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(54) **THERMAL BUFFER DEVICE AND INSTALLATION METHOD THEREFOR**

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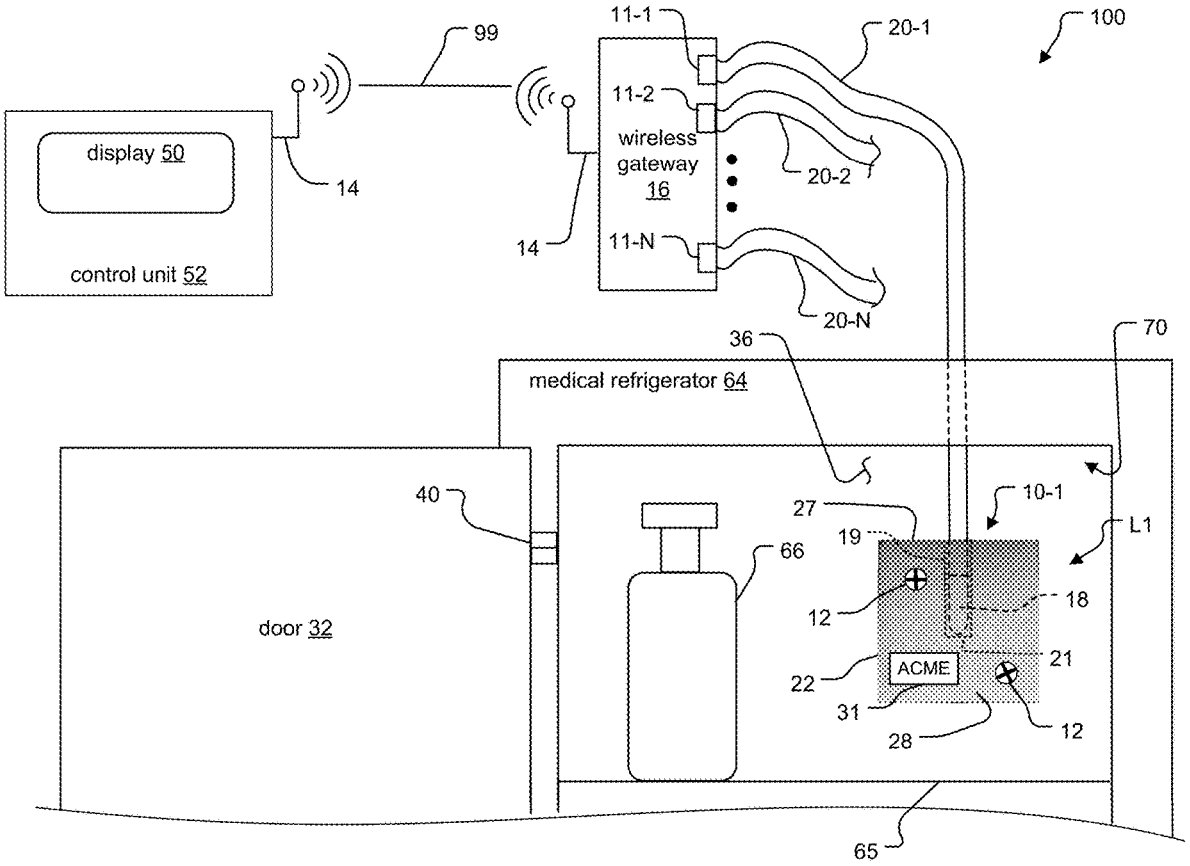
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(57) **ABSTRACT**

A thermal buffer device and installation method therefor are disclosed. The device includes a body and a fastening system. The body has a substantially planar rear surface, is generally cubic in shape, and is formed from a solid piece of thermally insulating material. The fastening system secures the rear surface of the body against an attachment surface within a temperature controlled enclosure, where the attachment surface is at a location in the enclosure selected for temperature monitoring. A temperature probe inserts into the body. The device is designed to resist air temperature changes in the temperature controlled enclosures in which the device is installed (i.e. to operate as a temperature buffer). In a preferred embodiment, the fastening system enables positive mechanical mounting of the device within the temperature controlled enclosures.



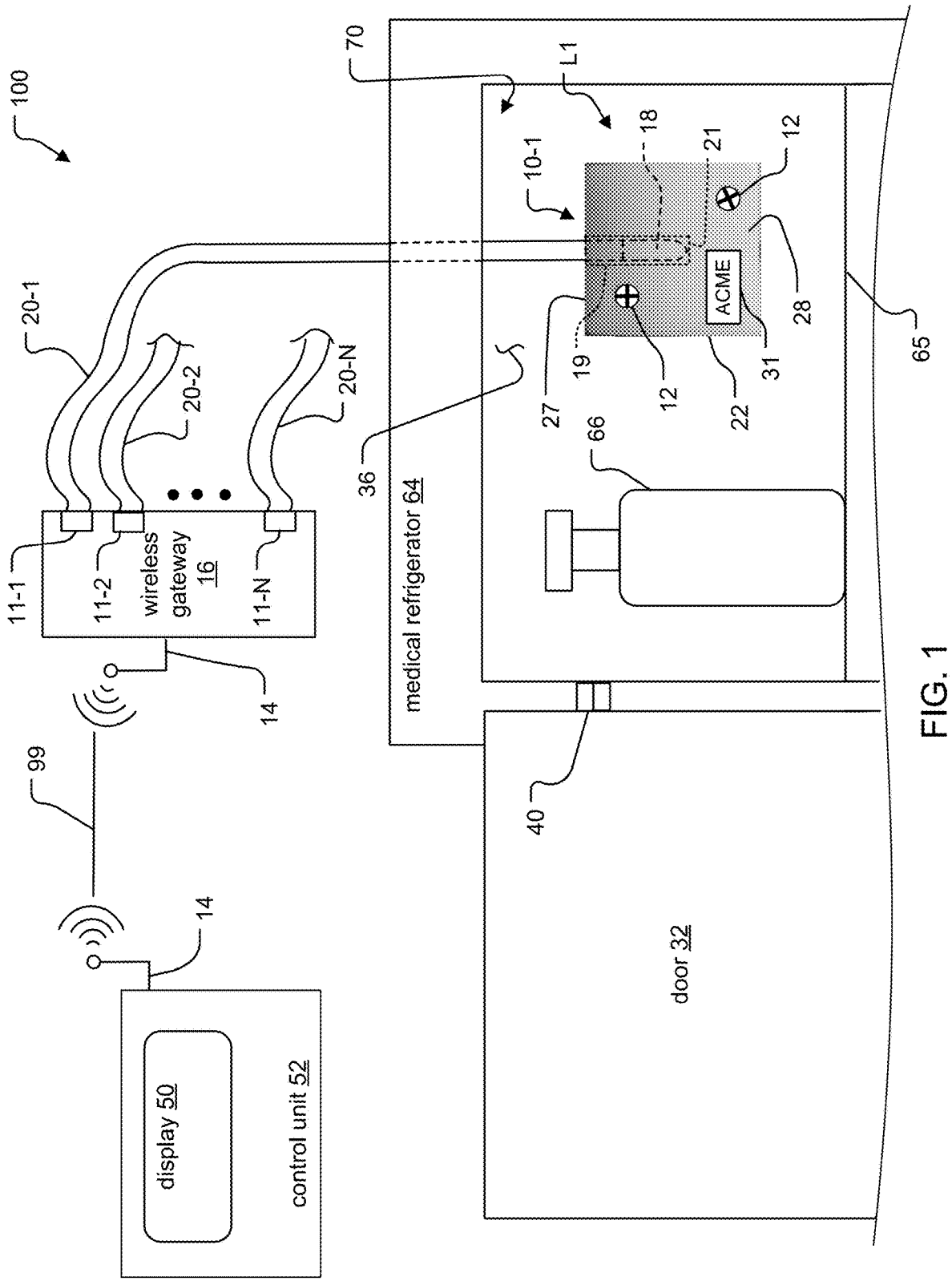

100
70
L1
10-1
18
21
12
20-1
20-2
20-N
11-1
11-2
wireless gateway 16
11-N
14
99
14
display 50
control unit 52
36
medical refrigerator 64
27
19
12
22
31
28
65
66
ACME
40
door 32

