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HOTTO

(54) ENERGY HARVESTING CONTAINER

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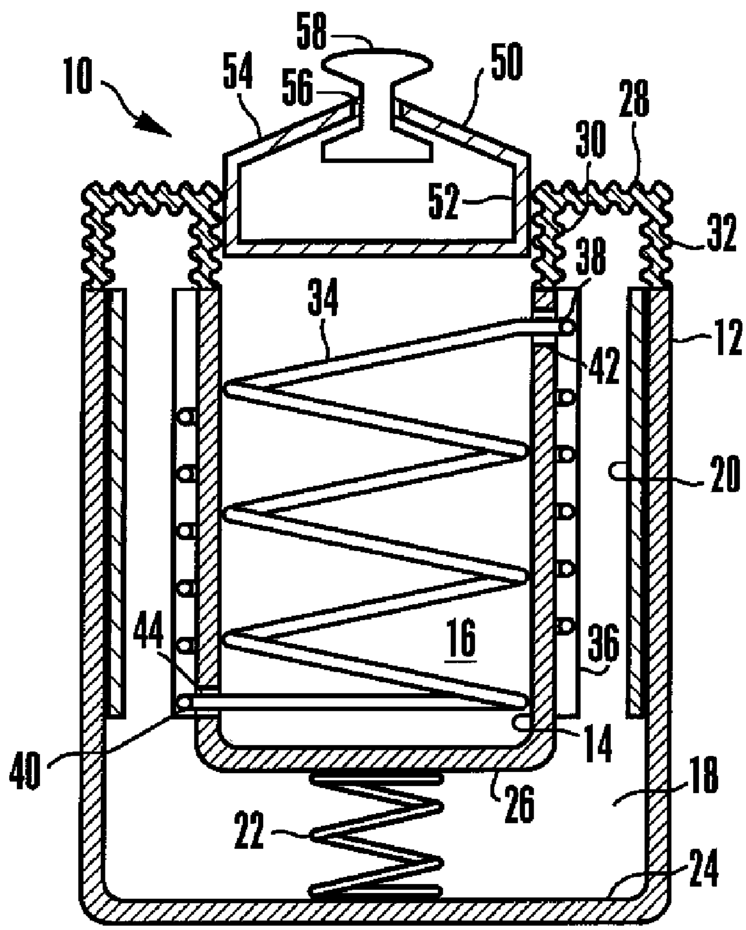
(57) ABSTRACT

A container that experiences vibrations when transported allows an inner container which defines a chamber holding a substance to move relative to an outer shell under the influence of vibrations. An energy generator such as a magnet and a corresponding coil or a piezoelectric generator that does not move with the inner container is juxtaposed with the inner container to cause an electrical current to be introduced in the inner container when the inner container moves relative to the magnet. The electrical current is dissipated as heat to transfer heat into the substance in the chamber.



