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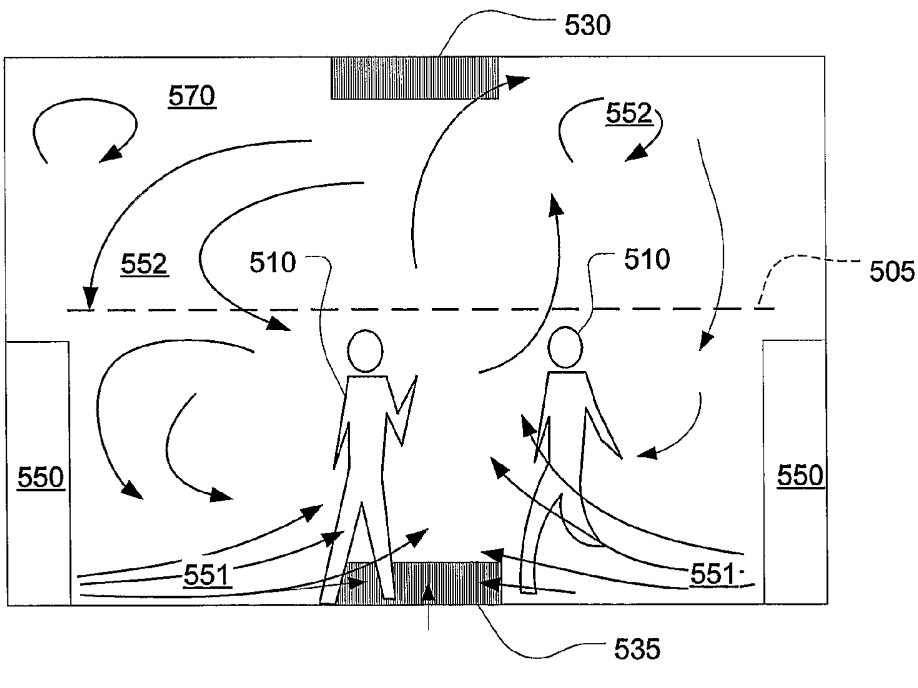
(54) Title: AUTOMATIC MODE SWITCHING VENTILATION REGISTER AND HEATING MODE AUGMENTATION SYSTEMS



(57) Abstract: Displacement ventilation systems are generally poor performers when it comes to heating. The instant patent application discusses a range of devices and systems for improving heating performance while retaining the benefits of displacement ventilation without wholesale co-location of independent space conditioning systems.

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AUTOMATIC MODE SWITCHING VENTILATION REGISTER AND HEATING MODE AUGMENTATION SYSTEMS

DESCRIPTION

Brief Description of the Drawings

Figs. 1A and 1B illustrates a conditioned space with configurable mixing/displacement ventilation registers in displacement and mixing modes, respectively.

Figs. 2A and 2B illustrate a first embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively.

Figs. 3A and 3B illustrate a second embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively.

Figs. 4A and 4B illustrate a third embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively.

Figs. 5A and 5B illustrate a fourth embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively.

Figs. 6A and 6B illustrate a fifth embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively.

Figs. 7A and 7B illustrate a sixth embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively.

Figs. 8A and 8B illustrate an alternative embodiment in which the return registers are changed over from heating to cooling mode, but the supply registers are the same.

Figs. 9A and 9B illustrate an alternative embodiment in which the return registers are changed over from heating to cooling mode, and hydronic heating is used in place of force air heating.

Fig. 10 is an illustration of a central control system that may be used with various embodiments discusser herein.

Fig. 11 shows a plan view of a room with multiple discharge registers 1125, 1135, and 1145.

Figs. 12A and 12B show an embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively, in which independent dampers are used to modulate total air volume, for example based on a VAV scheme.

Fig. 13 illustrates a simple example of a controller for VAV control as well as mode switching for a configurable mixing/displacement ventilation register such as illustrated at Figs. 12A and 12B.

Fig. 14 illustrates seventh embodiment of a configurable mixing/displacement ventilation register.

These figures are intended to show the concept and are not intended to show details of components whose designs are well understood in the field such as linkages, motor details, bearings, supports, etc. These are within the competence of skilled practitioners and are not discussed in detail herein.

Detailed Description of the Drawings

FIG. 1A and FIG. 1B illustrates a configurable mixing/displacement ventilation register 550 in an occupied room 570. People 510 in the room are warmer than the surrounding air, causing air to rise by convection. The room also contains a cooling-mode return register 530 in the upper portion of the room, and a heating mode return register 535 in the lower portion of the room. The temperature of the air within the room 570 is illustrated by isothermal layers of constant temperature air 505.

When the room is in displacement mode, which is generally used for cooling the conditioned space, the mixing/displacement ventilation register 550 supplies cooled air at a low velocity from a relatively high portion and over a relatively large face area of the mixing/displacement ventilation register 550. This cool air flows along the lower portion of the room. Any heat source within the room such as the occupants 510, causes air warmed by that source to rise by convective forces resulting in warm zones indicated by dips in contours of constant temperature 515. This rising air draws fresh cool air pooled near a floor 521 to replace the polluted and stale air surrounding the occupants 510. The warm air pools near the ceiling and is withdrawn by the return register 530. The higher regions of the room 570 remain relatively undisturbed and since it is not within the lower part of the room - the inhabited space - the air in contact with and breathed by occupants is relatively fresh. By not cooling this uninhabited space, the cooling efficiency is increased. Also, the immediate replacement of air polluted by heat sources increases comfort.

Figure 1B illustrates the mixing mode for heating the occupied space. In this mode, the mixing/displacement ventilation register 550 supplies heated air at a high velocity through a relatively small face area as illustrated by jets 551. This warm air flows rapidly along the lower portion of the room before it has time to rise from convection and encourages mixing of all the air in the room, as indicated by the randomly arranged and directed arrows 552. This rapid movement causes mixing of the air in the room due to the initial velocity of the jets 551, their turbulence, and the tendency of the heated air naturally to rise due to convection. The heating mode return register 535 removes cooled air which tends to sink from convection.

In the embodiment of Figs. 1A and 1B, and in further embodiments to be described below, it is desirable in many instances to ensure that the pressure drop through the registers 550 in both the displacement cooling mode (Fig. 1A) and mixing heating mode (Fig. 1B) be substantially the same. For example, a difference in pressure drop within about 10-20% would be acceptable. Now this difference is very low compared to the difference in face velocity in displacement and mixing modes. Typically the face velocity of a displacement register is 50-150 feet per minute ("low velocity"). For mixing ventilation, the velocities would be much higher as much as a factor of ten or higher ("high velocity"). The reason similar pressure drops is advantageous is that it may be desirable in many systems to satisfy air flow balance under all conditions. Having minimal pressure drop change between mixing and displacement modes would help to match the heating mode and cooling mode ventilation rates.

Also, by "face velocity" or simply "velocity" it should be clear from the discussion that it is an average velocity or a velocity of a coalesced stream (if emanating from a grill) that is referenced, not a local velocity through, for example, an individual aperture of a grill. In displacement registers, the slow velocity that is supplied into a room is generally achieved by distributing the flow across a grill with a large face and many individual holes. To achieve uniformity across the face of the grill, a relatively small free area may be provided with a substantial pressure drop across the grill. Such grills as used in displacement applications have, essentially, a relatively low percentage of free area. Thus, at each opening of the grill, the velocity may be high, but at a short distance from the grill the individual jets from the openings will coalesce and the effect will be of a slow moving current of air distributed uniformly over a large area. So by "slow," or "low velocity," when talking about the delivery of the air into a conditioned space, reference is being made to this final state or, alternatively and substantially equivalently, an average velocity taking into account not only the free flow area by the non-free area of the grill.

An alternative way to ensure matching of ventilation rates to minimize pressure drop of the register for both heating and cooling modes, such that they differ substantially, but to compensate in the supply system by ventilating at a higher static pressure in the mode corresponding to the higher pressure drop. For example, the system could employ a multiple-speed fan. The latter alternative - varying the supply pressure - may have the disadvantage of adding complexity, to the system, particularly with regard to balancing the distribution network.

Note that in the embodiment of Figs. 1A and 1B (and in further embodiments to be described below), the supply air is delivered at substantially the same rate in both heating and cooling modes. Commonly, particularly in commercial systems, different supply registers may be provided in which air is supplied at a high level in one mode and a low level in another mode. For example, cool air for cooling may be supplied from a high-mounted register and warm air for heating may be supplied from a low-mounted register.

Figs. 2A and 2B illustrate a first embodiment of a configurable mixing/displacement ventilation register 571 in displacement and mixing modes, respectively. Referring now to Fig. 2A the first embodiment of a configurable mixing/displacement ventilation register 571 is in displacement, or cooling, mode. As the cool air 160 enters the ventilation register plenum 130 it causes a thermal actuator 105 to move a thrust rod 110 attached to a baffle cage 115 toward a lower section 120 of the configurable mixing/displacement ventilation register 571, thereby moving it to the floor base 150 of the configurable mixing/displacement ventilation register 571. The baffle cage 115 allows air to pass through it and serves to spread the flow over the large face area that includes a larger baffle housing 100 of the configurable mixing/displacement ventilation register 571. The open area of the baffles 100 and 115 is such as to cause resistance across the face of the baffles 100 and 115 thereby spreading the incoming flow 160 broadly over the face area of the baffles 110 and 115. This results in flow over the majority of the outer diffusion baffle 100 of the configurable mixing/displacement ventilation register 571 as indicated by arrows 145. The air flowing from the baffle cage 115 and the baffle housing 110 therefore functions as displacement supply register venting air at a low velocity through relatively restrictive openings in the baffles of the baffle housing 100 and the baffle cage 115.

