

March 1, 1938.

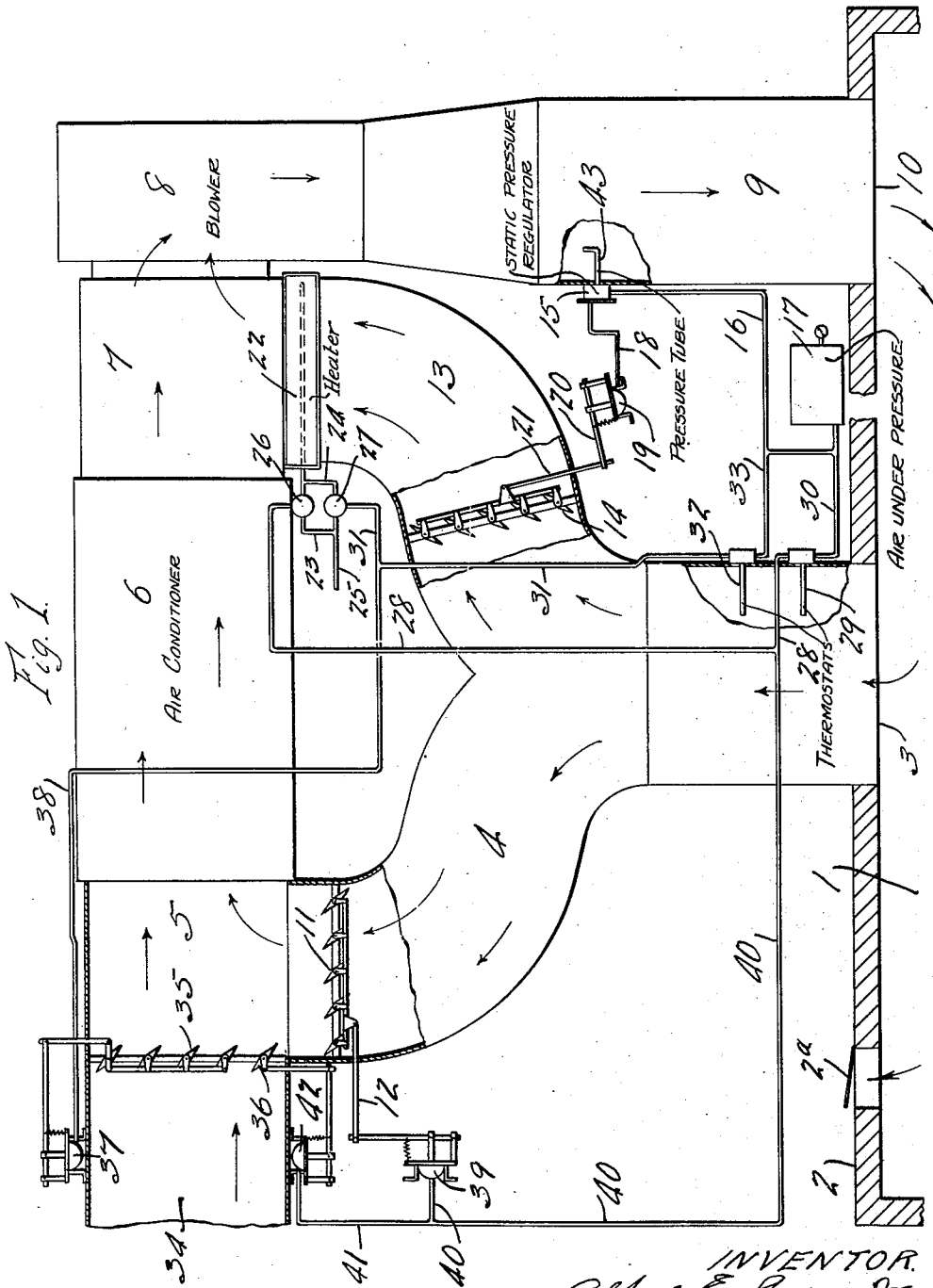
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2,109,512