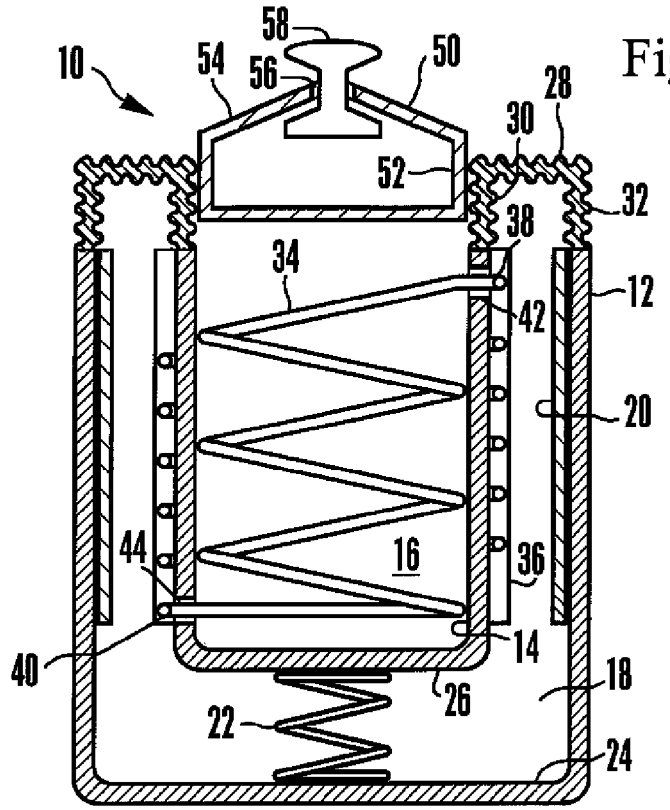


Figure 1

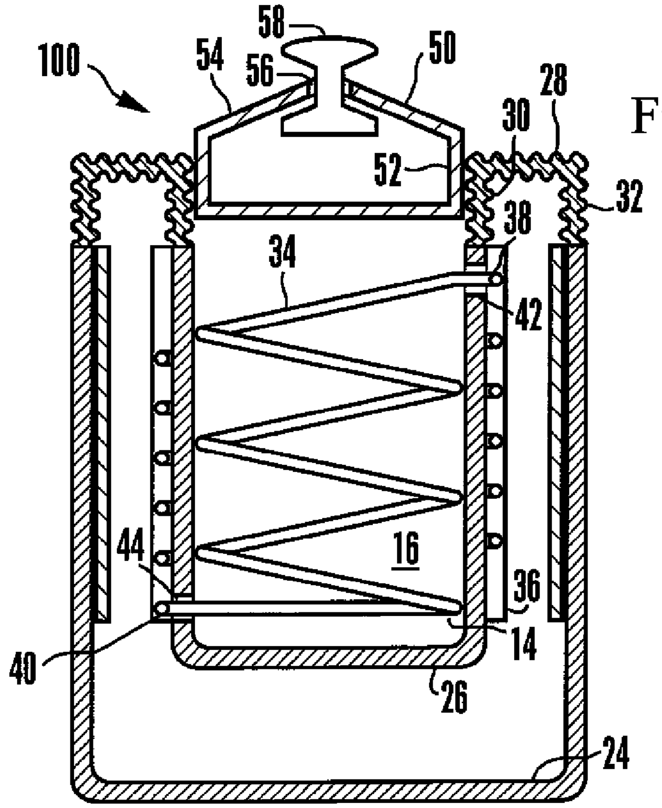


Figure 2

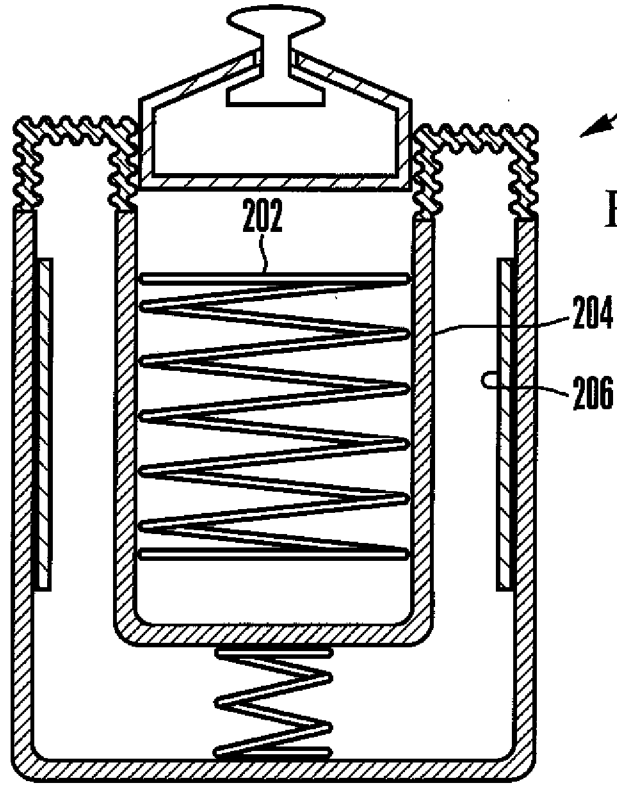


Figure 3

