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(54) **Automatic heating control system**

(57) A heating control system for buildings comprises at least one heater 18, 19 incorporating heat storage means 18a, 19a, a first sensor 22 for detecting temperature within the building, means for setting a demand temperature, a second sensor for detecting outside temperature, a timer, and means 26 for determining the switch on time of the heat storage means 18a, 19a on the basis of the demand temperature and the internal and external temperatures.

The system may additionally base the switch on time of the storage heater(s) on the heating and cooling rates of the building (as determined from the sensed temperatures); or on the anticipated daytime temperature (determined from the sensed night time temperature).

As shown, a house has bedrooms 12, 13 with direct heaters 16, 17 controlled by temperature sensors 20, 21; and living rooms 14, 15 with both storage heaters 18a, 19a and direct heaters 18b, 19b.

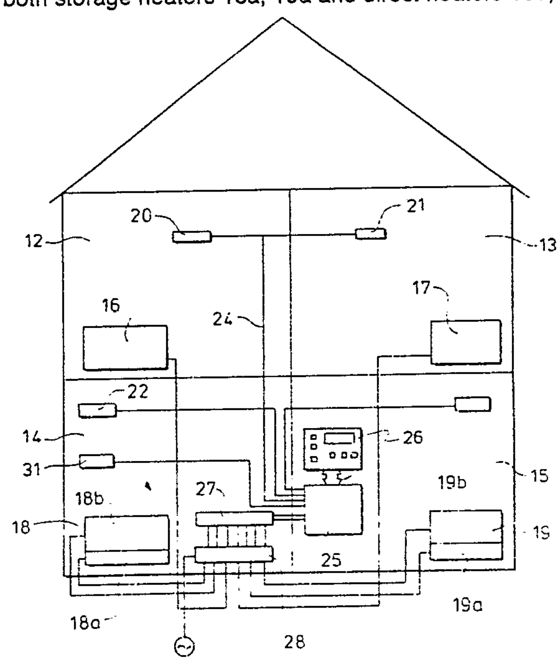

FIG 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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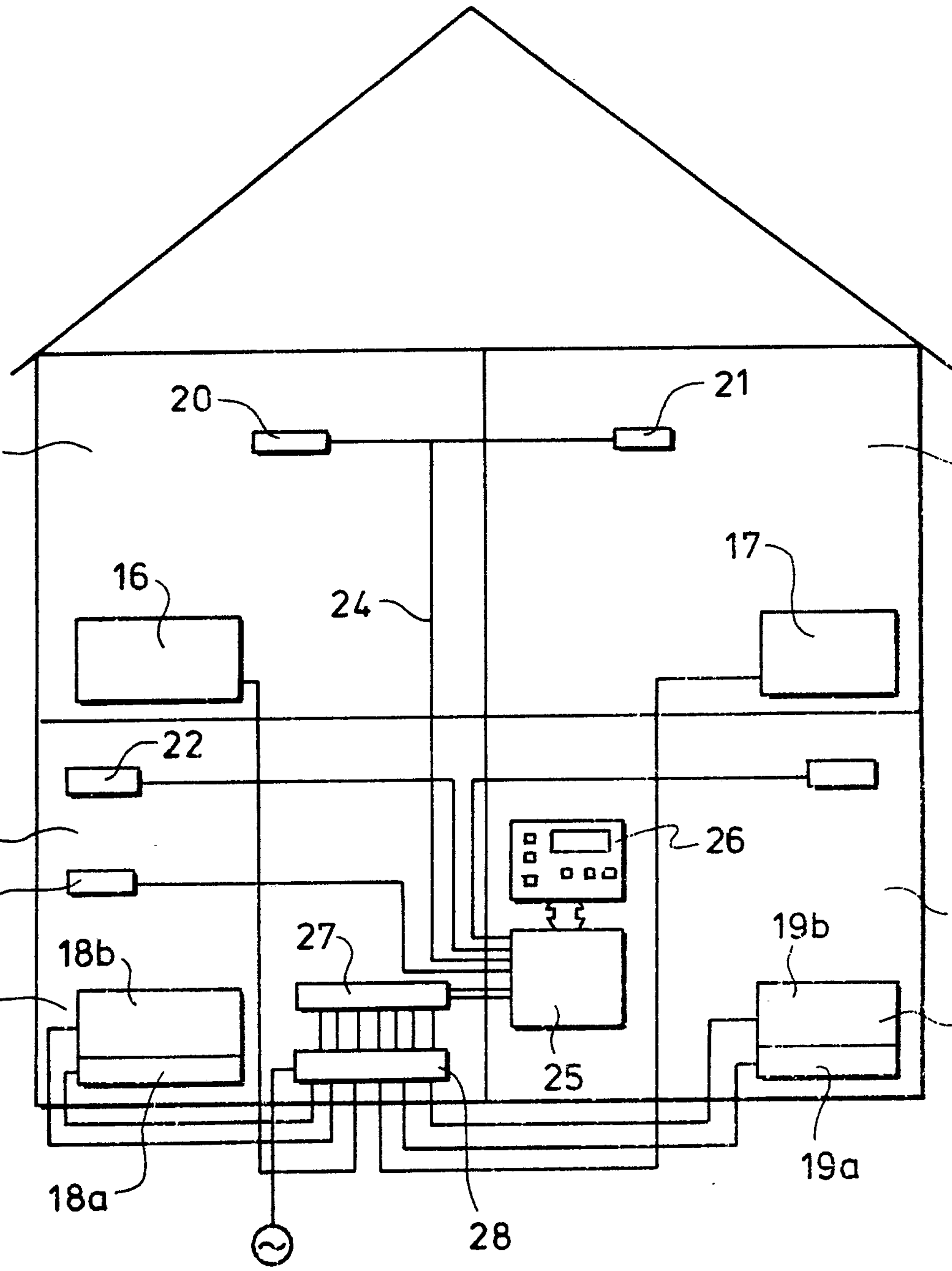

