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(54) Reactive cooling and heating control system.

(57) In a variable air volume system, chilled air is supplied from a cooler (10) to a number of zones (14, 16, 18). Zone controllers (30, 32, 34) send the supply air temperature detected by sensors (48, 50, 52) to a master controller (12) which issues a warning to all of the sensors when at least one of these temperatures drops too low, e.g. passed a trip temperature of one of the stages of the cooler (10). On receiving the warning, each zone controller (30, 32, 34) compensates by adjusting the air flow to its zone (14, 16, 18) using dampers (42, 44, 46). Different adjustments occur depending on whether the zone temperature is above or below a zone setpoint. The invention is also applicable to a heating system and to the monitoring of too great a rise in the temperature of supplied heated air.

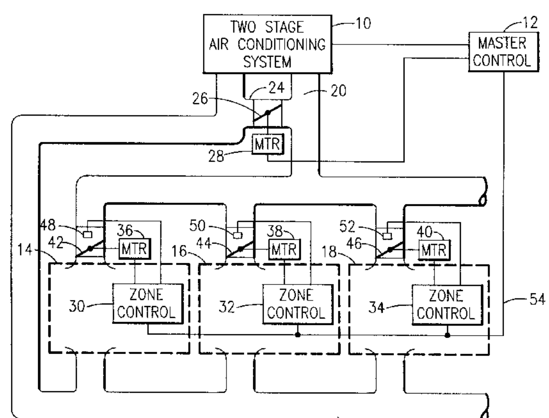

FIG.1

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This invention relates to the control of dampers in a variable air volume system wherein each damper defines the volume of chilled or heated air being made available to a zone to be cooled or heated respectively. In particular, this invention relates to the control of these dampers when the chilled air being supplied to the dampers drops below a permissible level,or the heated air rises above a permissible level.

Variable air volume (VAV) systems are widely used to supply chilled or heated air from a central source to different zones of a home or office building. The typical VAV system furnishes a variable volume of air to a particular zone depending on that zone's needs as measured by a thermostat sensing the temperature of the space or zone. The volume of air to be provided is controlled by at least one damper in a duct supplying the air to the zone. The damper is positioned within the duct in response to the measured needs of the zone. In this regard, when the temperature of the space deviates from a predetermined setpoint, the damper is moved to a more open position so as to allow a greater volume of chilled or heated air to flow into the zoned space. Conversely, as the temperature of the space approaches the setpoint, the damper is moved to a more closed position so as to decrease the volume of chilled or heated air flowing into the space.

There may be times when most of the dampers in a multiple zoned system have moved to a closed position as setpoints in their respective zones have been achieved. The remaining zones may suddenly be receiving large amounts of chilled or heated air previously going to the closed damper zones. This problem is normally solved by bleeding off some of the chilled or heated air going to the zones in a bypass configuration. This in turn leads either to the recycling of colder than normal air through the chiller unit and possible a frosting of the coils, or the recycling of hotter than normal air through the heat exchanger and possible overheating of the unit. There is a need under such circumstances to provide as much relief as possible to such frosting or overheating.

There may be other conditions occurring in the VAV system that would lead to the aforementioned frosting or overheating. In each case, there is a need to provide as much relief as possible.

The invention is a reactive control for a VAV system which begins with monitoring the condition of the supplied air in a plurality of zones and sensing when a supply air temperature in any zone passes an undesirable threshold e.g. drops below a threshold in the case of a chilled air system or rises above a threshold in the case of heated air system. When this occurs, a monitor sends a warning flag to each zone control within the VAV system. Each local zone control proceeds to compare its local space temperature with its local setpoint temperature. If the local space temperature is above local setpoint in the case of chilled air, or is below local setpoint in the case of heated air, the local zone control will incrementally add one damper position to the currently commanded damper position. The commanded increment will be followed by a timely inquiry as to whether the warning flag is still in effect. If so, the local zone control will incrementally add another damper position. The local zone control will continue to add damper positions until the monitor stops sending the warning flag, or the zoning stage has added a predefined number of incremental damper positions or the local space temperature drops below (in the case of chilled air) or rises above (in the case of heated air) local setpoint temperature. In this latter case, the local zone control proceeds to inquire as to whether the drop below or rise above local setpoint is less than one degree. If the drop or rise is one degree or less, the local zone control will immediately add damper positions corresponding to the amount by which the drop or rise is below or above setpoint. The local zone control will thereafter hold to the established position until the local space temperature drops (in the case of chilled air) or rises (in the case of heated air) more than one degree below or above setpoint respectively. In this case, the local zone control will immediately delete the added positions.

It is to be noted that each local zone control operates completely independent of other zone controls when responding to the monitor's warning. In this manner, each local zone control contributes to the relief of the monitor's detected supply air condition on the basis of that local zone's particular temperature situation. The above is accomplished by a series of communication protocols between the local zone control and the monitor which allows the flag warning to be received and selectively processed by each local zone control. The selective processing includes an ability by each local zone control to process every other warning communication from the monitor.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is an overall diagram of a VAV system including a master control and local zone controls of individual dampers associated with respective zones;

Figure 2 is a diagram of the microprocessor configuration within the master control;

Figure 3 is a diagram of the microprocessor configuration within one of the zone controls.

Figures 4A - 4C comprise a flow chart of a software program residing in the microprocessor of Figure 2 which is used in an embodiment in which chilled air is supplied to the zones, and ascertains the lowest supply temperature in the zones and transmits appropriate signals to the zone controls;

Figures 5A - 5C comprise a flow chart of a software program residing in each of the zone controls which responds to the various commands issued by the software program of Figures 4A-4C so as to provide supply temperatures upon request and to furthermore control the dampers within the respective zones as required; and

Figures 6A-6C and Figures 7A-7C comprise flow charts corresponding to Figures 4A-4C and Figures 5A-5C, but for use in an embodiment supplying heated air to the zones.

Referring to Figure 1, a two stage air conditioning system 10 under the control of a master control 12 provides chilled air to a plurality of zones 14, 16 and 18 via an air supply duct 20. The air in the zones is returned to the two stage air conditioning system 10 for further cooling via the air return duct 22. The air supply duct 20 and the air return duct 22 may have more than the three zones depicted as indicated by the breakline for each duct.

A bypass duct 24 including a bypass damper 26 and associated motor 28 allows air in the air supply duct to be selectively returned to the two stage air conditioning system 10. The selective return is dictated by the main control 12 operating the motor 28 so as to open or close the bypass damper 26.

Each of the zones 14, 16 and 18 is seen to include a zone control 30, 32, or 34 which controls a motor 36, 38 or 40 that positions a zone damper 42, 44 or 46 within a branch duct associated with the air supply duct 20. The damper positioning is normally a function of the difference in the sensed temperature in each zone and a setpoint temperature for the zone. Each zone control also receives a sensed supply air temperature in the respective branch duct as measured by a supply air sensor 48, 50 or 52. As will be explained in detail hereinafter, these sensed supply air temperatures are made available to the main control 12 via a communication bus 54. Further communication also occurs between the master control 12 and the respective zone controls when any of these sensed supply air temperatures fall below a predetermined level evidencing a condition needing correction. As has been previously noted, one such condition occurs when the bypass duct 24 is opened and cooled air is returned to the air conditioning system 10 due to a change in demand for supply air to the zones. In this instance the supply air temperatures may drop prompting the need for corrective action.

Referring to Figure 2, the main control 12 is seen to include a programmed microprocessor 56 having a control interface 58 to the two stage air conditioning system 10 of Figure 1. The control interface 58 may be a relay control or other well known interface that selectively activates stages of chilling or cooling in the air conditioning system in response to control signals from the microprocessor 56. The microprocessor 56 furthermore generates a control signal to a motor drive circuit 60 associated with the bypass duct motor 28 of Figure 1. Finally the microprocessor 56 sends and receives information to and from the zone controls 30, 32 and 34 of Figure 1 via the communication bus 54.

Referring to Figure 3, the zone control 30 is seen to include a programmed microprocessor 62 which receives and transmits information over the bus 54 to the microprocessor 56 within the master control 12. The microprocessor is furthermore connected to a zone temperature sensor 64 and a zone setpoint device 66 via an analog/digital interface 68. It is to be appreciated that temperature values defined by the sensor 64 and setpoint device 66 are periodically read and stored for use by the microprocessor 62. The microprocessor 62 also periodically stores the supply air temperature read over the line 70 that is connected to the air sensor 48 in Figure 1. In addition to the reading and storing of information, the microprocessor also controls the motor 36 through issuing control signals to a motor drive circuit 72. The motor 36 is preferably a stepper motor which receives predefined numbers of pulses from the motor drive circuit 72 defining a desired incremental movement of the motor 36 and the damper 42 associated therewith. The position of the motor and the damper 42 can always be tracked by first of all driving the motor to a home position corresponding to a closed damper position and thereafter defining additive incremental movements from the home position by digital commands from the microprocessor 62.

It is to be appreciated that the zone control of Figure 3 is similarly duplicated in the zone controls 32 and 34 of Figure 1. In this regard, each zone control includes a programmed microprocessor for reading and storing information and communicating with the microprocessor 56 via the bus 54. Each zone control furthermore includes a motor drive circuit under control of the programmed microprocessor for commanding various positions of the motor and associated damper in the local zone.

Referring to Figure 4A, the beginning of the program residing in the microprocessor 56 of the master control 12 is illustrated in detail. The program begins with an initialization routine in a step 80 which occurs when the microprocessor 56 is first switched on. The initialization routine includes setting the following program variables equal to zero: "TIMER", "LAT Flag", and supply air temperature, "T_S". The term LAT in "LAT Flag" is an abbreviation for "leaving air temperature" which is generally considered to be the temperature of the air leaving the two stage air conditioning system 10 following chilling. Following the initialization routine, the microprocessor 56 proceeds to a main master control loop in a step 82. The main master control loop determines when the microprocessor 56 is to execute a given program that has been stored for execution in the microprocessor. At the appropriate time within the main master control loop, the program which will hereinafter be described is invoked. At this time, the microprocessor will proceed to a step 84 and inquire as to whether TIMER is equal to zero. Since the timer variable is initially set equal to zero in step 80, the microprocessor will proceed to a step 86 and start a timer clock. The timer clock will begin to count down from a predetermined clock value. This value will depend on the particular variable air volume system in which the master control is to operate. In this regard, a sufficient amount of time must elapse for each local zone control in the variable air volume system to at least begin to react to any previous commands by the master control. This will of course depend on the number of zone controls in the system that must respond.

For a system including sixty four zone controls, an arbitrary clock value of ten seconds was selected for the timer clock of step 86.

Upon starting the timer clock, the microprocessor proceeds to a step 88 and loads the "master bus address minus one" into the outgoing packet buffer associated with the communication bus 54. In the preferred embodiment, the zone controls 30 through 34 will have successively lower addresses from that of the master control 12. In this regard, the first zone control 30 will have an address one lower than the master control address. The microprocessor will proceed to a step 90 and send a request for the identification of the entity addressed by the computed address of step 88. The microprocessor will thereafter await a packet interrupt signal in a step 92. When a packet interrupt is received, the microprocessor will inquire in a step 94 as to whether the identification (ID) that has been received identifies one of the zone controls 30 through 34. If the answer is yes, the microprocessor will proceed to a step 96 and send a request for the local supply air temperature from the identified zone control. The microprocessor 56 will thereafter look for a received packet interrupt in a step 98. When a packet interrupt is received, it will be interpreted to be the local supply air temperature for the particular addressed zone control. This local supply air temperature value is stored as the variable "T_L" in a step 100. The microprocessor will next proceed in a step 102 to send the "LAT Flag" value to the addressed zone control. It will be remembered that this value is initially zero in a step 80. The program will now proceed to decrement the address that has been stored in the outgoing packet buffer of the microprocessor 56. This will effectively allow for the addressing of the next zone control that is to be queried. Before making the next inquiry, the microprocessor proceeds to a step 106 and inquires as to whether the supply air temperature "T_S" is equal to zero in a step 106. Since this variable is initially equal to zero, the microprocessor will proceed to a step 108 and set the supply air temperature "T_S" equal to the stored local supply temperature "T_L".

The microprocessor will exit from step 108 and return to step 90 wherein a request for the identification of the entity addressed by the decremented address of step 104 will occur. Upon receiving the identification from the thus addressed entity, the microprocessor will inquire in step 94 as to whether the thus addressed entity is a zone control. In the event that another zone control has been addressed, the microprocessor will proceed to request the supply temperature and store the same in the variable "T_L" in step 100. Since the "LAT Flag" value is still equal to zero, the microprocessor will send this particular value to the thus addressed zone control in step 102. The addressing in the outgoing packet buffer will again be decremented in a step 104 before inquiry is again made as to whether "T_S" is equal to zero in step 106. "T_S" will no longer be zero since it will have been set equal to the local supply temperature of the previously addressed zone control. The microprocessor will hence proceed along the "no" path from step 106 to a step 110 and inquire as to whether the supply air temperature "T_S" is greater than the currently stored local supply temperature "T_L". If the supply air temperature "T_S" is greater than the currently stored local air supply air temperature then the microprocessor will proceed to set "T_S" equal to the currently stored local supply temperature, "T_L".

