April 10, 1962 N. WEINSTEIN 3,028,734

APPARATUS FOR CONTINUOUSLY CONDITIONING AIR

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FIG. 3

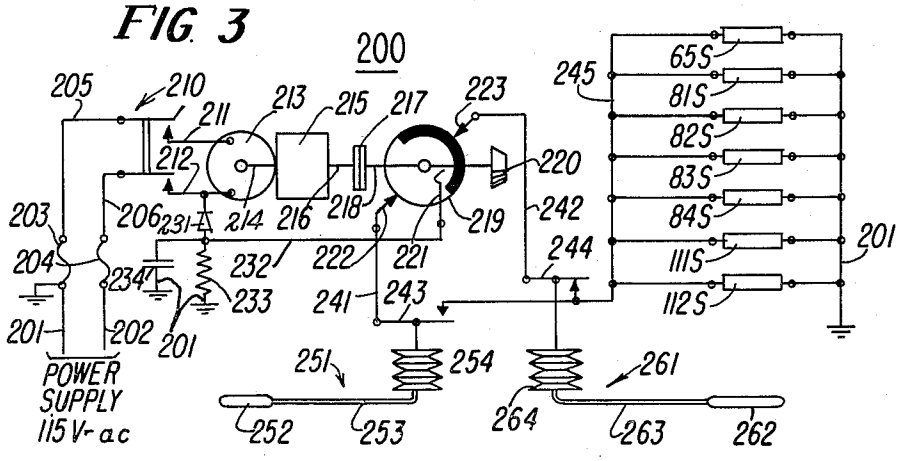
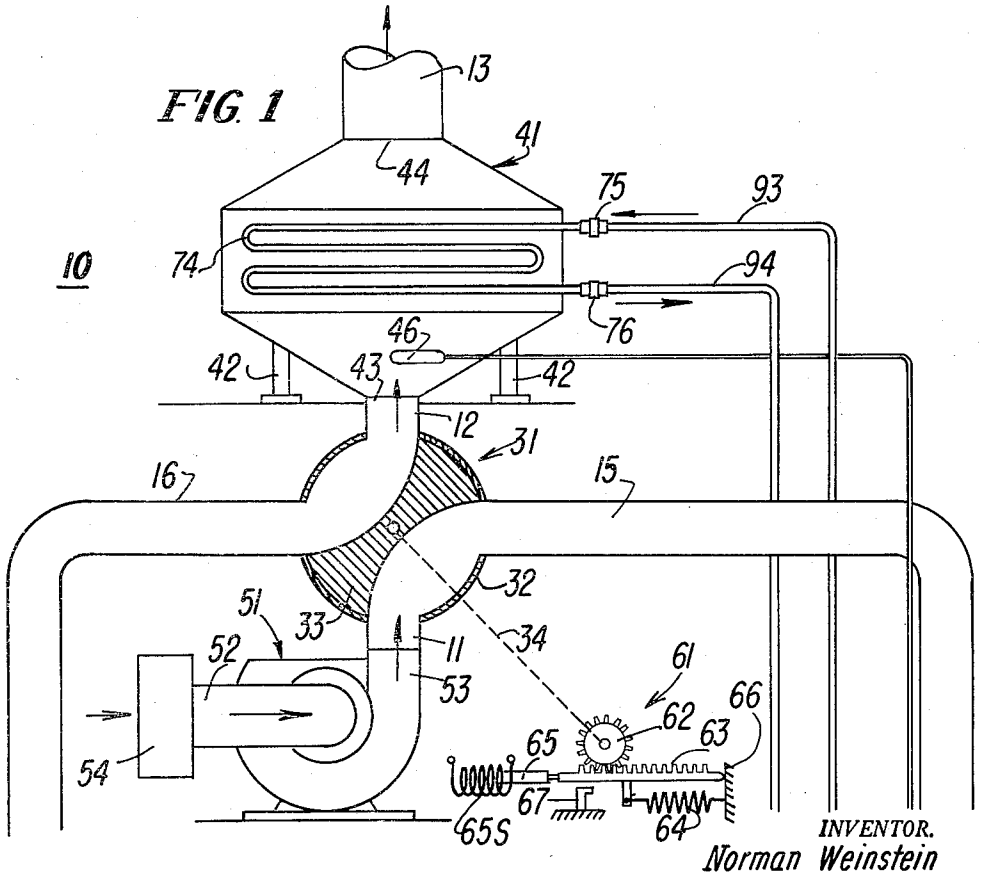


FIG. 1



INVENTOR.
Norman Weinstein

BY
Brumley, Baird, Clayton, Miller & Vogel
Attys.

