United States Patent [19]

Laing et al.

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[45] **May 20, 1975**

[54] **ELECTRIC STORAGE AIR HEATER**

[76] Inventors: **Nikolaus Laing; Ingeborg Laing,** both of Hofener Weg 35-37, 7141 Aldingen near Stuttgart, Germany

[22] Filed: **June 5, 1972**

[21] Appl. No.: **260,012**

Related U.S. Application Data

[63] Continuation of Ser. No. 13,747, Feb. 24, 1970, abandoned.

[52] **U.S. Cl.** **165/961;** 165/104; 219/365; 251/11

[51] **Int. Cl.** **F28f 27/00**

[58] **Field of Search** ..... 166/96, 104; 219/365; 251/11; 236/68 R, 101 R

[56] **References Cited**

UNITED STATES PATENTS

1,459,318	6/1923	Birdsall	165/32 X
2,494,035	1/1959	Christy	219/365
3,048,985	8/1962	Long	236/68 R X
3,131,865	5/1964	Roe	219/365 X

FOREIGN PATENTS OR APPLICATIONS

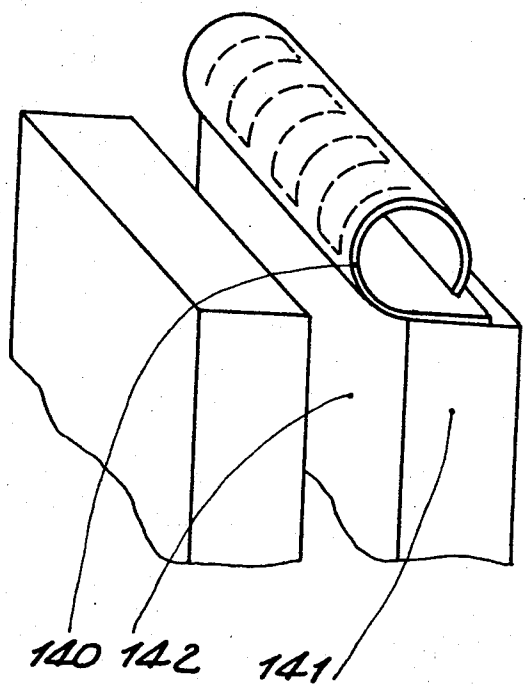
984,096	2/1965	United Kingdom	219/365
1,066,595	4/1967	United Kingdom	219/365

Primary Examiner—Albert W. Davis, Jr.
Attorney, Agent, or Firm—Pennie & Edmonds

[57] **ABSTRACT**

A heat storage device for heating rooms comprising a storage core and a fan which conveys air through said core in order to withdraw the heat. The storage core comprises a heat storage material consisting of a hydrate whose liquefaction temperature at solution in its own water of crystallisation comes within the range between approximately 70° and 95°C.