Referring to both steps 110 and 112, the microprocessor will either proceed out of step 110 to step 90 in the event that "T_L" is greater than "T_S" or it will return to step 90 after setting "T_S" equal to "T_L" in step 112. In either event, the microprocessor will again send a request for the identification of the entity whose address has been computed in step 104. Upon receiving the packet interrupt signal in step 92 the identification of the addressed entity will be examined in a step 94. As long as the identification continues to be that of a zone control, steps 96 through 112 will be repeated. Inquiry will ultimately be made in each instance in step 110 as to whether the currently stored supply air temperature "T_S" is greater than the local supply air temperature of the particularly addressed local zone control. If yes the currently stored supply air temperature "T_S" is set equal to the local supply air temperature of the currently addressed zone. In this manner, when the last addressed zone control has been queried, the supply air temperature "T_S" will be equal to the lowest local supply air temperature found in all of the queried zone controls.

Referring to step 94, when an ID is encountered that does not correspond to a zone control, the microprocessor will proceed to a Master LAT Flag routine in Figure 4C. This will occur when the last zone control has been encountered and appropriately queried as discussed above.

Referring to the Master LAT Flag routine in Figure 4C, it is seen that this routine begins with an inquiry in a step 114 as to whether "T_S" is less than the value of a second stage trip temperature. It will be remembered that the air conditioning system 10 of Figure 1 has two stages of chilling. Each stage of chilling will have a particular trip temperature dictating when the particular stage is to be deactivated. This particular value is stored as the second stage trip temperature for use by the microprocessor 56 in step 114. In the event that the lowest local supply air temperature in the zone controls 30 - 34 is less than this second stage trip temperature, the microprocessor proceeds to a step 116 and sets the "LAT Flag" equal to one. As has been previously noted, the term LAT in LAT Flag is an abbreviation for leaving air temperature. The leaving air temperature generally being referred to is the temperature of the air leaving the two stage air conditioning system 10 following chilling. The microprocessor next proceeds in a step 118 to inquire as to whether the second stage is on. In the event that it is, the second stage is deactivated in a step 120 and a time guard is activated in a step 122. The time guard is a safety feature which will not allow the second stage to be reactivated until a particular period of time has elapsed. Upon setting the time guard for the second stage, the microprocessor proceeds to a step 124 and inquires as to whether the supply air temperature "T_S" is also less than the first stage trip temperature. It is to be noted that the first stage trip temperature is lower than the second stage trip temperature and is unlikely to be exceeded by "T_S" at the same time that the higher trip temperature is encountered. In this regard the first stage temperature is more likely to be exceeded on subsequent executions of step 124. When "T_S" does drop below the first stage trip temperature, the microprocessor proceeds to a step 126 and turns the first stage off. The microprocessor will also set the first stage time guard in a step 128 before exiting to the main control loop in a step 130. Referring to step 124, in the event that the supply air temperature "T_S" is not less than the first stage trip temperature, then the microprocessor immediately proceeds to exit to the main control loop in step 130. Referring again to step 114, in the event that the supply air temperature, "T_S", is not below the second stage trip temperature, the microprocessor will immediately proceed to a step 132 and set the LAT Flag equal to zero before exiting to the main control loop in step 130.

It is hence to be appreciated that the microprocessor 56 will have either set the LAT Flag equal to zero in step 132 or set the LAT Flag equal to one in a step 116 before exiting to the Main Loop Control in step 130. This LAT Flag value will be subsequently sent to each zone control when the Main Loop Control returns to the program of Figures 4A and 4B and step 102 is successively implemented a number of times. In this regard, step 102 causes the LAT Flag value to be sent to each addressed zone control wherein the zone addresses are successively defined in step 104. In this manner, all zone controls will have been alerted when the supply air temperature in any zone falls below the second stage trip temperature.

Referring to Figure 5A, the zone control software program residing within each of the microprocessors in the zone controls 30, 32, and 34 is illustrated in detail. This software begins with a step 140 wherein an initialization routine is executed each time the microprocessor within a zone control is switched on and powered up. The initialization routine of step 140 includes setting the following variables equal to zero: "LAT Flag", Scan Counter, and "LAT Added Damper Positions". The zone control microprocessor proceeds to a step 142 and begins a main zone control loop. The main zone control loop will include a number of different programs that are to be executed by the zone control microprocessor including by way of example the monitoring of the zone temperature sensor 64, the zone setpoint device 66, and the supply air temperature sensor such as 48 for the microprocessor 62. As a result of this monitoring, the zone control microprocessors will always have present values of these parameters stored for use. Other examples of programs that are executed in a sequence by the main zone control loop would be the motor command program which would issue commands to the respective motor drive circuit such as 72 in response to any computed change in the motor command by the software of Figures 5A, 5B, and 5C. This computed change would be reflected in the upper half of possibly commanded motor positions which is reserved exclusively for the software of Figures 5A, 5B, and 5C. When the main zone control loop reaches a point within its loop for execution of a "leaving air temperature" program, it exits to a step 144 and inquires as to whether an incoming packet interrupt has occurred. When an interrupt is received, the microprocessor proceeds in a step 146 to note whether the interrupt is a request for the local supply air temperature. In the event that it is a request for supply air temperature, the microprocessor proceeds in a step 148 to load the previously read and stored supply air temperature into its packet buffer. This supply air temperature is subsequently sent to the master microprocessor 56 over the communications bus 54 in a step 150. The microprocessor will thereafter proceed to a checking routine in Figure 5C which will be described in detail hereinafter.

Referring again to step 146, in the event that the interrupt is not a request for the local supply air temperature, the microprocessor will proceed to a step 152 and inquire as to whether the interrupt is the control flag byte. In the event that the interrupt is the control flag byte, the zone control microprocessor will proceed to a step 154 and read and store the LAT Flag bit portion of this byte. The value of the thus stored LAT Flag bit will be examined in a step 156 for being equal to one. In the event that it is not, the microprocessor will proceed from step 156 along the "no" path and return to the check routine of Figure 5C. It is to be noted that the same will occur if the control flag byte has not been received in a step 152. Referring again to step 156, in the event that the LAT Flag bit value is one, the microprocessor will proceed to a step 158 and inquire as to whether the "scan counter" is equal to zero. It will be remembered that the "scan counter" is initially set equal to zero which will prompt the zone control microprocessor to proceed to step 160 and increment the "scan counter". The "scan counter" will hence be set equal to one which will indicate that the zone control has thus been queried once by the master control. Referring again to step 158, in the event that the "scan counter" is not equal to zero, the microprocessor will proceed to a step 162 and inquire as to whether the scan counter equals two. Since the scan counter will only equal one on the next time through, the microprocessor will proceed to a step 164 and increment the "scan counter" once again. The microprocessor will proceed to the check routine of Figure 5C at this point. Referring again to step 162, when the scan counter equals two, the program proceeds to a step 166 and clears the "scan counter" back to zero. It is hence to be appreciated that the "scan counter" will be successively incremented from zero to one in step 160 and then to two by step 164 before again being cleared in step 166. The program proceeds to a step 168 when the "scan counter" is either detected as zero in step 158 or two in step 162.

Referring to step 168, the microprocessor inquires as to whether the local space temperature that has been read and stored from the local zone temperature sensor is less than the setpoint temperature that has been read and stored from the local zone setpoint device. In the event that the space temperature is equal to or greater than the setpoint, the microprocessor will proceed along the "no" path from step 168 to a step 170 and read the value of "LAT Added Damper Positions". The thus read value will be compared to a maximum allowed value of added damper positions in a step 172. The maximum allowed value will be preferably one half of the total potential damper positions that may be commanded by the zone control microprocessor. In other words, if there are thirty possible incremental damper positions between a closed damper position and a completely open damper position, than the maximum value of "LAT Added Damper Positions" will be fifteen. Referring again to step 172, in the event that the value of added damper positions has not exceeded the maximum allowable, the microprocessor will proceed to a step 174 and add one incremental damper position to the present value of the "LAT Added Damper Position". The new "LAT Added Damper Positions" will subsequently be used by the motor command program that is triggered by the main control loop upon exiting thereto in a step 176. In this regard, the motor command program will execute any change in motor position occurring in the upper half of numerical motor positions. This is due to the upper half of numerical motor positions having been set aside as "LAT Added Damper Positions".

It is hence to be appreciated that the "LAT Added Damper Positions" will be used up one at a time to the extent that the space temperature remains above the setpoint temperature. This addition of one damper position will continue to occur until the "LAT Added Damper Positions" equal the maximum. At this point, the microprocessor will without adding any further damper positions exit from step 172 to the main loop control in step 176.

It is to be noted that the above incremental addition of damper positions occurs only when the local space temperature is equal to or greater than local setpoint. When a particular zone control microprocessor determines that the local space temperature is less than the local setpoint, it will proceed from step 168 to a step 178. Referring to step 178, it is seen that the zone control microprocessor subtracts one degree from setpoint value. The programmed microprocessor next proceeds to subtract the adjusted setpoint from the space temperature in a step 180. It is to be appreciated that a positive difference will result from step 180 if the space temperature is less than one degree below the original setpoint reading. This positive difference is noted by the microprocessor in step 182. The microprocessor will thereafter proceed to a step 184 and convert the temperature difference calculated in step 180 to a number of incremental damper positions. This conversion is a function of how far the damper is to be moved for a given calculated difference. In the preferred embodiment, each of the fifteen allowed added damper positions correspond to one tenth of a degree temperature difference. In this regard, the temperature difference of step 180 is divided by one tenth of a degree per damper position to arrive at the number of incremental damper positions. The thus determined number of incremental damper positions are loaded into the "LAT Added Damper Positions" storage location in a step 186. This new number of "LAT Added Damper Positions" replaces any previously stored value of "LAT Added Damper Positions". The new value of "LAT Added Damper Positions" is made available to the motor command program upon exiting to the main loop control in step 176. It is hence to be appreciated that in the event the space temperature in a given zone drops below setpoint by less than one degree, the amount by which the space temperature may be permitted to further drop will be converted to incremental damper positions allowing for an immediate opening of the damper by the motor command program.

Referring again to step 182, in the event that the difference between the set point and the space temperature is more than one degree, then the microprocessor proceeds to a step 188 and clears the "LAT Added Damper Positions" that may have been previously defined as a result of either step 174 or step 184. The microprocessor thereafter proceeds from step 188 to exit to the main loop control in step 176. The main loop will invoke the motor command program which will note the need to change commanded damper position due to the cleared "LAT Added Damper Positions". In this regard, the upper half of possible commanded damper positions will now be at zero. The zone control motor and associated damper will be appropriately repositioned.

It will be remembered that a check routine is invoked at several points within the software program of Figures 5A and 5B. For instance, the check routine may be invoked out of step 144 when the particular zone control software is entered into from the main zone control loop and no packet interrupt has occurred from the master control 12. The check routine might also be invoked if the master control is merely asking for the local supply air temperature in steps 146, 148 and 150. The check routine is also invoked if the interrupt is not the flag control byte in step 152. The check routine is furthermore invoked if the LAT Flag bit value is zero in step 156 or the "scan counter" is one as detected in steps 158 and 162.

Referring to Figure 5C, the check routine begins with a step 190 which inquires as to whether the "LAT Flag Bit" equals one. If this bit value is zero, the microprocessor will proceed to a step 192 and inquire as to whether the "LAT Added Damper Positions" is now zero. If yes, the microprocessor will proceed to exit in a step 194 to the main control loop. If on the other hand the "LAT Flag Bit" equals one or the "LAT Added Damper Positions" does not equal zero, the microprocessor will proceed from either step 190 or 192 to a step 196. Referring to step 196, an inquiry is made as to whether the space temperature in the particular zone is less than the setpoint for that zone. If the answer is no, than the microprocessor proceeds to step 194 and exits to the main control loop. When the space temperature is less than setpoint, the microprocessor proceeds from step 196 to step 198 and subtracts one degree from the setpoint and proceeds to step 200 and subtracts the thus adjusted setpoint from space temperature. The microprocessor next inquires in a step 202 as to whether the difference calculated in step 200 is positive. As has been previously discussed with regard to step 182, in the event that the space temperature is one degree or more below setpoint, then the difference calculated in step 200 will be negative. A negative difference will prompt the microprocessor to proceed to a step 204 and set the "LAT Added Damper Positions" equal to zero. The zone control microprocessor will in this instance exit through step 194 to the main control loop. The main control loop will subsequently invoke the motor command program which will reposition the particular zone damper as a result of the cleared "LAT Added Damper Positions".

