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(54) TEMPERATURE SENSING DEVICE

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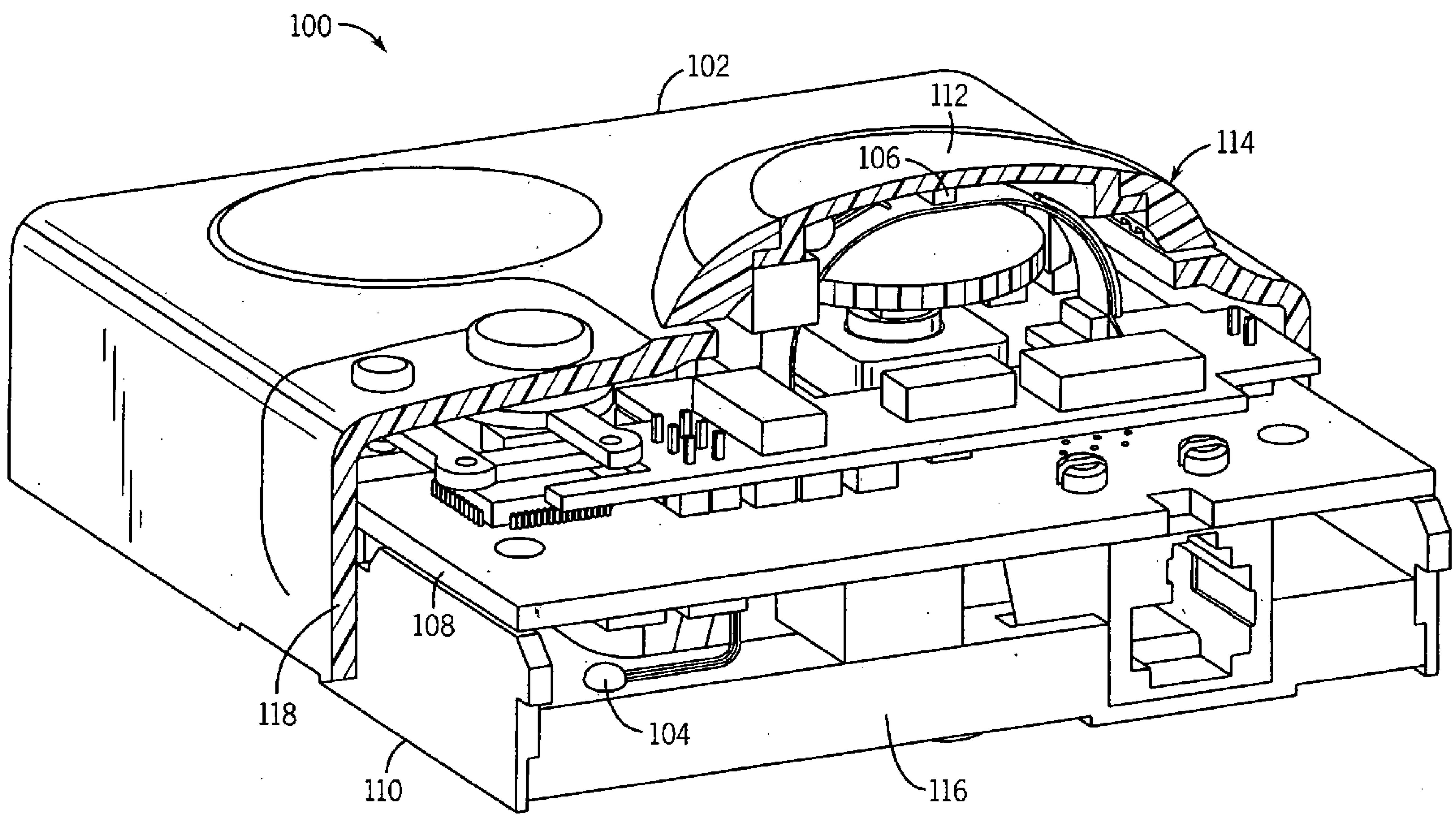
(57) **ABSTRACT**

A temperature sensing device includes a first temperature sensor configured for mounting to a structure at a first distance relative to the structure. The temperature sensing device also includes a second temperature sensor configured for mounting to the structure at a second distance relative to the structure. The temperature sensing device also includes a processor coupled to the first and second temperature sensors and configured to estimate a third temperature based on the first and second temperatures and the distance separating the first and second temperature sensors.



