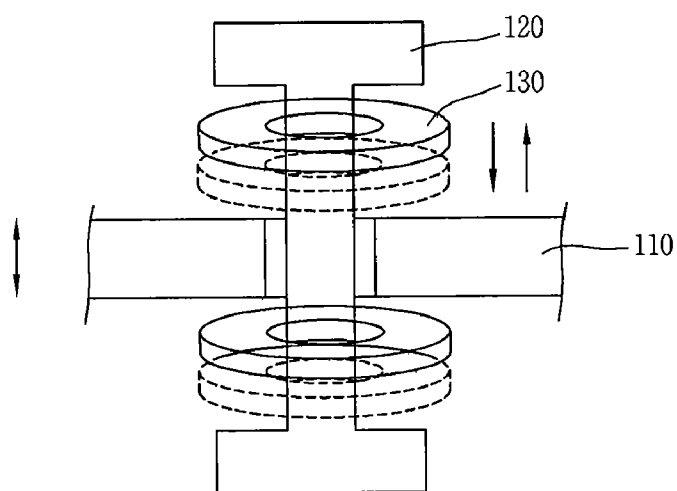


FIG. 8

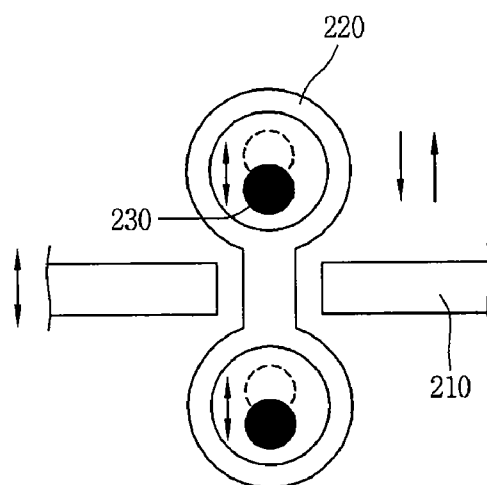


FIG. 9

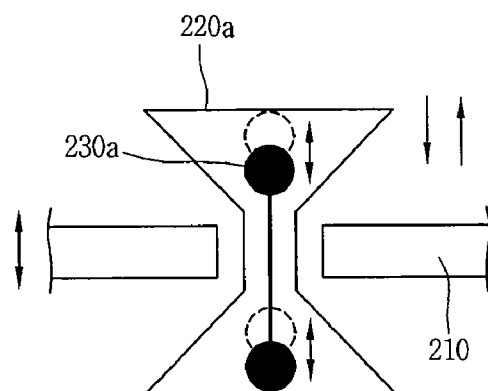


FIG. 10

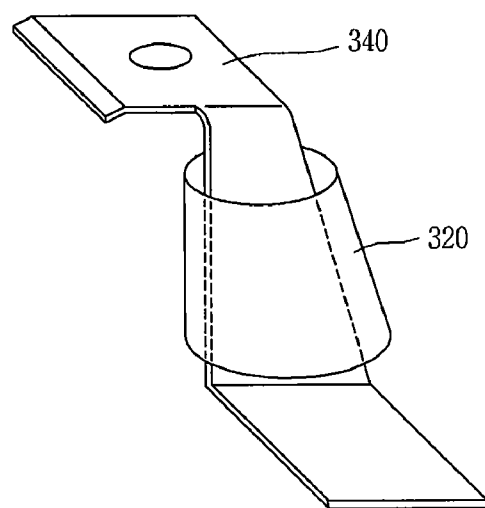


FIG. 11

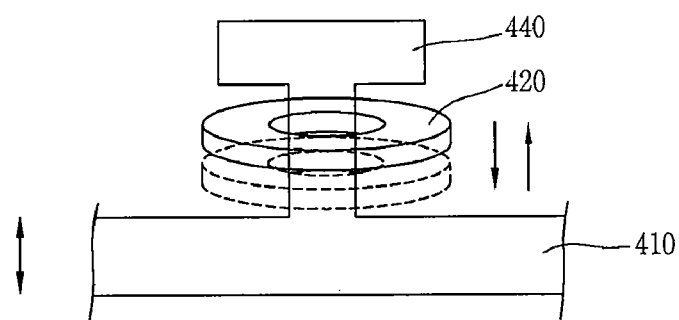