Referring again to step 202, in the event that a positive difference is detected, the zone control microprocessor will proceed to a step 206. As has been previously discussed with regard to step 182, a positive difference indicates that space temperature is less than one degree lower than the zone setpoint. This positive difference is converted into incremental damper positions in a step 208. The conversion is preferably one damper position for every one tenth of a degree difference in temperature. The thus calculated damper positions become the new "LAT Added Damper Positions" value in step 208. The microprocessor proceeds from step 208 to exit back to the main loop control in step 194. The motor command program will subsequently be invoked and the new "LAT Added Damper Positions" value will be used to reposition the zone damper.

It is to be appreciated from the above that the check routine of Figure 5C may update the zone control damper positioning anytime it is invoked during execution of the zone control software of Figures 5A and 5B. In all such instances, the check routine proceeds as has been previously described to possibly change the value of "LAT Added Damper Positions".

Referring to Figure 1, it is to be understood that each zone control 30, 32 and 34 having its own respective zone control software can potentially make an adjustment to its damper positioning. This adjustment may occur in response to a communication from the master control 12 indicating that the supply air temperature in at least one zone is below the second stage trip temperature. This adjustment may also occur when each zone control merely invokes its check routine at appropriate times during execution of its zone control software. Each zone control will make its adjustments based upon a comparison of its local space temperature and its setpoint temperature. Incremental additions of one damper position at a time will occur if the space temperature is above setpoint. More than one damper position may be commanded if the local space temperature falls below local setpoint by less than one degree. In this manner, each zone control will contribute as much as it can to the particularly detected supply air condition within the VAV system without unduly impacting the comfort level in any particular zone. This latter objective is of course accomplished by the corrective action being limited in any one zone control to a deviation of less than one degree from setpoint.

The invention also extends to systems wherein, for example, the air conditioning system 10 of Fig. 1 supplies heated air to the zones 14, 16 and 18, instead of chilled air. In a corresponding manner to the chilled air embodiment, the bypass duct 24 may be opened to return, in this case, heated air to the air conditioning system 10 due to a change in demand for supply air to the zones. This may cause the supply air temperature to increase, and prompt the need for corrective action.

Fig. 6A-6C, and Figs. 7A-7C comprise flow diagrams for use in the system of Fig. 1, when the system is designed to supply heated air to the zones, instead of cooled air. The Figures correspond respectively to Figs. 4A-4C and Figs. 5A-5C, and enable the system to provide corresponding relief. The differences between the flow diagrams of the chilled and heated embodiments are as follows:

1) In Fig. 6A-6C (the flow chart of the master control), the supply air temperature "T_s" will be set equal to the highest local supply air temperature found in all of the queried zone controls (cf. step 110'). Also, in steps 114' and 124', it is determined whether or not T_s is greater than second and first stage trip temperatures, so as to decide whether or not to turn off the first and second heating stages, respectively, and whether to set the LAT flag equal to one or zero.

2) In Fig. 7A-7C (the flow chart of each zone control), in step 168', it is determined whether or not the space temperature is greater than the setpoint temperature, and in steps 178' and 180' one degree is added to the setpoint before the space temperature is subtracted from it. Similar differences occur in steps 196', 198' and 200'.

In a similar manner to the chilled air embodiment, therefore, and referring to Fig. 1, it is to be understood that each zone control 30, 32 and 34 having its own respective zone control software can potentially make an adjustment to its damper positioning. This adjustment may occur in response to a communication from the master control 12 indicating that the supply air temperature in at least one zone is above the second stage trip temperature. This adjustment may also occur when each zone control merely invokes its check routine at appropriate times during execution of its zone control software. Each zone control will make its adjustments based upon a comparison of its local space temperature and its setpoint temperature. Incremental additions of one damper position at a time will occur if the space temperature is below setpoint. More than one damper position may be commanded if the local space temperature is above local setpoint by less than one degree. In this manner, each zone control will contribute as much as it can to the particularly detected supply air condition within the VAV system without unduly impacting the comfort level in any particular zone. This latter objective is of course accomplished by the corrective action being limited in any one zone control to a deviation of less than one degree from setpoint.

It is finally to be appreciated that only particular embodiments of the invention have been described. Alterations, modifications and improvements thereto will readily occur to those skilled in the art. Such alternation, modifications and improvements are intended to be part of this disclosure even though not expressly stated herein and are intended to be within the scope of the invention. Accordingly, the forgoing description is by way of example only and the invention is to be limited only by the following claims and equivalents thereto.

Claims

1. A system for controlling the positioning of dampers within a variable air volume system either when the supply air temperature drops below a predefined temperature level in the case of a system supplying chilled air, or when the supply air temperature increases above a predefined temperature level in the case of a system supplying heated air, said system comprising:

a plurality of motors for positioning the dampers within the variable air volume system;

a plurality of sensors for sensing the temperature of the air supplied to each damper within the variable air volume system;

a plurality of programmable zone control units, each connected to a respective motor and to a sensor so as to normally control the positioning of the damper and further monitor the supply air temperature sensed by the respective sensor;

a master programmable control unit connected to each programmable zone control unit, said master programmable control unit having a stored program therein for successively reading the sensed temperatures of the air supplied to each damper from the programmable zone control units and for comparing the sensed temperatures, with a predetermined limit for sensed supply air temperature, said programmable master control unit being operative to send a warning to each of said programmable zone control units within the variable air volume system when, in the case of a chilled air system, the temperature of the air sensed by any sensor is less than the predetermined limit, or, in the case of a heated air system, the temperature of the air sensed by any sensor is greater than the predetermined limit.

Claim 2. The system of claim 1, wherein each of said programmable zone control units has a program stored therein which comprises:

an instruction for comparing the temperature of a space supplied with air from a particular damper with a setpoint temperature for the space, and an instruction for increasing the presently commanded damper position by one additional incremental position upon receipt of the warning when the temperature within the space is above its setpoint temperature in the case of a chilled air system, or is below its setpoint temperature in the case of a heated air system.

Claim 3. The system of claim 2, wherein the program in each of said programmable zone control units further comprises:

a limit expressed in a predetermined number of added positions that the motor associated with the programmable zone control unit may successively move the damper in addition to a normally commanded position.

Claim 4. The system of claim 2 or 3, wherein the program in each of said programmable zone control units further comprises:

a set of instructions for periodically detecting whether a change in the warning has occurred from said programmable master control unit and for suspending the instruction for increasing the presently commanded damper position by one incremental position when a change in the warning is detected.

Claim 5. The system of claim 2,3 or 4, wherein the program in each of said programmable zone control units further comprises:

at least one instruction for checking whether the temperature of the space is less than the setpoint temperature for the space in the case of a chilled air system or greater than the setpoint temperature in the case of a heated air system, when a change in the warning is detected;

at least one instruction for checking whether the temperature of the space is within a predefined amount of the setpoint temperature for the space when the above check is true; and

at least one instruction, responsive to a determination that the temperature of the space is within the predefined amount of the setpoint temperature, for calculating a number of additional incremental positions to be immediately commanded.

Claim 6. The system of any of claims 2 to 5, wherein the program within each of said programmable zone control units comprises:

at least one instruction, responsive to the temperature of the space being less than the setpoint temperature for the space in the case of a chilled air system or being greater than the setpoint temperature in the case of a heated air system, for determining whether the temperature of the space is within a predefined amount of the setpoint temperature for the space; and

at least one instruction, responsive to a determination that the temperature of the space is within the predefined amount of the setpoint temperature, for calculating a number of additional incremental positions to be immediately commanded.

Claim 7. The system of claim 6, wherein the program in each of said programmable zone control units further comprises:

at least one instruction, responsive to a determination that the temperature of the space is not within the predefined amount of the setpoint temperature, for deleting all previously added incremental damper positions.

Claim 8. The system of any preceding claim, wherein the program in said master programmable control unit comprises:

at least one instruction for reading the sensed temperatures of the air supplied to the dampers in a predefined order; and

at least one instruction for defining a period of time which must elapse before again reading the sensed temperatures of the air supplied to the dampers in the predefined order.

Claim 9. The system of claim 8, wherein said instruction for reading the sensed temperatures in a predefined order comprises:

at least one instruction for addressing each programmable zone control unit;

at least one instruction for awaiting an identification from the programmable zone control unit; and

at least one instruction for requesting the temperature of the air supplied to a damper upon receipt of an identification as to the programmable zone control units being a zone control within the variable air volume system.

Claim 10. The system of any preceding claim, wherein said program in said master control unit further comprises:

an instruction for terminating a stage of the air conditioning system supplying the air to each damper when the sensed temperature of the air supplied to at least one damper is less than the predetermined limit of supply air temperature in the case of a chilled air system, or is more than the predetermined limit in the case of a heated air system.

Claim 11. The system of claim 10, wherein said program in said master control unit further comprises:

an instruction for terminating an additional stage in the air conditioning system supplying the air to each damper when the sensed temperature of the air supplied to at least one damper exceeds a still lower or higher temperature than the predetermined limit of supply air temperature in the case of a chilled or heated air system respectively.

12. A process for controlling the positioning of dampers within a variable air volume system either when the supply air temperature drops below a predefined temperature level in the case of a system supplying chilled air, or when the supply air temperature increases above a predefined temperature level in the case of a system supplying heated air, said process comprising the steps of:

controlling the positioning of dampers within the variable air volume system;

reading the respective temperatures of the air supplied to each damper;

determining the lowest temperature in the case of a chilled air system, or determining the highest temperature in the case of a heated air system, from among the respective temperatures that have been read;

comparing the determined lowest or highest sensed temperature with a predetermined limit of supply air temperature; and

warning controllers which position the dampers within the variable air volume system when the sensed temperature of the air supplied to at least one damper is less than the predetermined limit of supply air temperature in the case of a chilled air system, or is greater than the predetermined limit in the case of heated air system.

13. The process of claim 12, wherein said step of controlling the positioning of dampers within the variable air volume system comprises the steps of:

comparing the temperature of each space being supplied with chilled or heated air with a setpoint temperature for the space; and

increasing the presently commanded damper position by one additional incremental position upon receipt of the warning when the temperature within the space is above its setpoint temperature in the case of a chilled air system, or is below its setpoint temperature in the case of a heated air system.

14. The process of claim 12 or 13, further comprising the step of:

limiting said step of increasing the presently commanded damper position to a predetermined number of added positions.

15. The process of claim 12, 13 or 14, wherein said step of controlling the positioning of dampers within the variable air volume system further comprises:

detecting whether a change in the warning has occurred;

suspending said step of increasing the presently commanded damper position by one incremental position when a change in the warning is detected.

16. The process of claim 15, wherein said step of controlling the positioning of dampers within the variable air volume system further comprises:

checking whether the temperature of the space is less than the setpoint temperature in the case of a chilled air system or is greater than the setpoint temperature in the case of a heated air system, when a change in the warning is detected;

checking whether the temperature of the space is within a predefined amount of the setpoint temperature for the space when the above check is true; and

calculating a number of additional incremental positions to be immediately commanded when the temperature of the space is within the predefined amount of the setpoint temperature.

17. The process of any of claims 13 to 16, wherein said step of controlling the positioning of dampers within the variable air volume system comprises the steps of:

determining whether the temperature of the space is within a predefined amount of the setpoint temperature for the space when the temperature of the space is less than the setpoint temperature in the case of a chilled air system or is greater than the setpoint temperature in the case of a heated air system; and

calculating a number of additional incremental positions to be immediately commanded when the temperature of the space is within the predefined amount of the setpoint temperature.

18. The process of claim 17, wherein said step of controlling the positioning of dampers within the variable air supply system further comprises the step of:

deleting all previously added incremental damper positions when the temperature of the space is not within the predefined amount of the setpoint temperature.

19. The process of any preceding claim, wherein said step of reading the respective temperatures of the air supplied to each damper comprises the steps of:

reading the respective temperatures of the air supplied to the dampers in a predefined order; and

defining a period of time which must elapse before again reading the sensed temperatures of the air supplied to the dampers in the predefined order.

20. The process of any preceding claim, further comprising the step of:

terminating a stage of an air conditioning system supplying the air to each damper when the sensed temperature of the air supplied to at least one damper is less than the predetermined limit of supply air temperature in the case of a chilled air system, or is more than the predetermined limit in the case of a heated air system.

Claim 21. A system for responding to a change in temperature of the air being supplied to a plurality of individual zones to be cooled or to be heated, each zone having a controller for controlling the flow of chilled or heated air to the zone, said system comprising:

a master controller for determining the lowest supply air temperature in any of the zones in the case of the supply of chilled air, or for determining the highest supply air temperature in any of the zones in the case of the supply of heated air;

a communication link between said master controller and said zone controllers in each zone for sending a warning signal to each zone controller when the lowest zone supply air temperature in the case of the supply of chilled air, or the highest supply air temperature in the case of the supply of heated air, is respectively below or above a predetermined limit of supply air temperature; and

a program within each zone controller for adjusting the flow of air to the respective zone upon receipt of the warning signal.