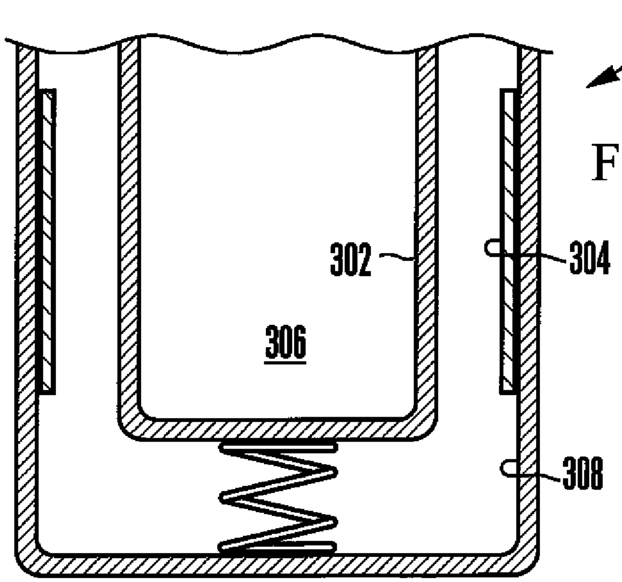


Figure 4

Figure 5

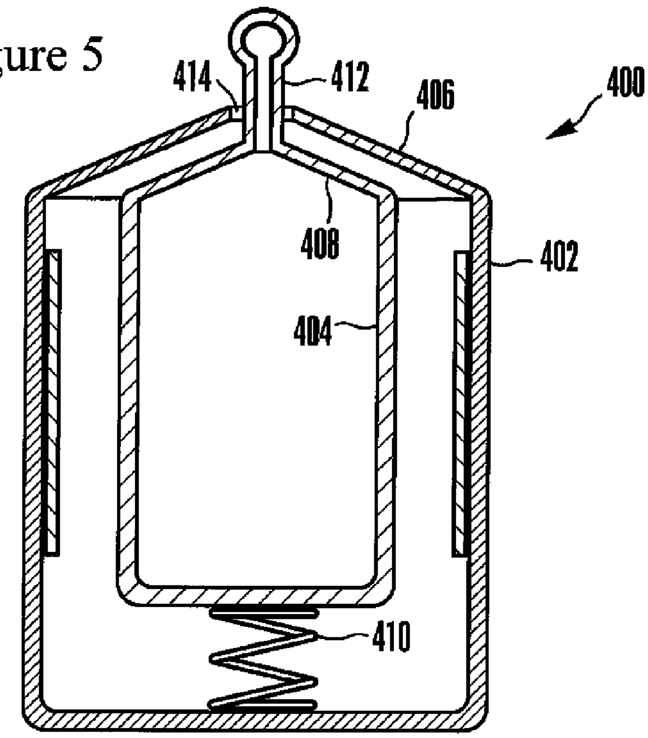


Figure 6

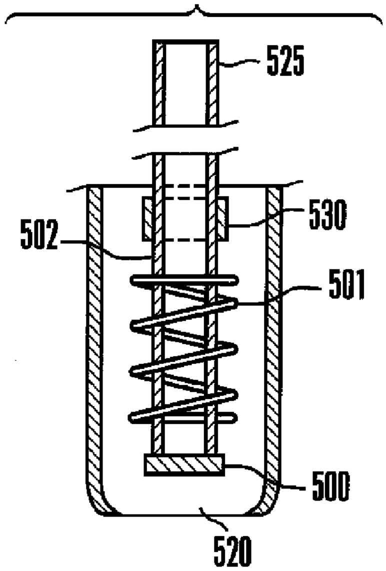
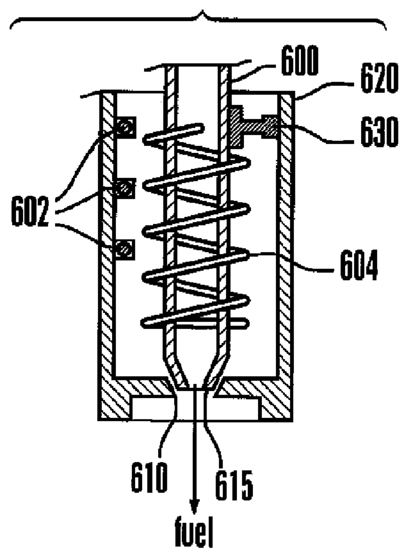