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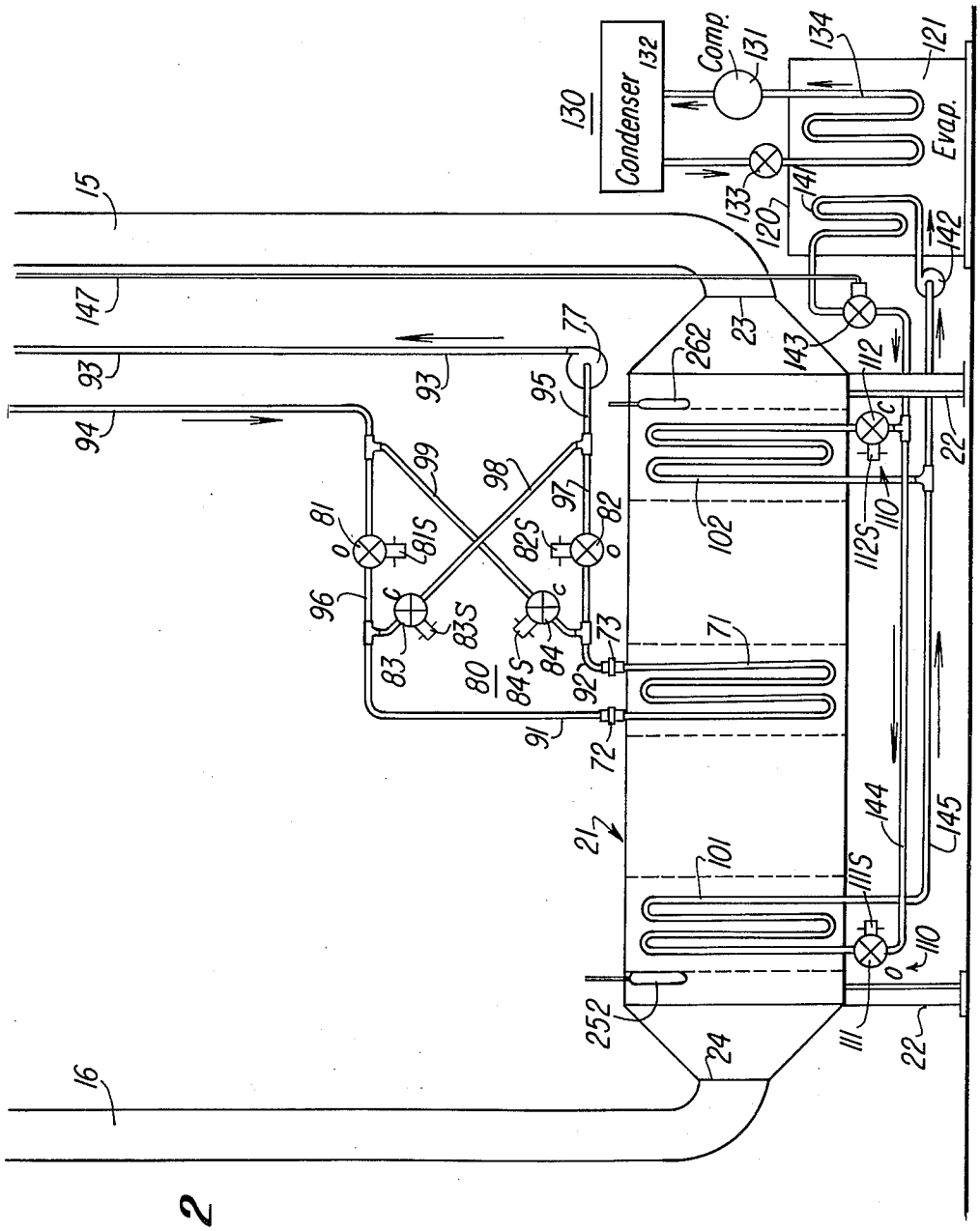


FIG. 2

INVENTOR.
Norman Weinstein

BY
Prangley, Baird, Clayton
Miller & Vogel

Attys.

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APPARATUS FOR CONTINUOUSLY CONDITIONING AIR

Norman Weinstein, 3300 N. Lake Shore Drive, Chicago, Ill.

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10 Claims. (Cl. 62—140)

The present invention relates to apparatus for continuously conditioning air.

It is the general object of the invention to provide apparatus for continuously conditioning air that requires no shut-down of the principal component elements of the apparatus and that requires no substantial duplexing of the principal component elements of the apparatus.

Another object of the invention is to provide continuously operating air conditioning apparatus of the character noted, in which the air is conditioned to a temperature at, or below, the frost point.

Another object of the invention is to provide in air conditioning apparatus of the character noted, an improved sequence of cooling and reheating stages so that the temperature of the air may be reduced with substantial dehumidification thereof in a simple and economical manner involving relatively small compact equipment.

Another object of the invention is to provide continuously operative apparatus for conditioning air by dehumidifying it and by subsequently reheating it so that the air is conditioned to a uniform moisture content and to a uniform temperature.

A further object of the invention is to provide air conditioning apparatus of improved and simplified construction and arrangement and wherein the conditioned air is of uniform moisture content and of uniform dry bulb temperature.

A further object of the invention is to provide apparatus of the character described that is capable of conditioning air at a predetermined rate to a substantially constant condition and that requires substantially less refrigeration capacity than has been employed heretofore.

Further features of the invention pertain to the particular arrangement of the elements of the air conditioning apparatus, whereby the above-outlined and additional operating features thereof are attained.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification, taken in connection with the accompanying drawings, in which:

FIGS. 1 and 2, taken together, illustrate diagrammatically air conditioning apparatus embodying the present invention; and

FIG. 3 illustrates diagrammatically the electric control circuit that is incorporated in the apparatus of FIGS. 1 and 2.