2 Claims, 22 Drawing Figures



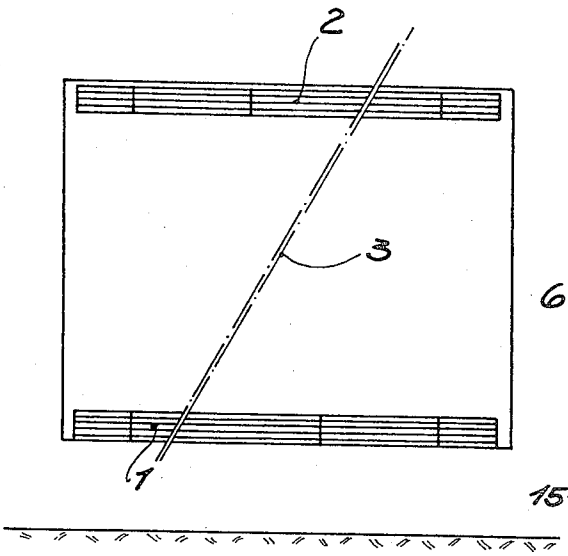


FIG. 1a

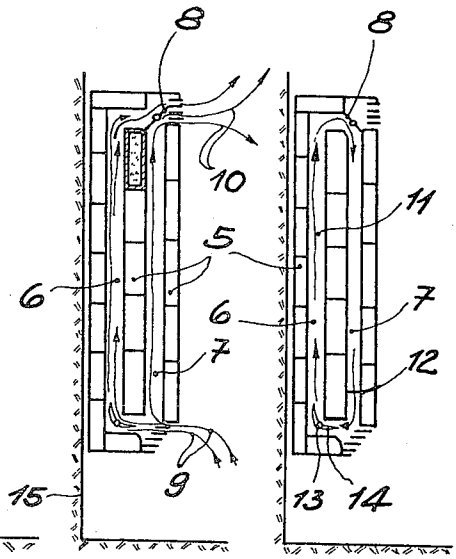


FIG. 1b FIG. 1c

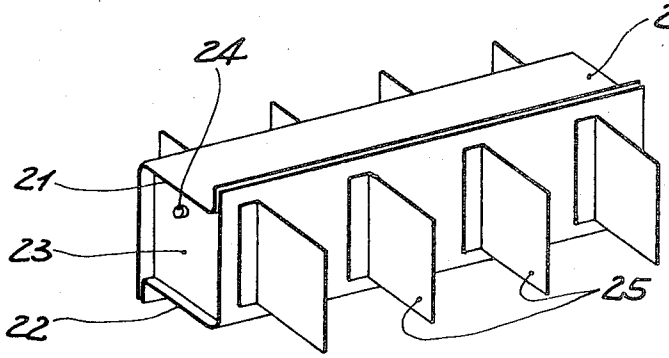


FIG. 2

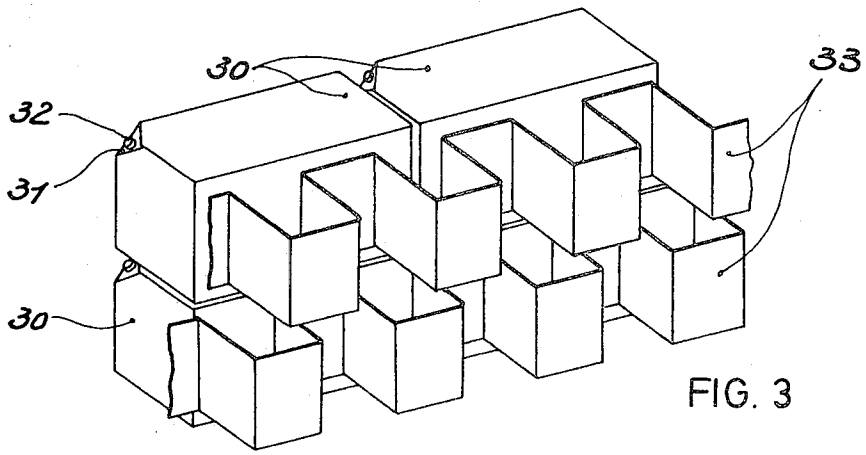