Figure 7



ENERGY HARVESTING CONTAINER

FIELD OF THE INVENTION

[0001] The present application relates generally to vibrational energy harvesting heaters in double container systems for heating fluid or other substances in the inner container using relative motion between the inner container and outer container.

BACKGROUND OF THE INVENTION

[0002] Double container systems are used for various purposes. An example non-limiting purpose is for fluid bottles to keep the fluid insulated and thus less likely to cool when in the inner container, owing to the insulative qualities of the arrangement. As understood herein, such fluid still cools down. As also understood herein, many such double container systems are intended to be used in moving and vibrational environments, and principles of this application leverage that fact.

SUMMARY OF THE INVENTION

[0003] Although a simple fluid container system is used as an example environment in which present principles may be employed, it is to be understood that present principles apply equally to other container systems, indeed, which may seek to keep not only fluid warm but also foodstuffs or other substances. For example, present principles may be used in containers on trucks or other vehicles that hold diesel or other fuel, to increase the temperature of the diesel or other fuel.

[0004] Accordingly, a container system has an outer container and an inner container defining a chamber for holding an item to be heated. The inner container is movable within the outer container when the container system vibrates or is subject to accelerations. One or more magnets are supported by the outer container and are electromagnetically coupled to at least a portion of the inner container to generate heat within the chamber when there is relative motion between the inner and the outer container.

[0005] In another embodiment a piezoelectric generator is connected to the end of the inner container, which mechanically impacts the outer container causing electrical current to be generated when impacted. The generated electrical current is feed into the attached coil that is wound around the inner container thereby heating the inner container and the contents.

[0006] If desired, a spring may be sandwiched between the respective bottoms of the containers to promote relative motion between the containers. In some embodiments an elastic joining element such as a rubber or plastic boot couples the inner container to the outer container.

[0007] In some implementations the inner container has no heater element and is ferromagnetic. In other implementations a heater element is within the chamber for generating heat under the influence of current flowing there through responsive to relative motion between the heater element and magnet. No coils may be interposed between the heater element and the magnet. Or, an outer pickup coil may surround the inner container and is electrically connected to the heater element.

[0008] In another aspect, an apparatus that experiences vibrations when transported includes a first inner container which defines a chamber configured for holding a substance. One or more magnets that do not move with the first container are juxtaposed with the first container to cause an electrical current to be introduced on or in the first container when the first container moves relative to the magnet. The electrical current is dissipated as heat to transfer heat into the substance in the chamber.

[0009] In another aspect, an apparatus that experiences movements when transported includes a first inner container which defines a chamber configured for holding a substance and an energy transducer that does not move with the first container. The energy transducer is juxtaposed with the first container to transform motion between the energy transducer and the first container to heat which is introduced on or in the first container when the first container moves relative to the energy transducer. The energy transducer may be a piezoelectric element or an electro-magnetic combination including a magnet.

[0010] The details of the present invention, both as to its structure and operation, can best be understood in reference to the accompanying drawings, in which like reference numerals refer to like parts, and in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a cross-sectional view in elevation of a first embodiment in which a cylindrical magnet in an outer container of a double container system is coupled to a heater coil within an inner fluid container of the system through an outer coil that surrounds the inner container and that is connected to the heater coil, with a bottom spring to promote vibration between the two containers, with some details of the upper closure not shown in cross-section;

[0012] FIG. **2** is a cross-sectional view in elevation of a second embodiment that is in all essential respects identical too the first embodiment shown in FIG. **1** except the bottom spring is omitted, with some details of the upper closure not shown in cross-section;