In order to form a unified diagram, FIG. 2 should be arranged in a horizontal position, and FIG. 1 should be arranged in a vertical position above the top central portion of FIG. 2.

Referring now to FIGS. 1 and 2 of the drawings, the continuous air conditioning apparatus there illustrated and embodying the features of the present invention comprises a first conduit **11**, a second conduit **12**, a third conduit **13**, a first elongated housing **21**, a first two-position valve mechanism **31** for selectively connecting the first housing **21** in opposite directions between the first conduit **11** and the second conduit **12**, and a second housing **41** directly connected between the second conduit **12** and the third conduit **13**. In the arrangement, the housing **21** may be arranged in any suitable position, and has been illustrated as being in the horizontal position as a matter of convenience, the housing **21** being supported by a plurality of upstanding feet or columns **22**. The second housing may be arranged in any suitable position, and has been illustrated as being in the vertical position as a matter of convenience, the housing **41** being supported by a plurality of upstanding feet or columns **42**. The housing **21** includes a first port **23** disposed at the right-hand end thereof and a second port **24** disposed at the left-hand end thereof, the two ports **23** and **24** respectively communicating with two transfer conduits **15** and **16**. Also, in the arrangement, the housing **41** includes a first port **43** disposed at the bottom thereof and a second port **44** disposed at the top thereof, the two ports **43** and **44** respectively communicating with the second conduit **12** and the third conduit **13**.

Ambient air to be conditioned is supplied to the first conduit **11** by an associated blower **51** that is provided with a casing having an inlet pipe **52** and an outlet pipe **53**, the inlet pipe **52** communicating with an associated dust filter **54** and the outlet pipe **53** communicating with the first conduit **11**. The conditioned air from the third conduit **13** is supplied to a missile crib, or the like, not shown, that requires the conditioned air.

The two-position valve mechanism **31** includes a casing **32** housing a rotatably mounted valve element **33** supported by a rotatably operated shaft, indicated at **34**; which valve element **33** has a normal position, illustrated in FIG. 1, and an operated position disposed 90° in the clockwise direction with respect to its normal position. The casing **32** terminates the first conduit **11**, the second conduit **12** and the two transfer conduits **15** and **16**. In the arrangement, when the valve element **33** occupies its normal position, the first conduit **11** is connected to the transfer conduit **15** and the second conduit **12** is connected to the transfer conduit **16**; whereby the air supplied from the blower **51** to the first conduit **11** proceeds into the transfer conduit **15** and thence through the housing **11** from right to left and therefrom via the transfer conduit **16** into the second conduit **12** and therefrom upwardly through the housing **41** into the third conduit **13**. On the other hand, when the valve element **33** occupies its operated position, the first conduit **11** is connected to the transfer conduit **16** and the second conduit **12** is connected to the transfer conduit **15**; whereby the air supplied from the blower **51** to the first conduit **11** proceeds into the transfer conduit **16** and thence through the housing **21** from left to right and therefrom via the transfer conduit **15** into the second conduit **12** and therefrom upwardly through the housing **41** into the third conduit **13**.

The valve element **33** is selectively actuated between its normal and operated positions by actuating mechanism **61** that is operatively associated with the operating shaft **34**; which mechanism **61** comprises a pinion **62** rigidly secured to the outer end of the operating shaft **34** and a cooperating rack **63**. The rack **63** is biased toward the right by an associated tension spring **64** and is operated toward the left by an associated armature **65** that is provided with a cooperating operating solenoid **65S**. The right-hand position of the rack **63** is established by a cooperating stop **66** and the left-hand position of the rack **63** is established by a cooperating stop **67**.

In the arrangement, when the solenoid **65S** is deenergized, the tension spring **64** returns the rack **63** toward the right as established by the stop **66**; whereby the rack **63** rotates the pinion **62** in the counterclockwise direction for the purpose of actuating through the operating shaft **34** the valve element **33** into its normal position, as illustrated in FIG. 1. On the other hand, when the solenoid **65S** is energized, the armature **65** is attracted moving the rack **63** toward the left as established by the stop **67**; whereby the rack **63** rotates the pinion **62** in the clock-

wise direction for the purpose of actuating through the operating shaft 34 the valve element 33 into its operated position.

A primary cooling coil 71 is arranged in the intermediate portion of the housing 21 and provided with first and second fixtures 72 and 73 at the opposite ends thereof; and a heating coil 74 is arranged in the housing 41 and provided with first and second fixtures 75 and 76 at the opposite ends thereof. The primary cooling coil 71 and the heating coil 74 are arranged in a local heat-exchange circuit, also including a circulating pump 77 and a second two-position valve mechanism, indicated generally at 80. More specifically, the two-position valve mechanism 80 comprises four individual valves 81, 82, 83 and 84 respectively provided with operating solenoids 81S, 82S, 83S and 84S. In the arrangement, the valves 81 and 82 are normally biased into their open positions and are respectively operated into their closed positions in response to energization of the corresponding solenoids 81S and 82S, while the valves 83 and 84 are normally biased into their closed positions and are respectively operated into their open positions in response to energization of the corresponding solenoids 83S and 84S. Accordingly, the two-position valve mechanism 80 occupies its normal position, as indicated in FIG. 2, when each of the solenoids 81S, 82S, 83S and 84S is deenergized; while the two-position valve mechanism 80 occupies its operated position, when each of the solenoids 81S, 82S, 83S and 84S is energized.