FIG. 3

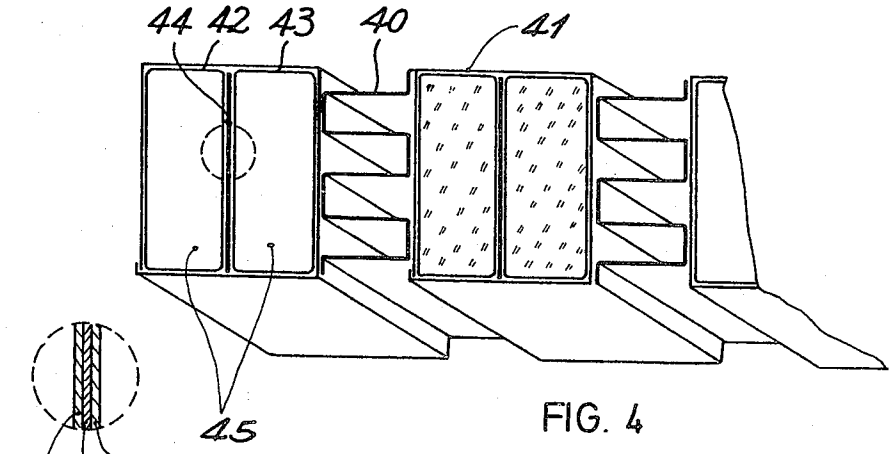


FIG. 4

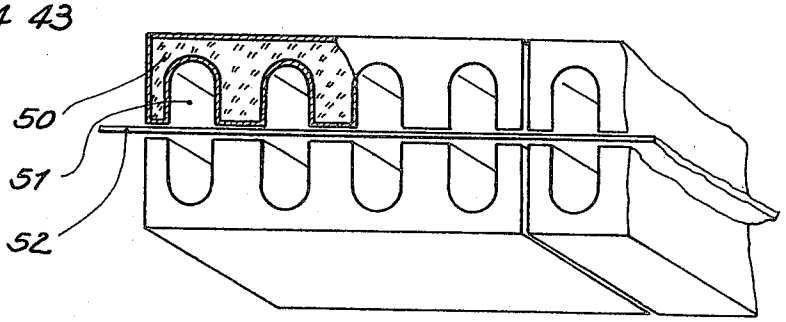


FIG. 5

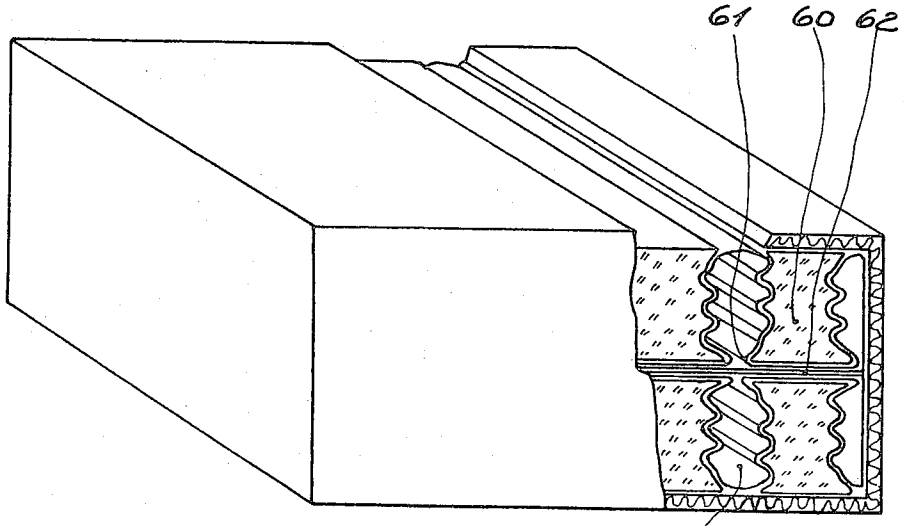


FIG. 6

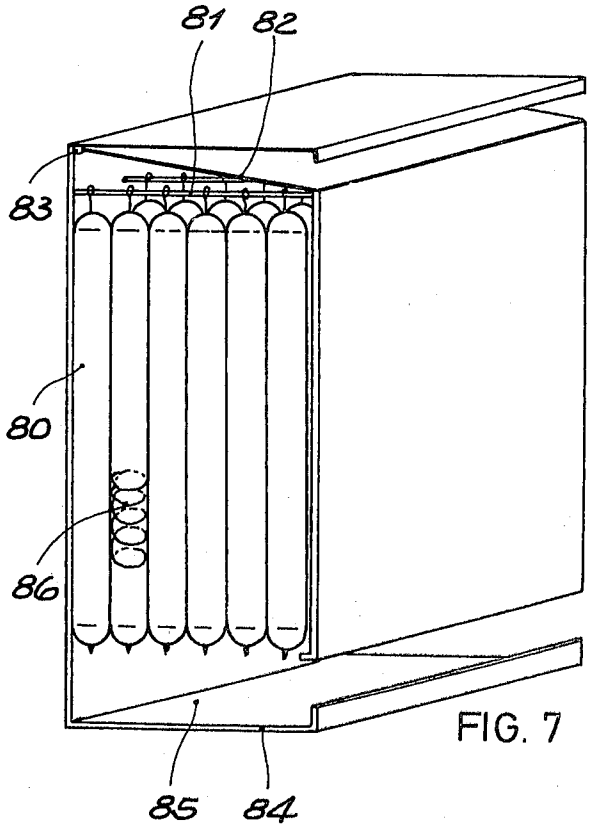


FIG. 7