CIRCULATION SYSTEM

Filed March 16, 1929

2 Sheets-Sheet 1



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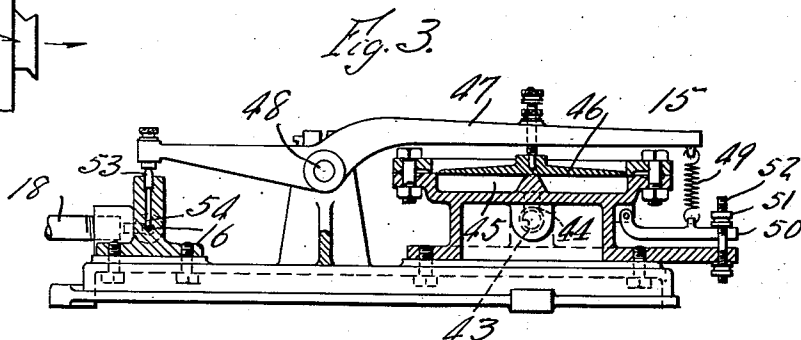
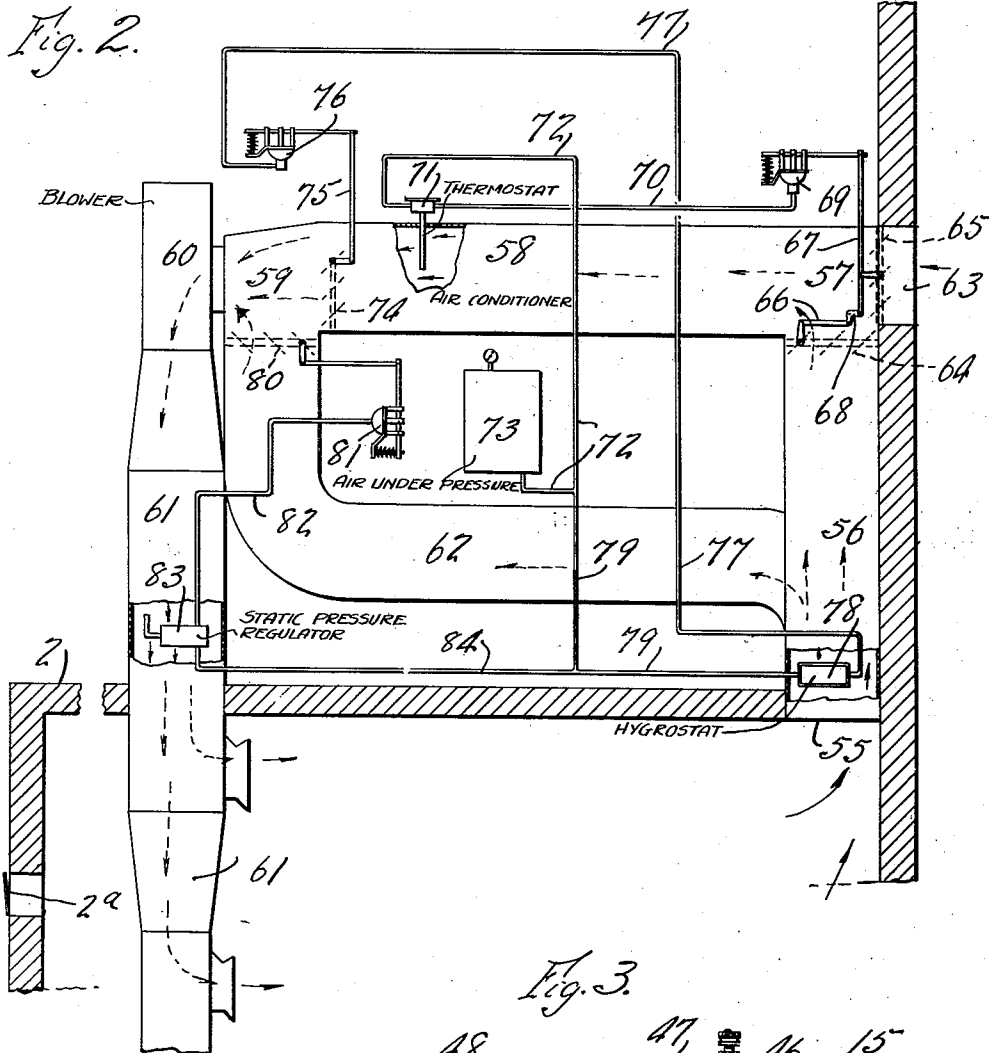
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CIRCULATION SYSTEM

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,109,512

CIRCULATION SYSTEM

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Application March 16, 1929, Serial No. 347,713

26 Claims. (Cl. 237—2)

This invention relates to fluid circulation systems, and particularly to means for, and methods of, supplying air or other gaseous fluids having desired characteristics to, and circulating it in, an enclosure.

An object of the invention is to provide an improved method and apparatus for creating and maintaining desired fluid conditions in an enclosure.

Other objects of the invention are to provide an improved system, with which desired atmospheric conditions in an enclosure may be obtained and maintained; also to provide an improved circulation system for enclosures, with which desired conditions in the enclosure may be created or maintained automatically, and with which uniform circulation in the enclosure may be obtained whether the desired conditions are variable or constant.

A further object of the invention is to provide an improved air or gas circulation system for enclosures; with which gaseous or atmospheric conditions in the enclosure may be changed or modified automatically or at will; with which a constant volume of gas will be supplied to the enclosure under all conditions, independently of any variations in its conditions; with which the maintenance of a constant supply of gas to the enclosure may be maintained automatically; with which the gas distribution in the enclosure may be maintained in a uniform and balanced condition under all operating conditions; with which desired conditions in the enclosure may be easily, economically and rapidly obtained at any time; and which will be relatively simple, practical, economical, efficient and inexpensive.

Various other objects and advantages will appear from the following description of an embodiment of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

In the accompanying drawings:—

Fig. 1 is a schematic diagram of a system embodying this invention;

Fig. 2 is a similar diagram illustrating a modified embodiment of the invention; and

Fig. 3 is a sectional elevation of one form of static pressure regulator which may be utilized as a part of either of the illustrated embodiments of the invention.

The invention is particularly valuable in connection with the circulation of a gaseous fluid through a chamber or enclosure, such as an auditorium or a treating room, and by way of example, the invention will be illustrated and de-

scribed as it may be applied to auditoriums through which a gaseous fluid, such as air or other gaseous fluid, is circulated. The invention is not, in its broader aspects, limited to auditoriums, but has many other commercial applications in which gaseous fluids other than air or with air may be circulated, such as in curing or treating rooms for tobacco and other products.

In the embodiment of the invention illustrated in Fig. 1, the chamber or enclosure 1 having the enclosing walls 2 may be of any suitable size and character where people may congregate. In this illustrated system, in which air is the fluid medium circulated through the enclosure, the air is withdrawn from one part of the enclosure through an opening 3 and conveyed by a conduit or duct 4 to a mixing chamber 5.

The chamber 5 communicates with one end of a suitable conditioner or device 6 for modifying or changing the characteristics of the air, such as a humidifier, dehumidifier, or other modifying or conditioning device, and this modifying device communicates through a chamber 7 with the intake side of a suitable circulating device 8, such as a fan or blower. The circulating device in turn communicates, such as by a duct or conduit 9, with another part of the enclosure, the air or fluid delivered by the conduit or duct 9 being discharged as a stream into the enclosure through the opening 10. Thus the fan or circulating device 8 is adapted to draw air or other gaseous fluid from the enclosure through the conditioning device 6, and then return it to the enclosure so as to cause a circulation of the air through the enclosure.

The amount of air drawn from the enclosure and through the conditioning device 6 may be variably controlled by any suitable regulating device 11, such as a damper illustrated conventionally on the drawings, operated by a suitable handle or member 12 extending exteriorly of the duct. The regulating damper 11 may be operated through various intermediate positions to open or closed positions in order to vary the amount of withdrawn air which will be treated by the conditioning device 6 in obtaining or maintaining a particular desired atmospheric condition in the enclosure. Because of this regulation, the quantity of air passing through the conditioning device and delivered by the fan 8 to the enclosure 1 will be variable, and consequently, if no correction is made, the circulation through the enclosure will vary.