The local heat-exchange circuit mentioned includes a quantity of coolant which may suitably comprise a brine solution; and specifically, the brine solution may comprise an aqueous solution of calcium chloride. In the arrangement of the local heat-exchange circuit, the fixtures 72 and 73 provided at the opposite ends of the primary cooling coil 71 are respectively connected to two pipes 91 and 92; the fixtures 75 and 76 provided at the opposite ends of the heating coil 74 are respectively connected to two pipes 93 and 94; a pipe 95 is connected to the inlet of the circulating pump 77; and the outlet of the circulating pump 77 is connected to the pipe 93. A bridging pipe 96 is connected between the pipes 91 and 94; a bridging pipe 97 is connected between the pipes 92 and 93; a cross-over pipe 98 is connected between the pipes 91 and 95; and a cross-over pipe 99 is connected between the pipes 92 and 94. In the arrangement, the valves 81 and 82 are respectively positioned in the bridging pipes 96 and 97, and the valves 83 and 84 are respectively positioned in the cross-over pipes 98 and 99.

When the two-position valve mechanism 80 occupies its normal position, the brine is circulated from the pump 77 via the pipe 93 and the fixture 75 through the heating coil 74 and thence via the fixture 76 into the pipe 94; from the pipe 94, the brine proceeds via the bridging pipe 96, the pipe 91 and the fixture 72 through the primary cooling coil 71 and therefrom via the fixture 73 into the pipe 92; and from the pipe 92, the brine proceeds through the bridging pipe 97 into the pipe 95 and thus back to the inlet of the circulating pump 77 to complete the cycle. On the other hand, when the two-position valve mechanism 80 occupies its operated position, the brine is circulated from the pump 77 via the pipe 93 and the fixture 75 through the heating coil 74 and thence via the fixture 76 into the pipe 94; from the pipe 94, the brine proceeds via the cross-over pipe 99, the pipe 92 of the fixture 73 through the primary cooling coil 71 and therefrom via the fixture 72 into the pipe 91; and from the pipe 91, the brine proceeds through the cross-over pipe 98 into the pipe 95 and thus back to the inlet of the circulating pump 77 to complete the cycle. Accordingly, it will be understood that when the two-position valve mechanism 80 occupies its normal position, the brine is circulated through the primary cooling coil 71 from left to right; on the other hand, when the two-position valve mechanism 80 occupies its operated position, the brine is circulated through the primary cooling coil 71 from right to left. Of course, the operation of the local heat-exchange circuit is effective to transfer heat from the primary cooling coil 71 to the heating coil 74, for a purpose more fully explained hereinafter.

Further, the apparatus 10 comprises a first secondary cooling coil 101 arranged in the housing 21 and disposed between the second port 24 therein and the adjacent left-hand side of the primary cooling coil 71, and a second secondary cooling coil 102 arranged in the housing 21 and disposed between the first port 23 therein and the adjacent right-hand side of the primary cooling coil 71. Also, a third two-position valve mechanism, indicated generally at 110 in FIG. 2 is provided for the purpose of selectively controlling the supply of a second coolant to the two secondary cooling coils 101 and 102. More specifically, the two-position valve mechanism 110 comprises two individual valves 111 and 112 respectively provided with operating solenoids 111S and 112S. In the arrangement, the valve 111 is normally biased into its open position and is operated into its closed position in response to energization of the solenoid 111S, while the valve 112 is normally biased into its closed position and is operated into its open position in response to energization of the solenoid 112S. Accordingly, the two-position valve mechanism 110 occupies its normal position, as indicated in FIG. 2, when each of the solenoids 111S and 112S is deenergized; while the two-position valve mechanism 110 occupies its operated position, when each of the solenoids 111S and 112S is energized.

Further, the apparatus 10 comprises a heat sump 120 containing a quantity of brine 121 of the character previously described; and operatively associated therewith is a refrigerating machine 130 that includes a compressor 131, an associated condenser 132, a cooperating expansion valve 133, and an associated evaporator 134, the evaporator 134 being submerged in the brine 121 contained in the heat sump 120. Of course, the refrigerating machine 130 contains a suitable refrigerant that is compressed in the gaseous stage in the compressor 131 and supplied to the condenser 132. In the condenser 132, the compressed gaseous refrigerant is liquified, and the liquified refrigerant is expanded by the expansion valve 133 into the evaporator 134. Ultimately, the expanded gaseous refrigerant is returned from the evaporator 134 back to the compressor 131 to complete the cycle. Of course, the operation of the refrigerating machine 130 effects cooling of the brine 121 contained in the heat sump 120, the heat mentioned being transferred from the evaporator 134 to the condenser 132 and discharged therefrom to the exterior in any suitable manner.