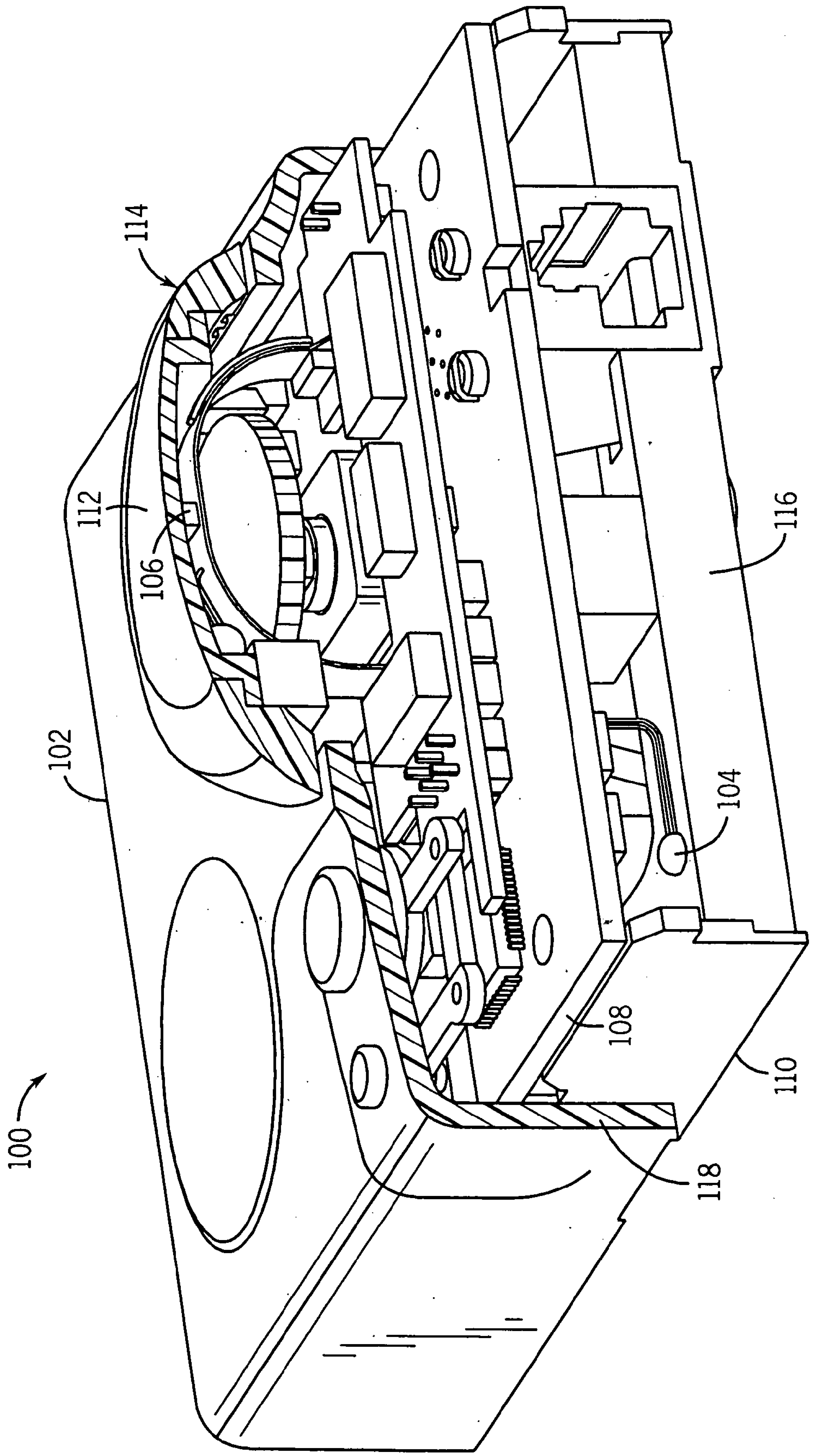


FIG. 1

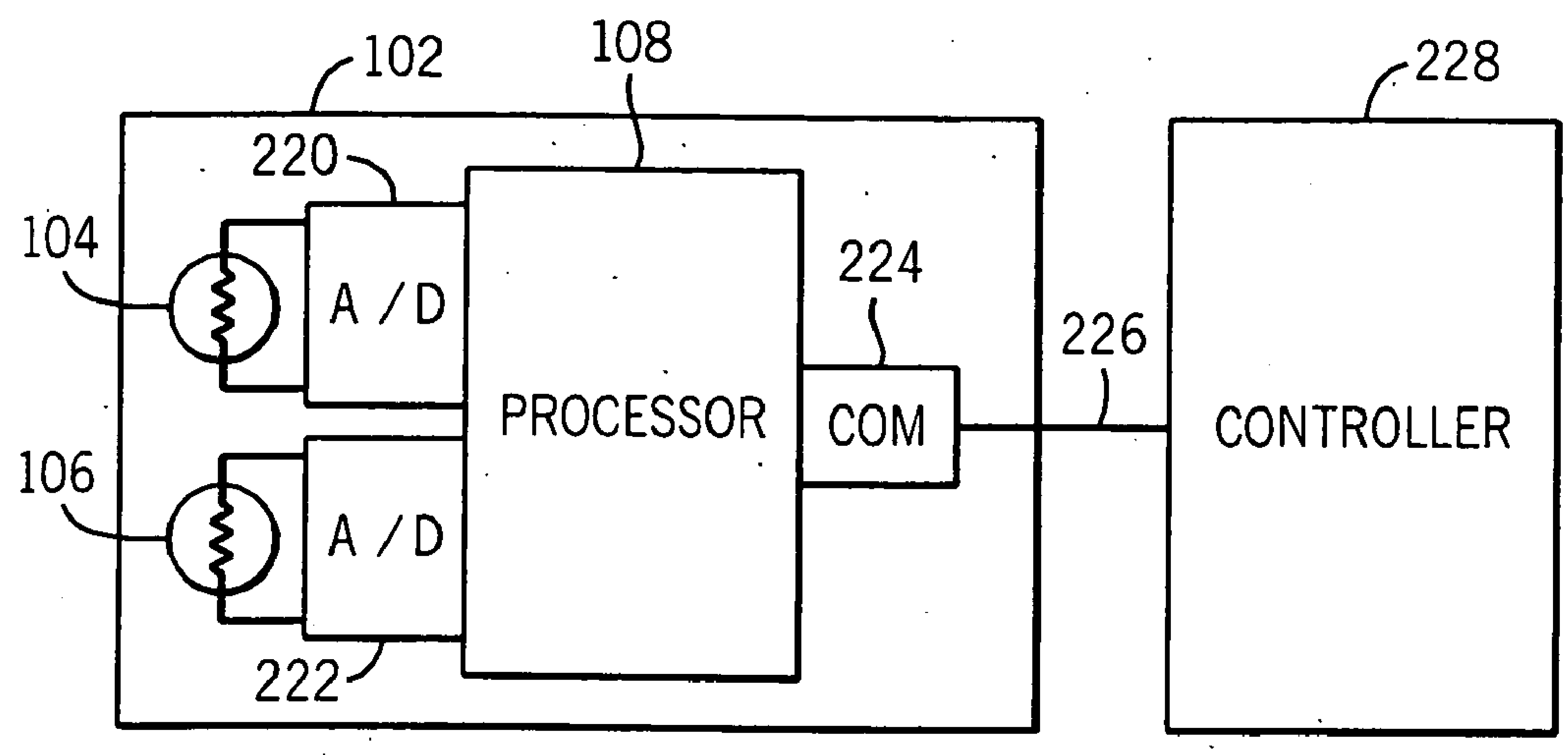

102
108
228
220
104
A / D
224
226
PROCESSOR
COM
CONTROLLER
106
A / D
222

FIG. 2A

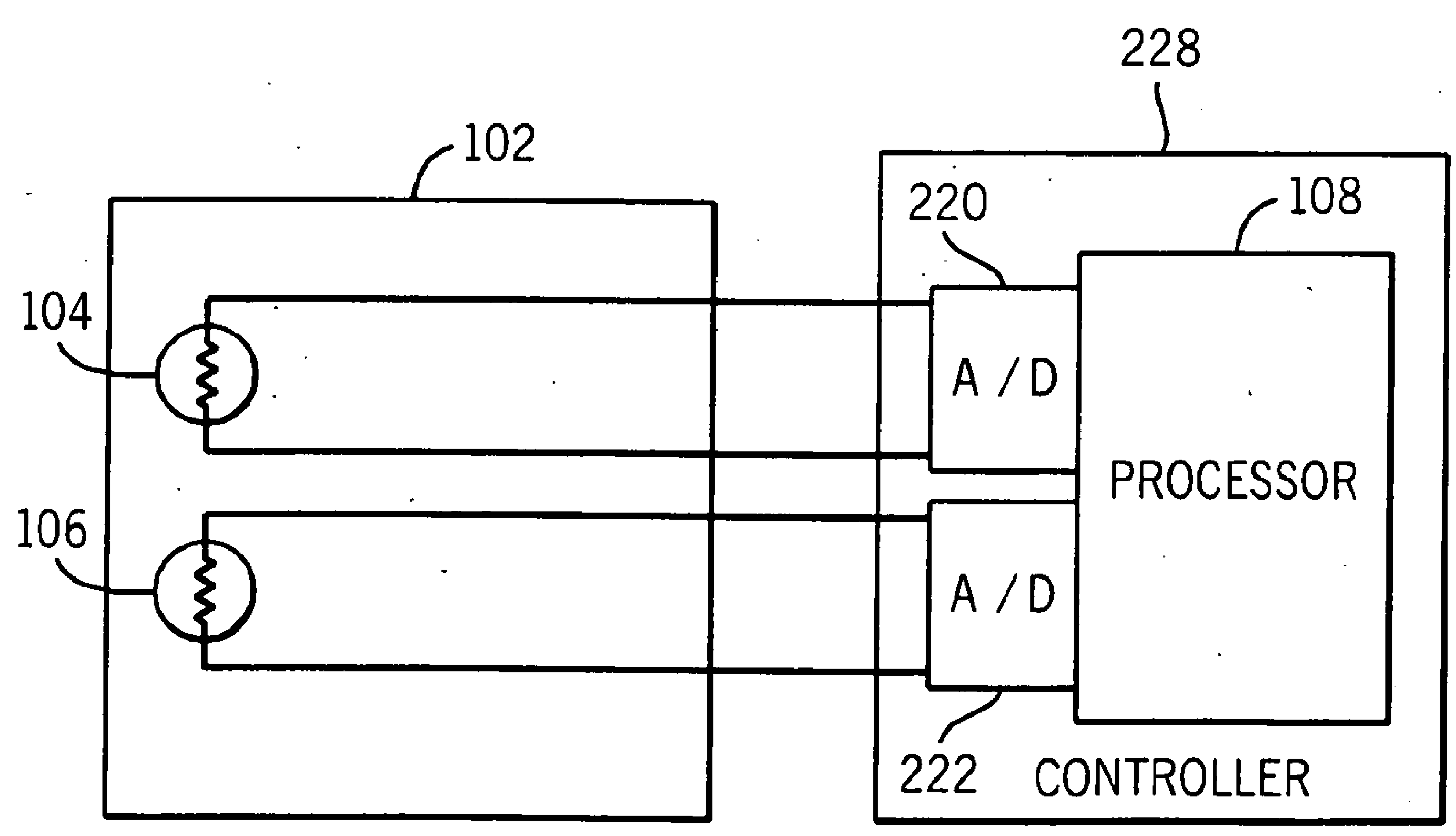

228
102
220
108
104
A / D
PROCESSOR
106
A / D
222
CONTROLLER

FIG. 2B

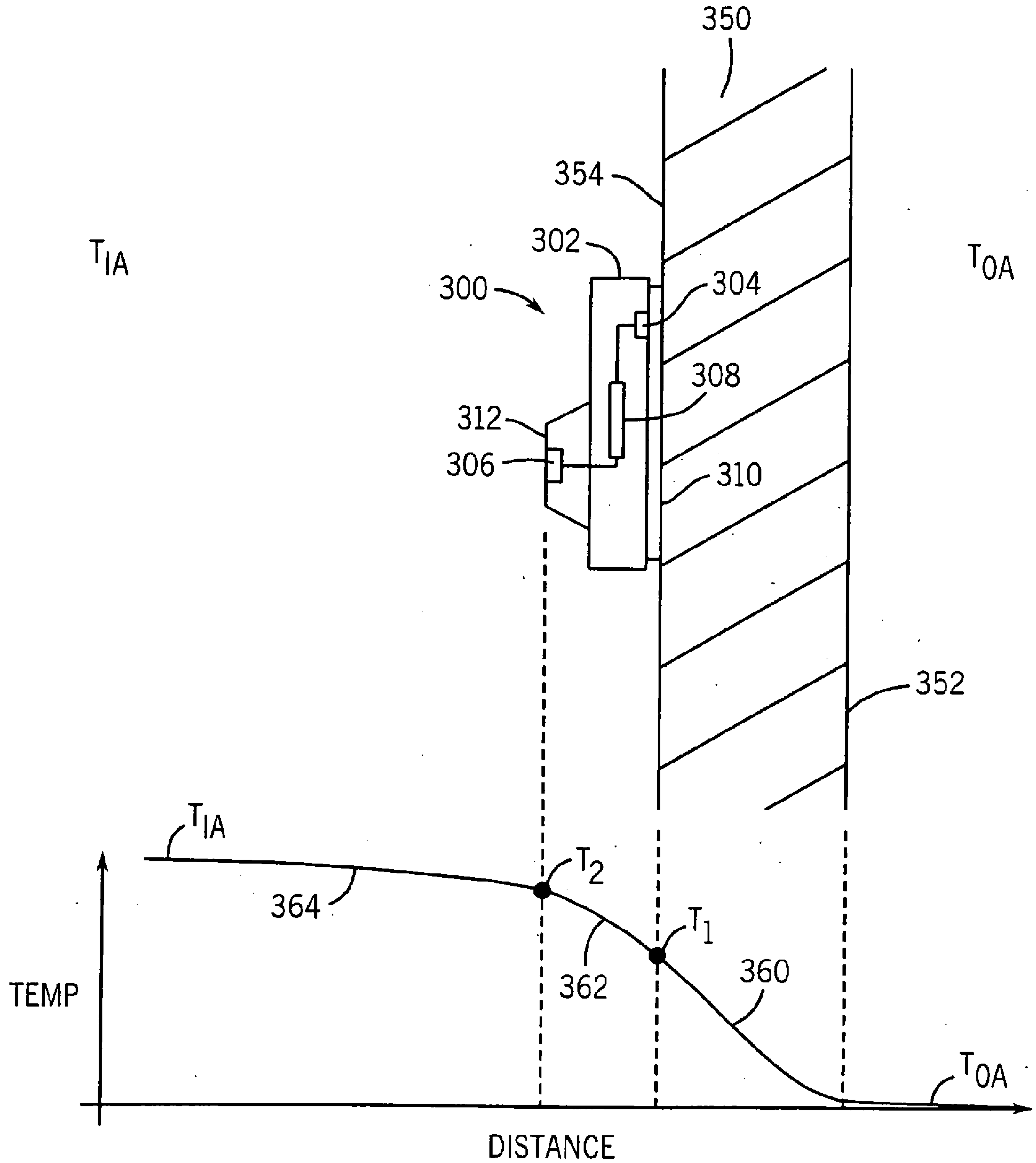

350
354
302
300
304
308
312
306
310
352
T_{IA}
T_{OA}
T_{IA}
T_2
T_1
364
362
360
TEMP
T_{OA}
DISTANCE

FIG. 3

TEMPERATURE SENSING DEVICE

BACKGROUND

[0001] The present description relates generally to temperature sensing devices such as thermostats, etc. More specifically, the present description relates to temperature sensing devices configured to compensate for mounting surface temperature effects.