FIG. 1

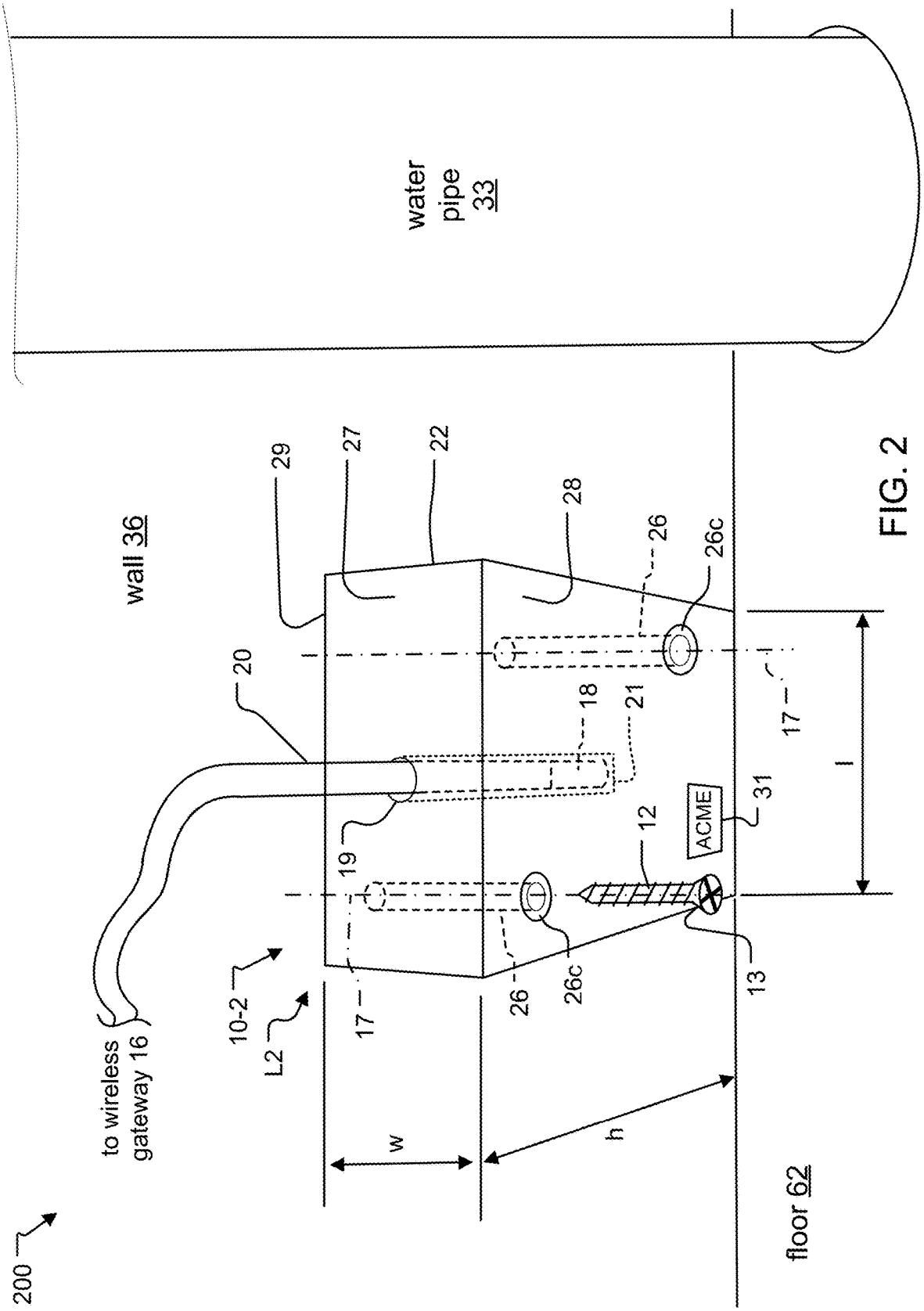

water pipe 33
wall 36
29
27
22
28
26
26c
20
18
21
17
l
31
ACME
12
19
13
26
26c
10-2
L2
17
to wireless gateway 16
w
h
floor 62
200

FIG. 2

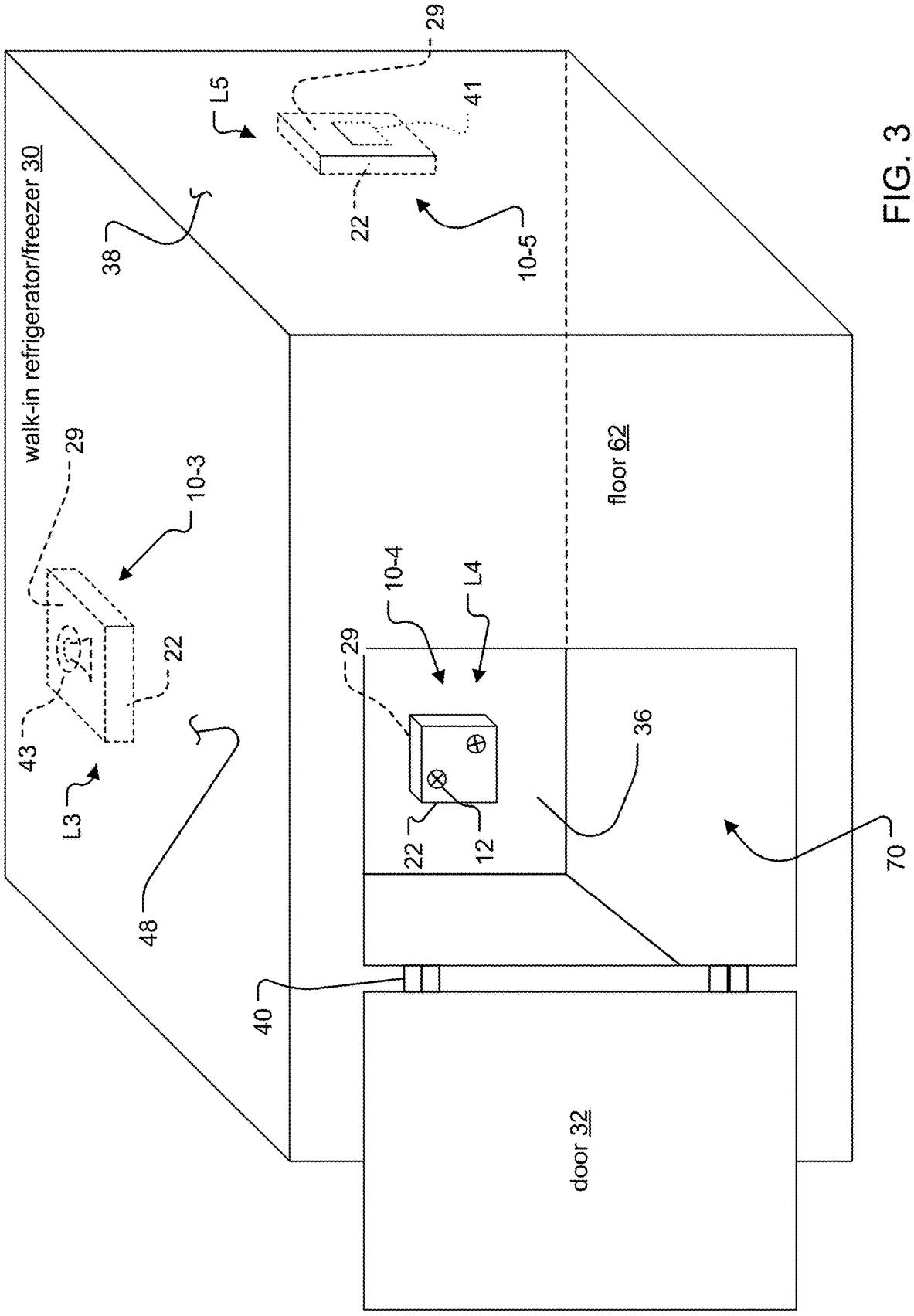

walk-in refrigerator/freezer 30
floor 62
door 32
29
L5
41
22
10-5
38
29
10-3
22
43
L3
48
10-4
L4
29
22
12
36
70
40