Fig. 2B illustrates the first embodiment in mixing, or heating, mode. As the warm air 165 enters the ventilation register plenum 135 it causes thermal actuator 105 to move the baffle cage 115 upwardly to uncover an open outlet 120 of the configurable mixing/displacement ventilation register 571. A bottom 116 of the baffle cage 115 has a high percentage open area and provides little resistance to flow as does the open outlet 120. As a result, a direct flow path through the plenum 135 to the open outlet 120 is created which results in low restriction - high velocity - flow of the warm air to the open outlet 120. Thus, most of the heating air 165 passes at a relatively high velocity out the lower, relatively small face area of the open outlet 120 of the configurable mixing/displacement ventilation register 571. Thus, in the present configuration, it functions as a mixing supply register.

Figs. 3A and 3B illustrate a second embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively. Fig. 3A illustrates the second embodiment of the configurable mixing/displacement ventilation register 572 in displacement, or cooling mode. A transmission 15 is indicated figuratively by a broken line. The transmission may be formed by any suitable means such as a pulley or gear system or by means of pushing or pulling or other rotating members. The details are outside the scope of invention and are readily created for various design arrangements.

As cool air 160 enters a ventilation register plenum 230 it causes the thermal actuator 10, by way of the transmission 15, to rotate a spring loaded capstan 220 which releases tension on a chord 225 allowing a spring-loaded cap plate 210 to pivot on an axis of the capstan/lever 215 to seal the end 212 of the ventilation register plenum 230. Cool air flow 270 is forced to spread the flow over the large face area of a flow-restricting baffle 250 and further distributed by an outer baffle 260. The capstan 220 also releases tension on a lower pull cord 235 releasing a spring loaded baffle panel 245 to pivot on a spring-loaded axel 240, securing it flush with the outer baffle 260 of the configurable mixing/displacement ventilation register 572.

Note that the transmission 15 and the pulley and capstan components are shown for illustration purposes only and can be replaced by any suitable mechanism for performing the described functions. These mechanisms could be mechanical or electromechanical and performed by means of a thermoactuator such as a wax motor or a linear actuator powered by electricity or pneumatic power or controls. There are many possible design variations and the details are unimportant for understanding the invention so they are not discussed at length here. Note also that the views of the present, foregoing, and further embodiments below are section views of suitable enclosures. They can be rectangular or other shapes. The materials used may be any combination of metal, plastic, or other materials suitable for conveying air.

The resulting configuration illustrated in Fig 3A allows the cool air 165 to flow through the outer baffle 260 of the configurable mixing/displacement ventilation register 572 in the manner of a displacement supply register. The open area of the baffle 260 is such as to cause resistance across the face of the baffle 260 and the baffle panel 245 thereby spreading the flow 160 broadly over the outer baffle 260 face area of the configurable mixing/displacement ventilation register 572 as indicated by arrows 265. It therefore functions as displacement supply register, venting air at a low velocity through relatively restrictive openings of the outer baffle 260 and the baffle panel 245.

Fig. 3B illustrates the second embodiment of the configurable mixing/displacement ventilation register 572 in mixing, or heating mode. As the heated air 165 enters the ventilation register plenum 230 it causes the thermal actuator 10 to act through the transmission 15 to rotate the spring-loaded capstan 220, exerting tension on the cap plate pull cord 225 causing the spring-loaded cap plate 210 to pivot on the axel 215 and open the end 212 of the plenum 230. The capstan 220 also exerts tension on the lower pull cord 235 causing the spring loaded baffle panel 245 to pivot on the axis 240, opening the lower portion of the configurable mixing/displacement ventilation register 572. As a result, most of the heated air 165 passes at a relatively high velocity out the lower, relatively small face area of an open outlet 243 of the configurable mixing/displacement ventilation register 572 so that it functions as a mixing supply register.

Figs. 4A and 4B illustrate a third embodiment of a configurable mixing/displacement ventilation register 573 in displacement and mixing modes, respectively. Fig. 4A illustrates the third embodiment of the configurable mixing/displacement ventilation register 573 in the displacement, or cooling, mode. As the cool air 160 enters the ventilation register plenum 330 it causes the thermal actuator 10 to act upon the transmission 15 to rotate a spring loaded capstan 320 which releases tension on a chord 325 allowing a spring-loaded cap plate 310 to pivot on an axis of capstan/lever 315 to seal the end 312 of a plenum 330. Cool air flow 370 is forced to spread over the large face area of a flow-restricting baffle 350. The capstan 320 also releases tension on a lower pull cord 335 releasing a spring loaded baffle panel 345 to pivot on an axel 340, securing it flush with an outer baffle 304 of the configurable mixing/displacement ventilation register 573. The releasing of the spring loaded baffle panel 345 also releases tension on a third pull chord 345 allowing a sliding baffle panel 306 to align with the outer baffle 304 allowing a cool air flow 370 flow through the large face area of the two baffle panels 304 and 306 which combine to form a single open baffle or grate 322A.

The resulting configuration illustrated in Fig 4A allows the cool air 160 to flow through the baffle/grate 322A of the configurable mixing/displacement ventilation register 573 in the manner of a displacement supply register. The open area of the baffle/grate 322 may be such as to cause substantial or little resistance across the face of the baffle/grate 322. The spreading of the flow may be provided by the inner baffle 350 or the outer baffle/grate 322 may assist by providing some resistance as well. By spreading the flow broadly over the face area of the configurable mixing/displacement ventilation register 573 as indicated by the arrows 365, it functions as displacement supply register.

Fig. 4B illustrates the third embodiment of the configurable mixing/displacement ventilation register 573 in mixing, or heating, mode. As the heated air 165 enters the ventilation register plenum 330, it causes the thermal actuator 10 to act upon the transmission 15 to rotate the spring loaded capstan 320 causing it to exert tension on the cap plate pull cord 325. This causes the spring-loaded cap plate 310 to pivot on the axel 315 and open the end of the plenum 330. The capstan 320 also exerts tension on the lower pull cord 335 causing the spring loaded baffle panel 345 to pivot on the axis 340, opening the lower portion of the configurable mixing/displacement ventilation register 573. The pivoting of the spring loaded baffle panel 345 also removes tension on the third pull chord 345 allowing the sliding baffle panel 306 to close the baffle/shutter 322 preventing the warm air flow 330 from passing through it. The heated air 165 thus passes at a relatively high velocity out the lower, relatively small face area of an open outlet 343 of the configurable mixing/displacement ventilation register 573 so that the configurable mixing/displacement ventilation register 573 functions as a mixing supply register.

In a variation of the embodiment of Figs. 4A and 4B, shown at Figs. 12A and 12B, or in variations of other embodiments, the variable flow-volume capability of variable air volume (VAV) register units can be satisfied, at least in part, by the active components that direct the flow for switching between mixing and displacement modes of the mixing/displacement ventilation register 579. As is generally known in the field, VAV is a technique where the total volume of the flow of a supply is modulated in proportion to the local load, supplying more heated or cooled air as needed to satisfy the local load. The integration of this feature may be accomplished with central or local thermostatic control, for example, of the dampers 1305 and 1310 which are independently controlled permit progressive adjustment of the total air volume through the selected discharge according to the mode. The progressive adjustment may be controlled according to known schemes used in VAV systems. Thus, a single actuation mechanism 1305/1310 can provide both VAV control and switchover between displacement and mixing ventilation modes. Of course this would be used with an active control system such as discussed with reference to Fig. 10 and elsewhere, at least in connection with the VAV control aspect. Fig. 13 shows, figuratively, a control system that actuates the independent dampers 1305 and 1310 by respective drives 1360 and 1365 in response to a detected temperature indicated by a temperature sensor t.

Figs. 5A and 5B illustrate a fourth embodiment of a configurable mixing/displacement ventilation register 574 in displacement and mixing modes, respectively. Fig. 5A illustrates the displacement, or cooling mode. As the cool air 160 enters a ventilation register plenum 425 it causes a rotating a thermal actuator capstan 450 to act upon a pull chord 455 to rotate a spring loaded flap cover 440 on a pivot 460 to seal off plenum 430. This action causes the cooled air 160 to enter only a cooling plenum 405 which is separated from a heating plenum 430 by a middle wall 435. The open area of the baffle 404 is such as to cause resistance across the face of the baffle 404 thereby spreading the flow 160 broadly over the large face area of the configurable mixing/displacement ventilation register 574. This causes it to function as a displacement supply register venting air at a low velocity over a large area.