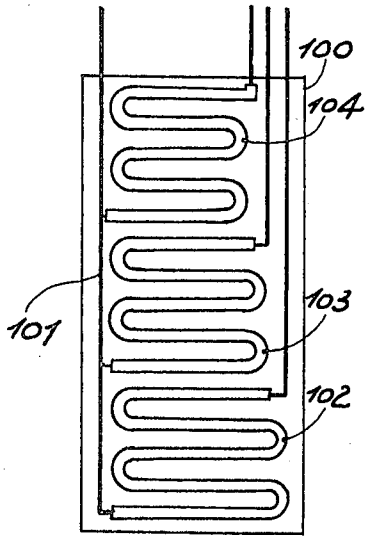


FIG. 8

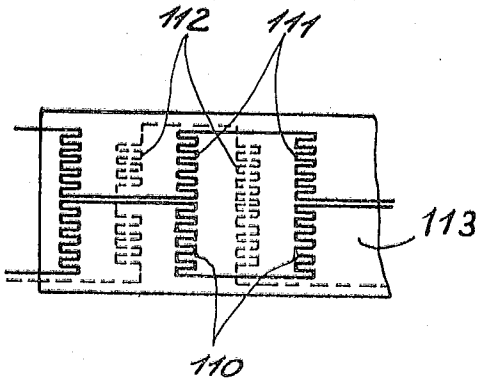


FIG. 9

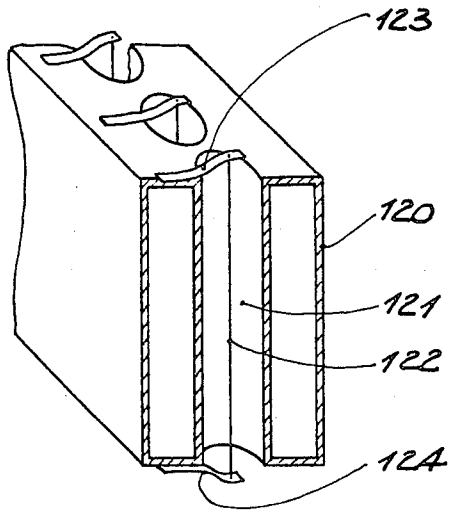


FIG. 10

FIG. 11

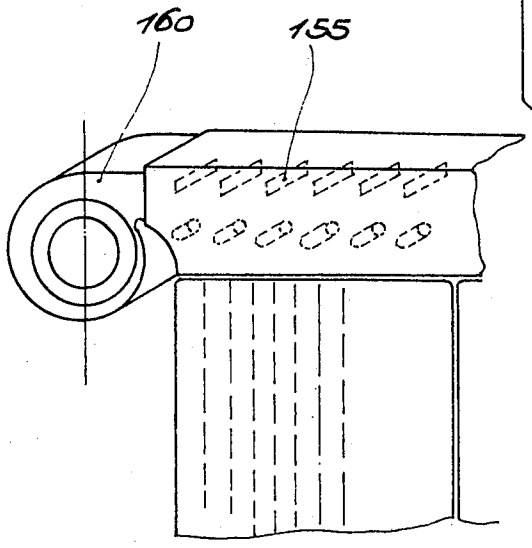
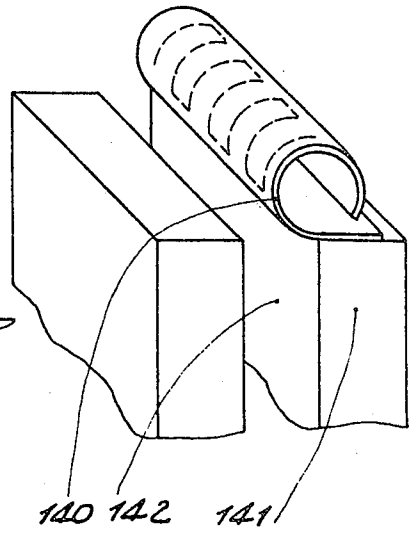


