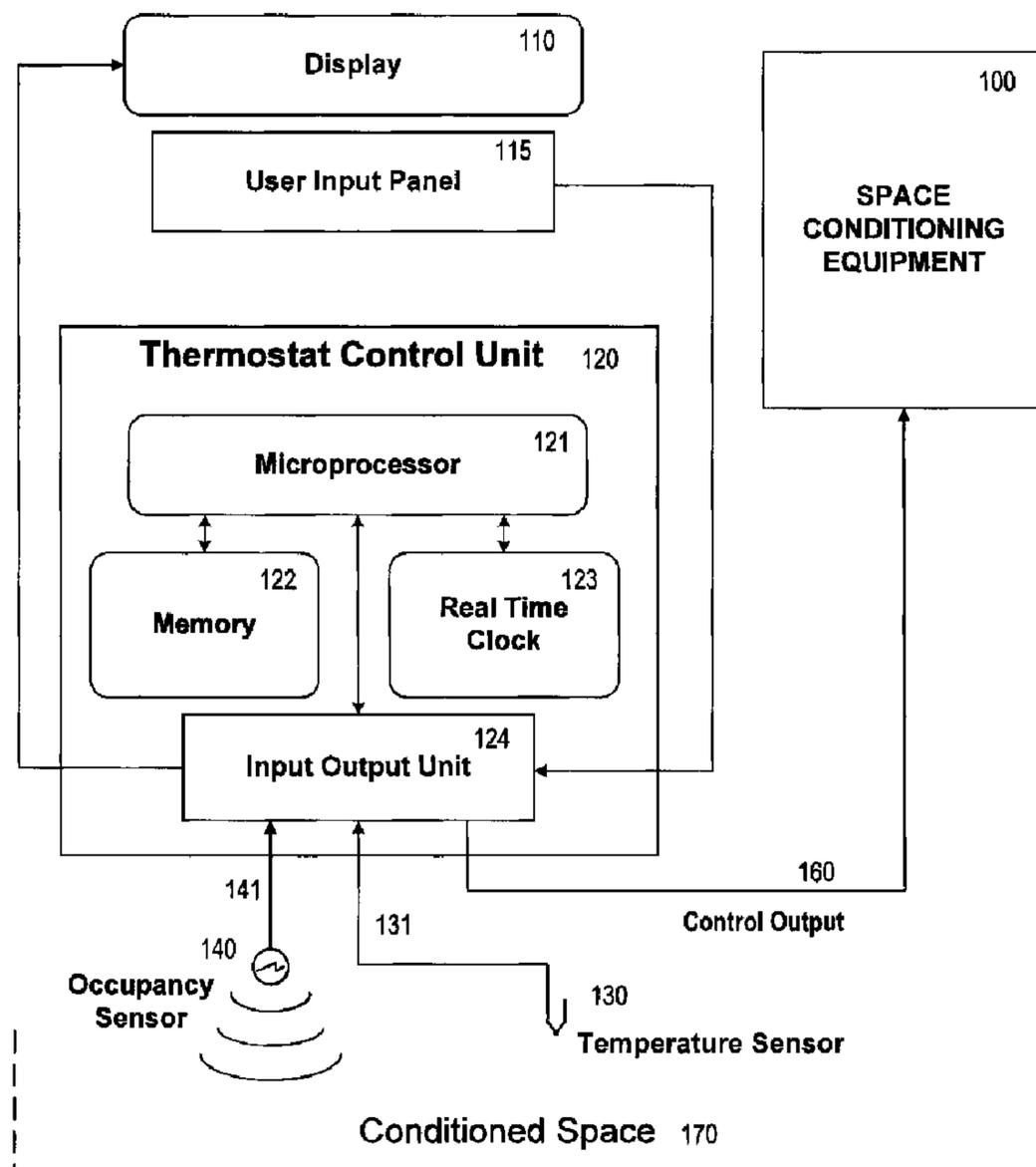




(22) Date de dépôt/Filing Date: 2008/06/20
 (41) Mise à la disp. pub./Open to Public Insp.: 2008/09/08
 (45) Date de délivrance/Issue Date: 2011/01/25
 (30) Priorité/Priority: 2007/10/29 (US11/926,950)

(51) Cl.Int./Int.Cl. *G05D 23/19* (2006.01),
F24D 19/00 (2006.01), *F24F 11/00* (2006.01)
 (72) Inventeur/Inventor:
ROSEN, HOWARD, CA
 (73) Propriétaire/Owner:
ROSEN, HOWARD, CA
 (74) Agent: GOWLING LAFLEUR HENDERSON LLP

(54) Titre : THERMOSTAT PROGRAMMABLE AVEC REGLAGE PREEMPTIF BASE SUR LA DETECTION D'UN OCCUPANT
 (54) Title: PROGRAMMABLE THERMOSTAT WITH PREEMPTIVE SETPOINT ADAPTATION BASED UPON DETECTION OF OCCUPANCY



(57) Abrégé/Abstract:

A thermostat system which incorporates a mechanism for detecting occupancy in a room or area in which a programmable thermostat is located when combined with user programming facility provides the ability for establishing programming sequences



(57) **Abrégé(suite)/Abstract(continued):**

that can reduce energy usage while still providing for comfort. The inclusion of a mechanism for detecting occupancy in the programmable thermostat increases the convenience and efficiency of operation by allowing a thermostat program to normally run in a user specified time-based temperature sequence mode designed for increased energy saving, and then to having that mode of normal operation automatically preempted when occupancy is detected.

ABSTRACT OF THE DISCLOSURE

A thermostat system which incorporates a mechanism for detecting occupancy in a room or area in which a programmable thermostat is located when combined with user programming facility provides the ability for establishing programming sequences that can reduce energy usage while still providing for comfort. The inclusion of a mechanism for detecting occupancy in the programmable thermostat increases the convenience and efficiency of operation by allowing a thermostat program to normally run in a user specified time-based temperature sequence mode designed for increased energy saving, and then to having that mode of normal operation automatically preempted when occupancy is detected.

**PROGRAMMABLE THERMOSTAT WITH PREEMPTIVE SETPOINT
ADAPTATION BASED UPON DETECTION OF OCCUPANCY**

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FIELD OF THE INVENTION

10 This invention relates to the art of environmental control systems and more particularly to the art of programmable thermostats. Additional related fields of art include electric heating, electric heaters, electric baseboard heaters, air-conditioning system control, thermostats, energy conservation, energy management, motion detectors, and occupancy sensors.

