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(54) **INNER ENCLOSURE WITH MICRO SHOCK ABSORBER FOR A CARRYING CASE**

(75) Inventor: **Bill Kwong**, Saratoga, CA (US)

Correspondence Address:
C.P. Chang c/o Pacific Law Group LLP
Suite 290
2 North Second Street
San Jose, CA 95113 (US)

(73) Assignee: **Addonics Technologies, Inc.**, Fremont, CA (US)

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Publication Classification

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(57) **ABSTRACT**

An improved soft inside enclosure for shock protection of a variety of external electronic and computer peripheral comprises a set of substantially evenly spaced small columns of Micro Shock Absorber (MSA) protrusions that are integrated on the inside surfaces of the soft inside enclosure. Additionally, the base wall of the MSA structure can include a set of micro venting features for the improvement of heat dissipation from the enclosed devices to the ambient. A number of specific candidate materials are also presented for the construction of the soft inside enclosure with the MSA structure. A method for the systematic and experimental determination of a specific design of the MSA structure based on its durometer, thickness, diameter, column height, and pitch are disclosed.

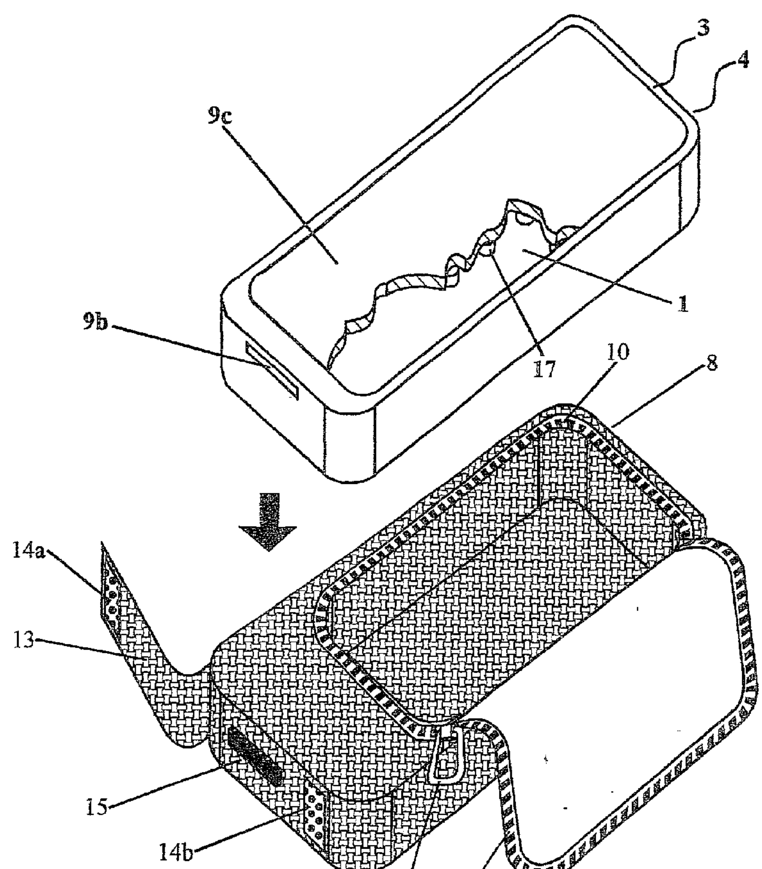


FIG.-1

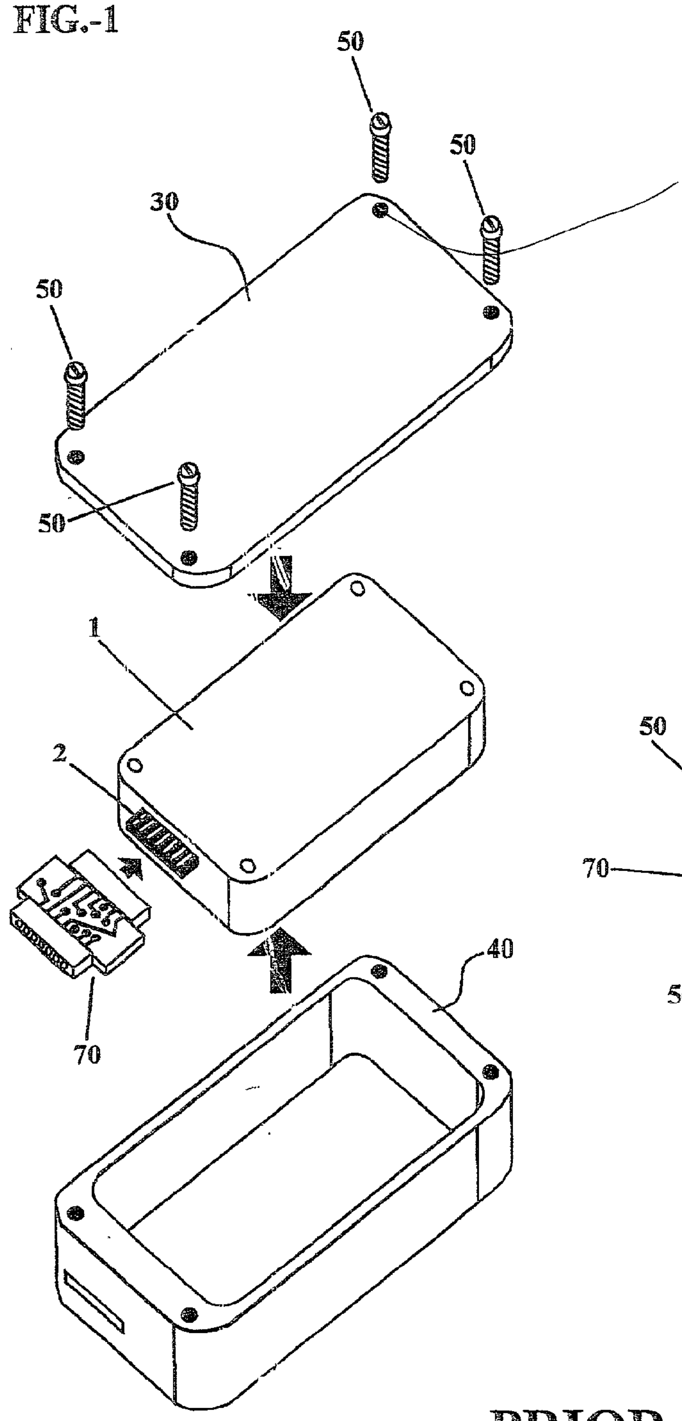
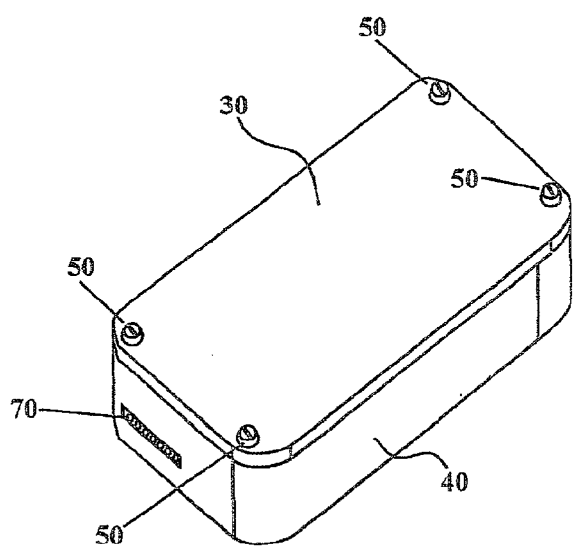


