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(54) **Title:** HIGH-TEMPERATURE PEST ERADICATION SYSTEM

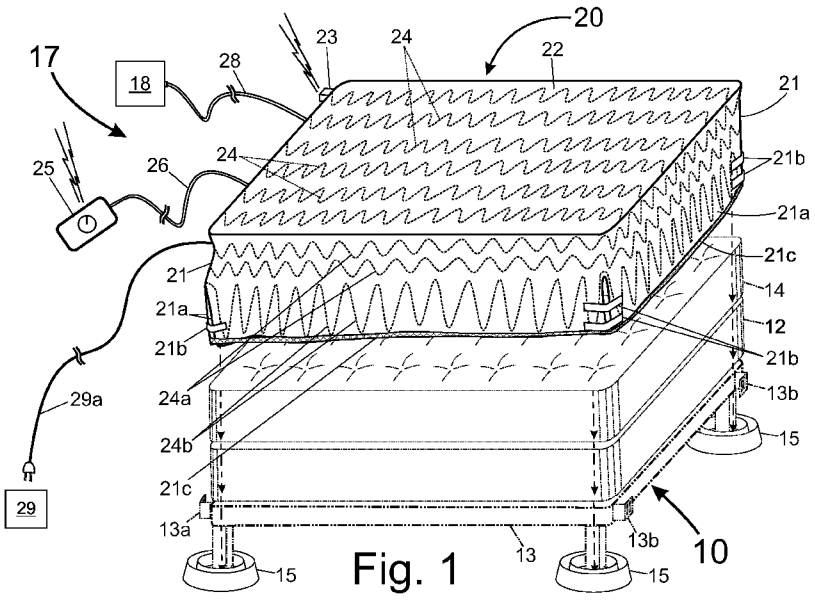



Fig. 1

(57) **Abstract:** A pest eradication system includes a thermal covering receivable over an article of furniture and having a top and one or more contiguous sides that extend from the top, wherein the sides extend and cover all sides and at least a portion of a bottom of the article of furniture. One or more heating elements are coupled to the thermal covering to apply heat to the article of furniture, wherein at least a portion of the heating elements extends to the bottom of the article of furniture. A programmable module communicates with the thermal covering to regulate operation of the heating elements. The programmable module is programmed to selectively operate the heating elements to reach a thermal death point for at least one of an insect pest or a microorganism present on or in the article of furniture.

*[Continued on next page]*

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# HIGH-TEMPERATURE PEST ERADICATION SYSTEM

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority to U.S. Provisional Patent App. Ser. No. 62/648,382, filed on March 26, 2018 and entitled "High-Temperature Bedbug Eradication System," the contents of which are hereby incorporated in their entirety.

## BACKGROUND

**[0002]** Bedbugs, fleas, ticks, dust mites, scabies, cockroaches, body lice, and other "insect pests" are incredibly difficult to control because they are capable of hiding in tiny cracks and crevices and, over time, have become increasingly resistant to common insecticides used for their control. Moreover, many viable insecticides used to eradicate such insect pests cannot be used on common household items like clothes, furniture, bedding, and mattresses.

**[0003]** Heat is an effective killer of mold and bacteria, but can also be used to exterminate insect pests. Heat is also non-toxic and can kill all life stages including bedbug eggs. The thermal death point at which most insect pests and their eggs die is dependent on temperature and the amount of time exposed to elevated temperatures. Bedbugs, for example, will die if exposed to 113°F for 90 minutes or more, and they will die within 20 minutes if exposed to 118°F. Bedbug eggs, however, must be exposed to 118°F for 90 minutes to reach 100% mortality.

**[0004]** Approximate example time and temperature needed to kill other common insect pests include: 15 minutes at 140°F for ticks, 20 minutes at 122°F for dust mites, 29 minutes at 120°F for cockroaches, 10 minutes at 120°F for scabies, 60 minutes at 116°F for body lice, and 105°F for 60 minutes for fleas. These foregoing times and temperatures are mere examples of thermal death points for these insect pests, and thus should not be considered to limit the scope of this disclosure.

**[0005]** Insect pests are commonly killed through the application of heat in the form of steam, hot dryers, and portable heat chambers. Heat is also used to kill dangerous microorganisms, such as mold, bacteria, fungus, viruses, and protozoa. Larger heat chambers can be used to treat furniture, while professional heating systems can be used to treat entire rooms and structures. However, heat

treatment of any kind is only temporary and insect pests and dangerous microorganisms can re-infest the day after treatment, not to mention the cost, hardware, and setup time. Still, heat treatment is one of the more effective tools in the fight against insect pests and dangerous microorganisms.

**[0006]** Since insect pests and dangerous microorganisms are difficult to access, and insecticides are not always available or function properly, homeowners and pest management professionals are continually searching for novel ways to kill insect pests and dangerous microorganisms inside a structure, particularly those near human sleeping areas.

## SUMMARY OF THE DISCLOSURE

**[0007]** The presently disclosed pest eradication systems and methods can be used for generating high-temperatures designed to kill insect pests including, but not limited to, bedbugs, ticks, dust mites, scabies, beetles, cockroaches, lice, fleas, larva and eggs of the foregoing, or other pests. The pest eradication systems and methods disclosed herein may also be used to kill dangerous microorganisms, such as, but not limited to, mold and other fungi, bacteria, viruses, protozoans, and other microbes. As described herein, the pest eradication systems may include large heat chambers that may be used to treat furniture, mattresses, and/or bedding. The heat can be distributed through natural convection and conduction, and also by forced air convention. Each of these pest eradication systems use heat to kill insect pests and microorganisms. In natural convection and conduction systems, one or more heating elements can be enclosed or otherwise included within a thermal covering that is received by the article of furniture and can cover the top, sides, and/or bottom of the article of furniture. As the heating elements heat the article of furniture, the heat slowly migrates through adjacent material of the article of furniture until a thermal death point of the insect pests and/or microorganisms is reached. After the thermal death point is reached, the pest eradication system can be turned off automatically.

**[0008]** In forced convection systems, an airflow is heated and blown through a particular article of furniture requiring eradication of insect pests and/or microorganisms. The high-temperature air combined with long duration airflow creates a type of "convection oven" effect through and/or around the article, which can quickly heat the insect pests and microorganisms to a lethal temperature. A

predetermined air temperature can be maintained by various control means and automatically turn off after a predetermined length of time.

**[0009]** To kill mold, an air temperature greater than 140°F for at least thirty minutes can be used. To kill ticks, an air temperature greater than 140°F for at least fifteen minutes can be used. To kill bacteria, an air temperature greater than 131°F for at least fifteen minutes can be used. To kill dust mites, an air temperature greater than 122° for at least fifteen minutes can be used. To kill scabies and cockroaches, an air temperature greater than 120°F for at least thirty minutes can be used. To kill bedbugs, an air temperature of 120°F can be applied for just one minute.

**[0010]** Air temperatures greater than 160°F can quickly kill nearly all insect pests and potentially dangerous microorganisms. Exhaust air temperatures of 160°F or more can be easily obtainable from a space heater or other common air heating systems (e.g., an air dryer). This hot air source can come through natural thermal convection and conduction from heating elements surrounding the article of furniture or from a hot air source under pressure to provide forced convection through an air manifold to be distributed to a particular article of furniture.

**[0011]** At lower temperatures of 118°F, the effective time durations needed to kill many insect pests and potentially dangerous microorganisms may be too long for the user's patience. More rapid eradication of heat-tolerant insect pests and potentially dangerous microorganisms can require temperatures above 140°F. Accordingly, as the temperature increases, the amount of time needed to kill certain insect pests and potentially dangerous microorganisms decreases. If longer application times are used, 125°F can kill most ticks, fleas and bedbugs. A hot air source can provide the heated air and can comprise one or more heating element(s) (e.g., natural convection and conduction) or a fan and electric heating element(s) to obtain almost any desired exhaust air temperature (e.g., 130°F, 140°F, 150°F, 160°F, or even higher).

**[0012]** A high-temperature airflow can be directed through a flexible hose to allow the hot air source to be placed physically separate from the specific article of furniture being treated for insect pests and potentially dangerous microorganisms. Air temperatures leaving such a hot air source may have a higher temperature than initially needed to allow for cooling of the hot air along the path to the specific article of furniture. This provides a margin of safety to

ensure the desired temperature is reached within the furniture. Having a hot air source located apart from pieces of furniture like a mattress can substantially eliminate the chance of catching that mattress on fire since the high-temperature components (i.e., electric heating systems) can be positioned away from such flammable furniture. For example, a hot air source can send its hot air output through a flexible hose allowing the hot air source to be positioned a safe distance away from flammable mattresses, box springs, or other furniture being treated to help prevent fires. The flexible hose can also attach the flexible hose and hot air to other thermal coverings that can cover and heat treat other large articles of furniture and fabric.

**[0013]** Several example pest eradication systems are presented in the present application for applying high-temperatures to eradicate insect pests and potentially dangerous microorganisms. A first example pest eradication system includes a heating element built into a mattress pad for increasing the temperature of the top and sides of a mattress and box spring to the desired temperature for the desired length of time. The system can have a timer that automatically turns off after a predetermined period of time, and temperature sensing can be added to hold a certain temperature for a specific amount of time and then turn off the system. A second example pest eradication system uses separate thermal coverings for the mattress and box spring to provide better extermination of pests that might hide in a bed. A third example pest eradication system includes a hot air source and an air manifold placed between a mattress and a box spring to distribute heated air from the hot air source into a bottom of a mattress. Hot air flows upward through the mattress under pressure to heat the mattress. As an option, heated air can also be distributed to an underlying box spring by directing some of the heated air downward into the top portion of the box spring. A fourth example pest eradication system can include a fitted sheet structure for either the mattress above and/or the box spring below. The fitted sheet structure not only helps maintain the position of the high-temperature air manifold, but also prevents excess heated air from escaping out the sides of a mattress or a box spring.

**[0014]** A fifth example pest eradication system includes an air port on a side of a mattress that communicates with an interior of the mattress. A hot air source is attached to the air port to provide hot air to the interior of the mattress. The porous nature of mattresses allows the hot air to slowly escape through the mattress fabric and simultaneously heats the mattress to the desired temperature.

Standard blankets and comforters can be used to hold in the heat for eradicating insect pests and potentially dangerous microorganisms in any of the above example pest eradication systems.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0015]** The following figures are included to illustrate certain aspects of the present disclosure, and should not be viewed as exclusive embodiments. The subject matter disclosed is capable of considerable modifications, alterations, combinations, and equivalents in form and function, without departing from the scope of this disclosure.

**[0016]** FIG. 1 is a schematic illustration of an example pest eradication system, according to one or more embodiments of the present disclosure.

**[0017]** FIG. 2 is a schematic illustration of another example pest eradication system, according to one or more additional embodiments of the present disclosure.

**[0018]** FIGS. 3A through 3F are example cross-sectional end views of the bug stop of FIG. 2.

**[0019]** FIG. 4 is a schematic illustration of another example pest eradication system, according to one or more additional embodiments of the present disclosure.