BACKGROUND OF THE INVENTION

15 Energy usage for environmental control, especially for heating or cooling, is a major expense in many homes and businesses. Even minor changes in environmental control procedures can result in significant energy savings. Typical approaches for saving energy include such procedures as manually turning off a heating or cooling system when a room is not used, or reducing the level of heating or cooling based upon some algorithm of
20 programmed control in a thermostat. It is common in thermostats intended for home use to provide programmable features allowing for temperature settings that are dependent upon the time of day, and also upon the day of the week with the desired temperature being set based upon the user's prediction of needs for heating or cooling, or possibly to shift energy usage to a time of day or day of the week when energy costs are lower.

25 When a user programs a programmable thermostat, the prediction of need and the setting of the programmed temperatures may be based upon the user's occupancy predictions, the typical use of a specific area or room, or to take into account lower cost energy during certain times of the day or on certain days of the week such as weekends. It is often true that rooms or areas of certain office buildings or houses are unoccupied on certain days, for
30 example weekends, which provides opportunity for potentially reducing energy usage. It may

also often be the case that a room or area is often unused or unoccupied during certain periods of a day or a room may be used only at night.

Prior art programmable thermostats for use in a home have provided for a user of the thermostat to input a user program which sets a desired temperature as the thermostat's setpoint temperature at or during user programmed times of the day, with typical provision for four periods of programming each day being common. Programmable thermostats also may provide for programmed settings that can be varied by the day of the week.

Typical programmable thermostats for home use however do not automatically provide for unpredictable or varying patterns of occupancy, or patterns of occupancy which may change over periods of time such as days, weeks, months, or seasons. For example, a person coming home from work unexpectedly in the middle of the day may have to manually override the programmed thermostat settings in order to achieve a comfortable environment. Also, a thermostat programmed to provide a certain level of comfort at night may waste energy if nobody is at home for one night or a few nights, particularly if the absence is unexpected or if there is no opportunity for the previously programmed settings to be manually changed by the user.

In environments such as a motel or hotel room, further difficulties in reducing energy use are encountered. Varying desires of individual guests and unpredictable patterns of occupancy make it difficult to predict a pattern of temperature settings that might be acceptable to a guest or desirable for energy savings. For these reasons programmable thermostats are often not chosen for use in many motels or hotels.

It is also often true that completely turning off a heating or cooling system, or manually changing the temperature setting too far away from a comfortable setting, makes the recovery time for achieving comfort in a room too long to be acceptable. For example, if the heating system were to be turned completely off on a very cold day, and the temperature in the room fell to 45 degrees Fahrenheit, the time to heat a typical motel room with a heat pump to a comfortable level when the desired temperature was changed to 72 degrees would be too long to suit the desires of many discriminating guests. In this case it would be advantageous to strike a compromise between saving energy and maintaining a programmed temperature.

Therefore, there is need for an improved programmable thermostat that would provide opportunity for potentially lower energy usage and reduced need for user interaction while achieving lower energy usage.

BRIEF SUMMARY OF THE INVENTION

The present invention provides an improved thermostat system and method described in an illustrated embodiment which incorporates a mechanism for detecting occupancy in a room or area in which a programmable thermostat is located with opportunity for programming that can reduce energy usage while still providing for comfort. The inclusion of a means for detection of occupancy in a programmable thermostat increases the convenience of operation by allowing a thermostat program to normally run in a mode designed for saving energy, and then to have that mode of normal operation preempted when occupancy is detected. This allows for reduced energy usage while still providing for comfort, without requiring manual override of the thermostat settings as a person enters a room or area, and without requiring that the person again interact with the thermostat when departing. The user programming for the unoccupied state can be optimized by the user for saving energy more so than just providing programming for comfortable temperatures during periods of occupancy as allowed by thermostats in the prior art.

DESCRIPTION OF THE DRAWINGS

The subject matter of the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, may better be understood by reference to the following description taken in conjunction with the subjoined claims and the accompanying drawing of which:

FIG. 1 is a diagram showing space conditioning equipment controlled by a programmable thermostat system which incorporates the teachings of the present invention that includes a programmable thermostat with input from a temperature sensor, a display, a user input panel for providing user input for programming, a thermostat control unit controlling operation of the thermostat system, and a motion detector serving as an occupancy detector providing an indication of occupancy to the thermostat control unit's microprocessor for the thermostat system;

FIG. 2 is a diagram showing a electric heater powered from house power connected through a programmable thermostat system that includes a programmable thermostat with input from a temperature sensor, a display, a user input panel providing for user input in programming the thermostat, a thermostat control unit controlling operation of the overall thermostat system, a triac device gated under control of the thermostat control unit for gating

house power through to an electric heater, and a motion detector serving as an occupancy detector providing an indication to the thermostat control unit of occupancy in the room or area in which the thermostat is mounted;

FIG. 3 is a diagram showing data on a touch sensitive display screen as might be used to provide user input describing a user's time-based normal thermostat control sequence intended by the user to be followed when no occupancy has been detected;

FIG. 4 is a diagram showing data on a touch sensitive display screen as might be used to provide user input specifying a preset comfortable room temperature to be used by the thermostat control program as the thermostat setting during periods of occupancy in accordance with the teachings of the present invention;

FIG. 5 is a diagram showing an example of data on a touch sensitive display screen as might be used to provide user input describing a user's time-based comfortable thermostat control sequence intended by the user to be followed when occupancy has been detected in accordance with teachings of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In a room or area such as a house or motel room it would be advantageous to reduce the cost of cooling or heating the room or area by providing a programmed time-based thermostat control sequence designed for energy savings and running that program as the normal case as long as the room or area is unoccupied. Programmable thermostats of the prior art as typically used in homes have provided for four periods of programming for each day of the week, with allowance for a thermostat setting that is different during each period of programming. Some thermostats of the prior art have also had occupancy sensors incorporated or attached to the thermostats, and allowed for invocation of a specific setback temperature at when no occupancy was determined.

The present invention improves over the prior art by providing in an illustrated embodiment, a programmable thermostat system for control of a heating or cooling system with provision for attachment or inclusion of an occupancy sensor which provides an indication of current occupancy to the thermostat system. A thermostat control unit included as part of the thermostat system in the illustrated embodiment provides for user programming that directly addresses the goal of energy savings during periods of no occupancy which is when the most energy can be conserved. Provision is made for automatic preemption of a

user's normal time-based thermostat control sequence when occupancy is detected which allows for using a programmed sequence during the unoccupied state with potential for more energy reduction than might be chosen if the override of the programmed settings was not automatic, or if the normal user programming were to be applied only while occupied.