FIG.-2



PRIOR ART

FIG.-3A

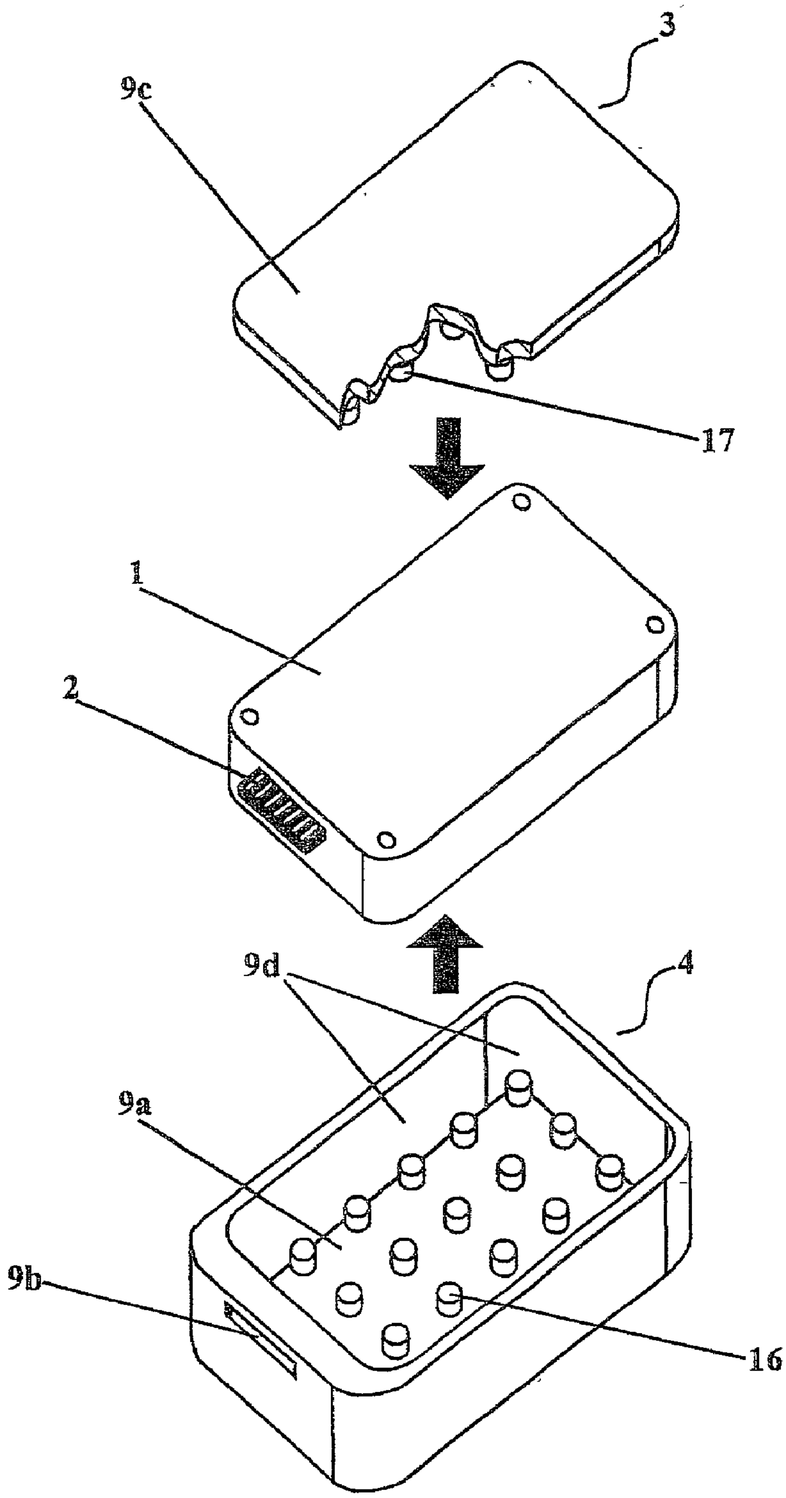


FIG.-3B

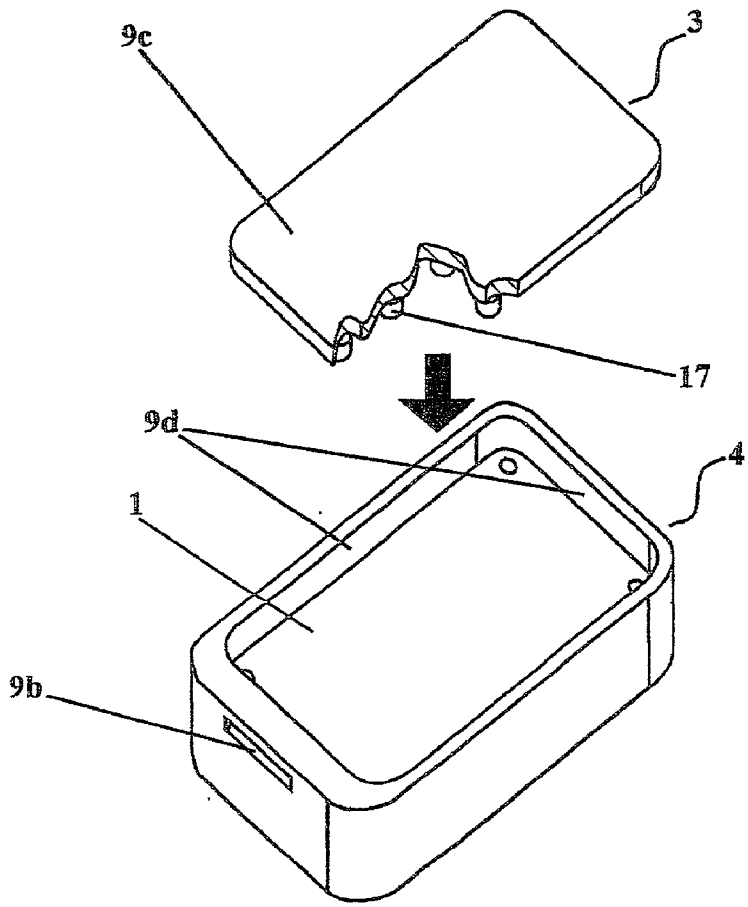


FIG.-3C