[0002] Climate control systems, such as heating, ventilating, and air conditioning (HVAC) systems, typically include one or more thermostats to monitor, for example, an ambient air temperature within a particular room or zone within a building to provide feedback as to whether the air temperature of the room needs to be adjusted to satisfy a predetermined set point. The thermostat is typically configured such that a temperature sensor is housed within an enclosure to sense the temperature of the air passing over, through, or in contact with the enclosure. The climate control system may then compare this air temperature to the predetermined set point to determine if the air temperature of the room needs to be adjusted to satisfy the predetermined setpoint.

[0003] For convenience, the thermostat may be mounted to a wall or other surface within the room or zone. However, when the thermostat is mounted to the surface of an outside wall or another location where the wall surface is significantly warmer or colder than the air temperature of the room or zone, there may be substantial differences between the air temperature measured by the thermostat and the actual ambient air temperature of the room or zone. Further, air flow through the thermostat may be minimal due to a low profile enclosure designed such that the thermostat is minimally noticeable and does not project undesirably from the wall or other mounting location. Under these conditions, the climate control system may perform inefficiently because the temperature measured by the thermostat may not be the ambient air temperature of the room, but rather a temperature somewhere between the air temperature of the room and the wall surface temperature. Thus there is need for an improved temperature sensing device with the capability to compensate for mounting surface temperature effects.

SUMMARY

[0004] According to a first exemplary embodiment, a temperature sensing device includes a first temperature sensor configured for mounting to a structure at a first distance relative to the structure, and a second temperature sensor configured for mounting to the structure at a second distance relative to the structure. The temperature sensing device also includes a processor coupled to the first and second temperature sensors and configured to estimate a third temperature based on the first and second temperatures and the distance separating the first and second temperature sensors.

[0005] According to a second exemplary embodiment, a method of sensing temperatures in a room includes mounting a first temperature sensor to a structure in the room at a first distance relative to the structure, mounting a second temperature sensor to the structure at a second distance relative to the structure, measuring a first temperature with the first temperature sensor, measuring a second temperature with the second temperature sensor, and estimating a third temperature from the first and second temperatures.

[0006] According to a third exemplary embodiment, a temperature sensing device includes a housing, a first temperature sensor mounted within the housing and configured to sense a first temperature, and a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor, and configured to sense a second temperature. The temperature sensing device also includes a processor coupled to the first temperature sensor and the second temperature sensor and configured to estimate a third temperature using the first temperature and the second temperature.

[0007] According to a fourth exemplary embodiment, a method includes measuring a first temperature using a first temperature sensor mounted within a housing, measuring a second temperature using a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor, and estimating a third temperature from the first temperature and the second temperature using a processor coupled to the first temperature sensor and the second temperature sensor.

[0008] According to a fifth exemplary embodiment, a temperature sensing device includes a housing, a first temperature sensing means mounted within the housing and configured to sense a first temperature, and a second temperature sensing means mounted within the housing and spaced apart from the first temperature sensing means, and configured to sense a second temperature. The temperature sensing device also includes means coupled to the first temperature sensor and the second temperature sensor for estimating a third temperature from the first temperature and the second temperature.

[0009] According to a sixth exemplary embodiment, a temperature sensing device includes a first temperature sensor configured to sense a first temperature and a second temperature sensor spaced apart from the first temperature sensor, and configured to sense a second temperature. The temperature sensing device also includes a processor coupled to the first temperature sensor and the second temperature sensor and configured to estimate a heat transfer rate associated with at least one of the first temperature and the second temperature; and determine an air temperature set point based on the heat transfer rate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **FIG. 1** illustrates a temperature sensing device according to an exemplary embodiment.

[0011] **FIG. 2A** is a diagram which schematically illustrates the electrical components of temperature sensing device of **FIG. 1** according to an exemplary embodiment.

[0012] **FIG. 2B** is a diagram which schematically illustrates the electrical components of the temperature sensing device of **FIG. 1** according to another exemplary embodiment.

[0013] **FIG. 3** illustrates a temperature sensing device mounted to an exterior wall of a building according to an exemplary embodiment.

DETAILED DESCRIPTION

[0014] **FIG. 1** illustrates a temperature sensing device **100** according to one exemplary embodiment. In one embodiment, temperature sensing device **100** is a thermostat, such as a wall-mounted electronic thermostat configured for use with a climate control system to measure the air temperature of a room. In other embodiments, temperature sensing device **100** may be adapted for use with other systems or locations. Temperature sensing device **100** includes a housing **102**, temperature sensors **104** and **106**, and a processor **108**. Temperature sensing device **100** may be generally used to sense a first temperature and a second temperature and to estimate a third temperature using the first temperature and the second temperature. More specifically, temperature sensing device **100** may be used to compensate for external temperature effects resulting from the location of temperature sensing device **100** by measuring a first temperature and a second temperature, and estimating the third temperature based on the first temperature and the second temperature.

[0015] Housing **102** is configured to provide a structure within which temperature sensors **104** and **106**, and optionally processor **108**, may be mounted and enclosed. In the illustrated embodiment, processor **108** is shown as being enclosed within housing **102**. In another embodiment, processor **108** is located within another device or controller remotely located and/or external to housing **102**. Housing **102** is made of a rigid material such as a plastic or metal or other material suitable to protect the internal components of housing **102**. In one embodiment, portions of housing **102** may be made of a thermally conductive material such that at least one of the temperatures sensed by temperature sensors **104** and **106** may be sensed by conduction through housing **102**'. In another embodiment, housing **102** may include one or more openings or vents to facilitate the flow of air through temperature sensing device **100** once it has been mounted such that at least one of the temperatures sensed by temperature sensors **104** and **106** may be sensed by convection through housing **102**.