5 As an example of how energy savings may be achieved with specific teachings of the present invention it is helpful to illustrate with an example. For example, it may be known by the occupant of a house that a room in the basement is only occasionally used during the evening when people are watching television. The room is not used every night, and the starting and ending times for usage vary significantly. During the winter the room is heated
10 with a baseboard heater that draws a significant amount of electricity because the room is not well insulated.

Without an occupancy sensor the user might choose a program that allows the temperature of the room to be fairly cool during the day, a little warmer in the early afternoon in case someone comes home early, then nice and warm during the evening and into the night
15 when someone might be watching television, and then once again fairly cool for the rest of the night when nobody is expected to be in the room.

With the programmable thermostat system having an occupancy sensor and automatic preemption of the normal program when occupancy occurs, the user might choose a modified approach to programming the thermostat that achieves significant energy savings
20 over the first approach. For example, the user might choose a significantly lower temperature during the early afternoon and evening than chosen with a thermostat of the prior art knowing that the baseboard heater can respond quickly if and when occupancy is detected and heat the room to a comfortable temperature. In a similar manner the user may choose to allow the room temperature to drift significantly colder during the night, and also during the day when
25 nobody is expected to be home. This would result in significant energy savings on days when the room is unused or lightly used. The automatic occupancy response still provides for comfort without manually touching the thermostat settings if a person came home during the day to watch television for a short time and then potentially saves some energy by lowering the thermostat setting even if the person leaves without further thought about the thermostat
30 or energy savings.

As another example, in a room or area which is a motel or hotel room it is again advantageous to reduce the cost of electrical heating by lowering the heat applied during

periods of non-use or no occupancy. Many motel and hotel rooms are unoccupied during much of the day. The power to an electric heater can be shut off when the room is not occupied, and turned on as needed when the room becomes occupied. In many motel rooms this is routinely done by having someone turn off the heater when a guest leaves, and then
5 either a motel person turns on the heater when a guest arrives or is about to arrive, or the guest turns on the heater when he or she enters the room. A problem with having motel or hotel personnel turn off the heater is that this may mean that the heater stays on for some period of time after a guest has left before it is convenient to enter the room and adjust the thermostat.

Another problem with switching the heater completely off during a period of no
10 occupancy is that the room may become too cold and it may take too long to recover and heat the room to a comfortable level when a guest arrives. The manual turning on or off of the heater also requires that task be done by people, who may forget or neglect to do that, thus potentially wasting energy that could have been saved. It is thus an advantageous approach of the present invention to provide a thermostat that automatically turns on the heat when
15 occupancy of the room is detected. It is a further advantage of the present invention to provide for following a programmable thermostat control sequence during periods of no occupancy that provides less setback of the temperature during periods when occupancy might be expected. That is, the invention provides for programming which anticipates possible occupancy during periods of no occupancy. This allows for energy savings to be
20 achieved while still providing reasonable response time in recovery during periods when occupancy is expected, but without wastefully changing the temperature completely to the temperature that would be invoked if occupancy were actually sensed.

Determination of occupancy or non-occupancy is not a completely trivial subject but is well known in the state of the art. For example, with a motion detector device such as an
25 infrared motion detector for determining occupancy a timer might be required to determine how often an occupant has to physically move in order to keep the condition of occupancy satisfied. The sensing mechanism has to be sensitive enough to continue a detection of occupancy even when a person is sitting fairly still or sleeping. A motion detector that detects infrared signals as from body heat is one good choice for an occupancy sensor because it
30 would be less likely to give a false signal due to curtains moving, for example. However, a false detection of no occupancy is not a fatal flaw with regards to operation of the present invention because when someone is in the room it is quite likely they will eventually move

enough to be noticed by a detector designed for that purpose. Even if they do not move for a time beyond that which might normally be expected and the control program enters a state where comfort is reduced, the system will still continue to run and recover eventually when occupancy is again detected. It is noted that the term occupancy sensor throughout discussion
5 of the present invention is intended to refer to a device which automatically senses occupancy without any interaction with the device by a person or user of the thermostat. An infrared motion detector is an example of a good device for serving as an occupancy sensor and sensing occupancy of an area near to the device.

Electric heaters and electric baseboard heaters are heavy users of electricity and
10 rooms in which these are installed can often be heated quite quickly when the heater is turned fully on as long as the room is not extremely cold, meaning that the recovery time is quite reasonable when occupancy is detected and a comfortable temperature is now what is desired.

Air-conditioning compressors are also heavy users of electricity and programming a thermostat in control of these units to follow a program designed for reducing energy usage
15 can provide significant energy and cost savings. In particular reducing usage at night or during periods of expected no occupancy can provide significant savings.

Electrical rates which vary based upon time of day or day of the week also provide opportunity for programming that saves energy and are particularly adaptable to savings using the teachings of the present invention. A thermostat control sequence might be chosen which
20 changes the setpoint temperature (the desired conditioned space temperature) significantly based upon the time periods during which electricity is most expensive. During peak periods a much larger setback might be utilized during periods of no occupancy, in comparison to the setback that might be desired during periods of more moderate energy cost.

Thus, as just discussed, one improvement offered by the present invention is to
25 utilize a detection of occupancy to invoke a preemption of a user's time based normal thermostat control sequence designed for maximum energy savings, in contrast to the prior art approach which provided for a detection of no occupancy causing an override of what had been a programmed temperature control sequence used during periods of detected occupancy.

A second further improvement is to provide for two user programmed thermostat
30 control sequences, one for use when occupancy is not determined, and a second for preemptive use when occupancy is determined. This approach is a further enhancement which provides for user programmable comfort to be set during periods of occupancy without

impacting the savings that can be achieved during the normal unoccupied state. For example, a family room might be kept cool during the day when people are passing through the room or there is significant activity, and then kept just a little warmer while occupied during the evening when people might be just sitting and watching television, or doing homework.

5 Detection of occupancy can be further enhanced by providing for an occupancy sensor or multiple occupancy sensors which are remote to the thermostat unit itself. For example, a thermostat unit with an occupancy sensor mounted in a hallway might not provide as good an indication of occupancy anywhere in the house as would be provided by a remote occupancy sensing unit mounted in the kitchen. Using multiple remote occupancy sensors
10 which can transmit signals to the thermostat unit may help the thermostat system in more accurately determining occupancy, for example in a large house with many rooms served by the same space conditioning equipment.