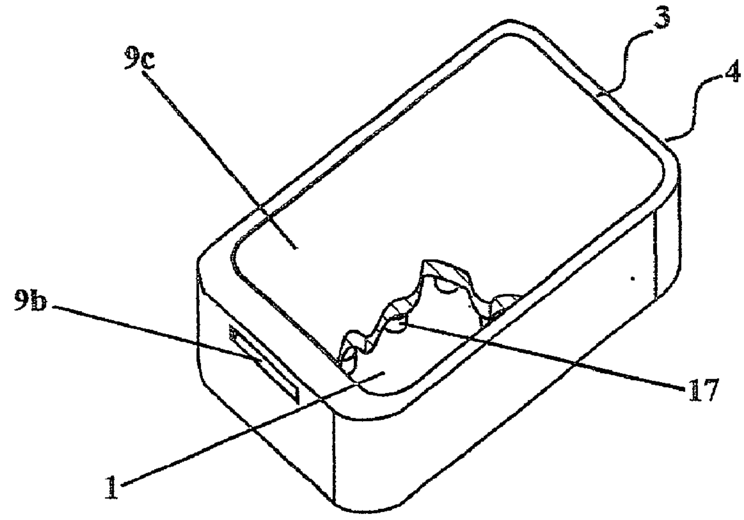


FIG.-4

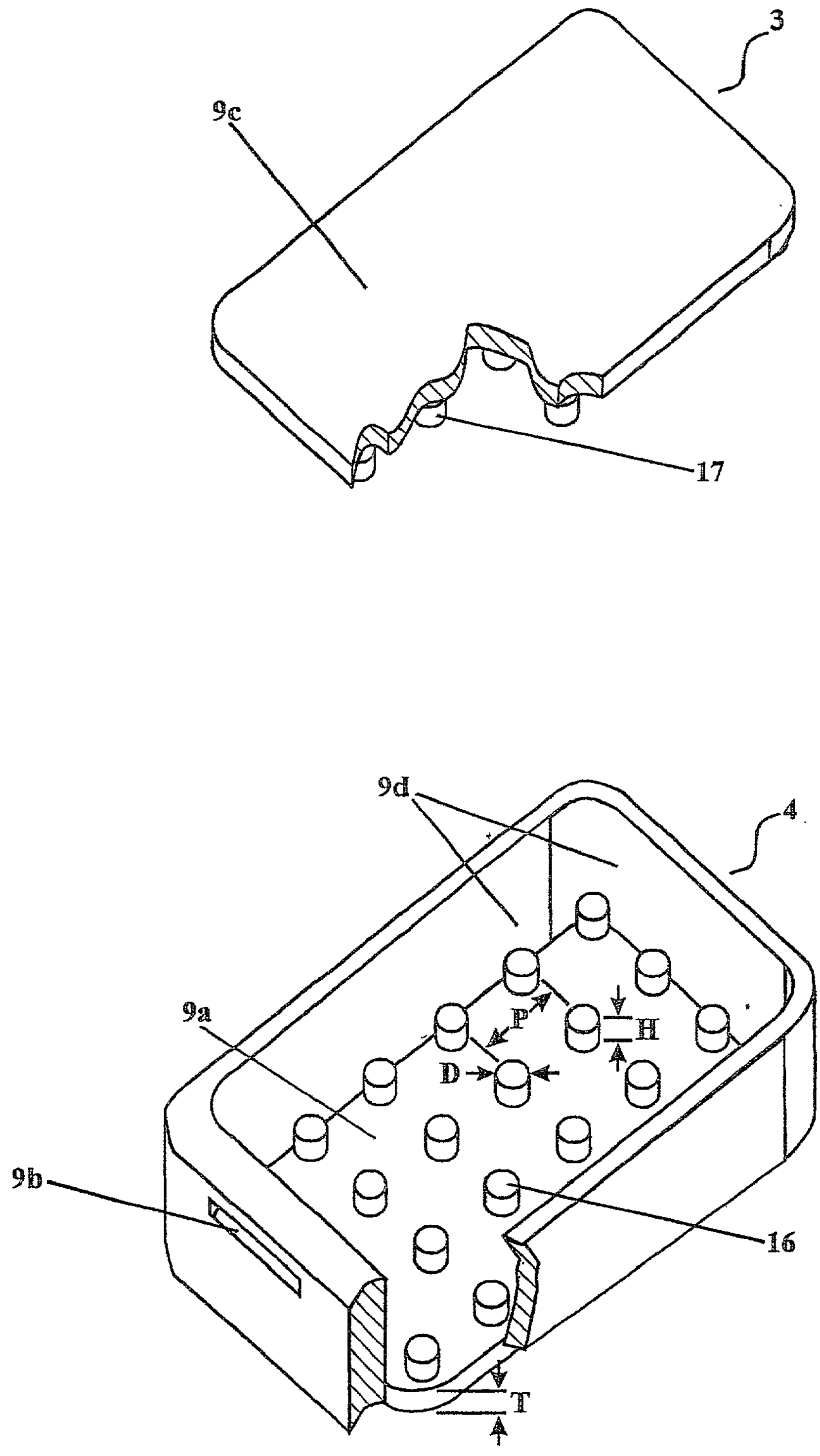
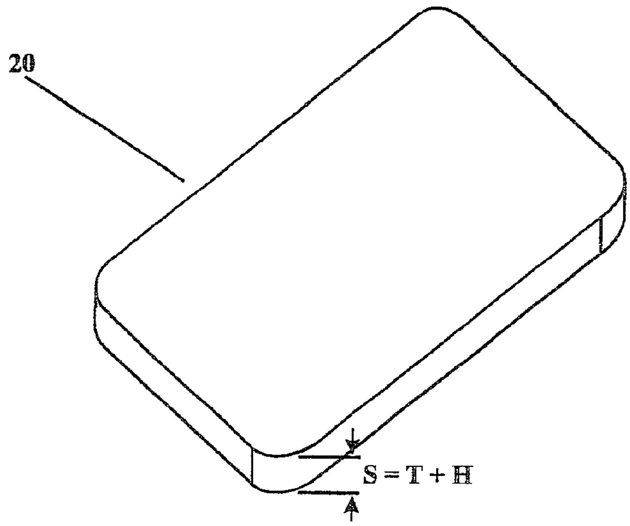
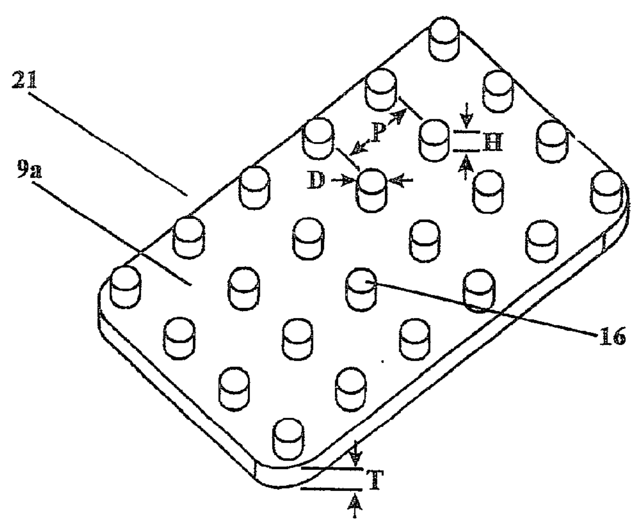


