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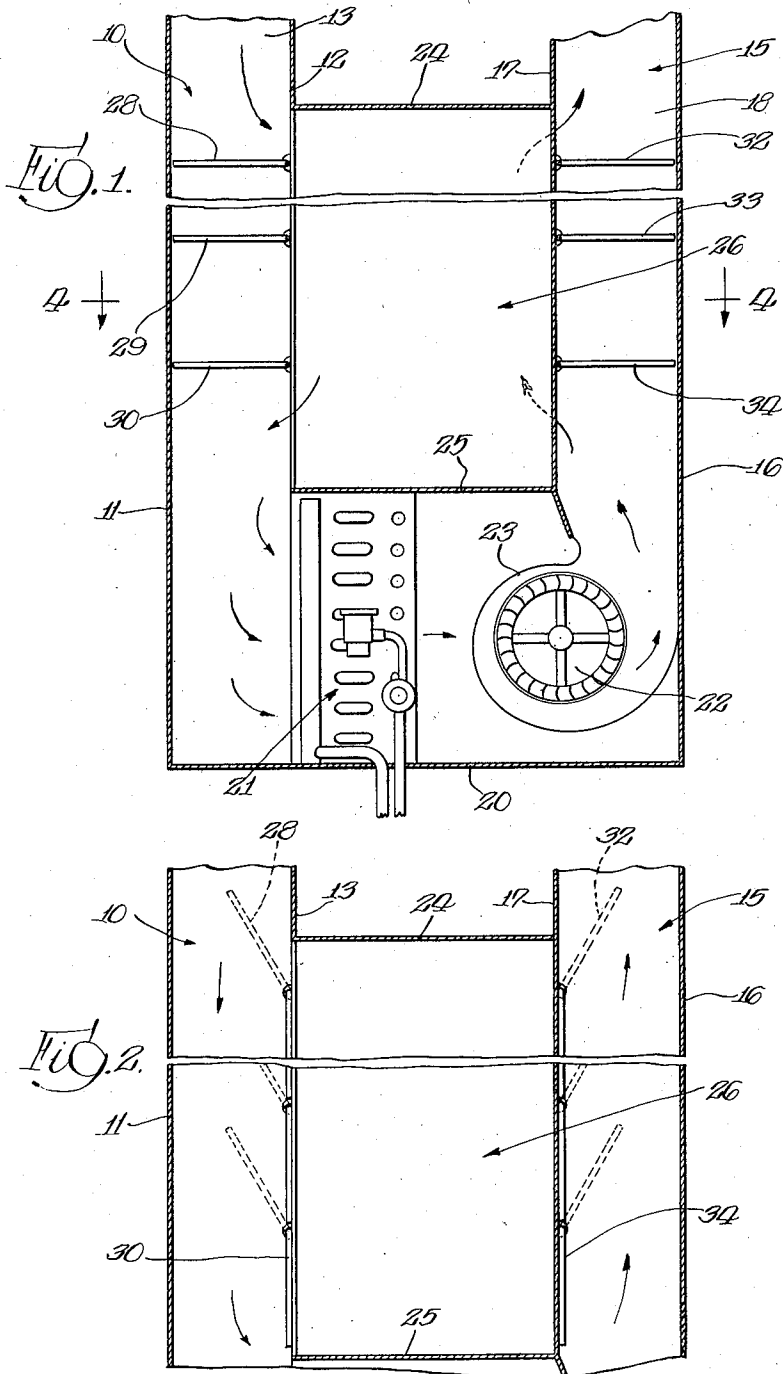
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APPARATUS FOR CONDITIONING AIR

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APPARATUS FOR CONDITIONING AIR

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4 Claims. (Cl. 62—129)

The invention relates to a method and apparatus for conditioning air and has particular application to air conditioning systems intended to maintain the desired temperature and relative humidity in public enclosures such as factories, theaters and like buildings.

In mechanically cooled and ventilated enclosures the comfort of the occupants is dependent upon the purity of the air supply, its temperature, relative humidity and movement of the air. It is also recognized that with air of standard purity a relative humidity of about fifty per cent and a temperature of seventy to seventy-five degrees gives the most satisfactory comfort conditions.