A further provision that may be utilized with the present invention for added energy savings is to provide as part of the thermostat user interface a way to override the sensing of
15 occupancy. This can be accomplished by providing an additional user input mechanism such as a button on a thermostat's touch sensitive display screen that tells the thermostat control unit to override the occupancy detection for a defined period, with the period being increased if the button is touched multiple times. For example, if someone enters the room and is already comfortable with the current temperature, or if they plan to be in the room for only a
20 short time, or if they are going in and out of the room but do not want a more costly user programmed thermostat control sequence to be invoked, they can touch the occupancy override button a few times and keep the thermostat either temporarily or permanently in the more economical mode. The user might also be provided with a way to select a mode of occupancy suspension which disables the occupancy sensor response until the selection is
25 removed by the user. A first touch of the occupancy override button might override the occupancy detection for a period of 15 minutes, a second for 30 minutes, a third for 1 hour and so on with the largest time being the mode of occupancy suspension. After that, another push of the button would cycle back to the mode where occupancy detection is again enabled. A user might also select the mode of occupancy detection suspension by holding the button a
30 significant amount of time more than one might normally hold a button such as more than two seconds.

If multiple occupancy sensors are utilized to achieve a wider coverage and better detection of occupancy in the conditioned space, a means for disabling occupancy detection on any one or more or all occupancy sensors is a further enhancement to the invention. The choice of disablement might be implemented utilizing a user input mechanism on the occupancy sensor itself, or by selection through user input at the programmable thermostat itself.

Another further provision in the illustrated embodiment of the present invention for added energy savings is to utilize the occupancy sensor to determine, in addition to occupancy, a level of activity in the room or area near the occupancy sensor. An occupancy sensor implemented as a motion detector circuit will provide a signal of occupancy whenever movement is detected. The thermostat control program can determine the frequency of any movement being detected in the room or area and if the frequency of detected movement is high the control program might decide that the room is being used by active people and that the temperature required for comfort might be lower in comparison to what would be needed if the room were occupied but with little activity or motion by the occupants. At a different time of day such as at night, a low level of activity might provide indication that the room is occupied but the occupant is asleep and that the temperature might be reduced while still retaining comfort. The level of activity could be used to select an alternate user provided thermostat control sequence with temperature settings dependent not only on the time of day or day of week with occupancy consideration, but also with the level of activity considered. An alternative implementation would be to provide an adjustment based upon level of activity to an already provided thermostat control sequence as another set of parameters provided as part of the user input.

For energy savings, electric heaters provide added opportunity for energy savings. In many motel rooms and houses heating is provided by electric heaters which produce heat from electrical energy and which are powered from the house electrical system. Oftentimes these heaters are "baseboard" heaters, so named because they are mounted along the baseboard of the walls in a room. These heaters are a fairly large user of electricity typically drawing more than 1 kWatt of power and often several kWatts of power. The electric heaters are controlled by a thermostat which includes an electrical gating device such as a mechanical relay or electronic switch.

A thermostat system for control of an electric baseboard heater utilizing the teachings of the present invention and a system which incorporates a thermostat, a triac switching device, a motion detector, a control program with a means for changing the settings of the control program provides for significant improvement over baseboard heaters of the prior art.

5 The quick recovery time achievable by electric baseboard heaters allows for user programming during unoccupied periods to maximize energy savings, while still providing automatic recovery in a reasonable time when occupancy is detected.

DESCRIPTION OF THE ILLUSTRATED

EMBODIMENT(S) OF THE PRESENT INVENTION

10 Certain aspects of the illustrated embodiment will now be described in greater detail with reference to the figures of the drawings.

FIG. 1 is a diagram showing space conditioning equipment 100 controlled by a programmable thermostat system that includes a programmable thermostat with input from a temperature sensor 130, a display illustrated as a liquid crystal display 110, a user input panel
15 115 for providing user input for programming, a thermostat control unit 120 controlling operation of the thermostat system, and a motion detector serving as an occupancy detector 140 providing an indication of occupancy for the room in which the thermostat is mounted to the thermostat control unit's microprocessor for the thermostat system.

The space conditioning equipment 100 provides conditioned air to the room 170
20 which is in the conditioned space. The conditioning can be in the form of heating or cooling or with other conditioning such as for humidity. The temperature sensor 130 and the occupancy sensor 140 provide input to the thermostat control unit.

The thermostat control unit 120 includes a microprocessor 121 for running a thermostat control program contained in memory 122, a real time clock 123, an input / output
25 unit, and other devices if or as necessary to support the microprocessor such as a power regulator and a timing crystal.

A display 110, which may be a liquid crystal display or other display type, serves as a mechanism for displaying various alphanumeric messages and icons which may be used to prompt the user for user programming and also for displaying system status, room
30 temperature, the time of day and other items that might be of interest to the thermostat system user.

The user input panel 115 may be implemented as a touch screen detector as an attachment or as part of the liquid crystal display, with buttons for touching being displayed on the liquid crystal display. The user input panel may also be buttons or touch sensors separate from the display, and may incorporate wheels, joystick type switches, trackballs, or other types of switches and sensors for user input.

The microprogram processor of the thermostat control unit generally performs many functions as part of its programming relating to maintenance of the display, monitoring the data inputs which come from the temperature sensor, and the motion detector, and other functions or threads necessary to implement the concepts of present invention, and also in general support of the functions of the thermostat system..

The microprogram processor has access to a real time clock 123 which is used to determine when to invoke temperature settings provided as programming by the thermostat user. The real time clock may be part of the microprocessor itself, or as another device part of the thermostat control unit. The real time clock may also be settable by the microprocessor.

The occupancy sensor device 140 and temperature sensor device 130 in one embodiment are contained within the housing of the thermostat system. In another illustrated embodiment either of these devices may be located external to the thermostat system with connections 141 and 131 respectively to the thermostat control unit.

If multiple occupancy sensors are in use, then a connection from each occupancy sensor to the thermostat control unit is provided. The connection of occupancy sensors can be by wire, by RF signal, or other wireless signal. The temperature sensor connection would typically be connected by wiring but could also be wireless if desired.

In this FIG. 1 illustration, the thermostat control unit sends signals over a wire 160 to the space conditioning equipment as control for the equipment. The thermostat control unit causes the space conditioning equipment to turn on heating or cooling to the conditioned space. The signal wire 160 might be replaced by a wireless type signal if desired.

