United States Patent [19]

Hall, Jr.

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[45] **June 12, 1973**

[54] **AIR FLOW CONTROL SYSTEM**

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Dallas, Tex. 75229

[22] Filed: **Dec. 30, 1971**

[21] Appl. No.: **214,350**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 636,748, May 8, 1967, Pat. No. 3,669,349, which is a continuation-in-part of Ser. No. 577,298, Sept. 6, 1966, abandoned.

[52] **U.S. Cl.** **236/49,** 236/51
[51] **Int. Cl.** **F24f 11/00**
[58] **Field of Search** 236/49, 13, 51; 165/16

[56] **References Cited**

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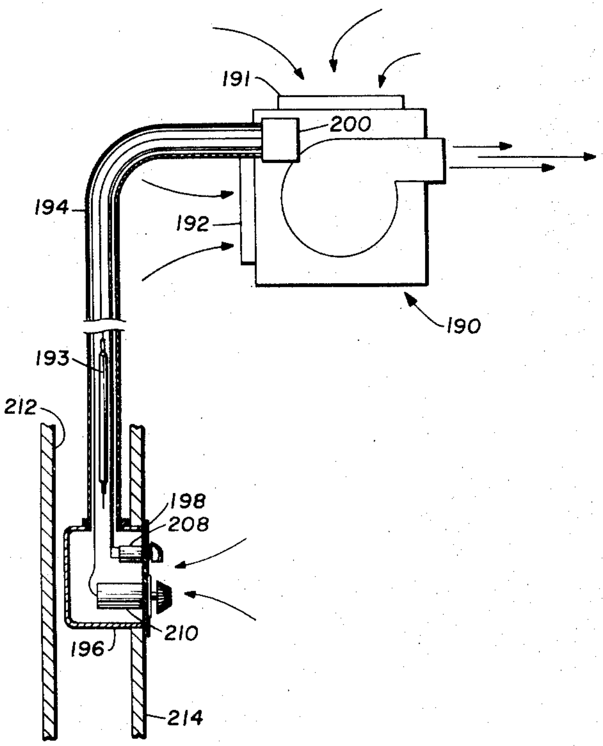
Primary Examiner—William E. Wayner
Attorney—Rey Eilers

[57] **ABSTRACT**

Environmental temperatures are controlled by selectively proportioning air flow from a pair of air flow paths by generation of a force proportional to temperature and dependent solely upon temperature for oppositely and proportionally changing registration of small openings in pairs of perforated plates laterally disposed in the air flow paths. A direct-acting, expandible-material, temperature-sensitive device is located adjacent those perforated plates and is used to generate that force; and a remote-control system permits the set point of that temperature-sensitive device to be adjusted.

8 Claims, 25 Drawing Figures



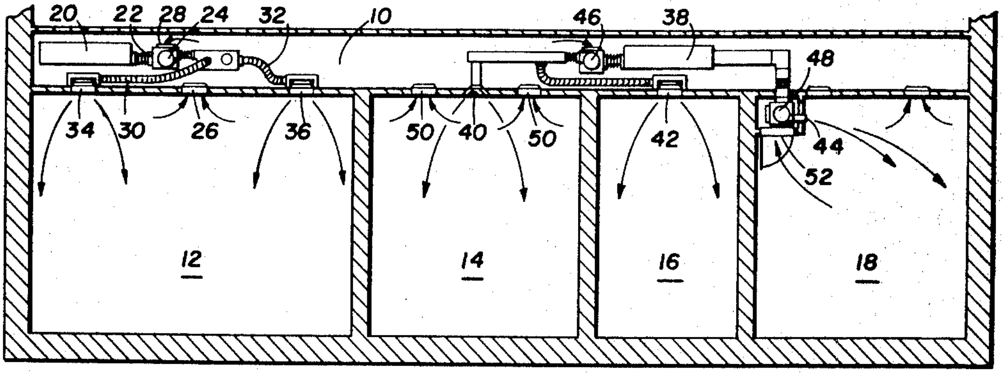

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FIG. 1

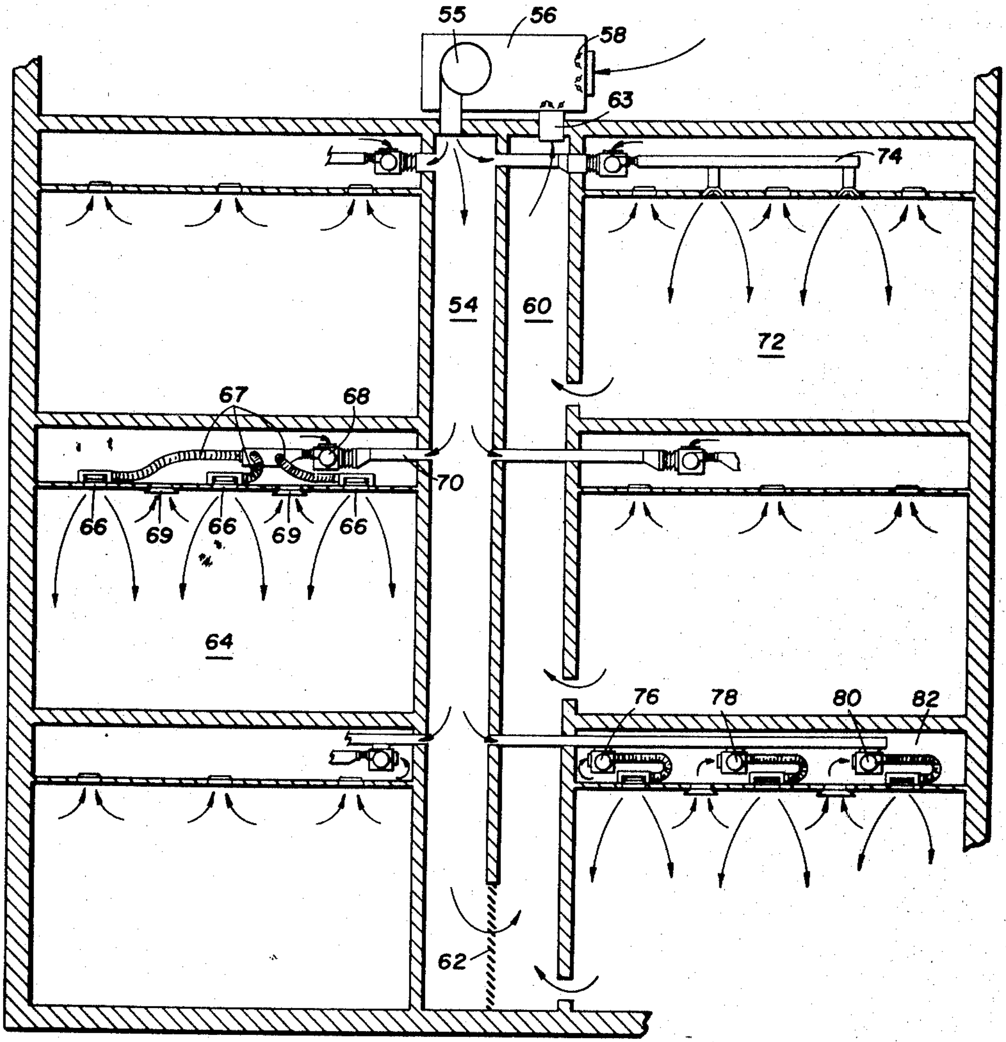
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FIG. 2

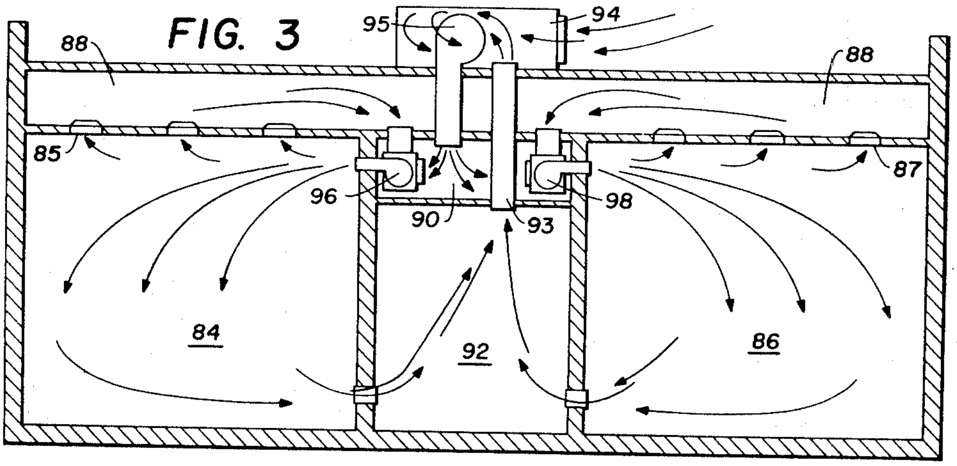


FIG. 3

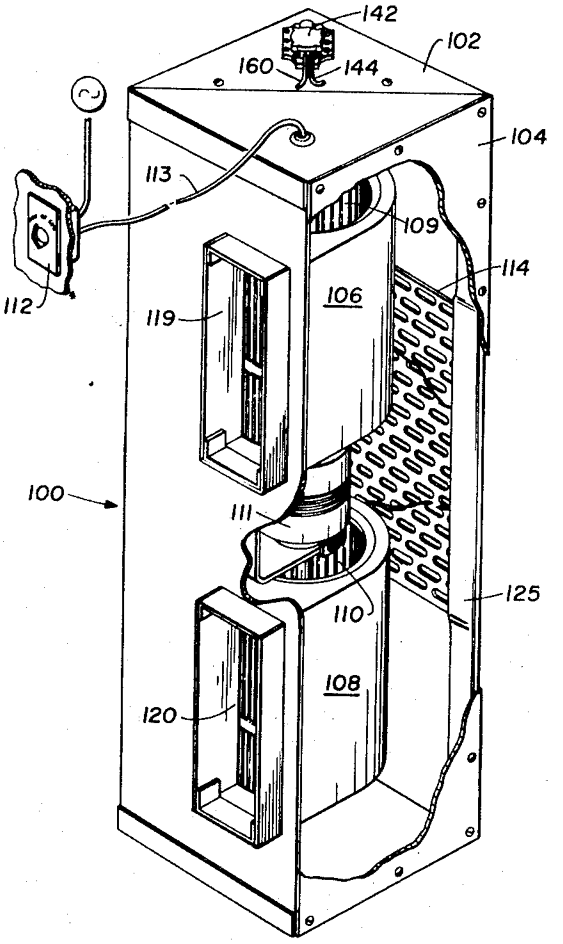


FIG. 4

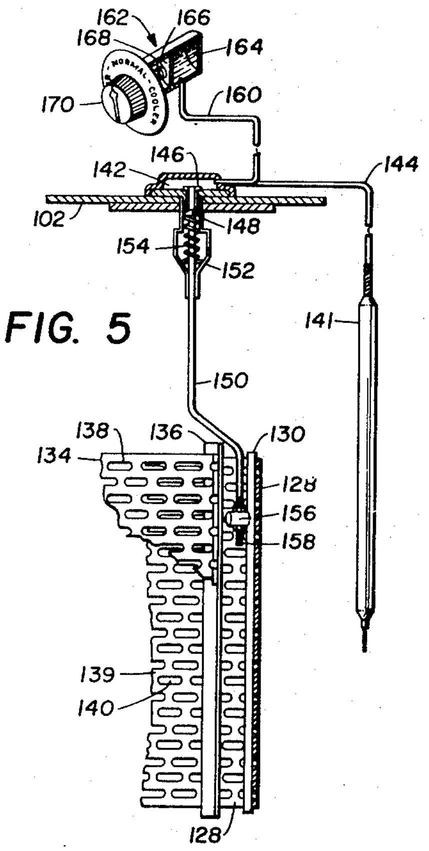


FIG. 5

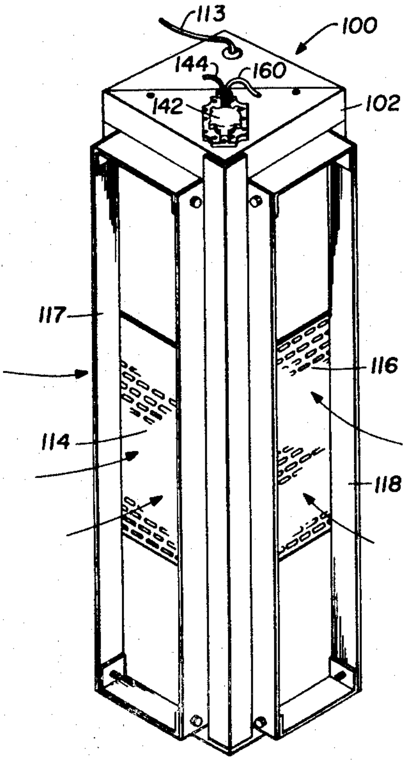
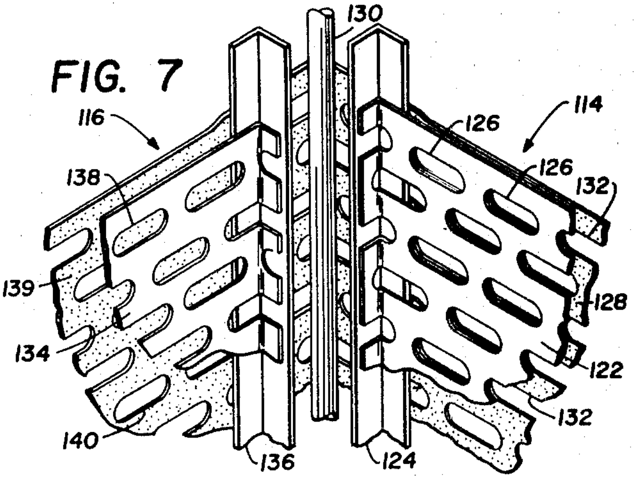


