HEAT PRODUCING DEVICE

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Filed Jan. 22, 1968

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ABSTRACT OF THE DISCLOSURE

A simple, economical device for generating heat which has particular utility when employed in articles of clothing, especially shoes, involves the provision of a sealed casing having relatively flat top and bottom members which serve to define a closed cavity with a relatively small top to bottom dimension. The cavity is filled with tightly packed particles of at least one piezoelectric or magnetostriuctive material and, when the top or the bottom member of the filled casing is repeatedly subjected to force, useful amounts of heat are produced. Additionally, it is preferred that one surface of the casing be relatively heat conductive, and the other surface be relatively nonconductive, whereby the system is biased to transfer heat in one direction only.

It is therefore a primary object of the present invention to provide a pressure-actuated heat producing device. A related object of the present invention is to provide an arrangement especially applicable for use in a shoe by which efficient, substantial amounts of heat may be produced for the purposes of warming the feet.

Another object of the present invention is to provide an arrangement that is economical and simple to manufacture and use. A further object is to provide an efficient method for the production of heat that may be utilized to warm the feet.

DESCRIPTION OF THE DRAWING

The foregoing and other objects, advantages, and features of the subject invention will hereinafter appear, and, for purposes of illustration, but not of limitation, the preferred and exemplary embodiments of the subject invention are illustrated in the accompanying drawing, in which:

FIGURE 1 is a partially cut away perspective view of an embodiment of the subject invention;

FIGURE 2 is a fragmentary sectional view taken along line 2-2 in FIGURE 1;

FIGURE 3 is a side elevational view of another embodiment of the present invention employed as an inner sole in a shoe;

FIGURE 4 is a top plan view of the inner sole shown in FIGURE 3;

FIGURE 5 is a fragmentary vertical sectional view of a shoe sole embodying a further embodiment of the present invention; and

FIGURE 6 is a fragmentary vertical sectional view taken through a shoe sole embodying a still further version of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the drawing, FIGURE 1 illustrates a heat producing device 10, which takes the form of a casing 12 comprising relatively flat top member 14 and a similar bottom member 16 (see FIGURE 2) interconnected by side walls 18 (only one of which is shown in the drawing) and end walls 20 (only one of which is shown in the drawing). Top member 14 and bottom member 16 are each relatively flat, and the top to bottom dimension of casing 12 is relatively small. Casing 12 serves to define a closed cavity 22 for a purpose that will hereinafter appear. In place of end walls 20 and side walls 18, casing 12 may satisfactorily be formed by directly bonding the edges of top member 14 to the edges of bottom member 16.

Particles 24 of at least one member selected from the group consisting of piezoelectric materials, magnetostriective materials, and mixtures thereof are tightly packed in the form of a thin layer in the cavity 22 formed within casing 12. When device 10 is subjected to repeated force, as indicated by arrows A in FIGURE 1, significant amount of heat are generated by the piezoelectric and/or magnetostriective particles 24. It is essential that the particles 24 be arranged in a relatively thin sheet and that they be tightly packed so that the force applied is directly applied to the individual particles.

In order to maintain the particles 24 in the form of a relatively thin sheet and in order to preclude the particles from "bunching or buckling" when the casing 12 is subjected to stress, relatively thin separator elements 26 (see FIGURE 2) may be provided in order to maintain the particles in bands of relatively narrow width. The provision of separator elements 26 separates particles 24 into
In order that separator elements 26 do not impede the application of force to the particles 24, elements 26 are preferably made of a material of relatively thin compressible or resilient plastic material.

Since device 10 may be employed as an efficient heat generating device, the particulate materials from which casing 12 is fabricated may be selected in order to bias the system for transmission of heat in a given direction. For example, bottom member 16 may be fabricated of a relatively non-heat conductive material (e.g., hard rubber, ceramics, fiber compositions, or the like), whereas top member 14 may be made of a good heat conductive material such as a metallic sheeting or the like such that heat generated by the particles 24 is preferentially conducted towards the object to be tested.

Substantially any materials exhibiting piezoelectric and magnetostrictive properties may be employed to fill cavity 22. Piezoelectric materials which have been found to be particularly useful include quartz and materials such as barium titanate (BaTiO₃), lead titanate (PbTiO₃), and calcium titanate (CaTiO₃). Other piezoelectric materials which could be successfully employed include Rochelle’s salt, potassium sodium tartrate tetrahydrate (KNaC₄H₄O₆·4H₂O) and tourmaline (a complex aluminum boro-silicate). Rochelle’s salt appears to have the greatest utility in accordance with the present invention, followed by BaTiO₃ and a mixture comprising 96% BaTiO₃, 6% CaTiO₃, and 4% PbTiO₃. Materials exhibiting magnetostrictive properties include iron, nickel, cobalt, and alloys thereof. Powdered nickel and powdered cobalt, iron, and chromium alloys are preferred magnetostrictive materials. Other materials exhibiting piezoelectric or magnetostrictive properties or mixtures of such materials may be employed. It is believed that particles of the order of magnitude of about 10 microns are most useful in accordance with the present invention but other particle sizes may be usefully employed.

FIGURES 3-4 illustrate preferred applications of the inventive structure shown in FIGURES 1 and 2. FIGURES 3 and 4 show a casing 28 configured in the form of an inner sole which may be removably placed in a shoe 30 shown in broken lines in FIGURES 3. A plurality of separator elements 29 maintain the piezoelectric and or magnetostrictive material in relatively thin narrow bands. The advantage of the provision of such a heat producing casing 28 in the form of an inner sole is that it may be removed at the option of the user so that the device may be selectively employed when the generation of heat is desired, as under wintry conditions. If desired, more than one such inner sole may be employed.