[0013] FIG. **3** is a cross-sectional view in elevation of a third embodiment in which a magnet in an outer container of a double container system is coupled to a heater coil within an inner fluid container of the system directly through the magnetically permeable wall of the inner container, with some details of the upper closure not shown in cross-section;

[0014] FIG. **4** is a cross-sectional view in elevation of a fourth embodiment in which strip magnets in an outer container of a double container system are directly coupled to the wall of a ferromagnetic inner fluid container of the system, with portions of the upper closure cut away for clarity;

[0015] FIG. **5** is a cross-sectional view in elevation of an embodiment in which magnets in an outer container of a double container system are directly coupled to the wall of a ferromagnetic inner fluid container of the system, with the upper ends of the containers not being coupled using elastic structure but rather freely movable relative to each other, showing an optional bottom spring;

[0016] FIG. **6** shows an alternate embodiment using piezoelectric principles; and

[0017] FIG. **7** illustrates a system for heating diesel fuel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] Referring initially to FIG. **1**, a container system **10** includes an outer container **12** and an inner container **14** defining a chamber **16** for holding an item to be heated. In the example shown, the containers **12**, **14** are coaxial with each other and the inner container **14** is substantially enclosed by the outer container **12** except at the top of the inner container. The outer container may be plastic, metal such as aluminum or steel, or a composite material. The inner container **14** may be plastic, metal such as aluminum or steel, or a composite material. Typically, the inner container is thermally insulative and an insulating air gap **18** may be established between the side walls of the containers **12**, **14** as shown. The containers **12**, **14** may have cylindrical side walls as shown.

[0019] In the embodiment shown in FIG. **1**, the inner container **14** is movable and more preferably is axially reciprocable within the outer container **12** when the container system **10** vibrates. This is important in the example of FIG. **1** because one or more magnets **20** are supported by the outer container **12** and are electromagnetically coupled a portion of the inner container **14** to generate heat within the chamber **16** when the inner container **14** moves relative to the outer container **12**. In the example shown, the magnet **20** is a single cylindrical magnet that is supported on the inside side wall of the outer container **12**, extending axially more than half the length of the inner container **14** as shown. However, as discussed further below one or more bar magnets may be used. When no outer container is provided the magnet **20** may be mounted outside the inner container **14** on a nearby surface with which the inner container **12** moves relatively under the influence of vibrations. The magnet **20** may be mounted by means of fasteners such as screws or by adhesives or other means.

[0020] To promote vibrational reciprocation of the inner container **14** relative to the outer container **12**, a spring **22** may be sandwiched between the containers to promote relative motion between the containers. In the embodiment of FIG. **1** the containers define respective bottoms **24**, **26** and the spring **22** is sandwiched between the bottoms **24**, **26**. The spring may be a coil spring in compression or a leaf spring or indeed other spring structure such as a resilient foam layer. However, FIG. **2** shows a container system **100** that in all essential respects is identical to the container system **10** shown in FIG. **1** except no spring is included.

[0021] On the opposite ends of the containers **12**, **14**, the containers **12**, **14** may be joined, in the example of FIG. **1**, by an elastic joining element **28**. In the embodiment shown, the elastic joining element **28** is a rubber or plastic boot that is ring-shaped and that connects the open circular top periphery **30** of the inner container **14** to the open circular top periphery **32** of the outer container **12** as shown. It may now be appreciated that owing to this elastic coupling the inner container **14** can move axially in the outer container **12** when the container system **10** is subject to vibrations.

[0022] In the embodiment shown in FIG. **1**, a heater element **34** is disposed within the chamber **16** for generating heat under the influence of current flowing there through responsive to relative motion between the heater element **34** and magnet **20**. In the embodiment shown, the heater element **34** includes a coil of resistive wire arranged in a cylindrical pattern on the inside side wall of the inner container **14**. The heater element may be made of steel, tungsten, or indeed even copper but it is preferable that the heater wire be made of material that is more electrically resistive rather than less to promote the generation of dissipative heat when electrical current passes through the heater element. The wire or wires of the heater element may be embedded in a cylindrical thin plastic sleeve and bonded to the inside surface of the inner container **14** for convenience.