FIG. 2 is a diagram showing a electric heater 200 powered from house power 220 connected through a programmable thermostat system including an input to a thermostat control unit 120 from a temperature sensor 130, a display 110 which is a liquid crystal display, a user input panel 115 providing for user input in programming the thermostat, the thermostat control unit 120 including a microprocessor with a memory controlling operation of the overall thermostat system, a triac device 240 gated under control by a control signal

260 from the thermostat control unit and gating house power 220 through as gated power 250 to the heating elements 201 of the electric heater 200, and a motion detector serving as an occupancy detector 140 providing an indication to the thermostat control unit of occupancy in the room or area in which the thermostat is mounted. The programmable thermostat system in FIG. 2 functions in manner similar to that shown in FIG. 1 but with adaptation for controlling an electric heater directly instead of sending signals to the space conditioning equipment. In FIG. 2, the space conditioning equipment being controlled is an electric heater, and the triac device 240 acts as an electronic switch with an input gating signal for turning on or allowing the house power through to the electric heater. The gating signal to the triac device 260 is an output from the thermostat control unit and used in manner similar to the signal wire 160 in FIG. 1 to turn on or off power to the electric heater' heating elements.

FIG. 3 is a diagram showing data on a touch sensitive display screen 300 as might be used to provide user input describing a user's time based normal thermostat control sequence intended by the user to be followed when no occupancy has been detected, as indicated by the data on the programming status screen. In the illustration four periods of programming 310 for each day are displayed but any number of periods could be provided. Days of the week 320 for alternative programming can be selected. This style of programming is for exemplary purposes only. Other styles of methods of programming could be designed by one knowledgeable in the state of the art without deviating from the teachings of this present invention.

FIG. 4 is a diagram showing data on a touch sensitive display screen as might be used to provide user input specifying a preset comfortable room temperature 400 to be used by the thermostat control program as the thermostat setting during periods of occupancy. In one embodiment, this value of temperature is provided by the user of the thermostat as the temperature to be used as the set temperature for the thermostat when occupancy is detected. That is, this is the temperature that is used when the normal thermostat sequence chosen during periods of no occupancy is preempted.

FIG. 5 is a diagram showing data on a touch sensitive display screen 500 as might be used to provide user input describing a user's time based comfortable thermostat control sequence intended by the user to be followed when occupancy has been detected. This user input program is part of an alternate embodiment of the invention which provides more flexibility in programming than the illustrative single temperature shown in FIG. 4. In this

FIG. 5 illustration, the user input screen 500 for programming the second thermostat control sequence programmed for use during periods of detected occupancy is shown, with the screen as shown in FIG. 3 showing the user input screen 300 which might be used for programming to be used during periods of no occupancy.

5 It will be appreciated that the present invention is not in any limited by the packaging of the devices. In addition, circuitry of the thermostat, the triac device, the thermostat control unit processing circuitry or other elements disclosed in connection with describing the invention may be changed without affecting the novel aspects of the invention. For example, the processing circuitry of the thermostat may be implemented in an Field
10 Programmable Gate Array (FPGA) or gate array chip without departing from the teachings of the present invention. The triac may be contained in a package with processing circuitry of its own or in conjunction with the processing circuitry of the thermostat, or all elements of the invention could be combined and packaged as a unit. The occupancy sensor can be a motion detector mounted as part of package housing the thermostat or externally from the thermostat
15 housing, but connected to the thermostat.

 In addition the thermostat control unit and the microprogram processor may be designed or packaged in many ways by a person knowledgeable in the state of the art. For example, the memory may be contained on the same silicon chip as the microprogram processor, and the input / output unit may be separate from the microprogram processor or on
20 the same chip. Some parts of the memory may be flash memory, Read-Only Memory (ROM) memory, or Random Access memory (RAM) memory.

 Thus, while the principles of the invention have now been made clear in an illustrative embodiment, there will be immediately obvious to those skilled in the art many modifications of structure, arrangements, the elements, circuitry, materials, and components,
25 used in the practice of the invention which are particularly adapted for specific environments and operating requirements without departing from those principles.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A compact programmable thermostat apparatus for controlling space conditioning equipment serving a conditioned space comprising:

A) a temperature sensor providing an electrical signal indicative of temperature of the conditioned space;

B) an occupancy sensor providing a signal indicative of current occupancy of the conditioned space;

C) a user interface mechanism including a display for selectively displaying an alphanumeric message, and a user input mechanism for entering user programming information including:

1) user time based normal program information which specifies a user programmable time based normal thermostat control sequence including multiple temperature settings dependent on time of day and day of week for use during periods of no occupancy; and

2) a user desired preset comfortable room temperature value specified for use during periods of occupancy;

D) a thermostat control unit, said thermostat control unit including:

1) a microprocessor for controlling operation of the thermostat control unit in response to a thermostat control program and the entered user programming information;

2) a memory operatively coupled to said microprocessor for storing the thermostat control program and data, the user time based normal program

information and the user desired preset comfortable room temperature value;

3) a real time clock connected to be accessible by the microprocessor for determining current date and time information;

4) an input/output unit operatively coupled to said microprocessor including:

a) a first sensor input for receiving the electrical signal indicative of temperature of the conditioned space from said temperature sensor;

b) a second sensor input for receiving the signal indicative of current occupancy of the conditioned space from said occupancy sensor;

c) a control output for issuing control signals to be used in controlling the space conditioning equipment in response to the thermostat control program;

d) an output connection to the display providing data to the display from the microprocessor generated in response to the thermostat control program; and

e) an input connection coupled to the user input mechanism for receiving the user programming information;

E) the microprocessor under control of the thermostat control program of the thermostat control unit being operative for calculating and maintaining a currently desired conditioned space temperature to be used for comparison with the electrical signal indicative of temperature of the conditioned space received from the temperature sensor, and for issuing an output control signal to the space conditioning equipment causing it to bring the conditioned space temperature closer to the user desired preset comfortable room temperature value;

F) in the absence of a signal of current occupancy, the microprocessor under control of the thermostat control program setting the currently desired value for conditioned space temperature to follow the user time based normal thermostat control sequence; and,

G) upon receiving a signal of occupancy, the microprocessor under control of the thermostat control program preempting the following of any previous user programmable thermostat control sequence and changing the currently user desired temperature specified for the conditioned space to the preset comfortable room temperature, the microprocessor thereafter maintaining the currently desired temperature for the conditioned space at the user desired preset comfortable room temperature value until the signal of occupancy has been continuously absent for a pre-established interval of time and then resuming processing as though no interruption of the user programmable time based normal thermostat control sequence had occurred.