FIG. 3

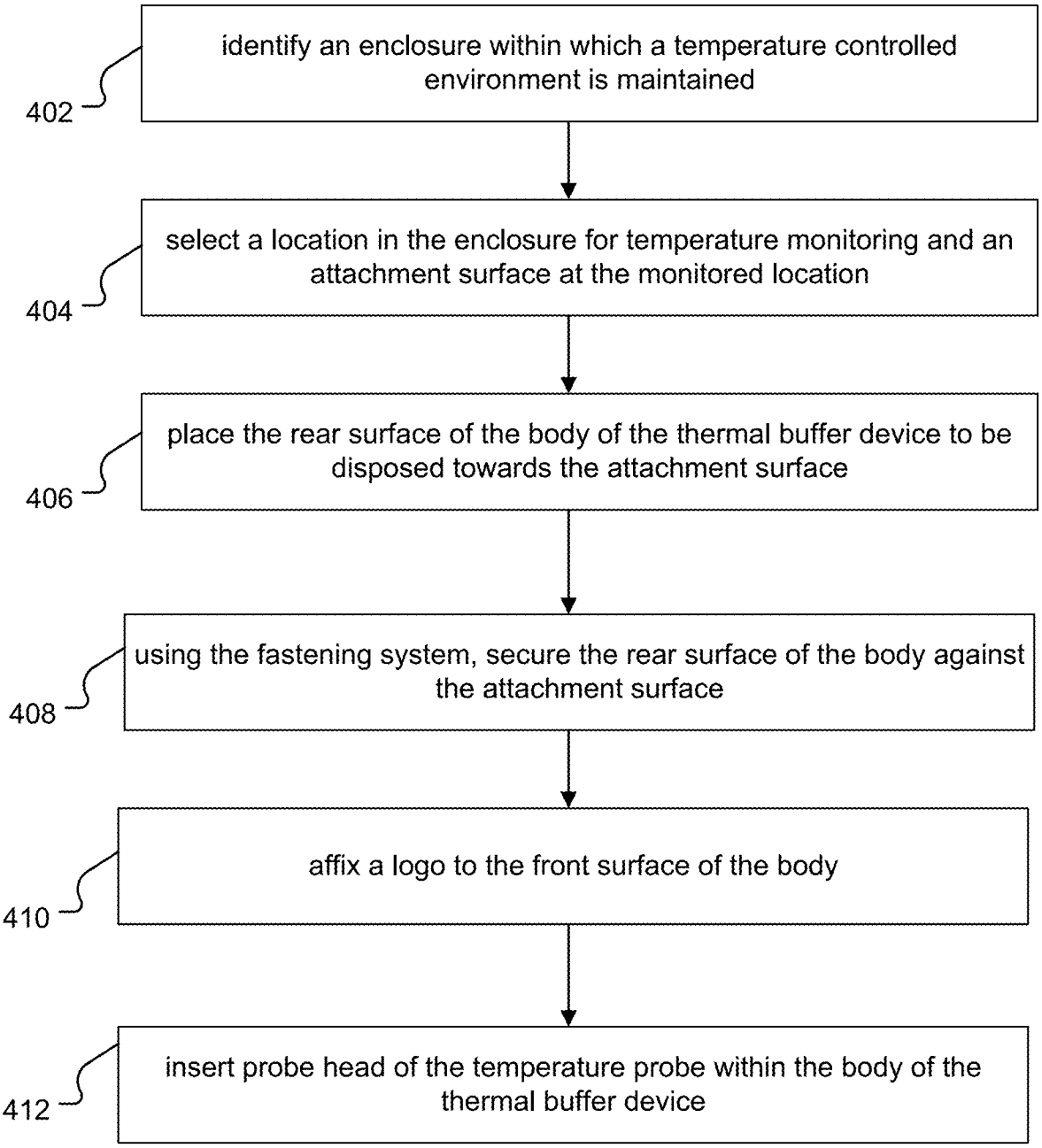
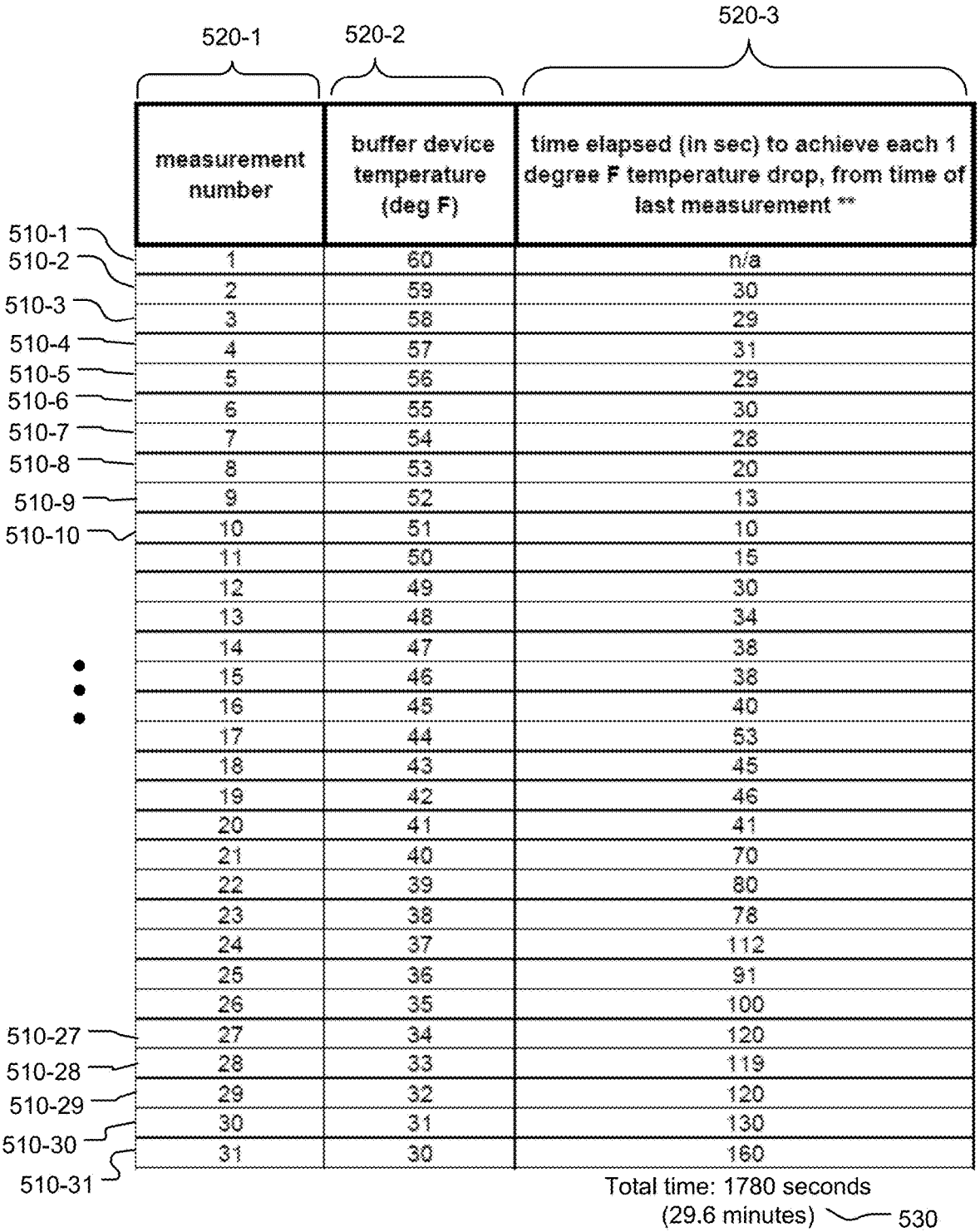

identify an enclosure within which a temperature controlled environment is maintained
402
select a location in the enclosure for temperature monitoring and an attachment surface at the monitored location
404
place the rear surface of the body of the thermal buffer device to be disposed towards the attachment surface
406
using the fastening system, secure the rear surface of the body against the attachment surface
408
affix a logo to the front surface of the body
410
insert probe head of the temperature probe within the body of the thermal buffer device
412

