Aug. 3, 1948. H. C. DEARBORN 2,446,411

AIR CONDITIONING UNIT

Filed Aug. 20, 1945 2 Sheets-Sheet 1

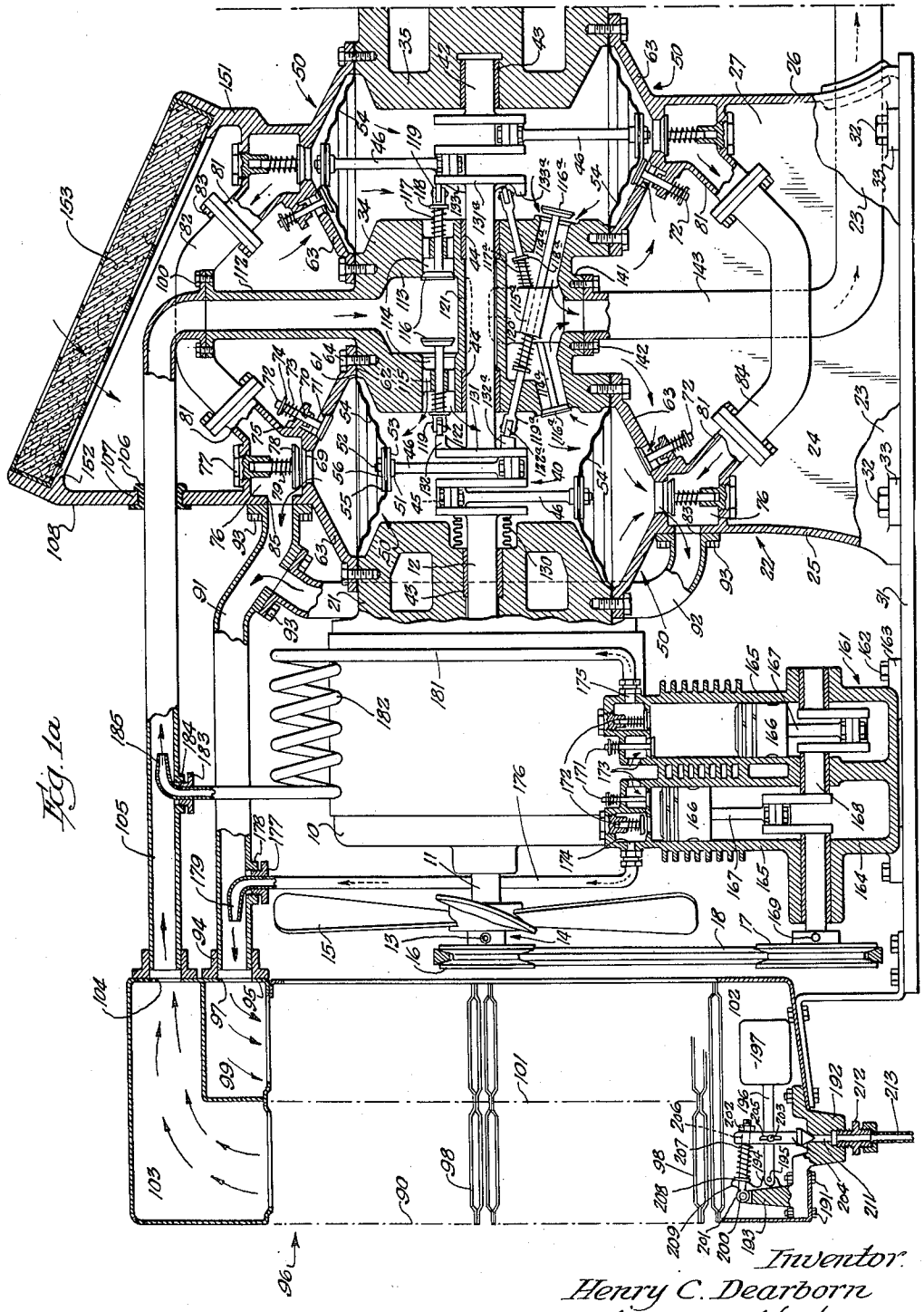


Fig. 1a

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Fig. 2

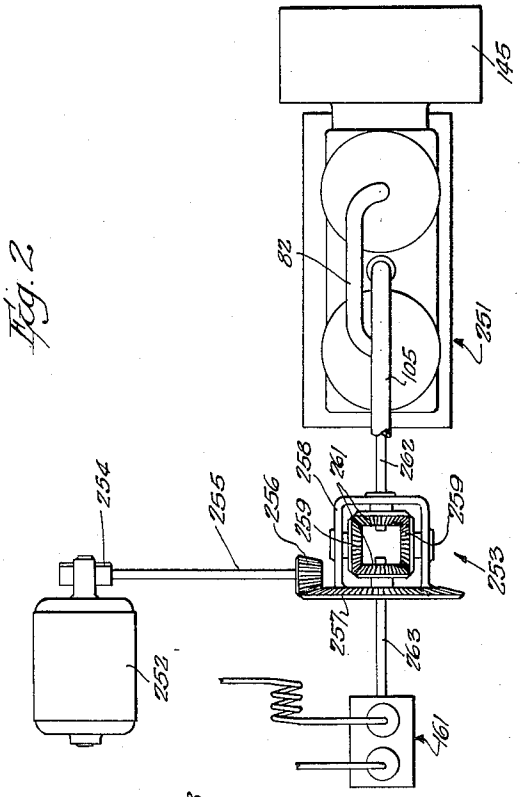
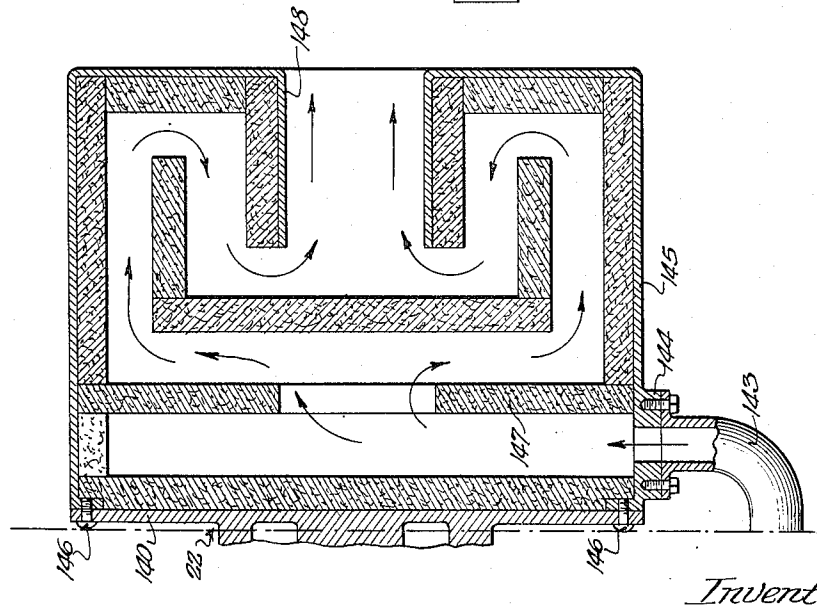


Fig. 1a



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UNITED STATES PATENT OFFICE

2,446,411

AIR-CONDITIONING UNIT

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Application August 20, 1945, Serial No. 611,625

8 Claims. (Cl. 62—137)

1

This invention relates to air conditioning apparatus and more particularly to a device for cooling, dehumidifying and circulating the air in a space.

Many of the conventional types of apparatus for cooling and dehumidifying air employ refrigerating means for the cooling phase and heating means for the dehumidifying phase and the resultant apparatus is not only initially relatively expensive but requires considerable maintenance.

It is the primary object of my invention to provide a device which does not use refrigerant or heating coils but takes advantage of the natural characteristics of air which has been compressed and then permitted to expand.