Claim 22. The system of claim 21, wherein said program within each zone controller for adjusting the flow of air to the respective zone comprises:

a set of instructions for incrementally adjusting the flow of air by a specified amount every other time a warning signal is received by the zone controller when the space temperature in the zone is greater than the setpoint temperature for the zone in the case of the supply of chilled air, or is less than the setpoint temperature in the case of the supply of heated air.

Claim 23. The system of claim 21 or 22, wherein said program within each zone controller for adjusting the flow of air to the respective zone further comprises:

at least one instruction for adjusting the flow of air by an amount calculated to cause the temperature of the zone to drop to predetermined amount below local setpoint when the temperature of the zone is less than the predetermined amount below setpoint in the case of the supply of chilled air, or to cause the zone temperature to rise a predetermined amount above local setpoint when the zone temperature is greater than the predetermined amount below setpoint in the case of the supply of heated air.

24. A process for responding to a change in temperature of the air being supplied to a plurality of individual zones to be cooled or heated, each zone having a controller for controlling the flow of chilled or heated air to the zone, said process comprising the steps of:

determining the lowest supply air temperature in any of the zones in the case of the supply of chilled air, or determining the highest supply air temperature in any of the zones in the case of the supply of heated air;

warning each zone controller when the lowest zone supply air temperature is less than a predetermined limit of supply air temperature in the case of the supply of chilled air, or when the highest zone supply air temperature is greater than a predetermined limit of supply air temperature in the case of the supply of heated air; and

adjusting within each controller the flow of air to the respective zone upon receipt of the warning.

25. The process of claim 24, wherein said step within each zone controller of adjusting the flow of air to the respective zone comprises the step of:

incrementally adjusting the flow of air by a specified amount every other time a warning signal is received by the zone controller when the space temperature in the zone is greater than the setpoint temperature for the zone in the case of the supply of chilled air, or is less than the setpoint temperature in the case of the supply of heated air.

26. The process of claim 24 or 25, wherein said step within each zone controller of adjusting the flow of air to the respective zone further comprises the step of:

adjusting the flow of air by an amount calculated to cause the temperature of the zone to drop only a predetermined amount below local setpoint when the temperature of the zone is less than predetermined amount below setpoint in the case of the supply of chilled air, or to cause the zone temperature to rise only a predetermined amount above local setpoint when the zone temperature is greater than the predetermined amount below setpoint in the case of the supply of heated air.

27. A system for controlling the supply of air to a plurality of zones in a variable air volume system, comprising:

a plurality of zone control units for monitoring the temperature of the air supplied to each zone and the temperature within each zone, and for controlling the amount of air supplied to each zone; and

a master control unit connected to the zone control units for reading the temperature of the air supplied to each zone from the zone control units, and for determining when at least one of these read temperatures passes a predetermined limit for supply air temperature,

the master control unit being operative to send a signal to each of the zone control units when the predetermined limit is passed.

28. A system according to claim 27, wherein, on receiving said signal, the zone control units modify the amount of air being supplied to their respective zones so as to increase the amount of air entering each zone in dependence on the conditions prevailing in that zone.

29. A system according to claim 27 or 28, wherein the air supplied to the zones is chilled, and wherein the master control unit signals the zone control units when the air supplied to at least one of the zones is below the predetermined limit.

30. A system according to claim 29, wherein when the temperature of a zone is above a setpoint temperature, the corresponding zone control unit increases the air supplied to the zone in incremental amounts upon receipt of said master control unit signal.

31. A system according to claim 29 or 30, wherein when the temperature of the zone is less than a setpoint temperature by less than a set amount, the corresponding zone control unit, on receiving said signal from the master control unit, increases the amount of air supplied to the zone by an amount dependent upon the difference between the zone and the setpoint temperatures.

32. A system according to claim 29. 30 or 31, wherein when the zone temperature is less than the setpoint temperature by more than a set amount, the corresponding zone control unit cancels any amount of air caused to be supplied to the zone because of a said signal from the master control unit.

33. A system according to claim 27 or 28, wherein the air supplied to the zones is heated, and wherein the master control unit signals the zone control units when the air supplied to at least one of the zones is above the predetermined limit.

34. A system according to claim 33, wherein when the temperature of a zone is below a setpoint temperature, the corresponding zone control unit increases the air supplied to the zone in incremental amounts upon receipt of said master control unit signal.

35. A system according to claim 33 or 34, wherein when the temperature of the zone is more than a setpoint temperature by less than a set amount, the corresponding zone control unit, on receiving said signal from the master control unit, increases the amount of air supplied to the zone by an amount dependent upon the difference between the zone and the setpoint temperatures.

36. A system according to claim 33, 34 or 35, wherein when the zone temperature is more than the setpoint temperature by more than a set amount, the corresponding zone control unit cancels any amount of air caused to be supplied to the zone because of a said signal from the master control unit.

37. A system according to any preceding claim, wherein the predeterimined limit is set as a trip temperature for turning off one of the stages of an air conditioning unit from which the air to the zones is supplied.