FIG. 6

FIG. 7



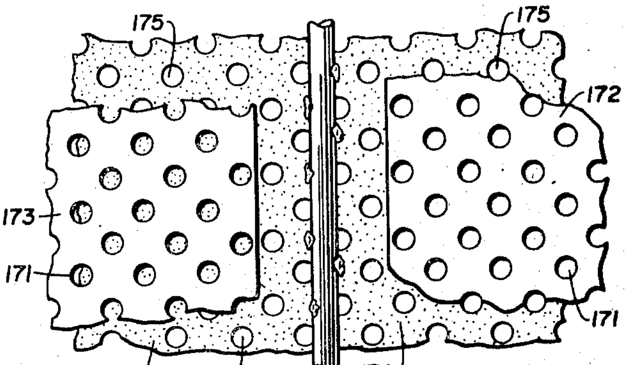


FIG. 8

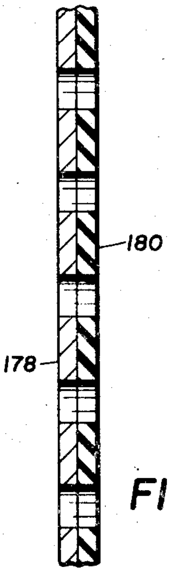


FIG. 9

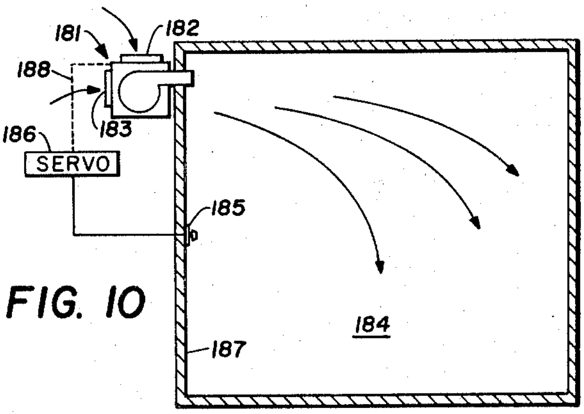


FIG. 10

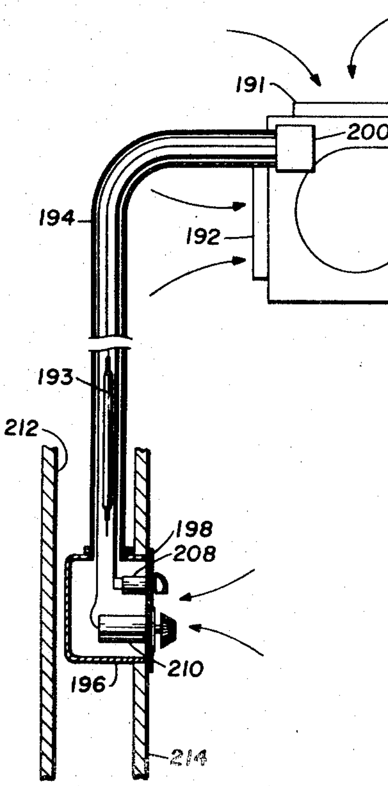


FIG. 12

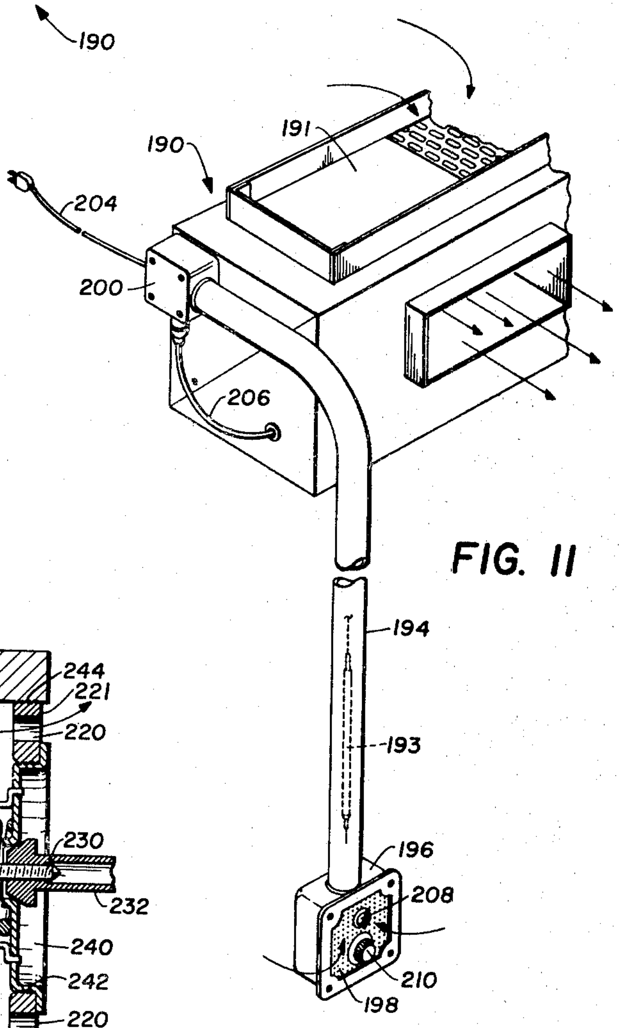


FIG. 11

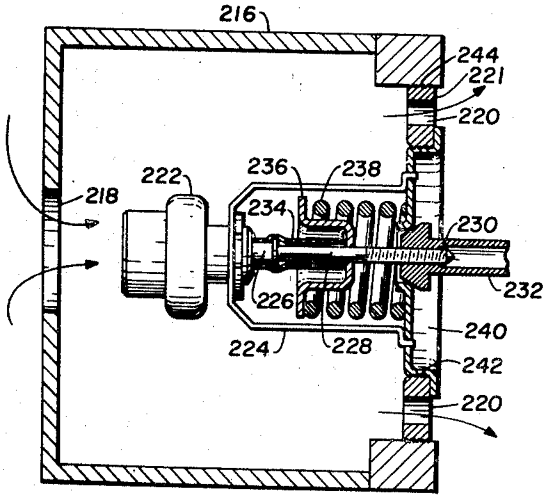


FIG. 13

FIG. 14

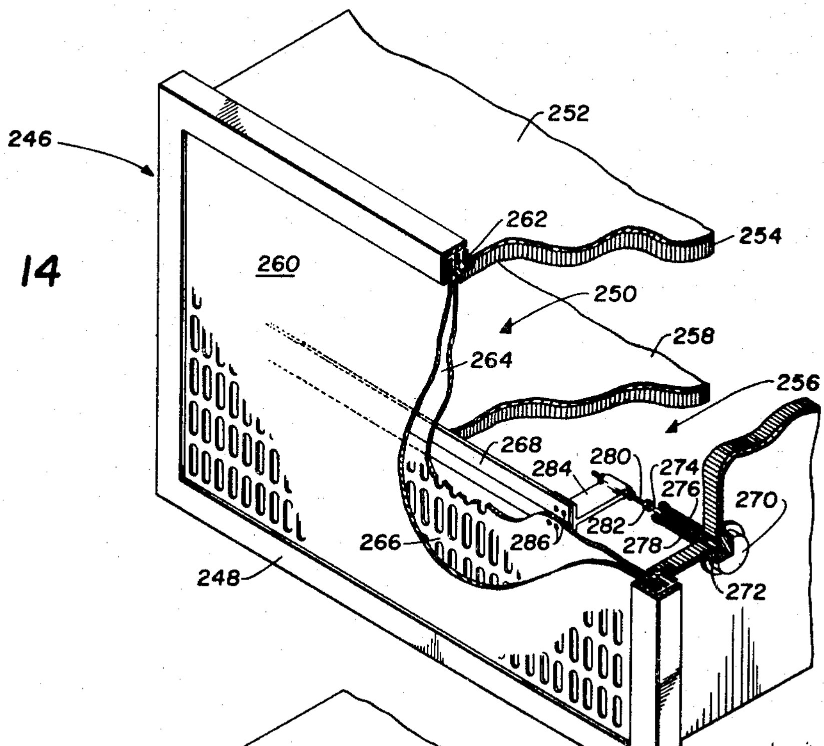

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FIG. 15

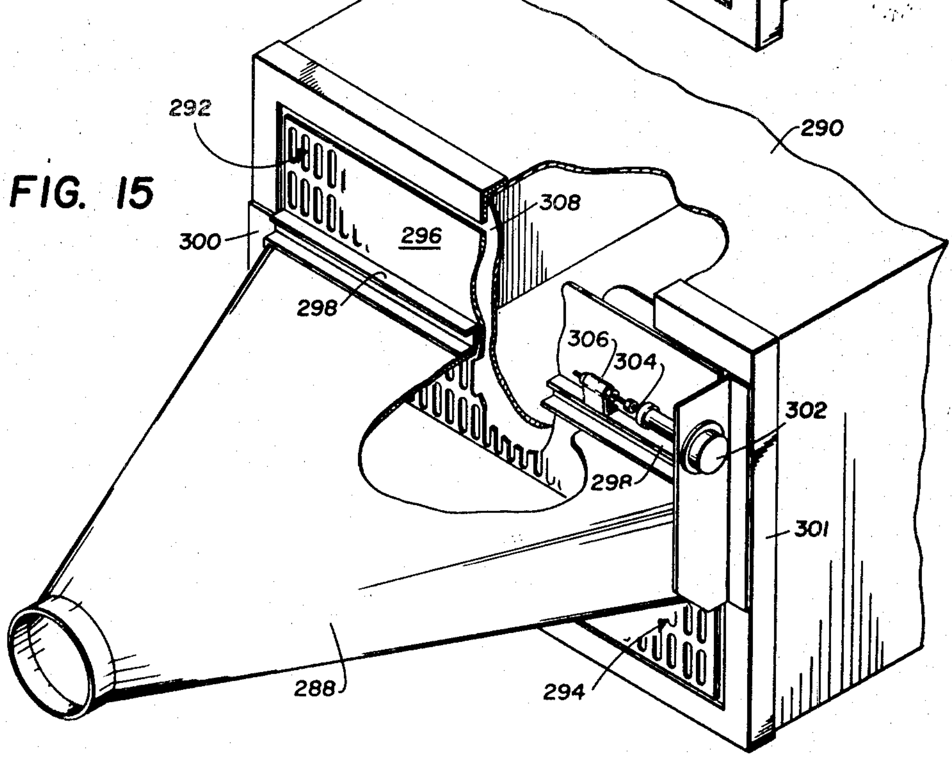
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FIG. 16