[0023] In the embodiment of FIG. **1**, an outer pickup coil **36** surrounds the inner container **14**. The pickup coil **36**, which may be wrapped around the outside of the cylindrical side wall of the inner container **14** as shown, is electrically connected to the heater element. In the example shown, the pickup coil **36** is connected to the heater element **34** via upper and lower leads **38**, **40** which respectively extend through upper and lower side channels **42**, **44** formed in the inner container **14**. In other embodiments the inner container **14** may be electrically conductive and the pickup coil **36** may be connected to the heater element **34** through the inner container **14** material.

[0024] Briefly referring to FIG. **3**, a container system **200** is in all essential respects is identical to the container system **10** shown in FIG. **1** except that no pickup coil is interposed between a heater element **202** within the inner container **204** and a magnet **206**. In this embodiment the inner container **204** is magnetically permeable so that the magnet **206** is electromagnetically coupled directly to the heater element **202**.

[0025] FIG. **4** takes it a step farther, in which a container system **300** includes no pickup coil and no heater element. Instead, an inner container **302** is ferromagnetic so that the magnetic coupling is between a magnet **304** and the inner container **302** walls, generating current in the walls that is dissipated as heat into the chamber **306** when the inner container **302** vibrates relative to an outer container **308**. Note that another difference between the systems **10** and **300** of FIGS. **1** and **4** is that plural elongated bar magnets are used to establish the magnet **304** in FIG. **1**.

[0026] Referring back to FIG. **1**, particularly when the substance within the chamber **16** is a liquid for applications in which the container system **10** is mounted on a bicycle or other moving conveyance, a closure **50** is provided to close the open end of the inner container **14**. In the example shown the closure **50** includes a cylindrical stopper **52** merging into inwardly tapering upper shoulders **54** and terminating at an opening **56**, which may be selectively blocked by a familiar plunger-type device **58**. Alternatively, the closure **50** may be threadably engaged with the neck of the outer container **14**.

[0027] Having completed the description of FIG. **1** and having attended to FIGS. **2-4**, attention is now drawn to FIG. **5**, which shows a container system **400** in which an outer container **402** supports an inner container **404**, but in which the upper peripheries of the containers **402**, **404** are not coupled together by an elastic boot. Instead, the upper portions **406**, **408** of the containers **402**, **404**, which may taper inwardly and upwardly as shown to establish slanted shoulders, are spaced from each other and are not connected together at all. The only limit to the upward motion of the inner container **404** within the outer container **402** is by operation of the outside surface of the upper portion **408** of the inner container **404** abutting the inside surface of the upper portion **406** of the outer container **402**.

[0028] If it is desired to couple the containers **402**, **404** together, a bottom spring **410** may be disposed between the container bottoms as shown, although this spring is optional. In effect, the inner container **404** may be allowed to freely move within the outer container **402** constrained only by the walls of the outer container **402**. The upper open neck **412** of the inner container **404** may extend upwardly beyond a top opening **414** in the outer container **402** if desired, a configuration that may be implemented in any of the previous embodiments where appropriate.

[0029] FIG. **6** illustrates an embodiment of the present invention employing a piezo-electric generator. Illustrated is an inner container **502**, with the piezo-electric generator **500**, attached to the end portion of the inner-container. Attached to the piezo electric generator **500**, is a coil assembly **501**. There are two leads coming from the piezo-electric generator **500**, to the coil assembly **501**. An outer-container **515** comprises a flexible supporting neck **530** that attaches the inner-container to the outer-container but allows for vibrational motion between the two components. The outer container comprises an end surface, **520**, which communicate with the piezo-electric generator **500**, and a cap **525**, for securing to the container system.