FIG. 4

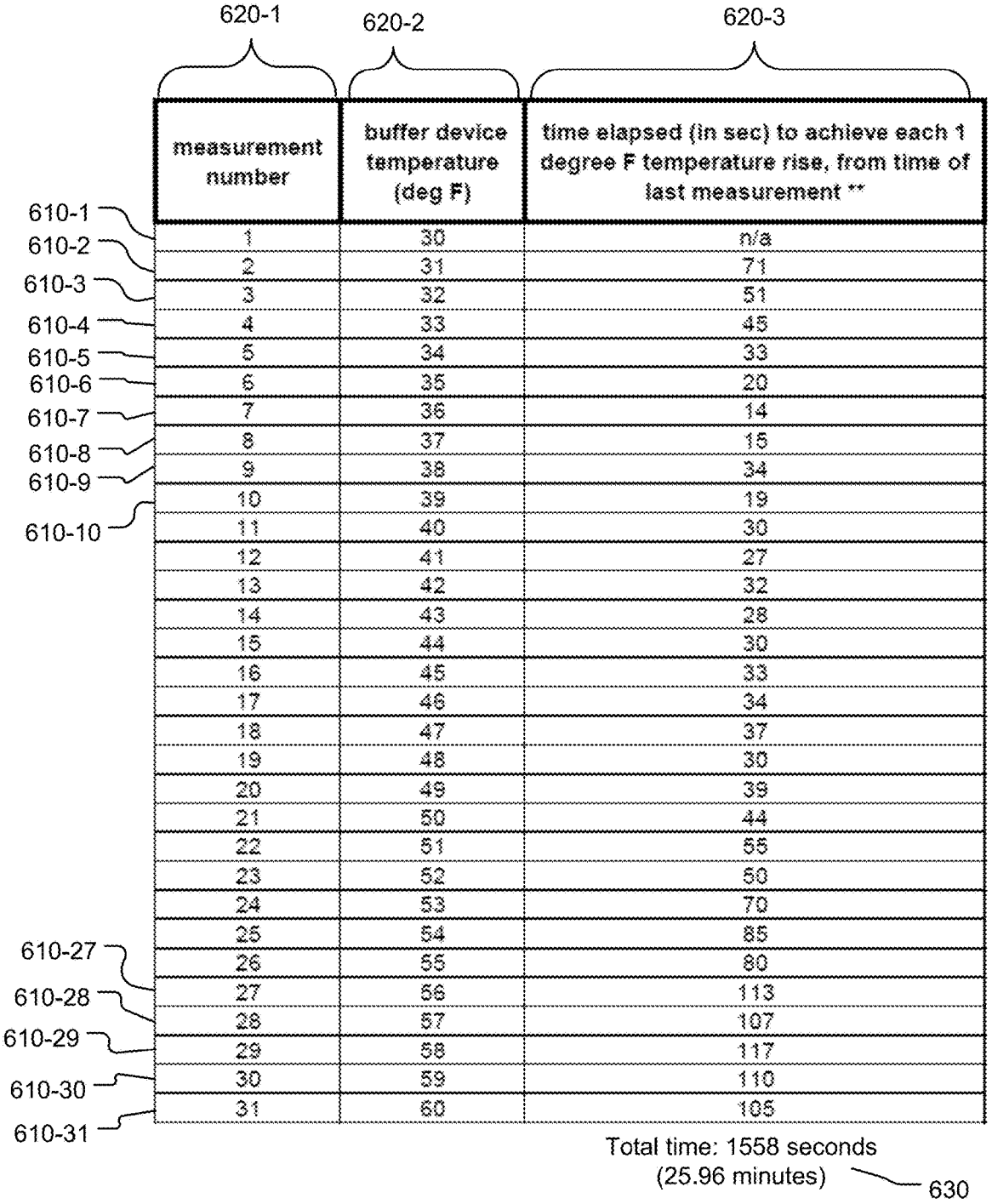


measurement number	buffer device temperature (deg F)	time elapsed (in sec) to achieve each 1 degree F temperature drop, from time of last measurement **
1	60	n/a
2	59	30
3	58	29
4	57	31
5	56	29
6	55	30
7	54	28
8	53	20
9	52	13
10	51	10
11	50	15
12	49	30
13	48	34
14	47	38
15	46	38
16	45	40
17	44	53
18	43	45
19	42	46
20	41	41
21	40	70
22	39	80
23	38	78
24	37	112
25	36	91
26	35	100
27	34	120
28	33	119
29	32	120
30	31	130
31	30	160

Total time: 1780 seconds (29.6 minutes)

** thermal buffer device originally stored in a room with an ambient temperature of 60 deg F (15.56 C) is installed in a refrigerator/freezer with temperature controlled environment of 15 deg F (-9.44 C)

FIG. 5



measurement number	buffer device temperature (deg F)	time elapsed (in sec) to achieve each 1 degree F temperature rise, from time of last measurement **
1	30	n/a
2	31	71
3	32	51
4	33	45
5	34	33
6	35	20
7	36	14
8	37	15
9	38	34
10	39	19
11	40	30
12	41	27
13	42	32
14	43	28
15	44	30
16	45	33
17	46	34
18	47	37
19	48	30
20	49	39
21	50	44
22	51	55
23	52	50
24	53	70
25	54	85
26	55	80
27	56	113
28	57	107
29	58	117
30	59	110
31	60	105

Total time: 1558 seconds
(25.96 minutes)

** thermal buffer device is installed for a time period in a refrigerator/freezer having a temperature controlled environment of 15 deg F (-9.44 C); the device is then removed to a room with a 60 deg F (15.56) ambient temperature

FIG. 6

THERMAL BUFFER DEVICE AND INSTALLATION METHOD THEREFOR

RELATED APPLICATIONS

[0001] This application claims the benefit under 35 USC 119(e) of U.S. Provisional Application No. 62/669,109 filed on May 9, 2018, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Temperature controlled enclosures are an integral part of modern living and business. For example, humans live and work in temperature controlled rooms as an example of a temperature controlled enclosure. The rooms are within a premises such as homes, government/public buildings and businesses. In another example, refrigerated enclosures are temperature controlled enclosures that enable extended use and storage of perishable food items and medicines. In yet another example, heated enclosures are temperature controlled enclosures that enable cooking and warming of food, and provide frost protection for chemicals that are likely to freeze at low temeratures, in examples.

[0003] Temperature monitoring systems are used to monitor the air temperature within the temperature controlled enclosures. These systems typically include one or more temperature probes that produce a temperature-dependent voltage, a wireless gateway to which the probes connect, and a control unit with a display. The control unit manages and communicates with the gateway over a wireless communications channel. The probes continuously sense the ambient air temperature in the enclosures and send the associated voltages to the wireless gateway. The gateway converts the voltages for each of the probes to an associated temperature, and reports the temperatures over the wireless comunications channel to the control unit. The control unit then displays the temperatures on its display.

[0004] In these temperature monitoring systems, multiple probes are often placed in different locations within the temperature controlled enclosures. In a refrigerated enclosure, for example, the air temperature is colder at the bottom than at the top. For this reason, probes are often installed near the center, the top, and the bottom of the enclosure to obtain a better overall temperature measurement of the enclosure. In addition, the temperature probes are often placed in different locations to monitor the temperature of specific objects (e.g. food items) at each location.

[0005] Refrigerated and heated enclosures that are used in the food service industry are also known as food service equipment. Examples of food service equipment include residential and industrial refrigerators/freezers, such as "walk in" refrigerators and freezers, reach-in coolers/freezers, beverage chillers such as milk coolers, holding units (hot or cold), and "drive-in" refrigerators and freezers.

[0006] Some temperature controlled enclosures are also subject to vibrations. Refrigerated enclosures, for example, require devices such as compressors and fans that often produce vibrations in the enclosures during operation.

[0007] Food service equipment requires monitoring of air temperature within the equipment. The air temperature monitoring is necessary to determine whether perishable food items stored in the equipment are within a temperature range that complies with local and national health codes, and to maintain quality of the food items while minimizing chance of spoilage. The monitoring is also necessary to determine whether failure of devices that maintain the temperature controlled environment within the equipment has occurred. Examples of these devices inlcude compressors, heating elements, and fans.

[0008] The food service equipment is often installed in hostile kitchen and food service environments. These environments are hostile due to the typically industrial nature and constant use of the equipment by food service workers.

[0009] The workers use the food service equipment in these hostile environments in many different ways. In one example, the workers periodically move shelving and racks that hold the food items. For this purpose, the racks often have wheels to facilitate the movement of the racks. In another example, the workers frequently remove and restock the food items. In a walk-in freezer, in one example, the food items can be very heavy and dense. In yet another example, the workers frequently remove and restock containers that hold the food items. Examples of containers include stainless steel pans and trays. The containers are often heavy and cumbersome, even without the added weight of the food items they hold. As a result, the equipment is generally "ruggedized" to withstand the ways in which the workers use the equipment and the frequency of its use.