[0016] Housing **102** is further configured to be mounted to a structure. In the illustrated embodiment, housing **102** is configured to be mounted to the surface of a structure of a building, such as a wall, floor, ceiling, column, or other structure, using any suitable mounting hardware or other means of attachment. The structure to which temperature sensing device **100** is mounted may be, for example, an exterior wall or other structure for which the temperature of the surface to which temperature sensing device **100** is mounted is different from, for example, the air temperature of a room or other area which includes or is exposed to the structure and in which temperature sensing device **100** is mounted.

[0017] Housing **102** may be any suitable size or shape depending on the particular application. For example, in the illustrated embodiment, housing **102** is an essentially rectangular hollow protrusion with a low profile such that housing **102** does not significantly extend beyond the surface of a structure, such as a wall, to which it is mounted. In this embodiment, housing **102** is shaped such that it has a surface **110** and a surface **112** spaced apart from surface **110**. In the illustrated embodiment, housing **102** is formed from a mounting base **116** and a mating cover **118** such that mounting base **116** includes surface **110** and mating cover **118** includes surface **112**. In other embodiments, housing **102** may be formed from additional pieces, or may be a single piece.

[0018] Surface **110** is configured to be adjacent to a surface of a structure, such as a wall, to which housing **102** is mounted. Surface **112** is configured to be spaced apart from the surface of the structure and exposed to a temperature at a distance from the surface of the structure, such as the temperature of the air at a distance from the surface of a wall to which temperature sensing device **100** is mounted. Preferably, surface **112** is spaced apart from surface **110** such that the distance between surface **110** and surface **112** is maximized while maintaining an overall low profile for temperature sensing device **100**. For example, the embodiment shown in **FIG. 1** includes a protrusion **114** extending from mating cover **118** which is configured to maximize the spacing between surface **110** and surface **112** while maintaining an overall low profile of temperature sensing device **100**. In other embodiments, protrusion **114** may be eliminated, such that mating cover **118** is substantially planar.

[0019] Temperature sensors **104** and **106** may be mounted within housing **102**, and may be any suitable temperature sensor. For example, in one embodiment, temperature sensors **104** and **106** may be resistance thermal detectors (RTDs). In another embodiment, temperature sensors **104** and **106** may be thermistors. In one embodiment temperature sensors **104** and **106** may be electrical or electronic devices that provide an analog output signal. In another embodiment, temperature sensors **104** and **106** may be electrical or electronic devices that provide a digital output signal.

[0020] Temperature sensors **104** and **106** are configured to sense temperatures at different locations within housing **102**. For example, in the illustrated embodiment, temperature sensor **104** is mounted proximate to surface **110** and temperature sensor **106** is spaced apart from temperature sensor **104** and mounted proximate to surface **112**. Preferably, the spacing between temperature sensors **104** and **106** is the maximum possible spacing that housing **102** will permit. For example, in the illustrated embodiment, housing may be approximately 35 millimeters between surface **100** and surface **112**, with temperature sensor **104** mounted on the inside of a 2 millimeter thick base **116**, and with temperature sensor **106** mounted on the inside of a 1 mm thick cover **118**. Of course, in other embodiments, other spacings between temperature sensors **104** and **106** may be optimal.

[0021] Temperature sensor **104** may be configured to sense the temperature at or near the surface of a structure, such as a wall to which housing **102** is mounted, and to which mounting base **116** and surface **110** are adjacent. Temperature sensor **106** may be configured to sense the temperature of the air to which mating cover **118** and surface **112** are exposed. In another embodiment, temperature sensor **106** may be placed directly behind mating cover **118** in order to position temperature sensor **106** as close as possible to the air to which mating cover **118** and surface **112** are exposed (i.e., as far as possible from the wall to which housing **102** is mounted), and to minimize the response time required for temperature sensor **106** to detect changes in temperature of the air to which mating cover **118** and surface **112** are exposed. In the illustrated embodiment, the temperatures sensed by temperature sensors **104** and **106** are sensed primarily by the conduction of these temperatures through housing **102**. In another embodiment, housing **102** may also include openings or vents to permit the flow of air through housing **102**, and temperature sensor **106** may be mounted within housing **102** such that it is spaced apart from temperature sensor **104** while being exposed to the flow of air such that the temperature of the air flowing through housing **102** is sensed.

[0022] While the illustrated embodiment shows both sensors **104** and **106** mounted within housing **102**, other mounting locations are possible. For example, in one embodiment, temperature sensor **106** may be mounted outside housing **102**. In another embodiment, temperature sensing device **106** may be mounted on an extension to housing **102** to increase the distance between temperature sensor **104** and **106**. In yet another embodiment, temperature sensors **104** and **106** may be mounted in separate housings, so long as they are both in communication with processor **108**.

[0023] Processor **108** is coupled to temperature sensors **104** and **106** and may be any suitable processor. Processor **108** is configured to receive a temperature measurement from temperature sensor **104** and a temperature measurement from temperature sensor **106**. In the illustrated embodiment, processor **108** is shown as being coupled to temperature sensors **104** and **106** and mounted within housing **102**. **FIG. 2A** illustrates a block diagram of this configuration according to one exemplary embodiment. In this embodiment, temperature sensors **104** and **106** provide analog output signals to analog-to-digital (A/D) converters **220** and **222**. A/D converter **220** is coupled to processor **108** and provides a digital version of the analog output signal from temperature sensor **104** to processor **108**. A/D converter **222** is coupled to processor **108** and provides a digital version of the analog output signal from temperature sensor **106** to processor **108**. In another embodiment, the outputs of temperature sensors **104** and **106** may be multiplexed such that a single A/D may be used. Processor **108** is mounted within housing **102** and is coupled to communication port **224** such that it may communicate digital data or information via digital bus **226** to a controller **228** or other external device or system, such as a climate control system. In another embodiment, temperature sensors **104** and **106** provide a digital output signal such that analog-to-digital (A/D) converters **220** and **222** are not necessary.

[0024] In another embodiment, processor **108** is coupled to temperature sensors **104** and **106**, but is located external to housing **102**. **FIG. 2B** illustrates a block diagram of this configuration according to one exemplary embodiment. In this embodiment, temperature sensors **104** and **106** provide analog output signals to processor **108**, which is externally located in, for example, controller **228** or other external device or system, such as a climate control system. A/D converter **220** is coupled to processor **108** and provides a digital version of the analog output signal received from temperature sensor **104** to processor **108**. A/D converter **222** is coupled to processor **108** and provides a digital version of the analog output signal received from temperature sensor **106** to processor **108**. In another embodiment, temperature sensors **104** and **106** provide a digital output signal such that analog-to-digital (A/D) converters **220** and **222** are not necessary.