In any comfort cooling system of the finned coil, tubular, or water spray type the air after passing through the conditioner will have a low dry bulb temperature but high relative humidity since the air will be completely or partly saturated with moisture. Usually this cold air is discharged directly into the enclosure by means of some sort of diffusing apparatus such as grills which mix the cold air with the warm air in the enclosure before coming in contact with the occupants. When the outside air is quite warm this is usually satisfactory but when the outside air is comparatively cool and has a high humidity it is not conducive to interior comfort to discharge the cold conditioned air into an enclosure wherein the air is relatively cool and also high in humidity. Under these conditions it has been common practice to reheat the cold air from the conditioner by means of a steam coil. It has also been proposed to by-pass part of the air from the enclosure around the cooling equipment and mix it with the cooled conditioned air so that combined air returned to the enclosure will have the right temperature and humidity for the comfort of the occupants. The first method is generally considered the most satisfactory but it involves the use of a heating plant during the summer months which may be operated for a period of perhaps only a few hours a day. This is expensive and inefficient. The by-pass method is cheap to operate and to control but it is evident that in this method no consideration has been given to the purity of the recirculated air since most of the same is returned in its previous condition without any material purification. Also the by-pass method is not entirely correct in practice as a means of obtaining a large percentage of latent cooling in ratio to the total cooling.

It is an object of the present invention to provide an improved method of reheating the cold

outlet air from the conditioner and which contemplates passing all, or at least a large proportion of the warm air from the enclosure through the conditioner so that the enclosure will be constantly supplied with purified air and which will have a temperature and relative humidity for the most satisfactory comfort conditions.

A further object of the present invention resides in the provision of an improved method which will reheat the cold outlet air from the conditioner by extracting heat from the warm air withdrawn from the enclosure. With the present method the operation of a heating plant or other extraneous heating means for summer cooling is entirely eliminated.

A further object is to provide an improved method of reheating the cold outlet air from the conditioner which will be efficient under widely varying conditions and wherein the apparatus required for carrying out the method will be simple in construction and economical to manufacture.

Another object of the invention is to provide apparatus which will operate on the heat exchange principle for reheating the cold outlet air from the conditioner and which will involve the use of simple control equipment so that the temperature and humidity of the air returned to the enclosure may be regulated automatically.

Another object of the invention is to provide apparatus of simple construction which will use the sensible heat in the warm air from the enclosure to raise the temperature of the cold conditioned air, the degree of sensible heat exchange being controlled either manually or automatically by a series of dampers. Since the warm air gives up a portion of its sensible heat the air to be conditioned on entering the cooling equipment is at a lower temperature and also at a higher relative humidity than before the heat exchange. Therefore, in the cooling equipment the heat removed is largely in latent form, or moisture removal. Also the air discharged by the cooling equipment will be at a lower dew point than without the exchange of heat. This cold conditioned air in passing through the cold side of the heat exchanger absorbs sensible heat from the warm air and is thus processed to be warmer and drier than if conventional steam heating were employed. This latter assumes of course that conditions in both instances are the same.

With these and various other objects in view, the invention may consist of certain novel features of construction and operation as will be more fully described and particularly pointed out

in the specification, drawings and claims appended hereto.

In the drawings which illustrate an embodiment of the invention and wherein like reference characters designate like parts—

Figure 1 is a vertical sectional view illustrating one form of heat exchange apparatus for carrying out the present method;

Figure 2 is a fragmentary vertical sectional view similar to Figure 1 but showing various positions of the dampers by which the amount of heat exchange can be effectively regulated;

Figure 3 is a perspective view of the heat exchange apparatus of Figure 1, parts being broken away to show the interior construction; and

Figure 4 is a horizontal sectional view taken substantially along line 4—4 of Figure 1.

Referring to the drawings, Figure 1 illustrates one form of apparatus for reheating the cool conditioned air by the heat exchange principle of the invention. For a proper understanding of the following description it must be borne in mind that the structure disclosed is to be associated with an enclosure such as a theater having an outlet duct for the warm air to be conditioned and also having return ducts whereby the conditioned air at the desired temperature and relative humidity is returned to the enclosure. In the drawings, the numeral 10 indicates the duct conducting the warm air from the enclosure to the cooling equipment, and numeral 15 indicates the duct for returning the conditioned air from the equipment to the enclosure.