[0010] During operation and use of the food service equipment, air temperature within the equipment can fluctuate over time. Normal operation and use of walk-in freezers and refrigerators, for example, includes momentary opening of doors of the walk-in freezers and refrigerators, and defrosting cycles of the walk-in freezers and refrigerators. In hostile kitchen and food service environments, however, the doors of the walk-in freezers and refrigerators are opened more frequently and often for longer time periods. During activities such as restocking, for example, the doors can be left open for extended time periods of **60** seconds or more.

[0011] While normal operation and use causes changes in the air temperature within the equipment, at the same time, the actual temperature of the items within the equipment typically changes very little. This can cause false temperature readings received by probes installed at the locations of the items.

SUMMARY OF THE INVENTION

[0012] Some temperature monitoring systems have been proposed that include food service thermal sensing devices. These devices are used in conjunction with the temperature probes of the systems. These devices are typically installed and used in cold refrigerators and freezers only, and each device is typically designed for a different purpose.

[0013] One existing food service thermal sensing device is designed to simulate the temperature of specific food items. The device has a solid, cylindrical body formed from a piece of thermal insulating material. The size of each cylinder is designed to mimic the thermal mass of a specific food item, and the device is installed near or placed among the food item. A sensing head of the temperature probe inserts into a top of the body and seats within the body. This device is referred to hereinafter as a cylinder-type sensing device.

[0014] The cylinder-type sensing device mounts within the cold refrigerators and freezers as follows. A single, plastic cable tie fastener is placed around the device, and is tightened against a post or other structural member of a shelf or rack in the cold refrigerators and freezers.

[0015] Another food service thermal sensing device is designed to resist momentary fluctuations in temperatures in the cold refrigerators and freezers. These momentary fluctuations in temperatures may be caused by standard refrigeration operations such as defrost cycles, opening of doors, and fans circulating air. This device is an elongated, hollow plastic vessel or vial that includes possibly dozens of glass beads, and has a rubber cap at the top of the vial. The beads resist changes in air temperature. The sensing head of the temperature probe inserts into a hole in the cap, and seats within the vial/rests among the glass beads. This device is referred to hereinafter as a vial-type sensing device.

[0016] Temperature monitoring systems that use the food service thermal sensing devices are configured to generate alarms. At the control unit, operators typically configure allowed temperature ranges for each of the devices. When the temperatures reported by the probes of the devices are outside the configured ranges, the control unit generates alarms. The alarms notify operators of possible problems at the locations. The alarms can be in the form of SMS messages, emails, and phone calls, in examples.

[0017] These food service thermal sensing devices have limitations. These limitations affect their usage in and applicability to the cold refrigerators and freezers for which they were designed.

[0018] The vial-type sensing device has limitations. One limitation is that the device is very fragile. As a result, it is poorly suited for use in many of the cold refrigerators and freezers for which it was designed. This is especially true when the cold refrigerators and freezers are in hostile kitchen and food service environments. In these environments, the rough nature of the operations performed by the workers and their frequent use of the equipment could easily damage or destroy the device and its probe. Another limitation is the number of and different type of objects required for the device. Glass, plastic, and rubber objects are required, and there are dozens of small, glass beads. This increases cost.

[0019] The cylinder-type sensing device also has limitations. One limitation is that the device is often the source of many false temperature alarms. This is because the device is designed to simulate the temperature of specific food items, as opposed to resisting momentary fluctuations in temperature caused by opening of doors/defrost cycles. As a result, these devices are poorly suited for use in cold refrigerators and freezers of hostile kitchen and food service environments, for example. Another limitation is that each device is sized to have a thermal mass that is substantially equal to the food item for which the device is monitoring. If food items having very different thermal masses are stored in the cold refrigerators and freezers, different sized devices might be required. This increases cost. Yet another limitation is the way the device mounts.

[0020] The mechanism for mounting the cylinder-type sensing device has limitations. First, the single plastic cable tie as the fastener is susceptible to vibrations, which are common in the cold refrigerators and freezers. The device can come loose over time as a result. Second, the device can be damaged or come loose from the shelf or rack when the the cold refrigerators and freezers are in hostile kitchen and food service environments. Third, a rack/shelf may not always be present as a mounting candidate. This can limit the locations within the cold refrigerators and freezers at which the device can be installed, which can lead to inaccurate temperature readings. Fourth, when a rack or shelf unit is available and the device is mounted to the rack or shelf unit, movement of the rack or shelf unit can damage the temperature probe.

[0021] A proposed thermal buffer device is disclosed. The thermal buffer device is designed to resist air temperature changes in the temperature controlled enclosures in which they are installed (i.e. to operate as a temperature buffer). The device is a component of a temperature monitoring system.

[0022] The device includes a body made from a solid piece of thermally insulating material such as polyethylene and is generally cubic in shape. A rear surface of the body is substantially planar, and the body also includes a fastening system for securing the rear surface to a preferably flat attachment surface. This enables mounting of the device against the many attachment surfaces (e.g. inside walls) of various temperature controlled enclosures. The body of the thermal buffer device has a temperature sensing channel that accepts a temperature probe.

[0023] The thermal buffer device has advantages over the existing food service thermal sensing devices. One advantage is that the thermal buffer device can be used in virtually any temperature controlled enclosure, not just in the cold refrigerators and freezers. In other advantages, its solid body of generally cubic shape provides protection for the temperature probe and is easy to manufacture, which lowers cost.

[0024] In yet another advantage of the thermal buffer device, in a preferred embodiment, the fastening system of the device enables positive mechanical mounting of the device within the temperature controlled enclosures. Positive mechanical mounting refers to the fact that the fastening system (and thus the thermal buffer device itself) is so secure that it cannot work loose from vibrations. This mounting is especially useful in food service equipment in hostile kitchen environments, where there is much movement of the food items, racks and containers. This mounting is also useful in refrigerated enclosures in general, because these enclosures are subject to frequent vibration from compressors when the compressors are running.

[0025] Another advantage of the thermal buffer device is as follows. Because the body of the device is formed from a thermally insulating material of generally cubic shape, it has sufficient thermal mass to resist momentary fluctuations in temperature caused by opening of doors/defrost cycles. When the temperature probe is installed in the device, the device delays the response time of the probe during these fluctuations. As a result, the thermal buffer device can reduce or possibly eliminate false temperature alarms that often occur when just the probes alone are used. This is especially the case when the device is installed in food service equipment in hostile kitchen and food service environments. The thermal buffer device resists the momentary fluctuations in temperature without the limitations of the vial-type sensing device.

[0026] Yet another advantage of the thermal buffer device over the cylinder-type and vial-type sensing devices is cost. The unit cost of the cylinder-type and the vial-type sensing devices are about 62 United States Dollars (USD) and 7 USD, respectively. In contrast, the unit cost of the thermal buffer device is about 5 USD or possibly less. This lower cost is a definite advantage, especially when installed in food service equipment. This is because multiple thermal buffer

devices are typically installed in each piece of equipment, and larger equipment such as walk in/drive in freezers and refigerators require more devices. Furthermore, many businesses in the food service industry require dozens, hundreds, or possibly even thousands of separate pieces of food service equipment. These businesses include large supermarket chains, restaurants, and businesses in the meat, poultry and seafood industries that process, package, and distribute food items, in examples. As a result, many hundreds or thousands of the thermal buffer devices would be required, so unit cost is a significant factor.

[0027] In general, according to one aspect, the invention features a thermal buffer device of a temperature monitoring system. The device comprises a body including a substantially planar rear surface, and a a fastening system. The body is formed from a solid piece of thermally insulating material, and the fastening system secures the rear surface of the body against an attachment surface within a temperature controlled enclosure. The attachment surface is at a location in the enclosure selected for temperature monitoring.

[0028] Preferably, the body is generally cubic in shape, and the fastening system provides positive mechanical mounting of the thermal buffer device.

[0029] In one example, the fastening system includes one or more screws that are introduced into thru-holes of the body, at a front surface of the body that opposes the rear surface. Typically, heads of the screws are countersunk below a plane of the front surface to secure the rear surface of the body against the attachment surface.

[0030] Preferably, the attachment surface is substantially planar. The attachment surface is also stationary.

[0031] In another example, the fastening system includes pieces of hook and loop fastening material affixed to the rear surface of the body and the attachment surface. The front surface of the body can also include a logo.