A further alternate version is shown in FIGURE 5 wherein such a casing is provided as a permanent part of a sole 32 of a shoe. The various layers of the sole include a top layer 34, immediately beneath which is provided the heat producing casing 36 below which forms the further leather, rubber, or composition layers 38, 40 which complete the shoe sole.

FIGURE 6 shows a similar arrangement in which a double pair of heat producing casings 42, 44 are disposed between the layers 44, 46 of the sole so that additional heat may be generated. An outer composition or rubber layer 48 completes the shoe sole. Thus, a plurality of such casings can be provided one above the other to provide for the generation of additional heat. The amount of heat that is provided is not limited by reason of the requirement that such piezoelectric and or magnetostrictive particles be disposed in a relatively thin sheet.

Where a heat producing casing is employed as a part of a sole insert as shown in FIGURES 5 and 6, the material from which the casing is fabricated should be of a water-impervious character. Likewise, as described hereinbefore, the upper surfaces of an inner sole such as inner sole 28 shown in FIGURES 3 and 4 should be relatively heat conductive (i.e., so as to conduct heat upwardly towards the foot of the shoe wearer). Likewise, the lower surface of inner sole 28 should be relatively nonconductive so as to minimize the downward transfer of heat.

While the subject invention has been particularly described with reference to use as a shoe inner sole or shoe sole constituent, it will be obvious to those skilled in the art that many other practical uses may be made of casings such as that shown in FIGURE 1 either in other articles of clothing to which repeated pressure or stress is applied (e.g., gloves) or in other similar environments.

The operation of the device of the present invention in the production of heat has been illustrated by the following experimental evaluations.

Example I

Thirty grams of powdered quartz were placed in a confined area defined by a casing, and the casing was closed so as to provide an enclosure tightly packed with the piezoelectric material. The initial temperature of the quartz particles was ascertainment, to be 24°C, a temperature corresponding to ambient conditions. The enclosure was then repeatedly stepped on by a leather shoe heel worn by the operator, with the enclosure resting on a solid insulating block. Sixty steps a minute were applied for ten minutes. At the end of this period, the temperature of the quartz material was determined to be about 30°C, representing a 6° increase in system temperature. Thirty minutes later, the temperature of the quartz had further risen to 31°C. The property of piezoelectric material such as quartz in providing a "slow release" of heat results in a lasting effect that is not dissipated as soon as the exertion of force on the particles is terminated.

Example II

Four grams of finely ground barium titanate particles of about one-half to three microns particle size were arranged in a thin layer in a polyethylene bag which was then placed in an aluminum device designed to permit force to be exerted periodically on the layer of particles. The initial temperature of the barium titanate particles was 25°C, a temperature corresponding to ambient conditions. Pressure and force were repeatedly exerted on the plastic casing for five minutes, and after five additional minutes, the temperature of the particles had risen to 28.5°C. After 30 minutes, the temperature had further risen to 29°C.

Example III

The method of Example II was carried out using 5 grams of powdered Rochelle's salt. Ambient temperature was 24°C, and, after five minutes of force being applied 60 times per minute, the temperature had risen to 27.5°C. After five additional minutes, the temperature had risen to 28°C.

Example IV

As a control, three grams of sodium chloride, a non-piezoelectric, non-magnetostrictive material was treated as in Example III with no perceptible increase in temperature being observed.

In accordance with the present invention, the heat producing characteristics of device 10, as shown in FIGURE 1, may be improved through the judicious admixture with the piezoelectric and or magnetostrictive particles 24 of appropriate polymorphous crystals which provide additional heat at temperature related crystalline phase transitions. Suitable polymorphous crystals include metallic tin, ammonium nitrate (NH₄NO₃) and the like, and best results are achieved where the polymorphous crystals are uniformly dispersed throughout the piezoelectric particles.

It will thus be seen that in accordance with the present invention, a simple, economical and easily used heat producing device has been obtained which may be employed
with great utility in connection with articles of clothing, especially shoes, to produce substantial amounts of heat. The applications of footwear embodying the subject invention have considerable value in terms of recreational use (skiing, winter hunting, ice fishing, and the like). In addition, such shoes are of great value for military purposes where troops are stationed in wintry or arctic conditions. Further, the present invention would have great utility for use in further space and interplanetary exploration activities where low temperatures are or are likely to be encountered.

It should be understood that various changes, modifications, and variations may be made in the structure and function of the present invention.

I claim:

1. A method for producing heat comprising the steps of repeatedly exerting force on a casing having a relatively flat top member and a relatively flat bottom member defining a closed cavity of relatively small top to bottom dimension, the cavity being filled with a relatively thin layer of tightly packed particles of at least one member selected from the group consisting of piezoelectric materials, magnetostrictive materials, and mixtures thereof.

2. A method, as claimed in claim 1, wherein the said member is a piezoelectric material.

3. A method, as claimed in claim 2, wherein the piezoelectric material is quartz.

4. A method, as claimed in claim 2, wherein the piezoelectric material is barium titanate, BaTiO₃.

5. A method, as claimed in claim 2, wherein the piezoelectric material is Rochelle's salt, KNaC₃H₅O₇·4H₂O.

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