Fig. 5B illustrates the fourth embodiment of the configurable mixing/displacement ventilation register 574 in mixing, or heating, mode. As the warm air 165 enters the ventilation register plenum 425 it causes the rotating thermal actuator capstan 450 to act upon the pull chord 455 to rotate the spring loaded flap cover 440 on the pivot 460 to seal off the cooling plenum 405. This action causes the warm air 165 to enter only the warm plenum 430 which is bound by the middle wall 435 and a back wall 420. The relatively smaller face area of a heating mode outlet 475 builds greater back pressure within the warm (heating) plenum 430 causing the flow 160 to exit through the small face area of the outlet 475 of the configurable mixing/displacement ventilation register 574 at high velocity. As a result, the register 574 functions as a mixing supply register.

Figs. 6A and 6B illustrate a fifth embodiment of a configurable mixing/displacement ventilation register 575 in displacement and mixing modes, respectively. Fig. 6A illustrates the fifth embodiment in displacement, or cooling, mode. As the cool air 160 enters a ventilation register a plenum 630 it causes the thermal actuator 10 to act upon a push rod 620 to rotate a cap plate 610 on a pivot 615 to seal the end of the plenum 630. Cool air flow 665 is forced to spread over the large face area of a flow-restricting inner baffle 650 and into a cooling plenum 605. The movement of the cap plate 610 also releases tension on a lower baffle panel 645 to pivot on an axel 640, securing it flush with an outer baffle 604 which forces a cool air flow 665 to spread over the large face area of a flow-restricting baffle 604.

The resulting configuration illustrated in Fig 6A allows the cool air 630 to flow through the flow-restricting inner baffle 650 then an outer baffle 604 of the configurable mixing/displacement ventilation register 575 in the manner of a displacement supply register. The open area of the baffle 604 is such as to cause resistance across the face of the baffle 604 and lower baffle panel 645 thereby spreading the flow 665 broadly over the face area of the configurable mixing/displacement ventilation register 575 as indicated by the arrows 665 and therefore functions as displacement supply register venting air at a low velocity through relatively restrictive openings within the outer baffles 604 and the baffle panel 645.

Fig. 6B illustrates the fifth embodiment of the configurable mixing/displacement ventilation register 575 in mixing, or heating mode. As the heated air 165 enters the ventilation register plenum 630 it causes the thermal actuator 10 to act upon the push rod 620 to rotate the cap plate 610 on the pivot 615 to open the end of the plenum 630. This causes engagement of the cap plate 610 and a lever arm 655 of the baffle panel 645 to swing the baffle panel 645 in an open position, opening the lower portion of the configurable mixing/displacement ventilation register 575. As a result, the heated air 165 passes at a relatively high velocity out the lower, relatively small face area of an open outlet 643 of the configurable mixing/displacement ventilation register 575 so that it functions as a mixing supply register.

Figs. 7A and 7B illustrate a sixth embodiment of a configurable mixing/displacement ventilation register in displacement and mixing modes, respectively. Fig. 7A illustrates the sixth embodiment in displacement, or cooling, mode. Note the present embodiment is similar to the embodiment of Figs. 6A and 6B so many of the reference numerals are common. As the cool air 160 enters the ventilation register plenum 630 it causes the thermal actuator 10 to act upon the push rod 620 to rotate the cap plate 610 on the pivot 615 to seal the end of the plenum 630. The cool air flow 160 is forced to spread over the large face area of the flow-restricting inner baffle 650 and into the cooling plenum 605. The resulting configuration illustrated in Fig 7A allows the cool air 630 to flow through the flow-restricting inner baffle 650 then the very open outer baffle 700 of the configurable mixing/displacement ventilation register 576 in the manner of a displacement supply register. The resistance across the face of the baffle 650 is such as to cause resistance across the face of the baffle 650 thereby spreading the flow 750 broadly over the face area of the baffle 650 and out through the low restriction baffle 700 as indicated by the arrows 710 and therefore functions as displacement supply register venting air at a low velocity through relatively restrictive openings within the inner baffles 650 and the open baffle panel 700.

Fig. 7B illustrates the sixth embodiment of the configurable mixing/displacement ventilation register 576 in mixing, or heating mode. As the heated air 165 enters the ventilation register plenum 630 it causes the thermal actuator 10 to act upon the push rod 620 to rotate the cap plate 610 on the pivot 615 to open the end of the plenum 630. The heated air 165 thus predominately passes at a relatively high velocity out the lower, relatively small face area of an open outlet 643 of the configurable mixing/displacement ventilation register 576 so that it functions as a mixing supply register.

Figs. 8A and 8B illustrate an alternative embodiment in which the return registers are changed over from heating to cooling mode, but the supply registers are in the same configuration in both heating and cooling mode. Displacement registers 850 are located in a room 850. Displacement registers 850 are normal displacement registers installed in a system in which return air registers 830 and 835 exist. During cooling mode, the displacement registers 850 deliver cool air at floor level as illustrated and warm air stratified near the ceiling is returned via return registers 830. As in previous embodiments, displacement supply air flow near the floor 821 and is heated by occupants 810 causing thermal plumes 815 which are indicated by isothermal lines 805. Warm air 870 near the ceiling is drawn into the return air register and 830.

Fig. 8B illustrates the alternative embodiment of the conventional displacement ventilation register 850 in a heating mode. Heated air enters the room 820 at low velocity and rises. A return register located near the floor draws cooled air in. By arranging the return registers at a position remote from the displacement registers 850, a circulation pattern can be established in the room that mitigates the undesirable stratification that can occur when using non-mixing type supply registers during heating.

Figs. 9A and 9B illustrate an alternative embodiment in which the return registers are changed over from heating to cooling mode, and hydronic heating is used in place of force air heating. In the present embodiment, heating is done with a separate heating system under common control, for example hydronic heating using hydronic heaters 980. Displacement registers 950 are normal displacement registers installed in a system in which return air registers 930 and 935 exist. During cooling mode, the displacement registers 950 deliver cool air at floor level as illustrated and warm air stratified near the ceiling is returned via return registers 930. As in previous embodiments, displacement supply air flow near the floor and is heated by occupants 915. Warm air 970 near the ceiling is drawn into the return air register and 930.

Fig. 9B illustrates the alternative embodiment of the conventional displacement ventilation register 850 in a heating mode. Heated air enters the room from hydronic heaters. A return register 935 located near the floor draws cooled air in. By arranging the return registers at a position remote from the hydronic heaters 980, a circulation pattern can be established in the room that mitigates the undesirable stratification that can occur when using non-mixing type supply registers during heating.

Fig. 10 is an illustration of a central control system that may be used with various embodiments discussed herein. A programmable controller 1000 is connected to various sensors such as outdoor air temperature 1010, indoor air temperature 1015, supply air temperature 1030, and return air temperature 1035. The controller 1000 is also connected to a clock/calendar 1020 and various actuators for controlling the mechanical state of a space conditioning system including the actuators of the described multimode displacement registers, separate heating and cooling systems, and other mechanical elements described above.

Fig. 11 shows a plan view of a room with multiple discharge registers 1125, 1135, and 1145. The discharge pattern of each of the registers 1125, 1135, and 1145, used individually, is shown at 1100, 1105, and 1110, respectively. In an embodiment of the invention, to increase mixing with a given volume flow rate and eliminate dead spots, a single supply volume is differentially applied to a number of different registers 1125, 1135, and 1145 with the majority of the flow being output by a subset of all the different registers 1125, 1135, and 1145 at any given time. Thus, for a given flow volume, the discharge velocity at any given time will be higher than if the same flow volume were distributed more uniformly to all registers 1125, 1135, and 1145. The above may be accomplished with any kind of register equipped with a flow-volume adjusting capability. The flow pattern may be shifted, for example, on a time-basis such that all flow is supplied to register 1125 for a period of a minute, then to register 1135 for a minute, and finally to register 1145 for a minute, then repeating and so on. The cycle of shifting can be varied to change faster or slower. Note that in the above embodiment, registers 1125, 1135, and 1145 may be configurable mixing/displacement ventilation registers according to any of the embodiments described herein. In one embodiment of the invention, flow may be cycled among the registers as described above, but only in the heating mode where a high velocity mixing effect is used whilst in a cooling mode, all registers are used since displacement ventilation is employed for cooling.

In an alternative embodiment, a single register 1150 has multiple outlets, each aimed in different directions as indicated by arrows 1155. The flow is directed to each outlet in turn in a cycling pattern such that most of the supply flow is directed a single direction and then shifted to the next direction in turn. This creates varying flow patterns. The latter may be accomplished using a ventilation register device with an internal flow director such that only one inlet connection needs to be made to the supply ductwork.

Referring now to Fig. 14, a configurable mixing/displacement ventilation register 1400 has an internal plenum space 1430 defined by top, 1484, rear 1481, and side 1482 and 1483 panels and a tilted baffle plate 1415 toward a front 1440. Air is supplied to the internal plenum space 1430 through an inlet collar 1460 that is attachable to an external duct system. A movable bottom plate 1425 is hinged at an edge 1425A thereof. The bottom plate 1425 is shown in an intermediate position between a heating mode, in which the bottom plate 1425 drops down allowing air in the plenum space 1430 to exit through a slot 1475 and a cooling mode in which the bottom plate 1425 is in a raised position forcing all air through the tilted baffle panel 1415. The slot is partly defined by a horizontal plate 1420. The bottom plate 1425 may be actuated by, for example, by a mechanical actuator 1465 which may be a thermal motor, for example, or an actuator controlled by an external or internal control mechanism (not shown in the present drawing).