**[0020]** FIG. 5 is a schematic illustration of another example pest eradication system, according to one or more additional embodiments of the present disclosure.

**[0021]** FIG. 6 is a schematic illustration of another example pest eradication system, according to one or more additional embodiments of the present disclosure.

## DETAILED DESCRIPTION

**[0022]** The present disclosure is related to pest control and, more particularly, to a programmable pest eradication system and method that relies on thermal exposure over predetermined time periods to eliminate insect pests and other dangerous microorganisms that may be present on common household items.

**[0023]** FIG. 1 is a schematic illustration of an example pest eradication system 17, according to one or more embodiments of the present disclosure. The

pest eradication system 17 (hereafter "the system 17") may be used to kill insect pests including, but not limited to, bedbugs, ticks, dust mites, scabies, beetles, cockroaches, lice, fleas, larva and eggs of the foregoing, or other pests. Alternatively, or in addition thereto, the system 17 may be used to kill various dangerous microorganisms, such as, but not limited to, mold and other fungi, bacteria, viruses, protozoans, and other microbes.

**[0024]** As illustrated, the system 17 can include a thermal covering 20 and a programmable module 18. The thermal covering 20 may be sized and otherwise configured to cover at least the top and the vertical sides of an article 10 of furniture. The article 10 may comprise any type of furniture or furnishing susceptible to the infestation and maintenance of insect pests and/or dangerous microorganisms, as defined herein. In the illustrated embodiment, for example, the article 10 comprises a bed and, more particularly, a mattress or bed assembly. In other embodiments, however, the article 10 may comprise other types of furnishings such as, but not limited to, a standalone mattress, a box spring, a bed assembly, a sofa, a loveseat, a futon, a recliner, a chair, an ottoman, or any combination thereof. Accordingly, while FIG. 1 depicts the article 10 as a mattress and bed assembly, this is merely for illustrative purposes and should not be considered limiting to the scope of the present disclosure.

**[0025]** In the illustrated embodiment, the article 10 includes a box spring 12, a bedframe 13, and a mattress 14. The box spring 12 and the bedframe 13 may be optional and either one, none, or both can be used in combination with the mattress 14. The bedframe 13 may comprise a headboard (not shown) and a footboard (not shown), which are common for bedroom furniture and may be attached to a pair of headboard brackets 13a (one visible in FIG. 1) and a pair of footboard brackets 13b for attaching a headboard and footboard respectively.

**[0026]** In some embodiments, one or more pest traps 15 may be placed under each support leg of the article 10. In the illustrated embodiment, the pest traps 15 comprise smooth-surfaced receptacles that prevent many insect pests that have difficulty gripping smooth surfaces from accessing the article 10 from the underlying floor and via the support legs. The pest traps 15 may also prevent insect pests from escaping the article 10 and onto the floor via the legs. Accordingly, the pest traps 15 may work in combination with the system 17 to help prevent re-infestation of the article 10 or re-location of the insect pests.

**[0027]** The thermal covering 20 may exhibit dimensions configured to cover at least the top and the sides of the article 10. In the illustrated embodiment, the thermal covering 20 may generally take the form of a mattress pad having a top 22 and four contiguous sides 21 that extend downward around the periphery of the top 22 and act as a heated skirt. The top 22 and four contiguous sides 21 may be sized to be received over the exterior of the article 10. In at least one embodiment, the contiguous sides 21 may be sized to extend to cover the sides of the mattress 14, box spring 12 and/or article 10 as illustrated by the vertical construction arrows seen in FIG. 1. In some embodiments, the thermal covering 20 may be large enough to cover at least a portion of the bottom of the article 10. In at least one embodiment, the thermal covering 20 may be sized to extend to or near the underlying floor to help prevent heat from escaping under the thermal covering 20 during use. In other embodiments, the thermal covering 20 may further include a bottom (not shown), thus allowing the article 10 to be fully encapsulated by the thermal covering 20.

**[0028]** The sides 21 may include a set of four side flaps 21a, each attached to or otherwise extending from a lower edge of the corresponding side 21. Each side flap 21a may be made of multiple layers of fabric including, but not limited to, an insulating fabric, a flexible insulation panel, an insulating polymer panel, and/or other thermal insulating structure. The side flaps 21a may extend to the floor or to a location between the box spring 12 and the underlying floor to provide heating to the underside (i.e., bottom) of the box spring 12. The four side flaps 21a may extend downward and may be separated at each corner to allow the thermal covering 20 to bypass the headboard and footboard brackets 13a,b or other obstacles that would prevent the article 10 of furniture from fully receiving the thermal covering 20. In some embodiments, however, the side flaps 21a may be optional and the sides 21 may instead extend to cover some or all of the mattress 14, the box spring 12, and the bedframe 13.

**[0029]** The thermal covering 20 can include one or more securing devices for securing the thermal covering 20 around the article 10. In some embodiments, for example, the gap at each corner between the side flaps 21a may be held closed with one or more closure devices 21b. In at least one embodiment, the closure devices 21b may comprise a strap with a VELCRO® fastener (hook and loop fastener), a snap fastener, a belt, or other type of closure device. In some embodiments, an elastic band 21c may be arranged (e.g., sewn) at the bottom

edge of each side flap 21a to help secure the thermal covering 20 around the mattress 14 and/or the box spring 12. In at least one embodiment, the closure devices 21b can be omitted and the elastic band 21c may be used independently to pull the bottom portions of the side flaps 21a inward to cover at least a portion of the bottom of the mattress 14. In other embodiments, the side flaps 21a may be omitted and the elastic band 21c may alternatively be attached to the bottom edges of the sides 21 to pull the bottom portion of the sides 21 inward to cover at least a portion of the underside surface (i.e., bottom) of the mattress 14 or box spring 12.

**[0030]** In some embodiments, the elastic band 21c can comprise an elastic skirt that holds the thermal covering 20 around the mattress 14. In such embodiments, the side flaps 21a can be sewn together at the corners to form the elastic skirt. Alternatively, the contiguous sides 21 may help form the elastic skirt and may be stretched to an extended length to cover the box spring 12, as needed. The side flaps 21a may be well insulated to hold in heat from the heating elements 24b and may extend to the floor, or near to the floor, to cover the bedframe 13. The gaps between the side flaps 21a at each corner may allow the side flaps 21a to be tucked under each side of the article 10 and help hold in heat and maintain their position when secured over the article 10. In at least one embodiment, the side flaps 21a can extend past the headboard brackets 13a and footboard brackets 13b with the closure devices 21b securing the gaps between the side flaps 21a above and/or below the headboard and footboard brackets 13a-b.

**[0031]** The elastic skirt may be pulled a short distance under the mattress 14 and, in some designs, can extend several inches under the mattress 14. Use of the elastic band 21c allows the thermal covering 20 to fit snugly over the mattress 14 or box spring 12 similar to how standard mattress pads with elastic skirts are constructed and used. This allows additional fitted sheets, flat sheets, blankets and other bedding materials to be tucked in between the mattress 14 and the box spring 12, which is presently common practice in bed making.

**[0032]** The thermal covering 20 may be capable of generating a thermal gradient sufficient to exterminate insect pests and potentially dangerous microorganisms. To accomplish this, in at least one embodiment, the thermal covering 20 may include one or more heating elements, including one or more top heating elements 24 positioned on the top 22, one or more side heating elements 24a positioned on the contiguous sides 21, and one or more flap heating elements

24b positioned on the side flaps 21a. In some embodiments, the heating elements 24, 24a, 24b may be embedded within the material (fabric) of the thermal covering 20. In other embodiments, however, the heating elements 24, 24a, 24b may be positioned on the underside of the thermal covering 20 and otherwise in direct contact with the outer surfaces of the article 10.

**[0033]** The heating elements 24, 24a, 24b may comprise any type of resistive heating element capable of converting electrical energy into heat through the process of Joule heating. Each heating element 24, 24a, 24b may comprise one or a plurality of heating elements. In at least one embodiment, one or more of the heating elements 24, 24a, 24b may include multiple heating element circuits.

**[0034]** In at least one embodiment, the heating elements 24, 24a, 24b may be arranged on the thermal covering 20 with a layer of thermally insulating material on the outside of the thermal covering 20. In some embodiments, the side flaps 21a can be folded under the mattress 14 to heat the underside edges of the mattress 14. In other embodiments, the side flaps 21a may be constructed without the heating elements 24b and simply provide insulation.

**[0035]** The heating elements 24, 24a, 24b may be in electrical communication with a power source 29. In some embodiments, the power source 20 may comprise a standard, local power outlet. In such embodiments, the thermal covering 20 may include a power cord 29a capable of being plugged into the power source to provide electrical power to the heating elements 24, 24a, 24b, and thereby energize and increase the temperature of the heating elements 24, 24a, 24b. In other embodiments, however, the power source 29 may instead comprise a localized (non-power grid) source of power, such as one or more rechargeable or non-rechargeable batteries, one or more fuel cells, or a renewable energy source with associated capacitors, such as one or more solar panels that can be positioned to generate power from solar energy.

**[0036]** In some embodiments, the side flaps 21a can be made of an insulating material and the heating elements 24b may be arranged on the inside surface(s) (interior surface) of the side flaps 21a. In such embodiments, the side heating elements 24b may dissipate a proportionally greater amount of energy supplied by the power source 29 so that natural convection can cause heat to rise through the box spring 12 and the mattress 14 more efficiently than if heat must

penetrate downward from the top 22 of the thermal covering 20 through the mattress 14 and then through the box spring 12 against natural convection.

**[0037]** The programmable module 18 may be communicably coupled (either wired or wirelessly) to the thermal covering 20 to regulate operation of the thermal covering 20. In some embodiments, for example, the thermal covering 20 may include a wireless transmitter/receiver 23 powered by the power source 29 and configured to wirelessly communicate with the programmable module 18. In such embodiments, suitable wireless protocols that may be employed include, but are not limited to, radio frequency (RF) transmission, Wi-Fi, Bluetooth®, ZigBee®, near field communication (NFC), infrared, or any combination thereof. In other embodiments, however, the thermal covering 20 may communicate with the programmable module 18 via wired means, such as by plugging an adaptor 28 of the thermal covering 20 into a local network in communication with the programmable module 18 or directly into the programmable module 18 itself.

**[0038]** The programmable module 18 may be programmed to selectively operate the thermal covering 20 to reach a thermal death point for the insect pests, their eggs, and any potentially dangerous microorganisms. As used herein, the phrase "thermal death point" refers to the temperature and time constraints necessary to kill the insect pests, their eggs, and any potentially dangerous microorganisms. The thermal death point for bedbugs and their eggs, for example, may require a temperature that meets or exceeds 118$^{O}$F and maintains the temperature at or above that temperature for at least 90 minutes.