FIG.-5A



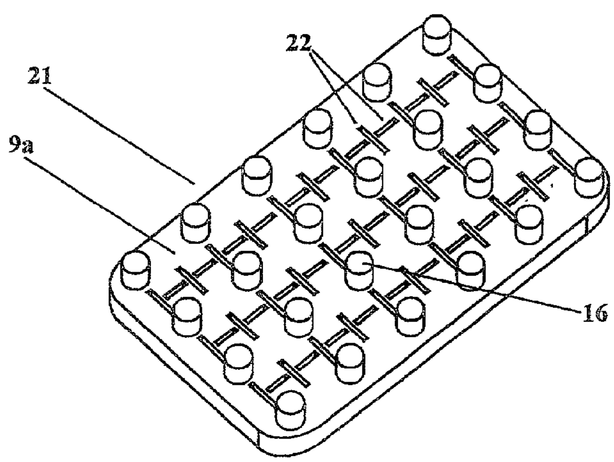
PRIOR ART

FIG.-5B



CURRENT INVENTION

FIG.-6



CURRENT INVENTION

FIG.-7A

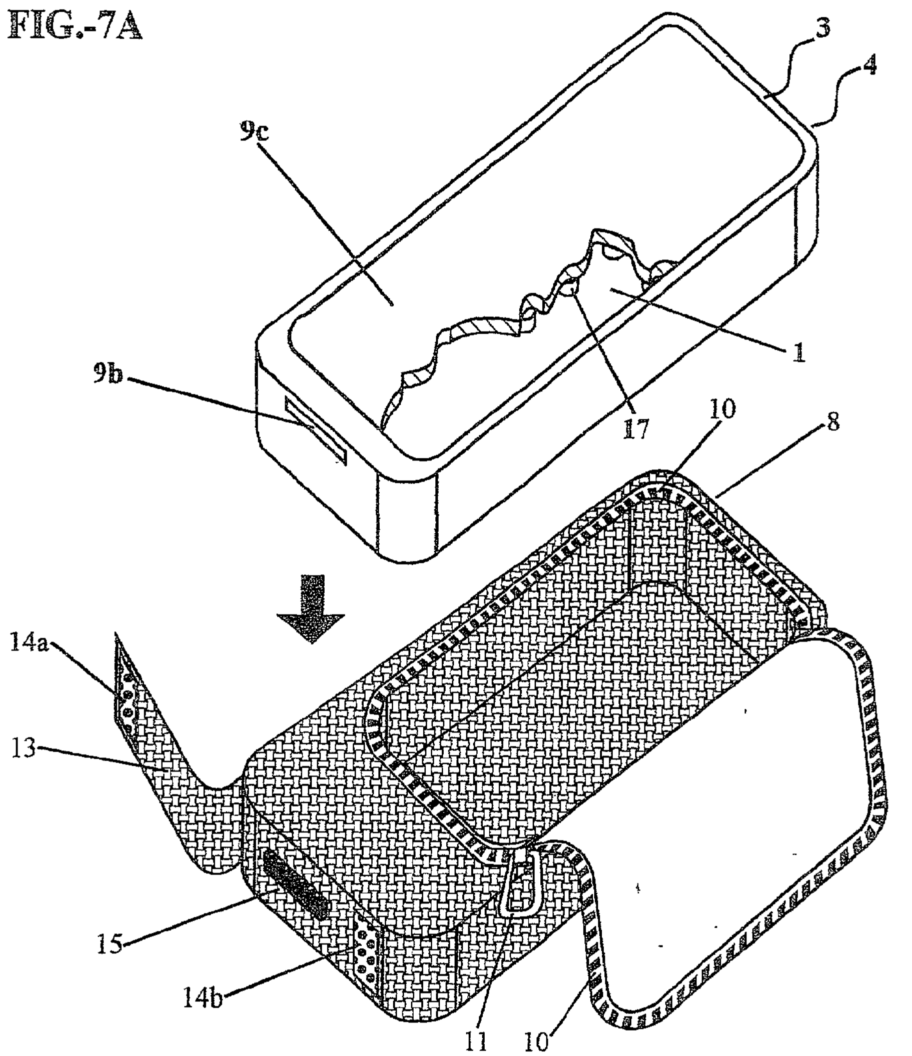


FIG.-7B

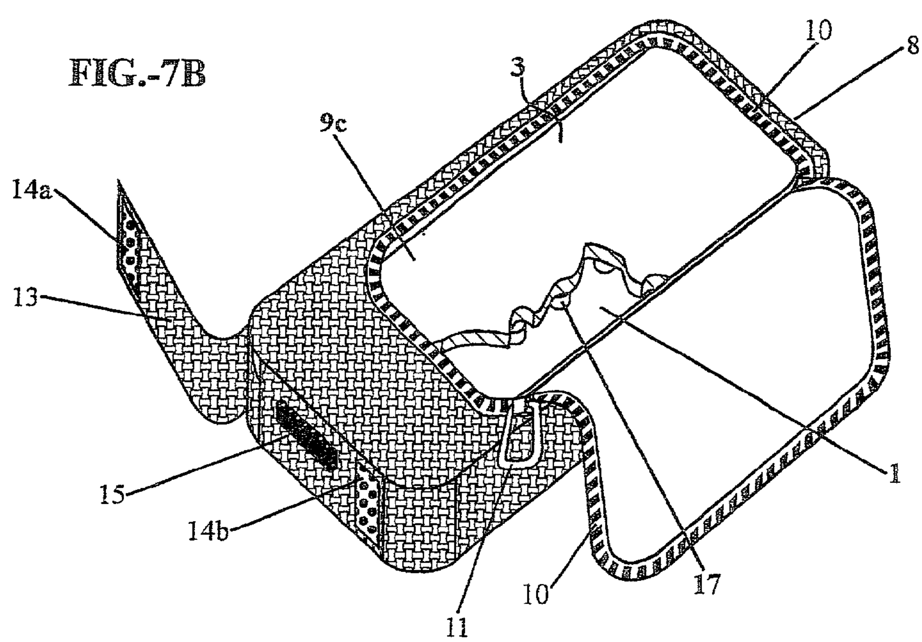


FIG.-8A

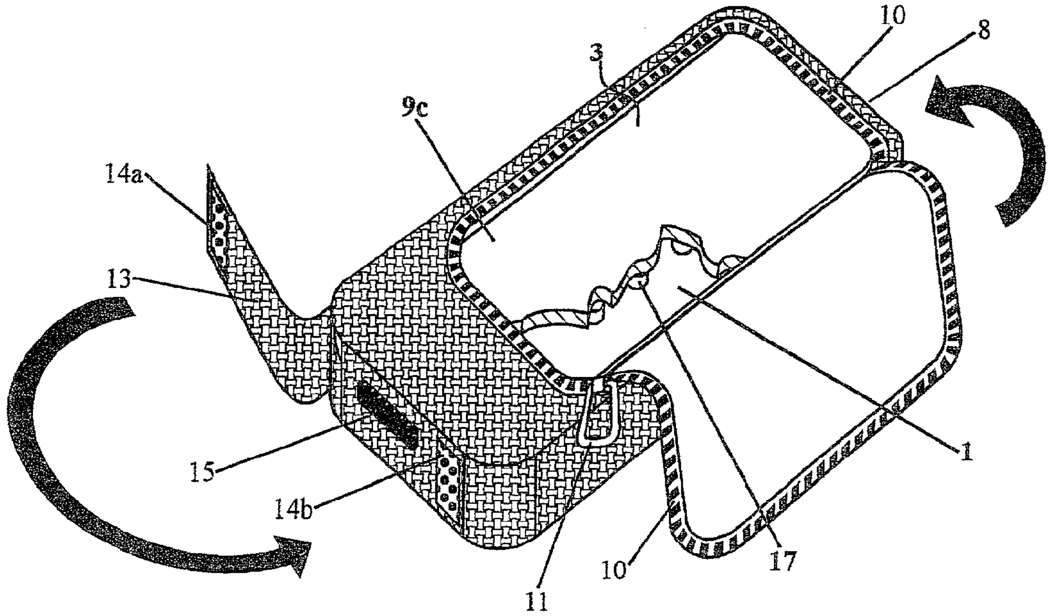
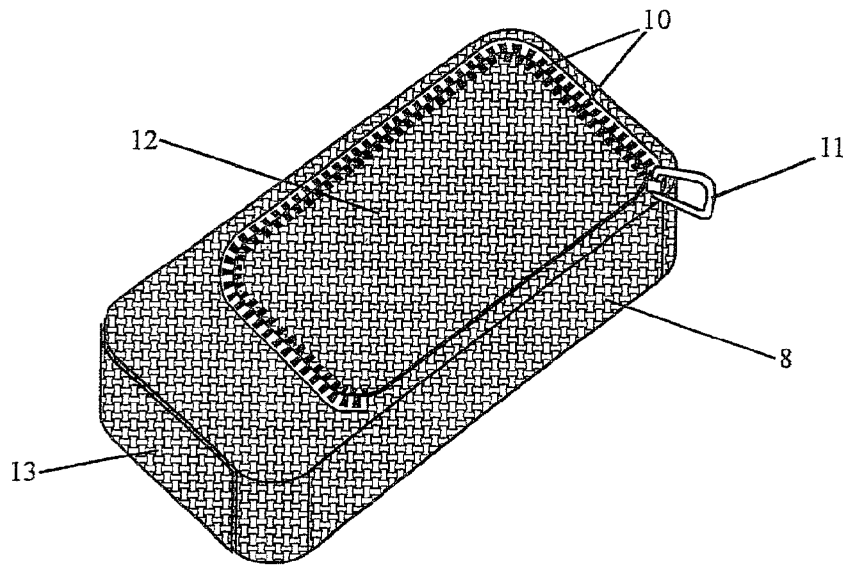


FIG.-8B



INNER ENCLOSURE WITH MICRO SHOCK ABSORBER FOR A CARRYING CASE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This invention is a formal application of a provisional application, filed on Dec. 18, 2000, Serial No, 60/256,735 and a continuation application filed Sep. 19, 2001, Ser. No. 09/956,727.

FILED OF INVENTION

[0002] This invention relates to a new design of a soft inner enclosure for the carrying case of an external data storage device or other electronic devices for shock protection of the external data storage device or other electronic devices in their storage, carrying and operating mode.

BACKGROUND OF INVENTION

[0003] The need of an enclosure for the protection of a variety of devices against shock has been around for a long time. A brief search and analysis of the prior art revealed the following US patents:

[0004] U.S. Pat. No. 4,786,121 (November 1988, by Lyons), titled computer protective enclosure, teaches the usage of outside panels with inner linings to acoustically isolate and additionally protect the stored computer. The outside panels, or covers, are made of rigid materials such as wood, plastic and metal. The inner linings are made of foam plastic with a space between the inner linings and the computer. Furthermore, the enclosure is intended for affixing to building construction members or other stationary objects for stability.

[0005] U.S. Pat. No. 4,846,340 (July 1989, by Walther), titled shock proof carrying enclosure for musical instrument, teaches the usage of an enclosure for the shock proof storage and carrying of a musical instrument like cello. However, in this case, the enclosed musical instrument is already retained within a rigid case to begin with. Therefore, effectively, the protective structure for the musical instrument itself consists of an inner rigid case and an outer flexible enclosure.

[0006] U.S. Pat. No. 5,010,988 (April 1991, by Brown), titled expandable shock protected carrying case, teaches the usage of a carrying case for a lap top computer, printers, facsimiles and the like where the carrying case comprises of functional elements like handle, shoulder strap, compartments and accessory pockets. The disclosed wall structure consists of at least three layers, that is, an outer shell, an inner shell and a three-ply shock protection structure sandwiched in between. The outer shell is made of a substantially rigid yet soft material. The disclosed carrying case looks to be primarily used when the enclosed device is in its non-operating mode. Thus, for example, thermally insulating materials and related structural design are employed there to protect the enclosed device from temperature extremes.