[0032] The temperature controlled enclosure can be a refrigerated enclosure, a heated enclosure, or a room within a premises, in examples.

[0033] Typically, the thermally insulating material is polyethylene.

[0034] In general, according to another aspect, the invention features a method of installation for a thermal buffer device of a temperature monitoring system. The method includes identifying a temperature controlled enclosure, and selecting a location in the temperature controlled enclosure for temperature monitoring and an attachment surface at the monitored location. The method also includes placing a substantially planar rear surface of a body of the thermal buffer device to be disposed towards the attachment surface, and securing the rear surface of body against the attachment surface.

[0035] In one example, securing the rear surface of the body to the attachment surface comprises using screws as the fastening system, by introducing the screws from a front surface of the body into thru-holes of the body, and tightening the screws. The front surface opposes the rear surface.

[0036] The above and other features of the invention including various novel details of construction and combinations of parts, and other advantages, will now be more particularly described with reference to the accompanying drawings and pointed out in the claims. It will be understood that the particular method and device embodying the invention are shown by way of illustration and not as a limitation of the invention. The principles and features of this invention may be employed in various and numerous embodiments without departing from the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] In the accompanying drawings, reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale; emphasis has instead been placed upon illustrating the principles of the invention. Of the drawings:

[0038] FIG. **1** is a diagram of an exemplary temperature monitoring system that includes a proposed thermal buffer device, where the device is installed in a medical refrigerator as an example of a temperature controlled enclosure;

[0039] FIG. **2** is a perspective view of a thermal buffer device installed in a room of a premises as the temperature controlled enclosure, where the device is mounted near a floor of the room for monitoring the temperature of a water pipe;

[0040] FIG. **3** is a perspective view of a walk-in freezer as an example of a temperature controlled enclosure, where three thermal buffer devices are installed in different locations of the walk-in freezer;

[0041] FIG. **4** is a flow chart that describes a method of installation for a thermal buffer device; and

[0042] FIG. **5** and FIG. **6** are tables of temperature measurements taken over at least a 25 minute time period, for a temperature buffer device in the freezer of FIG. **3**, where the measurements were taken to highlight the temperature buffering capabilities of the device during installation in FIG. **5**, and after installation and upon removal of the device from the freezer in FIG. **6**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0043] The invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0044] As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Further, the singular forms and the articles "a", "an" and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms: includes, comprises, including and/or comprising, when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Further, it will be understood that when an element, including component or subsystem, is referred to and/or shown as being connected or coupled to another element, it can be directly connected or coupled to the other element or intervening elements may be present.

[0045] It will be understood that although terms such as "first" and "second" are used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element

from another element. Thus, an element discussed below could be termed a second element, and similarly, a second element may be termed a first element without departing from the teachings of the present invention.

[0046] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0047] FIG. **1** shows an exemplary temperature monitoring system **100**. The system **100** monitors temperaure in different locations of a temperature controlled enclosure. Here, the enclosure is a type of refrigerated enclosure, a medical refrigerator **64**.

[0048] The system **100** includes various components. The components include thermal buffer devices **10**, temperature probes **20**, a wireless gateway **16**, and a control unit **52**.

[0049] The medical refrigerator **64** provides a temperature controlled environment **70** for medical products. The refrigerator has a door **32** that is pivotally attached using hinges **44**. A medical bottle **66** placed on a shelf **65** of the refrigerator **64**. In the figure, only a top portion of the refrigerator **64** is shown. A back wall **36** of the refrigerator **64** is visible.

[0050] The system **100** supports temperature monitoring of different locations N within the refrigerator **64**. For this purpose, multiple temperature probes **20-1** through **20**-N are each inserted into corresponding thermal buffer devices **10-1** through **10**-N. The devices **10** are then installed at each of the different locations.

[0051] Thermal buffer device **10-1** is shown and is installed at location L**1**. Location L**1** was selected to be close to items placed on the shelf **65**. Specifically, the device is mounted to the back wall **36** of the refrigerator **64** as an attachment surface. The back wall **36** is substantially planar.

[0052] In more detail, the thermal buffer device **10-1** has a body **22** and a fastening system **12**. The body has a top surface **27**, a rear surface, a temperature sensing channel **19**, a sensing point **21** and a front surface **28**. The front surface **28** is facing the viewer. The channel **19** is centrally located within the body **22** and extends from the top surface **17** partially down into the body **22**, ending at the sensing point **21**. The rear surface is attached to the back wall **36** using screws as the fastening system **12**. A logo **31** is also attached to the front surface **28**.

[0053] The body **22** is made from a thermally insulating material such as polyethylene or polytetrafluoroethene (PTFE) that resists changes in temperature. These materials are also extremely rigid so as to protect the probe **20** from everyday usage when the device **10** in hostile kitchen and food service environments. Polyethylene, in particualar, is "food safe," and is approved by the US Food and Drug Administration (FDA) for many uses in the food service and food equipment industries, in examples.

[0054] High Density Polyethylene (HDPE) is the preferred material for the body **22**. HDPE is preferred because it is a material approved for contact with food or drinking water by multiple government and industry regulatory agencies. HDPE is approved as "food safe" by both the United States Department of Agriculture (USDA) and the FDA, in examples. The non-governmental industry agency known as the National Sanitation Foundation (NSF) also certifies HDPE under its standard 51, also known as NSF 51.

[0055] HDPE has many properties that make it a very suitable material for installation in food service equipment, in particular. It is acid, odor, moisture and mildew resistant. It has a melting point of 266 degrees F. (Fahrenheit) and an operating range of −150 to 200 degrees F. In the food service industry, for example, 190 deg F is the standard warming box temperature.

[0056] The temperature probe **20-1** has a head **18** that inserts into the channel **19**. The head **18** typically includes a thermocouple device. The head **18** seats at the sensing point **21** of the channel **19**. The sensing point **21** is typically located at least halfway down from the top surface **27**, such that the probe head **18** is located below a plane of the top surface **27** when seated in the sensing point **21**.

[0057] The temperature probes **20-1** through **20**-N also connect to individual ports **11-1** through **11**-N of the wireless gateway **16**. The wireless gateway **16** has a wireless antenna **14** and communicates over a wireless communications channel **99** with the control unit **52**.

[0058] The control unit **52** has a display **50** and a wireless antenna **14**. Via its wireless antenna **14**, the control unit **52** communicates with the wireless gateway **16** over the wireless channel **99**. The control unit **52** is a computer device such as a computer workstation, laptop, tablet/phablet, or cellular "smart phone" device, in examples.

[0059] The wireless gateway **16** provides a source of power to the probes **20** at each of its ports **11**, and receives voltages associated with temperature sent from each of the probes. The gateway **16** periodically gathers the voltages received at each of the ports **11** at a rate known as a heartbeat of the gateway **16**.

[0060] The control unit **52** executes software programs for controlling the gateway **16**, and displays temperature information sent from the probes **20**. To control the gateway **16**, the control unit **52** sends control messages over the wireless channel **99**. The control messages enable or disable the ports **11** and adjust its heartbeat, in examples.

[0061] The system **100** generally operates as follows. The temperature probes **20-1** installed in each of the thermal buffer devices **10-1** through **10**-N report the temperature at each of the monitored locations L**1** through L**10** to the wireless gateway **16**. The reported temperatures are represented by voltages that are proportional to changes in the temperature detected by the heads **18** of the probes **20**. The gateway **16** accesses the ports **11** according to the heartbeat, converts the voltages to associated temperature values, and reports the temperature values to the control unit **52**. The control unit **52** displays the temperature values for the probes **20** at each of the locations L on its display **50**.

[0062] At the control unit **52**, an operator typically defines a range of allowed temperature values for each of the probes **20**/locations L, and possibly one or more temperature threshold values. When the temperatures reported by each of the probes **20** are outside the allowed range and/or exceed the threshold values for each location L, the control unit **52** generates alarm messages. The alarm messages notify operators of possible problems at the locations L.

[0063] More recently, some components of the temperature monitoring systems **100** are incorporating Internet of Things (IoT) capabilities. IoT-capable objects can communicate wirelessly to form networks of internet-connected objects that are able to collect and exchange data. Examples

of IoT-capable components in the temperature monitoring systems **100** can include the control units **52**, the gateways **16**, the temperature probes **20**, and possibly even the thermal buffer devices **10**.