In the cooling mode, air flows into the plenum space 1430 and is forced through the tilted baffle panel 1415 and then through a front baffle panel 1410. Little or no air escapes through the slot 1475 because, in the cooling mode, the bottom plate 1425 is in the up, or closed, position, thereby separating the plenum space 1430 from the slot 1475. The angle of the tilted baffle panel 1415 makes the plenum space 1430 progressively narrower toward the end of the plenum space 1430 that is remote from the inlet collar 1460. This helps to make the flow through the tilted baffle panel 1415 uniform along its face. Air then exits the configurable mixing/displacement ventilation register 1400 through the front baffle panel 1410 by passing through the gap 1435. The size of the front baffle panel 1410 is relatively large and the average velocity through the front baffle panel 1410 is relatively low consistent with the function of a displacement-type register.

The configurable mixing/displacement ventilation register 1400 is preferably located adjacent or near a floor. In the heating mode, the bottom plate 1425 drops down allowing air to escape from the plenum space 1430 into the slot 1475 and out. Although some air will still escape the plenum space 1430 by flowing through the tilted baffle panel 1415 and then through the front baffle panel 1410, much of it also escapes through the slot 1475. The configuration overall may be designed such that the flow through the slot 1475 in the heating mode is relatively high, consistent with mixing-type ventilation. This causes heated air to be projected (along the floor, in applications where the configurable mixing/displacement ventilation register 1400 is located adjacent or near the floor) well into the ventilated space. The velocity through the slot 1475 may be such that warm air from the front baffle panel 1410 is induced into the flow from the slot 1475.

According to an optional feature of the Fig. 14 embodiment, one or more flow deflector plates 1455 may be provided to deflect flow through the tilted baffle panel 1415 in the cooling mode. In the heating mode, the flow deflector plates 1455 may pivot down and against the tilted baffle panel 1415. In the heating mode the flow deflector plates 1455 may serve to partially (or completely) block the tilted baffle panel 1415 thereby forcing more air to pass through the slot. An arm may connect the flow deflector plates 1455 to the bottom plate 1425 so that the flow deflector plates 1455 are moved in unison with the bottom plate 1425 by the actuator 1465.

Note that in various foregoing embodiments, the bottom portion of the register remains fixed and flow is directed in a horizontal direction. By comparison, prior art multi-mode register devices, generally designed for commercial applications, direct air downwardly during a heating mode requiring the bottom to change configuration and may result in a change in overall height of the unit. According to inventive embodiments described herein, the bottom remains fixed and the space taken up by the register unit remains fixed. This is believed to be desirable in a floor-mounted register. Also, by directing high velocity flow adjacent the floor, a more persistent jet - a wall jet - may be generated as compared to a free jet which tends to lose momentum faster.

What is claimed is:

1. A displacement ventilation register device, comprising:

a unitary air control device configured to be operated at floor-level;

a mechanical control device responsive to a control signal to change the configuration of said unitary air control device in response to a temperature of supply air delivered to it such that it is configured to supply warm air at a high velocity into an external space at a floor level and cool air at a low velocity into said external space through a discharge face located adjacent said floor level.

2. A displacement ventilation register device, comprising:

a first diffuser grill having a first fractional free area and, at least partly, defining a first plenum;

said first plenum having an air inlet at an inlet end thereof and a selectively configurable portion at a terminal end opposite said inlet end;

said selectively configurable portion having a movable portion that moves to a first position to provide a second fractional free area, larger than said first free area, at said terminal end and moves to a second position to provide a third fractional free area smaller than or substantially the same as said first free area at said terminal end such that, when said movable portion is in said first position, a majority of a velocity pressure of air entering said inlet is substantially captured and redirected such that air entering said first plenum exits said terminal end at a high velocity and escapes into a conditioned space through a high velocity discharge and such that when said movable portion is in said second position, a majority of said velocity pressure is converted to static pressure within said first plenum and thereby causes air to be discharged from said first plenum through said first diffuser grill which.

3. A device as in claim 2, further comprising:

a diffuser second diffuser grill located between said first diffuser grill and an outside conditioned space, said first diffuser grill being tilted with respect to a wall opposite said first diffuser grill to make said plenum progressively narrower from said inlet to said terminal end.

4. A device as in claim 2, wherein said first diffuser grill has deflector plates attached thereto to deflect flow moving from said inlet end of said plenum toward said terminal end toward said first diffuser grill.

5. A device as in claim 4, wherein said deflector plates are hinged to be positioned to deflect said flow in movable portion is in said second position and to at least partially block flow through said first diffuser grill when said movable portion is in said first position.

6. A device as in claim 2, wherein said high velocity discharge is located adjacent a floor level.

7. A displacement ventilation register device, comprising:

a unitary air control device with a plenum with an inlet and at least one discharge;

said at least one discharge including a diffuser with a first face area;

said at least one discharge including a register with a second face area smaller than said first face area;

at least one air flow director configured to direct air supplied through said inlet into an external space through a selected one of said diffuser and said register responsively to a control signal indicating a cooling mode or a heating mode;

said diffuser having a first percentage free area over a face thereof and said register having a second percentage free area over a face thereof, said first percentage being lower than said second;

said at least one flow director being further configured to modulate a total volume of air according to a variable air volume control signal.

8. A displacement ventilation system, comprising:

a displacement supply register located in an human-occupiable enclosed space;

first and second return registers connected to withdraw air from said enclosed space;

said first return register being located above said second return register;

a space conditioning device connected between said first return register and said displacement register;

said space conditioning device being connected between said second return register and said displacement register;

said space conditioning device being configured to withdraw air from said first register and supply cool air from said displacement register when said space conditioning device is in a cooling mode;

said space conditioning device being configured to withdraw air from said second register and supply warm air from said displacement register when said space conditioning device is in a heating mode.

9. A displacement ventilation register device, comprising:

an air control device connectable, from an inlet thereof, to a ventilation system;

a mechanical controller responsive to a control signal to change the configuration of said air control device to configure said air control device to supply air, selectively, at a high velocity in heating mode and at a low velocity in a cooling mode;

said air control device being configured such that a pressure drop between said inlet and an outside space to which air is discharged is substantially the same whether the air is delivered at high velocity or low velocity.

10. A displacement ventilation register device, comprising:

an air control device connectable, from an inlet thereof, to a ventilation system;

a mechanical controller responsive to a control signal to change the configuration of said air control device to configure said air control device to supply air, selectively, at a high velocity in heating mode and at a low velocity in a cooling mode;

said air control device being configured such that air is delivered at substantially a floor level whether the air is delivered at said high velocity or said low velocity.

11. A displacement ventilation register device in which a first actuator deflects flow between two discharge flow patterns, one for a heating mode and characterized by a high discharge velocity and one for a cooling mode and characterized by a low discharge velocity, said high and low discharge velocities being provided by different flow paths defined by said register device, the first actuator substantially guiding an inlet flow to one or the other of said different flow paths, the first actuator also, at least in part, varying a total flow volume discharged in at least one of said heating and cooling modes based on a variable air volume demand-based control scheme.

12. A displacement ventilation register device, comprising:

a unitary air control device with an enclosed bottom portion suitable for installing on a floor and including a mechanical air flow control device responsive to a control signal to change the configuration of said unitary air control device in response to a temperature of supply air delivered to it such that it is configured to supply warm air at a high velocity into an external space in a horizontal direction and cool air at a low velocity into said external space through a discharge face in a substantially horizontal direction.

13. A ventilation system, comprising:

multiple supply registers configured to supply space conditioning to an occupied space;

a supply system configured to supply conditioned air to each of said multiple supply registers and to selectively apportion a total flow to cyclically vary the fraction of a total flow supplied to said occupied space such that at a first time, at least one of said registers receives a higher volume than another at first times and said at least one receives a lower volume than said another at second times, said first and second times repeating.

14. A system as in claim 13, wherein at least one of said multiple supply registers are configurable registers which can deliver heating air at a high velocity in a heating mode and cooling air at a low velocity in a cooling mode and said supply system is configured to cyclically vary said fraction during only during said heating mode.

15. A system as in claim 14, wherein said at least one of said multiple supply registers includes:

a unitary air control device configured to be operated at floor-level;

a mechanical control device responsive to a control signal to change the configuration of said unitary air control device in response to a temperature of supply air delivered to it such that it is configured to supply warm air at a high velocity into an external space at a floor level and cool air at a low velocity into said external space through a discharge face located adjacent said floor level.