Another object is to provide an apparatus including a relatively simple pumping unit for withdrawing the warm, humid air from a room or other space, for compressing the same and then permitting its expansion whereby dehumidification and cooling occurs.

Another object is to provide an apparatus as aforesaid in which the warm and humid air, after being compressed, is permitted to circulate through a radiator whereby the air is partially cooled.

A further object is the utilization of the partially cooled air to perform useful work against the pumping elements and thereby result in lowered pumping load and increased efficiency of the unit as a whole.

Yet another object is to include in an apparatus as aforesaid means for automatic disposal of the water resulting from the dehumidifying phase.

A further object is to provide in an apparatus as aforesaid an auxiliary air compressor, the discharge from which is used in an injector device for accelerating the velocity of the air passing from the pumping unit to the radiator and to accelerate the movement of the air leaving the radiator and returning to the pumping unit.

Another object is to provide, in connection with the auxiliary air compressor aforesaid, means for cooling the air discharged therefrom in order that this air when combined with the main body of conditioned air returning to the pump is not raised in temperature.

Another object is to provide an air conditioning unit characterized by relatively few and simple working parts in order that maintenance and repair costs may be reduced to a negligible degree.

Another object is to provide a pumping unit

2

which shall be compact, substantially self-contained and readily portable.

An additional object resides in the reversible nature of the device whereby upon simple repositioning of parts thereof the same may be used for heating the space by withdrawing cold air from the outside atmosphere, compressing the same sufficiently to cause it to flow through the radiator as hot air, the cold air in the space being circulated through the radiator to take up heat therefrom.

Still another object is to provide, in an alternate form of the apparatus, driving means including a differential gearing mechanism whereby the speed of the auxiliary compressor is rendered variable depending upon the demand placed thereon by the pump.

Other and further objects will become apparent as the description proceeds.

In carrying out my invention in one form I provide a diaphragm type of multiple pump adapted to draw air from the space to be conditioned through a filter and, after compression thereof, to deliver the air to a radiator. An electric motor drives the pump which motor also drives a fan for forced circulation of the air through the radiator for cooling thereof. After being cooled in the radiator the air is circulated through a return line back to the pump where it is delivered to the opposite side of the diaphragms in order to reduce the power required for driving the pump. After undergoing expansion, in doing the additional useful work in the pump, the now thoroughly cooled air is returned to the space being conditioned and preferably through a silencing maze. For disposing of the accumulated water of condensation resulting from the dehumidification of the air upon its expansion in the radiator there is provided a float-controlled valve discharging to a sewer. Additionally I may provide an auxiliary air compressor, driven by the motor aforesaid, and arranged to deliver compressed air through nozzles directed downstream in the main delivery conduit from the pump and in the main return conduit thereto whereby to accelerate the flow of air through both conduits. A cooling coil is incorporated in the discharge pipe leading from the air compressor to the main air return conduit.

One preferred form of the invention is shown in the appended drawings, in which—

Figs. 1*a* and 1*b*, comprising one view but broken as indicated because of limitation of sheet size,

show the entire unit principally in medial longitudinal cross section; and

Fig. 2 is a somewhat schematic plan view showing an alternate embodiment of the unit, including differential gearing whereby the speed of the air compressor may be varied depending upon the load to which the system is subjected.

Referring to Figs. 1*a* and 1*b*, I provide an electric motor 10 having shaft extensions 11 and 12 at each end thereof. The forwardly directed extension 11 has affixed thereto by means of a set screw 13 the combined fan and pulley 14. The fan portion includes a plurality of blades 15 of conventional style and the pulley 16 is of the common V-grooved type adapted to drive another V-grooved pulley 17 through the medium of the belt 18.

The rear housing 21 of the motor 10 serving to support the motor proper is formed as part of the main frame 22, the latter including a hollow, enclosed, substantially rectangular base portion having side walls 23 and 24 and end walls 25 and 26 defining a chamber 27. There is provided a main base plate 31 for carrying the entire unit and to which the frame 22 is fastened by means of cap screws 32 passing through ears 33.