[0064] To add IoT capabilities to an object, a small footprint, "single board" computer system is attached to the object. The single board computer system typically includes one or more low-cost computer processor cores with wireless networking interfaces, about 1 gigabyte (GB) of random access memory, a battery as a source of power, and a substrate. The processor cores, the memory, and the battery mount to the substrate and are connected to one another using wires or printed circuit traces within and/or upon the substrate. An operating system loaded into the memory of and executing on the processing cores of each IoT-equipped object enable the object to form the networks of internet-connected objects and exchange data. A common IoT single board computer system is Raspberry Pi.

[0065] The temperature monitoring systems **100** are also increasingly becoming more distributed in nature. Here, the control units **52** of these systems **100** might be connected to a computer network at a site or facility that is remote to/separate from the buildings or facilities where the temperature controlled enclosures are located. These remote networks are often owned and managed by a third party business entity (i.e. service provider) that is different from the business entities that own the temperature controlled enclosures to be monitored. In this way, the service provider can provide a "cloud based" temperature monitoring service for managing and operating the temperature monitoring systems **100** of multiple different business entities as clients. Typically, the gateways **16** of the systems **100** at each business entity communicate with the control units **52** at the service provider networks via cellular phone-based or Ethernet-based wireless communications, in examples.

[0066] FIG. **2** shows an embodiment of a thermal buffer device **10-2** of a temperature monitoring system. The device **10-2** is installed in a heated room **200** of a premises as the temperature controlled enclosure. The device **10-2** is mounted to a substantially planar wall **36** as the attachment surface.

[0067] The installation location of the device **10-2** is indicated by reference L**2**. The location L**2** is adjacent to a floor **62** of the room **200** and near a water pipe **33**. Here, the device **10-2** is installed to monitor the air temperature near the water pipe **33** to determine whether the pipe may freeze.

[0068] The view provided by the figure shows detail for the thermal buffer device **10-2** than was not possible in the device **10-1** of FIG. **1**. Specifically, thru-holes **26** of the body **22**, the rear surface **29** of the body **22**, and dimensions of the body **22** are shown. In addition, more detail for the location of the temperature sensing channel **19** within the body **22** is shown.

[0069] The body **22** is generally cubic in shape, with dimensions of length, width, and height indicated by references l, w, and h, respectively. In one example, the dimensions l, w, and h are 1.75 inches (in), 0.75 in, and 2.25 in, respectively.

[0070] The front surface **28** is opposite to the rear surface **29**, and the rear surface **29** is substantially planar.

[0071] The thru-holes **26** extend from the front surface **28** towards the rear surface **29** in a manner that is substantially parallel to a plane of the top surface **27**. Center lines **17** that run through a center of the thru-holes **26** are shown.

[0072] A screw as the fastening system **12** is also shown and is exploded from one of the thru-holes **26**. In one example, self-tapping stainless steel screws are used.

[0073] The screw as the fastening system **12** provides positive mechanical mounting of the rear surface **29** of the body **22** against the wall **36**. Preferably, the thru-holes are chamfered within the block, indicated by reference **26**c. This enables the head **13** of each screw to be countersunk below a plane of the front surface **28** when the body **22** is secured to the attachment surface/wall **36**.

[0074] In another implementation, rather than the rear surface **28** being mounted directly against the attachment surface, the rear surface **28** is mounted such that an air gap is maintained between the rear surface **22** and the attachment surface. For this purpose, standoffs such as neoprene standoffs might be placed between the rear surface **28** and the attachment surface. In this way, the device **10-2** is not affected by possible differences in heating/cooling between the material of the rear surface **28** and that of the attachment surface.

[0075] Other embodiments of the fastening system **12** are possible. In one example, the fastening system **12** includes pieces of hook and loop fastening material. An exemplary piece of hook and loop fastening material is manufactured by Velcro BVBA. The material is affixed to the rear surface **28** of the body **22** and the attachment surface. In another example, the fastening system **12** includes pieces of interlocking material affixed to the rear surface **28** of the body **22** and the attachment surface that provides an interference fit/press fit. In one example, the material is food grade plastic.

[0076] The probe head **18** is seated within the temperature sensing channel **19** and is seated at the sensing point **21**. The channel **19** is drilled or formed to provide a friction fit/snug fit of the head **18** within the body **22**, and protects the head **18**. Thermal paste may also be used to provide improved heat conduction between the head **18** and the block **22** and to more securely seat the probe head **18** within the body **22**.

[0077] In another implementation, the device **10-2** is formed by creating the body around the probe head **20**, such as via an injection molding process.

[0078] The temperature buffer device **10** can be used to monitor temperature controlled enclosures in many industries and applications. These industries and applications include agricultural monitoring, apartment property management, art gallery light and temperature monitoring, bank owned property monitoring, bed bug extermination temperature monitoring, beer cooler temperature monitoring, boat bilge pump monitoring, and boiler temperature monitoring, cold chain monitoring, cold weather protection, college dormitory monitoring, commercial and residential plumbing monitoring, property management and monitoring, commercial refrigeration monitoring, construction equipment monitoring, convenience store management, crawl space monitoring.

[0079] Other industries and applications include dairy cooler temperature monitoring, data center temperature monitoring, deli food cooler temperature monitoring, environmental monitoring solutions for wood floor maintenance, facility monitoring, farm to fork monitoring, fleet management, food service temperature monitoring, foreclosed property management, frozen pipes, greenhouse monitoring, grocery and cold chain monitoring, heating and cooling system monitoring, ice maker temperature monitoring, ice

freezer/cooler temperature monitoring, industrial pressure sensors and monitoring, inventory tracking, k9 unit temperature monitoring, laboratory monitoring, m2m - machine to machine solutions, medical refrigerator temperature monitoring, morgue temperature monitoring, mortuary cooler temperature monitoring, and organ and tissue transplant cooler monitoring.

[0080] Yet other industries and applications include parking garage monitoring, pet kennel temperature monitoring, pharmaceutical refrigeration temperature monitoring, production line monitoring, refrigerated trailer temperature monitoring, remote monitoring for business, remote property monitoring, remote second home monitoring, remote temperature monitoring, rental tool and equipment tracking, school cafeteria cooler temperature monitoring, server room temperature monitoring, smart power monitoring, storage unit monitorin, structural monitoring, student housing monitoring, supermarket food temperature monitoring, traffic monitoring, vacant property monitoring, vacation home monitoring, walk-in cooler temperature monitoring, warehouse monitoring, wastewater monitoring, water heater monitoring, and wine storage monitoring.

[0081] FIG. **3** is a perspective view of a walk-in freezer **30**. The walk-in freezer **30** is an example of food service equipment to which the thermal buffer device **10** is applicable. Here, three exemplary thermal buffer devices **10-3**, **10-4**, and **10-5** are mounted to different locations L**3**, L**4**, and L**5** within the freezer **30**. The probes **20** that insert into the devices **10-3**, **10-4**, and **10-5** and the other components of the temperature monitoring system **100** are not shown in the figure.

[0082] The walk-in freezer **30** has a door **32** connected to the walk-in freezer **30** via hinges **40**. The door **32** is currently open. A side wall **38**, a back wall **36**, a ceiling **48**, and the floor **62** of the freezer **30** are shown. These surfaces are all substantially planar (e.g. flat).

[0083] Each of the thermal buffer devices **10-3**, **10-4**, and **10-5** are mounted to different attachment surfaces at each of the locations L**3**, L**4**, L**5**, using different fastening systems **12**. Device **10-3** uses pieces of material that form an interference fit, indicated by reference **43**, as its fastening system **12**. The fastening system **12** secures the rear surface **29** of the body **22** to the ceiling **48** as the attachment surface. In a similar fashion, device **10-4** uses screws as its fastening system **12** to secure the rear surface **29** of the body **22** to the back wall **36** as the attachment surface. Typically, self-tapping stainless steel screws are used in the freezer **30**. Finally, device **10-5** uses pieces of hook and loop material, indicated by reference **41**, as its fastening system **12**. The fastening system **12** secures the rear surface **29** of the body **22** to the side wall **38** as the attachment surface.

[0084] It is also important to note that the attachment surfaces (e.g. ceiling **48**, back wall **36**, and side wall **38** of the freezer **30**) are stationary/are surfaces of stationary objects. This means that the objects having the surfaces, and thus the surfaces themselves, either do not move or are not intended to be moved. These stationary attachment surfaces help protect the temperature probe **20** from the foot traffic and movement of food items and racks that occur daily in the walk-in freezer **30**.