A second local brine circuit is provided that includes a heat exchange coil 141, a circulating pump 142, a regulating valve 143 and two circulating pipes 144 and 145. The circulating pipe 144 is commonly connected to the two valves 111 and 112 that are respectively connected to the inlets of the two secondary cooling coils 101 and 102; while the outlet of the two secondary cooling coils 101 and 102 are commonly connected to the circulating pipe 145. Operation of the circulating pump 142 withdraws brine from the circulating pipe 145 and forces the same through the heat exchange coil 141 and therefrom the brine, after cooling thereof in the heat sump 120, is returned via the regulating valve 143 back to the circulating pipe 144, the heat exchange coil 141 also being submerged in the brine 121 contained in the heat sump 120. One of the valves 111 or 112 occupies its open position; whereby the brine is circulated from the circulating pipe 144 through the corresponding one of the secondary cooling coils 101 or 102 and then is returned to the circulating pipe 145 to complete the circuit. Of course, it will be understood that the operation of the circulating pump 142 effects cooling of the one of the secondary cooling coils 101 and 102 through which the brine

is circulated between the circulating pipes 144 and 145. More specifically, when the two-position valve mechanism 110 occupies its normal positions, indicated in FIG. 2, the brine is circulated through the secondary cooling coil 101; on the other hand, when the two-position valve mechanism 110 occupies its operated position, the brine is circulated through the secondary cooling coil 102.

The regulating valve 143 is of the modulating or throttling type and is controlled by a wet bulb device 46 arranged in the housing 41 adjacent to the port 43 therein, the bulb device 46 being operatively connected to the regulating valve 143 via an associated tube 147. In the arrangement, the bulb device 46 is responsive to the dew point of the air proceeding from the second conduit 12 into the bottom of the housing 41 and is operative to effect throttling of the regulating valve 143 and the consequent control of the rate at which the brine is circulated by the circulating pump 142 between the heat exchange coil 141 and the operating one of the secondary cooling coils 101 or 102.

Further, the appartus 10 comprises an electric control circuit 200, illustrated in FIG. 3, that includes the seven solenoids 65S, 81S, 82S, 83S, 84S, 111S and 112S that have been previously described. Further, the control circuit 200 includes a source of electric power supply, including two conductors 201 and 202, that may be of 115-volts, single-phase, A.-C. In the arrangement, the conductor 201 may be grounded, while the conductor 202 is ungrounded, and the two conductors 201 and 202 are respectively connected by two fuses 203 and 204 to two conductors 205 and 206 that are terminated by a manually operable control switch 210. When the control switch 210 occupies its closed position, the conductors 205 and 206 are respectively connected to two conductors 211 and 212 across which a timer motor 213 is connected. The timer motor 213 may be of any suitable type, but preferably comprises a synchronous motor of the "Telechron" type that includes an operating shaft 214 that is rotated upon a timed basis. The operating shaft 214 is connected by reduction gearing 215 to an operating shaft 216; which operating shaft 216 is connected by a slip clutch 217 to an operating shaft 218. An electric control cam 219 is rigidly secured to the intermediate portion of the operating shaft 218, and the outer end of the operating shaft 218 carries a manually operable control knob 220. In the arrangement, the relative position of the operating shaft 218 may be selectively adjusted with respect to the position of the operating shaft 216 through the action of the slip clutch 217 by appropriate rotation of the manual knob 220; whereby the clock-time position of the electrical control cam 219 may be selectively set with respect to the clock-time position of the operating shaft 216. Operatively associated with the electric control cam 219 are a common wiper 221 and two individual control wipers 222 and 223; and the electric control cam 219 may be divided into a conducting "day" segment and a nonconducting "night" segment commonly cooperating with the control wipers 222 and 223.

Also, the conductor 212 is connected via a crystal diode 231 to a bus 232; a load resistor 233 is connected between the bus 232 and the grounded conductor 201; and likewise, a capacitor 234 is connected between the bus 232 and the grounded conductor 201. Accordingly, when the control switch 210 occupies its closed position, the crystal diode 231 is operative to effect rectification, with the result that a D.-C. voltage is developed across the load resistor 233 that is fairly constant by virtue of the filtering action of the capacitor 234; and the bus 232 is connected to the common wiper 221.

In the arrangement, the control wipers 222 and 223 are disposed diametrically opposite to each other in cooperating relation with the electric control cam 219; whereby the potential appearing upon the bus 232 is applied to the control wiper 222 during the "day" cycle of the electric control cam 219, and the potential appearing upon the bus 232 is applied to the control wiper 223 during the "night" cycle of the electric control cam 219. Further, the two control wipers 222 and 223 are respectively connected to two conductors 241 and 242 that are respectively terminated by two switches 243 and 244 that are respectively governed by two frost-responsive devices, indicated generally at 251 and 261. More particularly, the frost-responsive device 251 includes a bulb 252 that is directly secured to the secondary cooling coil 101, as indicated in FIG. 2; while the frost-responsive device 261 includes a bulb 262 that is directly secured to the secondary cooling coil 102, as indicated in FIG. 2. The bulb 252 is connected via a tube 253 to an expansible bellows 254 that, in turn, is connected to the switch 243; similarly, the bulb 262 is connected via a tube 263 to an expansible bellows 264 that, in turn, is connected to the switch 244.

In the arrangement, the switch 243 normally occupies its open position, and in response to the accumulation of an undue amount of frost upon the secondary cooling coil 101, the bulb 252 governs the bellows 257 in order to actuate the switch 243 into its closed position, for a purpose more fully explained below. Similarly the switch 243 normally occupies its closed position, and in response to the accumulation of an undue amount of frost upon the secondary cooling coil 102, the bulb 262 governs the bellows 264, in order to actuate the switch 244 into its open position, for a purpose more fully explained below.