2. The compact programmable thermostat apparatus of claim 1, wherein the apparatus is contained in a single package as a unit that is typically mounted on a wall within a room or area served by the space conditioning equipment.

3. The compact programmable thermostat apparatus of claim 1, wherein the apparatus excluding the occupancy sensor is contained in a single package as a thermostat unit that is typically mounted on a wall within a room or area served by the space conditioning equipment, the occupancy sensor being contained in a package external to the thermostat

and operatively coupled to the second sensor of the input/output unit for purpose of sending said signal indicative of current occupancy and located within the conditioned space.

4. The compact programmable thermostat apparatus of claim 1, wherein the space conditioning equipment to be controlled is an electric heater and the compact programmable thermostat apparatus further includes:

A) an electronic switch which is a triac device connected so as to be gated by the control output of the input/output unit of the thermostat control unit, and which is then used to gate house power for supply to the space conditioning equipment.

5. The compact programmable thermostat apparatus of claim 1, wherein the space conditioning equipment to be controlled is an electric baseboard heater and the thermostat control unit further includes:

A) an electronic switch which is a triac device connected so as to be gated by the control output of the input/output unit of the thermostat control unit, and then used to gate house power for supply to the space conditioning equipment.

6. The compact programmable thermostat apparatus of claim 1, further including:

A) an input button implemented as part of the user interface mechanism for easy accessibility, the input button being used to override any detection of current occupancy by the occupancy sensor and causes the microprocessor under control of the thermostat control program to resume processing as though no interruption

of the thermostat control sequence had occurred, thus invoking the normal thermostat control sequence normally intended for use when the conditioned space is unoccupied.

7. The compact programmable thermostat apparatus of claim 1 wherein said occupancy detector includes a motion detector, and wherein:

A) the microprocessor under control of the thermostat control program performs analysis of the output from the motion detector to determine a level of activity indication based upon frequency of movement detected by the motion detector, and

B) the microprocessor under control of the thermostat control program using the level of activity indication to effect determination of the currently desired conditioned space temperature.

8. The compact programmable thermostat apparatus of claim 1 wherein said occupancy detector includes a motion detector, and wherein:

A) the microprocessor further includes programming for performing a thermostat control program analysis of the output from the motion detector to determine a level of activity indication based upon frequency of movement detected by the motion detector; and

B) the microprocessor under control of the thermostat control program using a high level of activity indication to effect a lowering of the temperature determined by the microprocessor operating under the control of the thermostat control

program as the currently desired conditioned space temperature, compared to the temperature that would have been determined if the level of activity .

9. A compact programmable thermostat apparatus for controlling space conditioning equipment serving a conditioned space comprising:

A) a temperature sensor providing an electrical signal indicative of temperature of the conditioned space;

B) an occupancy sensor providing a signal indicative of current occupancy of the conditioned space;

C) a user interface mechanism including a display for selectively displaying an alphanumeric message, and a user input mechanism for entering time based user program information which specifies:

1) a first user programmable time based thermostat control sequence which is a user programmable time based normal thermostat control sequence to be followed during periods of no occupancy; and

2) a second user programmable time based thermostat control sequence which is a user programmable time based comfortable thermostat control sequence to be followed during periods of occupancy;

D) a thermostat control unit, said thermostat control unit including:

1) a microprocessor for controlling operation of the thermostat control unit in response to a thermostat control program and the entered user programming information;

2) memory operatively coupled to said microprocessor for storing a the

- thermostat control program, for storing data describing user program information and data including the user programmable time based normal thermostat control sequence and the user programmable time based comfortable thermostat control sequence;
- 3) a real time clock connected to be accessible by the microprocessor for determining current date and time information;
 - 4) an input/output unit operatively coupled to said microprocessor including:
 - a) a first sensor input for receiving the electrical signal indicative of temperature of the conditioned space from said temperature sensor;
 - b) a second sensor input for receiving the signal indicative of current occupancy of the conditioned space from said occupancy sensor;
 - c) a control output for issuing control signals to be used in controlling the space conditioning equipment in response to the thermostat control program;
 - d) an output connection to the display providing data from the thermostat control program running on the microprocessor to the display; and
 - e) an input connection coupled to the user input mechanism for receiving user programming information;
- E) the microprocessor under control of the thermostat control program of the thermostat control unit being operative for calculating and maintaining a currently desired conditioned space temperature to be used for comparison with the electrical signal indicative of temperature of the conditioned space received from the temperature sensor, and for issuing output control signals to the space

conditioning equipment causing it to bring the conditioned space temperature closer to the user desired preset comfortable room temperature;

F) in the absence of the signal indicative of current occupancy, the microprocessor under control of the thermostat control program setting the currently desired conditioned space temperature to follow said first user programmable time based thermostat control sequence;

G) upon receiving the signal indicative of current occupancy, the microprocessor under control of the thermostat control program preempting the following of any previous thermostat control sequence and then following said second user programmable time based thermostat control sequence until the signal indicative of current occupancy has been continuously absent for a pre-established interval of time, then setting the desired conditioned space temperature as though no interruption of the first user programmable time based thermostat control sequence had occurred, and resuming following of said first user programmable time based thermostat control sequence.

10. The compact programmable thermostat apparatus of claim 9, wherein the apparatus is wholly contained as a unit in a single package intended typically to be mounted on a wall within a room or area served by the space conditioning equipment.

11. The compact programmable thermostat apparatus of claim 9, wherein the space conditioning equipment controlled by the thermostat system is an electric heater and the thermostat system further includes:

A) an electronic switch which is a triac device connected so as to be gated by the control output of the input/output unit of the thermostat control unit, and then used to gate house power for supply to the space conditioning equipment which is the electric heater.

12. The compact programmable thermostat apparatus of claim 9, wherein the space conditioning equipment controlled by the thermostat system is an electric baseboard heater and the thermostat system further includes:

A) an electronic switch which is a triac device connected so as to be gated by the control output of the input/output unit of the thermostat control unit, and then used to gate house power for supply to the space conditioning equipment which is the electric baseboard heater.

13. The compact programmable thermostat apparatus of claim 9, further including:

A) thermostat control program analysis of the output from the occupancy sensor to determine a level of activity indication based upon frequency of movement detected by the occupancy sensor; and

B) using the level of activity indication to effect determination of the currently desired conditioned space temperature.