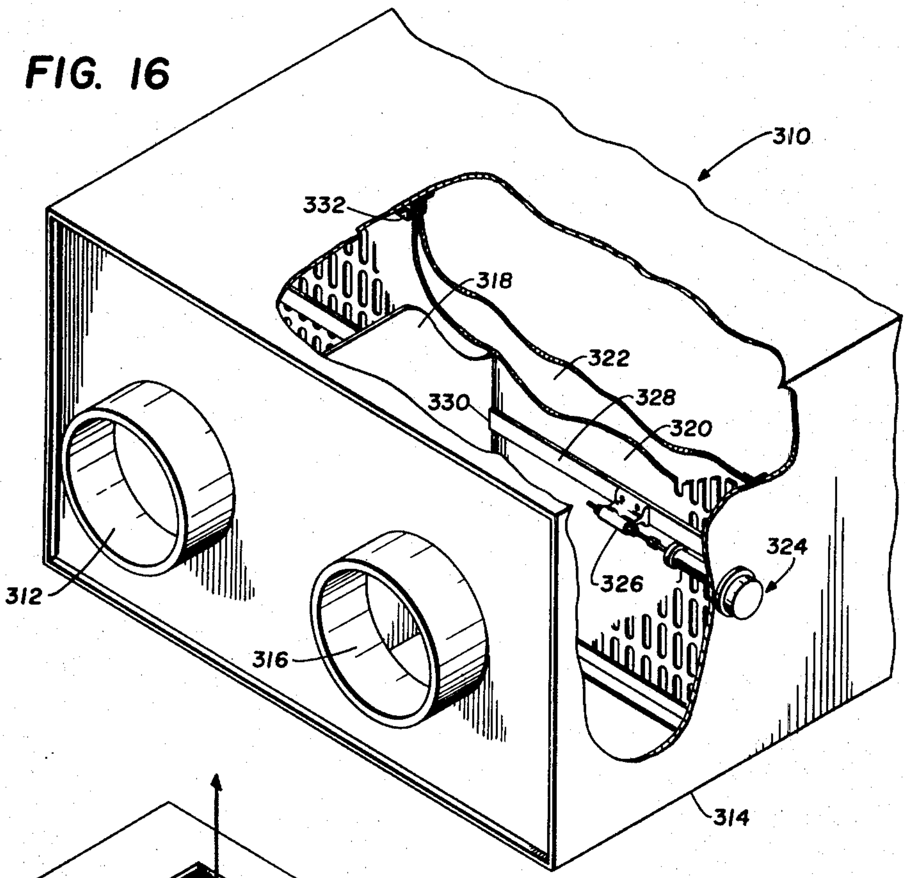
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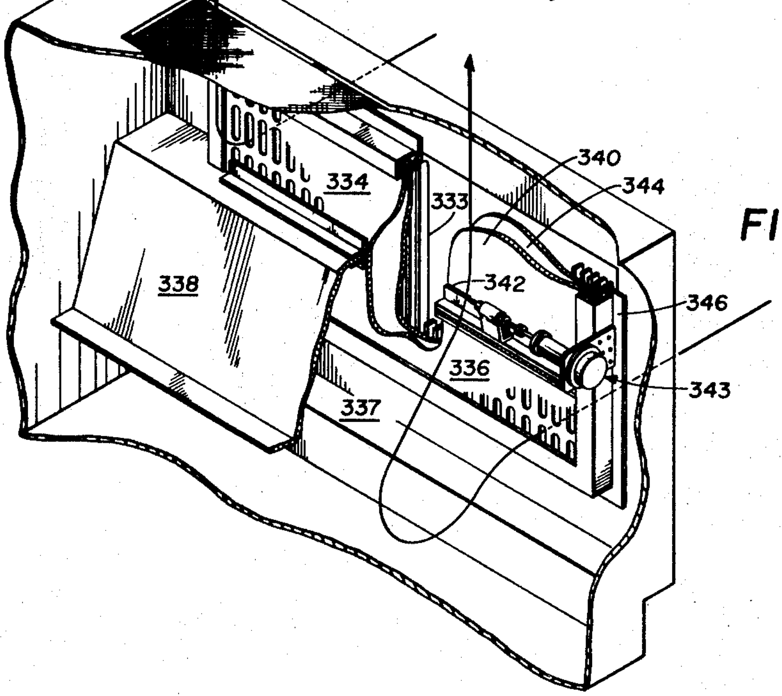
FIG. 17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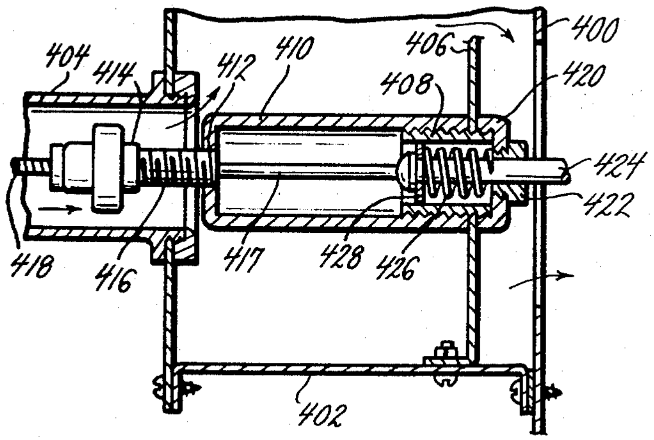


FIG. 18.

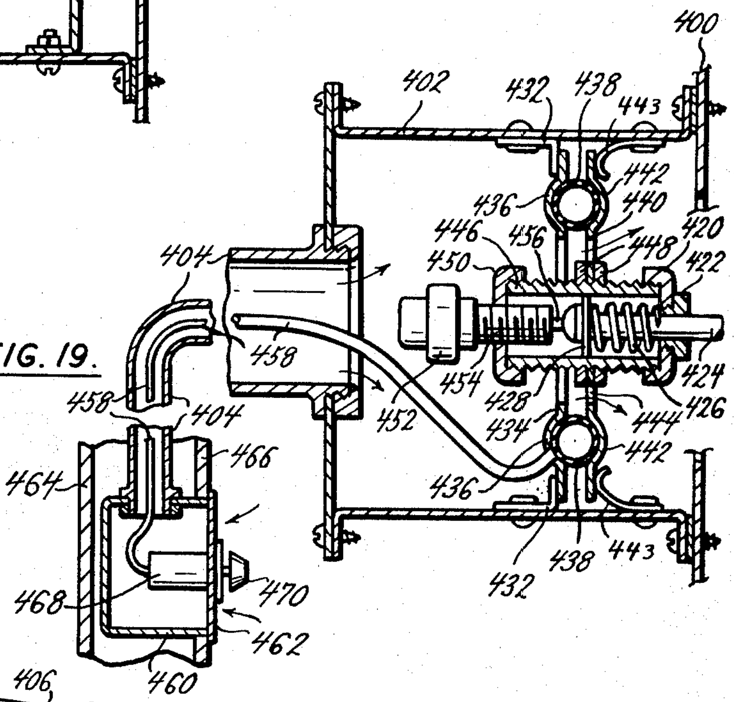


FIG. 19.

FIG. 20.

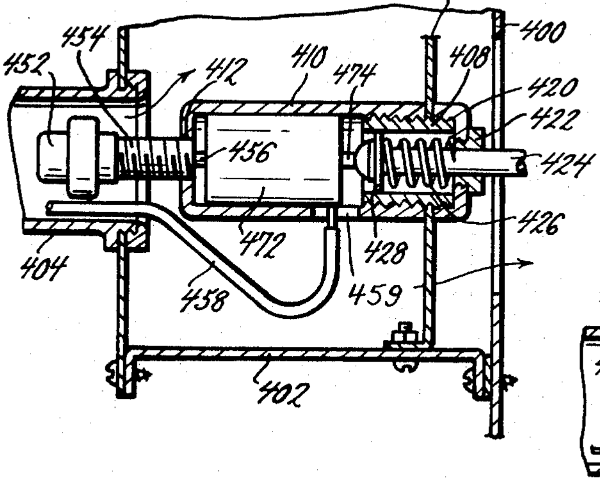
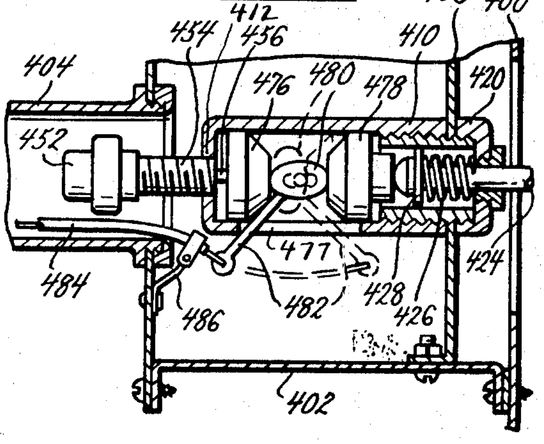


FIG. 21.



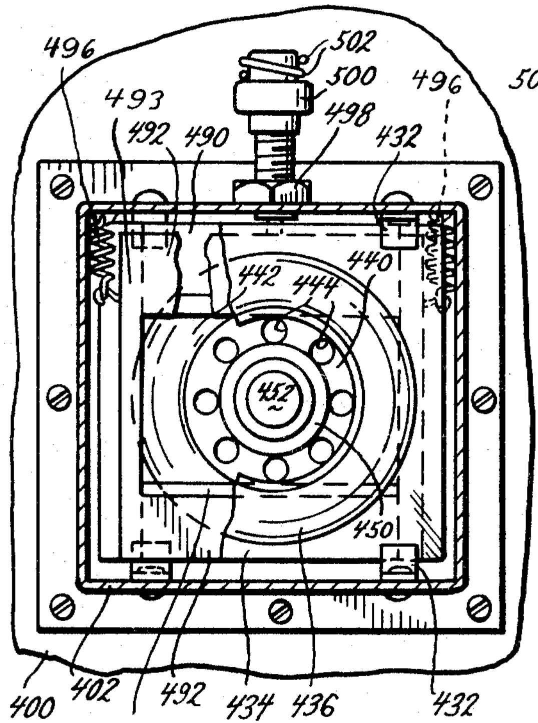


FIG. 23.

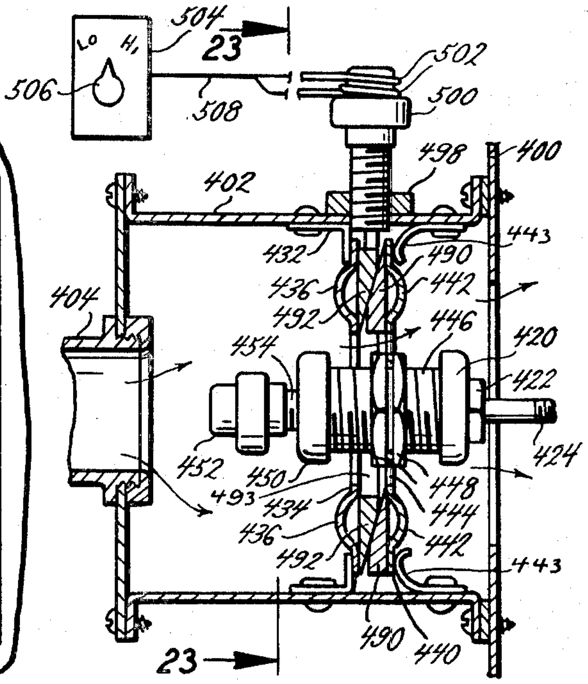


FIG. 22.

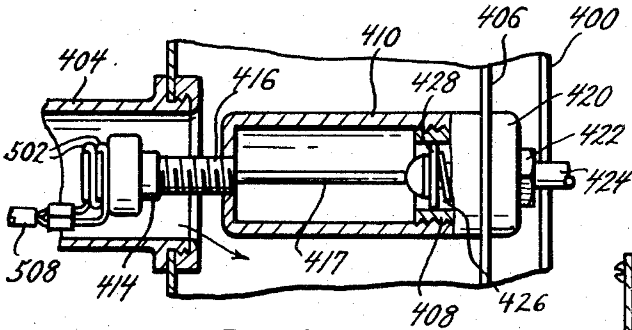


FIG. 24.