Finally, in the circuit arrangement, the switches 243 and 244 commonly terminate a conductor 245; and the seven solenoids 65S, 81S, 82S, 83S, 84S, 111S and 112S are commonly bridged in parallel relation across the conductors 201 and 245.

Considering now the general mode of operation of the control circuit 200, and assuming that the control switch 210 occupies its closed position, the timer motor 213 operates alternately to establish the "day" cycle and the "night" cycle of the electric control cam 219; and each of these cycles may conveniently comprise 12 hours of the 24-hour day. During the "day" cycle of the control circuit 200, the conducting segment of the electric control cam 219 is in contact with the control wiper 222 and the insulating segment of the electric control cam 219 is in engagement with the control wiper 223; whereby the potential appearing upon the conductor 232 is applied to the conductor 241 during the "day" cycle. On the other hand, during the "night" cycle of the control circuit 200, the conducting segment of the electric control cam 219 is in contact with the control wiper 223 and the insulating segment of the electric control cam 219 is in engagement with the control wiper 222; whereby the potential appearing upon the conductor 232 is applied to the conductor 242. The presence of the potential mentioned upon the conductor 241 is normally without effect with respect to the energization of the solenoids 65S, etc.; whereas the presence of the potential mentioned upon the conductor 242 normally effects energization of the solenoids 65S, etc. During the "day" cycle of operation of the control circuit 200, in the event of an abnormal accumulation of frost upon the secondary cooling coil 101, the device 251 responds to effect closure of the switch 243 and the consequent energization of the solenoids 65S, etc.; whereby the control circuit 200 is forced into its "night" cycle operation. On the other hand, durnig the "night" cycle of operation of the control circuit 200, in the event of an abnormal accumulation of frost upon the secondary cooling coil 102, the device 261 responds to effect opening of the switch 244 and the consequent deenergization of the solenoids 65S, etc.; whereby the control circuit 200 is forced into its "day" cycle operation.

Considering now the general mode of operation of the apparatus 10 in the "day" cycle of operation, as enforced by the control circuit 200, the seven solenoids 65S, etc.,

are deenergized, with the result that the two-position valve mechanisms 31, 80 and 110 occupy their normal positions; whereby the air that is supplied by the fan 51 into the first conduit 11 proceeds from right to left through the housing 21 and thence through the second conduit 12 and through the housing 41 into the third conduit 13. The air in passing from right to left through the housing 21 first encounters the secondary cooling coil 102 and then the primary cooling coil 71 and then the secondary cooling coil 101. Also, the brine is circulated from the pump 77 through the heating coil 74 and thence through the primary cooling coil 71 from left to right and thence back to the circulating pump 77. Furthermore, at this time, the pump 142 effects circulation of the brine through the heat exchange coil 141 and thence through the secondary cooling coil 101 from left to right and thence back to the circulating pump 142. At this time, in the event there is an accumulation of frost upon the secondary cooling coil 102 (resulting from the prior "night" cycle of operation of the apparatus 10), the frost mentioned is melted therefrom and is drained to the exterior of the housing 21 in any suitable manner, not shown. This contact of the circulated air with the secondary cooling coil 102 effects slight cooling thereof and also possibly some increase in the relative humidity thereof; however, these effects are not substantial and it may be assumed that the air passing into the port 23 in the right-hand end of the housing 21 is already at the ambient temperature and fully saturated. The air next encounters the primary cooling coil 71, as previously noted, whereby both sensible heat and latent heat are removed therefrom, with the consequent reduction of the temperature of the circulated air and of the dew point thereof. The air next encounters the primary cooling coil 101, as previously noted, whereby both sensible heat and latent heat are removed therefrom, with the consequent reduction of the temperature of the circulated air and of the dew point thereof. Next, the circulated air encounters the heating coil 74, as previously noted, whereby only sensible heat is supplied thereto, with the consequent increase of the temperature of the circulated air without alteration of the dew point thereof; whereby the circulated air delivered into the third conduit 13 is normally somewhat cooler and is exceedingly much drier than is the ambient air that is supplied to the first conduit 11.

Considering now the general mode of operation of the apparatus 10 in the "night" cycle of operation, as enforced by the control circuit 200, the seven solenoids 65S, etc., are energized, with the result that the two-position valve mechanisms 31, 80 and 110 occupy their operated positions; whereby the air that is supplied by the fan 51 into the first conduit 11 proceeds from left to right through the housing 21 and thence through the second conduit 12 and through the housing 41 into the third conduit 13. The air in passing from left to right through the housing 21, first encounters the secondary cooling coil 101 and then the primary cooling coil 71 and then the secondary cooling coil 102. Also, the brine is circulated from the pump 77 through the heating coil 74 and thence through the primary cooling coil 71 from right to left and thence back to the circulating pump 77. Furthermore, at this time, the pump 142 effects circulation of the brine through the heat exchange coil 141 and thence through the secondary cooling coil 102 from right to left and thence back to the circulating pump 142. At this time, in the event there is an accumulation of frost upon the secondary cooling coil 101 (resulting from the prior "day" cycle of operation of the apparatus 10), the frost mentioned is melted therefrom and is drained to the exterior of the housing 21 in any suitable manner, not shown. This contact of the circulated air with the secondary cooling coil 101 effects slight cooling thereof and possibly also some increase in the relative humidity thereof; however, these effects are not substantial and it may be assumed that the air passing into the port 24 in the left-hand end of the housing 21 is already at the ambient temperature and fully saturated. The air next encounters the primary cooling coil 71, as previously noted, whereby both sensible heat and latent heat are removed therefrom, with the consequent reduction of the temperature of the circulated air and of the dew point thereof. The air next encounters the primary cooling coil 102, as previously noted, whereby both sensible heat and latent heat are removed therefrom, with the consequent reduction of the temperature of the circulated air and of the dew point thereof. Next, the circulated air encounters the heating coil 74, as previously noted, whereby only sensible heat is supplied thereto, with the consequent increase of the temperature of the circulated air without alteration of the dew point thereof, whereby the circulated air delivered into the third conduit 13 is normally somewhat cooler and is exceedingly much drier than is the ambient air that is supplied to the first conduit 11.