**[0039]** In some embodiments, the article 10 and the installed thermal covering 20 may be insulated prior to operation of the thermal covering 20. More specifically, all or a portion of the thermal covering 20 may be covered with exterior insulation including, but not limited to, a comforter, a blanket, a quilt, or other insulating materials. In some embodiments, the exterior insulation can be incorporated into the makeup of the thermal covering 20. Increasing the amount of exterior insulation may accelerate the rate at which the thermal covering 20 reaches the desired thermal death point, and may also reduce the amount of power required to do so.

**[0040]** In example operation, the thermal covering 20 may be positioned over at least the top and the sides of the article 10. Once properly positioned on the article 10, and article 10 is properly (optionally) insulated, operation of the thermal covering 20 may be triggered through communication with the

programmable module 18. In some embodiments, for example, the programmable module 18 may allow a user to manually initiate operation of the thermal covering 20 as desired. In such embodiments, the programmable module 18 may include a graphical user interface (GUI) or another type of user input that enables the user to input a desired temperature and a desired time period for the thermal covering 20 to operate. In at least one embodiment, however, the programmable module 18 may simply include a "kill mode" option that can be selectively initiated by the user as desired. The "kill mode" may comprise an algorithm programmed into the programmable module 18 to operate the thermal covering 20 to achieve the thermal death point.

**[0041]** In other embodiments, the programmable module 18 may be programmed to autonomously operate the thermal covering 20 on a predetermined schedule or as needed. In such embodiments, for example, the programmable module 18 may be programmed to operate the thermal covering 20 once a day, once a week, or once a month, but may be programmed to operate the thermal covering 20 at intervals greater or less than once a day, once a week, or once a month, without departing from the scope of the disclosure.

**[0042]** In at least one embodiment, the thermal covering 20 may be used in a hotel setting or a similar type of habitation accommodation business. In such embodiments, the programmable module 18 may be incorporated into or otherwise communicable with a hotel computer system. More specifically, the programmable module 18 may be programmed to communicate with an internal hotel booking or room management software and initiate operation of the thermal covering 20 at various predetermined times or when a particular room receives a status change. Example status changes include, but are not limited to, when the room is booked, when a guest checks out of the room, a predetermined time before guest check-in, after the room has been cleaned, when the room has not been booked for a predetermined time period, a predetermined time after any of the foregoing status changes, or any combination thereof.

**[0043]** In some embodiments, the programmable module 18 may be programmed to cease operation of the thermal covering 20 once a guest checks in and the room is assigned to be occupied. In some embodiments, a guest at the hotel may have the option of manually operating the thermal covering 20 in "kill mode" when desired to provide peace of mind. In such embodiments, the thermal covering 20 can comprise a guest interface 25 connected wirelessly to the

programmable module 18 or hardwired to the programmable module 18 through a control cord 26.

**[0044]** Apart from the operational characteristics of killing insect pests, their eggs, and any potentially dangerous microorganisms, the thermal covering 20 may also operate as a general-use heating and/or cooling mattress cover that may help enhance the performance (e.g., comfort) of the underlying mattress. In such embodiments, the guest interface 25 may be used by the guest to control operation of the thermal covering 20 to provide a desirable temperature (significantly less than the thermal death point) for sleeping preferences. When used as a general-use heating and/or cooling mattress cover, the thermal covering may heat and/or cool only the top of the mattress 14, and not the sides. Accordingly, the thermal covering 20 may be designed to be covered with traditional bedding materials, such as sheets and blankets. Moreover, the thermal covering 20 may generally remain on the article 10 when the bedding materials are removed for laundering. In some embodiments, however, the thermal covering 20 may also be washable.

**[0045]** FIG. 2 is a schematic illustration of another example pest eradication system 17A, according to one or more additional embodiments of the present disclosure. As illustrated, the pest eradication system 17A (hereafter "the system 17A") can comprise a first thermal covering 20A for covering the mattress 14, a second thermal covering 30 for covering the box spring 12, and the programmable module 18 as previously described.

**[0046]** The first thermal covering 20A may be similar in some respects to the thermal covering 20 of FIG. 1 and therefore may be best understood with reference thereto, where similar numerals refer to similar components not described in detail again. Similar to the thermal covering 20 of FIG. 1, the first thermal covering 20A may include the wireless transmitter/receiver 23, the top heating elements 24, one or more side heating elements 24c arranged within the contiguous sides 21, the elastic band 21c positioned along a bottom edge of the contiguous sides 21, and the guest interface 25.

**[0047]** The second thermal covering 30 may include the four side flaps 21a and the closure devices 21b, as generally described above. The second thermal covering 30 may further include at least one top heating element 34, at least one side heating element 34a, a bug stop 35, a top sheet 36, and a power connector 37. A power plug 27 that may extend from or otherwise form part of

the control cord 26 may be used provide power to the second thermal covering 30. More specifically, the power plug 27 may be removably connected to the power connector 37. The top heating elements 34 can be adapted to heat the outer edge of the top surface of the box spring 12 and the bottom surface of the mattress 14. The side heating elements 34a are adapted to heat the side flaps 21a and can be constructed similar to the heating elements 24c. The programmable module 18 can be connected to the first thermal covering 20A with the adaptor 28 and operate in any of the previously discussed operational modes to reach the thermal death point for exterminating insect pests or eradicating dangerous microorganisms.

**[0048]** In at least one embodiment, the second thermal covering 30 is omitted and the first thermal covering 20A may be used exclusively to cover and heat the mattress 14. In such embodiments, the contiguous sides 21 can extend downward sufficiently to allow the elastic band 21c to pull a significant portion of the contiguous sides 21 under the mattress 14 to secure the first thermal covering 20A such that the lower portions of the heating elements 24c can also be tucked under the mattress 14 a short distance (e.g., more than one inch) by the pulling action of the elastic band 21c on the contiguous sides 21. This allows heat generated by the heating elements 24c to heat the bottom of the mattress 14.

**[0049]** The second thermal covering 30 may be constructed with the top sheet 36 providing support for the bug stop 35 and the top heating elements 34. The top sheet 36 can help to maintain the shape and position of the bug stop 35 and top heating elements 34. The top sheet 36 can comprise an impermeable material and/or a breathable fabric. The top sheet 36 can cover the top surface, sides, and/or bottom surface of the box spring 12. The heating elements 34 can stop at the bug stop 35 because pests cannot migrate laterally past the bug stop 35 in either direction. In at least one embodiment, the bug stop 35 may comprise a loop of polymer cord attached to the periphery or outer edges of the top sheet 36. In FIG. 2, the top sheet 36 is visible on the interior portion of the bug stop 35 but can extend into the areas heated by the top heating elements 34. The bug stop 35 may be sized to be positioned at a predetermined distance from the edge of the box spring 12 and beneath the bottom edge of the mattress 14. In other embodiments, the bug stop 35 can be used separate from the second thermal covering 30 and the top sheet 36. In such embodiments, the bug stop 35 may be

positioned at a predetermined location between the mattress 14 and the box spring 12.

**[0050]** The bug stop 35 may have a cross-section (i.e., depth) that can stop insect pests from being able to crawl (migrate) laterally past the bug stop 35 and to the interior and underside of the mattress 14. In some embodiments, the bug stop 35 can have elastic properties allowing it to stretch around the periphery of the mattress 14 and then retract back to size smaller than the outer periphery of the mattress 14. In at least one embodiment, the bug stop 35 can serve as a physical stop to provide a consistent and repeatable positioning of the elastic band 21c when placed around the mattress 14. In other embodiments, an elastic version of the bug stop 35 can be placed on the first thermal covering 20A replacing the elastic band 21c. In such embodiments, the bug stop 35 could be attached to the lower edge of the four contiguous sides 21 and replace the elastic band 21c. This allows the elastic version of the bug stop 35 to act as both the elastic band for the first thermal covering 20A and a bug stop for thermal covering 30 to prevent pests from migrating to and from the center of the box spring 12 and mattress 14.

**[0051]** In one or more embodiments, the elastic band 21c can assume the bug stopping properties of the bug stop 35. In such embodiments, the elastic band 21c may comprise an elastic cord having relatively stiff longitudinal ridges or protrusions to help stop pests from traversing the elastic band similar to the bug stops 35 and 35a-f, thus eliminating the need for the bug stop 35 on the thermal covering 30. In some embodiments, the elastic band 21c can have a small amount of elasticity while still being able to be slipped around the mattress 14 and maintain a hoop shape similar in size and shape to the bug stop 35. Having similar properties to the bug stop 35, the elastic band 21c can be positioned between the mattress 14 and the box spring 12. In such embodiments, the elastic band 21c can be pressed into both the bottom surface of the mattress 14 and the top surface of the thermal covering 30 (which then presses into the top surface of the box spring 12). The pressure from the weight of the mattress 14 on the elastic band 21c can tend to indent the bottom surface of the mattress 14 and the top surface of the box spring 12, and thereby making it difficult for insect pests to traverse from one side of the elastic band 21c to the other. In this way, insect pests are either trapped inside the ring formed by the elastic band 21c (i.e., the interior space between the box spring 12 and the mattress 14), or on the outside

of the elastic band 21c where the heating elements 24c can heat the top edge of the box spring 12 and the bottom edge of the mattress 14. This can effectively prevent insect pests from reaching the interior of the elastic band 21c so that the heating elements 24c need only cover an edge portion of the mattress 14 that the insect pests can reach. This allows the interior surfaces of the box spring 12 and the mattress 14 to be unheated, while insect pests in the outer gap between the box spring 12 and the mattress 14 can reach lethal temperatures because of the top heating element 34 to exterminate insect pests.

**[0052]** In some arrangements, the bug stop 35 can be a standalone cord that is separate from any thermal covering. In such arrangements, the mattress 14 can be placed directly on the floor, and the standalone cord can be tucked underneath the mattress 14 until snug against the floor and the underside of the mattress 14. In such embodiments, the bug stop 35 can be pressed into the space between the mattress 14 and then the floor and the elastic band 21c can pull the lower edge of the four continuous sides 21 up against the standalone cord. In other embodiments, the first thermal covering 20A can be used in combination with the bug stop 35 to provide heat to the area outside the bug stop 35 and prevent pests from reaching inner locations under the mattress 14 where the heating elements 24c of the first thermal covering 20A do not reach. Each of the above-mentioned arrangements can be used without the box spring 12 and/or the bedframe 13.

**[0053]** The side flaps 21a can be attached at their upper edge to the outer edge of the top sheet 36 (i.e., at the outer edge of the top heating elements 34). The heating elements 34 and 34a can be covered with fabric to enclose them within the second thermal covering 30. In some embodiments, the bug stop 35 can be sewn onto the top sheet 36 at a predetermined distance from the edge of the top sheet 36 (i.e., a predetermined distance from the tops of the side flaps 21a). The top heating elements 34 can extend between the bug stop 35 and the side heating elements 34a to provide heating to the top and side areas on the box spring 12 where insect pests can crawl. Accordingly, the bug stop 35 can prevent pests from crawling in either direction, i.e., to the interior portion of the bug stop 35 as well as from crawling out of the interior portion of the bug stop 35.