[0030] When the system is subjected to motion, the inner container **502**, is allowed to move relative to the outer-container **515**, by means of the flexible supporting neck element **530**, which allows for a degree of inertial isolation between the inner container **502**, and the outer container **515**. The piezo-electric generator **500** is attached to the end of the inner container **502** which when subjected to accelerations and vibrational motion impacts with the end of portion **520** of the outer container assembly **515**. These impacts are converted to electro-motive forces in the piezo electric generator **500**, which powers the coil assembly **501**, thereby heating the inner-container **502** and the contents contained therein.

[0031] FIG. **7** illustrates an embodiment of present principles for use in a diesel fuel tank or fuel tank for use in transportation vehicles such as cars, trucks, airplanes, and ships. The system heats the fuel so to provide improved operations especially in cold environments.

[0032] The fuel tank comprises an inner container **600**, which contains the fuel, and an outer-assembly **620**, which has attached to its inside a set of permanent magnets **602** and provides the mechanical attachments to the vehicle. A coil system **604**, is wrapped around the inner-container **600** and is connected to a resistive heater **610** that is located on the neck of the inner container **600**, as illustrated. Connecting the inner-container to the outer-assembly is the flexible neck element **615**. Illustrated is a mechanical roller guide arrangement **630** allowing the two moving parts to translate smoothly.

[0033] The inner-container has a coil system **604** which communicates with the magnetic system, **602**, thereby generating electro-motive force which is applied to the resistive heater **610** located at the neck output of the fuel tank.

[0034] While the particular ENERGY HARVESTING CONTAINER is herein shown and described in detail, it is to be understood that the subject matter which is encompassed by the present invention is limited only by the claims.

What is claimed is:

1. Container system comprising:

at least one outer member;

at least one inner container defining a chamber for holding an item to be heated, the inner container being movable within the outer member when the container system moves; and

at least one magnet supported by the outer member and electromagnetically coupled to at least a portion of the inner container to generate heat within the chamber when the inner container moves relative to the outer member.

2. The system of claim **1**, comprising a spring sandwiched between the outer and inner member to promote relative motion.

3. The system of claim **2**, wherein the containers define respective ends and the spring is sandwiched between the ends.

4. The system of claim **1**, comprising a movable joining element coupling the inner container to the outer container.

5. The system of claim **4**, wherein the movable joining element is a flexible boot connecting a top of the inner container to the outer container.

6. The system of claim **1**, wherein the inner container has no heater element and is ferromagnetic.

7. The system of claim **1**, comprising a heater element within the chamber and generating heat under the influence of current flowing there through responsive to relative motion between the heater element and magnet.

8. The system of claim **7**, wherein no coils are interposed between the heater element and the magnet.

9. The system of claim **7**, wherein an outer pickup coil surrounds the inner container, the pickup coil being connected to the heater element.

10. An apparatus that experiences movements when transported, comprising:

a first inner container which defines a chamber configured for holding a substance;

at least one energy transducer that does not move with the first container, the energy transducer being juxtaposed with the first container to transform motion between the energy transducer and the first container to heat which is introduced on or in the first container when the first container moves relative to the energy transducer.

11. The apparatus of claim **10**, wherein the first container is an inner container and the apparatus further comprises an outer container surrounding the first container.

12. The apparatus of claim **11**, wherein the outer container is movably engaged with the inner container such that as the apparatus vibrates the inner container moves relative to the energy transducer.

13. The apparatus of claim **12**, comprising a spring sandwiched between the containers to promote relative motion between the containers.

14. The apparatus of claim **13**, wherein the containers define respective ends and the spring is sandwiched between the ends.

15. The apparatus of claim **12**, comprising an elastic joining element coupling the inner container to the outer container.

16. The apparatus of claim **15**, wherein the elastic joining element is a rubber or plastic boot connecting a top of the inner container to the outer container.

17. The apparatus of claim **12**, wherein the inner container is ferromagnetic.

18. The apparatus of claim **12**, wherein the energy transducer includes a magnet and a heater element within the chamber and generating heat under the influence of current flowing therethrough responsive to relative motion between the heater element and magnet.

19. The apparatus of claim **18**, wherein no coils are interposed between the heater element and the magnet.

20. The apparatus of claim **12**, wherein the energy transducer is a piezoelectric element.

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