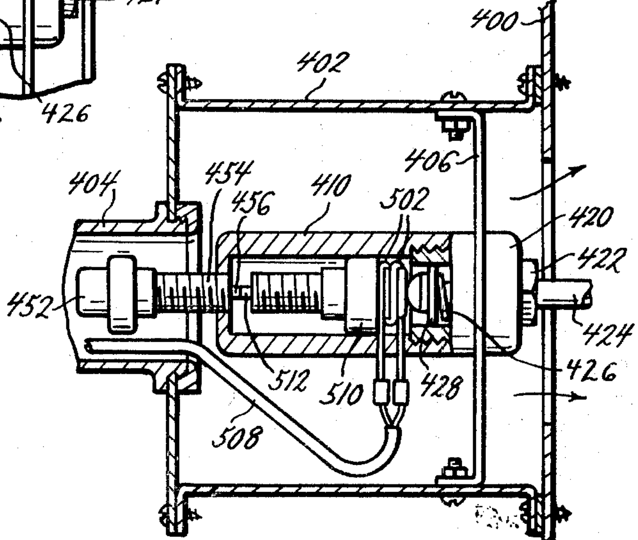


FIG. 25.

AIR FLOW CONTROL SYSTEM

Related Applications: This application is a continuation-in-part of application Ser. No. 636,748, filed May 8, 1967, now U.S. Pat. No. 3,669,349 issued June 13, 1972 which is a continuation-in-part of application Ser. No. 577,298, filed Sept. 6, 1966, now abandoned.

This invention relates to environmental control systems and more particularly to the control of air flow from warm and cool sources. In a more specific aspect, the invention relates to a flow control system which includes pairs of relatively slidable perforated plates positioned transversely of the flow paths leading from the sources. In a still further aspect, the invention relates to the development and direct use of forces produced solely in response to change in temperature for varying relative positions of such perforated plates.

Prior Art: A wide variety of systems has been heretofore employed in the delivery of air to one or more zones where individual control of the temperature for each zone is desired. In the past, heat exchange units have been supplied for each zone with temperature sensing means for controlling the heat supplied to, or extracted from, air flowing to such zone. In air flow systems, motor-driven mechanically-actuated dampers have been widely employed. Further, in high pressure systems, the flow of super-cooled air under high pressure to a particular area has been employed for inducing circulation.

The practical utilization of many of these previously developed temperature control systems has been limited by several factors. Many of the prior systems have not only required complex and expensive control and actuation devices for each temperature control unit, but have often required a separate control unit for each zone for which temperature control is desired. In addition to the economic limitations thus imposed upon many previously developed systems, the complex motor-operated construction of some systems has often not been entirely satisfactory with respect to maintenance requirements or operating efficiency. Further, many of the systems previously employed for zone temperature control have not been responsive to the temperature of air in the desired zone.

Summary: In accordance with the present invention, conduit means is mounted adjacent to a supply opening leading to a zone to be temperature controlled. Structure is provided which forms a pair of air supply paths which lead to the conduit means. A pair of perforated plates are transversely disposed in each air supply path and means is provided for moving one plate of one plate pair relative to the other plate in a first sense while moving one plate of the other plate pair relative to the other plate in a second sense to increase the proportion of air supplied through one path while concurrently decreasing the proportion of air supplied through the second path.

The drawings: Other objects and intended advantages of this invention will be more readily appreciated as they become better understood by reference to the following detailed description in connection with the accompanying drawings wherein:

FIG. 1 illustrates a system according to the present invention for individually controlling the temperature in a plurality of adjacent rooms;

FIG. 2 illustrates a system for conditioning the temperature in a plurality of vertically disposed room zones;

FIG. **3** illustrates a system utilizing common returned air to temperature condition adjacently disposed room zones;

FIG. **4** is a perspective view, partially cut away, of one embodiment of the present invention;

FIG. **5** is a cross-sectional view of the sensing unit of the device shown in FIG. **4**;

FIG. **6** is another perspective view of the device shown in FIG. **4**;

FIG. **7** is a perspective sectional view of a portion of the perforated plates shown in FIGS. **4** and **5**;

FIG. **8** is a sectioned view of another embodiment of the perforated plates of the present invention;

FIG. **9** is a cross-sectional view of another embodiment of the perforated plates of the present invention;

FIG. **10** is a schematic diagram of a temperature conditioning system utilizing the present invention;

FIG. **11** is a perspective sectional view of the system embodying the device shown in FIG. **4**;

FIG. **12** is a somewhat schematic view, partially in cross section, of the system shown in FIG. **11**;

FIG. **13** is a cross-sectional view of another embodiment of a sensing unit of the present invention;

FIGS. **14–17** are perspective views, partially cut away, of four different temperature control systems utilizing perforated plate control according to the present invention;

FIG. **18** is a broken sectional view of a direct-acting,expandible-material, temperature-sensitive device and of part of a remote-control system to mechanically adjust the set point of that temperature-sensitive device;

FIG. **19** is a broken-away sectional view of another direct-acting, expandible-material, temperature-sensitive device and of part of a remote-control system to hydraulically adjust the set point of that temperature-sensitive device;

FIG. **20** is a broken sectional view of a further direct-acting,expandible-material,temperature-sensitive device and of part of a remote-control system to hydraulically adjust the set point of that temperature-sensitive device;

FIG. **21** is a broken sectional view of yet another direct-acting, expandible-fluid, temperature-sensitive device and of part of a remote-control system to mechanically adjust the set point of that temperature-sensitive device;

FIG. **22** is a broken sectional view of a still further direct-acting,expandible-material, temperature-sensitive device and of part of a remote-control system to electro-mechanically adjust the set point of that temperature-sensitive device;

FIG. **23** is a sectional view through the structure shown in FIG. **22**, and it is taken along the plane indicated by the line **23—23** in FIG. **22**;

FIG. **24** is a broken sectional view of still another direct-acting,expandible-material, temperature-sensitive device and of part of a remote-control system to electrically adjust the set point of that temperature-sensitive device; and

FIG. **25** is a broken sectional view of an additional direct-acting,expandible-material, temperature-sensitive device and of part of a remote-control system to electrically adjust the set point of that temperature-sensitive device.

The Preferred Embodiments: FIGS. **1–3** illustrate air temperature control systems wherein warm air or cool air reservoirs common to a plurality of individual zones to be temperature controlled may be utilized with the application of the present invention. FIG. **1** discloses a control system wherein the temperature of air in several adjacently disposed rooms may be maintained individually in accordance with their separate requirements. A warm air reservoir or plenum **10**, which may, for example, be an attic space fed by return air from rooms therebelow, is commonly disposed to each of the rooms **12, 14, 16** and **18.** Cool air is supplied from a suitable source through a duct **20** which forms a cool air supply path leading to a first control section **22** in a flow control unit **24** constructed in accordance with the present invention. Warm air is returned from the room **12** through the opening **26** to combine with the warm air in the reservoir **10** to form a warm air supply path leading to a second control section **28** on the control unit **24.** The control sections each comprise pairs of perforated plates, one slidable with respect to the other, and so actuated as to proportion the air flowing therethrough in dependence upon temperature, as will be described in greater detail. A fan is located in the control unit **24** to pull air through the control sections **22** and **28** in such proportions as required to control the temperature of room **12.** The air from the warm and the cool supply paths is mixed and then supplied to room **12** through conduits **30** and **32** and through supply openings **34** and **36**, respectively.

Also illustrated in FIG. **1** is another embodiment of a system utilizing the present invention, wherein cool air from a duct **38** supplies a portion of air through openings **40** into room **14**, opening **42** into room **16**, and opening **44** into room **18** in such proportions as determined by the control units **46** and **48**, constructed in accordance with the present invention. Warm air is returned through opening **50** from room **14** into the reservoir **10** for mixture with the cool air supplied by the duct **38** in such proportions as is determined by the control unit **46.** In a somewhat similar manner, warm air is supplied to an opening **52** from room **18** to be mixed with the cool air supplied by the duct **38** in such proportions as is determined by the control unit **48.** The proportions of warm air and cool air are accurately controlled in response to sensing devices exposed to air of the temperature of the air in the individual rooms, thus allowing individual temperature control of each of the adjacently disposed rooms.

FIG. **2** illustrates the use of the present invention in a temperature control system for a plurality of vertically disposed rooms in a building. A cool air reservoir or plenum **54**, common to a plurality of vertical rooms, contains cool air supplied by a blower **55** in a conventional cooling unit **56**, which may utilize conventional dampers **58** to control the inflow of outside air. A warm air return plenum **60** contains warm exhaust air supplied by the rooms and from the cool air reservoir **54** through the grille **62.** The plenum **60** is connected through conduit **63** and suitable dampers to the cooling unit **56.**

As may be seen, a system utilizing the present invention may take any one of a variety of forms. For instance, the system for independently controlling the temperature of room **64** supplies conditioned air to the inlets **66** through conduits **67**, the conditioned air being mixed by the control unit **68** from the warm air returned through the outlets **69** and the cool air supplied through the path **70.** A similar system is shown for conditioning the air of room **72** wherein rigid ductwork **74** is utilized instead of flexible conduits. If desired, a plurality of control units may be utilized for conditioning a single room, as shown by the three units **76, 78** and **80**, which selectively proportion the amount of cool air from the reservoir **54** and the warm air from the attic plenum **82** mixed and provided to the room.

FIG. **3** illustrates a conditioning system for a pair of rooms **84** and **86** which are commonly disposed to a warm air attic reservoir **88** and a cool air reservoir **90.** Warm air from rooms **84** and **86** flows to a common plenum **92** and a conduit **93** and thence into a conventional cooling system **94.** A blower unit **95** supplies a continuous supply of cool air to the reservoir **90.** Warm air also flows from the rooms **84** and **86** into the attic reservoir **88** through openings **85** and **87**, respectively. A pair of air-mixing control units **96** and **98**, constructed in accordance with the present invention, are mounted between the warm air reservoir **88** and the cool air reservoir **90** in order to selectively proportion the mixture of the two air supplies which is fed into rooms **84** and **86**, respectively.

While refrigeration units have been illustrated in conjunction with the embodiments described, it will be appreciated that, if desired, cold air could be provided from an outside environment and heating means could be provided to supply a source of warm air.

The construction of an air-mixing control unit in accordance with the present invention may be best understood by reference to FIGS. **4–6**, wherein the unit **100** is enclosed by a main housing **102.** Housing **102** is an elongated rectangular polyhedron conveniently formed of sheet metal. Housing **102** may have one or more removable panels **104** for repair or maintenance access. A pair of conventional blower fan units **106** and **108** include rotatable vaned cages **109** and **110** driven by an electric motor **111.** The operation of electric motor **111** is controlled by a suitably placed wall switch **112** connected through cable **113** which controls the application of power from a suitable source (not shown) to the motor. Rotation of the cages **109** and **110** induces flow of supply air through a first perforated plate unit **114** and a second perforated plate unit **116.**

Perforated plate units **114** and **116**, as shown in FIG. **6**, are disposed relative to one another at an angle corresponding with the junction of warm and cool air supply paths. Rectangular flanges **117** and **118** may be provided about the outer openings of the plate sections in order to enable connection with air conduits. As shown in FIG. **7**, plate unit **114** comprises a fixed plate **122** adjacent to a slidable plate **128.** Plates **122** and **128** have perforations therein which may be brought into registration or moved out of registration to open or close the air flow path and thus proportion the air passing through the housing **102.** Plate unit **116** includes slidable plate **139** and fixed plate **134.** Air flowing through the plate units **114** and **116** is expelled by the fan units through their respective outlets **119** and **120.**

Referring again to FIG. **7**, plate unit **114** comprises a first plate **122** which is fixedly connected at one edge to a bracket member **124** which is in turn connected to the main housing **102** of the unit. The other edge of the plate **122** is connected to housing **102** by means of a folded flange **125** (FIG. **4**). Plate **122** includes a plurality of elongated perforations **126** defined therethrough in a predetermined alternating pattern. A second plate **128**, comprising one-half of an integral plate having a central right angle bend, is slidable adjacent to the plate section **122.** Plate **128** is connected to the rod **130,** as by welding, for slide movement relative to plate **122.**

Plate **128** includes a plurality of elongated perforations **132** disposed in the same pattern as the perforations **126** in the plate **122,** so that the perforations in the adjoining plates may be selectively brought into registration or moved out of registration in order to control the flow of air therethrough. In FIG. **7,** the perforations **126** and **132** are disposed in exact registration so that the passage of air therethrough is substantially unimpeded. Upon a slight vertical movement of the rod **130,** the perforations may be moved out of registration in order to accurately adjust the magnitude of the air flow therethrough.