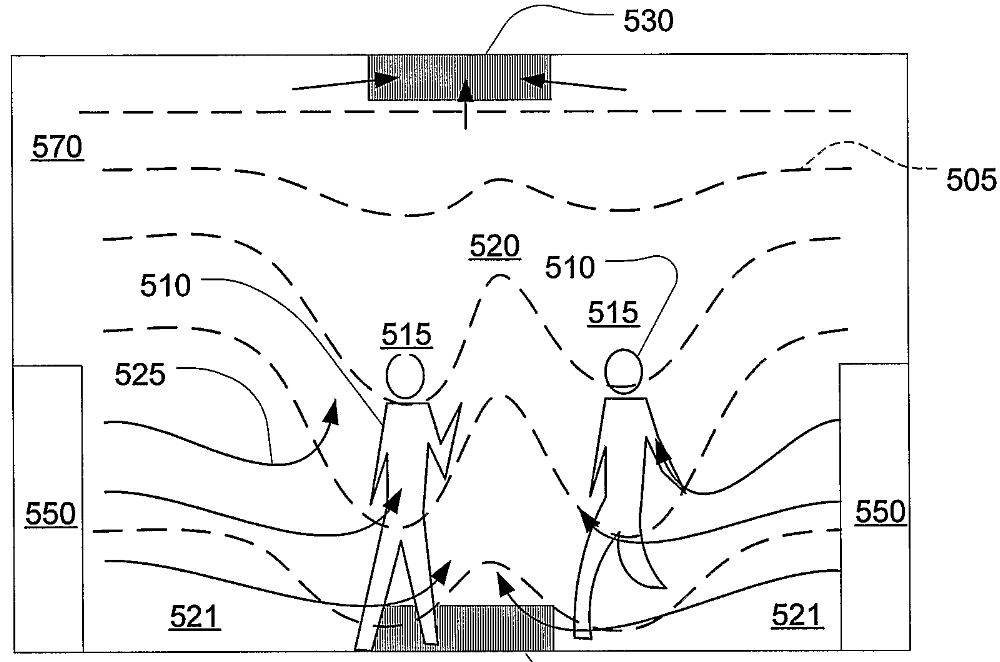
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Fig. 1A

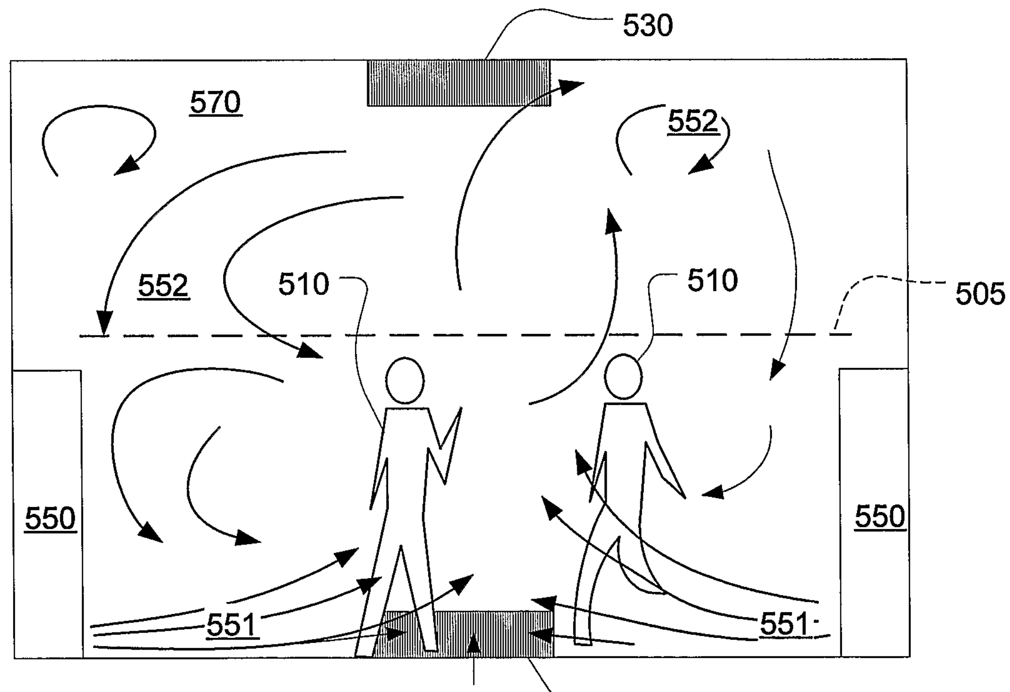
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Fig. 1B