[0007] U.S. Pat. No. 6,034,841 (March 2000, by Albrecht, Khanna, Kumar and Sri-Jayantha), titled disk drive with composite sheet metal and encapsulated plastic, describes the usage of a metal base with integrally molded plastic peripheral flanges plus elastomeric comer bumpers for shock protection. As described, except for the elastomeric comer bumpers, all the other enclosure pieces are made of rigid material.

[0008] As described in a pending application filed earlier by the inventor, a soft enclosure design for an external data storage device or other electronic devices in their storage, carrying and operating mode is disclosed. The inside shock absorbing layer of the soft enclosure design, now called inner enclosure for simplicity, provides many functions. Some examples of the functions are shock protection, heat dissipation, fire retardation, shielding against radio frequency interference, prevention of build up of static electricity and prevention of dirt penetration into the interior of the enclosure. This invention deals with a more specific design of the inner enclosure with additional merits. For clarity, it is remarked that the inner enclosure is also commonly referred to as the inner lining for a carrying case.

SUMMARY OF INVENTION

[0009] The current invention is conceived to realize a more specific design of the inner enclosure, or the inner lining for a carrying case, of an external data storage device with additional merits. Specifically, it is an objective of this invention to provide an inner enclosure for an external data storage device whereby the function of shock protection for the data storage device is achieved by using a minimum amount of materials thus saving manufacturing cost and reducing the associated product weight.

[0010] It is another objective of this invention to provide an inner enclosure for an external data storage device whereby improved heat dissipation for the data storage device is achieved by using a minimum amount of materials thus saving manufacturing cost and reducing the associated product weight.

[0011] A third objective of this invention is to provide an inner enclosure for an external data storage device whereby the functions of fire retardation, shielding against radio frequency interference and prevention of build up of static electricity are achieved with a selection of specific materials for the inner enclosure.

[0012] Accordingly, the invention disclose a new design of the inner enclosure for the carrying case of, but without limitation to, an external data storage device as mentioned in the said prior application. The inner enclosure is made of a soft shock absorbing material and provides for a snug fit and an all around shock protection for the enclosed data storage device in both non-operating and operating modes. The inner enclosure consists of a device compartment and a removable cover. Once the inner enclosure is completely closed within an outer enclosure, the inner enclosure will provide a snug fit to the enclosed device all around. For good shock absorption while using a minimum amount of material, the inner surface of the inner enclosure is constructed with an array of substantially evenly spaced miniature columns called Micro Shock Absorber (MSA). In addition to shock protection, the MSA also provides air circulation to the enclosed storage device by creating a thin air space between the device and the inner enclosure. As needed, the material of the inner enclosure can be selected to be fire retardant, shielding against radio frequency interference, preventing build up of static electricity, allowing better heat dissipation from the data storage device while preventing dirt penetration into the interior of the enclosure.

BRIEF DESCRIPTION OF DRAWINGS

[**0013**] The invention is explained in full detail with the following detailed description of the preferred embodiments, with reference made to the accompanying drawings, wherein:

[**0014**] **FIG. 1** is one perspective illustration of a commonly practiced prior art wherein two rigid covers with mounting means are employed to enclose a storage device;

[**0015**] **FIG. 2** is one more perspective illustration of a commonly practiced prior art wherein two rigid covers with mounting means are employed to enclose a storage device;

[**0016**] FIGS. **3**A-C are perspective illustrations of the current invention wherein two soft inner enclosures, or alternatively called inner linings, are employed to enclose a storage device;

[**0017**] **FIG. 4** is a perspective illustration of the current invention wherein the details of the MSA structure and its associated design parameters are shown;

[**0018**] FIGS. **5**A-B are comparison of the wall structure between a traditional and the current design of the inner enclosure with design parameters illustrating the benefit of materials saving with the current invention;

[**0019**] **FIG. 6** illustrates an additional embodiment of the current invention wherein a set of micro venting slots are added to the wall structure of the current invention with MSA for further improved heat dissipation;

[**0020**] FIGS. **7**A-B are additional perspective illustrations of the current invention wherein a fully enclosed storage device, within two soft inner enclosures with MSA, similar to that illustrated in **FIG. 3C** is progressively shown to be loaded into a soft outside enclosure; and

[**0021**] FIGS. **8**A-B are the final perspective illustrations of the current invention wherein the fully enclosed storage device from **FIG. 7B** is progressively shown to be fully enclosed with the closure of a soft device cover and a soft connector cover.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[**0022**] **FIG. 1** and **FIG. 2** are perspective illustrations of a commonly practiced prior art wherein two rigid covers with mounting means are employed to enclose a storage device. **FIG. 1** illustrates, with two arrows, the progressive enclosure of a storage device **1** with a storage device interface connector **2** and an associated rigid connector interchanger **70**. The wall material of the storage device **1** is usually made of metal to house the precision mechanism inside. The storage device interface connector **2**, when hooked up, through the associated rigid connector interchanger **70**, with the corresponding mating connector of a computer not shown here, would provide all the necessary electrical power and interface signals to insure proper operation of the storage device **1**. As shown, the storage device **1** will generally be housed between a rigid top cover **30** and a rigid bottom cover **40** with a set of mounting screws **50**. The finished product is illustrated in **FIG. 2**. Usually these rigid covers are made of plastics or metal. Thus, the enclosed storage device **1** is still very susceptible to shock damage as the rigid covers do not provide any damping protection against shock.

[**0023**] **FIG. 3**A, **FIG. 3**B and **FIG. 3C** are perspective illustrations of the current invention wherein two soft inner enclosures, or alternatively called inner linings, are employed to enclose a storage device. The two soft inner enclosures are, as shown in **FIG. 3A, a** soft top inner enclosure **3** and a soft bottom inner enclosure **4**. The storage device to be enclosed by the soft top inner enclosure **3** and the soft bottom inner enclosure **4** is the storage device **1** with a storage device interface connector **2**. The storage device interface connector **2**, when hooked up with the corresponding mating connector from a computer not shown here, would provide all the necessary electrical power and interface signals to insure proper operation of the storage device **1**. Many storage device **1**, such as external or portable hard drives, optical storage devices or computers with built in magnetic and optical storage devices, can be easily damaged when it is dropped accidentally. Thus, the soft top inner enclosure **3** and the soft bottom inner enclosure **4** are used together to provide protection for the storage device **1** in both operating and non-operating modes. The soft top inner enclosure **3** consists of a soft top inner enclosure base **9***c* whose inside surface has a set of soft top enclosure MSA **17** which will be described in more detail later. The soft bottom inner enclosure **4** consists of a soft bottom inner enclosure base **9***a*, four soft bottom inner enclosure side walls **9***d* with a connector access slot **9***b* located on one of the soft bottom inner enclosure side walls **9***d*. Like the soft top inner enclosure **3**, the soft bottom inner enclosure base **9***a* also has a set of soft bottom enclosure MSA **16** located on its inside surface which will also be described in more detail later. Thus, following the direction of the arrows, the soft top inner enclosure **3** and the soft bottom inner enclosure **4** will provide a snug fit to the enclosed storage device **1** all around except for the mechanical accessibility to the storage device interface connector **2** through the connector access slot **9***b* of the soft bottom inner enclosure **4**. This is illustrated in **FIG.** 3B and **FIG. 3C**.