The second plate unit **116** comprises a first plate **134** rigidly secured to the bracket member **136** and having a plurality of elongated perforations **138** disposed therethrough in a predetermined pattern. The plate **134** is offset with respect to the plate **122** so that the perforations through the two plates are not aligned. The second half of the bent plate, plate **139,** has a plurality of perforations **140** and is adjacent to the plate **134.** Because the perforation patterns of plates **122** and **134** are offset, when the perforations of the plate unit **114** are exactly aligned, the perforations of the second plate unit **116** are unaligned. In such case, the flow of air through the second plate unit **116** is thus totally obstructed.

Upon movement of the rod **130,** however, the plates **128** and **139** would be moved relative to both the plates **122** and **134,** thereby decreasing the proportion of air allowed to pass through the first plate unit **114,** while concurrently increasing the proportion of air allowed to pass through the second plate unit **116.** It will be understood that fine control of the passage of air, and similar control of mixing of air from two different air supply paths, may be accomplished by the present device. Only a very small mechanical movement is required to change one pair of plates from open to closed. The elongated slot configuration shown in FIG. **7** has the distinct advantage of not requiring extremely accurate manufacturing dimensioning to provide substantial registration of the perforations while maintaining at a minimum the travel necessary to open and close a pair of plates.

FIG. **5** discloses means for moving rod **130** to adjust the positions of the perforated plates. A fluid filled sensor **141** is connected in fluid communication with a fluid chamber **142** by means of a line **144.** An insert **146** within the chamber **142** limits the upward movement of the end **148** of an elongated linkage **150.** A housing **152** provides a fluid-tight seal about the linkage **150,** and a bias spring **154** is disposed between the end **148** and the housing **152.** A threaded portion **158** on the linkage **150** provides for connection to an extension **156** on the rod **130** in order to allow initial adjustment of the position of the rod **130** for proper alignment of the perforations.

A fluid conduit **160** connects the chamber **142** in fluid communication with an adjustment mechanism **162** comprising a hollow chamber **164** also filled with the fluid. A slidable piston **166** is biased against the fluid in the chamber **164** by a spring **168.** A dial **170** may be manually turned to selectively increase or decrease the tension applied by the piston **166** against the fluid. The variance of pressure on the fluid acts on the end **148** to move the linkage **150** vertically. By suitable adjustment of dial **170,** therefore, the static position of the rod **130** and the outer plate sections **128** and **139** may be adjusted to provide either warmer or cooler air flow.

In operation of the present unit, the dial **170** is set to the desired operating temperature. The sensor **141** senses air of the temperature of air in a room. If the temperature increases, the fluid inside the sensor **141** tends to expand, overcoming the bias pressure of the spring **154** and moving the linkage **150** downwardly. This causes the rod **130** and thus the perforated plate sections **128** and **139** to move downwardly, thereby changing the registration of the perforations. This movement concurrently increases the amount of cool air and decreases the amount of warm air supplied to the room.

Conversely, if the temperature of the room air drops, the volume of the fluid inside the sensor **141** and the chamber **142** will decrease. Spring **154** moves the perforated sections **128** and **139** upward. The change causes the temperature of the air in the room to be raised. The novel construction of the present invention thus allows very accurate control of the air supply to a room in response to only a very slight mechanical movement. This movement is within the capabilities of the expandible-material sensing device **141.**

Other configurations of perforations may be employed in the perforated plates. For example, FIG. **8** illustrates a plurality of substantially circular perforations **171** distributed in predetermined patterns through fixed plates **172** and **173.** A movable outer plate **174** is connected, as by welding, to the rod **176** for movement relative to the fixed plates **172** and **173.** The plate **174** includes a plurality of circular perforations **175** which may be moved into registration with the openings of only one of the fixed plates **172** or **173** at a time.

FIG. **8** illustrates a position of the plate **174** such that the perforations **175** are in registration with the perforations in plate **172.** In this position, the perforations in plate **174** are out of registration with the openings of the plate **173,** thereby preventing the passage of air therethrough. It will be understood that other configurations of perforations may also be employed for the plates, as, for example, square, rectangular, and the like.

The plates above described may advantageously be constructed of rigid material, preferably of stainless steel. Plate sections of other metals, such as aluminum or the like, may also be used when corrosion will not adversely affect operation.

It may be found advantageous to construct one or more of the plates from a flexible material, in the manner illustrated in FIG. **9.** In this embodiment, the perforated plate **178** is constructed from stainless steel, while the perforated plate **180** is constructed from a flexible material, such as neoprene-covered canvas or the like. By placing the flexible plate upstream of the rigid plate section, the pressure of the air flow against the flexible plate will press it against the rigid plate, thereby minimizing the loss of air through the space between the plates. Alternatively, a felt-like material may be bonded to one side of two stainless steel plates of a pair, and between them, in order to cut down air loss and to resist corrosion.

FIG. **10** illustrates another embodiment of a sensing apparatus for use with the present control unit **181** above described for control of the temperature in room **184.** A bimetallic circuit controller **185** is mounted on the wall **187** or in some other suitable place in order to sense the temperature of air in room **184.** Such a bimetallic controller conventionally changes from one position to another in order to open or close an electrical contact (not shown). The controller **185** serves to energize and de-energize a servo motor **186** which is connected through a mechanical linkage **188** to the movable perforated plate sections **182** and **183.** Energization of the servo motor **186,** also of a conventional construction, selectively varies the alignment of the perforations in the plate sections in order to control the content of the air being supplied to room **184.**

FIGS. **11** and **12** illustrate a system utilizing the sensing device shown in FIG. **5.** In this application, the control unit **190** has perforated plate sections **191** and **192** operated in dependence upon an expandible-material sensor **193.** Sensor **193** is disposed in an air conduit **194** which could be a short length of thin-wall electrical conduit. The conduit **194** is connected at one end to a wall panel box **196** having a perforated front panel **198** to allow the passage of air from a room therethrough. The wall panel box **196** can be an electrical outlet box of standard design. The other end of the air conduit **194** is connected to a junction box **200** mounted on the unit **190.** Electric power from a suitable source may be provided to energize the blower fans in the unit **190** through cables **204** and **206.**

An electrical switch **208** is remotely disposed from the unit **190** and is mounted on the perforated panel **198** in order to allow remoted adjustment of the speed of the blower in unit **190.** Similarly, a temperature selector mechanism **210,** similar to that shown in FIG. **5,** in fluid communication with the expandible liquid sensor **193,** is mounted on the perforated panel **198** in order to allow remote adjustment of the temperature of the air of the room.

The wall panel box **196** ordinarily will be mounted in the space between room wall panels **212** and **214.** The end of the air conduit **194** connected to the junction box **200** is disposed upstream of the blower of the unit **190** so that room air passes through the conduit **194** and flows over the sensor **193.** If desired, the remote end of the conduit **194** may be disposed between the wall panels **212** and **214** in order to sample warm air from the room being returned to a warm air reservoir. Alternatively, the sensor **193** may be disposed in a region downstream from the blower fans of the unit **190** in order to sample the air flow to a given room.

FIG. **13** illustrates another embodiment of a suitable temperature sensor for mechanically moving perforated plates relative to one another. A housing **216** includes an inlet port **218** for entry of air whose temperature is to be sampled and further includes an annular ring **221** having outlet ports **220** for exhausting air.

A temperature-sensitive device **222** contains an expandible material and may be of the type presently or formerly manufactured by American-Standard Control Division, Detroit, Mich., and sold under the name Vernatherm. Alternatively, the temperature-sensitive expandible-material device manufactured by The Dole Valve Company, Morton Grove, Ill. or the temperature-sensitive expandible-material device manufactured by Fulton Sylphon Division of Robertshaw, Knoxville, Tenn. could be used as the temperature-sensitive unit **222.** Unit **222** is mounted on a bracket **224.** A piston **226** is movable into and out of unit **222** in response to expansion of the material therein in response to temperature changes. A pin **228** is connected to the piston **226** and includes a threaded portion **230** adapted to connect to a rod **232.** Rod **232** is to be connected to the movable perforated plates above described. A sleeve **234** abuts a cup **236** which is biased by a spring **238.** A base cup **240** abuts the lower end of spring **238** and has a central opening through which pin **228** passes.

The base cup **240** includes a threaded section **242** which threadedly mates with threads in the annular ring **221.** Ring **221** also includes a threaded portion **244** which mates with threads in the housing **216.** The threaded portions **242** and **244** may be provided with threads of different pitch to allow for initial adjustment of the static position of the sensing device. A coarse adjustment may be made by rotation of the annular ring **221.** A fine adjustment may be made by rotation of the base member **240** relative to the ring **221.**

The sensor illustrated in FIG. **13** preferably is mounted on or near a control unit and is mechanically linked to movable perforated plates through the rod **232.** The unit of FIG. **13** may be mounted in the conduit opening into a room in order to sense the temperature of the air being supplied to the room. Alternatively, it may be mounted in or near the return paths from a room. In each of these embodiments, a mechanical linkage may connect the cup **240** to a readily-accessible manually operable wall-mounted actuator or control knob to allow adjustment of the set point.

Other applications of the present invention will be apparent upon consideration of FIGS. **14–17,** wherein perforated plate control according to the present invention is utilized in four different types of temperature control systems. FIG. **14** illustrates a supply grille or conduit **246** which has a rectangular frame **248** adapted to be releasably mounted in a supply opening leading to a room. A warm air supply path **250** is partially defined by a duct collar **252** having insulation **254** installed therein. A cool air supply path **256** is located beneath the warm air supply path **250** and is defined by the collar **252** and an insulated divider partition **258.**

The two air supply paths **250** and **256** are fed into the room from suitable sources through pairs of perforate plates constructed in accordance with the present invention. More particularly, an integral perforated plate **260** is rigidly mounted between the frame **248** and a bracket **262** connected to the duct collar **252.** A pair of movable perforated plates **264** and **266** are slidably disposed in a groove in the bracket **262** and are connected to the horizontally movable bar **268.** Thus, a first pair of perforated plates comprising the upper portion of plate **260** and the movable plate **264** is transversely disposed in the warm air path **250.** Similarly, a second pair of perforated plates comprising the lower portion of the fixed perforated plate **260** and the movable plate **266** is transversely disposed in the cool air supply path. The plate section pairs may thus be relatively moved, in the manner previously described, to selectively adjust the registration of the perforations in adjacent plates to control the mixture of warm and cool air which is supplied to the room.

The force for moving bar **268** is provided by the power unit **270,** which may, for instance, be of the expandible fluid or material type previously described. Pressure resulting from fluid expansion in the power unit **270** acts upon the head **272** of a rod **274**. A spring **276** biases the head **272** against the bottom of the lower housing **278** of the power unit. The lower end of rod **274** is connected to a threaded member **280** by adjusting nut **282** in order to allow initial adjustment of the position of the perforated plates. The threaded member **280** is connected to a projection **284** from bar **268** by a plurality of screws **286**. The frame **248** and the fixed perforated plate **260** are thus made to be easily removed for maintenance purposes. More particularly, screws **286** are disposed to be easily accessible upon the removal of frame **248** and plate **260** to allow the movable plates **264** and **266** to be removed for servicing.

FIG. **15** illustrates the use of perforated plates in a temperature control system wherein cool air is forced into a room through a nozzle **288** and a duct **290**. Return air from a warm air plenum may be selectively mixed with the cool air by means of a venturi type action created by the flow of air through the nozzle **288**. This venturi action induces flow of warm air into the duct **290** through the perforated plate pairs **292** and **294**.

The perforated plate pairs include a horizontally slidable plate **296** which is transversely disposed across both of the warm return air paths and also across the cool air supply path. Plate **296** is connected to a guide bar **298** which is horizontally slidably mounted upon a frame member **300** which rigidly connects nozzle **288** to the front duct frame **301**. A power unit **302** is connected to move the rod **304**, which in turn moves a projecting member **306** and bar **298**.

A perforated plate **308** is mounted in the duct **290** adjacent to the movable perforated plate **296**. The fixed perforated plate **308** may comprise a unitary plate having a predetermined pattern of aligned perforations at the top and the bottom portions of the plate which are disposed adjacent the movable plates **292** and **294**, and a pattern of horizontally offset perforations in the middle portion of the plate which is disposed transversely across the opening of the nozzle **288**.

Alternatively, the movable plate **296** may comprise three sheets mounted adjacent to each other, with the perforations of the top and bottom plate sections being aligned and the perforations of the middle plate being horizontally offset. In either embodiment, it will now be apparent that when the movable perforated plate **296** is horizontally translated in response to changes of air temperature in the room to be conditioned, the proportion of cool air supplied through the duct **290** may be selectively modulated in one sense while the porportion of warm return air is concurrently modulated in the opposite sense.