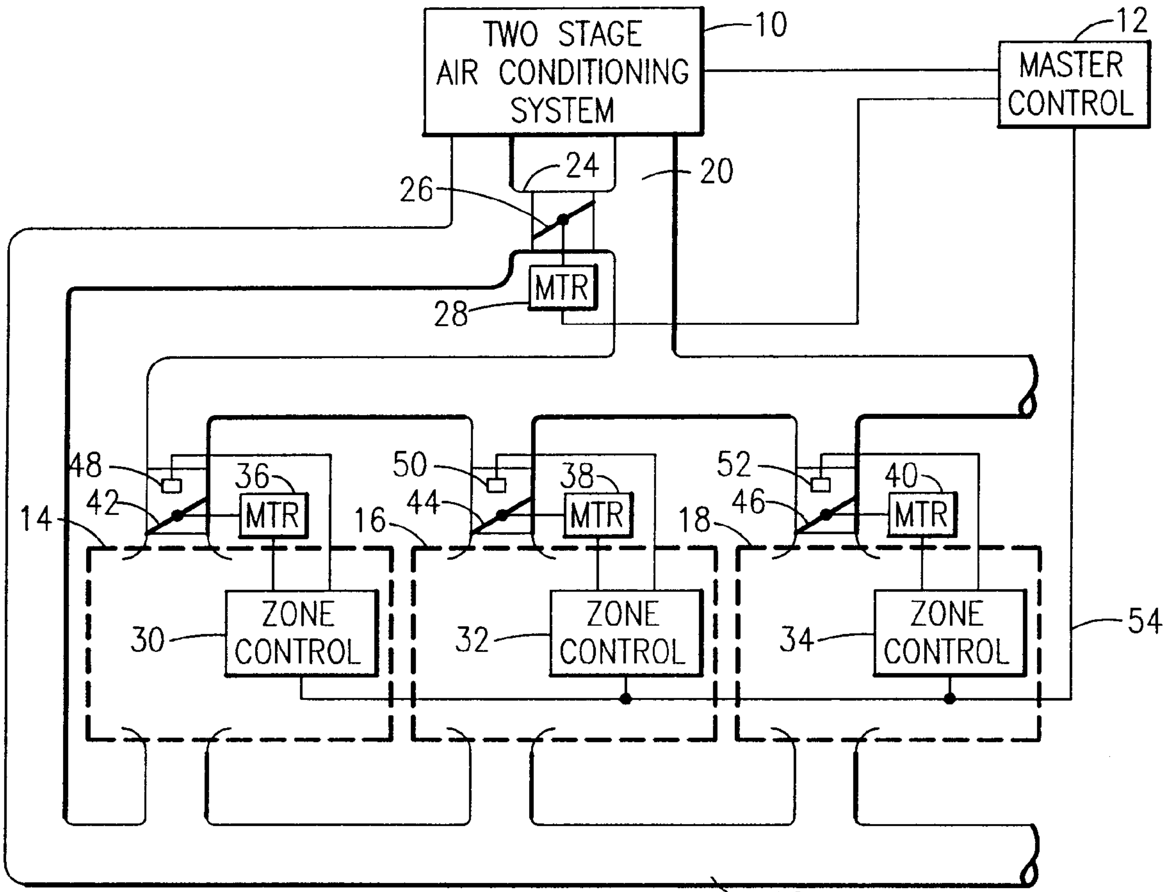


FIG.1

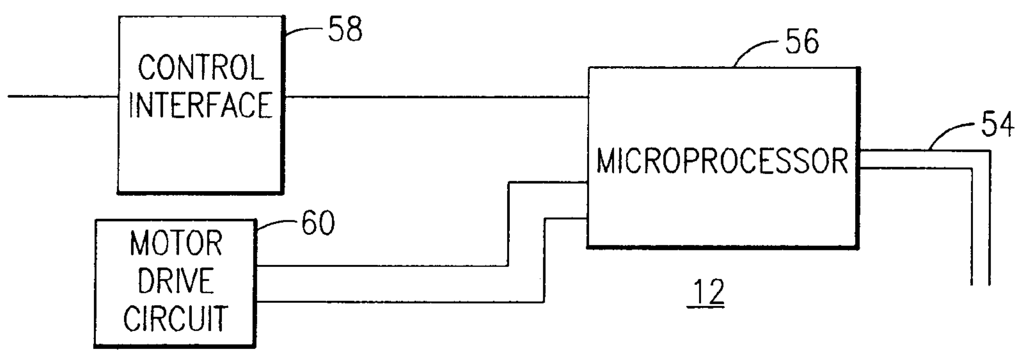


FIG.2

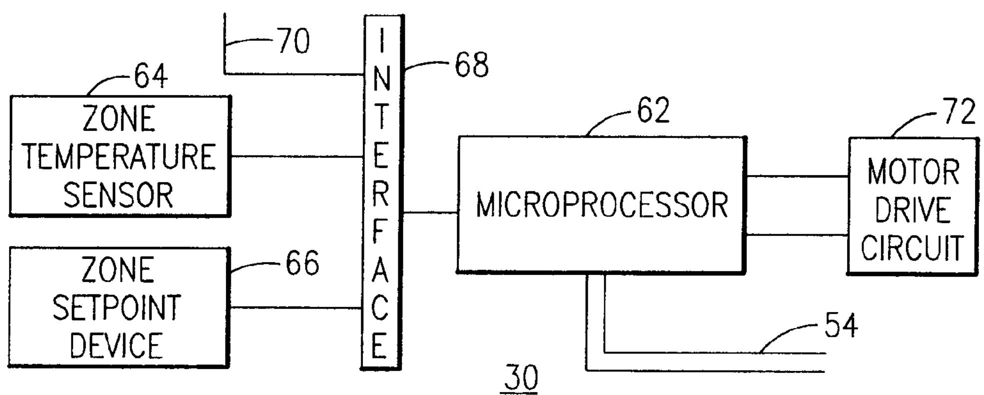


FIG.3

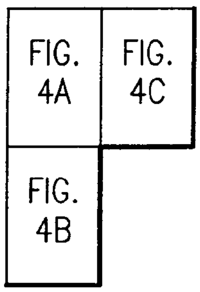


FIG. 4A
FIG. 4C
FIG. 4B

FIG.4

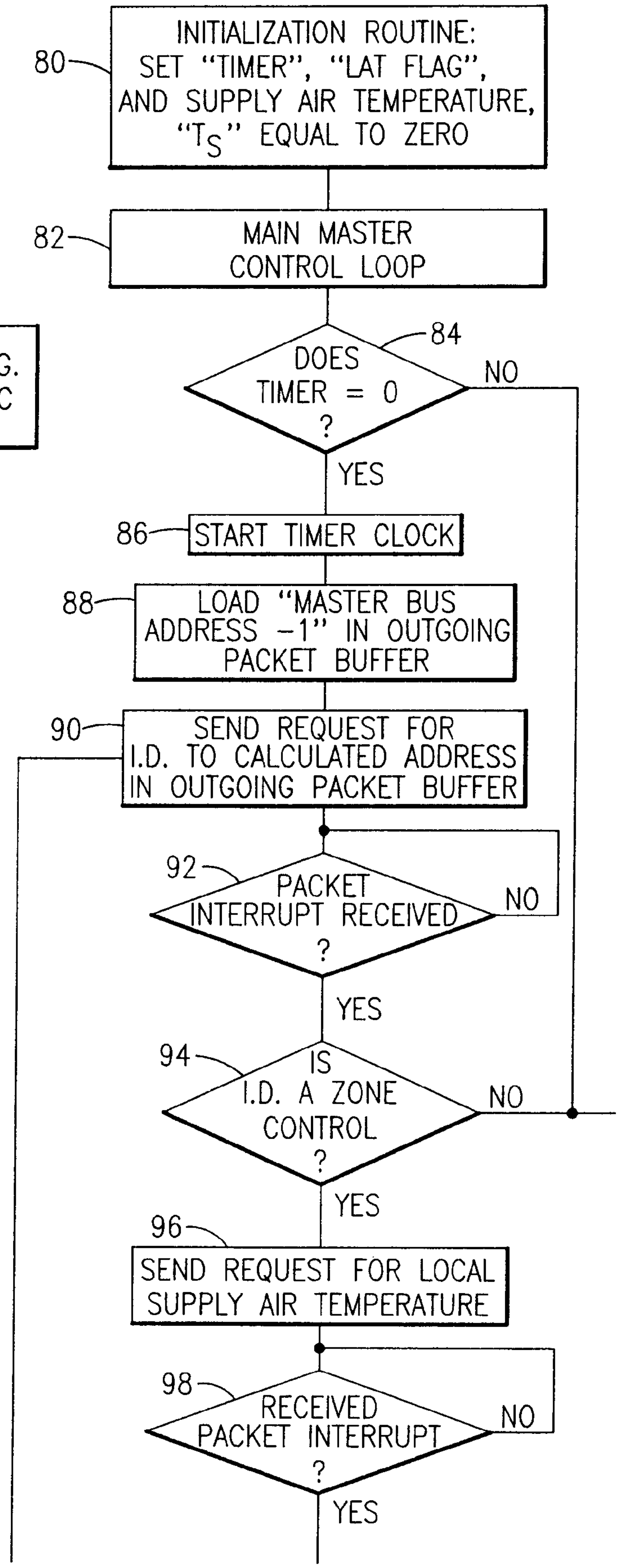

80
INITIALIZATION ROUTINE: SET "TIMER", "LAT FLAG", AND SUPPLY AIR TEMPERATURE, "T_S" EQUAL TO ZERO
82
MAIN MASTER CONTROL LOOP
84
DOES TIMER = 0 ?
NO
YES
86
START TIMER CLOCK
88
LOAD "MASTER BUS ADDRESS -1" IN OUTGOING PACKET BUFFER
90
SEND REQUEST FOR I.D. TO CALCULATED ADDRESS IN OUTGOING PACKET BUFFER
92
PACKET INTERRUPT RECEIVED ?
NO
YES
94
IS I.D. A ZONE CONTROL ?
NO
YES
96
SEND REQUEST FOR LOCAL SUPPLY AIR TEMPERATURE
98
RECEIVED PACKET INTERRUPT ?
NO
YES

FIG.4A

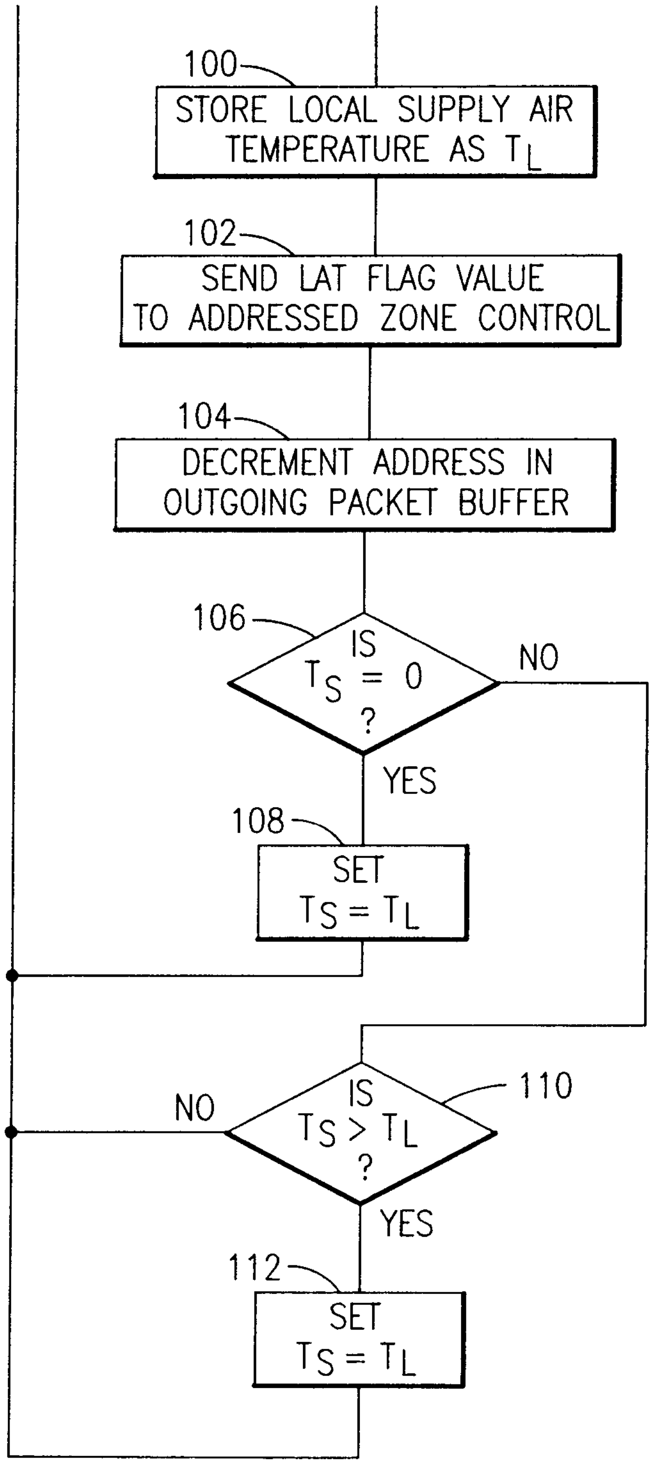

100
STORE LOCAL SUPPLY AIR TEMPERATURE AS T_L
102
SEND LAT FLAG VALUE TO ADDRESSED ZONE CONTROL
104
DECREMENT ADDRESS IN OUTGOING PACKET BUFFER
106
IS $T_S = 0$?
NO
YES
108
SET $T_S = T_L$
110
IS $T_S > T_L$?
NO
YES
112
SET $T_S = T_L$

FIG.4B

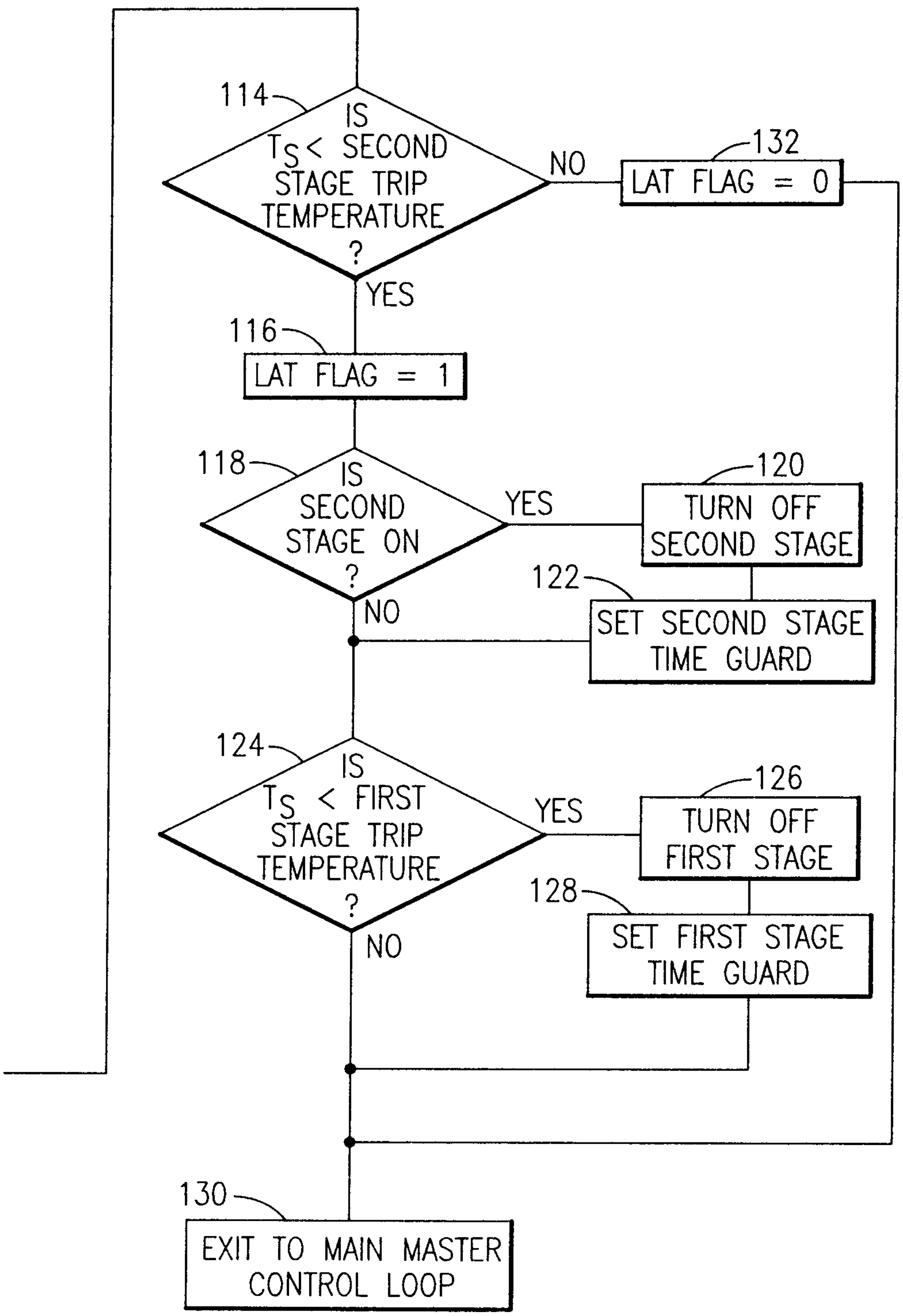

114
IS
T_S < SECOND
STAGE TRIP
TEMPERATURE
?
NO
132
LAT FLAG = 0
YES
116
LAT FLAG = 1
118
IS
SECOND
STAGE ON
?
YES
120
TURN OFF
SECOND STAGE
122
SET SECOND STAGE
TIME GUARD
NO
124
IS
T_S < FIRST
STAGE TRIP
TEMPERATURE
?
YES
126
TURN OFF
FIRST STAGE
128
SET FIRST STAGE
TIME GUARD
NO
130
EXIT TO MAIN MASTER
CONTROL LOOP