[0025] Processor **108** is also configured to use the temperature measurements from temperature sensors **104** and **106** to estimate a third temperature. For example, in one embodiment processor **108** may be configured to estimate the temperature of an air mass in a room or other area in which temperature sensing device **100** is mounted using temperature measurements from temperature sensors **104** and **106**. Because temperature sensing device **100** may be located on the boundary surface of the room air mass, neither temperature sensor **104** nor temperature sensor **106** may be sufficiently exposed to the actual temperature of the air mass. Additionally, temperature sensing device **100** may further be mounted to the surface of a structure, such as an exterior wall, such that it is exposed to various external or other temperature effects. Accordingly, in this embodiment processor **108** may be configured to estimate the third temperature from the temperature measurements from temperature sensors **104** and **106** by compensating for the various external temperature effects due to the mounting location of temperature sensing device **100**.

[0026] The third temperature may be estimated from the temperature measurements from temperature sensors **104** and **106** in a number of ways. For example, in one embodiment, the third temperature is estimated using a predetermined extrapolation function which defines an approximate mathematical relationship between the temperature measurements from temperature sensors **104** and **106** and the third temperature to be estimated. In other embodiments, methods other than mathematical extrapolation may be used alternatively or in addition to the extrapolation function.

[0027] The extrapolation function may be a linear extrapolation function, or alternatively, a non-linear extrapolation function. The particular choice of either a linear or non-linear extrapolation function depends upon the particular application and/or location of temperature sensing device **100**, as well as the desired level of accuracy. For example, the extrapolation function may be selected based on known or estimated environmental (e.g., airflows, etc.) or structural conditions (e.g., building materials, etc.) where temperature sensing device **100** is located. In one embodiment, where the air temperature distribution across a room in which temperature sensing device **100** is located is expected to be approximately linear based on known environmental or structural conditions (e.g., low airflow velocities through the room or area in which temperature sensing device **100** is mounted, or through temperature sensing device **100** itself), a first order linear extrapolation function of the form $y=mx+b$ may be used to estimate the third temperature, where y is the temperature to be estimated, m is a predetermined coefficient, x is the mathematical difference between the temperatures sensed by temperature sensors **104**, and **106**, and b is the temperature sensed by temperature sensor **104**. In other embodiments, a non-linear extrapolation function or a more complex linear extrapolation function may be used to compensate for additional or more complex factors such as, for example, erratic airflows in the room or area in which temperature sensing device **100** is mounted, or through temperature sensing device **100** itself, or different materials in either temperature sensing device **100** or in the exterior structure of the building structure to which temperature sensing device **100** is mounted. In other embodiments, the extrapolation function may also include additional terms or variables to accommodate additional temperature sensors or other inputs depending on the desired accuracy.

[0028] Any number of extrapolation functions may be used to estimate the third temperature. For example, in one embodiment, temperature sensing device **100** may use a first linear extrapolation function where the temperature sensed by temperature sensor **104** is lower than the temperature sensed by temperature sensor **106**, and a second linear extrapolation function where the temperature sensed by temperature sensor **104** is higher than the temperature sensor **106** to account for differing thermodynamic conditions to which temperature sensing device **100** is exposed. In other embodiments, additional or fewer extrapolation functions may be used.

[**0029**] The extrapolation function may also include one or more predetermined coefficients which may function as correction factors. Each correction factor may be determined based on, for example, the shape, size, and temperature sensor locations of device **100**, as well as the magnitude of known environmental or structural conditions such that the error of the temperature estimate from the extrapolation function is minimized. For example, in one embodiment using a first order linear extrapolation function of the form y=mx+b, the coefficient m may be a predetermined correction factor which compensates for the shape, size, and location of the temperature sensors of temperature sensing device **100**, as well as one or more known or estimated environmental or structural conditions of a building or room in which temperature sensing device **100** is located, such as known or estimated air flow velocities, room dimensions, expected outdoor and indoor temperature ranges, building materials, etc. In another embodiment, the predetermined correction factor may be determined using computational fluid dynamic (CFD) simulations. CFD similations utilize the size, shape, and sensor locations of temperature sensing device **100**, various estimated or known environmental and structural conditions, and various conservation of energy, mass and momentum equations in order to model, for example, the air mass in a room or area in which temperature sensing device **100** is located. For example, the CFD simulations may determine the contours of one or more temperature gradients due to external temperature effects in areas where temperature sensing device **100** may be located, which may then by used to determine each correction factor.

[**0030**] In this way, temperature sensing device **100** may compensate for errors due to external or other temperature effects such as a wall surface temperature that is significantly warmer or colder than the air temperature of the room or zone, or minimal airflow in the area where temperature sensing device **100** is located. Reduced errors in temperature measurements provide, for example, more accurate and efficient climate control system performance.

[**0031**] Temperature sensing device **100** may also be used to determine air temperature set points which improve the thermal comfort of an occupant in a room or area in which temperature sensing device **100** is located. For example, in a typical setting, thermal comfort may be achieved when the occupant's skin temperature is in a range of approximately 91.0 degrees Fahrenheit to 93.0 degrees Fahrenheit. Skin temperature is related to the balance between body heat generated by the occupant and body heat transfers in the form of body heat losses or gains to the environment of the room or area.

[**0032**] The dominant body heat transfer mechanisms are convection and radiation. Convective body heat transfer rates are a function of room air velocity and room air temperature. In most cases the room air velocity is constrained within narrow limits by, for example, the HVAC system design, and the air temperature is measured using a temperature sensor such as a thermostat. Accordingly, air temperature set points that provide thermal comfort, in the absence of significant radiation heat transfer, may be identified over time.

[**0033**] However, if radiation heat transfer rates are high, then occupants will not be comfortable using these air temperature set points. Radiation heat transfer rates are a direct function of photon exchange rates between the occupant and the surfaces of the room or area that encloses the occupant. The primary driving force for photon emission is temperature, and thermal comfort problems may occur when external surfaces of the room or area are warmer or colder than normal. This can occur, for example, when an external surface of a ceiling or wall associated with the room or area is in contact with the outdoors. Temperature sensing device **100** may be accordingly configured to sense the temperature at or around the wall or ceiling, estimate the associated radiation heat transfer rates, and estimate an air temperature set point to compensate for the radiation effects. Thus, occupant comfort may be improved when radiation heat transfer rates are high.