FIG. **16** illustrates another type of temperature control system **310**, generally known as a double duct constant volume system. Warm air under a high pressure is fed through the supply inlet **312** into the housing **314**, while cool air under high pressure is supplied through the inlet **316**. A partition **318** divides the air supply paths inside the front portion of the housing **314**. The warm and the cool air are then mixed in the back portions of the housing **314** in proportions determined by transversely disposed perforated plates **320** and **322**. The plate **322** is rigidly connected to the housing **314**. Plate **320** is movable in response to movements of the temperature sensitive power unit **324**. The power unit **324** moves the movable plate **320** by means of a projection **326** mounted on a transversely disposed bar **328** rigidly connected to plate **320**. The bar **328** is slidable through a slot **330** in the partition **318**.

The perforated plates are supported by a spacer member **332** which has provisions to allow a sliding movement of the plate **320**. The perforations in the movable plate disposed in the warm air supply path are horizontally offset with respect to the perforations in the movable plate disposed in the cool air supply path. This allows the proportion of air supplied to the room by the warm air supply path to be selectively increased while concurrently the proportion of air supplied to the room by the cool air supply path is decreased, or vice versa.

FIG. **17** illustrates the use of the present invention in a temperature control system commonly termed a high velocity induction unit. In this system, a bypass control simultaneously modulates the amount of return room air which passes over heating or cooling coils and the amount of return room air bypassed around the coils. For example, in the illustrated system of FIG. **17**, return room air is induced to flow through a grille **333** and then through perforated plate units **334** and **336**. Air flow through plates **334** bypasses the heating or cooling coils in zone **337**.

A baffle **338** separates the two flows of air. Air passing through plates **336** contacts the heat exchange elements in zone **337**. The perforated plate pairs are constructed in a manner similar to the units previously described, with a slidable plate **340** being connected to a bracket **342** which is horizontally moved by a power unit **343**. The bracket **342** slides along an edge portion of the baffle **338**. A fixed plate **344** is connected to the frame **346**.

It will be understood from the embodiments previously described that the perforations of one perforated plate section in each of the perforated plate pairs **334** and **336** are horizontally offset with respect to one another so that the proportion of room air return supplied through one path may be concurrently increased while the proportion of room air return supplied through the second path is concurrently decreased.

Referring particularly to FIG. **18**, the numeral **400** denotes one wall of an air-mixing control unit such as the air-mixing control unit **190** of FIGS. **11** and **12**. A generally-cylindrical housing **402** is suitably secured to the wall **400**, adjacent an opening in that wall, by self-tapping metal screws; and an air conduit **404** such as the air conduit **194** in FIGS. **11** and **12** is secured to the end wall of the housing **402**. A strut **406** extends transversely of the housing **402**; but that strut does not prevent the flow of air through that housing, because the width of that strut is only about one-third the inner diameter of that housing.

The numeral **408** denotes an externally-threaded sleeve which is mounted within an opening in the strut **406**; and a cup-like bracket **410** has an internal thread at the right-hand end thereof which mates with the external thread on the sleeve **408**. That cup-like bracket has a thread **412** at the left-hand end thereof which mates with an external thread **416** of a direct-acting,expandible-material, temperature-sensitive device **414** which can be a Vernatherm unit. The numeral **417** denotes the actuator of that temperature-sensitive device; and the numeral **418** denotes a flexible cable which is secured to the housing of that temperature sensitive device. That cable can be of the type used in the speedometers of automotive vehicles; and it will have its left-hand end connected to a knob or dial, not shown, located in or close to the space or room which is supplied with air by the air-mixing control unit.

The numeral **420** denotes a nut which has an internal thread that mates with the external thread on the sleeve **408.** A threaded bushing **422** is held by an internal thread of the nut **420**; and that bushing accommodates a reciprocable rod **424.** A washer **428** is mounted on the left-hand end of the rod **424**; and a helical compression spring **426** has one end thereof bearing against that washer and has the other and thereof bearing against the bushing **422.** The spring **426** biases the spherical surface of the head of the rod **424** into engagement with the right-hand end of the actuator **417** of the temperature-sensitive device **414.** However, that spring can yield to permit movement of the rod **424** to the right in response to right-hand movement of the actuator **417.**

The air conduit **404** will have the left-hand end thereof in communication with the space or room which is supplied with air by the air-mixing control unit **400,** in the same manner in which the air conduit member **194** of FIGS. **11** and **12** is in communication with the room which is supplied with air by the air-mixing control unit **190.** As a result, return air will be drawn through the air conduit **404** past the temperature-sensitive device **414,** through the housing **402,** and then through the opening in the wall **400.** That air will cause the actuator **417** of that temperature sensitive device to assume a position corresponding to the temperature of that air; and the rod **424** will respond to that position to appropriately set the perforated plates or movable dampers within the air-mixing control unit. The temperature-sensitive device **414** will be essentially inaccessible from the space or room served by the air-mixing control unit; but the flexible cable **418** will enable a maintenance man within that space or room to adjust the set point of the temperature-sensitive device **414.** To adjust that set point, the maintenance men will actuate the knob or dial in the room to cause the cable **418** to rotate the housing of the temperature-sensitive device **414.** As that housing rotates, the thread **416** thereon will coact with the thread **412** of the cup-like bracket **410** to axially displace the actuator **417,** with a consequent displacement of the rod **414.** The resulting adjustment of the position of the perforated plates or movable dampers will shift the proportion of warm air introduced into the space or room to the desired value.

To lower the set point of the temperature-sensitive device **414,** the housing of that temperature-sensitive device will be rotated to cause that housing to shift a short distance to the right in FIG. **18.** The resulting axial displacement of the actuator **417** will force the spring **426** to yield and permit a corresponding axial displacement of the rod **224.** The perforated plates or movable dampers will respond to that displacement of that rod to decrease the proportion of warm air in the air which the air-mixing control unit supplies to the space or room. As a result, the temperature of the air within the space or room will decrease to a lower average value.

As the temperature of the air within that space or room decreases, the temperature of the air flowing through the air conduit **404** will decrease correspondingly. The expandible fluid within the temperature-sensitive device **414** will respond to that decrease in temperature to experience a decrease in the volume thereof; and hence the actuator **417** will shift to the left in FIG. **18.** However, the shifting of that actuator to the right in response to the rotation of the housing of the temperature-sensitive device will be greater than the shifting of that actuator to the left, in response to the reduction in the temperature of the air in the air conduit **404.** As a result, the set point of the temperature-sensitive device **414** will have been lowered; and hence the average value of the temperature of the air within the space or room will have been reduced.

If the average temperature within the space or room is to be increased, the maintenance man will use the knob or dial within that space or room to cause the cable **418** to rotate the housing of the temperature-sensitive device **414** in the opposite direction. The resulting shift of that housing to the left will enable the spring **426** to shift the rod **424** to the left. Thereupon the perforated plates or movable dampers within the housing of the air-mixing control unit will supply a higher percentage of warm air — and hence the average temperature within the space or room will be increased.

As the temperature of the air within that space or room increases, the temperature of the air flowing through the air conduit **404** will increase correspondingly. The expandible-material within the temperature-sensitive device **414** will respond to that increase in temperature to experience an increase in the volume thereof; and hence the actuator **417** will shift to the right in FIG. **18.** However, the shifting of that actuator to the left, in response to the rotation of the housing of the temperature-sensitive device **414,** will be greater than the shifting of that actuator to the right, in response to the increase in the temperature of the air in the air conduit **414.** As a result, the set point of the temperature-sensitive device **414** will have been increased; and hence the average value of the temperature of the air within the space or room will have been increased.

Once the set point of the temperature-sensitive device **414** has been set, that temperature-sensitive device will automatically operate to maintain a corresponding average temperature within the space or room. If the temperature of the air within the space or room tends to fall below that average temperature, the temperature of the air flowing through the air conduit **404** will decrease; and the resulting reduction in volume of the expandible material within the temperature-sensitive device **414** will permit the actuator **417** to move to the left. The spring **426** will provide a corresponding movement of the rod **424** to the left — with a consequent increase in the proportion of warm air introduced into the space or room by the air-mixing control unit. The overall result is that the temperature of the air within the space or room will move back up to the desired level, and the actuator **417** and rod **424** will return to their set positions. Conversely, if the temperature of the air within the space or room tends to rise above the average temperature, the temperature of the air flowing through the air conduit **404** will increase; and the resulting increase in volume of the expandible material within the temperature-sensitive device **414** will cause the actuator **417** to shift to the right. The spring **426** will yield to permit a corresponding shift of the rod **424** to the right — with a consequent decrease in the proportion of warm air supplied to the space or room by the air-mixing control unit. The overall result is that the temperature of the air within the space or room will move back down to the desired level, and the actuator **417** and rod **424** will return to their set positions.

It thus should be apparent that by using the structure in FIG. **18**, it is easy to adjust the set point of the temperature sensitive device **414** from a point within the space or room. This is important because that temperature-sensitive device is essentially inaccessible from that space or room — being located immediately adjacent the wall **400** of the air-mixing control unit.

The left-hand end of the air conduit **404** will preferably be in direct communication with the space or room, as indicated by FIGS. **11** and **12**; so air from that space or room can pass directly into that air conduit and thence directly to the temperature-sensitive device **414**. To minimize costs of installation, the cable **418** will usually be located within that air conduit; and the knob or dial on that cable will usually be mounted on a perforated plate at the outer face of a wall panel box to which that air conduit is connected. However, if desired, the cable **418** could have a substantial portion of the length thereof disposed outwardly of the air conduit **418**; and it could have the knob or dial therefor located in a box or panel which was located in a corridor or hall exteriorly of the space or room.

FIG. **19** shows a remote-control arrangement which is specifically different from the remote-control arrangement of FIG. **18**, although some of the components thereof are identically numbered and can be identical. The numeral **432** denotes L-shaped brackets which are secured to the inner surface of the cylindrical housing **402**; and those brackets fixedly support an annular plate **434** which has a concave annular recess **436** in the right-hand face thereof. A liquid-tight annulus **438** of expandible material is cemented or otherwise secured in position within the concave annular recess **436**; and a concave annular recess **442** in the left-hand face of a circular plate **440** also is cemented or otherwise secured to that expandible annulus. The circular plate **440** is supported by the expandible annulus **438**, but it is biased toward the annular plate **434** by spring clips **443** which are suitably secured to the inner surface of the housing **402**.

The circular plate **440** has air passages **444** therethrough, and also has a central passage which accommodates an externally-threaded sleeve **446**. Nuts **448** are threaded onto that sleeve in abutting engagement with the opposite faces of that circular plate to fixedly secure that sleeve to that plate. A nut **450** is threaded onto the left-hand end of the sleeve **446**, and the external thread **454** of a temperature-sensitive device **452**, which can be a Vernatherm unit. is held by an internal thread of that nut. The spring **426** holds the head of the rod **424** in engagement with the actuator **456** of that temperature-sensitive device. The numeral **458** denotes a hollow tube which has the right-hand end thereof connected to the expandible annulus **438**, and which has the left-hand end thereof connected to a transducer **468** that responds to the rotation of a knob **470** to change the pressure on the liquid therein — and thus on the liquid within the tube **458** and within the expandible annulus **438**. The transducer **468** is located within a wall box **460** that is disposed between two walls **464** and **466**; and the front of that wall box is covered by a perforated plate **462** which can be identical to the plate **198** in FIGS. **11** and **12**.

The perforated plate **462** will preferably be located in the space or room which is supplied with air by the air-mixing control unit of which the wall **400** is a part. That air-mixing control unit will draw some of the return air from that space or room through the perforations of that plate, through the air conduit **404**, past the temperature-sensitive device **452**, through the center of the annular plate **434**, through the openings **444** of the circular plate **440**, and then through the opening in the wall **400**. That air will cause the expandible material within that temperature-sensitive device to assume a volume comparable to that temperature.