**[0054]** The side flaps 21a can be secured to the box spring 12 at their corners with the closure devices 21b to ensure the corners of the box spring 12 are heated evenly. In other embodiments, the closure devices 21b can be

replaced by an elastic band similar to the elastic band 21c. This elastic band can be placed along the bottom edges of the side flaps 21a and adapted to wrap the bottom edges of the side flaps 21a under the box spring 12 similar to how the contiguous sides 21 wrap under the mattress 14.

**[0055]** The first thermal covering 20A can be used in combination with the second thermal covering 30 to apply lethal heat to both the mattress 14 and the box spring 12, respectively. In some embodiments, the second thermal covering 30 can be combined with the first thermal covering 20A to provide heating to the bottom edge of the mattress 14. In other embodiments, the first thermal covering 20A can be modified and combined with an alternate arrangement of the second thermal covering 30 where the top heating elements 34 are omitted. With the top heating elements 34 gone, the first thermal covering 20A can be modified by lengthening the four contiguous sides 21 and the heating elements 24c such that the longer heating elements can extended to wrap under the bottom surface 14c and heat the same area previously heated by the top heating elements 34. In these embodiments, it is important that the heating elements 24b, 24c and/or 34a not overlap each other or themselves significantly. Overlapped areas of the heating elements 24a, 24b, 24c, 34 and/or 34a can cause higher temperatures in those overlapped areas, which can damage the heating elements, the thermal covering 20A, 30, and/or the user.

**[0056]** When combining the thermal coverings 20A and 30, the length of the side heating elements 24c can be adapted so that the bottom edges of the side heating elements 24c extend to cover only the sides of the mattress 14, but not the underside of the mattress 14. The elastic band 21c can pull the bottom, unheated portion, of the contiguous sides 21 against the underside of the mattress 14 to secure it to the mattress. Similarly, if the side heating elements 24c extend to the underside of the mattress 14, then the top heating elements 34 of the second thermal covering 30 may be omitted. In some embodiments, the pest traps 15 (FIG. 1) can be used in combination with the pest eradication system 17A to reduce re-infestation of the article 10 after being heat treated.

**[0057]** The thermal coverings 20 and 20A of FIGS. 1 and 2, respectively, can also include one or more temperature sensors used to sense the real-time temperature level of the thermal coverings 20, 20A and/or the article 10. This may provide a safety feature that helps prevent over-heating of the heating elements 24, 24a, 24b and 24c during use. In at least one embodiment, the

heating elements 24, 24a, 24b and 24c can themselves function as temperature sensors since the wire from which they are generally constructed increases in electrical resistance at a known rate as their temperature increases. When a predetermined temperature is reached and sensed, power to the heating elements 24, 24a, 24b and 24c can be turned off to allow them to cool down. In other embodiments, dedicated thermocouples can be used to measure the temperature within the thermal coverings 20 and 20A.

**[0058]** Taking temperature measurements over a period of time can provide a temperature profile that can be used to determine, among other things, whether a person is laying on the heating elements since a person's body tends to heat the wires up faster below body temperature and slow heating above body temperature. The temperature profile may also be used to determine whether the thermal coverings 20 and 20A are properly insulated since a properly insulated article 10 of furniture will reach a particular temperature at a known time window after startup. If these particular temperatures are not reached within the known time window, this may be an indication of insufficient insulation covering or that a person is laying on the thermal coverings 20 or 20A.

**[0059]** Power to the heating elements 24, 24a, 24b and/or 24c can be activated through either the guest interface 25, the programmable module 18, and/or the wireless transmitter/receiver 23. After the predetermined time period is reached, the programmable module 18, the wireless transmitter/receiver 23, and/or the guest interface 25 can turn off power to the heating elements 24, 24a, 24b and/or 24c and the article 10 can be allowed to cool before use. The control systems for operation of the systems 17 and 17A (i.e., programmable module 18, wireless transmitter/receiver 23, and/or guest interface 25) can be greatly simplified to comprise a timer controlled electrical power switch. In this way, the timer can control power to systems 17 and 17A and provide heating for a predetermined time period that is consistent with reaching the thermal death point for specific pests.

**[0060]** In embodiments where the article 10 is a mattress for a bed, the systems 17 and 17A may comprise two guest interfaces, each with controls for their side of the thermal coverings 20 and 20A, respectively. The top heating elements 24 can be formed into one or more left-side heating element and one or more right-side heating element to allow individual control of comfort heating to the left and right sides of article 10, independently. The guest interface 25 may

be a master guest controller for controlling both the left and right-side heating elements, while a second similar guest controller may have controls for only controlling the right-side heating elements. In this way, two users can control their desired level of heat to their side of the article 10 for individual comfort while sleeping or resting.

**[0061]** FIGS. 3A through 3F are example cross-sectional end views of the bug stop 35 of FIG. 2. More particularly, FIGS. 3A through 3F display six embodiments of the bug stop 35, shown as bug stops 35a through 35f, respectively. It will be appreciated, however, that the shapes of the bug stops 35a-f of FIGS. 3A-3F may alternatively be applied to the elastic band 21c of FIGS. 1-2, without departing from the scope of the disclosure. Accordingly, the following discussion may be equally applicable to the elastic band 21c.

**[0062]** The bug stops 35a-f can comprise a cord of material connected at its ends to form a ring or loop that can be loosely positioned between the mattress 14 (FIGS. 1 and 2) and the underlying box spring 12 (FIGS. 1 and 2). The structural shape of the bug stops 35a-f make it difficult for insect pests to laterally traverse the bug stops 35a-f when squeezed between the mattress 14 and the box spring 12. The weight of the mattress 14 can provide the pressure to hold the bug stops 35a-f against the fabric of the mattress 14 and/or the second thermal covering 30 (FIG. 2) covering the box spring 12. In some embodiments, the bug stops 35a-f may provide or otherwise define one or more hard edges that press into the mattress 14 and the box spring 12 to provide a shaped ridge that is difficult for insect pests to traverse. Pressing the bug stops 35a-f into the fabric of the box spring 12 and the mattress 14 can create a continuous high-pressure line along the bug stops 35a-f, which makes it difficult for insect pests to push past.

**[0063]** Thus, the bug stops 35a-f can be used to trap insect pests between the interior of the box spring 12 (FIGS. 1 and 2) and the mattress 14 (FIGS. 1 and 2), and may stop insect pests from traveling between the area inside the bug stop 35 (e.g., inner area of top sheet 36 between mattress 14 and box spring 12) and the area outside the bug stop 35. The one or more hard edges on the bug stops 35a-f can also create a sharp angle in the fabric of the mattress 14, which many insect pests can find difficult to navigate even if they might be able to squeeze between the mattress 14 and the bug stops 35a-f if the interface were relatively flat. Accordingly, insect pests may be prevented from laterally

traversing the bug stops 35a-f since the bug stops 35a-f create a high-pressure line that the insect pests cannot cross, and/or the bug stops 35a-f deform the surface of the mattress 14 and/or the box spring 12 to create an arduous path (sharply turning path) that the insect pests cannot navigate.

**[0064]** The bug stops 35a-f can be made of various polymer or elastomeric materials including, but not limited to, hard rubber, high-impact plastic, polypropylene, nylon, polyester, urethane, thermoplastic polyurethane (TPU), acrylonitrile butadiene styrene (ABS), styrene-ethylene-butylene-styrene (SEBS), other elastomers, or any combination thereof. The bug stops 35a-f can be formed from an extruded cord with a particular cross-sectional shape, which is then cut to length and its ends bonded together to form a closed loop of cord.

**[0065]** In some embodiments, the bug stops 35a-f can be secured to the top sheet 36 (FIG. 2) of the second thermal cover 30 (FIG. 2) such as by gluing, sewing, thermal bonding, adhesives, or any combination thereof. The bug stops 35a-f can snugly fit between the mattress 14 (FIGS. 1 and 2) and box spring 12 (FIGS. 1 and 2) so that no gaps exist between the bug stops 35a-f and the mattress 14 and/or box spring 12, thereby preventing insects or bugs from traversing across the bug stops 35a-f. Since insect pests are trapped within or without the loop of the bug stops 35a-f, the bug stops 35a-f can eliminate the need to heat the entire top surface of the second thermal covering 30 and instead only the outer edge of the box spring 12 and the mattress 14 need be heated. By not having to heat the entire top surface of the second thermal covering 30, the power requirements and cost of the second thermal covering 30 can be reduced.

**[0066]** In FIG. 3A, the cross-section of the bug stop 35a is circular, but could alternatively be oval or ovoid. The diameter of the bug stop 35a can be sized to generate a continuous pressure line around the underside of the mattress 14.

**[0067]** In FIG. 3B, the cross-section of the bug stop 35b is generally in the shape of a "T". More specifically, the bug stop 35b can define or otherwise provide one or more flanges 41 and a ridge 41a that protrudes (extends) from the flanges 41. In some embodiments, the flanges 41 can be sewn into the top sheet 36 (FIG. 2) such that the ridge 41a extends upward and presses into the underside of the mattress 14 (FIG. 2) during use and create a barrier that prevents insect pests from crossing. In other embodiments, the flanges 41 can extend at various angles with respect to the ridge 41a other than the ninety degrees illustrated.

**[0068]** In FIG. 3C, the cross-section of the bug stop 35c is generally circular with a plurality of longitudinal ridges 42. The ridges 42 extend along the length of the bug stop 35c and are adapted to create one or more pressure lines against the mattress 14 and the box spring 12.

**[0069]** In FIG. 3D, the cross-section of the bug stop 35d is generally circular and a plurality of harder polymer longitudinal cords 43 may be embedded on the exterior. The longitudinal cords 43 may be adapted to press into the soft fabric of the mattress 14 and prevent insect pests from crossing the bug stop 35d. The longitudinal cords 43 may be made of any of the materials mentioned above for the bug stops 35a-f.

**[0070]** In FIG. 3E, the cross-section of the bug stop 35e comprises a hollow, circular cylindrical, which may provide a lower cost version of the bug stop 35a of FIG. 3A. In some embodiments, the hollow cord can be filled with a foam polymer to provide additional rigidity. In at least one embodiment, the bug stop 35e can be adapted to include the longitudinal ridges 42 (FIG. 3C) and/or the longitudinal cords 43 (FIG. 3D).

**[0071]** In FIG. 3F, the cross-section of the bug stop 35f is in the general shape of an "X" forming longitudinal protrusions 44. Two of the longitudinal protrusions 44 can rest on the top surface of the box spring 12 and the opposing two longitudinal protrusions 44 may press into the underside of the mattress 14. In some embodiments, the bug stop 35f may also provide or otherwise define an attachment flange 45 that can be sewn into or otherwise bonded to a particular thermal covering (i.e., thermal coverings 20, 20A and 30 of FIGS. 1-2).