FIG 1

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AN AUTOMATIC HEATING CONTROL SYSTEM

The present invention relates generally to a heating control system for buildings, and particularly to a heating control system capable of providing automatic operation to maintain a selected temperature or range of temperatures for pre-selected periods of time regardless of variations in external temperature.

Conventional heating systems for buildings offer the user relatively limited control over the system. Such controls are usually limited to a diurnal selection of two or four heater operating periods during which the system is energised, and between which the system is de-energised. In a circulated hot water heating system this means that the boiler is running for, typically, two periods during the day when it is anticipated that the major heating requirement will be experienced, and individual areas or regions within the building are separately controllable by varying the setting on a valve which controls the quantity of water flowing through each radiator. Sometimes these valves have so-called thermostat settings which purport to enable the user to select a range of temperatures and allow the system to operate automatically to maintain the room temperature at that setting. However, because the valve is very close to the radiator it is highly influenced by it and less influenced by the actual air temperature within the room and such systems are notoriously ineffective. Other "automatic" systems involve the positioning of a temperature sensor at a position remote from a heat source in a room, but again these systems are constrained by the overriding controls on the heating boiler which is timed to be switched on or off at a predetermined time regardless of the variations in occupation patterns of the rooms during the working week and at weekends.

Over recent years, in order to extend the demand period for electricity the generating authority has offered considerable discount for consumption during the night, typically from midnight to 7 am so that the generating equipment can be used continuously and therefore more efficiently. Since for most domestic dwellings there is no requirement, or very little requirement, for heating during the night this has led to the development of storage heating systems in which electricity consumed during the night can be converted into heat which is stored in elements having a high thermal capacity and released gradually to the room through controlled venting of a casing.

Storage heaters have a number of disadvantages, among which are the fact that they contain the maximum amount of heat early in the working day and this is dissipated during the day to leave only a small amount of residual heat during the evening when some of the rooms in a domestic dwelling are occupied more fully than during the remainder of the day. Such storage heating systems thus heat the rooms at times when the heating is least needed and are virtually exhausted by the time such heating is required. To overcome this problem dual-operation heating units have been developed comprising a storage heating component and a convection heater which can be energised to supply heat from the unit when the storage element is exhausted. These dual element heaters thus make it possible to enjoy the benefits of cheap electricity by storing up to their maximum capacity during the night and releasing this during the day, with the possibility of boosting the heat output once the storage element is exhausted in order to maintain a comfortable temperature within the room. Many heating systems operate extremely inefficiently by consuming energy at times when this is not strictly required, particularly if the heating system is programmed to turn the boiler on at predetermined times without reference to the external temperature, whilst at other times inadequate heating is provided and has to be compensated by manually overriding the system in order to regain a comfort level. In such circumstances not only is additional energy required to raise the building to the desired temperature, but a tendency to over compensate and over heat, thereby wasting energy, is also experienced.