FIG.4C

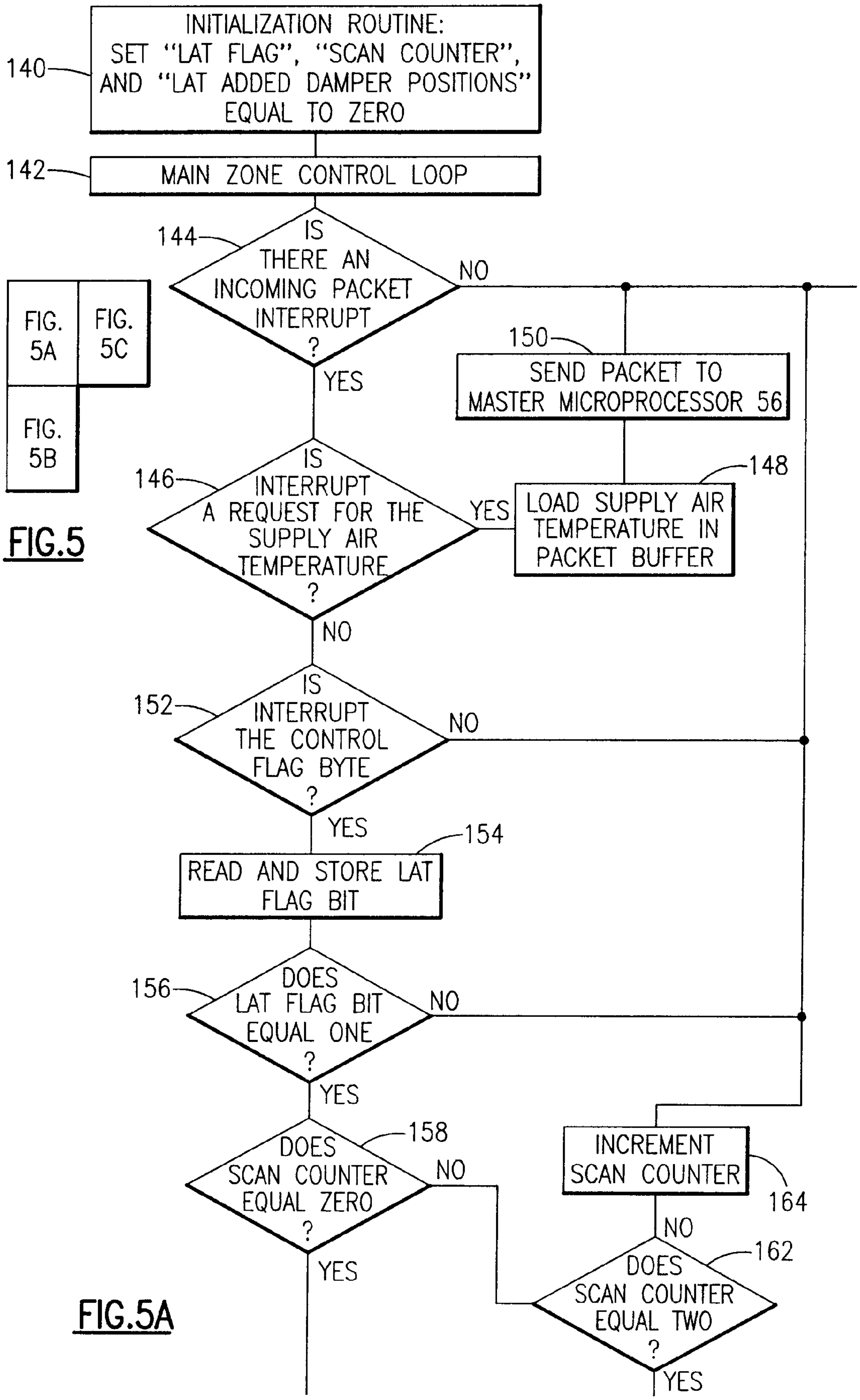

INITIALIZATION ROUTINE:
SET "LAT FLAG", "SCAN COUNTER", AND "LAT ADDED DAMPER POSITIONS" EQUAL TO ZERO
140
MAIN ZONE CONTROL LOOP
142
144
IS THERE AN INCOMING PACKET INTERRUPT ?
NO
YES
150
SEND PACKET TO MASTER MICROPROCESSOR 56
146
IS INTERRUPT A REQUEST FOR THE SUPPLY AIR TEMPERATURE ?
YES
LOAD SUPPLY AIR TEMPERATURE IN PACKET BUFFER
148
NO
152
IS INTERRUPT THE CONTROL FLAG BYTE ?
NO
YES
154
READ AND STORE LAT FLAG BIT
156
DOES LAT FLAG BIT EQUAL ONE ?
NO
YES
158
DOES SCAN COUNTER EQUAL ZERO ?
NO
YES
INCREMENT SCAN COUNTER
164
NO
162
DOES SCAN COUNTER EQUAL TWO ?
YES
FIG. 5A
FIG. 5C
FIG. 5B

FIG.5

FIG.5A

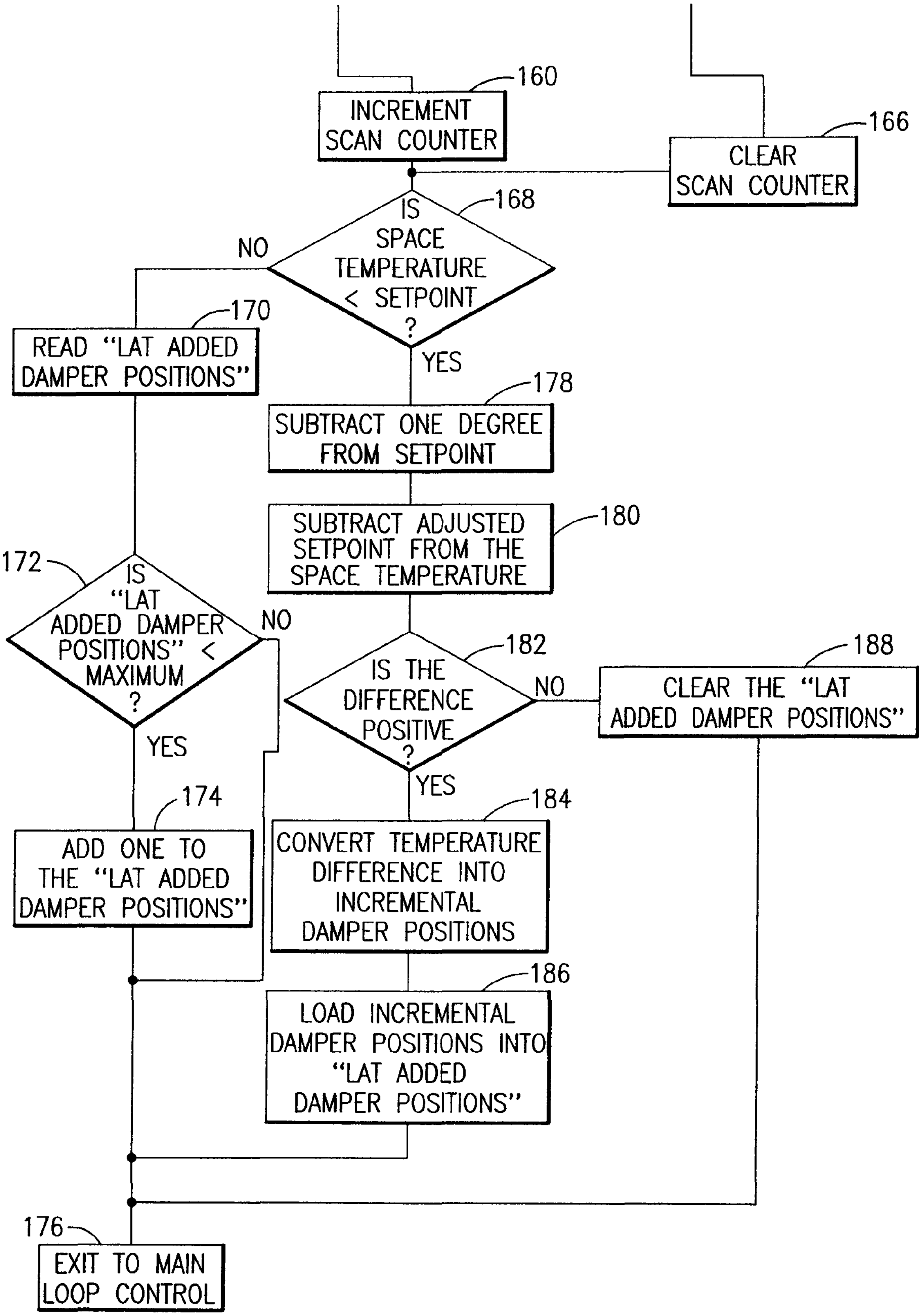
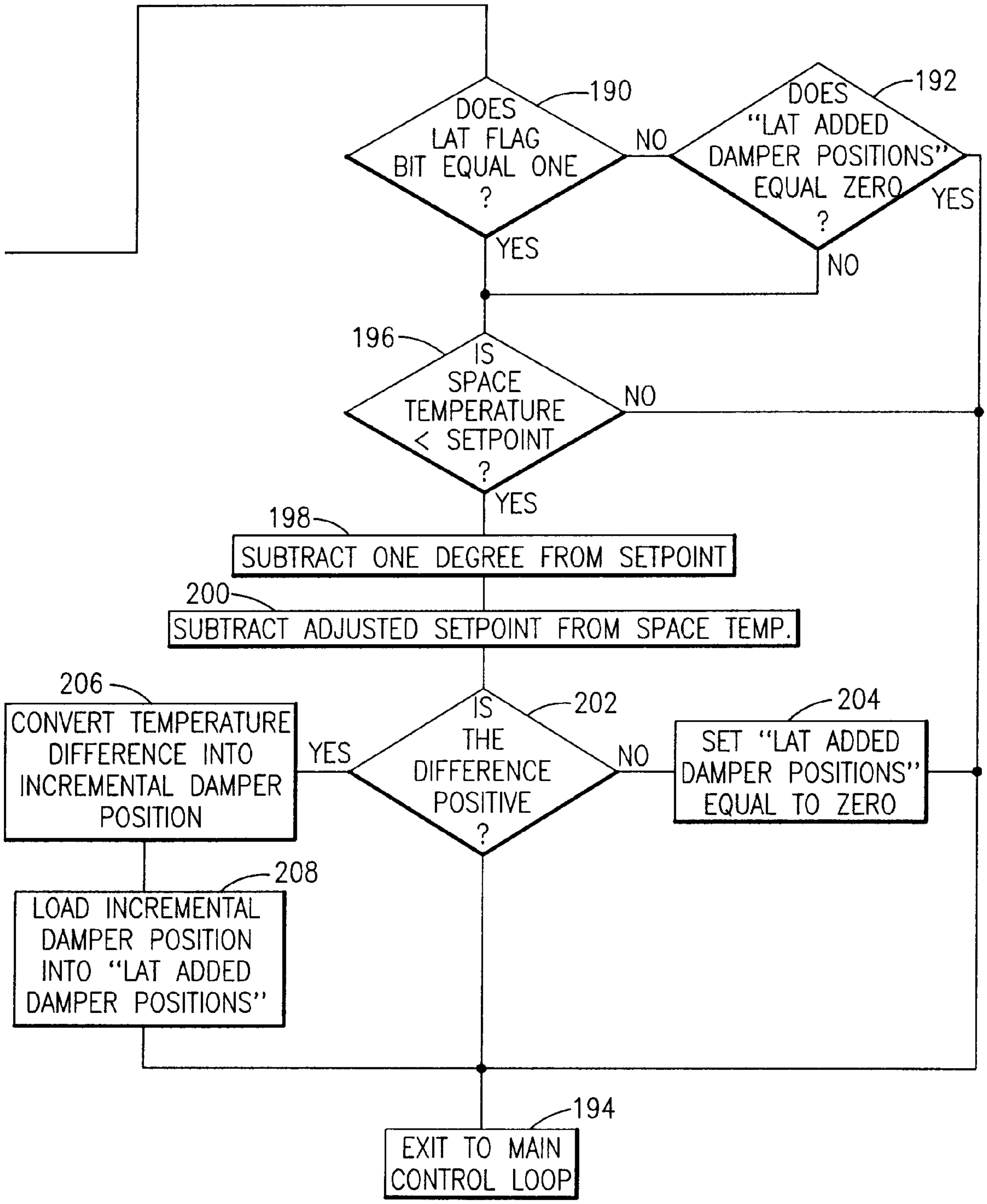

160
INCREMENT SCAN COUNTER
166
CLEAR SCAN COUNTER
168
IS SPACE TEMPERATURE < SETPOINT ?
NO
YES
170
READ "LAT ADDED DAMPER POSITIONS"
178
SUBTRACT ONE DEGREE FROM SETPOINT
180
SUBTRACT ADJUSTED SETPOINT FROM THE SPACE TEMPERATURE
172
IS "LAT ADDED DAMPER POSITIONS" < MAXIMUM ?
NO
YES
182
IS THE DIFFERENCE POSITIVE ?
NO
YES
188
CLEAR THE "LAT ADDED DAMPER POSITIONS"
174
ADD ONE TO THE "LAT ADDED DAMPER POSITIONS"
184
CONVERT TEMPERATURE DIFFERENCE INTO INCREMENTAL DAMPER POSITIONS
186
LOAD INCREMENTAL DAMPER POSITIONS INTO "LAT ADDED DAMPER POSITIONS"
176
EXIT TO MAIN LOOP CONTROL

FIG.5B



DOES LAT FLAG BIT EQUAL ONE ?
190
NO
DOES "LAT ADDED DAMPER POSITIONS" EQUAL ZERO ?
192
YES
YES
NO
196
IS SPACE TEMPERATURE < SETPOINT ?
NO
YES
198
SUBTRACT ONE DEGREE FROM SETPOINT
200
SUBTRACT ADJUSTED SETPOINT FROM SPACE TEMP.
206
CONVERT TEMPERATURE DIFFERENCE INTO INCREMENTAL DAMPER POSITION
YES
IS THE DIFFERENCE POSITIVE ?
202
NO
204
SET "LAT ADDED DAMPER POSITIONS" EQUAL TO ZERO
208
LOAD INCREMENTAL DAMPER POSITION INTO "LAT ADDED DAMPER POSITIONS"
194
EXIT TO MAIN CONTROL LOOP