**[0072]** Each of the bug stops 35a-f described above can include a degree of longitudinal elasticity to allow them to function as either the bug stop 35 (FIGS. 1-2) or the elastic band 21c (FIGS. 1-2). In other embodiments, the bug stops 35a-f can be used at other locations on the thermal coverings 20, 20A and 30 (FIGS. 1-2) to provide elastic retraction and bug stopping ability.

**[0073]** FIG. 4 is a schematic illustration of another example pest eradication system 70, according to one or more additional embodiments of the present disclosure. As illustrated, the pest eradication system 70 (hereafter "the system 70") includes an air distribution pad 71 and a heating unit 80. While not shown, the system 70 can also include the programmable module 18 (FIGS. 1-2) for turning on and off the heating unit 80 in a preprogrammed or other controlled manner.

**[0074]** The air distribution pad 71 may include a main manifold 72 with a hose port 74, a multiplicity of air conduits 74a, and a sheet manifold 75. The sheet manifold 75 can include two polymer sheets bonded together to define air passageways with a multiplicity of air outlet holes 75a. The main manifold 72 is adapted to receive pressurized hot air from the heating unit 80 through hose port 74 and distribute the pressurized hot air to the air conduits 74a, which can then distribute or communicate the hot air across the surface of the air distribution pad 71. In some embodiments, the sheet manifold 75 and the air outlet holes 75a can distribute the hot air instead of the multiplicity of air conduits 74a. In other embodiments, spaces between fibers in a fabric structure forming the sheet manifold 75 may define the air outlet holes 75a. Alternatively, the sheet manifold 75 and the air outlet holes 75a can be omitted and the air conduits 74a can comprise tubing with holes periodically spaced along their length to distribute the pressurized hot air from the heating unit 80. In other embodiments, the air outlet holes 75a can comprise multiple holes cut into two layers of non-porous material forming the sheet manifold 75. In some embodiments, the air conduits 74a can comprise tubing with holes periodically spaced along their length to distribute the hot air to the interior of the sheet manifold 75. In other embodiments, the sheet manifold 75, with its air outlet holes 75a, can be omitted and instead holes may be formed in the air conduits 74a to distribute the hot air across a bottom surface 14c of the mattress 14.

**[0075]** The air distribution pad 71 may be sized and otherwise configured to cover all or a portion of the horizontal surface between the box spring 12 and the mattress 14. As illustrated, the air distribution pad 71 is sized and otherwise configured to cover substantially a top surface 12a of the box spring 12 and a bottom surface 14c of the mattress 14. In some embodiments, the air distribution pad 71 might be sized to cover only a portion of the bottom surface 14c of the mattress 14 and can be placed near a center position of the mattress 14 during use. The smaller-sized air distribution pad 71 may have sufficient surface area to contact the bottom surface 14c of the mattress 14 to provide sufficient heated air to the mattress 14 to raise the temperature of the mattress 14 to (or above) the thermal death point.

**[0076]** The air conduits 74a and the air outlet holes 75a can be designed in communication with each other to expel a flow of the hot air against the bottom surface 14c of the mattress 14 with sufficient air pressure to cause the flow of hot

air to pass through the bottom surface 14c and into a central region within the mattress 14. From the central region of the mattress 14 the flow of hot air can spread out and flow out through the lateral sides of the mattress 14 so that all portions of the mattress 14 can be heated to the thermal death point. The flow of hot air generated by the heating unit 80 can be adjusted to a sufficiently high output temperature and pressure that the mattress 14 may be quickly heated to the thermal death point.

**[0077]** The air conduits 74a can be attached to the sheet manifold 75 or otherwise form an integral part thereof. The sheet manifold 75 may support the air conduits 74a and define the air outlet holes 75a, which may be in fluid communication with the air conduits 74a such that hot air entering the main manifold 72 can be distributed into the air conduits 74a through sheet manifold 75 and ultimately out through the air outlet holes 75a. In some embodiments, the sheet manifold 75 may incorporate an elastic material that helps the air distribution pad 71 maintain its position when placed under the mattress 14. In other embodiments, the sheet manifold 75 may incorporate multiple polymer layers of material that can be bonded together along parallel lines to form a multiplicity of air channels within the sheet manifold 75 for directing heated air to the air outlet holes 75a. In such embodiments, the air conduits 74a may or may not be needed. In other embodiments, the sheet manifold 75 can comprise a fabric sheet and/or skirt to assist in maintaining the position of the sheet manifold 75 with respect to the mattress 14 and/or box spring 12.

**[0078]** The main manifold 72 can comprise a coated fabric tube, a flexible tube, a polymer tube, or other sealed conduit design. A coated fabric tube may be able to lay flat when not in use and inflate as hot air is forced therethrough. In some embodiments, the main manifold 72 can be thermally insulated to conserve heat in the heated air flowing through it. The hose port 74 can be adapted to removably connect to a hose end 85 on a flexible hose 84 coupled to the heating unit 80. The flexible hose 84 can be insulated to help reduce temperature loss as heated air moves through the flexible hose 84.

**[0079]** The heating unit 80 may include a hot-air source 82, an electrical power cord 88, and the flexible hose 84. The electrical power cord 88 may provide electrical power to the hot-air source 82. In some embodiments, the hot-air source 82 may comprise one or more electrical heating elements and a fan that blows air past the heating elements. The hot-air source 82 may output high-

temperature air (hot air) to the flexible hose 84 at a sufficiently high air pressure to force the hot air through the air distribution pad 71 and into the fabric on the bottom surface 14c of the mattress 14. More specifically, from the main manifold 72, the hot air can separate and flow into the air conduits 74a and distribute the hot air through the air outlet holes 75a directed at the bottom surface 14c. The hot air can then flow through the mattress 14 fabric and, once within the interior of the mattress 14, air pressure may force the hot air outward (laterally and radially) through the top and sides of the mattress 14. Accordingly, the hot-air source 82 can provide a sufficiently high air pressure to force the hot air through the interior and fabric construction of the mattress 14. In this way, the mattress 14 may be heated to a predetermined lethal temperature that can be adjusted depending on the insect pest being eradicated. In some embodiments, the hot-air source 82 may be capable of generating heated air at or above 140°F. In order to reduce heat loss, one or more standard blankets and/or comforters can be placed over the mattress 14 to help retain the heat within the mattress 14 and the box spring 12.

**[0080]** Apart from the operational characteristics of killing insect pests and dangerous microorganisms, the system 70 may also be used to provide comfortable heating and cooling to the mattress 14 for comfortable sleeping. In some embodiments, for example, the heating unit 80 may also include or otherwise operate as a cooling unit for providing air-conditioned and/or otherwise cooled air through the flexible hose 84 to deliver the cooled air to the user. The heating unit 80 may include multiple settings for selectively heating and cooling to the preference and comfort of the user. That is, the heating unit 80 may provide heating or cooling at air temperatures that are appropriate for delivery to a mattress for sleeping or resting of a person or user.

**[0081]** In some embodiments, the hot-air source 82 can also force (pump) ambient temperature air through the flexible hose 84 to the air distribution pad 71 to quickly cool the mattress 14 (also mattress 94 in FIG. 6) for a guest after a heat treatment. In such embodiments, a pest eradication procedure may include the steps of: 1) producing hot air of a predetermined temperature with the hot-air source 82, 2) providing the hot air to the mattress 14 for a predetermined length of time via the flexible hose 84, and 3) blowing ambient air through the flexible hose 84 with the hot-air source 82 for a predetermined length of time to cool the mattress 14 for use. Accordingly, the hot-air source 82 can

operate as a heating and cooling system that alternately forces hot or cooled air to the air distribution pad 71 and ultimately into the mattress 14 as needed. Such embodiments may provide both warming and cooling to the mattress 14 for a guest's comfort while sleeping, as well as, provide a lethal temperature mode that heats the mattress 14 to lethal temperatures for insect pests. Various prior art control systems exist, such as thermostat systems, to control the air temperature produced by the hot-air source 82.

**[0082]** FIG. 5 is a schematic illustration of another example pest eradication system 70A, according to one or more additional embodiments of the present disclosure. As illustrated, the pest eradication system 70A (hereafter "the system 70A") may comprise the air distribution pad 71, the heating unit 80, an upper skirt 77, and a lower skirt 78. The air distribution pad 71 includes the main manifold 72 with the hose port 74, and the sheet manifold 75 includes the air conduits 74a and the air outlet holes 75a. As with the prior embodiment, the air conduits 74a may distribute or communicate the hot air from the main manifold 72 to the air outlet holes 75a or simply direct the hot air to the bottom surface 14c of the mattress 14 and/or to the top surface 12a of the box spring 12.

**[0083]** The upper skirt 77 and the lower skirt 78 may be attached to or otherwise extend from the air distribution pad 71. More specifically, the upper skirt 77 extends upward from the air distribution pad 71 to receive (or cover) a least a portion of the sides 14b of the mattress 14, and the lower skirt 78 extends downward to cover at least a portion of the sides of the box spring 12. In other embodiments, the lower skirt 78 may extend to the floor and otherwise enclose the air space under a bedframe.

**[0084]** As illustrated, the air distribution pad 71 is sized and otherwise configured to extend across substantially the top surface 12a (FIG. 4) of the box spring 12 and the bottom surface 14c of the mattress 14. In some embodiments, the air distribution pad 71 can comprise a smaller-sized air distribution pad that covers only a portion of the bottom surface 14c. In such embodiments, an additional fabric sheet can be used to attach the smaller-sized air distribution pad to the upper and lower skirts 77, 78 to allow the smaller-sized air distribution pad or pads to be held in place with respect to the mattress 14 during use.

**[0085]** The upper skirt 77 and/or the lower skirt 78 may be designed to provide thermal insulation at the side surfaces 14b of the mattress 14 and side surfaces of the box spring 12, respectively, to make the system 70A more energy

efficient. In some embodiments, the upper skirt 77 may be constructed of a non-porous, insulating material that directs the hot air exiting the air outlet holes 75a mostly through the bottom surface 14c of the mattress 14. In other embodiments, the upper skirt 77 may be constructed of a porous, insulating material that allows some of the hot air exiting the air outlet holes 75a to escape through the side surfaces 14b of the mattress 14.

**[0086]** In alternate embodiments, the air distribution pad 71 may comprise additional air outlet holes on its underside to direct some of the hot air from the main manifold 72 into the box spring 12. In such embodiments, the lower skirt 78 may be constructed of a non-porous material to help contain the hot air entering the box spring 12. Moreover, in such embodiments, the lower skirt 78 may extend to the floor to trap the heat from these downward facing air outlet holes. In other embodiments, the lower skirt 78 may be constructed of a porous material to allow some of the hot air to escape through the side surfaces of the box spring 12 and from under the bed if a bedframe is used.

**[0087]** In some embodiments, a non-porous sheet 79 may be placed at the bottom of the box spring 12 to prevent the hot air from the air distribution pad 71 from escaping the bottom of the box spring 12. In some embodiments, the non-porous sheet 79 can comprise a plastic sheet stapled or otherwise bonded or attached to the underside of the box spring 12.