The present invention seeks to provide an automatic heating system in which a programmed range of temperature variation can be introduced with full account being taken of different occupation patterns at different parts of the week whilst also automatically taking account of variations in external temperature so that desired temperatures within different regions of a building can be maintained between preselected time points regardless of differences in external temperature and thereby minimise any wastage in energy heating the building at times when this is not required but nevertheless ensuring that an adequate comfort temperature is maintained. The present invention also seeks to provide a heating control system in which different regions of a building can be treated differently and programmed to have different heat variation patterns with time so that economy of operation and comfort levels can both be achieved.

The present invention also offers a heating control system in which flexibility of programming, reliability in attaining predetermined temperature levels, and adaptability to a wide range of heat sources or to make use of different heat sources at different times to make most efficient use of the available energy resources is provided.

It has been observed that diurnal and nocturnal temperature variations and relatioships are related to one another and to the heating curve of a particular building. That is to say, the temperature curve experienced during the night strongly influences the pattern of temperature variation during the following day and this is employed in the heating control system of the present invention to enable the control to be effected in such a way as to maximise both the economy, and the comfort offered by the heating system whilst maintaining a high level of reliability and convenience and still offering adaptability to changing personal circumstances departing from the predetermined anticipated pattern of occupation, for example during holidays when buildings are largely or entirely vacant or at times when unexpected visitors result in room occupation later into the evening than normal. In commercial buildings it may occasionally be required for staff to work late such as during periods of stocktaking or when work loads are unexpectedly increased, and the heating control system of the present invention makes it possible for a predetermined programme which normally closes down the heating system when a building is unoccupied to be modified so that heating can be automatically supplied without requiring separate control operations. The automatic system of the present invention also makes it unnecessary for differences between summer and winter settings to be determined since the selected temperature levels required to maintain comfort would normally be achieved in the summer period simply from environmental sources and the heating system would then not be energised although should the temperature fall unexpectedly the heating system will automatically maintain a required temperature and need no human supervision.

According to one aspect of the present invention a heating control system for buildings comprises at least one heater incorporating heat storage means, a first sensor for detecting the temperature at least within a limited zone within the building, means for setting a demand temperature for the said zone, a second sensor for detecting the external environmental temperature, a timer, and means for determining the commutation times of switching means controlling the supply of energy to the heat storage means on the basis of the setting of the demand temperature and the values of the internal and external temperatures detected by the said first and second temperature sensors.

The said means for determining the commutation times preferably comprises computing means operable to generate control signals at selectable times by reference to a real time clock incorporated therein and including comparison means for comparing a demand temperature with a detected temperature in order to generate the said control signal. Such computing means may also include a data store in which information on the rate of change of temperature of a building or certain zones within the building may be retained for reference in determining how far in advance of a predetermined time the heating must commence in order to achieve a preselected temperature by that time. Such data may also incorporate reference to the external environmental temperature which, necessarily, influences the rate of temperature rise for a given heat input.

According to another aspect of the present invention, there is provided a heating system for a building in which regions occupied only at opposite ends of a diurnal period are heated by direct heaters whilst regions occupied during a central part of the diurnal period are heated at least in part by heat storage means, and the quantity of heat stored during a nocturnal period is determined by the temperature difference between a demand temperature and the external environmental temperature with reference to the instantaneous temperature determined by sensors within the building.

Thus, regions such as bedrooms, which are occupied only at opposite ends of a diurnal period, namely first thing in the morning and last thing at night, only need to be heated for the two short periods during which they are occupied and may remain unheated or heated to a "minimum" temperature during the remainder of the day and during the night. On the other hand, reception rooms and kitchen areas, which are occupied during the main part of the day, may be heated by heat storage means and thereby maximise the economy achieved by the system.