[**0034**] **FIG. 3** illustrates an embodiment of temperature sensing device **100** (shown in **FIG. 1**) wherein a temperature sensing device **300** is mounted to an exterior wall **350** of a building. Temperature sensing device **300** includes a housing **302**, temperature sensors **304** and **306**, and a processor **308**. Housing **302** is shaped such that it has a surface **310** and a surface **312** spaced apart from surface **310**. Surface **310** is configured to be adjacent to a surface **354** of exterior wall **350**, to which housing **302** is mounted, and surface **312** is configured to be spaced apart from surface **354** of exterior wall **350** and exposed to an air temperature at a distance from surface **354**. Temperature sensor **304** is mounted proximate to surface **310** of housing **302**, and temperature sensor **306** is mounted proximate to surface **312** of housing **302**. Temperature sensor **304** is configured to sense the temperature T_1 at or near surface **354** of exterior wall **350**, to which housing **302** is mounted, and to which surface **310** is adjacent. Temperature sensor **306** in this embodiment is configured to sense the temperature T_2 of the air at a distance from surface **354**. Temperature sensing device **300** is configured to estimate temperature T_{1A} of the air mass inside the room or area including exterior wall **350** using the temperature T_1 of surface **354** of exterior wall **350** sensed by temperature sensor **304**, and temperature T_2 of the air at a distance from surface **354** sensed by temperature sensor **306**.

[**0035**] In the illustrated embodiment, the temperature T_{OA} of the outside air is significantly lower than the temperature T_{1A} of the air inside a room or area including exterior wall **350**. The external effect of the lower outside air temperature T_{OA} on the inside air temperature T_{1A} is manifested in the form of several temperature gradients. The temperature graph shown in **FIG. 3** illustrates various temperature gradients that may be identified given several known or estimated environmental or structural conditions and using CFD simulations to model the air mass inside the room under these conditions. For example, a temperature gradient **360** may exist across the thickness of exterior wall **350** such that the temperature of wall **350** increases from exterior surface **352** to interior surface **354**. A temperature gradient **362** may exist across temperature sensing device **300** between surface

310 and surface 312 of housing 302. A temperature gradient 364 may exist between surface 312 of housing 302 and a distance beyond surface 312 at which temperature T_{1A} is to be estimated. Accordingly, due to the location of temperature sensing device 300 within a different temperature gradient than T_{1A}, neither the temperature sensed by temperature sensor 304 nor the temperature sensed by temperature sensor 306 is the actual temperature of the inside air T_{1A}.

[0036] Temperature sensing device 300 is configured to estimate temperature T_{1A} from T_1 and T_2 using one of the following two linear extrapolation functions:

$$T_{1A}=T_1+C_1(T_2-T_1) \quad (1)$$

$$T_{1A}=T_1+C_2(T_2-T_1) \quad (2)$$

[0037] where C_1 and C_2 are predetermined correction factors. Eq. (1) is used by temperature sensing device 300 where T_1 is lower than T_2, and Eq. (2) is used by temperature sensing device 300 where T_1 is higher than T_2. In this embodiment, two linear extrapolation functions are used in order to account for differing thermodynamic conditions. Linear extrapolation functions may used as an approximation of the temperature distribution across the room from surface 354 to the location where T_{1A} is to be estimated based on, for example, low airflow velocities in the room or through temperature sensing device 300. Predetermined correction factors C_1 and C_2 may be determined using, for example, CFD simulations, including the temperature gradients shown in **FIG. 3**.

[0038] According to Eq. (1), where T_1 is lower than T_2, the difference between T_2 and T_1 is multiplied by correction factor C_1 to estimate the increase in temperature from surface 354 to the location where T_{1A} is to be estimated. This quantity is then added to T_1 to estimate T_{1A}. For example, in one embodiment, C_1 may be set at 1.24, T_1 may be measured to be 56 degrees Fahrenheit, and T_2 may be measured to be 67 degrees Fahrenheit. According to Eq. (1), T_{1A} is estimated to be 69.64 degrees Fahrenheit, which represents a 2.64 degree compensation of the temperature measured by temperature sensor 306. Similarly, according to Eq. (2), where T_1 is higher than T_2, the difference between T_2 and T_1 is multiplied by correction factor C_2 to estimate the decrease in temperature from surface 354 to the location where T_{1A} is to be estimated. This quantity is then added to T_1 to estimate T_{1A}. For example, in one embodiment, C_1 may be set at 1.45, T_1 may be measured to be 67 degrees Fahrenheit, and T_2 may be measured to be 56 degrees Fahrenheit. According to Eq. (2), T_{1A} is estimated to be 51.05 degrees Fahrenheit, which represents a 4.95 degree compensation of the temperature measured by temperature sensor 306.

[0039] It should be understood that the construction and arrangement of the elements of the temperature sensing device in the exemplary embodiments are illustrative only. Although only a few embodiments of the present invention have been described in detail in this disclosure, many modifications are possible without materially departing from the novel teachings and advantages of the subject matter recited in the claims. For example, the temperature sensing device may be adapted for use in other systems or locations, may incorporate additional temperature sensors or other inputs, or may include other variables or factors in the extrapolation function. Accordingly, all such modifications are intended to be included within the scope of the present invention as defined in the appended claims. Unless specifically otherwise noted, the claims reciting a single particular element also encompass a plurality of such particular elements. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. In the claims, any means-plus-function clause is intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Other substitutions, modifications, changes and/or omissions may be made in the design, operating conditions and arrangement of the preferred and other exemplary embodiments without departing from the spirit of the present invention as expressed in the appended claims.

1. (canceled)

2. The temperature sensing device of claim 4, wherein the first and second temperature sensors are mounted in a housing.

3. The temperature sensing device of claim 4, wherein the second distance is greater than the first distance.

4. A temperature sensing device comprising:

a first temperature sensor configured for mounting to a structure at a first distance relative to the structure and configured to sense a first temperature;

a second temperature sensor configured for mounting to the structure at a second distance relative to the structure and configured to sense a second temperature; and

a processor coupled to the first and second temperature sensors and configured to estimate a third temperature based on the first and second temperatures and the distance separating the first and second temperature sensors, wherein the third temperature is an estimate of a temperature at a third distance from the structure, the third distance being greater than the first and second distances.

5. (canceled)

6. The method of claim 10, further including coupling a processor to the first and second temperature sensors, and wherein the third temperature is calculated by the processor.

7. The method of claim 6, wherein the first and second temperature sensors are mounted in a housing.

8. The method of claim 7, wherein the processor is mounted in the housing.

9. The method of claim 10, wherein the second distance is greater than the first distance.

10. A method of sensing temperatures in a room, comprising:

mounting a first temperature sensor to a structure in the room at a first distance relative to the structure;

mounting a second temperature sensor to the structure at a second distance relative to the structure;

measuring a first temperature with the first temperature sensor,

measuring a second temperature with the second temperature sensor, and

estimating a third temperature from the first and second temperatures, wherein the third temperature is an estimate of a temperature at a third distance from the structure, the third distance being greater than the first and second distances.