Journaled in the housing 21 and in the central and end portions 34 and 35, respectively, of the framework 22 is the crank shaft 40 including the extension 12 of the motor shaft, intermediate bearing section 41 and terminal stub shaft 42, the crank shaft being arranged to rotate in bushings 43 and 44 pressed into the housing 21 and frame portions 34 and 35. The crank shaft 40 includes the four crank pins 45, one individual to each of the pumps 50, the pins 45 being arranged in two pairs spaced 180° apart about the crank shaft. Pivotally connected to the crank pins 45 are the connecting rods 46, four in number, each including the usual bolted cap to retain the rods with respect to the crank pins 45. Each connecting rod 46 is provided with a concentric flange 51 and a threaded end portion 52 over which is received the backing washer 53, the flexible corrugated diaphragm 54, the clamping washer 55 and the clamping nut 56.

The diaphragms 54 are preferably circular in form and may be of rubber or of canvas impregnated with varnish, plastic composition, or similar material for long wear. They are retained at the margin 61 thereof by being clamped between an annular smooth surface 62 of the framework 22 and the pump housings 63, the plurality of cap screws 64 being utilized to force the housing 63 against the diaphragm 54.

Each housing 63 is provided with a side inlet port 71 and a central outlet port 69. Associated with the inlet port 71 is the poppet type valve 72 including a compression spring 73 and spring retaining washer 74, the valve being guided by and reciprocable in an aperture 70 of the bracket 75 integral with the housing 63. The discharge port 69 opens into a chamber 76 formed as a part of the housing 63, and threadedly inserted through one wall of the chamber 76 is the valve guide 77 in which is adapted to reciprocate the poppet-type valve 78 provided with the usual compression spring 79. The upper housings 63 are also provided with an inclined flanged nozzle 81 interconnected by means of the flanged conduit 82 to a corresponding nozzle of the adjacent housing 63, cap screws 83, together with gaskets (not shown) being utilized to yield a tight joint at each junction. The lower housings 63 are provided with similar nozzles 81 interconnected similarly to the two housings at the top of the pump by means of a conduit 84.

A side outlet 85 of the two left-hand chambers 76 are connected together and to the radiator 96 by means of the main air delivery conduit 91 and the branch air delivery conduit 92, gaskets (not shown) and cap screws being availed of to complete the flanged joints for the conduits 91 and 92. The main conduit 91 is welded or otherwise attached to a flange 94 fastened to the wall 95 of the radiator 96.

The radiator 96 may be of the conventional fin and tube type schematically represented for clarity by means of a dot and dash line 90 and by a few sections at 98, it being understood that the fins and the tubes (not shown) are continuous over the entire extent of the radiator 96 and are of sufficient area to effect the proper heat exchange between the air circulated outside of the radiator and the warm air circulated therethrough.

The fins and tubes 98 are disposed on both sides of a partition diagrammatically indicated by the dot and dash line 101. Thus warm air entering the radiator through the conduit 91, aperture 97 and manifold 99 is forced downwardly through the tubes in the right-hand portion of the radiator 96 into the lower manifold 102 and then upwardly on the left-hand side of the partition 101 into the upper manifold 103 from whence it passes through the aperture 104 into the main air return conduit 105.

The conduit 105 passes through a rubber sealing grommet 106 inserted through an aperture 107 in the wall 108 forming part of the two upper housings 63 and is connected by means of cap screws 109 and a gasket (not shown) to the nozzle 112 extending upwardly from the central portion 34 of the frame.