**[0088]** In some embodiments, one or both of the upper and lower skirts 77, 78 may comprise a fabric skirt similar to those found on a standard fitted sheet and include an elastic band at the open end (i.e., similar to the elastic band 21c of FIGS. 1-2). In some embodiments, the lower skirt 78 may be attached to the air distribution pad 71 without the upper skirt 77. Alternatively, the upper skirt 77 may be used without the lower skirt 78. However, if the upper and lower skirts 77, 78 are non-porous, then the majority of hot air from the hot air source 82 can flow out the top surface 14a of the mattress 14.

**[0089]** FIG. 6 is a schematic illustration of another example pest eradication system 90, according to one or more additional embodiments of the present disclosure. As illustrated, the pest eradication system 90 (hereafter "the system 90") may include the heating unit 80 and a mattress 94, and the mattress 94 may provide a top surface 94a, four contiguous side surfaces 94b, and a bottom surface (not labeled). In at least one embodiment, the mattress 94 may have an interior that allows air to flow freely even though it may contain springs and other

support structure common to mattress construction. In other embodiments, the mattress 94 can be hollow and comprise an outer structure that can inflate when provided with pressurized air from the heating unit 80.

**[0090]** A hose port 92 may be coupled to the mattress 94 to place the heating unit 80 in communication with the interior of the mattress 94. More specifically, the hose end 85 of the flexible hose 84 may be removably coupled to the hose port 92, which fluidly communicates with the interior of the mattress 94. Consequently, pressurized hot air from the heating unit 80 can be distributed throughout the interior of the mattress 94 via the hose port 92. Pumping hot air into the interior of the mattress 94 may increase the interior pressure of the mattress 94 and cause the hot air to escape (leak out) through the top surface 94a and the side surfaces 94b. In some embodiments, the hot air can also escape (leak) downward through the bottom of the mattress 94 and into the box spring 12. The mattress 92 can be covered with sheets, blankets, quilts, comforters and/or other fabric cover(s) to help maintain the heat from the hot air within the mattress 94 and causing the mattress 94 to reach the required thermal death point.

**[0091]** In some embodiments, the hot air source 82 may also be configured as a cooling system, and the user can select through buttons, knobs, touch panels or other interface to generate either warm or cool air temperatures that provide comfortable sleep conditions for the user. In some embodiments, the hot air source may blow ambient air for a period of time after the heating elements have been turned off to provide more rapid cooling of the mattress 14 and the box spring 12.

**[0092]** The hose port 92 is shown positioned on the lengthwise side of the mattress 94. In other embodiments, however, the hose port 92 may be mounted on the headboard end of the mattress 94 and near its bottom surface so that the flexible hose 84 can gain access to the hose port 92 with the least possible obstruction to the user and placement of fitted sheets, blankets and comforters around the mattress 94.

**[0093]** During the use of the disclosed bedbug eradicating systems 70, 70A and 90, the heating unit 80 can service multiple air distribution pads 71 and multiple mattresses 94 by simply moving the heating unit 80 around from room to room (i.e., from article of furniture to article of furniture). This can save considerable money. For example, a hotel can buy many of the inexpensive air

distribution pads 71 for their beds and service them with one or just a few heating units 80 to keep their beds free of bedbugs and other pests.

**[0094]** Computer hardware used to implement the various illustrative blocks, modules, elements, components, methods, and algorithms described herein can include a processor configured to execute one or more sequences of instructions, programming stances, or code stored on a non-transitory, computer-readable medium. The processor can be, for example, a general purpose microprocessor, a microcontroller, a digital signal processor, an application specific integrated circuit, a field programmable gate array, a programmable logic device, a controller, a state machine, a gated logic, discrete hardware components, an artificial neural network, or any like suitable entity that can perform calculations or other manipulations of data. In some embodiments, computer hardware can further include elements such as, for example, a memory (e.g., random access memory (RAM), flash memory, read only memory (ROM), programmable read only memory (PROM), erasable read only memory (EPROM)), registers, hard disks, removable disks, CD-ROMS, DVDs, or any other like suitable storage device or medium.

**[0095]** Executable sequences described herein can be implemented with one or more sequences of code contained in a memory. In some embodiments, such code can be read into the memory from another machine-readable medium. Execution of the sequences of instructions contained in the memory can cause a processor to perform the process steps described herein. One or more processors in a multi-processing arrangement can also be employed to execute instruction sequences in the memory. In addition, hard-wired circuitry can be used in place of or in combination with software instructions to implement various embodiments described herein. Thus, the present embodiments are not limited to any specific combination of hardware and/or software.

**[0096]** As used herein, a machine-readable medium will refer to any medium that directly or indirectly provides instructions to a processor for execution. A machine-readable medium can take on many forms including, for example, non-volatile media, volatile media, and transmission media. Non-volatile media can include, for example, optical and magnetic disks. Volatile media can include, for example, dynamic memory. Transmission media can include, for example, coaxial cables, wire, fiber optics, and wires that form a bus. Common forms of machine-readable media can include, for example, thumb drives, floppy

disks, flexible disks, hard disks, magnetic tapes, other like magnetic media, CD-ROMs, DVDs, other like optical media, punch cards, paper tapes and like physical media with patterned holes, RAM, ROM, PROM, EPROM, and flash EPROM.

**[0097]** Therefore, the disclosed systems and methods are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the teachings of the present disclosure may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope of the present disclosure. The systems and methods illustratively disclosed herein may suitably be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some amount. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the elements that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

**[0098]** As used herein, the phrase "at least one of" preceding a series of items, with the terms "and" or "or" to separate any of the items, modifies the list as a whole, rather than each member of the list (i.e., each item). The phrase "at

least one of" allows a meaning that includes at least one of any one of the items, and/or at least one of any combination of the items, and/or at least one of each of the items. By way of example, the phrases "at least one of A, B, and C" or "at least one of A, B, or C" each refer to only A, only B, or only C; any combination of A, B, and C; and/or at least one of each of A, B, and C.

## CLAIMS

What is claimed is:

1. A pest eradication system, comprising:

a thermal covering receivable over an article of furniture and having a top and one or more contiguous sides that extend from the top, wherein the one or more contiguous sides extend and cover all sides and at least a portion of a bottom of the article of furniture;

one or more heating elements coupled to the thermal covering to apply heat to the article of furniture, wherein at least a portion of the one or more heating elements extends to the bottom of the article of furniture; and

a programmable module in communication with the thermal covering to regulate operation of the one or more heating elements, wherein the programmable module is programmed to selectively operate the one or more heating elements to reach a thermal death point for at least one of an insect pest or a microorganism present on or in the article of furniture.

2. The system of claim 1, wherein the at least one of the insect pest and the microorganism is selected from the group consisting of bedbugs, ticks, dust mites, scabies, cockroaches, lice, fleas, any larva or eggs of the foregoing, mold and other fungi, bacteria, viruses, protozoans, other microbes, and any combination thereof.

3. The system of claim 1, wherein the article of furniture has one or more support legs and the system further comprises a pest trap placed under at least one of the one or more support legs to prevent the insect pest from escaping the article of furniture onto an underlying floor or prevent additional insect pests from accessing the article of furniture via the one or more support legs.

4. The system of claim 1, wherein the one or more contiguous sides define side flaps that are separated from each other.

5. The system of claim 4, further comprising one or more securing devices extending between adjacent side flaps to hold the adjacent side flaps closed at corners of the thermal covering.

6. The system of claim 4, wherein the one or more heating elements include side heating elements arranged on the side flaps, and wherein the side flaps are folded under the article of furniture and the side heating elements provide heat to the bottom of the article of furniture.

7. The system of claim 1, further comprising an elastic band secured to a bottom edge of the one or more contiguous sides, wherein the elastic band helps pull the one or more contiguous sides inward to cover the portion of the bottom of the article of furniture.

8. The system of claim 7, wherein the elastic band is adapted to operate as a bug stop exhibiting a cross-section that prevents the insect pest from migrating laterally past the elastic band in either direction.

9. The system of claim 1, wherein the one or more heating elements comprise one or more top heating elements arranged on the top and one or more side heating elements arranged on the one or more contiguous sides.

10. The system of claim 1, wherein the article of furniture includes a mattress and a box spring, the thermal covering is a first thermal covering receivable over the mattress, and the one or more heating elements are one or more first heating elements, the system further comprising:

a second thermal covering receivable over the box spring and having a top and one or more contiguous sides that extend from the top, wherein the one or more contiguous sides of the second thermal covering cover all vertical sides of the box spring; and

one or more second heating elements coupled to the second thermal covering to apply heat to at least the sides of the box spring.

11. The system of claim 10, further comprising a bug stop interposing the bottom of the mattress and a top of the box spring, wherein the bug stop exhibits a cross-section that prevents the insect pest from migrating laterally past the bug stop in either direction.

12. The system of claim 1, wherein the programmable module is communicable with a hotel computer system and programmed to communicate with an internal hotel booking or room management software.

13. The system of claim 12, wherein the programmable module is programmed to initiate operation of the thermal covering when a given hotel room receives a status change.

14. A method of operating a pest eradication system, comprising:

placing a thermal covering over an article of furniture, the thermal covering having a top and one or more contiguous sides that extend from the top;

covering all sides and at least a portion of a bottom of the article of furniture with the one or more contiguous sides;

applying heat to the article of furniture and the portion of the bottom with one or more heating elements coupled to the thermal covering; and

selectively operating the one or more heating elements to reach a thermal death point for at least one of an insect pest or a microorganism present on or in the article of furniture.

15. The method of claim 14, further comprising using the article of furniture while the thermal covering is placed on the article of furniture.

16. The method of claim 14, further comprising pulling the one or more contiguous sides inward to cover the portion of the bottom of the article of furniture with an elastic band secured to a bottom edge of the one or more contiguous sides.

17. The method of claim 16, wherein the article of furniture is a mattress and the method further comprises preventing the insect pest from migrating laterally past the elastic band in either direction with a cross-sectional shape of the elastic band.

18. The method of claim 14, wherein the article of furniture includes a mattress and a box spring, the thermal covering is a first thermal covering receivable over the mattress, and the one or more heating elements are one or more first heating elements, the method further comprising:

placing a second thermal covering over the box spring, the second thermal covering having a top and one or more contiguous sides that extend from the top;

covering all sides of the box spring with the one or more contiguous sides of the second thermal covering;

applying heat to a top and the sides of the box spring with one or more heating elements coupled to the second thermal covering; and

selectively operating the one or more heating elements of the second thermal covering to reach the thermal death point for at least one of the insect pest or the microorganism present on or in the box spring.

19. The method of claim 18, further comprising preventing the insect pest from migrating in either direction laterally past a bug stop interposing the bottom of the mattress and a top of the box spring.

20. The method of claim 14, further comprising:

selectively operating the one or more heating elements with a programmable module in communication with a hotel computer system, the programmable module being programmed to communicate with an internal hotel booking or room management software; and

initiating operation of the thermal covering with the programmable module when a given hotel room receives a status change.