11. (canceled)
12. (canceled)
13. A temperature sensing device, comprising:

a housing;

a first temperature sensor mounted within the housing and configured to sense a first temperature;

a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor, and configured to sense a second temperature; and

a processor coupled to the first temperature sensor and the second temperature sensor and configured to estimate a third temperature using the first temperature and the second temperature, wherein the first temperature sensor is positioned proximate to a first surface of the housing and the second temperature sensor is positioned proximate to a second surface of the housing spaced apart from the first surface, and wherein the housing is configured to be mounted to a structure of a building such that the first surface is adjacent to a surface of the structure of the building.

14. The temperature sensing device of claim 13, wherein the first temperature is the temperature at or near the surface of the structure of the building.

15. The temperature sensing device of claim 14, wherein the structure of the building is a wall.

16. The temperature sensing device of claim 15, wherein the third temperature is an air temperature of a room including the wall.

17. (canceled)
18. A temperature sensing device, comprising:

a housing;

a first temperature sensor mounted within the housing and configured to sense a first temperature;

a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor, and configured to sense a second temperature; and

a processor coupled to the first temperature sensor and the second temperature sensor and configured to estimate a third temperature using the first temperature and the second temperature, wherein the third temperature is estimated from the first temperature and the second temperature using an extrapolation function, and wherein the extrapolation function is a linear extrapolation function.

19. The temperature sensing device of claim 21, wherein the extrapolation function is a non-linear extrapolation function.

20. The temperature sensing device of claim 18, wherein the extrapolation function includes a correction factor.

21. A temperature sensing device, comprising:

a housing;

a first temperature sensor mounted within the housing and configured to sense a first temperature;

a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor, and configured to sense a second temperature; and

a processor coupled to the first temperature sensor and the second temperature sensor and configured to estimate a third temperature using the first temperature and the second temperature, wherein the third temperature is estimated from the first temperature and the second temperature using an extrapolation function, and wherein the extrapolation function includes a correction factor, and wherein the correction factor is based on estimated environmental or structural conditions of a building.

22. A temperature sensing device, comprising:

a housing;

a first temperature sensor mounted within the housing and configured to sense a first temperature;

a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor, and configured to sense a second temperature; and

a processor coupled to the first temperature sensor and the second temperature sensor and configured to estimate a third temperature using the first temperature and the second temperature, wherein the temperature sensing device is a thermostat configured to be used with a climate control system.

23. The temperature sensing device of claim 22, wherein the climate control system is a heading, ventilating, and air conditioning system.

24. The temperature sensing device of claim 22, wherein the processor is mounted within the housing.

25. (canceled)
26. (canceled)
27. A method comprising:

measuring a first temperature using a first temperature sensor mounted within a housing;

measuring a second temperature using a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor; and

estimating a third temperature from the first temperature and the second temperature using a processor coupled to the first temperature sensor and the second temperature sensor, wherein the third temperature is estimated from the first temperature and the second temperature using an extrapolation function, and wherein the extrapolation function is a linear extrapolation function.

28. The method of claim 30, wherein the extrapolation function is a non-linear extrapolation function.

29. The method of claim 27, wherein the extrapolation function includes a correction factor.

30. A method comprising:

measuring a first temperature using a first temperature sensor mounted within a housing;

measuring a second temperature using a second temperature sensor mounted within the housing and spaced apart from the first temperature sensor; and

estimating a third temperature from the first temperature and the second temperature using a processor coupled to the first temperature sensor and the second temperature sensor, wherein the third temperature is estimated from the first temperature and the second temperature using an extrapolation function, and wherein the extrapolation function includes a correction factor, and wherein the correction factor is based on estimated environmental or structural conditions of a building.

31. The method of claim 30, wherein the first temperature sensor is positioned proximate to a first surface of the housing and the second temperature sensor is positioned proximate to a second surface of the housing.

32. The method of claim 31, wherein the housing is configured to be mounted to a structure of a building such that the first surface is exposed to a surface of the structure of the building.

33. The method of claim 32, wherein the first temperature is the temperature at or near the surface of the structure of the building.

34. The method of claim 33, wherein the structure of the building is a wall.

35. The method of claim 34, wherein the third temperature is an air temperature of a room including the wall.

36. (canceled)

37. (canceled)

38. A temperature sensing device, comprising:

a housing;

a first temperature sensing means mounted within the housing and configured to sense a first temperature;

a second temperature sensing means mounted within the housing and spaced apart from the first temperature sensing means, and configured to sense a second temperature; and

means coupled to the first temperature sensor and the second temperature sensor for estimating a third temperature from the first temperature and the second temperature, wherein the first temperature sensor is positioned proximate to a first surface of the housing and the second temperature sensor is positioned proximate to a second surface of the housing, and wherein the housing is configured to be mounted to a structure of a building such that the first surface is adjacent to a surface of the structure of the building.

39. The temperature sensing device of claim 38, wherein the first temperature is the temperature of the surface of the structure of the building.

40. The temperature sensing device of claim 39, wherein the structure of the building is a wall.

41. A temperature sensing device, comprising:

a housing;

a first temperature sensing means mounted within the housing and configured to sense a first temperature;

a second temperature sensing means mounted within the housing and spaced apart from the first temperature sensing means, and configured to sense a second temperature; and

means coupled to the first temperature sensor and the second temperature sensor for estimating a third temperature from the first temperature and the second temperature, wherein the third temperature is an air temperature of a room including the wall.

42. A temperature sensing device, comprising:

a housing;

a first temperature sensing means mounted within the housing and configured to sense a first temperature;

a second temperature sensing means mounted within the housing and spaced apart from the first temperature sensing means, and configured to sense a second temperature; and

means coupled to the first temperature sensor and the second temperature sensor for estimating a third temperature from the first temperature and the second temperature, wherein the temperature sensing device is a thermostat configured to be used with a climate control system.

43. The temperature sensing device of claim 42, wherein the climate control system is a heating, ventilating, and air conditioning system.

44. A temperature sensing device comprising:

a first temperature sensor configured to sense a first temperature;

a second temperature sensor spaced apart from the first temperature sensor, and configured to sense a second temperature; and

a processor coupled to the first temperature sensor and the second temperature sensor and configured to:

estimate a heat transfer rate associated with at least one of the first temperature and the second temperature; and

determine an air temperature set point based on the heat transfer rate.

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