FIG. 12

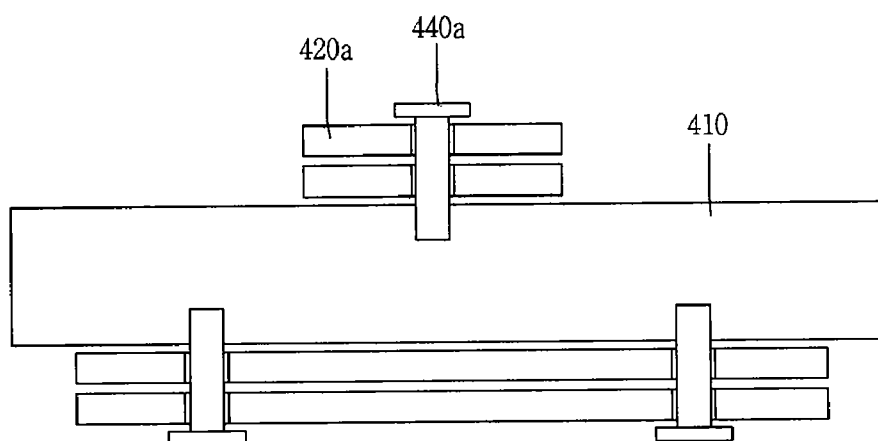


FIG. 13

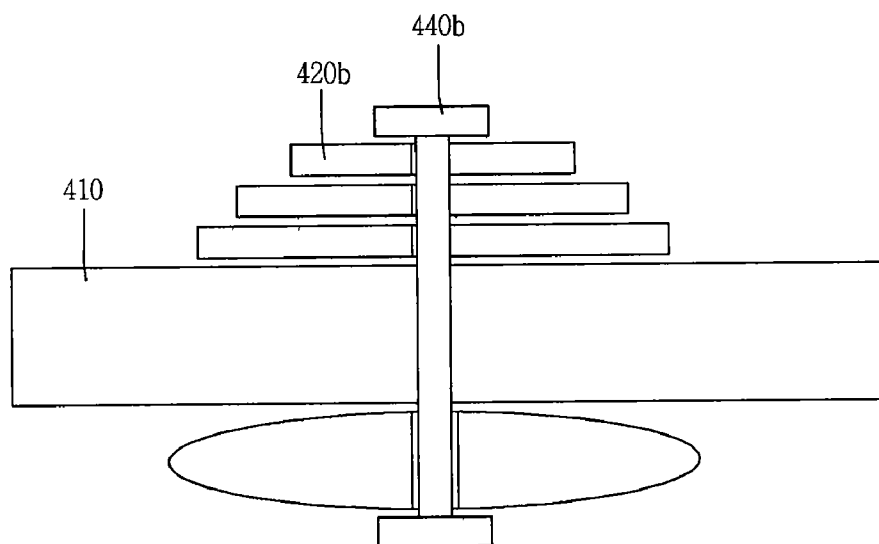


FIG. 14

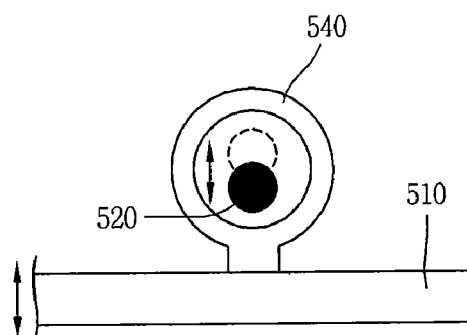


FIG. 15

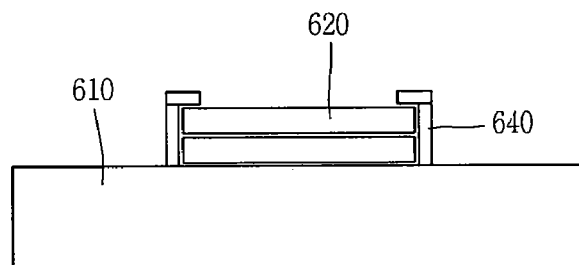


FIG. 16

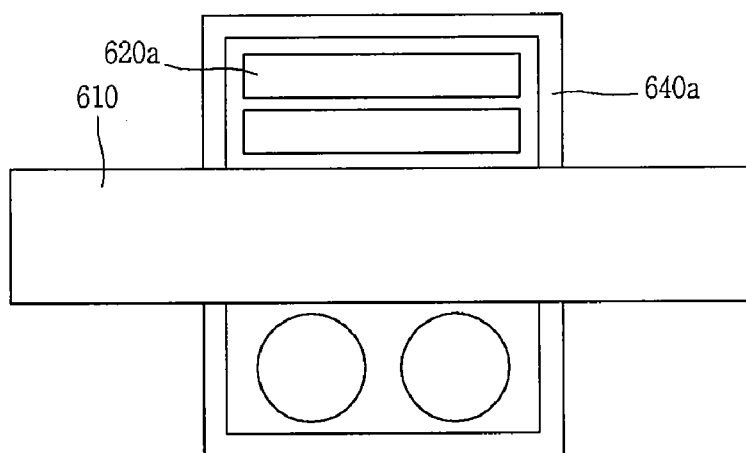