FIG.5C

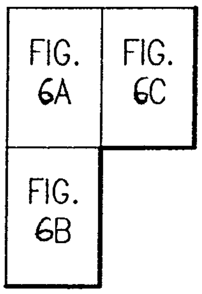


FIG. 6A
FIG. 6C
FIG. 6B

FIG.6

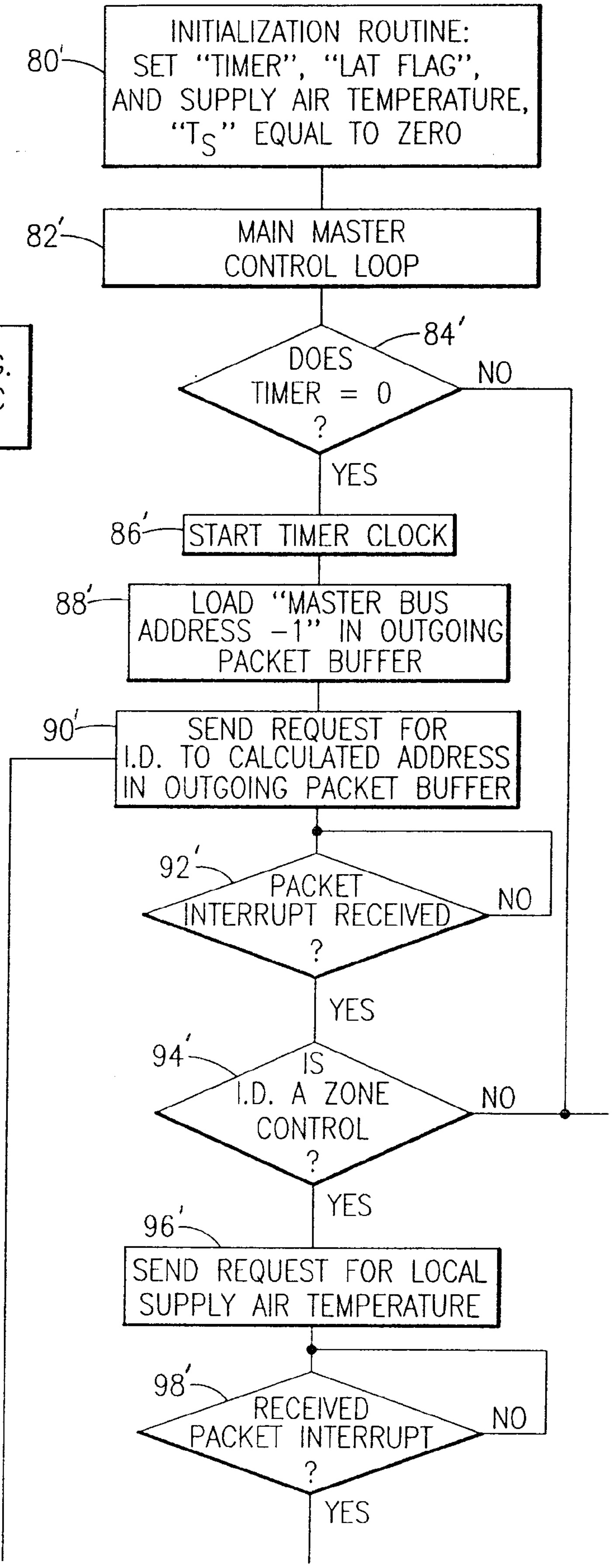

80'
INITIALIZATION ROUTINE: SET "TIMER", "LAT FLAG", AND SUPPLY AIR TEMPERATURE, "T_S" EQUAL TO ZERO
82'
MAIN MASTER CONTROL LOOP
84'
DOES TIMER = 0 ?
NO
YES
86'
START TIMER CLOCK
88'
LOAD "MASTER BUS ADDRESS -1" IN OUTGOING PACKET BUFFER
90'
SEND REQUEST FOR I.D. TO CALCULATED ADDRESS IN OUTGOING PACKET BUFFER
92'
PACKET INTERRUPT RECEIVED ?
NO
YES
94'
IS I.D. A ZONE CONTROL ?
NO
YES
96'
SEND REQUEST FOR LOCAL SUPPLY AIR TEMPERATURE
98'
RECEIVED PACKET INTERRUPT ?
NO
YES

FIG.6A

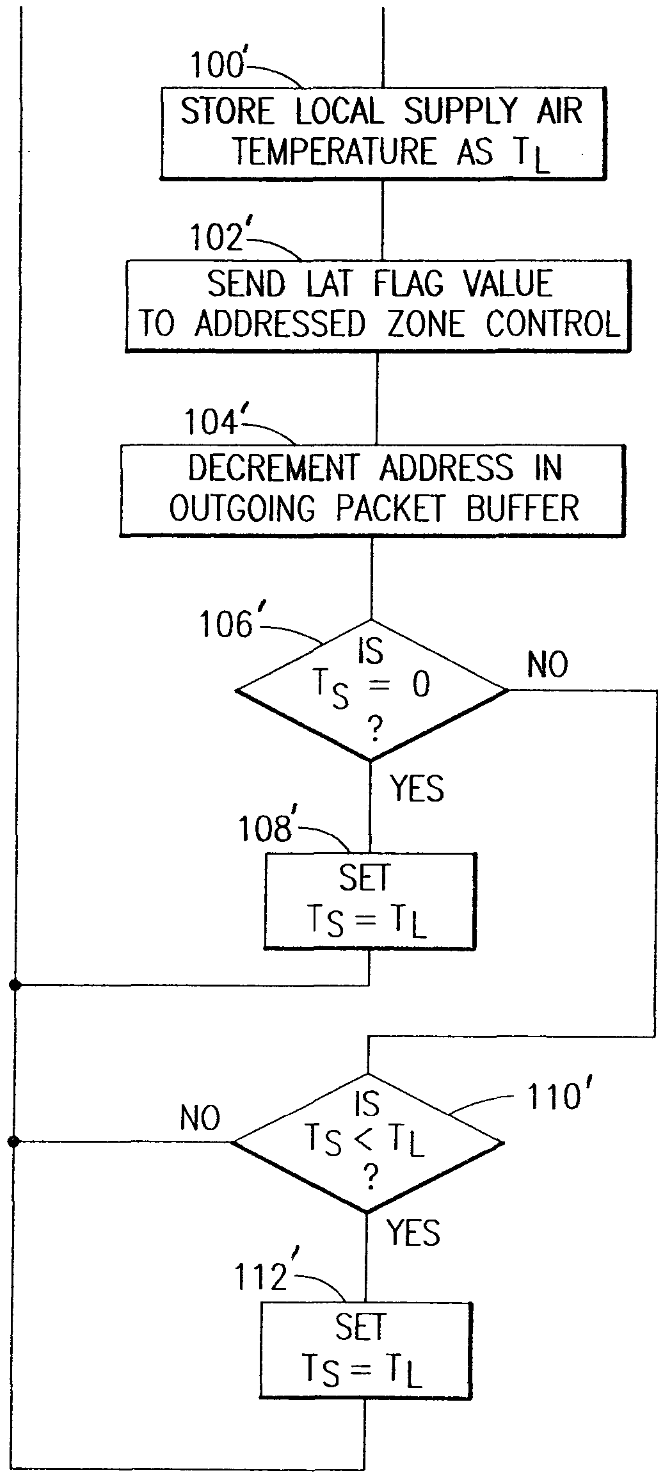

100'
STORE LOCAL SUPPLY AIR TEMPERATURE AS T_L
102'
SEND LAT FLAG VALUE TO ADDRESSED ZONE CONTROL
104'
DECREMENT ADDRESS IN OUTGOING PACKET BUFFER
106'
IS $T_S = 0$?
NO
YES
108'
SET $T_S = T_L$
110'
IS $T_S < T_L$?
NO
YES
112'
SET $T_S = T_L$

FIG.6B

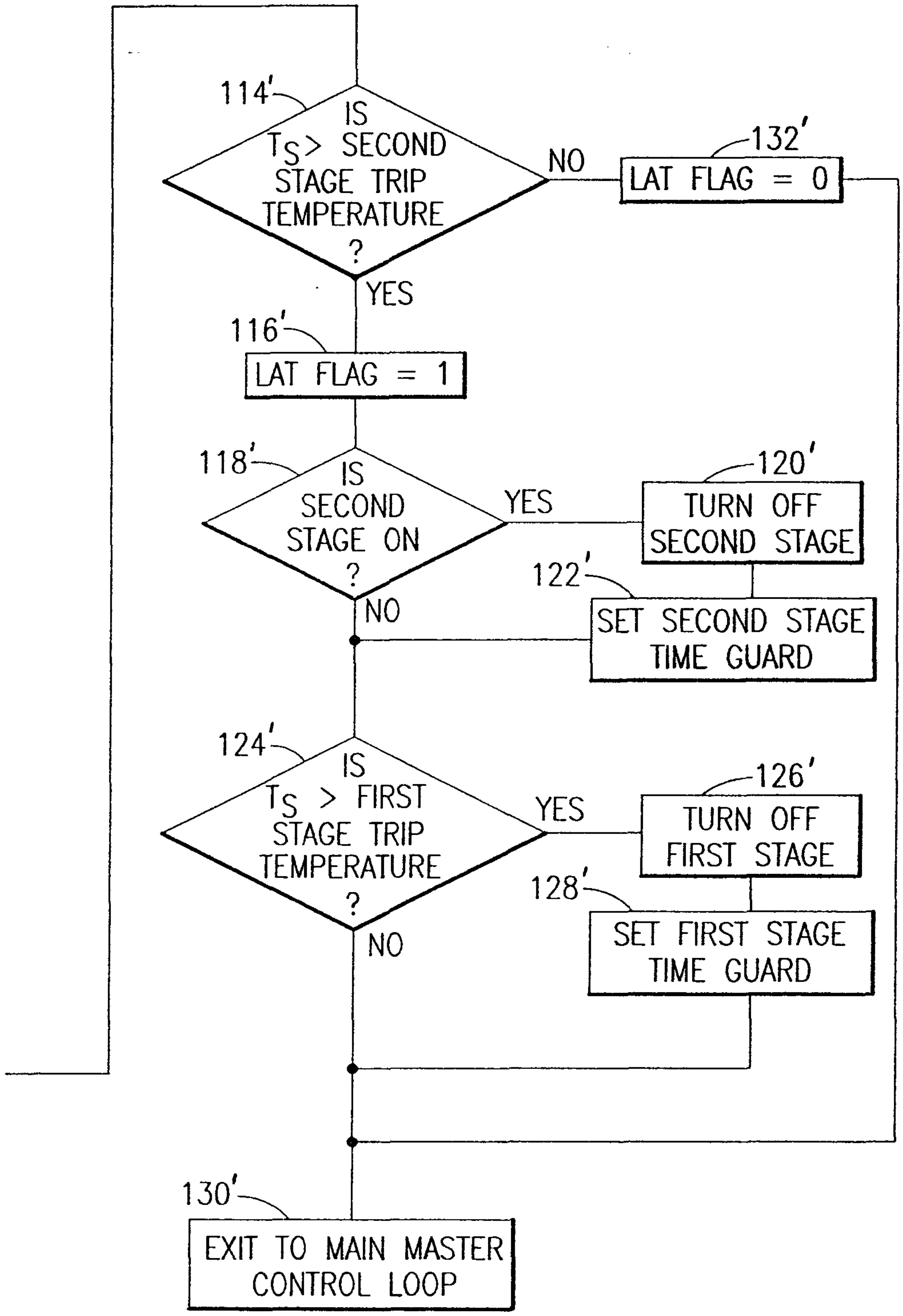

114'
IS T_S > SECOND STAGE TRIP TEMPERATURE ?
NO
132'
LAT FLAG = 0
YES
116'
LAT FLAG = 1
118'
IS SECOND STAGE ON ?
YES
120'
TURN OFF SECOND STAGE
122'
SET SECOND STAGE TIME GUARD
NO
124'
IS T_S > FIRST STAGE TRIP TEMPERATURE ?
YES
126'
TURN OFF FIRST STAGE
128'
SET FIRST STAGE TIME GUARD
NO
130'
EXIT TO MAIN MASTER CONTROL LOOP