FIG. 12 b



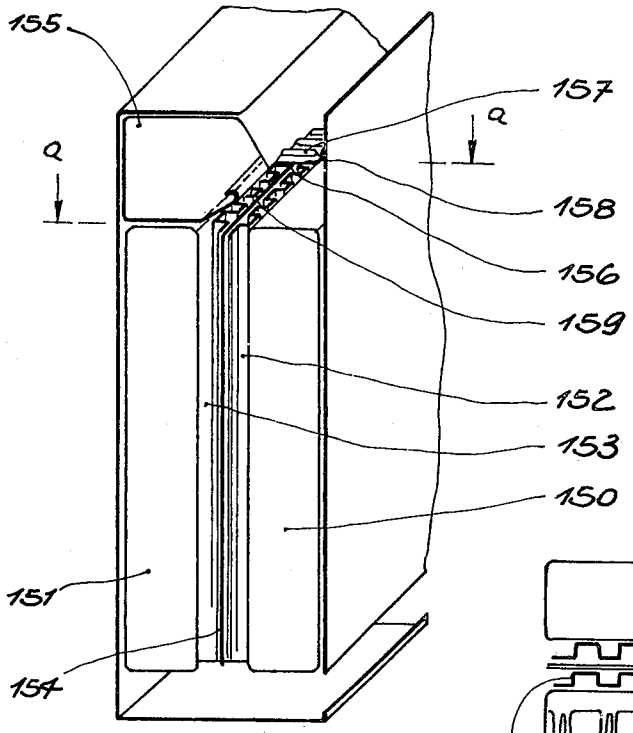


FIG. 12 a

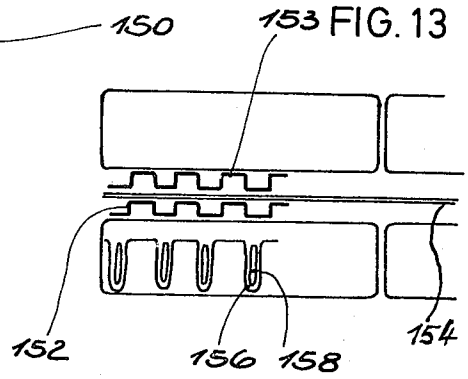


FIG. 13

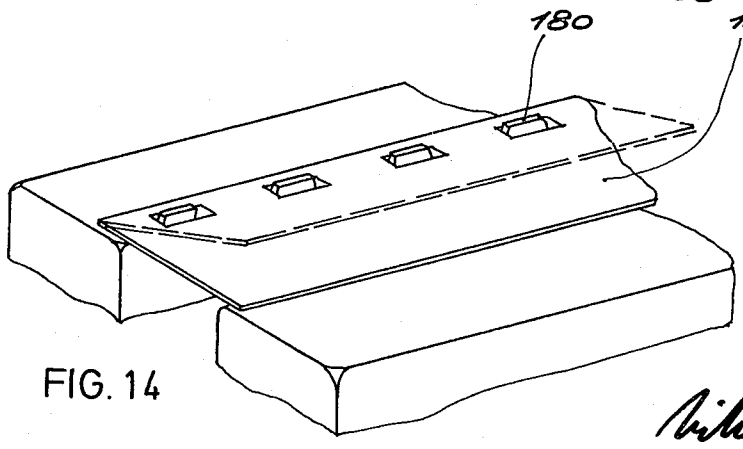


FIG. 14

FIG.15c

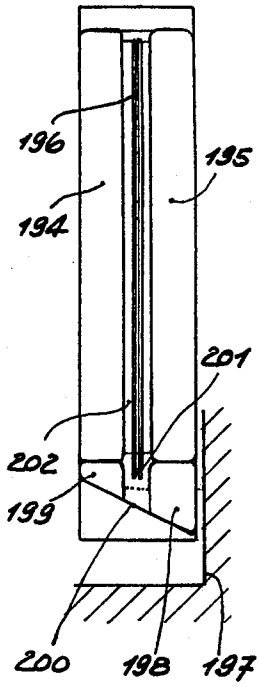


FIG.15b

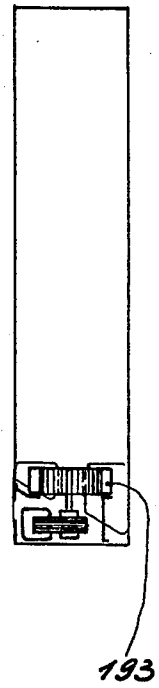
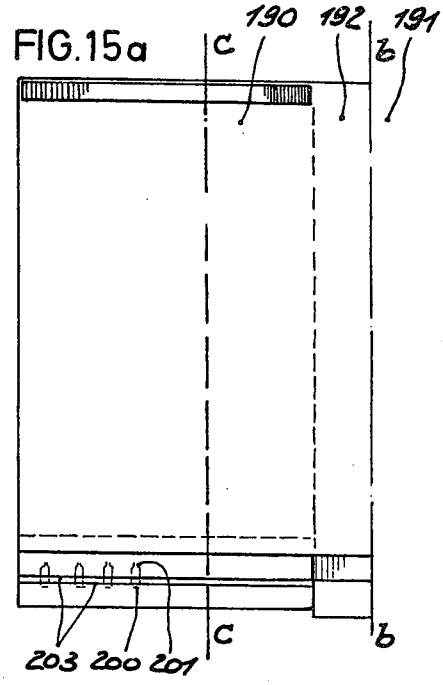


FIG.15a



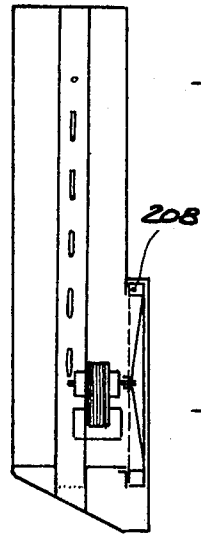


FIG. 16 b

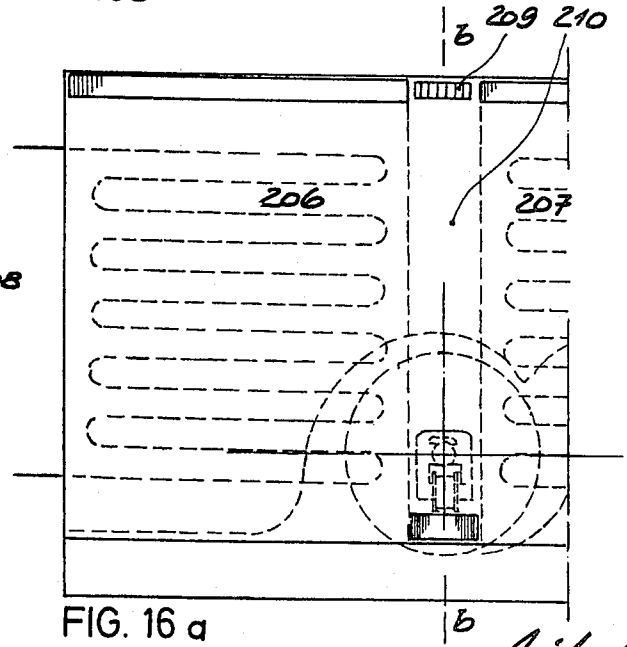


FIG. 16 a

ELECTRIC STORAGE AIR HEATER

This is a continuation of application Ser. No. 13,747, filed Feb. 24, 1970, now abandoned.

THE PRIOR ART

Indirect heat storage by electrical power, steam or hot oil, and transported heat, are becoming increasingly more important.

Stored heat is used, for example, for space heating. Known storage devices for space heating use storage elements which are heated to some hundreds of degrees C, with the result that dust mixed with the room air becomes carbonised at low temperature in said storage elements. This has an adverse effect on the occupants' comfort, because of smell for example, and may even have adverse consequences on health.

THE OBJECT OF THE INVENTION

The invention therefore relates to a heat storage device in which the air adjacent to the storage core is heated below the (dust) carbonisation temperature of about 95°C when the storage device is being discharged.