FIG. 17

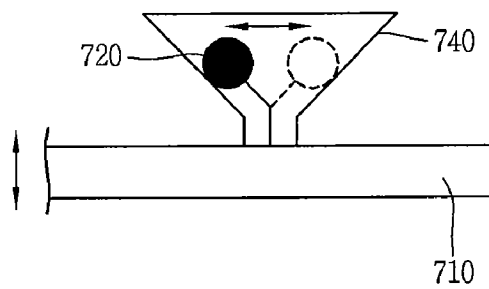


FIG. 18

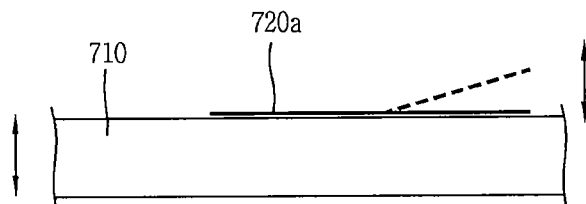


FIG. 19

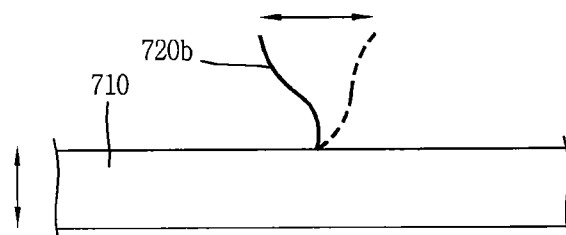
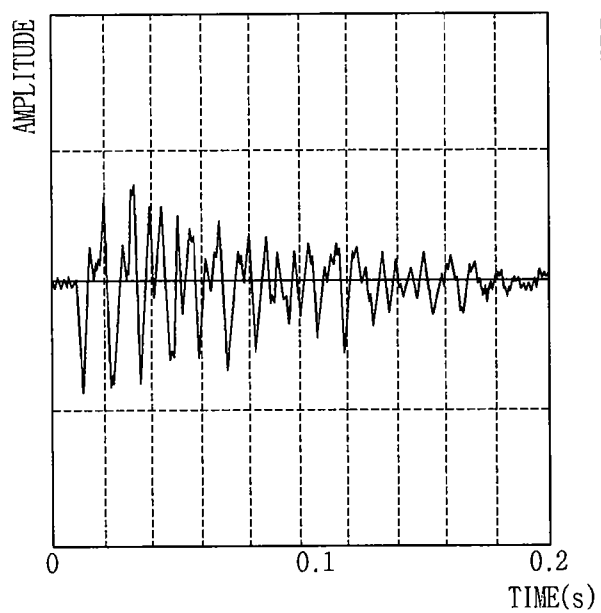
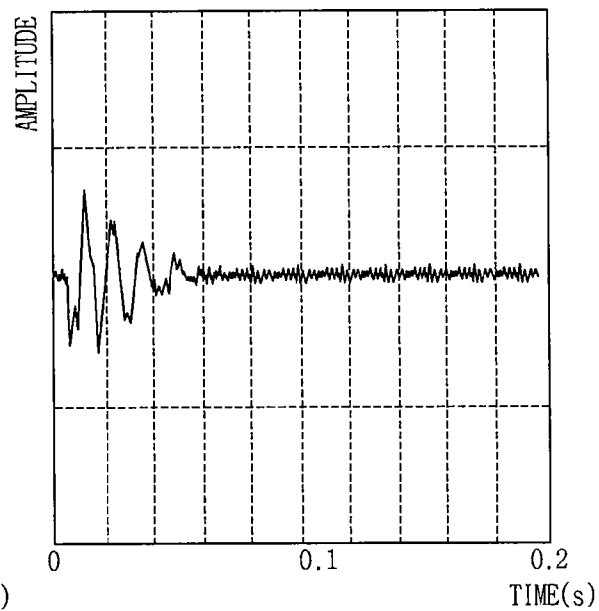