The central frame portion 34 includes a chamber 113 interconnecting by means of the ports 114 with the two spaces intermediate each pair of diaphragms 54, the said space being otherwise closed by appropriate walls constituted as part of the main frame and by horizontal partitions 120 intermediate the central shaft housing 121 and the walls 23 and 24. Supported by ribs extending radially from the wall of each port 114 is the guide 115 in which the poppet-type valves 116 are adapted to reciprocate, these including the usual compression spring 117, retaining washer 118 and a bifurcated end 119 in which the cam following roller 122 is adapted to rotate. Corresponding to the upper pair of valves 116 is a similar lower pair 116*a* adapted to open and close ports 114*a* and supported on guides 115*a*. Springs 117*a* and retaining washers 118*a* are provided together with the bifurcated ends 119*a* and cam rollers 122*a* corresponding to similar parts associated with the upper valves 116.

Formed on the outer face of the crank throws 131 and 131*a* are the cams 132, 132*a*, 133 and 133*a*, each pair being spaced 180° apart and for a purpose to be described.

The chamber 113 interconnects with the ports 114*a* and with a nozzle 141 to which is connected by means of a gasket (not shown) and the cap screws 142 the cooled air supply conduit 143. The latter continues (Fig. 1*b*) to connect with a nozzle 144 forming part of the rectangular casing 145 attached by means of screws 146 to a bracket plate 140 forming part of the main frame 22.

The casing 145 is adapted to support therein

the panels of sound absorbent material 147 arranged in labyrinthine manner as shown, in order that the cool air being delivered therethrough is effectively baffled to reduce its velocity and eliminate drafts, and to throttle any pulsating motor noise caused by the pumping strokes to the greatest possible extent. Delivery of the cooled air to the room is through the opening 148.

The framework 22 includes also an upper right hand wall portion 151 which, together with the walls 23, 24 and 108, carries a flange 152 supporting the air filter unit 153. The latter is of the conventional type having a perforated sheet metal frame enclosing glass wool or similar fibers saturated with a viscous fluid or the like to trap foreign particles.

A bellows or similar type of seal 130 is interposed between the extreme left hand crank throw 131 and the housing 21 to prevent leakage of air past the left hand bushing 43.

Although the principal embodiment herein described and illustrated includes four pumping units, it will be comprehended that a greater plurality or even a single pump may be employed.

Mounted on the base plate 31 is the auxiliary air compressor 161 attached thereto by means of cap screws 162 passing through the ears 163 formed as part of the compressor housing 164. The compressor is of the conventional type including a pair of cylinders 165, a pair of pistons 166, connecting rods 167 and crank shaft 168, to one outboard end of which the pulley 17 hereinbefore referred to is affixed by means of the set screws 169. There are also provided the usual inlet valves 171 and exhaust valves 172, the inlet ports being designated at 173 and the exhaust ports at 174 and 175.

Connected to the port 174 is the conduit 176 which extends upwardly through a threaded bushing 177 inserted in a flange 178 extending from the wall of the main delivery conduit 91. Within the conduit 91 the conduit 176 is bent into a right angle and terminates in a tapered nozzle 179 directed downstream. The port 175 connects to a conduit 181 which has the helical coil 182 formed therein and continues through a threaded bushing 183 inserted in a flange 184 extending from the wall of the return conduit 105. The upper end of the conduit 181 is bent at a right angle and terminates in a tapered nozzle 185 also directed downstream.

Attached to the floor of the manifold 102 by means of bolts 191 is the bracket 192 having an upstanding post 193. To a projection 194 of the bracket 192 is pivoted as at 195 the lever 196 carrying the float 197. At the upper extremity of the post 193 a pivot 200 carries the link 201 bearing a nut 202. Adapted to slide vertically on a pin 203 outstanding from the lever 196 is the needle valve plunger 204 having a slotted aperture 205 to engage the pin 203 and a circular aperture 206 at right angles thereto, the link 201 passing through the aperture 206 and a compression spring 207 together with its retaining washer 208 being interposed between the plunger 204 and a bifurcated guide 209 extending from the side of the post 193. The bracket 192 includes the bore 211 interconnecting by means of the threaded adapter 212 with the discharge line 213 passing to a drain.