14. The compact programmable thermostat apparatus of claim 9 with said occupancy detector being a motion detector, further including:

A) the microprocessor under control of the thermostat control program performs analysis of the output from the motion detector to determine a level of activity indication based upon frequency of movement detected by the motion detector;
and

B) the microprocessor under control of the the thermostat control program using the level of activity indication to effect the determination of the currently desired conditioned space temperature.

15. The compact programmable thermostat apparatus of claim 9 with said occupancy detector being a motion detector, further including:

A) the microprocessor under control of the thermostat control program performing analysis of the output from the motion detector to determine a level of activity indication based upon frequency of movement detected by the motion detector; and

B) the microprocessor under control of the the thermostat control program using a high level of activity indication to effect a lowering of the temperature determined by the thermostat control program as the currently desired conditioned space temperature, compared to the temperature that would have been determined if the high level of activity indication was not considered.

16. A method of constructing and operating a compact programmable thermostat device for controlling space conditioning equipment supplying conditioned air to a conditioned space comprising the steps of:

- A) Including a thermostat control unit within a thermostat housing designed to be mounted on a wall, the thermostat control unit including a microprocessor controlled by a thermostat control program;
- B) Attaching to the thermostat control unit an occupancy sensor and a temperature sensor which are located within the conditioned space so as to provide a signal indicative of occupancy and a signal indicative of temperature in the conditioned space respectively;
- C) Attaching a display device to the thermostat control unit;
- D) Attaching a user control interface to the thermostat control unit for capturing user input;
- E) Utilizing the display device and the user control interface to capture user input in the form of at least one user programmable time based thermostat control sequence as a normal thermostat control sequence for invocation during periods of no occupancy;
- F) Capturing further user input in the form of a temperature value to be used as a comfortable set temperature during periods of occupancy;
- G) Running a thermostat control program which, in the absence of the signal indicative of occupancy, follows the user programmable time based normal thermostat control sequence to set a desired condition space temperature;
- H) The microprocessor during the running of the thermostat control program, upon

reception of the signal indicative of occupancy from the occupancy sensor, preempting the user programmable time based normal thermostat control sequence and setting the desired condition space temperature to the comfortable set temperature value specified by the user for use during periods of occupancy; and,

I) The microprocessor during the running of the thermostat control program, when the signal indicative of occupancy is continuously absent for a pre-selected period of time, setting the desired condition space temperature to a value as though the user programmable time based normal thermostat control sequence had not been interrupted, and then resuming normal thermostat operation by returning to step G).

17. A method of constructing and operating a compact programmable thermostat device for controlling space conditioning equipment supplying conditioned air to a conditioned space comprising the steps of:

A) Including a thermostat control unit within a thermostat housing designed to be mounted on a wall, the a thermostat control unit including a microprogram processor controlled by a thermostat control program;

B) Attaching to the thermostat control unit an occupancy sensor and a temperature sensor situated so as to detect occupancy and temperature respectively;

C) Attaching to the thermostat control unit a display device for displaying alphanumeric messages;

D) Attaching to the thermostat control unit a user control interface for capturing user input;

- E) Utilizing the display device and the user control interface, capture user input in the form of a first time based thermostat control sequence which is a user programmable time based normal thermostat control sequence intended for invocation during periods of no occupancy;
- F) Capturing further user input in the form of a second time based thermostat control sequence which is a user programmable time based comfortable thermostat control sequence intended for invocation during periods of occupancy;
- G) Running a thermostat control program which, in the absence of a signal indicating detected occupancy, follows the first time based thermostat control sequence as intended by the user for invocation during periods of no occupancy;
- H) The thermostat control program, upon reception of a signal of occupancy from the occupancy sensor preempting the normal first time based thermostat control sequence and invoking execution of said second time based thermostat control sequence as intended by the user for invocation during periods of occupancy;
- I) When the signal of occupancy is continuously absent for some pre-selected period of time, setting the desired condition space temperature to a value as though the first time based thermostat control sequence had not been interrupted, and then resuming normal operation by returning to step G).