To adjust the set point of the temperature-sensitive device **452**, the maintenance man will rotate the knob **470**, and will thereby change the pressure on the liquid within the transducer **468**, within the tube **458**, and within the expandible annulus **438**. If that maintenance man rotates the knob **470** in a direction which reduces the pressure within the expandible annulus **438**, the spring clips **443** will reduce the thickness of that expandible annulus by shifting the circular plate **440** to the left; and thus will shift the sleeve **446**, the nut **450**, the temperature-sensitive device **452**, the spring **426** and the rod **424** to the left. That shift will cause the perforated plates or movable dampers within the air-mixing control unit to increase the proportion of warm air which that air-mixing control unit will supply to the space or room. Consequently, the average temperature of the air within that space or room will increase.

As the temperature of the air within that space or room increases, the temperature of the air flowing through the air conduit **404** will increase correspondingly. The expandible fluid within the temperature-sensitive device **452** will respond to that increase in temperature to experience an increase in the volume thereof; and hence the actuator **456** will shift to the right in FIG. **19**. However, the shifting of that actuator to the left, in response to the reduction in thickness of the expandible annulus **438**, will be greater than the shifting of that actuator to the right, in response to the increase in the temperature of the air in the air conduit **404**. As a result, the set point of the temperature-sensitive device **452** will have been raised; and hence the average value of the temperature of the air within the space or room will have been increased.

If the maintenance man rotates the knob **470** in a direction which increases the pressure within the expandible annulus **438**, the thickness of that expandible annulus will increase — with a consequent shift of circular plate **440**, sleeve **446**, nut **450**, the temperature-sensitive device **452**, spring **426** and rod **424** to the right. That shift will cause the perforated plates or movable dampers within the air-mixing control unit to decrease the proportion of warm air which that air-mixing control unit will supply to the space or room. Consequently, the average temperature of the air within that space or room will decrease.

As the temperature of the air within that space or room decreases, the temperature of the air flowing through the air conduit **404** will decrease correspondingly. The expandible material within the temperature-sensitive device **452** will respond to that decrease in temperature to experience a decrease in the volume thereof; and hence the actuator **456** will shift to the left in FIG. **19.** However, the shifting of that actuator to the right, in response to the increase in thickness of the expandible annulus **438**, will be greater than the shifting of that actuator to the left, in response to the decrease in the temperature of the air in the air conduit **404.** As a result, the set point of the temperature-sensitive device **452** will have been lowered; and hence the average value of the temperature of the air within the space or room will have been decreased.

Once the set point of the temperature-sensitive device **452** has been set, that temperature-sensitive device will automatically operate to maintain a corresponding average temperature within the space or room — in the manner described hereinbefore in connection with FIG. **18.** It thus should be apparent that by using the structure in FIG. **19,** it is easy to adjust the set point of the temperature-sensitive device **452** from a point within the space or room. This is important because that temperature-sensitive device is essentially inaccessible from that space or room.

FIG. **20** shows a remote control arrangement which is specifically different from the remote-control arrangement of either of FIGS. **18** and **19,** although some of the components thereof are identically numbered and can be identical. The external thread **454** of a temperature-sensitive device **452** is mounted within the internal thread **412** of a cup-like bracket **410,** and that cup-shaped bracket has a slot **459** therein which accommodates the inlet fitting of a hydraulic cylinder **472** that has a piston **474.** That hydraulic cylinder is dimensioned so it can slide freely within the cup-like bracket **410**; and the actuator **456** of the temperature-sensitive device **452** bears against the closed end of that hydraulic cylinder, while the piston **474** bears against the head of the rod **424.** The air-mixing control unit, of which the wall **400** is a part, will draw air through the air conduit **404,** past the temperature-sensitive device **452,** and past the strut **406** through the opening in the wall **400.** The temperature of that air will cause the expandible-material within that temperature-sensitive device to assume a volume which is comparable to that temperature.

The spring **426** urges the head of the rod **424** against the piston **474** of the hydraulic cylinder **472,** and thereby urges the left-hand end of that hydraulic cylinder against the actuator **456** of the temperature-sensitive device **452.** To adjust the set point of that temperature-sensitive device, the maintenance men will rotate the knob of a pressure transducer, such as the pressure transducer **468** in FIG. **19,** to change the pressure on the hydraulic liquid within the hydraulic cylinder **472.** If that knob is rotated to reduce the pressure on that hydraulic liquid, the spring **426** will be able to force the piston **474** further into the hydraulic cylinder **472** and will thereby be able to shift the rod **424** further to the left — with a consequent increase in the set point of the temperature-sensitive device **452.** On the other hand, if the knob of the pressure transducer is rotated to increase the pressure on the hydraulic fluid within the hydraulic cylinder **472,** the piston **474** will force the spring **426** to yield and permit the rod **424** to shift to the right — with a consequent decrease in the set point of the temperature-sensitive device **452.** In this way, the set point of that temperature-sensitive device can be set at any desired level by merely rotating the knob of the transducer.

When the set point of the temperature-sensitive device **452** is being increased, the temperature of the air flowing through the air conduit **404** will increase; and that temperature-sensitive device will tend to shift the rod **424** to a position wherein the proportion of warm air will be reduced. Conversely, as that set point is being decreased, the temperature of the air flowing through the air conduit **404** will decrease; and that temperature-sensitive device will tend to permit the spring **426** to shift the rod **424** to a position wherein the proportion of warm air will be increased. However, because the movement of the piston **474** can be much greater than temperature-induced movement of the actuator **456,** the change in the set point of the temperature-sensitive device **452** will be essentially controlled by the movement of that piston rather than by the temperature-induced movement of the actuator **456.**

Once the set point of the temperature-sensitive device **452** in FIG. **20** has been set, that temperature-sensitive device will automatically operate to maintain a corresponding average temperature within the space or room — in the manner described hereinbefore in connection with FIG. **18.** It thus should be apparent that by using the structure in FIG. **20** it is easy to adjust the set point of the temperature-sensitive device **452** from a point within the space or room. This is important because that temperature-sensitive device is essentially inaccessible from that space or room.

FIG. **21** shows a remote control arrangement which is specifically different from the remote-control arrangements of FIGS. **18–20,** although some of the components thereof are identically numbered and can be identical. The external thread **454** of a temperature-sensitive device **452** is mounted within the internal thread **412** of a cup-like bracket **410,** and that cup-shaped bracket has a long slot **477** in the bottom thereof which accommodates the crank arm **482** of generally-elliptical cam **480.** A bearing element **476,** which is generally cylindrical in form but which has a frusto-conical right-hand end, is slidably interposed between the actuator **456** of the temperature-sensitive device **452** and the cam **480.** A bearing element **478,** which is generally cylindrical in form but which has a frusto-conical left-hand end and a reduced diameter cylindrical right-hand end, is slidably interposed between the cam **480** and the head of the rod **424.** A flexible cable **484** has the right-hand end of the reciprocable center element thereof connected to the crank arm **482**; and it will have the left-hand end of that center element suitably connected to a lever, knob or dial, not shown. A bracket **486** holds the sheath of that flexible cable against shifting relative to the crank arm **482.**

The spring **426** will urge the head of the rod **424** against the right-hand face of the bearing element **478,** will urge the left-hand face of that bearing element into engagement with the cam **480,** will urge that cam into engagement with the right-hand face of the bearing element **476,** and will urge the left-hand face of that bearing element into engagement with the actuator **456.** Whenever the crank arm **482** is in the solid-line position of FIG. **21,** the rod **424** will be in a position where only a limited proportion of warm air will be supplied to the space or room by the air-mixing control unit of which the wall **400** is a part. However, whenever that crank arm is in the dotted-line position in FIG. **21,** the rod **424** will be spaced to the left of the position shown in that FIGURE, and it will permit a large proportion of warm air to be introduced into that space or room. As a result, by appropriate manipulation of the lever, knob or dial which is connected to the left-hand end of the reciprocable inner element of the cable **484**, a maintenance man can set any desired set point for the temperature-sensitive device **452**.

When the set point of the temperature-sensitive device **452** is being increased, the temperature of the air flowing through the air conduit **404** will increase; and that temperature sensitive device will tend to shift the rod **424** to a position wherein the proportion of warm air will be reduced. Conversely, as that set point is being decreased, the temperature of the air flowing through the air conduit **404** will decrease; and that temperature-sensitive device will tend to permit the spring **426** to shift the rod **424** to a position wherein the proportion of warm air will be increased. However, because the movement of the cam **480** can be much greater than temperature-induced movement of the actuator **456**, the change in set point of the temperature-sensitive device **452** will be essentially controlled by the movement of that cam rather than by the temperature-induced movement of the actuator **456**.

Once that set point has been set, that temperature-sensitive device will automatically operate to maintain a corresponding average temperature within the space or room. If the temperature of the air within the space or room tends to fall below that average temperature, the temperature of the air flowing through the air conduit **404** will decrease; and the resulting reduction in volume of the expandible material within the temperature-sensitive device **452** will permit the actuator **456** to move to the left. The spring **426** will then shift rod **424**, bearing element **478**, cam **480** and bearing element **476** to the left — with a consequent increase in the proportion of warm air introduced into the space or room by the air-mixing control unit. The overall result is that the temperature of the air within the space or room will move back up to the desired level, and the actuator **456** and rod **424** will return to their set positions. Conversely, if the temperature of the air within the space or room tends to rise above the average temperature, the temperature of the air flowing through the air conduit **404** will increase; and the resulting increase in volume of the expandible material within the temperature-sensitive device **452** will cause the actuator **456** to shift to the right. The spring **426** will yield to permit a corresponding shift of bearing element **476**, cam **480**, bearing element **478** and rod **424** to the right — with a consequent decrease in the proportion of warm air supplied to the space or room by the air-mixing control unit. The overall result is that the temperature of the air within the space or room will move back down to the desired level, and the actuator **456** and rod **424** will return to their set positions.

It thus should be apparent that by using the structure in FIG. **21**, it is easy to adjust the set point of the temperature-sensitive device **452** from a point within the space or room. This is important, because that temperature-sensitive device is essentially inaccessible from that space or room.

FIGS. **22** and **23** show a remote control arrangement which is specifically different from the remote-control arrangement of each of FIGS. **18–21**, although some of the components thereof are identically numbered and can be identical. The circular plate **440** differs from the similarly-numbered plate in FIG. **19** in having inclined planes **490**, rather than an expandible annulus, secured to the left-hand face thereof. Those inclined planes engage inclined planes **492** which are part of a frame that includes vertically-directed spacers **493**. That frame is confined and guided on the left by the fixed annular plate **434**, and it is confined and guided on the right by the inclined planes **490**. Helical extension springs **496** bias that frame upwardly toward the top of the housing **402**.

The numeral **498** denotes a nut which is fixedly secured to the upper surface of the housing **402**; and that nut surrounds an opening in that upper surface. That nut receives the external thread on a temperature-sensitive device **500** such as a Vernatherm unit. A heating coil **502** is mounted in heat-exchanging relation with the temperature-sensitive device **500**; and conductors **508** extend between that heating coil and an adjustable power source, not shown, which is mounted behind a control panel **504** and which is controlled by a knob **506**. While various forms of adjustable power sources could be used to control the amount of current flowing through the heating coil **502**, one of the standard light dimmers, which are mounted in electrical outlet boxes to control the lights within rooms in residences, could be used. Also, if desired, a silicon controlled rectifier and a firing circuit therefor could be used to vary the amount of power supplied to the heating coil **502**.

The spring clips **443** will urge the circular plate **440** to the left in FIG. **22**, and thus will cause the inclined planes **490** to apply upwardly-directed forces to the inclined planes **492**. In addition, the springs **496** will apply upwardly-directed forces to the inclined planes **492**. However, the actuator of the temperature-sensitive device **500** overlies and bears against the uppermost inclined plane **492**, and thereby limits the extent to which those inclined planes can move upwardly. As the inclined planes **490** respond to the forces from the spring clips **443** to apply upwardly-directed forces to the inclined planes **492**, the latter inclined planes will apply downwardly-directed forces to the inclined planes **490**, and thus to the circular plate **440**. The rod **424** will resist those downwardly-directed forces; but, if desired, anti-friction skids or rollers could be provided at the lower edge of the lower inclined plane **490** to keep those inclined planes from shifting downwardly from the position shown in FIGS. **22** and **23**.