Operation

While it will be understood that the device is primarily intended for room cooling and is shown and described with that object in view, it is not, of course, limited to such applications and may, without alteration affecting the essence of the invention, be adapted to installations of other kinds, some of which will be referred to hereinafter.

In the illustrative embodiment shown, the air is drawn from the space being conditioned through the filter 153 by means of the plurality of pumps 50, the air in its passage to the pumps being confined between the walls 108, 151, 23, 24, 25 and 26 and is admitted to the interior of the pumps through the valves 72, these opening inwardly upon the suction stroke of the pump and being normally spring-closed. Rotation of the motor 10 reciprocates the rods 46 to flex the diaphragms 54 for pumping action, it being noted that due to the arrangement of the crank pins 45 the two left-hand pumps 50 are on suction while the two right-hand pumps are on discharge. In this manner a smooth, relatively non-pulsating flow is effected, as is understood in the art. Upon the compression stroke the air is forced from the pumps outwardly through the valves 78, these being normally spring-closed and through the conduits 82 and 91, or 84, 92 and 91, through the aperture 97 and into the tubes 98 of the radiator 96 wherein the compressed air is permitted to cool. Such a drop in temperature precipitates moisture carried by the air.

After being circulated through the radiator 96 the cooled air passes through the chamber 103, aperture 104, main return line 105, nozzle 112 to the valves 116. At the instant when the diaphragm 54 of the upper left-hand pump is beginning its compression stroke the cam 132 has rotated to a position wherein it has fully opened the valve 116. Thus the air being returned from the radiator 96 is admitted to the lower face of the diaphragm 54, or upper face depending upon whether the lower pumps are referred to, to assist the same in its succeeding compression stroke. Thus during the compression stroke the air may expand and perform useful work in reducing the power required to drive the pumps. Upon the following reciprocation of the diaphragm 54, that is, on the suction stroke, the cam 133*a* has rotated to a position to open the valve 116*a* and the spent air is discharged through the valve 116*a* and the conduit 143.

Inasmuch as the air has, by this time, undergone a drop in temperature in the radiator 96 and a further drop by reason of the work performed within the pump, it has been cooled to a substantial extent whereupon it is discharged through the silencing maze within the casing 145 and the opening 148 therein into the space being conditioned.

It will be understood that by reason of the symmetrical arrangement of the four pumps 50 and of the cams 132, 132*a*, 133 and 133*a* the action just described in connection with the two left-hand pumps occurs in the two ring-hand pumps, but in alternate phase.

As hereinbefore mentioned, cooling of the air in the radiator 96 results in the precipitation of a substantial amount of moisture. This water is permitted to accumulate in the space 102 whereupon, as the fluid level rises, the float 197 will be swung counterclockwise to urge the pin 203 to the top of the slot 205. Due to the over-center action of the spring 207 the valve 204 is snapped open and the water allowed to drain through the pipe 213. Upon consequent lowering of the water level the action is reversed, whereupon the over-center spring will snap the valve 204 to closed position.

Cooling of the air in the radiator 96 is effected by the fan blades 15 in an obvious manner. The heat yielded by the air cooled within the radiator 96 is discharged through any suitable opening in the wall of the building and to the outside atmosphere.

To accelerate the flow of air through the main and return delivery conduits 91 and 105 respectively, and to increase the volume thereof in order to attain substantially equal pressures on both sides of the diaphragms 54, the auxiliary compressor 161 is arranged to force air compressed therein through the pipes 176 and 181 and to deliver the same through the nozzles 179 and 185 at a substantial velocity in a downstream direction. An injector effect accordingly results and creates a vacuum behind the nozzles 179 and 185 to accelerate the flow of air through the conduits 91 and 105. Inasmuch as the air returning in the conduit 105 has been cooled it is necessary that the compressed air used for the injector action therein likewise be cooled before being blended with the returning air. This step is effected in the radiator coil 182.