The warm air duct is formed by side walls 11, 12 and by end walls 13, 14, Figure 4. The conditioned air duct 15 which returns the conditioned air to the enclosure is of similar construction, comprising side walls 16, 17 and end walls 18, 19. For housing the cooling equipment the outer walls of the ducts above described form a large cylindrical box or container having a base or bottom wall identified by numeral 20, Figure 1. Within this container and located toward the side of the warm air duct 10 there is located cooling equipment 21 of the mechanical refrigerating type. For a full description of this mechanism reference is made to the copending application of Fred R. Erbach filed March 10, 1937, Serial No. 130,028. The warm air in passing through the conditioner is brought into contact with a plurality of finned cooling coils which lower the temperature of the air and thus reduce the total heat and moisture content thereof. The air is drawn through the conditioner by a blower designated in its entirety by numeral 22 mounted within a spiral housing 23, which equipment is likewise located in the lower part of the box or container. The outlet side of the spiral housing forms the entrance to the conditioned air duct 15 so that the air from the conditioner is delivered under pressure to said duct which in turn delivers air of proper temperature and humidity to the enclosure.

However, the air from the conditioner has a relatively low temperature and its humidity is too high for the best comfort of the occupants. In other words, the cooling reduces the air to a dew-point temperature generally below that required for ventilation. It is necessary to raise the temperature of this cool air above the dew-point by adding a quantity of heat which may be referred to as superheat. However, the warm air from the enclosure is generally above its dew-point and thus contains superheat. Adding heat to the conditioned air is therefore accomplished

according to the present invention by a heat exchanger located between the warm air duct 10 and the conditioned air duct 15. As best shown in Figure 3, the top wall of the heat exchanger is indicated by numeral 24 and the base or bottom wall thereof by 25, which also provides the top wall for the space containing the cooling equipment and the blower. The corrugated member 26 extends the full height of the heat exchanger and for the full width between the ducts 10 and 15. Said member therefore provides the interior wall for both ducts 10 and 15 between the top wall 24 and the bottom wall 25. The heat transfer surface is formed by the partition 27. Each partition on one side thereof is in contact with the warm air from duct 10, whereas, the other side of the said partition will be in contact with the cold air from the cooling equipment. It may also be noted that the corrugations provide warm air passages 36 wherein the air flows downwardly and conditioned air passages 37 wherein the conditioned air flows upwardly, Figure 3.

For automatically regulating the amount of air from the warm air duct 10, which will flow into the heat exchanging passages the invention provides a plurality of dampers such as indicated by numerals 28, 29 and 30. As clearly shown in the drawings, the dampers are rectangular in plan and when horizontally disposed the said dampers completely close the air duct, forcing the warm air flowing therethrough into the heat exchanging passages 36. Each damper is pivotally supported at 31 from the end walls 13 and 14 of the air duct 10.

Dampers 32, 33 and 34 are located in the conditioned air duct 15 and which are likewise rectangular in plan so that when horizontally positioned the said dampers completely close the air duct forcing all the cold air from the conditioner into the heat exchanging passages 37. The said dampers 32, 33 and 34 are pivotally supported at 35 from the end walls 18 and 19 of the said air duct 15.

By varying the position of the several dampers within their respective air ducts it is possible to control the degree of reheating effected by the heat exchanger. With the damper 28 in the duct 10 horizontally positioned, as shown in Figures 1 and 3, all the warm air from the duct will be diverted into the heat exchanging passages 36. The horizontal position of the remaining dampers, namely, 29 and 30, requires that the air travel the full length of the heat exchanger, whereupon the air is delivered to the cooling equipment. Referring to dampers 32, 33 and 34, it will be noted that these have different positions in Figure 3 so that only part of the cool air from the conditioner is diverted into the heat exchanging passages 37. Damper 32 is horizontally disposed and thus it will be seen that the cold air can not completely by-pass the heat exchanger. However, since damper 33 is at an angle of approximately forty-five degrees and since damper 34 is vertical, only part of the air from the conditioner will be diverted to the heat exchanger and caused to travel the greater part of the length of the same.