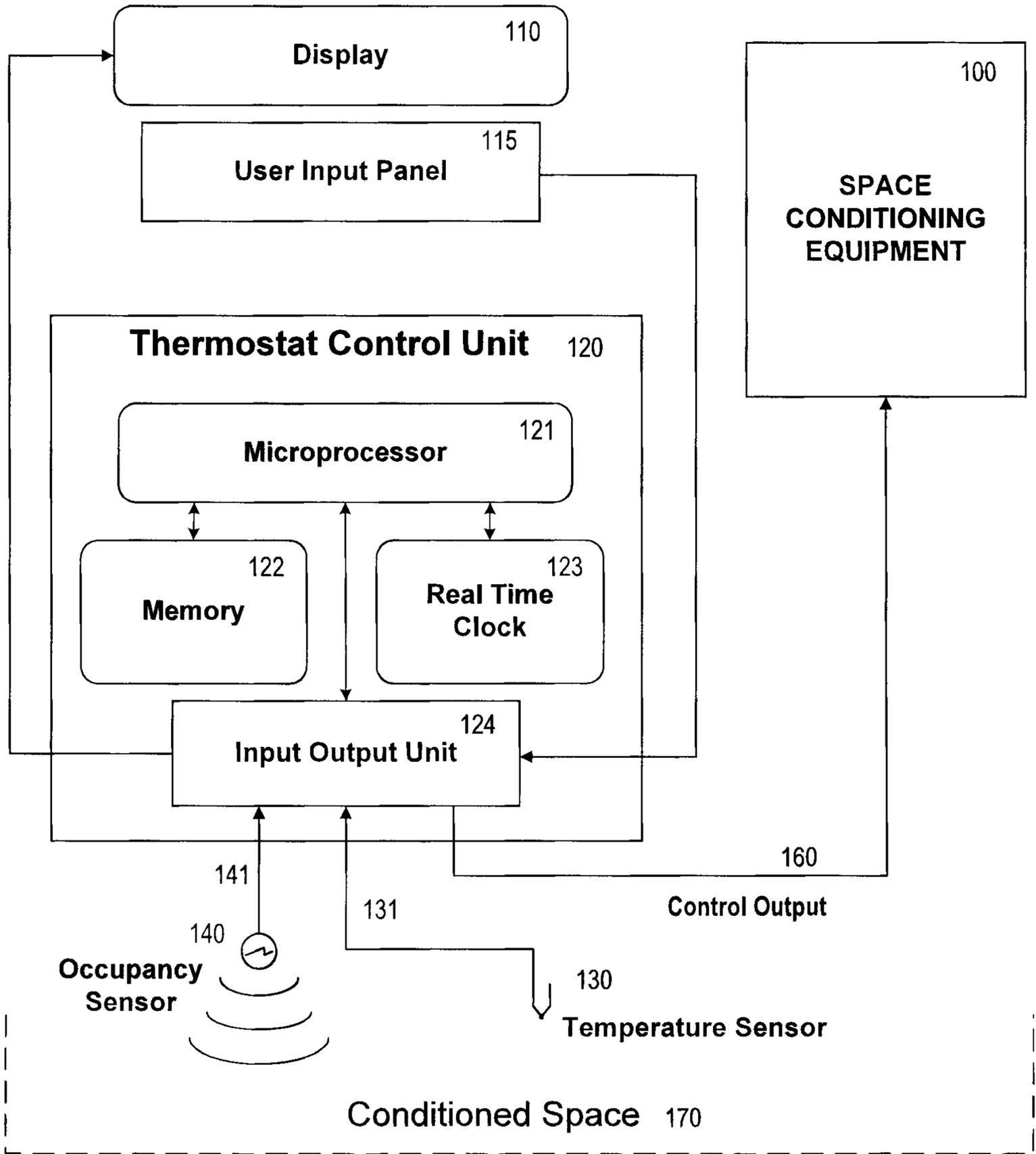


FIG. 1

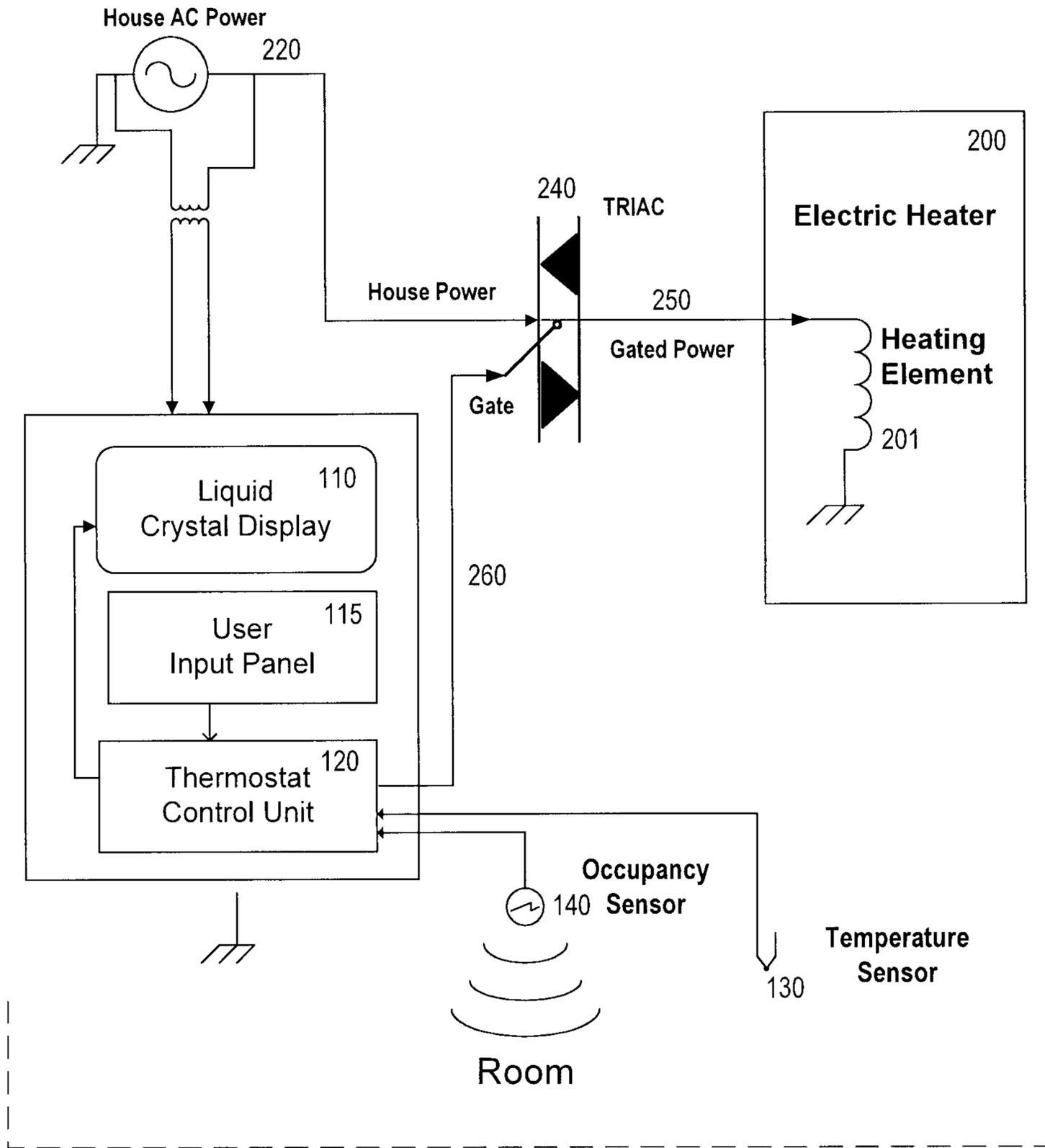


FIG. 2

300

No Occupancy Programming Screen:

During no occupancy:

Select Specific Days of Week:

| M | Tu | W | TH | F | Sa | Su | or 320
 | WEEKDAYS | or | WEEKENDS |

Period 1: From: _____ to _____ set temperature to _____ °F
 Period 2: From: _____ to _____ set temperature to _____ °F 310
 Period 3: From: _____ to _____ set temperature to _____ °F
 Period 4: From: _____ to _____ set temperature to _____ °F

| ^ | | v | | Next | | Exit |

FIG. 3

400

Occupied Programming Screen

During periods of detected occupancy:

Set desired temperature to: _____ °F

| ^ | | v | | Exit |

FIG. 4

500

Occupied Programming Screen

During periods of detected occupancy

Select Specific Days of Week::

| M | Tu | W | TH | F | Sa | Su | or
 | WEEKDAYS | or | WEEKENDS |

Period 1: From: _____ to _____ set temperature to _____ °F
 Period 2: From: _____ to _____ set temperature to _____ °F
 Period 3: From: _____ to _____ set temperature to _____ °F
 Period 4: From: _____ to _____ set temperature to _____ °F

| ^ | | v | | Next | | Exit |

FIG. 5