According to another aspect, a method of heating a building comprises the steps of empirically determining the quantity of heat required to raise the temperature of the building through a predetermined temperature interval whereby to produce data for programming a computer to enable it to determine the time at which heat storage must commence in dependence on the ambient temperature and the building temperature in order to achieve a desired or demand temperature for a determined diurnal period.

If, during the night, the temperature falls steeply to a low value, for example less than 2°C, then the heat storage will commence at a point where the maximum quantity of heat which can be stored by the storage heaters is achieved. During a following day, then, the heat stored in the storage heaters is gradually released to the building and even this may not be sufficient to maintain a demand temperature throughout the whole of the day and the evening before a new heat charging period commences. However, in marginal conditions where the temperature during the night does not fall to such a low temperature, it is to be anticipated that the heat requirements during the following day will not be so great and, correspondingly, the required quantity of heat stored in the storage heaters will not necessarily be a complete charge. Depending on the data stored in the computer on the temperatures required to be maintained during the day and the anticipated diurnal temperature on the basis of the experienced nocturnal temperature, the point during the night at which the storage heaters are connected to the energy supply can be determined in such a way that the quantity of heat stored in the heaters will be sufficient to maintain the required temperatures during the whole of the subsequent diurnal period.

Expressed differently, the present invention may be considered as a method of controlling a building heating system by calculating the likely quantity of heat to be required for a succeeding diurnal period on the basis of the demand temperature and the temperature during the preceding nocturnal period, whereby the point during the night at which the heat storage is commenced may be determined by the difference between the environmental temperature and the demand temperature set in the system.

Subsidiary heating, in addition to the storage heating, may be provided by any known heating means, including solid fuel boilers, gas boilers, oil boilers or the like, and such heaters are controlled simply to supplement the quantity of heat released by the storage heaters in order to maintain the required selected temperatures at the lowest cost. The maximum heat quantity is stored if the nocturnal temperature falls below a critical threshold value whilst a smaller quantity of heat is stored during marginal conditions if the temperature does not fall to the critical threshold during the night.

One embodiment of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawing, in which Figure 1 shows a schematic diagram illustrating a heating system having a number of zones within a building

Referring now to the drawing the heating system is shown schematically installed in a building 11 and for the purpose of the present description it will be assumed that the heaters are all electrical resistance heaters either of the direct heating (convector or radiator) type or the combined storage heating and direct heating type.

In the schematic diagram of Figure 1 the building 11 is shown as incorporating four rooms 12, 13, 14, 15 which will be heated as three zones, namely the upper two rooms 12, 13 which will be assumed to be bedrooms, the lower room 14 which will represent the reception rooms and kitchen, and a zone 15 which will represent the hallway and circulation space of the building. Typically, a building such as the building 11 requires heating in zone 1 only for a short period during the morning whilst the occupants are rising and dressing, and a short period during the evening immediately before bedtime so that the rooms are comfortable to enter. For this reason they are fitted with heaters 16, 17 of the direct heating type whereas in zones 2 and 3 the heaters 18 and 19 are combined storage heaters and direct heaters represented by a lower section 18a, 19a which represents the storage heating component and an upper part 18b, 19b which represent the direct heating part.

Each of the rooms 12, 13, 14, 15 is provided with a respective sensor 20, 21, 22, 23 and since the two rooms 12, 13 are treated together as a common zone the sensors 20, 21 are connected in parallel. The output from these sensors is connected by a lead 24 to an interface unit 25 which is linked between the sensors 20, 21, 22, 23, a computer 26 and a consumer unit 27 comprises fuses and switches linking the control signals from the computer 26 via the interface 25 to a contactor unit 28 which is linked by respective lines to the heaters 16, 17 and by respective pairs of lines to the heaters 18, 19 such that the storage heater component 18a, 19a or the direct heating component 18b, 19b may be energised selectively. In addition the interface unit is connected by a line 29 to an external temperature sensor 30. The internal and external temperature sensors 20, 23 and 30 generate signals which are supplied to the computer 26 via the interface unit 25 to provide an indication of the instantaneous temperature within the region sensed, namely within zones 1, 2 and 3 within the building and the external environment.