This variation in the amount of air delivered to the enclosure will be, in many cases, very un-

desirable, because the air circulation or distribution currents in the enclosure would be unbalanced. For example, in a theatre or other auditorium, the duct system is designed to deliver air to the auditorium at a uniform rate, and the inlet and outlet of the duct system are so arranged in the enclosure that the desired distribution or circulation in the enclosure is obtained. If the volume of air delivered is changed, the distribution and balance of the air currents will be changed, and an undesired and different air circulation in the enclosure will result.

If the original design was made to obtain a circulation which would not cause discomfort to the occupants, a change in this circulation might produce drafts, or cause untempered air to strike the occupants, either of which would be objectionable. It is therefore important that while the air in the enclosure be given certain characteristics, such as to temperature and humidity, nevertheless the volume of air delivered by the duct system must be maintained constant if the desired circulation in the enclosure is to be effective and unobjectionable.

For such reasons a branch duct 13 may be provided between the duct 4 and the chamber 7, or other suitable provision made, so as to by-pass the control damper 11, the chamber 5 and the modifying device 6, and thus some of the air withdrawn from the enclosure may be by-passed directly to the chamber 7 where it will meet the other stream of air coming through the conditioning device, mix therewith, and be delivered to the enclosure by the fan 8 and duct 9.

The branch duct or by-pass 13 may also be provided with a suitable circulation controlling device 14 for regulating the air or fluid flow therethrough. When the amount of air sent through the conditioning device 6 is changed, the regulating device 14 may be operated to change inversely the amount of air which is by-passed, so that the quantity of air delivered by the fan 8 to the enclosure 1 may be maintained constant through all variations in the operation of the conditioning device.

It is desirable, especially where the damper or regulating device 11 is operated automatically, that the other regulating device 14 be automatically varied in order that there will be no material change or interruption in the uniformity of the quantity of air delivered to the enclosure by the circulating system. Accordingly, a static pressure regulator 15 may be arranged at a suitable point in the air circulating system, such as in the inlet connection to the fan or in the delivery duct 9, and this regulator is suitably connected to the damper device 14 in a manner to open or increase the opening of the damper device 14 when the pressure in the duct 9 falls, and to close or reduce the opening of the damper device and decrease the amount of by-passed air or fluid when the pressure in the delivery duct 9 increases.

This regulator 15 may be of the pneumatically operated type, in which case compressed air may be supplied thereto by a pipe 16 which leads from any suitable source of compressed air 17. A delivery pipe 18 leads from the regulator 15 to a suitable air motor 19 which operates, by air under pressure from pipe 16, the dampers of the regulating device 14 toward open position when the air pressure in the duct 9 falls, and toward closed position when the air pressure in the duct 9 increases.

In systems, such as used for theatres or auditoriums, where it is desirable to add some heat

to the circulating air, a heater 22 may be arranged at some suitable point in the air circulating system, as for instance in the by-passing duct 13. This heater may be of the steam coil type, and steam is admitted to the coils through branch pipes 23 and 24 leading from the steam supply pipe 25. The branch pipe 23 is provided with a controlling valve 26 which may be of the pneumatic reverse-acting type, which opens by pressure, and having a capacity to cause a small temperature rise in the air through the heater, such as a 5° rise, for example. The other branch pipe 24 is controlled by a suitable valve 27 which may be of the direct acting type, which closes by pressure, and having a larger capacity for steam, such, for example, as a capacity to cause a 15° rise in the temperature of the air passing through the heater.

The valve 26 is supplied with an operating fluid under pressure by a pipe 28 leading from a thermostat 29 disposed in a position where it is responsive to the temperature conditions in the enclosure. For example, the thermostat 29 may be disposed in the duct 4 through which air is withdrawn from the enclosure.

The thermostat 29 may be supplied with an operating fluid, such as air under pressure, through a pipe 30 also leading from the compressed air supply 17. The thermostat 29 may also be of the reverse-acting type which permits the passage of compressed air therethrough to the steam valve 26 to hold the valve open until the temperature in the enclosure reaches the predetermined temperature for which the thermostat is set and then shuts off the air to cause the steam valve to close. The direct-acting valve 27 is closed by compressed air supplied thereto by a pipe 31 leading to a direct acting thermostat 32 which also is placed in a position in which it is responsive to the temperature of the air in the enclosure, such as in the withdrawn air duct 4.

The compressed air is supplied to this direct acting thermostat 32 through a pipe 33 leading to the pipe 16 and the source of compressed air 17. The direct acting thermostat 32 permits the passage of air therethrough to close the valve 27 only when the temperature of the air to which that thermostat responds exceeds the predetermined temperature for which the thermostat is set. With this arrangement the heater will be operated automatically to bring the air in the enclosure to a desired temperature by heating the by-passed air throughout all the variations in the quantity of air circulated through the modifying device 6.

In many instances, such as in theatre or auditorium installations, and also in some other commercial applications of the invention, it is desirable to admit to the enclosure some fresh or outside air, that is, air from a source other than that of the enclosure, and for that purpose a fresh or outside air duct 34 may be provided for admitting this outside air to the stream of air which is delivered into the enclosure. In such a case, a suitable relief opening 2a may be provided so that air may be displaced from the enclosure in an amount equal to the quantity of outside air which is admitted to the enclosure.

The outside air duct 34 may, for convenience, be connected to the chamber 5, so that this outside air will pass through the conditioning device 6, and a suitable damper or other regulating device 35 may be provided in the duct 34 for regulating the amount of outside air which is admitted. Where it is desired to admit a minimum

amount of fresh or outside air to the enclosure, as in theatre installations, a second damper device 36 may be arranged across the duct 34 for operation independently of the damper 35, so that when the damper 35 is closed, the damper 36 may be opened to permit the passage of a minimum quantity of outside air through the duct 34 into the chamber 5.