In Figure 2 all the dampers depend vertically from their pivot and approximately close the entrance to the heat exchanging passages. With the dampers in this position the air is caused to by-pass the heat exchanger and no reheating of the conditioned air takes place. The dotted line position of the dampers, Figure 2, illustrates

still another positioning thereof whereby the degree of heat exchange is intermediate the full position of Figure 1 and the vertical positioning of the dampers just described.

- 5 The dampers may be operated manually. However, as the ventilating conditions in an enclosure are variable, depending upon the number of occupants, it may be desirable to provide automatic operating means for the damper.
- 10 Many known means may be employed to operate the dampers independently of each other or operate groups in unison for the purpose of automatically controlling the degree of heat extracted from the warm air. One effective method
- 15 of damper control is to provide thermostats responsive to the air as it is withdrawn from the room. In addition to thermostatic means it is of course possible to use in conjunction therewith a humidostat and either one or both
- 20 may be located in the conditioned air duct as well as the warm air duct.

- The method and apparatus above described will maintain comfortable air conditions in an enclosure where people assemble without requiring the use of extraneous heating means for summer cooling. Thus the method is economical in operation and further the apparatus may be simply constructed out of the cheapest form of heat transfer material such as galvanized sheet iron.
- 30 The many and varied conditions of the dampers assure a wide range in the degree of heat exchange to suit widely varying conditions in the enclosure. Because of the high air velocity in ducts of the kind described the heat transfer coefficients are quite high and a relatively small surface is required. It is very important that the counter-flow principle of heat exchange be employed. In other words, to secure efficient heat exchange the warm air should enter on the end
- 40 opposite from the cold air inlet.

- Another advantage which is secured only by the present method resides in the fact that the sensible heat extracted from the warm air renders the same cooler and higher in relative
- 45 humidity than would otherwise be the case. As a result the heat removed from the air in passing through the conditioner is largely in latent form, or moisture removal, and the air from the conditioner is at a lower dew-point than without the
- 50 exchange of heat.

The invention is not to be limited to or by details of construction of the particular embodiment thereof illustrated by the drawings, as various other forms of the device will of course be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims.

What is claimed is:

1. An apparatus for conditioning air withdrawn from an enclosed space, comprising a warm air duct for withdrawing air from said space, a conditioned air duct for returning the conditioned air to said space, cooling means for said warm air located between said ducts, and a heat exchanger located between said ducts in advance of said cooling means, said heat exchanger comprising corrugations extending the width between said ducts and forming passages for the warm and conditioned air respectively.

2. An apparatus for conditioning air withdrawn from an enclosed space, comprising a warm air duct for withdrawing air from said space, a conditioned air duct for returning the conditioned air to said space, cooling means for said warm air located between said ducts, and a heat exchanger located between said ducts in advance of said cooling means, said heat exchanger including a member having corrugations forming alternating warm and cold air passages.

3. An apparatus for conditioning air comprising a warm air duct for the air to be conditioned, a second air duct for the conditioned air, cooling means for said warm air and which is positioned between said ducts so that the warm air duct delivers air to said cooling means which is in turn discharged into said conditioned air duct, a heat exchanger located between said ducts and in advance of the cooling means, said heat exchanger including a metal partition member providing passages communicating with the warm air duct, and other passages communicating with the conditioned air duct, and dampers located in each duct respectively for closing the entrance to said passages.

4. An apparatus for conditioning air comprising a warm air duct for the air to be conditioned, a second air duct for the conditioned air, cooling means for said warm air and which is positioned between said ducts so that the warm air duct delivers air to said cooling means which is in turn discharged into said conditioned air duct, a heat exchanger located between said ducts and in advance of said cooling means, said exchanger having a metal partition member providing passages communicating with the warm air duct and other passages alternating with said first mentioned passages and communicating with said conditioned air duct, and dampers located in each air duct for controlling the amount of air diverted from said duct and caused to flow through its respective passages.

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