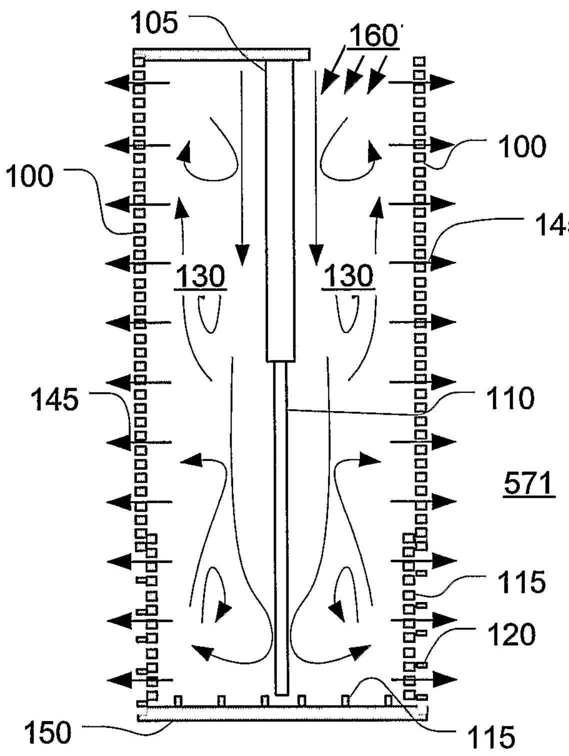

Fig. 2A

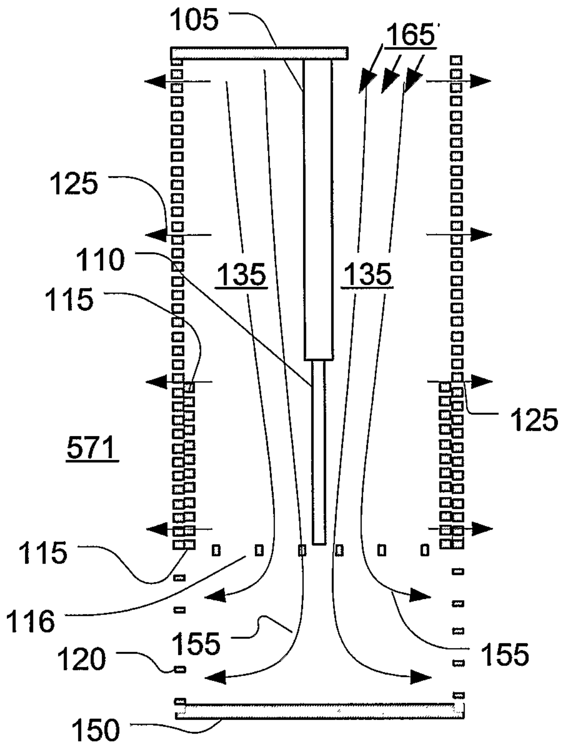

Fig. 2B

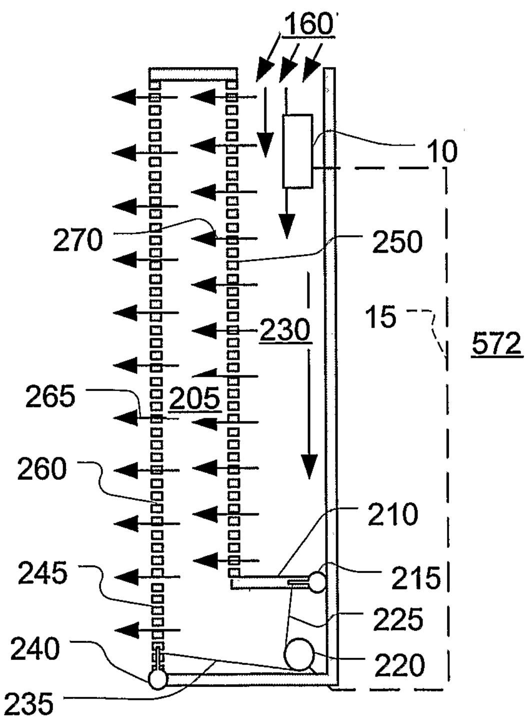

Fig. 3A

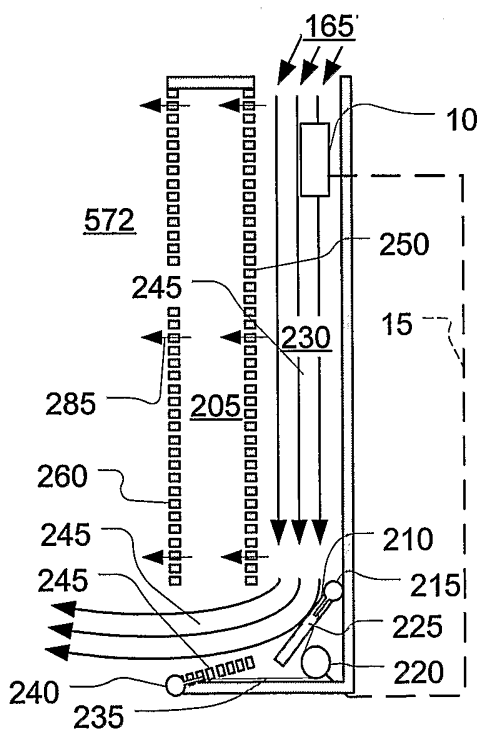

Fig. 3B

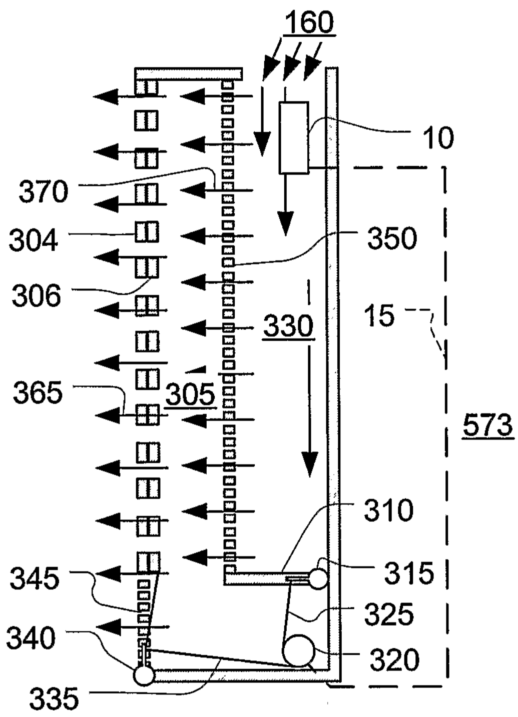

Fig. 4A

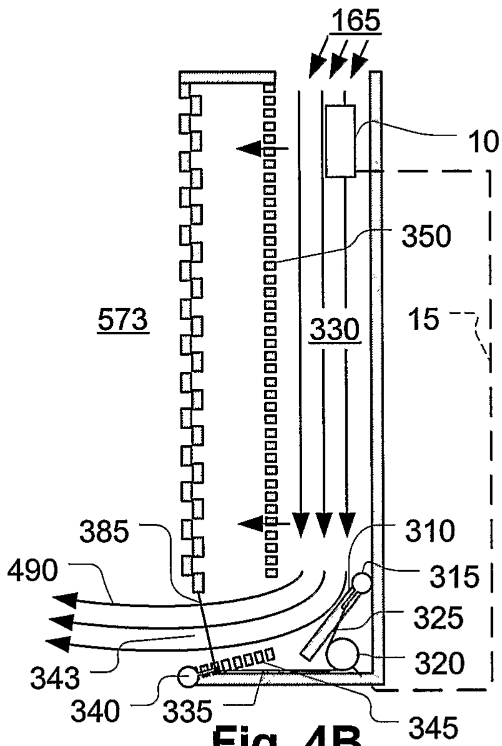

Fig. 4B

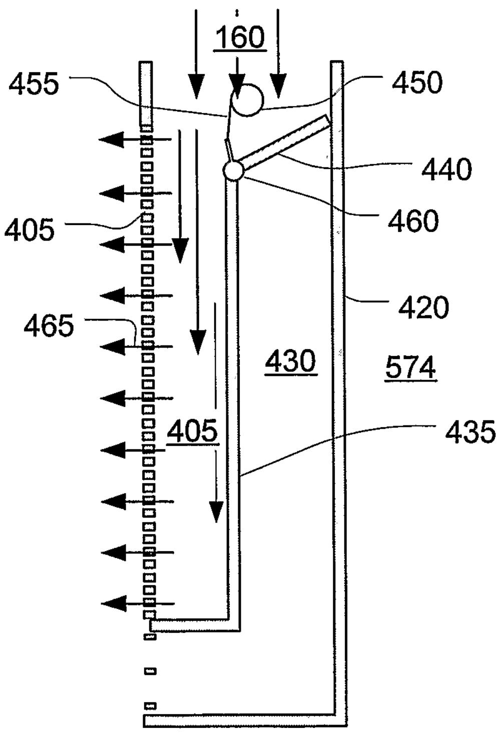

Fig. 5A

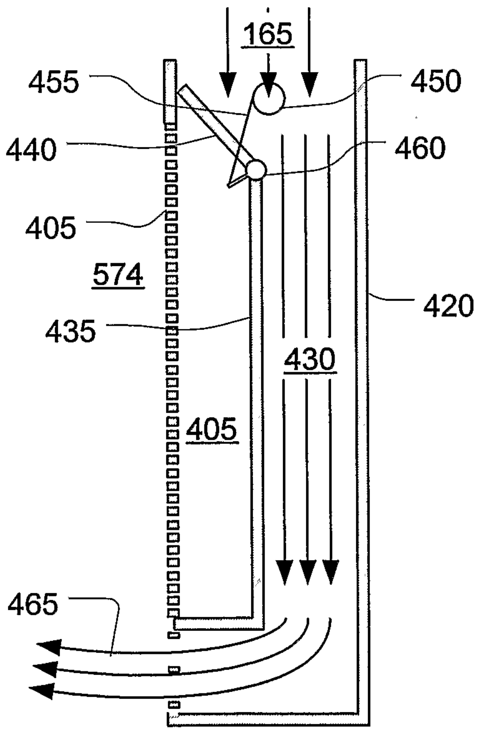

Fig. 5B

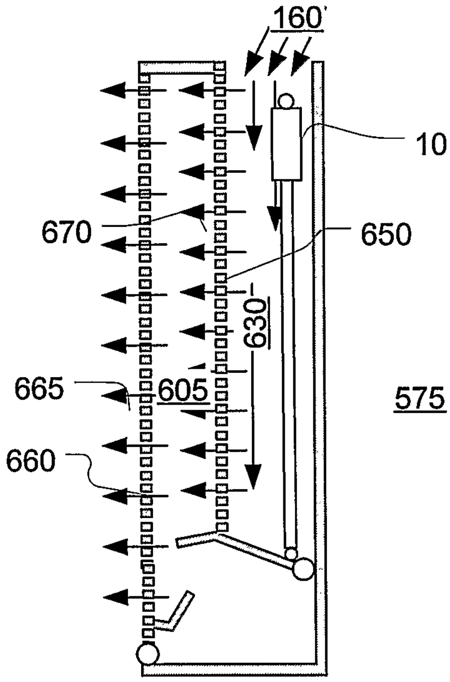

Fig. 6A

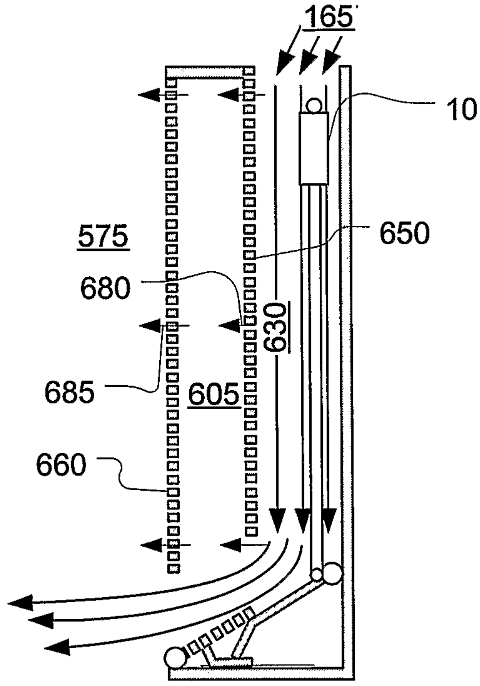

Fig. 6B

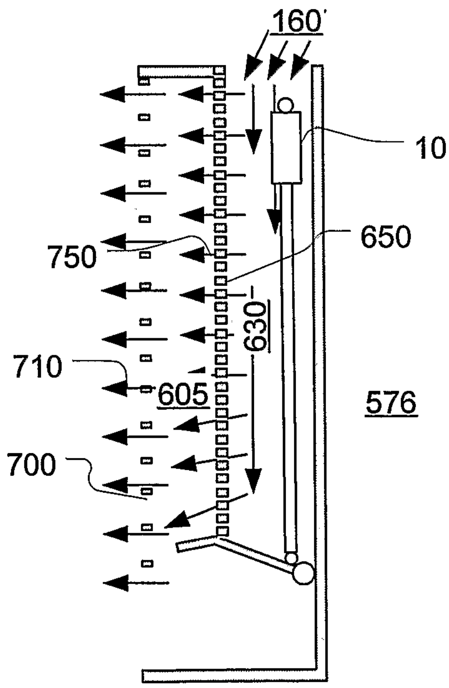

Fig. 7A