The damper 35 may be controlled or operated by a suitable motor or other operating device 37. The motor 37 may be of the air pressure operated type and supplied with compressed air through a pipe 38 leading thereto from the pipe 31 and thermostat 32, so as to open damper 35 in response to air pressure in pipe 38 when the temperature of the room air is above a selected temperature for which thermostat 32 is set. The damper or controlling device 11 may be operated through its actuating handle or member 12 by a suitable motor 39, which may be of the air operated type and supplied with compressed air through a pipe 40 leading thereto from the pipe 28 and thermostat 29, so as to close damper 11 in response to air pressure in pipe 40 which is passed by thermostat 29 until the temperature of the room air exceeds a selected temperature for which the thermostat 29 is set. A branch pipe 41 leads from the pipe 40 to an air motor 42 which is connected to and operates the minimum supply damper 36 into open position by air pressure in pipe 40 whenever motor 39 closes damper 11.

The static pressure regulator 15 may be of any suitable type, but by way of example, a suitable type is illustrated diagrammatically in Fig. 1 and in more detail in Fig. 3. Such a regulator is provided with a Pitot tube 43 which extends into the interior of the inlet connection to the fan 8 or the duct 9, and in this particular example, it opens towards the fan 8, so that the pressure in the tube 43 will be increased with an increase in the volume of air delivered by the fan and duct 9.

The Pitot tube 43 is connected by a passage 44 (see Fig. 3) to a chamber 45 having a movable wall or diaphragm 46 that operates a lever 47 about a pivot 48 and against the tension of a spring 49. The spring 49 is connected to a lever 50 which may be adjusted to vary the tension of the spring by the action of a nut 51 engaging with the lever 50 and threaded upon a suitable rod 52.

The opposite end of the lever 47 is adapted to open and close a suitable bleeder port 53, so that when the bleeder port is open, the compressed air entering the communicating chamber 54 from the pipe 16 will escape instead of passing into the pipe 18 leading to the operating motor 19 for the damper 14. Any compressed air in the pipe 18 may also escape when the bleed port is opened. If, however, the bleed port is closed by the lever 47, which occurs when pressure in the Pitot tube 43 is increased, the escape of the compressed air entering from pipe 16 will be prevented and the compressed air will pass through pipe 18 to the motor 19 to cause an operation of the latter in a direction to close the damper 14.

When the pressure in the duct 9 falls, the pressure in the tube 43 will decrease, and consequently the pressure in chamber 45 will decrease. The spring 49 will thereupon operate the lever 47 in the opposite direction to uncover the port 53 which releases the air from the motor 19, and thereupon the damper 14 will be operated automatically towards open position by a suitable spring as usual in such air motors. By varia-

bly restricting the bleed port by greater or less movements of the lever 47, the motor 19 will operate the damper 14 through various intermediate positions or stages.

In the operation of a system, such as illustrated in Fig. 1, let it be assumed, for example, that the enclosure is an auditorium, and that the system is being started up just preceding a meeting or performance. Let it be also assumed that the temperature of the air in the enclosure is lower than that desired in the enclosure, and that the reverse acting thermostat 29 is set to operate at say 74° for example, and the direct acting thermostat 32 is set to operate at say 71° for example.

The fan 8 in operation will draw air from the enclosure through the duct 4 and this withdrawn air will pass either through the conditioning device 6 or through the by-pass duct 13 into the chamber 7. Since the temperature in the enclosure is below 71°, the compressed air from the source 17 will be passing through the reverse acting thermostat 29 to the reverse acting valve 26, so as to open the valve and hold it open, thereby admitting steam to the heater 22, and air will also be passing through the same reverse acting thermostat 29 and through the pipes 40 and 41 to the motors 39 and 42. The motor 39, when operated by pressure, closes the damper device 11 and the motor 42 when operated by pressure opens the minimum fresh air damper 36.

The compressed air from source 17 cannot pass through the direct acting thermostat 32, and therefore there will be no air pressure in the pipes 31 and 38. With no pressure in pipe 31, the steam valve 27, which shuts off by air pressure, will now be open and it also will admit steam to the heater 22. The motor 37 is of the type which operates its dampers into open position when air pressure is supplied to the motor, and therefore since there is now no air pressure on the motor, the motor will hold the damper device in closed position.

Therefore under these conditions no withdrawn air can pass through the duct 4 into the conditioner 6 and only the required minimum of outside air can enter the conditioner 6. This minimum of air, however, will pass through the conditioner 6 where its characteristics or condition will be changed, such as by being humidified or dehumidified, and its temperature changed for example, and will then pass to the fan 8 where it is transferred under pressure through the duct 9 to the chamber 1 of the enclosure. By the terms "characteristic" or "condition" I mean a distinguishing property or trait by which it is identified in distinction to a mere movement or position. For example, it includes temperature, humidity, composition, or other similar properties.

Since the air available to the intake side of the fan 8 is considerably restricted by the closed dampers 11 and 35, the pressure in the duct 9 will be relatively low and consequently the damper 14 will be opened automatically, thus permitting movement of the withdrawn air through the by-pass 13 into the chamber 7, where it meets any outside air coming from the conditioner 6 and the two together pass through the fan 8 and the duct 9 to the enclosure. The fan 8 thus delivers a full uniform quantity of air to the enclosure.

The by-passed air moving through the heater 22 will be heated and this heated air will raise the temperature of the mixture entering the fan 75

8, and then the tempered air will be delivered to the enclosure to raise the temperature of the air therein. This operation will continue and the temperature in the enclosure will rise until the temperature in the enclosure reaches the temperature at which the direct acting thermostat 32 is set to operate, such as 71° in the selected example. A change in operating conditions will then occur.

10 The direct acting thermostat 32 will now permit the passage of compressed air therethrough into the pipe 31 and 38. Compressed air entering the direct acting valve 27 will cause the latter to operate in a closing direction, and thus the steam entering the heater through branch 15 24 will be shut off, and only a small amount of steam will be admitted to the heater through the valve 26. The action of the heater 22 will thus be materially reduced so long as the temperature in the enclosure remains at or above say 71°.