DESCRIPTION OF THE INVENTION

It has been found that when the heat storage materials used are certain hydrates whose heat of solution on dissolving in, or liquifying in the presence of their own water of crystallisation comes within the range of between about 70° and 95°C, that the heat of fusion of the hydrate can be utilised to store and yield up again the heat in the temperature range below the carbonisation temperature. Hydrates that may be used are barium hydroxide octahydrate, ammonia alum dodecahydrate, magnesium hydrate hexahydrate and trisodium phosphate monohydrate. The use of the above hydrates as heat storage materials has the additional advantages that the storage core of heat storage devices according to the invention requires very little external insulation. The insulation, the storage material containers and the casing materials may be made of plastic so that the storage unit casing may have thin walls and may even consist of wood, while a very flat construction is also rendered possible. Thus heat storage devices according to the invention can be used for the production of flat heaters which can be arranged architecturally in interiors and at the optimum place as regards air conditioning, i.e. beneath windows.

A heat storage device according to the invention also has the great advantage of absolutely excluding any risk of fire and explosions.

Another advantage of using the above low-temperature storage materials is that chemically inert plastics, e.g. highly cross-linked polythene, which are not of mechanically stable shape at elevated temperatures, but which are at the temperatures now being considered, can be used for the storage material containers. This also solves the problem arising when metal containers are used in known storage devices, which are subjected to inadmissible forces owing to the expansion of the storage materials on melting. The hydrates according to the invention can be used alone or in the form of mixtures with substances which influence the melting point or the discharge temperature/time function.

A preferred heat storage device comprising a storage core containing the above-listed storage materials according to the invention, is constructed as follows:

The storage core comprises a plurality of containers which are filled with heat storage materials and which include between them passages or ducts through which the room air can be conveyed during the discharge period. The storage core can be heated directly or by means of a flowable heat vehicle. The latter is particularly applicable when steam or hot oil are used as heat vehicles. Both of these heat vehicles usually operate at relatively high temperature: steam up to 130°C and hot oil up to 350°C, so that the heat losses of the pipes may be very high especially if the pipes carrying the heat vehicle carry the heat vehicle during 24 hours. In conjunction with heat storage devices according to the invention, charging can be limited, for example, to two or three periods each of one hour distributed throughout the day, so that the heat losses are reduced to about one-tenth.

The invention is explained by way of example with reference to the drawings.

FIG. 1*a* is a front elevation of a storage device according to the invention.

FIGS. 1*b* and 1*c* are side elevations of the device shown in FIG. 1*a*, with various valve positions, the side wall of the housing of the device having been omitted.

FIG. 2 is a perspective view of an embodiment of a storage element for the heat storage device shown in FIG. 1*a* to 1*c*.

FIGS. 3 to 7 are partly perspective views and partly sectional views of various embodiments and possible associations of storage elements for a heat storage device according to the invention.

FIG. 8*a* is a broken plan view of a plate-shaped heater element for a heat storage device according to the invention.

FIG. 8*b* is a side sectional view of FIG. 8*a*.

FIG. 9 is a diagrammatic elevation of a plate-shaped heating register for a heat storage device according to the invention.

FIG. 10 is a partial perspective and partial section of one embodiment of a storage core for a heat storage device according to the invention, with heating elements in the form of resistance-heating wires.

FIG. 11 is a partial perspective and partial section of a roller type closure for the air duct of a storage device according to the invention.

FIG. 12*a* is a partial vertical section and partial perspective of another embodiment of a storage device according to the invention.

FIG. 12*b* is a front elevation of the storage device shown in FIG. 12*a*, the front plate having been removed.

FIG. 13 is a section on the line *a*—*a* in FIG. 12*a* showing the storage core of the device shown in FIG. 12*a*.

FIG. 14 is another embodiment of a closure flap for an air duct of a storage device according to the invention.

FIG. 15*a* is an elevation of another embodiment of a storage device according to the invention having an injector disposed at the bottom.

FIGS. 15*b* and 15*c* are sections on the lines *b*—*b* and *c*—*c* in FIG. 15*a*.

FIG. 16*a* is a front elevation of a similar device to FIG. 15*a*.

FIG. 16*b* is a section on the line *b*—*b* in FIG. 16*a*.

FIG. 1*a* shows a storage device according to the invention comprising an air inlet grid **1** and an air outlet grid **2.** As indicated by the lines **3,** the width of the device can be selected to any desired size in units of dimension corresponding with the storage elements which are constructed as modules. Since in practice little or no insulation is necessary the device can be made very flat and, unlike some known devices, can be suspended at a very small distance from the wall.