By reason of cooling within the radiator 96 the air is, as mentioned, dehumidified to some extent and expansion occurring within the pumps 50, as already described, will effect further dehumidification. Although not shown, it will be comprehended that any condensate accumulated within the pumps may be disposed of by suitable vents associated with a float and valve mechanism as described in connection with the radiator, or by any other suitable type of trap.

It will be understood that for the air-cooled radiator 96 I may substitute an equivalent heat exchanger utilizing water. Thus the heat yielded by the air upon expansion may heat the water which, in turn, may be utilized for any purpose wherein hot water is desired. In this event the fan blades 15 would be dispensed with.

It is not intended to limit the invention to a unit including pumps employing flexible diaphragms since piston, gear type or vane pumps could be used with equal effect. Nor is the invention intended to be limited to poppet-type valves since these may be of the disc, flutter, or rotary types.

The unit may be so arranged that the auxiliary compressor 161 and the radiators 96 and 182 are exteriorly of the room to be cooled, for example, contained in a box supported outside of a window. Thus any cooling effect inherent in the outside atmosphere may be utilized to facilitate the cooling action for those portions of the apparatus.

In order to insure the circulation of a sufficient volume of air within the unit to provide the necessary pressure on the under side or top side of the diaphragms, a suitable valve may be inserted in the conduit 143 to control the exit of spent air from the unit. Such valve may be provided with a pressure-operated device for automatic opening and closing thereof.

In Fig. 2 is shown in somewhat schematic form an alternate arrangement wherein the pumping unit shown collectively at 251 and the auxiliary compressor 161 are driven from the motor 252 through a differential gearing mechanism 253. Power is taken from the motor 252 through a suitable speed reducing unit 254, the output shaft 255 of which carries the bevel drive pinion 256.

The pinion 256 drives the bevel ring gear 257 to which is affixed the usual differential case 258 carrying the pair of differential pinions 259 driving the differential gears 261. The latter are affixed to the shafts 262 and 263 driving the pumping unit 251 and compressor 161 respectively.

By using the differential gearing arrangement shown, the entire unit is enabled to adjust itself to varying conditions of operation. In the event an insufficient volume of air does not reach the underside of the diaphragms 54 to assist them in their compression stroke as already described, the auxiliary compressor 161 will operate at higher speed to supplement the volume of air flowing through the supply and delivery conduits 91 and 105, respectively, and thereby deliver the additional volume of air required to the underside of the diaphragms 54. At the same time the differential will drive the pumping unit 251 at a slower speed and these relative differences in speed between the compressor 161 and unit 251 will continue until the system is required to accommodate itself to a different set of conditions, the differential meanwhile adjusting the speeds of its output shafts 262 and 263 as required by the relative loads.

It will be apparent that the unit may be employed for heating the air in a space by arranging the apparatus so that cold air may be drawn in from the outside atmosphere, compressed in the pumping units and circulated through the radiator. By means of the fan the cold air in the space is circulated past the radiator to extract heat from the air therein. By a suitable arrangement of ducts and dampers the unit may be arranged so that it may be easily converted from air cooling to air warming for summer or winter conditioning or vice versa, as desired.

While I have shown particular embodiments of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A space air conditioning apparatus comprising in combination an air pump, air cooling means, means interconnecting said pump with said cooling means including a delivery conduit and a return conduit, said pump including a diaphragm for withdrawing air from the space, compressing the same and delivering the air to said cooling means, said withdrawal, compression and delivery being effected on one face of said diaphragm, said return conduit being adapted to deliver the partially cooled air to the other face of said diaphragm to impart energy to said diaphragm, and means for delivering the spent, thoroughly cooled air to the space.

2. A space air conditioning apparatus comprising in combination an air pump adapted to draw air from the space and to compress the same, means for cooling the compressed air and permitting its expansion while undergoing cooling, a delivery conduit for passage of air from said pump to said cooling means, a return conduit for passage of the cooled air from said cooling means to said pump for performance of useful work therein, means for delivering the spent air from said pump to the space, an auxiliary air compressor, means for delivering supplementary air from said compressor at substantial velocity to within said delivery and return conduits, the said last mentioned means being arranged to direct said supplementary air in a downstream direc-

tion within said conduits to accelerate the flow of air in said conduits.