The computer is programmable to produce output control signals to the interface 25 to maintain the temperature within each of the interior zones at a value predetermined by the preliminary setting of the computer 26. To set the computer 26 the operator selects the zone, and determines from a computer screen the times at which the selected temperature is to vary. For example, it may be desired for the bedroom zone 1 constituted by the bedrooms 12 and 13 to achieve a temperature of 20°C at 7.30 am and to remain at this temperature until 8.45 am and then to fall to a temperature of, typically, 14°C until 11 pm and to return to 20°C from 11 pm to midnight thereafter reverting to 14°C until the next diurnal cycle. This may be repeated daily between Monday and Friday but varied on Saturday and Sunday with a morning temperature rising, again to 20°C, but not until 9.30 am and remaining there until 10.30 am with the evening temperature/time control remaining the same. This data is stored in the memory of the computer 26 and, by comparing the demand temperature corresponding to the time read from a real time clock with which the computer 26 is provided, and by comparing the output signal from the sensors 20, 21 indicating the instantaneous temperature within the rooms 12, 13 to generate an output control signal which either energises the heater 16, 17 if the instantaneous temperature detected by the sensors 20, 21 is below the demand temperature or leaves these heaters de-energised if the instantaneous temperature is at or above the preselected demand temperature for that time period.

The heating control for the reception rooms constituting zone 2 follows a different pattern and may, for example, involve reaching a temperature of 19°C by 8 am and maintaining this temperature from 8 am until noon in one room whilst the temperature in another room remains at 14°C until noon and then rises to 20°C for the remainder of the day until 11 pm. Zone 2 is represented in Figure

1 only by a single room and a single heater 18 but it will be appreciated that this zone may in fact constitute a number of rooms each treated differently as described above. Both of the rooms, however, have a requirement for heat during a central part of the diurnal period and therefore it is relevant to seek to heat these rooms using low cost electrical energy stored as heat in the heat storage component 18a of the heater unit 18. In this case the computer 26 acts during the preceding night to determine, from the detection of the internal temperature generated by the sensor 22 and the external temperature generated by the sensor 30 to determine the quantity of heat likely to be required to maintain the temperature within a given room for the period set in the computer memory whereby to determine the point during the night at which the storage heater should be energised. For example, in the above-indicated hypothetical case where a first room is required to be heated for three and a half hours from 8.30 am to noon whilst a second room is required to be heated for eleven hours from noon to 11 pm it will be seen that the total quantity of heat stored in the heating elements for the first room will be very much less than that required in the second room and, consequently, the storage heater component of the heating unit in the first room will need to be switched on later

in the night (assuming that the heat charge should be taken as late as possible in order to avoid, as far as is possible, heat loss between the end of the charging period and the commencement of the use period.

The computer 26 may also be provided with a programme which allows it to compensate on subsequent days for any variation between the intended heat output from the heater units and the experienced heat output which may vary in dependence on the immediate environmental conditions so that, for example, during a particularly windy period (which may last for several days) when the heat loss from the building increases, it may be necessary to increase the quantity of heat stored in order to achieve a desired temperature for the set period and the computer can continually update the data stored in its memory representing the heating and cooling curves of the building in order to optimise the performance for the purpose of obtaining maximum economy and avoiding the necessity for manual intervention. Thus, in the above postulated windy period, although the temperature set by the operator when setting up the computer will be maintained in the room 14 during the morning period this may involve energising the direct heater 18b, during the latter part of the morning in order to supply heat to compensate for any shortfall in that supplied by the storage heater. On a subsequent day, then, the computer will act to store a greater charge in the storage heater 18a by commencing the storage period somewhat earlier, and will modify the data on the cooling curve stored in its memory so that this will then act to utilise the cheaper nocturnal electricity to heat the room 14 for the whole of the morning. Likewise, the computer will detect the rate at which the room cools down at the end of the heated period so that, as the conditions vary, the quantity of heat stored in the heat storage component 18a will not exceed that required simply to heat the room for the desired period and if the temperature remains too high after the "heated" period on any one day the subsequent heating charge during the following night will be reduced in relation to the same temperature variations. Of course other factors such as a variation in the nocturnal temperature may also influence the length of charge. In this way the gradually varying diurnal and nocturnal temperatures during the year are taken into account by the computer as it operates from day to day so that only the minimum amount of energy is drawn from the energy source in order to maintain the required temperature without heating the rooms unnecessarily.