In view of the foregoing, it will be understood that either in the "day" cycle or in the "night" cycle of operation of the apparatus 10, the first encounter of the circulated air with one of the secondary cooling coils 101 or 102 that is not in operation is for the fundamental purpose of defrosting the secondary cooling coil mentioned. Moreover, either in the "day" cycle or in the "night" cycle of operation of the apparatus 10, the circulated air is first cooled by the primary cooling coil 71 and is then further cooled by the operating one of the secondary cooling coils 101 or 102, and ultimately the circulated air is heated by the heating coil 74 before delivery to the third conduit 13. Also, it will be understood that the wet bulb device 46 is responsive to the dew point of the air delivered via the port 43 into the bottom of the housing 41; whereby the regulating valve 143 is correspondingly throttled so as to regulate the temperature of the operating one of the secondary cooling coils 101 or 102, thereby to maintain substantially constant the dew point of the air delivered into the bottom of the housing 41.

Considering now a typical operating example of the apparatus 10: the ambient air supplied by the fan 51 into the first conduit 11 may have a temperature of 70° F. and may be fully saturated. In passing over the primary cooling coil 71, the temperature of the air may be reduced to 57.5° F. and completely saturated. In passing over the operating one of the secondary cooling coils 101 or 102, the temperature of the air may be reduced to 25° F. and completely saturated. In passing over the heating coil 74, the temperature of the air may be increased to 60° F., with a dew point of 25° F. Accordingly, the conditioned air that is supplied via the third conduit 13 to the missile crib, or other equipment making utilization thereof, has a temperature of 60° F. and a dew point of 25° F.; whereby the dew point thereof is well below the frost point (32° F.). Hence the ambient air at complete saturation is conditioned to the lower temperature (60° F.) and substantially dried (25° F. dew point) prior to the supply thereof from the third conduit 13, as noted above.

Furthermore, it will be understood that by virtue of the operation of the local heat-exchange circuit, including the primary cooling coil 71 and the heating coil 74, both the sensible heat and the latent heat that are extracted from the air in passing over the primary cooling coil 71 are supplied as sensible heat to the air in passing over the heating coil 74. This arrangement contributes substantially to the efficiency of the overall conditioning of the air by the apparatus 10. In the present example, 10,000 c.f.m. of ambient air may be conditioned by the apparatus 10 requiring a refrigerating capacity in the refrigerating machine 130 of only 56 tons of refrigeration; on the other hand, the same conditioning of 10,000 c.f.m. of the ambient air, utilizing only the operating one of the secondary cooling coils 101 or 102 would require a

refrigerating capacity in the refrigerating machine 130 of 90 tons of refrigeration.

In view of the foregoing, it is apparent that there has been provided apparatus for continuously conditioning air, both with respect to the temperature thereof and with respect to the relative humidity thereof, that requires no shut-down of any of the principal component elements of the apparatus and that requires no substantial duplexing of the principal component elements of the apparatus.

In the foregoing description, it is noted that the invention has been described in conjunction with the conditioning of air, although the same is equally applicable to the corresponding conditioning of other gases, such as natural gas, methane, ethane, etc.; whereby in the appended claims, the expression "air" should be deemed to cover not only air, but other such gases with respect to the corresponding conditioning thereof.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. Air conditioning apparatus comprising a first conduit, means for supplying air into said first conduit, a second conduit, a first elongated housing having first and second spaced-apart ports therein, means including a first two-position valve mechanism for selectively connecting said first housing in opposite directions between said first and second conduits, wherein the air flows from said first conduit through said first housing in a first direction from the first port therein toward the second port therein and into said second conduit when said first valve mechanism occupies its first position and wherein the air flows from said first conduit through said first housing in a second direction from the second port therein toward the first port therein and into said second conduit when said first valve mechanism occupies its second position, a third conduit, a second housing connected between said second and third conduits, wherein the air flows from said second conduit through said second housing into said third conduit, a primary cooler arranged in the intermediate portion of said first housing, a heater arranged in said second housing, means for connecting said primary cooler and said heater in series relation to form a local heat-exchange circuit, a first secondary cooler arranged in said housing and disposed between said first port therein and said primary cooler, a second secondary cooler arranged in said housing and disposed between said second port therein and said primary cooler, whereby the air flowing through said first housing in said first direction encounters said second secondary cooler and then said primary cooler and ultimately said first secondary cooler and whereby the air flowing through said first housing in said second direction encounters said first secondary cooler and then said primary cooler and ultimately said second secondary cooler, means including a second two-position valve mechanism for selectively supplying a coolant to said first and second secondary coolers, wherein the coolant is supplied to said first secondary cooler when said second valve mechanism occupies its first position and wherein the coolant is supplied to said second secondary cooler when said second valve mechanism occupies its second position, and control means having a first condition for simultaneously operating said valve mechanisms into their first positions and having a second condition for simultaneously operating said valve mechanisms into their second positions.