As will be apparent from FIGS. 1*b* and 1*c*, the three storage elements **5** are so disposed that they form two air ducts **6** and **7** extending over the entire width of the device and which communicate with one another at the top and bottom. In FIG. 1*b*, a butterfly valve **8** is shown in a position in which air can flow in the direction of the arrow **9** through the ducts **6, 7,** of the device. In the position of the valve **8** shown in FIG. 1*c*, the air outlet to the room through the grid **2** is blocked and the air can circulate in a closed circuit in the direction of the arrows **11** and **12,** the heating element **13,** formed like a guide blade, heating and guiding the air flow.

FIG. **2** shows a storage element whose storage material container **20** consists of two identical L-sectioned members **21** and **22** and end walls **23.** A filling connection **24** is provided in one of the end walls **23.** Heat exchange surfaces **25** like fins are secured to the container on one or both sides, depending upon whether the storage element is disposed in the middle or on the outside of the storage core in the manner of FIGS. 1*b* and 1*c*. The containers may consist of sheet metal but are preferably made from plastic.

FIG. **3** shows four storage material container units **30** made of plastic, in which in order to simplify stacking, filler connections **32** are disposed at bevelled corners **31.** Heat conducting surfaces **33** of metal are stuck to the individual containers or else they are fitted, on assembly, in the form of resilient firmly-contacting intermediate members having a length corresponding to the total usable width of the device.

FIG. **4** is a perspective and a horizontal section illustration through a heat storage device according to the invention. The storage elements **45** are supported on a frame (not shown) which has apertures equal to the width of the rectangular zig-zag conductive fins **40.** The storage elements are constituted by means of rectangular-sectional tubular sheet metal casings **41.** The storage material in each container is accommodated in additional containers **42** and **43** comprising plastic sheeting. Between the sheet-metal casing and the containers **42** and **43** a flat heater **44** is provided and will be explained in detail with reference to FIG. **8.** The storage material which is introduced in the flowable state presses the walls of the plastic containers **42** and **43** tightly against the heater **44.**

In the embodiment illustrated in FIG. **5,** the storage material containers consist of rectangular-sectional casings **50,** preferably formed of plastic. These containers have groove-like ducts **51** for the passage of air. Between two opposite storage elements and exposed on both sides to its ducts **51** is a flat heater element **52** described in detail with reference to FIG. **9.**

FIG. **6** shows another embodiment of a storage core of a device according to the invention, in which the storage material is contained in containers consisting of tubes made from foil or plastics containers **60.** The individual containers are contained as illustrated in corrugated sheet-metal strips **61** which are spaced apart to form the air duct **63.** The groups of storage elements situated opposite the metal strips **61** forming the air ducts are in contact with a flat heater **62** which also corresponds to the flat heater described with reference to FIG. **9.**

The corrugated sheet-metal strips **61** preferably consist of aluminium and during charging and discharging conduct heat to and away from the storage elements. The heat-exchanging surface area is preferably enlarged by corrugation as illustrated. When the heating is switched on and the valve **8** is open to the exit **2,** cooling is so intensive that the melting point of the storage material is not reached, so that all the heat is discharged via the sheet-metal strips **61** to the passing air for immediate (non-storage) heating purposes.

FIG. **7** shows a storage device according to the invention wherein the storage material is disposed in elongated foil tubes **80.** The tubes **80** are suspended from rods **81** and are so spaced apart that they present but little resistance to the air rising between them. The control flap **82** for discharging and charging is hinged at **83.** In the changing condition the flap **82** closes the top of the casing in which the storage elements are housed. The bottom **84** of the casing forms a channel-shaped recess **85** so that in the event of any of the containers **80** leaking, none of the storage material can escape. The individual containers **80** enclose resistance heating coils **86** consisting of very thin resistance wire or a conductive polymer. These coils **86** are used primarily to heat the storage element, while secondarily they may increase the mechanical strength of the walls of the storage elements **80** in respect of bursting stress. Instead of the coils **86,** thin metal sheets may be used, to act as heating resistances and contribute to mechanical strength.

FIG. 8*a* and FIG. 8*b* illustrate in a broken plan and side sectional views a heater for a device according to the invention. The heater comprises a plastic sheeting or foil foundation **100,** on which heating conductors have been deposited. The supply lead **101** feeds the resistance circuits **102, 103** and **104** which can each be switched on independently of one another so that recharging is possible without overheating already melted or recrystallized storage material. The plastic sheeting or foil **100** bearing the heating conductor is enclosed in an insulating foil **106** which is welded along the seam **107.**

FIG. **9** shows a heating element constructed in the same way and wherein the heating elements, divided into two circuits **110** and **111** for charging purposes, are provided on one side of the heating conductor carrier, while the other side of the carrier bears the heating conductor coating **112** which is used for supplementary heating. The latter, by means of which the air can be heated directly, is situated in the region of the air ducts and cannot therefore deliver heat to the storage material, but only to the air passing through the air duct.