In the third zone represented by the room 15, assumed to be constituted by the circulation space in the building, the pattern of heating may be entirely different, with merely a relatively low temperature, for example 15 or 16°C being maintained during the whole of a diurnal period from 8.30 am to 11 pm, with this temperature being reduced to 14°C during known periods when the building will certainly not be occupied.

A further refinement offered by the system of the present invention enables automatic monitoring of the occupation level within the building to override a predetermined heating pattern. This is achieved by means of a further sensor 31 which is not necessarily a temperature sensor, but rather one which will provide an indication that a room is occupied rather than unoccupied. This may be achieved, for example, by using an infra red sensor to detect the presence of people in the room or, more simply a current sensor in parallel with the room lighting circuit to detect whether the lights are switched on or not. This simpler system would operate satisfactorily in rooms where extended occupation during the latter part of the evening may be anticipated but would not be sufficient if, for example, the extended occupation may be during the middle of the day when the lights would not necessarily be switched on, and for such circumstances the infra red detector or a series of detectors may be preferred. The sensor 31 produces a signal which indicates that the room 14 is occupied, and this is detected by the computer 26 as an override signal to maintain energisation to the direct heater component 18b of the heater 18 associated with the room 14 even after the termination of the programmed heating period. Thus, for example, if the occupants should receive unexpected visitors during an evening or decide to stay up late to watch the television during the winter months when the temperature in a room is likely to fall rapidly immediately the heating is turned off, there is no need to perform any manual override function on the computer and the system will remain energised for as long as the sensor 31 provides an indication that the room is occupied.

CLAIMS

1. A heating control system for buildings, comprising at least one heater incorporating heat storage means, a first sensor for detecting the temperature at least within a limited zone within the building, means for setting a demand temperature for the said zone, a second sensor for detecting the external environmental temperature, a timer, and means for determining the commutation times of switching means controlling the supply of energy to the heat storage means on the basis of the setting of the demand temperature and the values of the internal and external temperatures detected by the said first and second temperature sensors.

2. A heating control system for buildings as claimed in Claim 1, in which the said means for determining the commutation times comprises computing means operable to generate control signals at selectable times by reference to a real time clock incorporated therein.

3. A heating control system for buildings as claimed in Claim 2, further including comparison means for comparing a demand temperature with a detected temperature in order to generate the said control signal.

4. A heating control system for buildings as claimed in Claim 2 or Claim 3, in which the said computing means also include a data store in which information on the rate of change of temperature of a building or certain zones within the building are retained for reference in determining how far in advance of the predetermined time the heating must commence in order to achieve a preselected temperature by that time.

5. A heating system for a building, in which regions occupied only at opposite ends of a diurnal period are heated by direct heaters whilst regions occupied during a central part of the diurnal period are heated at least in part by heat storage means, and the quantity of heat stored during a nocturnal period is determined by the temperature difference between a demand temperature and the external environmental temperature with reference to the instantaneous temperature determined by sensors within the building.

6. A method of heating a building comprising the steps of determining empirically the quantity of heat required to raise the temperature of the building through a predetermined temperature interval whereby to produce

data for programming a computer to enable it to determine a time at which heat storage must commence in dependence on the ambient temperature and the building temperature in order to achieve a desired or a demand temperature for a determined diurnal period.

7. A method of controlling a building heating system by calculating the likely quantity of heat to be required for a succeeding diurnal period on the basis of a demand temperature and the temperature during the preceding nocturnal period, whereby the point during the said nocturnal period at which the heat storage is commenced is determined by the difference between the environmental temperature and demand temperature set in the system.

8. A heating control system for buildings substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

9. A method of controlling a building heating system substantially as hereinbefore described with reference tc the accompanying drawings.

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