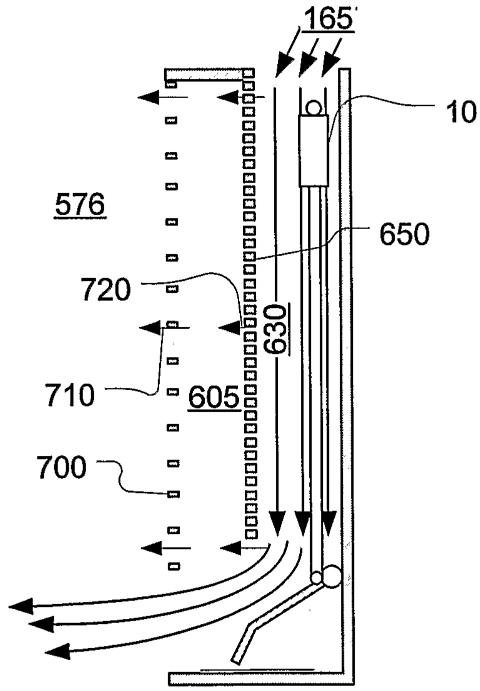

Fig. 7B

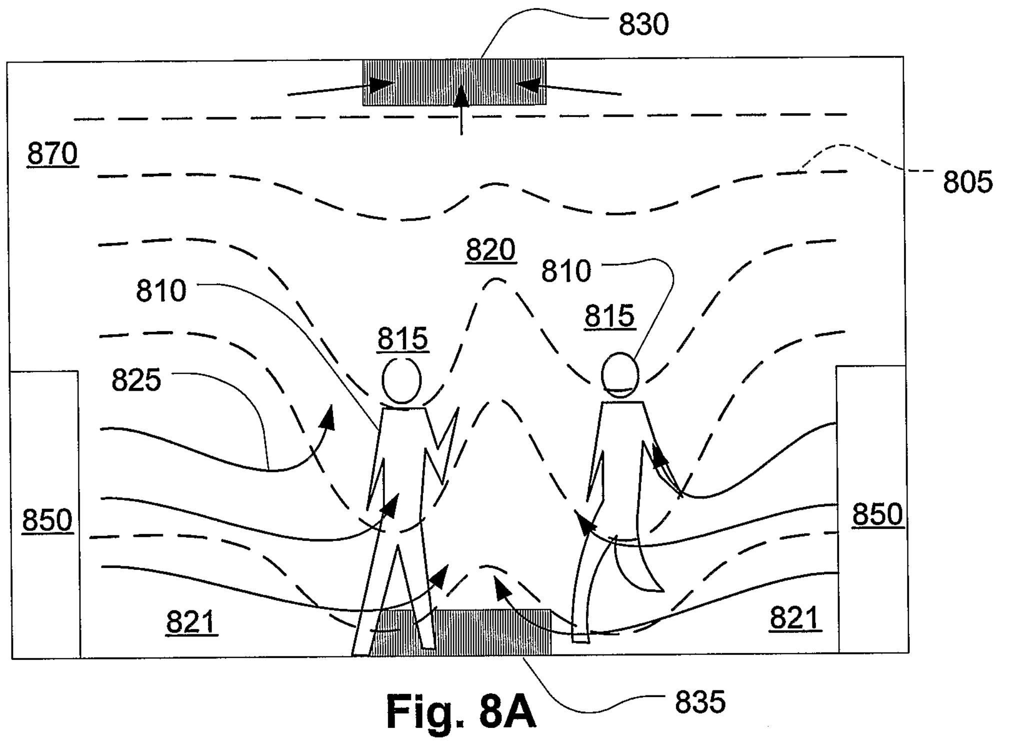
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Fig. 8A

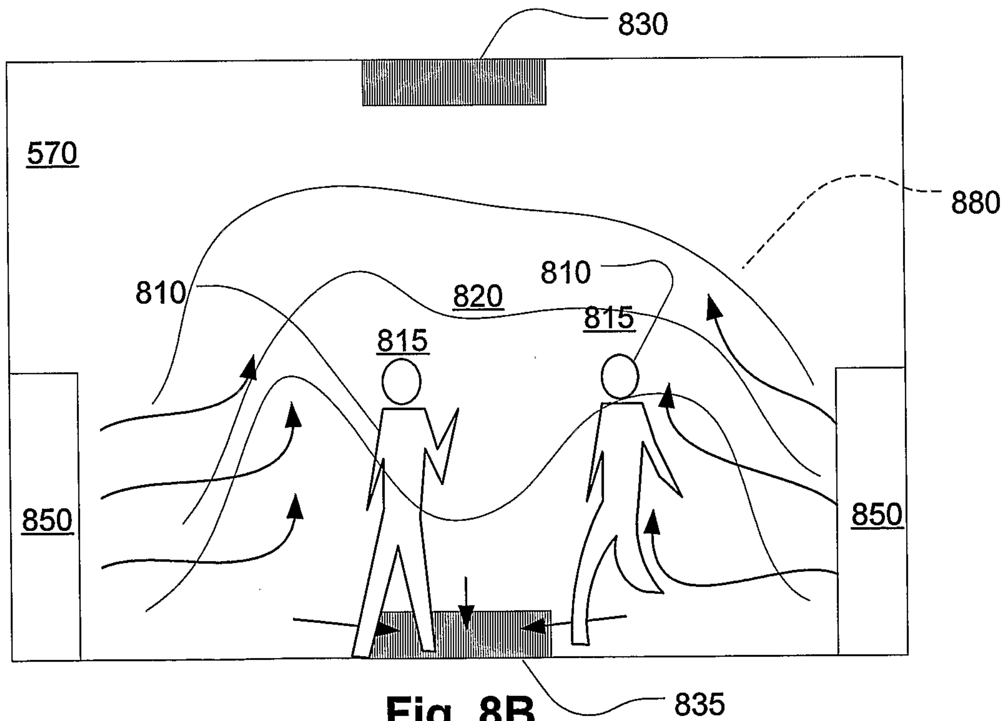
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Fig. 8B

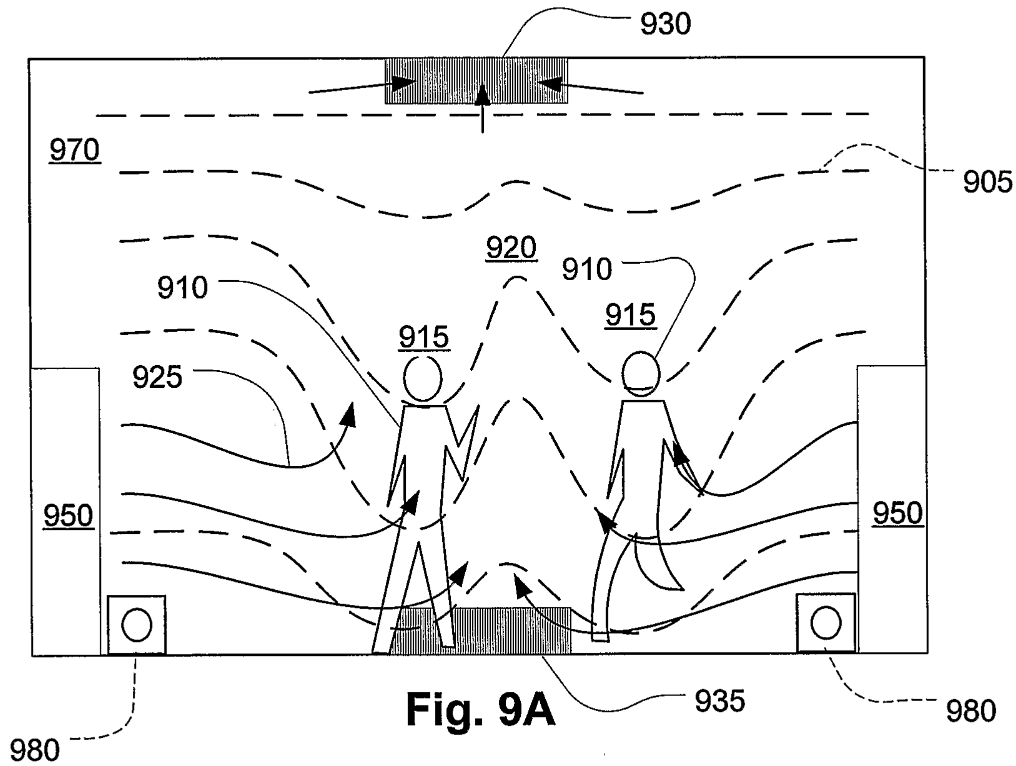
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Fig. 9A

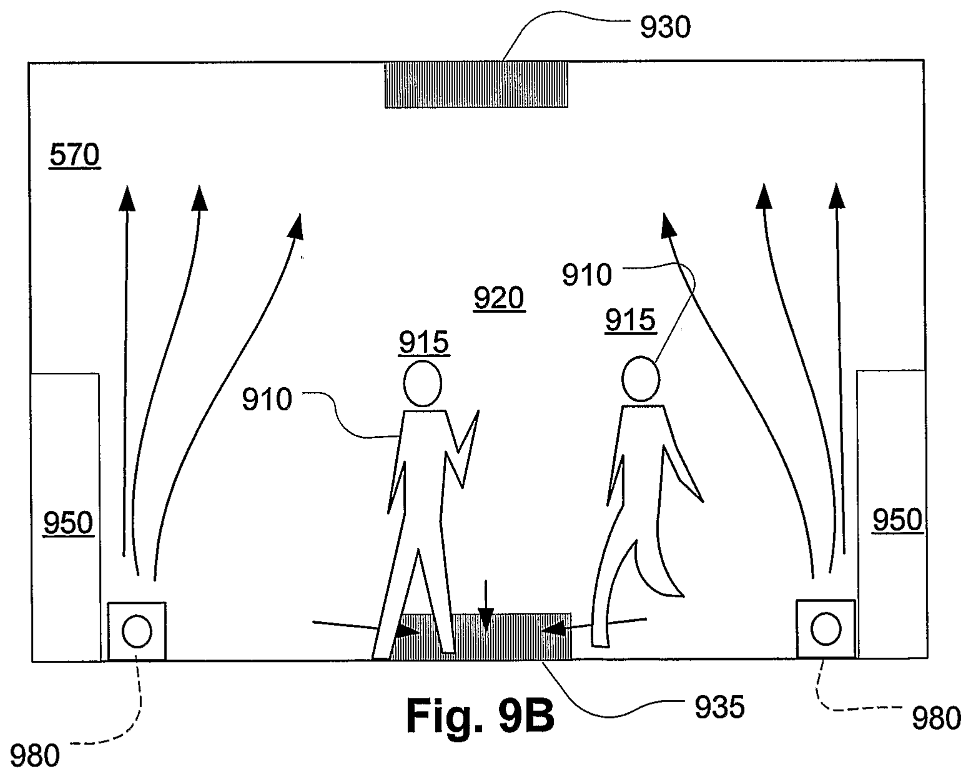
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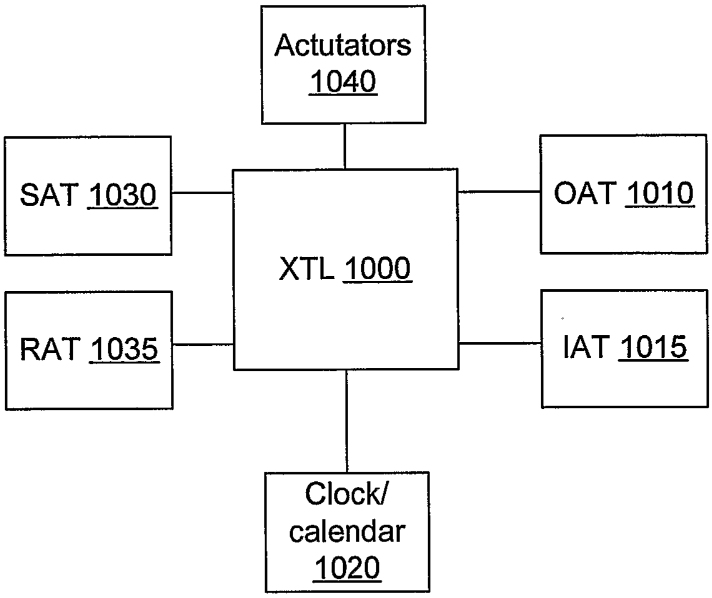
Fig. 9B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RAT 1035
IAT 1015
Clock/
calendar
1020