The air pressure in pipe 38 will cause an operation of the motor 37 and through it an opening of the damper device 35 to increase the amount of outside air which enters the conditioner 6. With the system operating under these conditions, a greater amount of outside air will pass through the conditioner 6, and the increased pressure in the delivery duct 9 acting through the static pressure regulator 15 will cause a partial shutting off of the damper 14 which decreases the amount of withdrawn air which is by-passed through the duct 13, so that the volume of air delivered to the enclosure will continue to be the same. The by-passed air, however, will still be heated to some extent, and this operation will continue until the temperature in the enclosure either falls below 71° in which event the previously described conditions will be restored, or rises above say 74°.

40 When the rising temperature reaches say 74°, as selected for this particular example, no change occurs in thermostat 32, but the reverse acting thermostat 29 will operate to shut off the pipes 28 and 40 from the source 17 of compressed air. Thereupon the reverse acting valve 26, which closes upon a fall of the pressure, will close and the steam entering the heater from the branch 23 will be shut off, so that there will now be no steam entering the heater. The valves 26 and 27 will continue in closed position as the temperature in the enclosure remains the same or rises. The shutting off of the pressure from the pipe 40 will cause the operation of the motors 39 and 42.

The motor 39, which pressure operates to close the damper, will now automatically open the damper 11, and permit movement of withdrawn air through the duct 4 into and through the conditioner 6 and chamber 7 to the fan 8. The motor 42, which operates to open the minimum outside air damper 36 when pressure is supplied, will now be operated to close this damper 36, but outside air will continue to enter as permitted by the damper device 35.

65 Withdrawn air will now be circulated through duct 4 and mixed with outside air, the mixture passed through the conditioner 6, where the characteristics of the mixture will be changed, and then delivered by the fan 8 to the enclosure. The greater volume of air then reaching the fan 8 will cause an increase of pressure in the delivery duct 9, and thereupon the static pressure regulator 15 will cause a further closing of the damper 14 in a manner to cut down the amount of by-passed air sufficiently to cause the volume of air delivered

by the fan 8 and duct 9 to be kept constant and uniform.

When the temperature of the air in the enclosure falls, the operations just described will be reversed in a similar manner until the desired conditions in the enclosure are reached, and thereupon those conditions will be maintained automatically, with uniform circulation through the enclosure.

In the embodiment of the invention illustrated in Fig. 2, the chamber 1 with relief opening 2a may be of any size or shape, and similar to chamber 1 of Fig. 1. Air or other fluid from the chamber 1 may be withdrawn through an opening 55, communicating with a duct 56 leading to a chamber 57 and thence to one end of a fluid modifying or air conditioning device 58, such as a humidifier or dehumidifier, for example. The other end or outlet of the conditioner 58 is connected to a mixing chamber 59, which in turn communicates with the intake side of a suitable circulating device 60, which may be a fan or blower that delivers the air or fluid through a duct 61 into the enclosure.

A by-pass duct 62 functions similarly to the by-pass duct 13 in Fig. 1, and delivers the withdrawn air to the mixing chamber 59 at the intake side of the fan or blower 60. A fresh or outside air duct or opening 63 serves to admit outside air to the conditioner, the same as explained in connection with Fig. 1. A damper or shutter device 64 variably controls the passage of withdrawn air through the duct 56 into the conditioner 58, and a damper or shutter device 65 similarly controls the entrance of outside air through the duct 63.

In this particular example, the shutter devices or dampers 64 and 65 may be operatively connected to one another by suitable links 66 and 67, and a bell crank 68, for concomitant operation, the connection being such that the damper 64 closes when the damper 65 opens. The link 67 may be connected to a pressure operated motor 69, such as an air motor, and this motor may be supplied with compressed air by a pipe 70 controlled by a direct acting thermostat 71. The thermostat 71 is a standard dewpoint instrument and may control the temperature of saturation of the air passing thru the air conditioner. In a humidifying system, the air will saturate at the entering wet bulb temperature. The wet bulb temperature of the outside air, in this case, would be lower than that in the room, so that if the dewpoint increased beyond that point at which the thermostat 71 was set, air pressure on air motor 69 would tend to open damper 65 and close damper 64. In case of dehumidifying, this thermostat may control a three-way valve, admitting cold water from some source to the sprays or it may operate a reverse acting valve in a cold water supply line to the sprays. If it is a case of the use of centrifugal refrigeration, where the temperature of the spray water is controlled at the equipment, then thermostat 71 might act only as an anti-freezing device on dampers 65 and 68. In this case, the thermostat would close damper 65 and open 68, should the temperature in the air conditioner go below some predetermined point, such as 40°.

This thermostat 71 is supplied with compressed air by a pipe 72 leading to a source 73 of compressed air. The thermostat 71 may be disposed in or adjacent the outlet of the conditioning device 58 so as to be responsive to the conditions or characteristics of the air or fluid leaving the

modifying device, and thus the temperature of the air leaving the modifying device will cause an operation of the thermostat 71 to admit variable amounts of compressed air to the pressure motor 69 and cause operations of the dampers 64 and 65 in a desired manner.

A damper or shutter device 74 may be arranged across the connection between the outlet end of the conditioner 58 and the mixing chamber 59, so as to regulate, variably, the passage of fluid through the conditioner to the mixing chamber 59. If desired the damper 74 may only extend partially across the passage so as to always pass a minimum quantity of conditioned air. The damper 74 is operated through suitable mechanism 75 by a suitable motor 76, such as an air motor.

The motor 76 is supplied with compressed air by a pipe 77 leading from the motor to a suitable instrument, such as a hygrostat 78, which is disposed in a position where it is responsive to the atmosphere of the enclosure. For that purpose it may conveniently be disposed in the withdrawn air or fluid duct 56 near its inlet.

This hygrostat controls the passage of compressed air or fluid to the fluid pipe 77 and motor 76 from the source 73 of compressed air which is connected to the hygrostat by pipes 72 and 79. With this arrangement, the hygrostat will admit compressed air to the air motor 76 in a manner and quantity to operate the damper 74 and pass more or less of the conditioned air or fluid to the chamber 59 and thus maintain desired characteristics in the air or fluid of the enclosure automatically.