FIG.6C

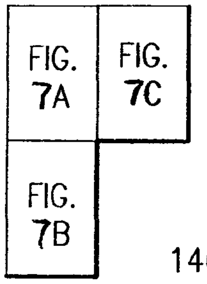


FIG. 7A
FIG. 7C
FIG. 7B

FIG.7

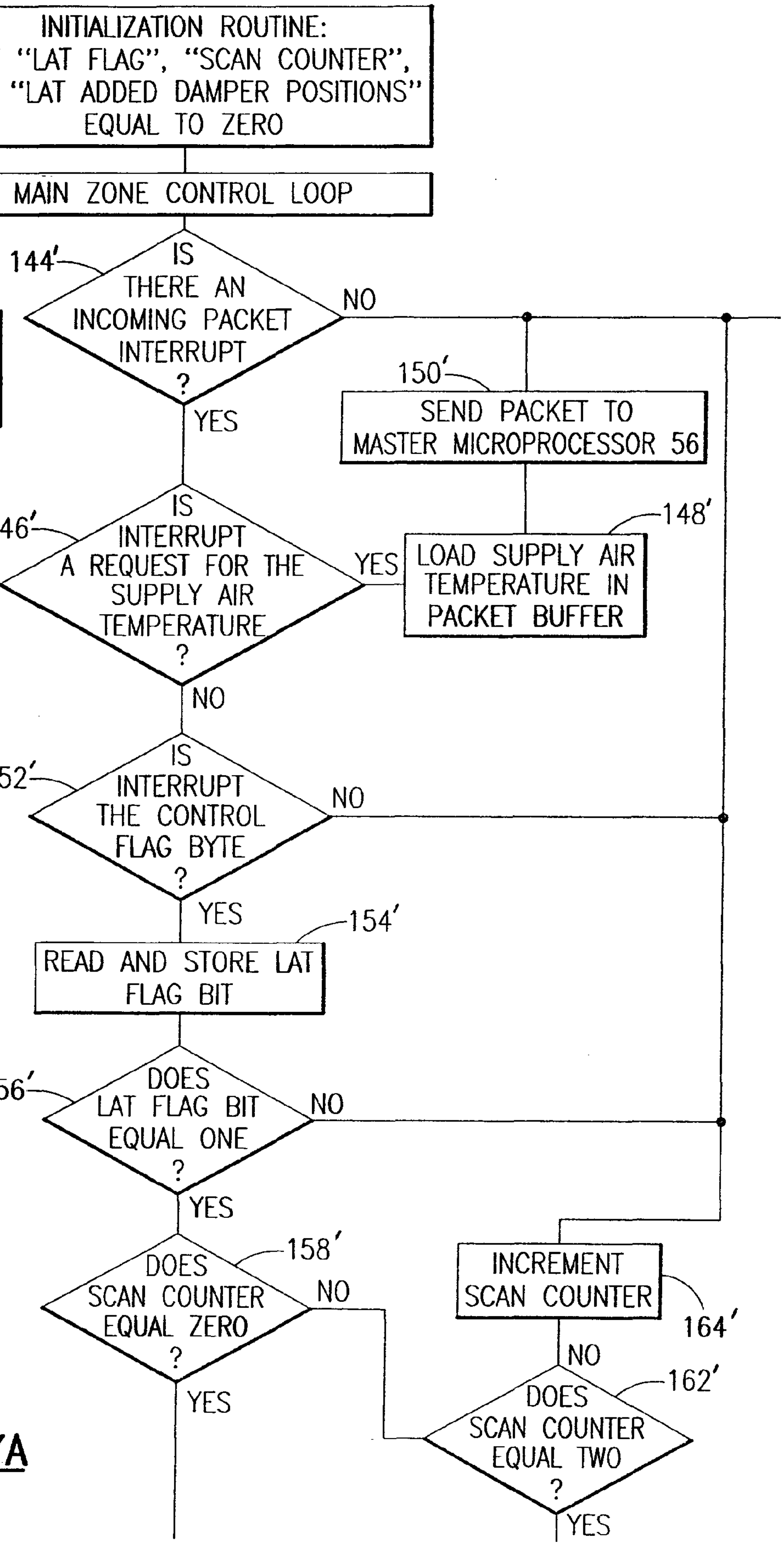

INITIALIZATION ROUTINE: SET "LAT FLAG", "SCAN COUNTER", AND "LAT ADDED DAMPER POSITIONS" EQUAL TO ZERO
140'
MAIN ZONE CONTROL LOOP
142'
IS THERE AN INCOMING PACKET INTERRUPT ?
144'
NO
YES
SEND PACKET TO MASTER MICROPROCESSOR 56
150'
LOAD SUPPLY AIR TEMPERATURE IN PACKET BUFFER
148'
IS INTERRUPT A REQUEST FOR THE SUPPLY AIR TEMPERATURE ?
146'
YES
NO
IS INTERRUPT THE CONTROL FLAG BYTE ?
152'
NO
YES
READ AND STORE LAT FLAG BIT
154'
DOES LAT FLAG BIT EQUAL ONE ?
156'
NO
YES
DOES SCAN COUNTER EQUAL ZERO ?
158'
NO
YES
INCREMENT SCAN COUNTER
164'
NO
DOES SCAN COUNTER EQUAL TWO ?
162'
YES

FIG.7A

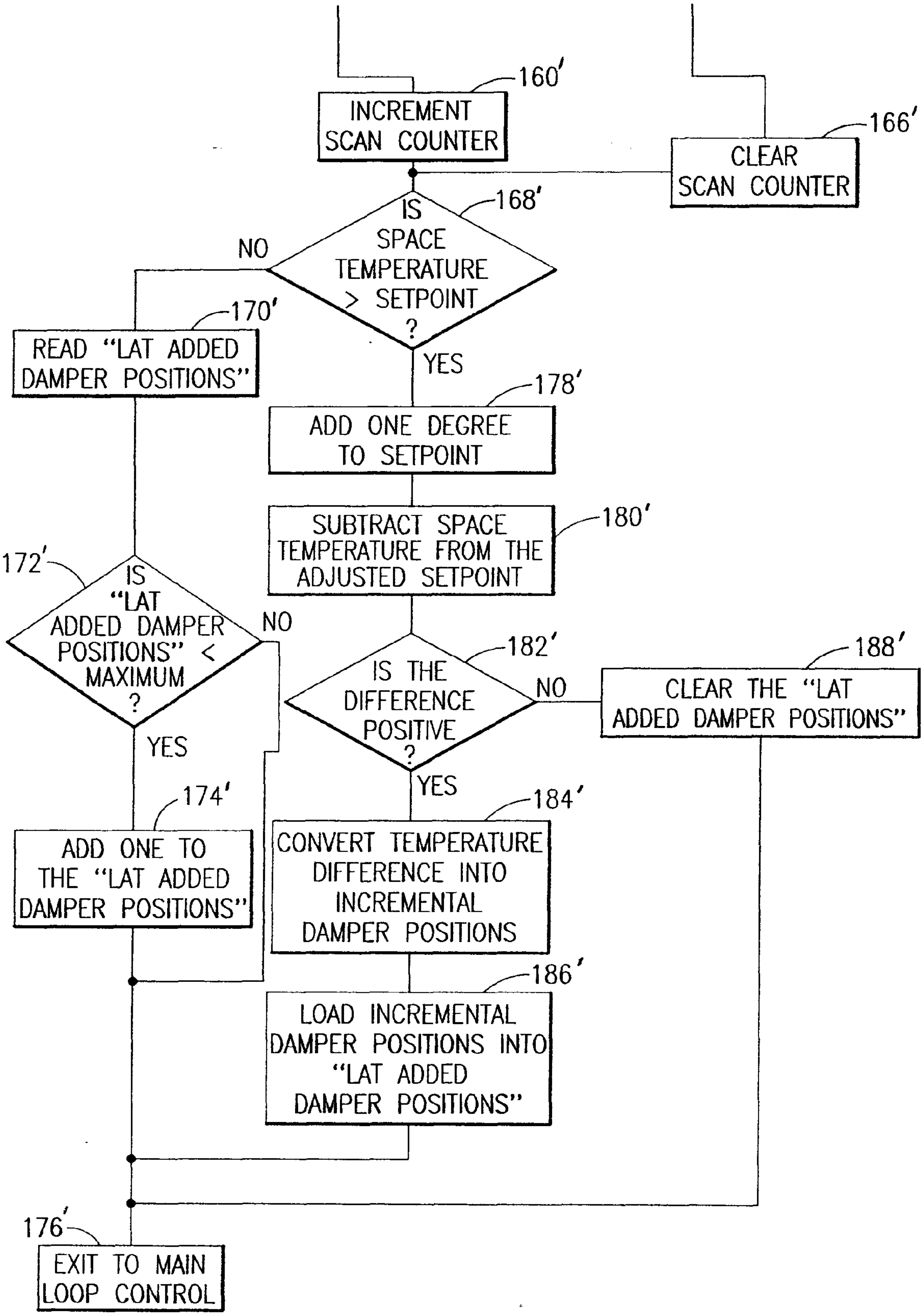

160'
INCREMENT SCAN COUNTER
166'
CLEAR SCAN COUNTER
168'
IS SPACE TEMPERATURE > SETPOINT ?
NO
YES
170'
READ "LAT ADDED DAMPER POSITIONS"
178'
ADD ONE DEGREE TO SETPOINT
180'
SUBTRACT SPACE TEMPERATURE FROM THE ADJUSTED SETPOINT
172'
IS "LAT ADDED DAMPER POSITIONS" < MAXIMUM ?
NO
YES
182'
IS THE DIFFERENCE POSITIVE ?
NO
YES
188'
CLEAR THE "LAT ADDED DAMPER POSITIONS"
174'
ADD ONE TO THE "LAT ADDED DAMPER POSITIONS"
184'
CONVERT TEMPERATURE DIFFERENCE INTO INCREMENTAL DAMPER POSITIONS
186'
LOAD INCREMENTAL DAMPER POSITIONS INTO "LAT ADDED DAMPER POSITIONS"
176'
EXIT TO MAIN LOOP CONTROL

FIG.7B

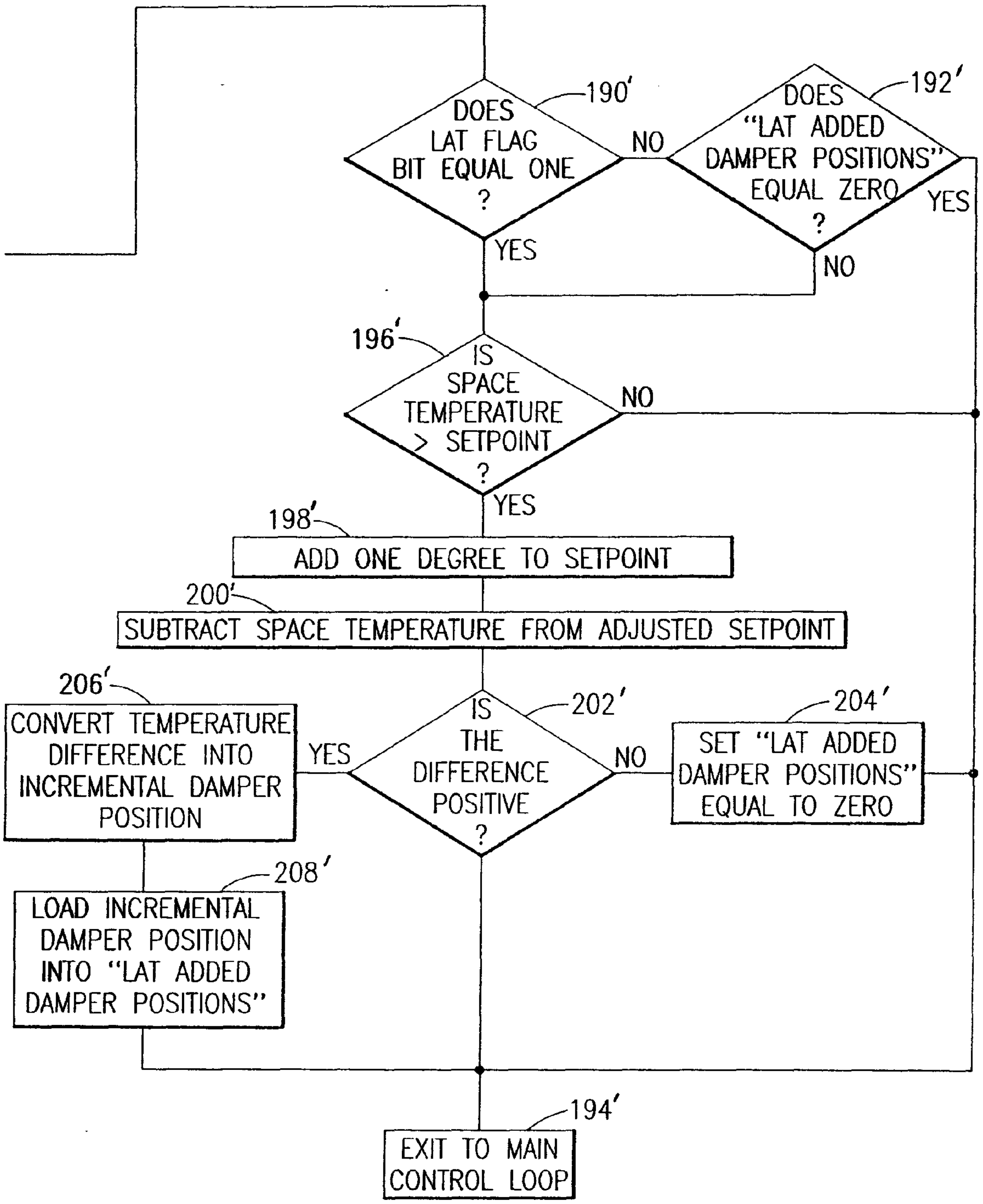

DOES LAT FLAG BIT EQUAL ONE ?
190′
NO
DOES "LAT ADDED DAMPER POSITIONS" EQUAL ZERO ?
192′
YES
YES
NO
196′
IS SPACE TEMPERATURE > SETPOINT ?
NO
YES
198′
ADD ONE DEGREE TO SETPOINT
200′
SUBTRACT SPACE TEMPERATURE FROM ADJUSTED SETPOINT
206′
CONVERT TEMPERATURE DIFFERENCE INTO INCREMENTAL DAMPER POSITION
YES
IS THE DIFFERENCE POSITIVE ?
202′
NO
204′
SET "LAT ADDED DAMPER POSITIONS" EQUAL TO ZERO
208′
LOAD INCREMENTAL DAMPER POSITION INTO "LAT ADDED DAMPER POSITIONS"
194′
EXIT TO MAIN CONTROL LOOP

FIG.7C

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 4776

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	CH-A-672 851 (CARRIER CORPORATION) * page 4, right column, line 1-54; figures 1,2 *	1,27	F24F11/053 F24F3/044
A	US-A-5 025 638 (YAMAGISHI ET AL) * column 4, line 42 - column 5, line 7; figure 2 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 October 1994	Van der Wal, W

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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