Fig. 10

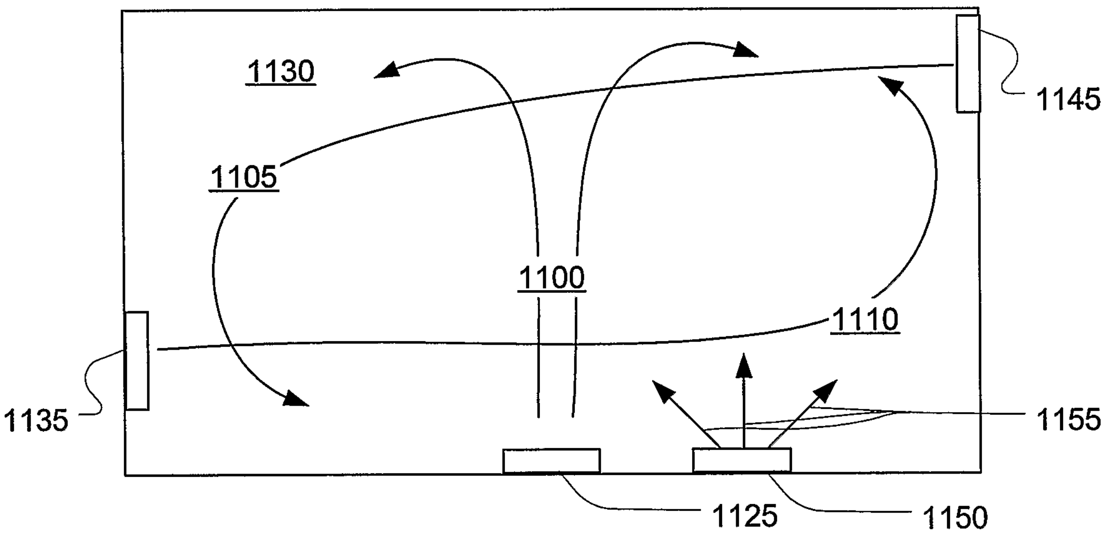
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Fig. 11

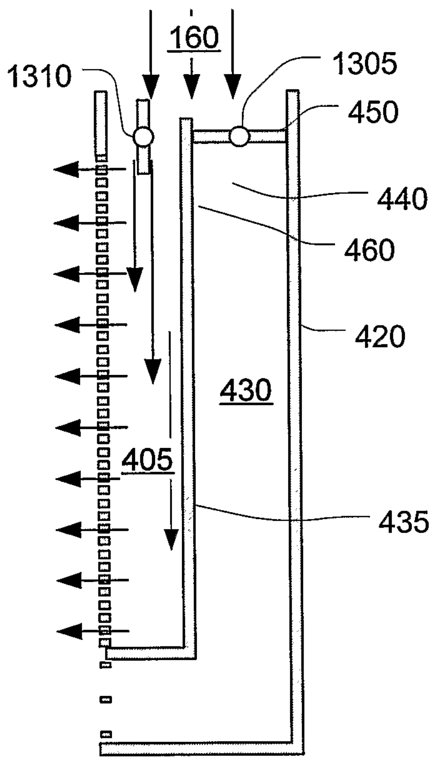

Fig. 12A

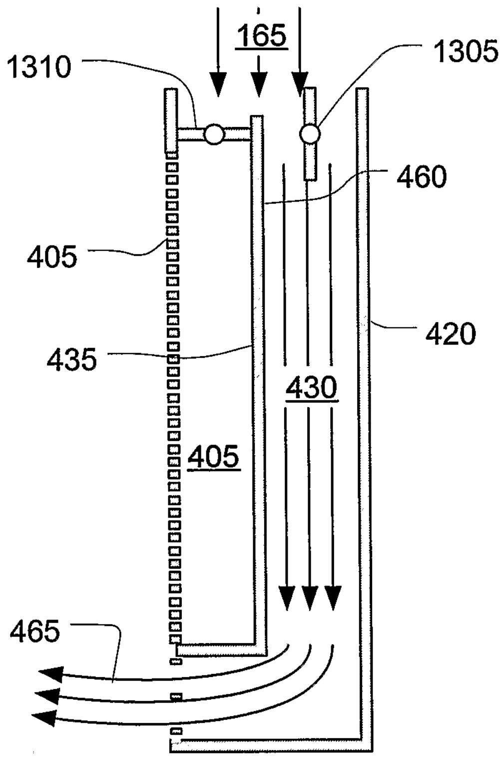

Fig. 12B

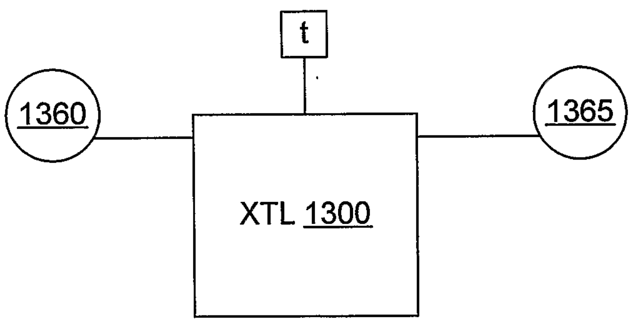

Fig. 13

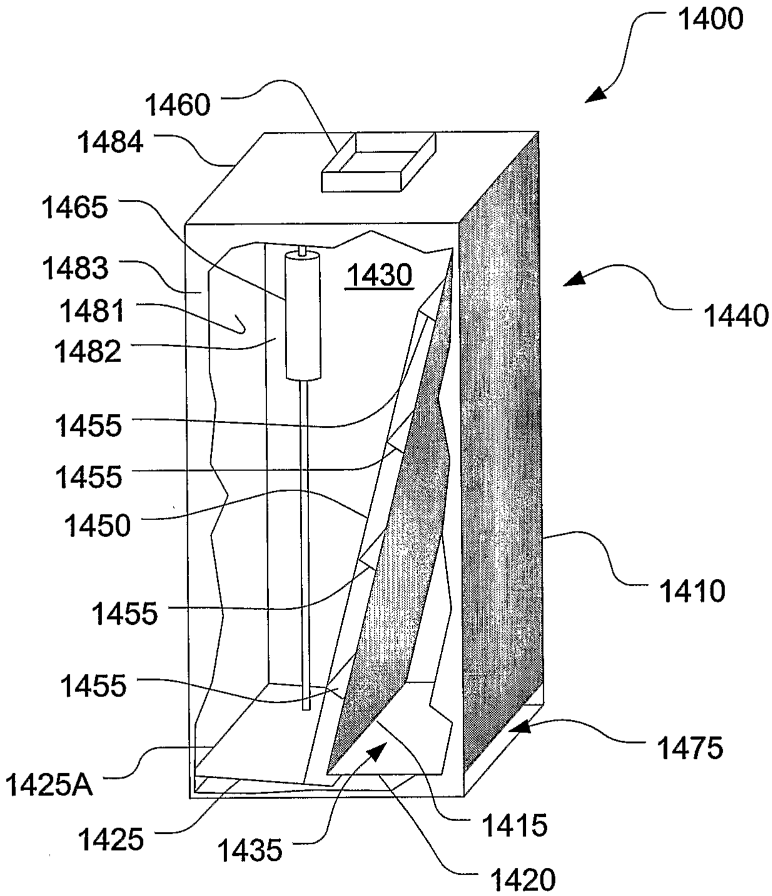
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Fig. 14