FIG. 20



<COMPARATIVE EXAMPLE>



<PREFERRED EXAMPLE>

DAMPING STRUCTURE

RELATED APPLICATION

[0001] The present disclosure relates to subject matter contained in priority Korean Application No. 10-2007-0113848, filed on Nov. 8, 2007, which is herein expressly incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a damping structure which is capable of effectively damping vibration of structures.

[0004] 2. Background of the Invention

[0005] Vibration of a structure causes great damage to a workplace. The vibration of the structure causes a noise. And, the noise may cause a noise-induced hearing loss to workers, which takes the first rank in vocational diseases and causes the workers to shirk working in a manufacturing part. Also, the vibration causes weariness and cracks to the structure such as a manufacturing plant. In addition, due to the vibration, it may be difficult to perform precise processes.

[0006] Various methods for suppressing vibration of a structure have been proposed so far.

[0007] One of them is using a special alloy having a high vibration damping (absorbing) force in itself. However, this method requires composition of the special alloy and a special process, thus it is seriously difficult to satisfy all of a cost, a mechanical performance and vibration suppression performance. Various alloys, such as Fe—Al based, Fe—Cr based, Mn—Cu based alloys, have been developed, however, they have hardly been commercially used.

[0008] As another method, a composite resin metallic plate in which a resin is interposed between metallic plates, that is, a sandwich steel plate structure is proposed. This structure implements excellent damping characteristic and mechanical performance. However, a special device is required for fabrication, which causes a fabrication cost to increase. And, it has an inferior welding or molding characteristic, thus it has a limitation to be used.

[0009] Besides, there are a method for increasing a mass and stiffness using a thick material and a method using a cover or a noise suppresser. However, these methods respectively have drawbacks that a weight may increase and that it is effective only in a limited space.

SUMMARY OF THE INVENTION

[0010] Therefore, a first object of the present invention is to provide a damping structure which is excellent in aspects of a cost, a mechanical characteristic and vibration damping performance and has compatibility with various devices.

[0011] A second object of the present invention is to provide a damping structure which is capable of being easily fabricated because it can be installed only by a simple process and of reducing an installation cost and time. Particularly, the damping structure according to the present invention is configured to be installed in a state that a structure to be damped is an end product, accordingly it is capable of obtaining a damping effect by simply installing the damping structure without changing a structure of a pre-fabricated device.

[0012] A third object of the present invention is to provide a damping structure which is capable of substantially damp-

ing vibration without increase of a weight and of being installed regardless of an installation space.

[0013] A fourth object of the present invention is to provide a damping structure which is capable of damping vibration of a structure formed by a thick metallic plate or a container for storing liquid.

[0014] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a damping structure comprising a vibration controlling medium fixed at a structure and vibrating with an amplitude greater than that of the structure upon vibration; and a damper vibrating separately from the vibration controlling medium as a result of being loosely fitted into the vibration controlling medium or a damper supporter extended therefrom, and thus having a vibration frequency different from that of the vibration controlling medium.

[0015] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0017] In the drawings:

[0018] FIG. 1 is a side view showing a damping structure in accordance with a first exemplary embodiment of the present invention;

[0019] FIG. 2 is a section view showing a structure of a damper used in the damping structure of FIG. 1;

[0020] FIG. 3 is a view schematically showing a device for measuring a specific damping capacity according to a thickness of a metallic plate;

[0021] FIG. 4 is a graph showing a method for measuring a strain caused by free vibration of a metallic plate;

[0022] FIG. 5 is a graph showing a specific damping capacity according to a thickness of a metallic plate;

[0023] FIG. 6 is a view schematically describing a principle applied to the present invention;

[0024] FIGS. 7 to 19 are section views or perspective view showing damping structures in accordance with each embodiment of the present invention; and

[0025] FIG. 20 is a graph showing results of measurement of specific damping capacity in a comparative example and a preferred example of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0026] Description will now be given in detail of the present invention, with reference to the accompanying drawings.