The humidistat 78, if direct acting, will cause an increased air pressure on air motor 76 with an increased humidity. In a dehumidifying system, the connection to dampers 74 would be so made that the dampers would open, allowing air with a lower dewpoint to pass into the distributing system, and, in order to maintain constant static pressure in the distributing system 61, damper 80 would be partially closed by an increasing air pressure on air motor 81. In other words, the action of static pressure regulator 83 would offset, by closing damper 80, the opening of damper 74. In case the system is a humidifying system, and if the dewpoint in the air conditioner was higher than that of the room, the action would be opposite to that described above. In other words, the control of the room depends upon the condition and amount of air passing thru the air conditioner. All of the air passing thru the bypass is only recirculated in the room and has no effect upon the room condition due to its being at the same temperature and humidity as the room.

It will be observed that air can always enter the conditioner 58 past either of dampers 64 or 65 or both, but the air so passing into the conditioner 58 is only admitted to the mixing chamber 59 in amounts required to create or maintain the desired atmospheric conditions in the enclosure, the regulation being in this particular example accomplished automatically.

In this example of the invention, as well as in the example illustrated in Fig. 1, it is desirable to avoid fluctuations in the quantity of air delivered by the fan to the enclosure, and to obtain the delivery of a uniform quantity of air to the enclosure. Accordingly the by-pass duct 62 for the withdrawn air may be provided with a controlling damper or shutter device 80 which may be operated by a suitable motor 81, such as an air motor.

The operation of the motor 81 is controlled by a static pressure regulator 83, which may be similar to that illustrated in Figs. 1 and 3, and function in a similar manner, as well as being disposed so as to be responsive to the quantity of air being delivered through the duct 61 to the enclosure.

The regulator 83 controls the passage of compressed air from the source 73 of compressed air through pipes 79 and 84 to a pipe 82 leading to the motor. The regulator 83 will control the operation of the damper 80 in a manner to by-pass air around the conditioner 58 sufficient in amount to maintain a constant volume of the air delivered to the enclosure, as explained in connection with Fig. 1.

In the operation of the apparatus illustrated in Fig. 2, the thermostat 71 will operate the motor 69 in a manner to vary the relative proportions of outside and return air which are admitted to the conditioner 58. The volume of air admitted to the device 58 by the dampers 64 and 65 will remain approximately constant, but the relative proportions will vary, and the thermostat will vary these proportions through intermediate stages in a manner such that the air leaving the conditioner 58 will have an approximately uniform dewpoint and temperature.

The amount of this conditioned air which is admitted to the enclosure will be determined by the hygrostat 78, which controls the motor 76 and damper 74 in a manner to automatically vary the amount of conditioned air admitted to the delivery fan 60. The humidity of the room will therefore be maintained approximately constant by the automatic control of the amount of air at a known dewpoint and temperature which is delivered to the enclosure.

The static pressure regulator 83 and the motor 81 and damper 80 controlled thereby, will automatically by-pass sufficient withdrawn air to maintain a constant pressure in the delivery duct 61, and therefore the volume of air delivered to and circulated through the enclosure will remain substantially constant throughout the various regulatory actions which occur.

The conditioners or modifying devices 6 and 58 have been illustrated only conventionally, since the type of conditioner adopted will depend upon the nature of the treatment to be given the air or other gaseous fluid which is circulated. For example, when the humidity of air is to be modified, a liquid spray of the usual or any type may be used in the conditioner, at a temperature depending upon whether moisture is to be added to or taken from the circulating air or gaseous fluid, or the air or gaseous fluid may be heated or cooled in any suitable manner to produce the desired conditions in the enclosure.

It will be understood that both of the illustrated examples of the invention are equally useful in both summer and winter, the heaters being shut off in the summer when the auditorium or enclosure is to be cooled. In summer, of course, the air would be dehumidified in the conditioner 6 or 58, in order to cool the enclosure. In winter the air or gas delivered to the enclosure could be either humidified or dehumidified, as may be necessary to give the desired conditions in the enclosure by suitable operation or regulation of the conditioner.

It will be obvious that various changes in the details, which have been hereindescribed and illustrated in order to explain the nature of the invention, may be made by those skilled in the

art within the principle and scope of the invention as expressed in the appended claims.

I claim as my invention:

1. A circulation system for an enclosure comprising means for delivering a stream of gaseous fluid having a desired condition to said enclosure, means for varying the amount of such fluid so delivered, and means automatically responsive to the quantity of fluid delivered to the enclosure for adding to the said delivered fluid additional fluid withdrawn from the enclosure in an amount that will maintain substantially constant the quantity of gaseous fluid entering said enclosure.
2. A circulation system for an enclosure, comprising a fan connected to said enclosure to deliver a stream of fluid thereto, means for supplying a gaseous fluid to said fan for delivery thereby to said enclosure, means for regulating the quantity of said fluid supplied to the fan, a connection from said enclosure to the intake side of said fan for supplying thereto fluid from the enclosure for recirculation, and means responsive automatically to the quantity of fluid handled by the fan for varying the amount of fluid flowing in said connection inversely to the quantity of fluid supplied by the first mentioned means to said fan, whereby the quantity of fluid delivered to the enclosure by the fan will be substantially constant.
3. A circulation system for an enclosure, comprising means for delivering to said enclosure a stream of air having a desired condition, means for varying the quantity of said air in said stream, means for adding to said stream air from another source, and means controlled by the air pressure in said stream for varying the quantity of said additional air which is added to said stream in a manner to obtain delivery of a substantially uniform quantity of air to the enclosure.
4. A circulation system for an enclosure, comprising means for delivering to said enclosure a stream of air having a desired condition, means for varying the quantity of such air so delivered, means for adding air withdrawn from the enclosure to said stream, means controlled by the pressure of the stream delivered to the enclosure for varying the quantity of said withdrawn air which is added to said stream, by increasing the withdrawn air upon a decrease in the other air in said stream, and vice versa, so as to make the stream of air delivered to the enclosure substantially constant in quantity, and means responsive to the temperature of the air in said enclosure for heating the air of said stream before it reaches said enclosure, until the air of the enclosure reaches a selected temperature.
5. A circulation system for an enclosure, comprising means for withdrawing a gaseous fluid from said enclosure and returning it as a stream to said enclosure, means for treating such withdrawn fluid, means for varying the amount of such fluid, and means responsive to the pressure in said stream for admitting additional untreated gaseous fluid to said stream for delivery to said enclosure, upon a decrease in the quantity of treated air returned to said enclosure.
6. A circulation system for an enclosure, comprising means for delivering to the enclosure a stream of gaseous fluid having a desired condition, means responsive to the condition of the gaseous atmosphere of said enclosure for varying the quantity of such gaseous fluid delivered to the enclosure, and means responsive to the

pressure in said stream for admitting additional gaseous fluid having a different condition to the stream in a quantity that will maintain the quantity of fluid delivered to the enclosure substantially constant throughout all variations in the quantity of fluid having said desired condition.