To adjust the set point of the temperature-sensitive device **452** in FIGS. **22** and **23**, the maintenance man will shift the knob **506** to a desired position. Specifically, to raise the set point of that temperature-sensitive device, the maintenance man will shift the knob **506** to a position wherein less current will flow through the heating coil **402**. Thereupon, the volume of the expandible material within the temperature-sensitive device **500** will decrease; and the springs **496** will move the inclined planes **492** and the actuator of the latter temperature-sensitive device upwardly. The spring clips **443** then will shift the inclined planes **490** and the circular plate **440** to the left; and the resulting shift of the rod **424** to the left will increase the proportion of warm air which the air-mixing control unit, of which the wall **400** is a part, will introduce into the space or room. The consequent increase in the temperature of the air flowing into the housing **402** from the air conduit **404** will cause the expandible material within the temperature-sensitive device **452** to expand, and to act through the actuator of that temperature-sensitive device to shift the rod **424** to the right. However, the change in the temperature of the expandible material within the temperature-sensitive device **500** will be so much greater than the change in the temperature of the material within the temperature-sensitive device **452** that the new set point of the latter temperature-sensitive device will provide an increase in the proportion of warm air introduced into the space or room.

Conversely, to lower the set point of the temperature-sensitive device **452** in FIG. 22 and 23, the maintenance man will shift the knob **506** to a position wherein more current will flow through the heating coil **502.** The resulting increase in volume of the expandible material within the temperature-sensitive device **500** will force the actuator of that temperature-sensitive device and the inclined planes **492** to move downwardly. The consequent shift of the inclined planes **490** to the right will cause the sleeve **446** to shift the rod **424** to the right, and thereby move the perforated plates or movable dampers of the air-mixing control unit to reduce the proportion of warm air introduced into the space or room. The resulting reduction in the temperature of the air flowing through the air conduit **404** will permit the expandible material within the temperature-sensitive device **452** to contract; and the helical compression spring **426** within the sleeve **446** will shift the rod **424** to the left. However, the change in the temperature of the expandible-material within the temperature-sensitive device **500** will be so much greater than the change in the temperature of the expandible material within the temperature-sensitive device **452** that the new set point of the temperature-sensitive device **452** will provide a decrease in the proportion of warm air introduced into the space or room.

FIG. **24** shows the temperature-sensitive device **414** of FIG. **18** equipped with a heating coil **502** rather than with the flexible cable **418.** Conductors **508** extend from that heating coil to a variable-power source, not shown, such as that which is controlled by the knob **506** in FIG. **22.** To adjust the set point of the temperature-sensitive device **414** in FIG. **24,** the maintenance man will actuate that variable-power source to change the amount of current flowing through the heating coil **502.**

If the maintenance man actuates the variable-power source to decrease the current flowing through the heating coil **502** in FIG. **24,** the volume of the expandible material within the temperature-sensitive device **414** will decrease; and the spring **426** will shift the rod **424** and the actuator **417** to the left -- with a consequent increase in the proportion of warm air introduced into the space or room by the air-mixing control unit of which the wall **400** is a part. As a result, the set point of that temperature-sensitive device will have been raised. However, if the maintenance man actuates the variable-power source to increase the current flowing through the heating coil **502** in FIG. **24,** the resulting increase in the volume of the expandible material within that temperature-sensitive device will shift the actuator **417** and the rod **424** to the right — with a consequent decrease in the proportion of warm air introduced into the space or room. As a result, the set point of that temperature-sensitive device will have been lowered.

When the set point of the temperature-sensitive device **414** is being increased, the temperature of the air flowing through the air conduit **404** will increase; and that temperature-sensitive device will tend to shift the rod **424** to a position wherein the proportion of warm air will be reduced. Conversely, as that set point is being decreased, the temperature of the air flowing through the air conduit **404** will decrease, and that temperature-sensitive device will tend to permit the spring **426** to permit the spring **426** to shift the rod **424** to a position wherein the proportion increased. in the temperature of the expandible material within the temperature-sensitive device **414,** due to the change in current flow through the heating coil **502,** will be so much greater than the change in that expandible material due to changes in temperature of the air flowing through air conduit **404,** the set point of the temperature sensitive device **414** will be essentially controlled by the heat from the heating coil **502.**

Once the desired set point has been established for the temperature-sensitive device **414** in FIG. 24, that temperature sensitive device will respond to the temperature of the air flowing through the air conduit **404** to appropriately adjust the position of the rod **424.** As a result, that temperature-sensitive device will be able to maintain the desired temperature level within the space or room.

FIG. **25** shows a temperature-sensitive device **510** disposed within a cup-like bracket **410** in lieu of the hydraulic cylinder **472** of FIG. **20** or of the rotatable cam **480** and the bearing elements **476** and **478** of FIG. **21.** The actuator **512** of the temperature-sensitive device **510** is aligned with, and abuts, the actuator **456** of a temperature-sensitive device **452** which has the external thread **454** thereof mounted within an internal thread at the left-hand end of that cup-shaped bracket. The helical compression spring **426** within the cup-shaped bracket **410** urges the head of the rod **424** against the housing of the temperature-sensitive device **510** and thereby urges the actuator **512** of that temperature-sensitive device into abutting engagement with the actuator **456** of the temperature-sensitive device **454.** A heating coil **502** is wound around the housing of the temperature sensitive device **510**; and conductors **508** extend to a variable power source such as the variable-power source controlled by the knob **506** in FIG. **22.**

If a maintenance man adjusts the variable power-source to decrease the current flowing through the heating coil **502** in FIG. **25,** the volume of the expandible material within the temperature-sensitive device **510** will decrease; and the spring **426** will shift the rod **424** and the housing and actuator of that temperature-sensitive device and the actuator of temperature-sensitive device **452** to the left. Such a shift will increase the proportion of warm air introduced into the space or room by the air-mixing control unit of which the wall **400** is a part. As a result, the set point of the temperature-sensitive device **452** will have been raised. However, if the maintainance man actuates the variable-power source to increase the current flowing through the heating coil **502** in FIG. **25,** the resulting increase in the volume of the expandible material within that temperature-sensitive device will shift the actuator **456** and the actuator and housing of that temperature-sensitive device to the right. That shift will decrease the proportion of warm air introduced into the space or room. As a result, the set point of the temperature-sensitive device **452** will have been lowered.

When the set point of the temperature-sensitive device **452** in FIG. **25** is being increased, the temperature of the air flowing through the air conduit **404** will increase; and that temperature-sensitive device will tend to shift the rod **424** to a position wherein the proportion of warm air will be reduced. Conversely, as that set point is being decreased, the temperature of the air flowing through the air conduit **404** will decrease; and that temperature-sensitive device will tend to permit the spring **426** to shift the rod **424** to a position wherein the proportion of warm air will be increased. However, because the change in the temperature of the expandible material within the temperature-sensitive device **510** will be so much greater than the change in the temperature of the expandible material within the temperature-sensitive device **452**, the new set point of the latter temperature-sensitive device will be essentially controlled by the adjustment of the amount of current flowing through the heating coil **502**.

The embodiments of FIGS. **13** and **18–25** are particularly desirable. Those embodiments enable Vernatherm units to be used to control the settings of the perforated plates or adjustable dampers of air-mixing control units, and yet permit the set points of those Vernatherm units to be readily adjusted — even though those Vernatherm units are essentially inaccessible from the spaces or rooms where the control levers, knobs, or dials are located.

Whereas the present specification has been described in considerable detail with respect to several embodiments, it is to be understood that this description is merely for the purposes of illustration and that changes or variations in the described embodiments may be made by persons skilled in the art without departing from the scope of the invention as defined in the appended claims.

What I claim is:

1. A system for controlling the temperature within a conditioned space which comprises an air-handling control unit that is connected to said conditioned space to supply air to said conditioned space, means within said air-handling control unit to create a pressure in said air-handling control unit which is less than the pressure within said conditioned space, an elongated sampling passage extending between and in communication with said conditioned space and said air-handling control unit so air can flow from said conditioned space through said sampling passage to said air-handling control unit, a temperature-sensitive device that has an adjustable set point, said temperature-sensitive device being located so it is not readily accessible from said conditioned space, said temperature-sensitive device being mounted adjacent the outlet end of said sampling passage so it is close to said air-handling control unit and so the air passing through said sampling passage directly engages said temperature-sensitive device, whereby said temperature-sensitive device can sense the temperature of said air which flows from said conditioned space through said sampling passage to said air-handling control unit, an adjusting means with a settable element which is settable to set said adjustable set point of said temperature-sensitive device, said adjusting means being mounted adjacent the inlet end of said sampling passage and thus being mounted so it is remote from said temperature-sensitive device, connecting means extending from said adjusting means to said temperature-sensitive device to enable the adjusting of said settable element of said adjusting means to adjust said adjustable set point of said temperature-sensitive device, and mechanical connecting means connecting said temperature-sensitive device to said air-handling control unit to enable changes in the temperature of said air which flows from said conditioned space through said sampling passage to said air-handling control unit to enable said temperature-sensitive device to cause said air-handling control unit to adjust the temperature of the air which it supplies to said conditioned space, said temperature-sensitive device being mounted adjacent said air-handling control unit so said mechanical connecting means can be short in length and thus can have a small mass, the first said connecting means being disposed within and extending through said sampling passage, whereby said sampling passage performs the dual functions of conducting air from said conditioned space to said temperature-sensitive device and of enclosing and protecting said first said connecting means.

2. A system as claimed in claim **1** wherein said means within said air-handling control unit is a motor-driven blower, wherein said sampling passage is connected to the suction side of said motor-driven blower, wherein said sampling passage is a small cross-section tube located within a wall of said conditioned space, and wherein said mechanical connecting means includes a push-pull linkage.

3. A system as claimed in claim **1** wherein a portion of said mechanical connecting means provides said adjustable set point for said temperature-sensitive device, and wherein said portion of said mechanical connecting means responds to a change in the setting of said settable element of said adjusting means to change the effective distance between said temperature-sensitive device and said air-handling control unit and thereby change said adjustable set point for said temperature-sensitive device.

4. A system as claimed in claim **1** wherein a portion of said mechanical connecting means provides said adjustable set point for said temperature-sensitive device, wherein said portion of said mechanical connecting means includes a hydraulic cylinder and the piston thereof, and wherein said hydraulic cylinder and the piston thereof respond to a change in the setting of said settable element of said adjusting means to change the effective distance between said temperature-sensitive device and said air-handling control unit and thereby change said adjustable set point for said temperature-sensitive device.

5. A system as claimed in claim **1** wherein a portion of said mechanical connecting means provides said adjustable set point for said temperature-sensitive device, wherein said portion of said mechanical connecting means includes a cam that is movable to vary the effective distance between said temperature-sensitive device and said air-handling control unit, wherein an actuator for said cam is movable by said settable element of said adjusting means, and wherein said cam and actuator therefor respond to a change in the setting of said settable element of said adjusting means to change the effective distance between said temperature-sensitive device and said air-handling control unit and thereby change said adjustable set point for said temperature-sensitive device.

6. A system as claimed in claim **1** wherein a portion of said mechanical connecting means provides said adjustable set point for said temperature-sensitive device, wherein said portion of said mechanical connecting means includes a second temperature-sensitive device and a heating coil in heat-transferring relation with said second temperature-sensitive device, wherein adjusting of said settable element of said adjusting means will change the value of the current flowing to said heat coil, and wherein said heat coil responds to a change in the setting of said settable element of said adjusting means to change the amount of heat supplied to said second temperature-sensitive device and thereby enable said said second temperature-sensitive device to change the effective distance between the first said temperature-sensitive device and said air-handling control unit with a consequent change in said adjustable set point for said first said temperature-sensitive device.

7. A system as claimed in claim **1** wherein an expandible element helps provide said adjustable set point for said temperature-sensitive device, wherein said expandible member is expandible to effect movement of said temperature-sensitive device in one direction relative to said air-handling control unit, wherein said expandible element is contractible to effect movement of said temperature-sensitive device in the opposite direction relative to said air-handling control unit, and wherein said expandible member responds to shifting of said settable element of said adjusting means in one direction to expand and responds to shifting of said settable element of said adjusting means in the opposite direction to contract.

8. A system as claimed in claim **1** wherein a second temperature-sensitive element and a heat coil help provide said adjustable set point for said temperature-sensitive device, wherein said heating coil is in heat-transferring relation with said second temperature-sensitive device, wherein a change in the current flowing through said heating coil will enable said second temperature-sensitive device to change the effective distance between the first said temperature-sensitive device and said air-handling control unit and thereby change said adjustable set point for said first said temperature-sensitive device, and wherein a change in the setting of said settable element of said adjusting means will change the amount of current flowing through said heating coil.

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