[0027] The present invention is configured to attach a vibration controlling medium to a structure and then control vibration of the vibration control medium so as to control vibration of the structure.

[0028] Referring to FIG. 1, a damping structure 1 in accordance with a first embodiment of the present invention includes a vibration controlling medium 10 and a damper 20 controlling vibration of the vibration controlling medium 10.

[0029] The vibration controlling medium 10 is configured to be fixed to a structure (S) in a welding manner, and to have amplitude greater than that of the structure (S) at a time of vibration. To this end, in this embodiment, the vibration controlling medium 10 is implemented as a plate having a thickness lower than that of a plate forming the structure (S). The vibration controlling medium 10 may be formed of various materials such as metal, ceramic, rubber according to a vibration condition.

[0030] Also, the damper 20 is loosely fitted into the vibration controlling medium 10, and thus separately vibrates from the vibration controlling medium 10. Accordingly, the damper 20 has a vibration frequency different from that of the vibration controlling medium 10. Referring to FIG. 2, the damper 20 is loosely fitted into the vibration controlling medium 10 by passing through a hole formed at the vibration controlling medium 10, accordingly the damper 20 vibrates separately from the vibration controlling medium 10. In this embodiment, the damper 20 is formed in a rivet shape, but it is not limited thereto. And, though it is not shown, the damper 20 also may be loosely fitted into a damper supporter extended from the vibration controlling medium 10 by passing through a hole formed at the damper supporter.

[0031] In the present invention, a principle that the damper 20 controls the vibration of the vibration controlling medium 10 is using a collision between two members 10, 20 respectively vibrating. That is, when respectively vibrating the damper 20 and the vibration controlling medium 10, two members 10, 20 collide with each other because each vibration frequency of the two members 10, 20 is different from each other. Accordingly, the vibration can be damped.

[0032] To properly execute a performance of the damping structure, effect of the collision between two members 10, 20 should be great. Thus, the amplitude of the vibration controlling medium 10 should be large. A simple method for increasing the amplitude of the vibration control medium 10 is reducing a thickness of the vibration controlling medium 10. However, a metallic plate forming a structure used for a plant has a thickness of 10 mm in many cases, and it is difficult to make a hole in a container containing fluid therein. Therefore, in the present invention, the vibration controlling medium is attached to a structure and then the vibration of the vibration controlling medium is controlled using the damper so as to control the vibration of the structure, rather than directly installing the damper at the structure.

[0033] To research how thick the metallic plate should be so as to be suitable for the damper shown in FIG. 2, multiple metallic plates 30 having different thickness from each other are made to have holes and then a damper 40 formed in a rivet shape same as FIG. 2 is installed in each hole, as shown in FIG. 3. A strain gage sensor is attached onto each metallic plate 30. And then, each metallic plate 30 executes in a free vibration mode so as to measure a strain. The measured strain is represented in FIG. 4 and evaluated as a Specific Damping Capacity (SDC) of the following formula (1):

$$SDC = (\epsilon_n^2 - \epsilon_{n+1}^2) / \epsilon_n^2 \quad \text{Formula (1)}$$

[0034] Here, ϵ_n denotes a strain occurring at a time of n^{th} vibration and ϵ_{n+1} denotes a strain occurring at a time of $n+1^{th}$ vibration. Since an elastic energy is proportional to the square of a value of the strain, the formula (1) indicates a ratio of an energy absorbed when vibration of one cycle is generated.

[0035] FIG. 5 shows an SDC according to a thickness of the metallic plate 30. Referring to FIG. 5, approximately 25% of

SDC was obtained when the thickness of the metallic plate is 0.5 mm. The SDC rose to the maximum as 43% and 40% respectively, when each thickness of the metallic plates is respectively 1.0 mm and 1.5 mm and then drastically decreased. And, when the thickness of the metallic plate is over 3.5 mm, the vibration damping effect was hardly obtained. This is because, in the same strain, a thin metallic plate increases the amplitude to enhance the collision effect of the damper, but a thick metallic plate decreases the amplitude upon vibration so as to lower the collision effect. Therefore, when using the damper shown in FIG. 2, the thickness of the metallic plate has great influence thereon. The vibration damping effect can be greatly obtained in a thickness of 0.5~3.5 mm, preferably, 1~1.5 mm.