[**0024**] **FIG. 4** shows more details of the soft top inner enclosure **3** and the soft bottom inner enclosure **4**. To provide for sufficient shock protection with the proper range of softness, or durometer, the selected material for the inner enclosure is soft Microcellular Urethane (trade name: PORON), Polyurethane or other material with similar properties. For further enhancement of shock protection, the inside surfaces of both inner enclosures **3** and **4** are constructed with a set of substantially evenly spaced small columns of MSA protrusions. These are soft top enclosure MSA **17** for the soft top inner enclosure **3** and the soft bottom enclosure MSA **16** for the soft bottom inner enclosure **4**. As the MSA and the inner enclosure body are made of the same material, the MSA can be easily casted or molded as part of the enclosure in volume production. Furthermore, as neither the MSA nor the inner enclosure body requires high dimensional accuracy, the need of expensive tooling for the cast or mold is eliminated.

[**0025**] The amount of shock protection provided by the MSA depends primarily on the following parameters: the durometer of the Microcellular Urethane, the MSA base thickness T, the MSA diameter D, the MSA height H, the MSA pitch P as well as the density of the enclosed storage device **1**. In general, the following qualitative design guidelines were discovered: (1) lower durometer of the inner enclosure base material yields higher shock protection; (2) higher MSA base thickness T yields higher shock protection;

(3) larger MSA diameter D yields higher shock protection; (4) larger MSA height H yields higher shock protection; (5) lower MSA pitch P yields higher shock protection and (6) lower density of the enclosed storage device **1** allows higher shock protection.

[**0026**] However, in practice, the complexity of the involved quantitative functional relationship amongst the above design parameters is found to be too complicated to warrant a mathematical treatment. Instead, an empirical design must be reached through a set of parametric experiments following the above qualitative design guidelines. As a quantitative example of this invention, we have made the following findings.

[**0027**] A typical 2.5 inch hard disk storage device can be adequately shock protected from a drop height of up to 4 feet onto a hard surface with an MSA structure of the following parametric design: (1) inner enclosure base material is Microcellular Urethane; (2) durometer of the inner enclosure base material is 30 durometer; (3) MSA base thickness T=6.4 mm; (4) MSA diameter D=7 mm; (5) MSA height H=4 mm height; (6) MSA pitch P=17 mm.

[**0028**] Another point to be made here is that, given the aforementioned complexity of the functional relationship among the design parameters, multiple combinations within a range of parameters exist for the same desired shock protection. For example, in the above case, an MSA diameter D from 6 mm to 8 mm and an MSA height H from 4 mm to 5 mm would all produce similar shock protection.

[**0029**] A subtle but important benefit of the current invention is illustrated in **FIG. 5**A and **FIG. 5B**. **FIG. 5A** represents a prior art inner enclosure wall structure **20** which is plain while **FIG. 5B** represents the current invention with the MSA wall structure **21** optimized for a minimum overall thickness of the MSA structure T+H, for a specified amount of shock protection. While the prior art inner enclosure wall structure **20** has the same overall wall thickness S=T+H as the current invention, it was found that the prior art design can not provide the specified amount of shock protection as does the current invention. The reason is that, upon impact of the enclosed storage device with an external object, the numerous soft bottom enclosure MSA **16** of the current invention act as an initial spacer during the first stage of the shock absorption process where most of the associated kinetic energy is dissipated. That is, only the soft bottom enclosure MSA **16** go through related geometric deformation to dissipate the kinetic energy while the enclosed storage device stays free of contact with the soft bottom inner enclosure base **9***a*. While the storage device still contacts the soft bottom inner enclosure base **9***a* during the second, or last, stage of the shock absorption process, by this time the remaining kinetic energy to be dissipated is significantly lower than its value during the first stage. In summary, given the same specified amount of shock protection and the same overall wall thickness, the net kinetic energy to be dissipated upon impact by the enclosed storage device with the current invention would be significantly less than that with a traditional prior art design. Or equivalently, given the same specified amount of shock protection, the current invention will provide a design which has a significantly less overall wall thickness than the traditional design. This translates into an advantage of size and weight reduction with the current invention. Furthermore, given the MSA structure, the net volume occupied by the shock absorbing material is significantly less than that enclosed in the overall wall thickness T+H, this translates into another advantage of weight reduction with the current invention. A third advantage of the current invention is that, upon closure of the soft top inner enclosure **3** and the soft bottom inner enclosure **4**, a thin air space is formed between the enclosed storage device **1** and the inner enclosure with MSA wall structure **21**. The thin air space thus provides the function of air circulation resulting in a more uniform distribution of heat from the storage device **1** for a more efficient heat dissipation to the outside ambient.

[**0030**] **FIG. 6** illustrates an additional embodiment of the current invention wherein the inner enclosure with MSA wall structure **21** has a set of substantially evenly spaced micro venting slots **22** cut through its wall to further improve heat dissipation to the outside ambient. Of course, the cross section of these venting features does not have to be a slot. For example, it can be a circle, an ellipse or any other shape as long as easy manufacturability is maintained.

[**0031**] Finally, Microcellular Urethane, one of the selected material for the inner enclosure with MSA, possesses additional physical properties which are important or beneficial to the enclosed storage device. Microcellular Urethane has low memory effect, which is important for the preservation of the MSA geometry after long termed usage or storage of the storage device. Microcellular Urethane is reasonably heat conductive which helps the dissipation of heat from the storage device. It does not accumulate static electricity thus provides good ESD protection for the storage device. It is fire retardant with UL-approval for a safe product. It can be metallically coated to shield against EMI/RFI for reliable data transfer.

[**0032**] **FIG. 7**A and **FIG. 7B** are additional perspective illustrations of the current invention wherein a storage device is fully enclosed with a set of soft inner enclosures, similar to that shown in **FIG. 3**C, the storage device is progressively shown to be loaded into a soft outside enclosure **8**. Following the direction of the arrows in **FIG. 7**A, the now enclosed storage device **1** is first loaded into the soft outside enclosure **8**. Afterwards, the storage device **1**, now enclosed in both inner and outer soft enclosures with shock protection, is shown in **FIG. 7B**. Notice that the mechanical accessibility to the interface pins of the storage device **1** is maintained through the corresponding connector access slot **9***b* of the soft bottom inner enclosure **4** and the connector access slot **15** of the soft outside enclosure **8**.