7. In a circulation system for an enclosure, means for delivering a stream of air to the enclosure, means for regulating the quantity of such air in said stream, and means responsive to the air pressure in said stream for admitting to that stream additional air of a different condition and in an amount that will maintain the delivery of a constant volume of air to the enclosure.

8. An air circulation system for an enclosure comprising means for receiving air from said enclosure and returning it to said enclosure to cause a circulation in the latter, means for treating a portion of said withdrawn air, means for varying the quantity of air passing through said treating means, means for bypassing a quantity of the withdrawn air around said treating means, whereby some of the withdrawn air may be unaffected by said treating means, means for heating the air returned to the enclosure, a pair of valves controlling said heating means and having different capacities, and means responsive to the temperature of the air in the enclosure for operating both of said valves in a manner to jointly admit a fluid medium to said heating means, to shut off one of said valves when the air in the enclosure reaches one temperature and to shut off the other valve when the air in the enclosure reaches a somewhat higher temperature.

9. An air circulating system for an enclosure, comprising means for receiving air from the enclosure and returning it to said enclosure to cause a circulation therein, means for treating a portion of the withdrawn air, controlling means for varying the quantity of air passing through said treating means, means for bypassing a portion of the withdrawn air past both said controlling means and said treating means, a heating device for heating the withdrawn air prior to its return to the enclosure, and means responsive to the temperature of the air in said enclosure for controlling said heater in a manner to cause a maximum action of the heater until the air in the enclosure reaches a selected temperature, then partially decreasing the activity of said heater until the air in said enclosure reaches a predetermined higher temperature, and then cutting off said heater entirely, while the temperature of the air in the enclosure remains above said predetermined temperature, and means for varying the quantity of by-passed air inversely proportional to the treated air, whereby the air returned to said enclosure may be maintained approximately uniform in quantity independently of the amount of air subjected to said treating means.

10. The method of creating and maintaining a desired air condition in an enclosure, which comprises withdrawing air from said enclosure, treating said air to impart a desired condition thereto, circulating said treated air as a stream and delivering it to said enclosure to cause a circulation through the enclosure, adding untreated air to said treated air, and automatically varying the proportions of treated air and untreated air in response to pressures in said stream by increasing the quantity of untreated air added to said stream upon a decrease in the treated air in said stream, and in quantities that will maintain a constant quantity of air flow in said enclosure.

11. In a circulation system for an enclosure, the method which comprises circulating as a stream and delivering to the enclosure air having a desired condition tending to create and maintain desired air conditions in the enclosure, varying the quantity of such air to produce said desired air conditions and supplying to said stream, in accordance with the air pressure in the stream, additional air having the condition of the air in said enclosure in a quantity that will maintain the delivery of a constant volume of air to the enclosure.

12. A fluid circulation system for an enclosure which comprises means for delivering to said enclosure a stream of gaseous fluid from a plurality of sources, means for varying the amount of fluid from one of said sources in said stream for altering the condition of the stream, and means automatically responsive to the pressure of the gaseous fluid in said stream for varying the quantity of gaseous fluid which is added from another of said sources to said stream in a manner to maintain approximately constant the volume of fluid delivered to said enclosure.

13. An air circulation system for an enclosure, comprising a duct system for withdrawing air from said enclosure and returning it to said enclosure, a fan in said duct system for causing a circulation through said duct system, means associated with one portion of said duct system for treating said air during its circulation to change its condition, means for bypassing a portion of the withdrawn air past said treating means, means for varying the quantity of withdrawn air passing through said treating means, means responsive to the temperature of the air in the enclosure for heating the bypassed air until the air of the enclosure reaches a selected temperature, and means automatically responsive to the quantity of air delivered by said duct system for varying the amount of bypassed air by an amount that will make the quantity of air delivered to the enclosure by said duct system approximately constant independently of the variations of the amount of air which is treated.

14. The method of creating and maintaining a desired air condition in an enclosure, which comprises withdrawing air from said enclosure, treating the withdrawn air to impart a desired condition thereto and returning it to said enclosure to create a circulation through the enclosure, varying the quantity of withdrawn air which is treated, in a quantity that will create desired atmospheric conditions in said enclosure, and adding untreated withdrawn air to the treated air automatically in response to the air pressure in the air stream delivered to said enclosure in a quantity that will maintain substantially uniform the quantity of air delivered to the enclosure.

15. The method of producing desired atmospheric conditions in an enclosure which comprises delivering to said enclosure a stream of gaseous fluid composed of fluids having different conditions, varying the proportions of the component fluids of said stream as necessary to obtain the desired condition in said enclosure, and increasing and decreasing the quantity of a component fluid of said stream under the control of the static pressure of the fluid delivered to the enclosure by an amount that will maintain approximately constant the quantity of fluid delivered to the enclosure.

16. A fluid circulation system for an enclosure, which comprises means for delivering to said en-

closure a stream of gaseous fluid composed of fluids having respectively different conditions, means for varying the amount of one of said component fluids in said stream for altering the condition of the stream, and fluid pressure controlled means for varying the quantity of another of said component fluids in said stream in a manner to maintain approximately constant the volume of fluid delivered to the enclosure.