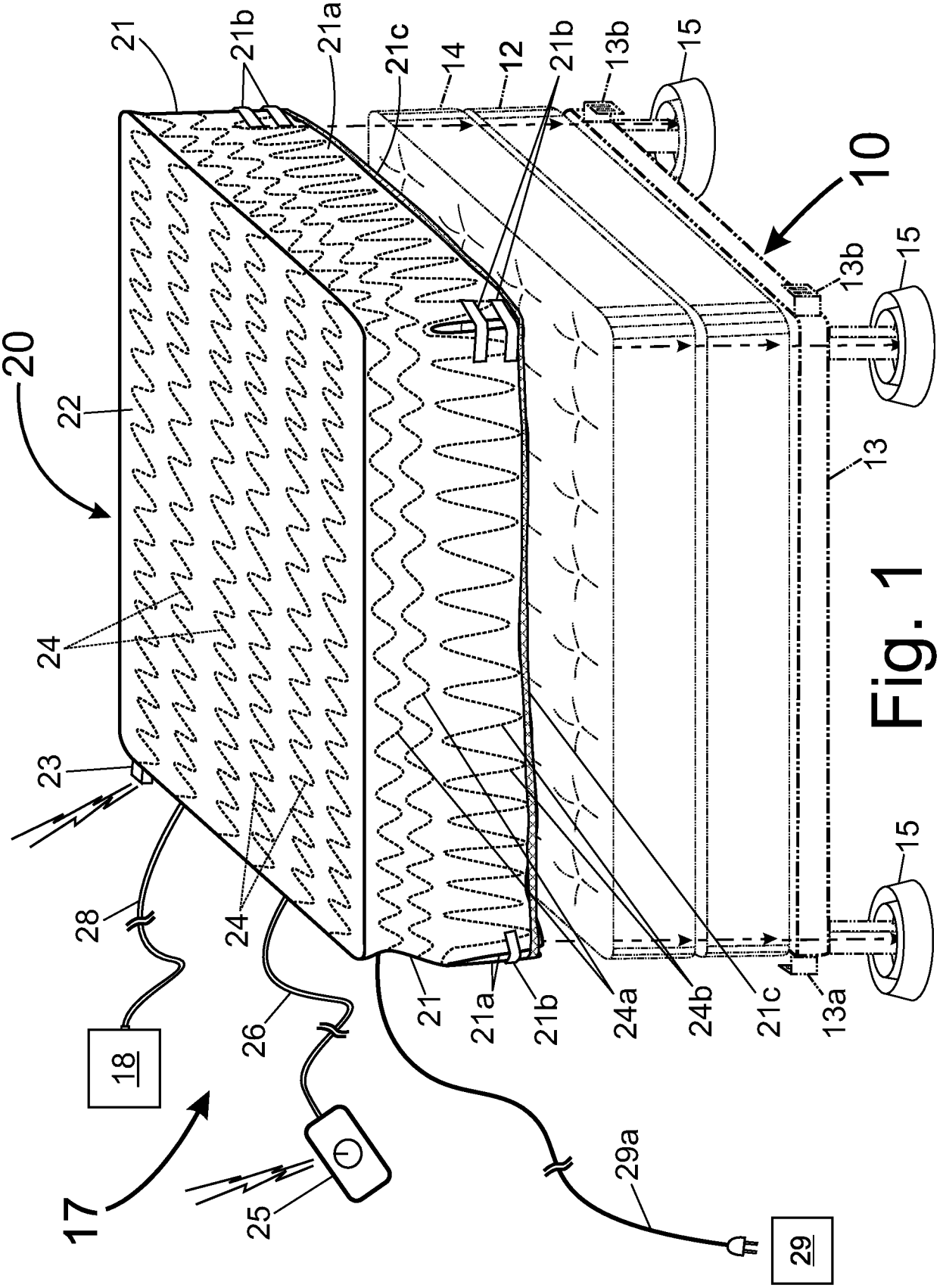

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Fig. 1

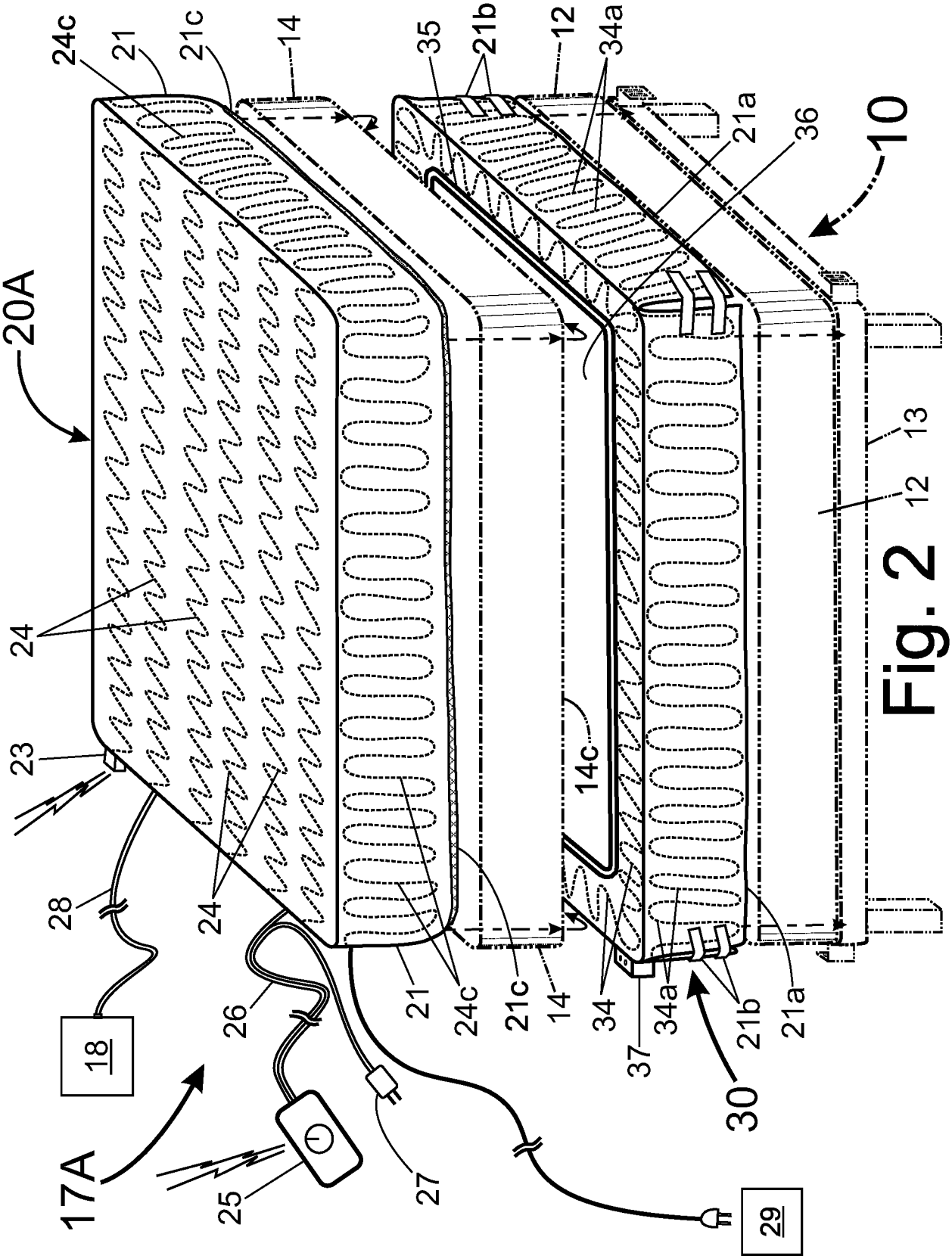

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Fig. 2

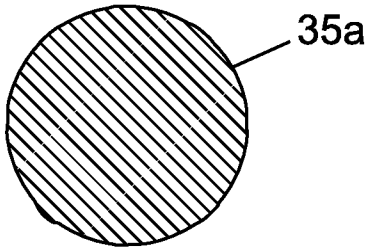



Fig. 3A

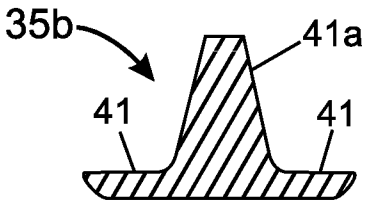



Fig. 3B

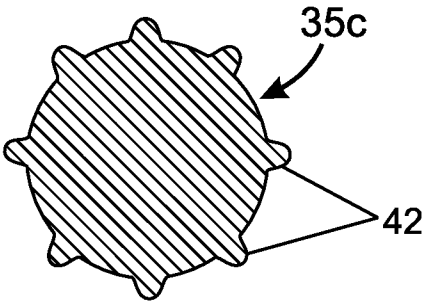



Fig. 3C

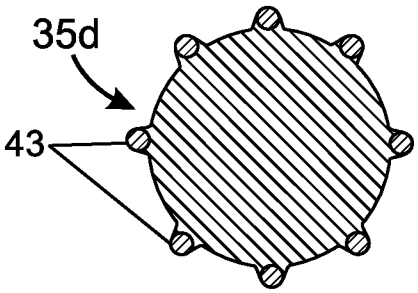



Fig. 3D

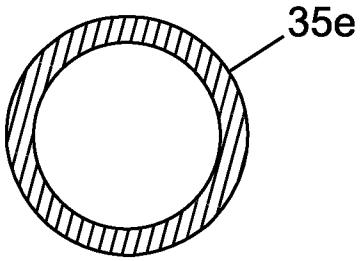



Fig. 3E

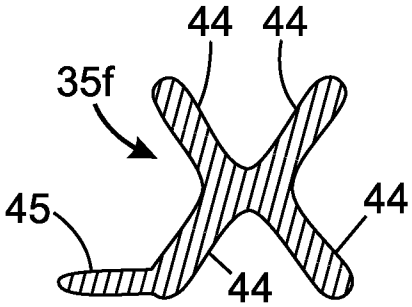



Fig. 3F

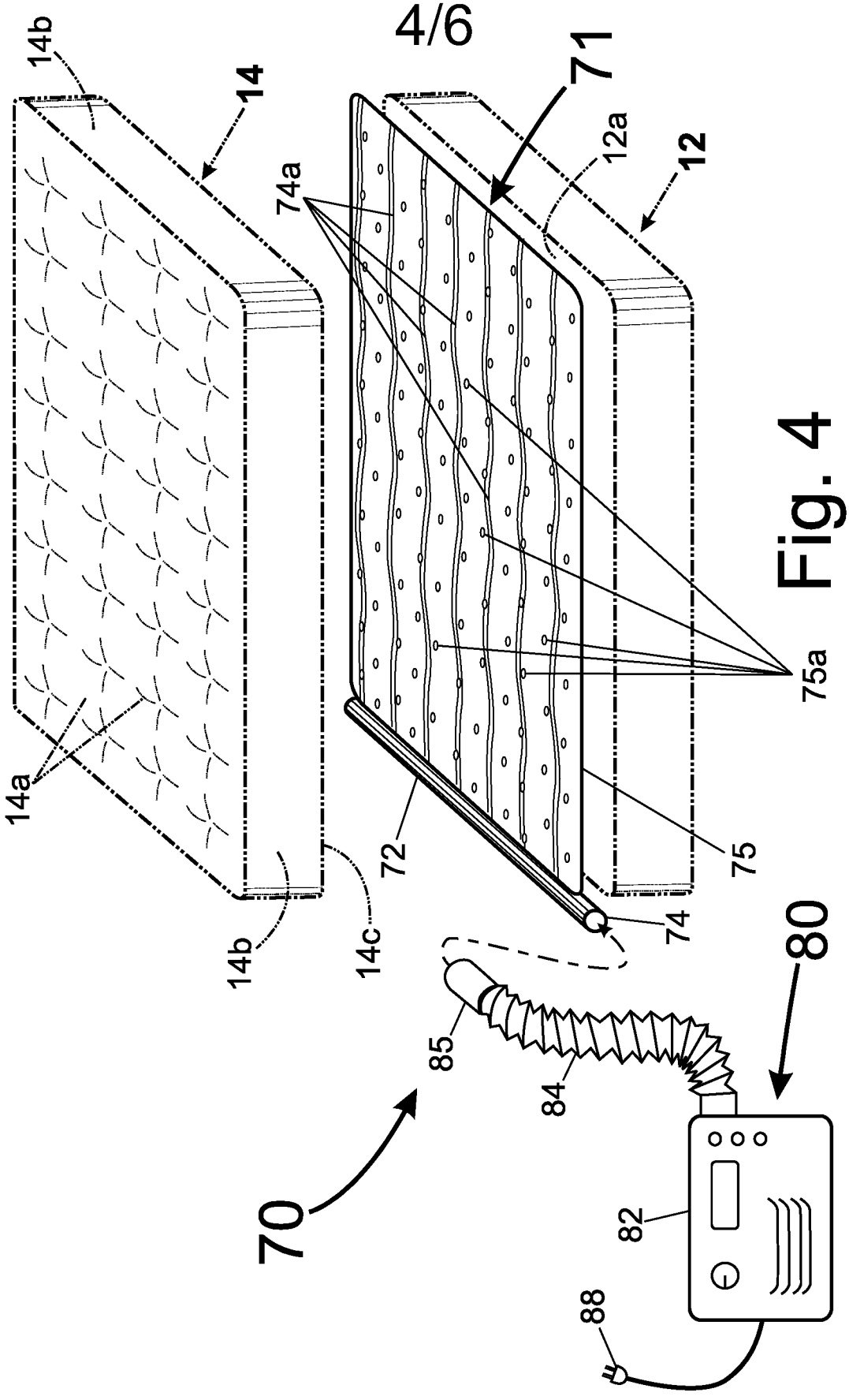



Fig. 4

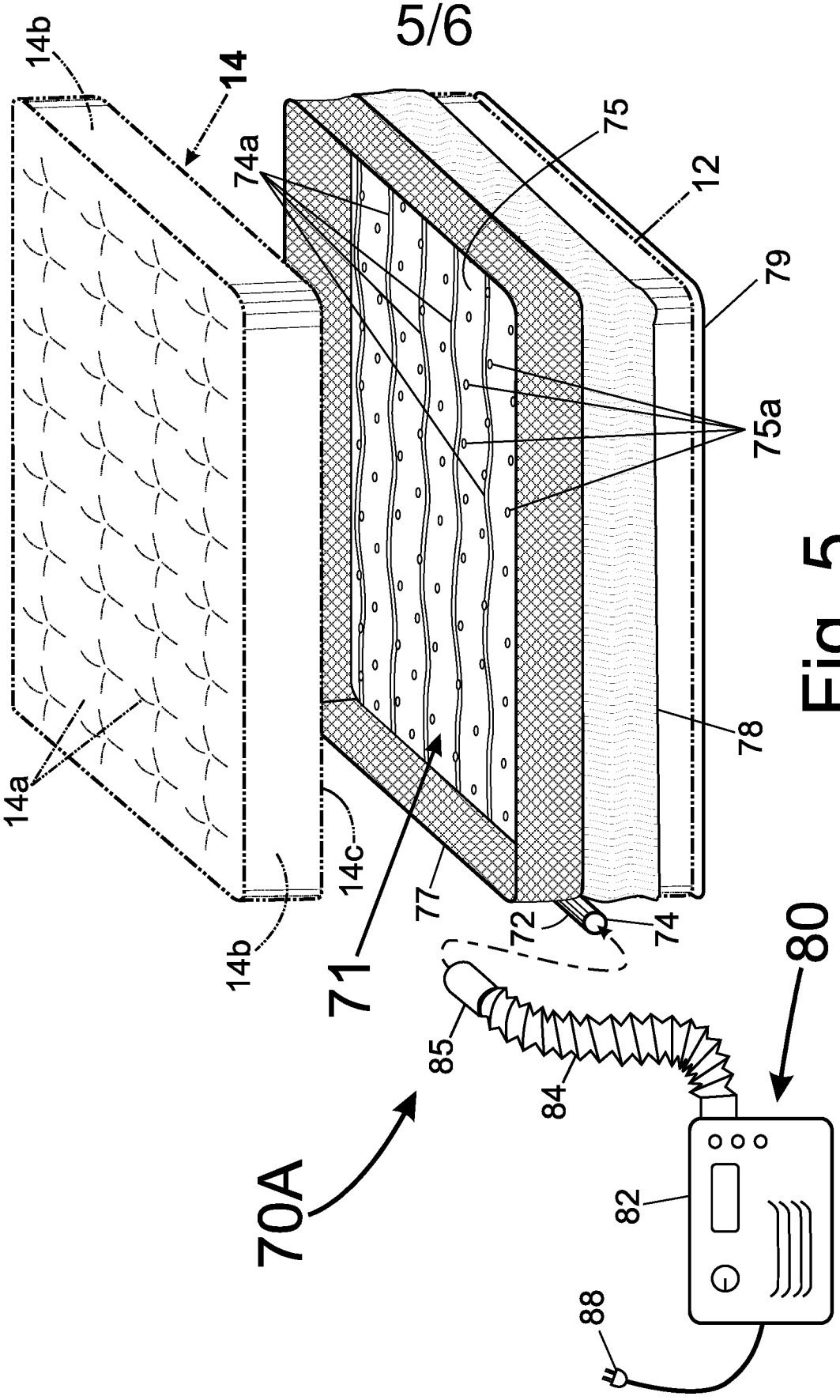



Fig. 5

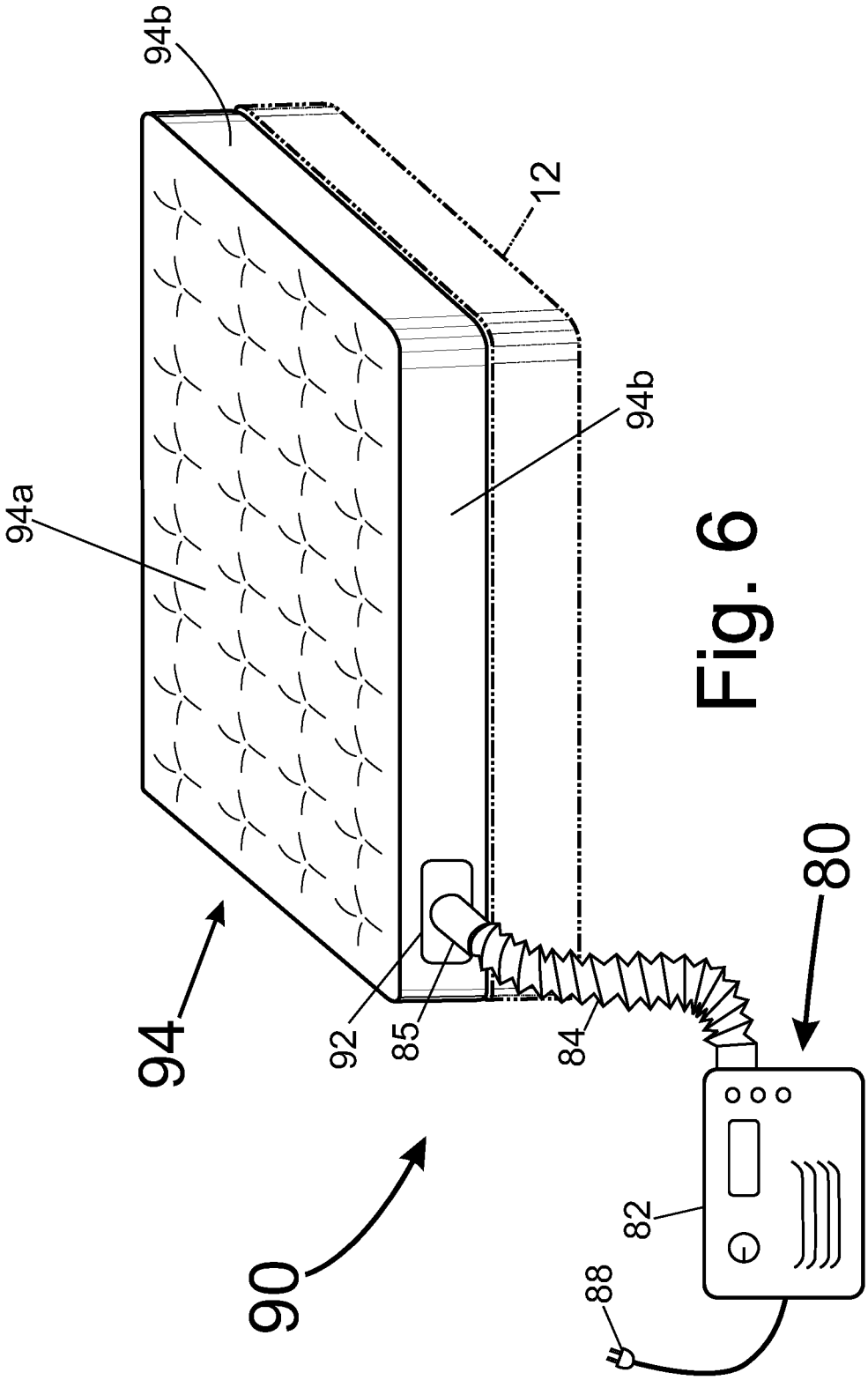



Fig. 6

**INTERNATIONAL SEARCH REPORT**

International application No.
**PCT/US2019/023967**

**A. CLASSIFICATION OF SUBJECT MATTER**

**A01M 1/20(2006.01)i, A61L 2/04(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
A01M 1/20; A47B 61/00; A47C 21/04; A47C 21/06; A47C 27/00; A47C 31/00; A47C 31/10; A61L 2/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: pest, heating, mattress, control, communication

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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☐ Further documents are listed in the continuation of Box C.

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* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 04 July 2019 (04.07.2019) | **09 July 2019 (09.07.2019)** |

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