[0036] In many cases, structures or manufacturing facilities at a noisy place such as a plant are formed by a steel plate having a thickness of several tens of mm. In these cases, if the damper having the structure shown in FIG. 2 is directly installed, the vibration damping effect is hardly obtained as shown in FIG. 5.

[0037] To solve such problem, the present invention is configured to adhere a thin plate 60 to serve as a vibration controlling medium onto a thick plate 50 forming a structure in a welding manner. When an impact is applied to the thick plate 50 from outside, both of the plates 50, 60 may vibrate together. In this case, the thick plate 50 may vibrate with small amplitude and the thin plate 60 may vibrate with large amplitude. Here, if the thin plate 60 is forced not to vibrate, the thick plate 50 may easily stop vibrating. Accordingly, when adhering the thin plate 60 having a proper thickness onto the thick plate 50, as shown in FIG. 6, and then installing the damper configured as shown in FIG. 2 at the thin plate 60, it is capable of easily damping the vibration. The thick plate 50 corresponds to the structure (S) shown in FIG. 1 and the thin plate 60 corresponds to the vibration controlling medium 10 shown in FIG. 1. As aforementioned, the thin plate, that is, the vibration controlling medium, had better have a thickness of 0.5~3.5 mm, preferably, 1~1.5 mm so as to enhance the vibration damping effect.

[0038] The damper 20 shown in FIGS. 1 and 2 can be configured to have various modifications. The modifications are illustrated in FIGS. 7 to 19. However, the present invention is not limited to the modifications.

[0039] Referring to FIG. 7, the damping structure according to the present invention further includes a sub damper 130 formed in a washer shape and loosely encompassing the damper 120, as well as the damper 120 formed in the rivet shape loosely fitted into the vibration controlling medium 110 with passing through a hole formed in the vibration controlling medium 110. Here, the sub damper 130 has a vibration frequency different from that of the vibration controlling medium 110 and assists the damper 120 executing the damping operation. As another embodiment, the reference numeral 110 in FIG. 7 may be a damper supporter extended from the vibration controlling medium, not the vibration controlling medium. Here, the term "extended" may be applied to both a case that the damper supporter is coupled and fixed to the vibration controlling medium, as a member separated from the vibration controlling medium, and a case that the damper supporter is integrally formed with the vibration controlling medium.

[0040] Referring to FIGS. 8 and 9, damping structures according to the present invention further include sub dampers 230, 230a disposed in dampers 220, 220a and vibrating

with being separated from dampers **220**, **220a**, respectively, as well as the dampers **220**, **220a** loosely fitted into a vibration controlling medium **210** with passing through a hole formed in the vibration controlling medium **210**. As another embodiment, the reference numeral **210** in FIGS. **8** and **9** may be a damper supporter extended from the vibration controlling medium, not the vibration controlling medium.

[0041] Referring to FIGS. **10** to **13**, dampers **320**, **420**, **420a**, **420b** forming a damping structure according to the present invention loosely encompass damper supporter **340**, **440**, **440a**, **440b** extended from a vibration controlling medium. As another embodiment, a reference numeral **340** shown in FIG. **10** may not denote the damper supporter but denote the vibration controlling medium.

[0042] Referring to FIG. **14**, a damper **520** forming a damping structure of the present invention is disposed in a damper supporter **540** extended from a vibration controlling medium **510**.

[0043] Referring to FIGS. **15** and **16**, dampers **620**, **620a** forming damping structures of the present invention are defined by a space formed by the damper supporters **640**, **640a** and the vibration controlling medium **610**.

[0044] Referring to FIGS. **17** to **19**, dampers **720**, **720a**, **720b** forming damping structures of the present invention separately vibrate in a state that each one point thereof is fixed at a vibration controlling medium **710**. As another embodiment, the reference numeral **710** shown in FIGS. **17** to **19** may denote a damper supporter extended from the vibration controlling medium, not the vibration controlling medium.