17. An air circulating system for an enclosure, comprising a duct system connecting different parts of said enclosure, means associated with said system for circulating air therethrough and through said enclosure, means associated with one section of said system for modifying the characteristics of air moving in that section of said system, means for supplying outside air to said system, means controlling the amount of outside air admitted to said system and the amount of withdrawn air circulating through said section, thermostatic means responsive to the temperature of the air in the enclosure for operating said controlling means in accordance with temperature changes in said enclosure, means for by-passing withdrawn air past said section, means for varying the amount of air by-passing said section, and a static pressure regulator responsive to pressures in the air being delivered by said system to the room for controlling the means for varying the amount of by-passed air, inversely to the quantity of treated air passing through said one section, and in such amount that the air delivered by said system to said enclosure will be substantially constant independently of the amount of air passing through said section.

18. An air circulation system for an enclosure, comprising a duct system for withdrawing air from said enclosure and returning it to said enclosure to cause a circulation in the latter, means for treating the air passing through one portion of said duct system, damper means for varying the quantity of air passing through said treating means, means for bypassing a quantity of the withdrawn air around said treating means, whereby some of the withdrawn air may be unaffected by said treating means, means for heating the air delivered to the enclosure, a pair of valves controlling said heating means, thermostatic means responsive to the temperature of the air in the enclosure and connected to said valves for rendering both active to admit the fluid medium to said heater until the air of the enclosure reaches one selected temperature, for then shutting off one valve, and for shutting off the other valve when the air of the enclosure reaches a predetermined temperature above that at which the first valve was shut off, damper controlled means for admitting outside air to said withdrawn air for delivery therewith to said enclosure, motors operating said damper means and said damper controlled means, and means also controlled by said thermostatic means and operating said motors to decrease the quantity of outside air admitted to said withdrawn air and the quantity of air passing through said treating means whenever the temperature within the enclosure falls below a predetermined minimum.

19. An air circulation system for an enclosure, comprising a duct system for withdrawing air from said enclosure and returning it to said enclosure to cause a circulation in the latter, means for treating the air passing through one portion of said duct system, means for varying the quantity of air passing through said treating means,

means for bypassing a quantity of the withdrawn air around said treating means, whereby some of the withdrawn air may be unaffected by said treating means, means for heating the air delivered to the enclosure, a pair of valves controlling said heating means, thermostatic means responsive to the temperature of the air in the enclosure and connected to said valves for rendering both active to admit the fluid medium to said heater until the air of the enclosure reaches one selected temperature, for then shutting off one valve, and for shutting off the other valve when the air of the enclosure reaches a predetermined temperature above that at which the first valve was shut off, means for admitting outside air to said withdrawn air, for delivery therewith to said enclosure, means also controlled by said thermostatic means for varying the quantities of outside air admitted to said withdrawn air and for operating the said means which varies the quantity of air passing through said treating means, and means responsive to the pressure in the current of air delivered to the enclosure for increasing or decreasing the amount of bypassed air upon a decrease or increase respectively in the amount of the treated air in the air delivered to said enclosure, in an amount that will maintain the quantity of air delivered to the enclosure substantially constant at all times.

20. An air circulation system for an enclosure, comprising means for uniting air from a plurality of different sources into an air stream having desired characteristics, and delivering it to said enclosure, separate means for controlling and varying the amount of air from each of said sources which is delivered to the enclosure, separate operating means for each of said varying means, means for withdrawing air from the enclosure and adding it to said stream, and means responsive to the air pressure of the air stream delivered to the enclosure for varying the addition of said withdrawn air to the stream in a manner to insure uniformity in the quantity of air in said stream reaching said enclosure.

21. A heating and ventilating system for an enclosure in which people congregate in substantial numbers, comprising a blower operating at a substantially constant speed, duct means connecting said blower to said enclosure and having one portion thereof divided into a plurality of branches and another undivided portion, means for conditioning air supplied by one of said branches, volume control means for variably changing the volume of air moving in another of said branches, and means responsive to air pressure in the undivided portion of said duct and operative automatically to vary the volume control means to maintain a constant air pressure in said undivided portion of said duct means while said blower continues to operate at said constant speed.

22. A fluid circulation system for an enclosure, which comprises means for delivering to said enclosure a stream of air from a plurality of sources,

means for varying the amount of air from one of said sources in said stream for creating desired atmospheric conditions in said enclosure, and means responsive to air pressure in said delivered stream and automatically operative to vary the quantity of air from the other of said sources in said stream to a quantity which will maintain approximately constant the volume of air delivered to said enclosure.

23. A fluid circulation system for an enclosure, which comprises means for delivering to said enclosure a stream of air from a plurality of sources, means for varying the amount of air from one of said sources in said stream for creating desired atmospheric conditions in said enclosure, and means automatically responsive to the pressure of the air of the said stream delivered to said enclosure for varying the amount of air from the other of said sources to an amount that will maintain approximately constant the volume of air delivered to said enclosure.

24. A fluid circulation system for an enclosure which comprises a blower, a duct connecting said blower and enclosure, means for supplying air to said blower from a plurality of different streams, means for varying the amount of air in one of said streams reaching said blower in order to create desired atmospheric conditions in said enclosure, and means automatically responsive to the air pressure in said duct and varying the amount of air in the other of said streams by an amount that will maintain a substantially constant air pressure in said duct.

25. A fluid circulation system for an enclosure which comprises an air circulating device, a duct connecting said device to said enclosure for delivering thereto a stream of air, means for supplying to said device a stream of air having a desired condition, means for varying the amount of conditioned air in said stream of air supplied to said device, to create desired atmospheric conditions in said enclosure, and means automatically responsive to the air pressure in said duct for supplying to said device additional air having a different condition in air amount that will maintain approximately constant the pressure of air in said duct.

26. A heating and ventilating system for an enclosure in which people are accommodated, comprising a blower operating at a substantially constant speed, duct means connecting said blower to said enclosure and having one portion thereof divided into a plurality of branches, and another undivided portion, means for variably changing the amount of air moving in one of said branches, and means responsive to the air pressure in the undivided portion of said duct and operative automatically to vary the quantity of air moving in said duct means and maintain a constant air pressure in said undivided portion of said duct means while said blower continues to operate at said constant speed.

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