2. Air conditioning apparatus comprising a first conduit, means for supplying air into said first conduit, a second conduit, a first elongated housing having first and second spaced-apart ports therein, means including a first two-position valve mechanism for selectively connecting said first housing in opposite directions between said first and second conduits, wherein the air flows from said first conduit through said first housing in a first direction from the first port therein toward the second port therein and into said second conduit when said first valve mechanism occupies its first position and wherein the air flows from said first conduit through said first housing in a second direction from the second port therein toward the first port therein and into said second conduit when said first valve mechanism occupies its second position, a third conduit, a second housing connected between said second and third conduits, wherein the air flows from said second conduit through said second housing into said third conduit, a primary cooler arranged in the intermediate portion of said first housing and provided with first and second fixtures, a heater arranged in said second housing, means including a second two-position valve mechanism for selectively connecting said primary cooler in opposite directions in series relation with said heater to form a local heat-exchange circuit containing a first coolant, wherein the first coolant is circulated from said heater through said primary cooler in a first direction from the first fixture thereof toward the second fixture thereof and back into said heater when said second valve mechanism occupies its first position and wherein the first coolant is circulated from said heater through said primary cooler in a second direction from the second fixture thereof toward the first fixture thereof and back into said heater when said second valve mechanism occupies its second position, a first secondary cooler arranged in said housing and disposed between said first port therein and said primary cooler, a second secondary cooler arranged in said housing and disposed between said second port therein and said primary cooler, whereby the air flowing through said first housing in said first direction encounters said second secondary cooler and then said primary cooler and ultimately said first secondary cooler and whereby the air flowing through said first housing in said second direction encounters said first secondary cooler and then said primary cooler and ultimately said second secondary cooler, means including a third two-position valve mechanism for selectively supplying a second coolant to said first and second secondary coolers, wherein the second coolant is supplied to said first secondary cooler when said third valve mechanism occupies its first position and wherein the second coolant is supplied to said second secondary cooler when said third valve mechanism occupies its second position, and control means having a first condition for simultaneously operating said valve mechanisms into their first positions and having a second condition for simultaneously operating said valve mechanisms into their second positions.

3. The air conditioning apparatus set forth in claim 1, and further comprising means responsive to the dew point of the air flowing into said second housing for selectively regulating the coolant that is supplied to the one of said secondary coolers as established by the position of said second valve mechanism.

4. The air conditioning apparatus set forth in claim 1, and further comprising timing means for selectively operating said control means between its first and second conditions upon a predetermined time schedule.

5. The air conditioning apparatus set forth in claim 1, and further comprising a first device controlled by the formation of an undue amount of frost upon said first secondary cooler for operating said control means from its first condition into its second condition, and a second device controlled by the formation of an undue amount of frost upon said second secondary cooler for operating said control means from its second condition into its first condition.

6. The air conditioning apparatus as set forth in claim 1, wherein said primary cooler extracts both sensible heat and latent heat from the air flowing through said first housing, wherein said heater supplies sensible heat to

the air flowing through said second housing, and wherein the total heat extracted by said primary cooler is substantially equal to the total heat supplied by said heater.

7. The air conditioning apparatus set forth in claim 1, wherein said first secondary cooler is in a cooling phase and said second secondary cooler is in a defrosting phase when said second valve mechanism occupies its first position, and wherein said first secondary cooler is in a defrosting phase and said second secondary cooler is in a cooling phase when said second valve mechanism occupies its second position.

8. The air conditioning apparatus set forth in claim 1, wherein said primary cooler extracts both initial sensible heat and initial latent heat from the air flowing through said first housing, wherein the one of said secondary coolers as established by the position of said second valve mechanism extracts additional sensible heat and additional latent heat from the air flowing through said first housing, and wherein said heater supplies sensible heat to the air passing through said second housing without increasing the dew point thereof.

9. The air conditioning apparatus set forth in claim 1, wherein the air supplied into said first conduit is substantially at ambient temperature and is substantially completely saturated, and wherein the air supplied into said third conduit has a temperature below the ambient and a dew point below the frost point.

10. The air conditioning apparatus set forth in claim 1, wherein said first two-position valve mechanism essentially comprises a casing housing a rotatably mounted valve element having first and second positions, said casing communicating with said first and second conduits and also with said first and second ports provided in said first housing, wherein rotation of said valve element into its first position connects said first conduit to the first port in said first housing and connects said second conduit to the second port in said first housing, and wherein rotation of said valve element into its second position connects said first conduit to the second port in said first housing and connects said second conduit to the first port in said first housing.

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