EMBODIMENT

[0045] A vibration experiment was executed with respect to a carbon steel plate of 250 mm (length)×250 mm (width)×15 mm (thickness). In a comparative example, there was no additional installation. In a comparative example, metallic plates respectively having a length of 100 mm, a width of 15 mm and a thickness of 1.0 mm were adhered to four edges of the carbon steel plate. And then, the dampers formed in a rivet shape were installed as shown in FIG. **1** by boring holes in the metallic plate.

[0046] After impacting the carbon steel plate by shooting a steel ball of 1 kg in a speed of 1 m/sec, the vibration of the carbon steel plate was measured using a strain gage sensor attached onto the carbon steel plate. As a result, in case of the comparative example, the vibration lasted for approximately 0.2 seconds after the impact. On the other hand, in case of the preferred example, the vibration lasted for approximately 0.05 seconds, that is, one-fourth of the vibration time of the comparative example, which means that the preferred example obtained a great vibration damping effect (refers to FIG. **20**).

[0047] The foregoing embodiments and advantages are merely exemplary and are not to be construed as limiting the present disclosure. The present teachings can be readily applied to other types of apparatuses. This description is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art. The features, structures, methods, and other characteristics of the exemplary embodiments described herein may be combined in various ways to obtain additional and/or alternative exemplary embodiments.

[0048] According to the present invention, the vibration controlling medium is adhered onto the structure and then the vibration of the vibration controlling medium is controlled

using the damper having a simple structure, accordingly it is capable of efficiently damping the vibration of the structure. Also, it is capable of easily controlling vibration with a low cost even in case of a thick plate or a container for storing liquid, the container having difficulty in installation of the damper.

[0049] As the present features may be embodied in several forms without departing from the characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its scope as defined in the appended claims, and therefore all changes and modifications that fall within the metes and bounds of the claims, or equivalents of such metes and bounds are therefore intended to be embraced by the appended claims.

1. A damping structure comprising:
 - a vibration controlling medium fixed at a structure and vibrating with an amplitude greater than that of the structure upon vibration; and
 - a damper vibrating separately from the vibration controlling medium as a result of being loosely fitted into the vibration controlling medium or a damper supporter extended therefrom, and thus having a vibration frequency different from that of the vibration controlling medium.
2. The damping structure of claim 1, wherein the damper is loosely fitted by passing through a hole formed at the vibration controlling medium or a damper supporter extended therefrom.
3. The damping structure of claim 2, further comprises a sub damper loosely encompassing the damper.
4. The damping structure of claim 2, wherein the damper is formed in a rivet shape.
5. The damping structure of claim 2, further comprises a sub damper disposed in the damper and vibrating separately from the damper.
6. The damping structure of claim 1, wherein the damper is loosely encompassing the vibration controlling medium or a damper supporter extended therefrom.
7. The damping structure of claim 1, wherein the damper is disposed in the damper supporter.
8. The damping structure of claim 1, wherein the damper is defined by a space formed by the damper supporter and the vibration controlling medium.
9. The damping structure of claim 1, wherein the damper separately vibrates in a state that one point thereof is fixed at the vibration controlling medium or the damper supporter extended therefrom.
10. The damping structure of claim 1, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.
11. The damping structure of claim 10, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.
12. The damping structure of claim 1, wherein the vibration controlling medium is adhered to the structure in a welding manner.
13. The damping structure of claim 2, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.
14. The damping structure of claim 3, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.

15. The damping structure of claim **4**, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.

16. The damping structure of claim **5**, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.

17. The damping structure of claim **6**, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.

18. The damping structure of claim **7**, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.

19. The damping structure of claim **8**, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.

20. The damping structure of claim **9**, wherein the vibration controlling medium is implemented as a plate having a thickness thinner than a plate forming the structure.

21. The damping structure of claim **13**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

22. The damping structure of claim **14**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

23. The damping structure of claim **15**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

24. The damping structure of claim **16**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

25. The damping structure of claim **17**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

26. The damping structure of claim **18**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

27. The damping structure of claim **19**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

28. The damping structure of claim **20**, wherein the vibration controlling medium is implemented as the plate having a thickness of 0.5~3.5.

* * * * *