In the embodiment shown in FIG. **10,** a storage material container **120** is provided with vertical air ducts **121** within which are supported radiation heating elements **122** which in the simpled case are constructed as flat wires suspended between resilient bowed member **123** and **124.** When the air flow is interrupted these wires are used for charging purposes by yielding their heat by radiation to the surrounding storage elements, while when the air ducts are open most of the heat of

the wires is yielded by direct exchange to the air flowing through the ducts **121** so that the same heating elements are usable both for storage and for direct air convection heating.

FIG. **11** illustrates a further embodiment wherein the top part of an air ventilation duct can be opened or closed by means of a roll **140.** Hinge mounted flaps conventionally used for closing ventilation passages or ducts have a disadvantage in that when the flap is nearly closed, a region of low pressure is created in the gap between the flap and the duct due to the velocity of the moving air. This region of low pressure causes the flap to close completely after which it will then reopen due to the static pressure in the duct acting on the flaps. The result is that the flap will continually open and shut causing an undesirable chattering sound. Further, hinge mounted flaps require sensitive mechanical support means for the pivot axis of the flap further adding to the cost of the structure.

An advantage of using a role type flat as shown in FIG. **11** is that, among other things, the use of an expensive hinge type structure is eliminated and the tendency of chattering is reduced. As illustrated, the roll **140** comprises two laminae having different coefficients of thermal expansion where the roll is connected at one end to a heat storage member **141** and to an electrical circuit. One lamina may be made of a conductive polymer with the other lamina being nonconductive or the two laminae may comprise a very thin bimetallic strip. The construction of the roll is such that when the circuit is energized, the two laminae or bimetallic strips will become heated. Because of the difference in coefficient expansion, the roll will tend to unroll and close the duct **142.** The installation could of course be reversed so that when the current is switched on the roll is rolled up and frees the flow through duct **142** while the duct is closed when the current is switched off.

Examples of lamina material used to form the individual lamina are phenolic resin, polyamide, polytetrafluorethylene, polytrifluorochlorethylene and polyvinyl chloride. As the co-efficient of thermal expansion of each of the materials is different, any two lamina when sandwiched together and where each lamina is made from one of the materials will form a laminate which will roll or curl when subjected to a temperature change. Any of the lamina from the above materials may be made electrically conductive by coating the lamina with carbon.

FIG. **12***a*, **12***b* and **13** show another embodiment of a storage device according to the invention wherein the storage materials are contained in plastics containers **150** and **151.** Two identical sinuously-shaped heat exchange elements **152** and **153** are disposed between the containers **150**/151 and are offset in relation to one another as illustrated. The surface heating element **154** corresponds to the heating element shown in FIG. **8.** Above the device is an air duct **155** from which oval nozzles **158** lead into a diffuser **157.** The air emerging from the nozzles **158** draws in secondary air. The entire air flow passes through the device. When the air delivery is started, the foil strip **159** opens by reason of becoming hot, said strip being rigidly anchored at one edge. As will be seen in FIG. **12***b*, a fan **160** is connected to the air duct **155.** The storage material containers are so dimensioned that they can be readily transported in the form of boxes.

FIG. **13** is a section on the line *a–a* in FIG. **12***a*, showing the arrangement of the nozzles **156** and elements **152** and **153.** The heating element **154** is disposed between elements **152** and **163.**

FIG. **14** shows the construction of the flap **159** of the device according to FIG. **12***a*, which is suspended in eyelet-like hinges **180** and is opened by the pressure of the incoming air.

FIGS. **15***a* to **15***c* show another embodiment of a device according to the invention, comprising two identical halves **190** and **191,** and an air shaft **192** at the feet of which is a fan **193.** As will be clear from the sectional views in FIGS. **15***b* and **15***c*, the storage elements **194** and **195** enclose the heat-exchanger plates **196** between them. Beneath the device is an air space which diverges towards the wall **197** of the room and comprises two ducts **198** and **199.** These two ducts communicate with a plurality of profiled tubes **200** which have nozzles **201** extending towards the air shaft **198.** Air passes through these nozzles **201** from the ducts **198** and **199** into the duct **202** and draws in secondary air through the intermediate spaces **203** between adjacent tubes **200.** The fan **193** maintains the pressure in the ducts **198** and **199** and supplies primary air to said ducts.

In the embodiments shown in FIGS. **16***a* and **16***b*, which again comprises two identical halves **207,** the fan **208** is disposed at the back of the storage device and draws in air through the entry grid **209** and the shaft **210.**

What we claim is:

1. A heat storage device having an air duct therein and a closure for said duct, said closure comprising a flexible composite laminated strip member normally wound in a roll form and made up of at least two laminae of polymeric material having different coefficients of thermal expansion, said strip being secured at one end thereof adjacent said air duct, an electrical resistance heating means associated with one of said lamina whereby said one lamina may be heated to cause said one lamina to expand relative to said other lamina and to unwind said strip to mask said air duct in order to regulate passage of air therethrough.

2. A heat storage device according to claim **1** whereby said one lamina having the heating means associated therewith comprises an electrically conductive polymeric material.

* * * * *