[0085] FIG. **4** is a flow diagram that describes a method of installation for an exemplary thermal buffer device **10**. The device is a component of a temperature monitoring system **100**.

[0086] In step **402**, an installer identifies an enclosure within which a temperature controlled environment is maintained. According to step **404**, the installer selects a location in the enclosure for temperature monitoring and an attachment surface at the monitored location. The attachment surface is a substantially planar surface such as a wall of the temperature controlled enclosure.

[0087] Then, in step **406**, the installer places the rear surface **29** of the body **22** of the temperature buffer device **22** to be disposed towards the attachment surface. In step **408**, using the fastening system **12**, the installer secures the rear surface **29** of the body **22** against the attachment surface. In one example, the fastening system is screws that enter the thru-holes **26** at the front surface **28** of the body. The screws enable positive mechanical mounting of the body **22** against the attachment surface when the screws are tightened.

[0088] According to step **410**, the installer affixes a logo **31** to the front surface **28** of the body **22**. Alternatively, the logo **31** was previously affixed at the factory/prior to installation.

[0089] Finally, in step **412**, the installer inserts the probe head **18** of the temperature probe **20** within the body **22** of the temperature buffer device **22**. For this purpose, the installer places the probe head **18** in the temperature sensing channel **19** until the head **18** seats at the sensing point **21**.

[0090] FIG. **5** and FIG. **6** are tables of temperature measurements taken over time for a thermal buffer device **10** in FIG. **3**. These measurements illustrate the temperature buffering capabilities of the device **10**. The dimensions l, w, and h for this device are 1.75 inches (in), 0.75 in, and 2.25 in, respectively.

[0091] In FIG. **5**, the measurements began once the device **10** was installed in the freezer **30**.

[0092] The table of FIG. **5** is arranged into rows **510** and columns **520**. There are 31 rows, numbered **510-1** through **510-31**. There are three columns, **520-1**, **520-2**, and **520-3**.

[0093] Column **520-1** indicates the measurement number (1-31). Column **520-2** includes the temperature measurement reported by the probe **20** in the temperature buffer device **10**. Column **520-3** shows elapsed time, in seconds, to achieve a 1 deg F temperature rise, relative to the time of the last/prior measurement.

[0094] Row **510-1** shows that the initial temperature of the device **10** was 60 deg F (15.56 C) when it was installed into the temperature controlled environment of the freezer **30**. A second, unbuffered probe reported that the temperature of the freezer was 15 degrees F. (−9.44 C).

[0095] Row **510-2** shows the time taken for the device **10** to decrease 1 deg F from the last measurement taken, in row **510-1**. In a similar fashion, row **510-3** shows the time taken for the device **10** to decrease 1 deg F from the last measurement taken, in row **510-2**. This repeats until the last measurement **31** in row **510-31**.

[0096] As the number of measurements increase, the time that it takes for the device to decrease 1 deg F from each prior measurement gradually becomes greater, and then stabilizes. For example, the time values in column **510-3** for rows **510-27**, **510-28**, **510-29**, **510-30**, and **510-31** are 120 sec, 119 sec, 120 sec, 130 sec, and 160 sec, respectively.

[0097] The last portion of measurements **510-27** through **510-31** illustrate that once the device **10** has been installed

for a time period of approximately 15 minutes, it takes nearly a minute and a half for the device **10** to sense a 1 deg F decrease in temperature.

[0098] The final time of 1780 seconds (29.66 minutes) is indicated by reference **530**. This value is the sum of the time values in column **510-3**, for each of the rows **510-1** through **510-31**.

[0099] In FIG. **6**, the measurements began after the device **10** had been installed for a time period within the freezer **30**, and then removed from the freezer **30** to a room with a 60 deg F (15.56 C) ambient temperature. As in FIG. **5**, the unbuffered temperature of the freezer was 15 deg F.

[0100] The table of FIG. **6** is arranged into rows **610** and columns **620**. There are 31 rows, numbered **610-1** through **610-31**. There are three columns, **620-1**, **620-2**, and **620-3**.

[0101] Column **620-1** indicates the measurement number (1-31). Column **620-2** includes the temperature measurement reported by the probe **20** in the temperature buffer device **10**. Column **620-3** shows elapsed time, in seconds, to achieve a 1 deg F temperature rise, relative to the time of the last/prior measurement.

[0102] Row **610-1** shows that the temperature of the device **10** for the first measurement was 30 deg F.

[0103] Row **610-2** shows the time taken for the device **10** to increase 1 deg F from the last measurement taken, in row **610-1**. In a similar fashion, row **610-3** shows the time taken for the device **10** to increase 1 deg F from the last measurement taken, in row **610-2**. This repeats until the last measurement **31** in row **610-31**.

[0104] As the number of measurements increase, the time that it takes for the device to increase 1 deg F from each last/prior measurement gradually becomes greater, and then stabilizes. For example, the time values in column **610-3** for rows **610-27**, **610-28**, **610-29**, **610-30**, and **610-31** are 113 sec, 107 sec, 117 sec, 110 sec, and 105 sec, respectively.

[0105] The final time of 1558 seconds (25.96 minutes) is indicated by reference **630**. This value is the sum of the time values in column **610-3**, for each of the rows **610-1** through **610-31**.

[0106] While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

What is claimed is:

1. A thermal buffer device of a temperature monitoring system, the device comprising:

a body including a substantially planar rear surface, wherein the body is formed from a solid piece of thermally insulating material; and

a fastening system for securing the rear surface of the body against an attachment surface within a temperature controlled enclosure, wherein the attachment surface is at a location in the enclosure selected for temperature monitoring.

2. The thermal buffer device of claim **1**, wherein the body is generally cubic in shape.

3. The thermal buffer device of claim **1**, wherein the fastening system provides positive mechanical mounting of the thermal buffer device.

4. The thermal buffer device of claim **1**, wherein the fastening system includes one or more screws that are introduced into thru-holes of the body, at a front surface of the body that opposes the rear surface, and wherein heads of the screws are countersunk below a plane of the front surface to secure the rear surface of the body against the attachment surface.

5. The thermal buffer device of claim **1**, wherein the attachment surface is substantially planar.

6. The thermal buffer device of claim **1**, wherein the attachment surface is stationary.

7. The thermal buffer device of claim **1**, wherein the fastening system includes pieces of hook and loop fastening material affixed to the rear surface of the body and the attachment surface.

8. The thermal buffer device of claim **1**, wherein the body has a front surface that includes a logo.

9. The thermal buffer device of claim **1**, wherein the temperature controlled enclosure is a refrigerated enclosure.

10. The thermal buffer device of claim **1**, wherein the temperature controlled enclosure is a heated enclosure.

11. The thermal buffer device of claim **1**, wherein the temperature controlled enclosure is a room within a premises.

12. The thermal buffer device of claim **1**, wherein the thermally insulating material is polyethylene.

13. A method of installation for a thermal buffer device of a temperature monitoring system, the method comprising:

identifying a temperature controlled enclosure;

selecting a location in the temperature controlled enclosure for temperature monitoring and an attachment surface at the monitored location;

placing a substantially planar rear surface of a body of the thermal buffer device to be disposed towards the attachment surface; and

securing the rear surface of body against the attachment surface.

14. The method of claim **13**, further comprising the body of thermal buffer device being substantially cubic in shape.

15. The method of claim **13**, wherein securing the rear surface of body against the attachment surface is accomplished via a fastening system of the thermal buffer device.

16. The method of claim **13**, wherein securing the rear surface of the body against the attachment surface comprises:

using screws as the fastening system, by introducing the screws from a front surface of the body into thru-holes of the body, the front surface opposing the rear surface; and

tightening the screws.

17. The method of claim **13**, wherein selecting an attachment surface at the monitored location comprises identifying surfaces at the monitored location, and selecting a surface that is substantially planar.

18. The method of claim **13**, wherein selecting an attachment surface at the monitored location comprises identifying surfaces near the monitored location, and selecting a surface that is stationary.

19. The method of claim **13**, further comprising the temperature controlled enclosure being a refrigerated enclosure.

20. The method of claim **13**, further comprising the temperature controlled enclosure being a heated enclosure.

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