3. A space air conditioning apparatus comprising in combination an air pump adapted to draw air from the space and to compress the same, means for cooling the compressed air including a chamber to permit expansion of the air while undergoing cooling, a delivery conduit for passage of air from said pump to said cooling means, a return conduit for passage of the cooled air from said cooling means to said pump for performance of useful work therein, means for delivering the spent air from said pump to the space, and means for adding air to the volume of air extracted from the space.

4. A space air conditioning apparatus comprising in combination an air pump adapted to draw air from the space and to compress the same, means for cooling the compressed air including a chamber to permit expansion of the air while undergoing cooling, a delivery conduit for passage of air from said pump to said cooling means, a return conduit for passage of the cooled air from said cooling means to said pump for performance of useful work and further cooling therein, means for delivering the spent air from said pump to the space, and an auxiliary air compressor for adding air to the volume of air extracted from the space.

5. A space air conditioning apparatus comprising in combination an air pump adapted to draw air from the space and to compress the same, means for cooling the compressed air including a chamber to permit expansion of the air while undergoing cooling, a delivery conduit for passage of air from said pump to said cooling means, a return conduit for passage of the cooled air from said cooling means to said pump for performance of useful work and further cooling therein, means for delivering the spent air from said pump to the space, an auxiliary air compressor, means for injecting air from said compressor to said conduits to accelerate flow therein.

6. A space air conditioning apparatus comprising in combination driving means, a pump operated by said driving means and adapted to withdraw air from the space and to compress the same, a heat exchanger including a chamber to receive the compressed air and to permit its cooling and expansion therein and means for disposal of water condensed from said cooled air, means for cooling the air contained in said chamber, means for delivering the compressed air from said pump to said chamber, and means for returning the cooled air from said chamber to said pump, said pump having air displacing

elements adapted during the compression stroke to compress the air removed from the space and to utilize the expansive force of the expanded cooled air in aiding said compression stroke.

7. A space air conditioning apparatus comprising in combination a heat exchanger having an inlet and an outlet, a pump including a diaphragm, intake valve means and discharge valve means both adjacent one face of said diaphragm, recycling valve means adjacent the other face of said diaphragm, a pumping chamber on either face of said diaphragm, each said valve means including a port, the intake port being in fluid communication with the space to be conditioned, the discharge port being in fluid communication with the inlet of said heat exchanger, and the recycling port being in fluid communication with the outlet of said heat exchanger, means for cooling the contents of said heat exchanger, and means for delivering recycled air from the chamber associated with the recycling port to the space to be conditioned.

8. A space air conditioning apparatus comprising in combination a heat exchanger having an inlet and an outlet, a pump including an air displacing element having two working faces, a chamber associated with each said face, an intake valve and a discharge valve, each said valve including a port associated with one said chamber, a recycling valve including a port associated with the other said chamber, means forming a passage from the space to be conditioned to the intake port, means forming a second passage from the discharge port to the inlet of said exchanger, and means forming a third passage from the recycling port to the outlet of said exchanger, means for delivering recycled air from the chamber associated with the recycling port to the space to be conditioned, an auxiliary air compressor including a pair of discharge ports and means interconnecting said second and third passages with said last mentioned discharge ports respectively whereby compressed air from said compressor supplements the volume of air flowing through said second and third passages and accelerates the velocity thereof.

HENRY CURREY DEARBORN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,495,663	Belluzzo	May 27, 1924

Certificate of Correction

Patent No. 2,446,411. August 3, 1948.

HENRY CURREY DEARBORN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 5, line 5, strike out the word "motor"; column 6, line 62, for "ring-hand" read *right-hand*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of November, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.