[**0033**] **FIG. 8**A and **FIG. 8B** are the final perspective illustrations of the current invention wherein the enclosed storage device **1** from **FIG. 7B** is progressively shown to be fully enclosed like a carrying bag in the non-operating state of the storage device **1** with the closure of a soft device cover and a soft connector cover. Following the right hand arrow of **FIG. 8**A, the soft outside enclosure device cover **12** will be closed with the movement of the zipper mechanism consisting of two soft outside enclosure zippers **10** and an outside enclosure zipper handle **11**. Finally, following the left hand arrow of **FIG. 8**A, the soft outside enclosure connector cover **13** will be closed with the mating of a velcro hook pad **14***a* to a velcro loop pad **14***b*. The final enclosure in the form of a carrying bag is illustrated in **FIG. 8B**.

[**0034**] In summary, as illustrated above, a first advantage of the current invention is that, given the same specified amount of shock protection, the current invention provides an inner enclosure for a storage device whose overall wall thickness is significantly less than that of a traditional design. The net result is a size and weight reduction of the product.

[0035] The second advantage of the current invention is that, with the MSA geometry, the net volume occupied by the shock absorbing material is significantly less than that enclosed within the overall wall thickness. This means additional cost and weight reduction of the product.

[0036] A third advantage of the current invention is that a thin air space is formed between the enclosed storage device and the inner enclosure with the MSA wall structure. The thin air space thus provides the function of air circulation resulting in a more uniform distribution of heat from the storage device for a correspondingly more efficient heat dissipation to the outside ambient.

[0037] A fourth advantage of the current invention is that a set of micro venting slots are provided on the MSA wall structure to further improve heat dissipation from the storage device to the outside ambient.

[0038] A fifth advantage of the current invention is that the selected base material for the inner enclosure has a set of physical properties which result in the following benefits such as preservation of the MSA geometry after long termed usage or storage of the storage device; improved heat dissipation from the storage device; good ESD protection for the storage device; fire retardation with UL-approval and shielding against EMIRFI for reliable data transfer.

[0039] In conclusion, an improved inner enclosure, or alternatively called inner lining, with MSA has been described for an external storage device providing shock protection, improved heat dissipation plus a set of additional functions while reducing the cost, size and weight of the product. The invention has been described using exemplary preferred embodiments. However, for those skilled in this field the preferred embodiments can be easily adapted and modified to suit additional applications without departing from the spirit and scope of this invention. Thus, it is to be understood that the scope of the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements based upon the same operating principle. The scope of the claims, therefore, should be accorded the broadest interpretations so as to encompass all such modifications and similar arrangements.

I claim:

1. A soft inside enclosure of a carrying case for shock protection of an electronic device in its storage, carrying and operating modes, comprising:

a soft top inner enclosure having a soft top base wherein said soft top base comprises further a set of small columns of protrusions made of a first shock absorbing material;

a soft bottom inner enclosure having a soft bottom base and four side walls with a connector access slot located on one of the side walls wherein said soft bottom base further comprises a set of small columns of protrusions made of a second shock absorbing material; and

whereby the soft top inner enclosure and the soft bottom inner enclosure snug fit the enclosed electronic device all around to provide for a desirable shock absorption for the enclosed electronic devices.

2. The soft inside enclosure according to claim 1 wherein said set of small columns of protrusions further comprises a set of micro venting features for the improvement of heat dissipation from the enclosed electronic devices to the ambient.

3. The soft inside enclosure according to claim 2 wherein said set of micro venting features is selected from the group consisting of a slot, a circle, an ellipse or any other shape suitable for heat dissipation.

4. The soft inside enclosure according to claim 1 wherein the first shock absorbing material is selected from the group consisting essentially of soft microcellular urethane, metallically coated soft microcellular urethane and polyurethane.

5. The soft inside enclosure according to claim 1 wherein the second shock absorbing material is selected from the group consisting essentially of soft microcellular urethane, metallically coated soft microcellular urethane and polyurethane.

6. A method of making an soft inside enclosure of a carrying case for an electronic device for providing a customer-specified amount of shock protection to said electronic device in its storage, carrying and operating modes, comprising the steps of:

providing a soft top inner enclosure having a soft top base wherein said soft top base comprises further a first set of substantially evenly spaced small columns of Micro Shock Absorber ("MSA") protrusions made of a shock absorbing material;

providing a soft bottom inner enclosure having a soft bottom base and four side walls with a connector access slot located on one of the side walls wherein said soft bottom base further a second set of substantially evenly spaced small columns of Micro Shock Absorber ("MSA") protrusions made of a shock absorbing material;

snagging fit the enclosed electronic device by the soft top inner enclosure and the soft bottom inner enclosure to provide for a shock absorption for the enclosed electronic devices;

determining the customer-specified amount of maximum shock protection in terms of a maximum allowable non-damaging drop height of the enclosed device and a hardness of a drop surface of impact;

measuring the size and weight of the enclosed device; and

systematically varying a variety of parameters including durometer, thickness, diameter, column height and pitch of the MSA until one or more combination of said parameters satisfies said maximum allowable non-damaging drop height of the enclosed device upon said drop surface of impact with said specified hardness.

7. The method of making a soft inside enclosure according to claim 6 wherein the enclosed device is a typical 2.5 inch hard disk storage device.

8. The method of making a soft inside enclosure according to claim 7 wherein the enclosed device is a typical 2.5 inch hard disk storage device.

9. The method of making a soft inside enclosure according to claim 8 wherein the maximum allowable non-damaging drop height is 4 feet and the drop surface of impact is a hard concrete surface.

10. The method of making a soft inside enclosure according to claim 9 wherein the durometer of the MSA is 30.

11. The method of making a soft inside enclosure according to claim 10 wherein the thickness of the MSA is 6.4 mm.

12. The method of making a soft inside enclosure according to claim 11 wherein the diameter of the MSA is 7 mm with an acceptable range of 6 mm to 8 mm.

13. The method of making a soft inside enclosure according to claim 12 wherein the column height of the MSA is 4 mm with an acceptable range of 4 mm to 5 mm.

14. The method of making a soft inside enclosure according to claim 13 wherein the pitch of the MSA is 17 mm.

15. The method of making a soft inside enclosure according to claim 6 wherein the first shock absorbing material is selected from the group consisting essentially of soft microcellular urethane, metallically coated soft microcellular urethane and polyurethane.

16. The method of making a soft inside enclosure according to claim 6 wherein the second shock absorbing material is selected from the group consisting essentially of soft microcellular urethane, metallically coated soft microcellular urethane and polyurethane.

* * * * *