

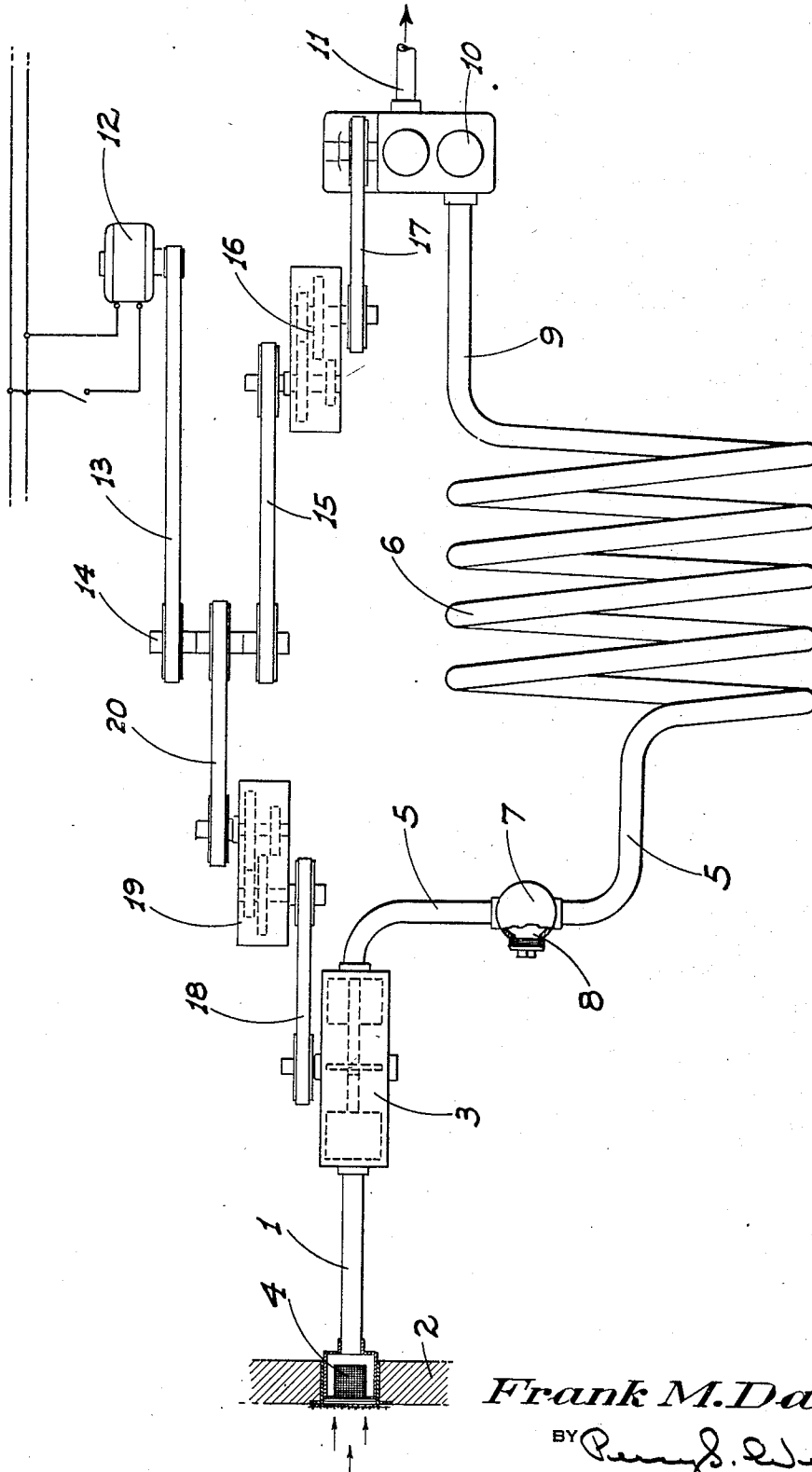
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MECHANICAL SYSTEM FOR HEATING OR COOLING AIR

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MECHANICAL SYSTEM FOR HEATING OR COOLING AIR

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This invention relates to a mechanical system for heating or cooling air for use in hospitals, theaters and other public buildings as well as for residences and various industrial purposes.

The principal object of my invention is to provide a system for the purpose which is especially useful for heating purposes and one in which great efficiency and economy in operation is attained, since the heating effect produced is greater than the net mechanical power consumed.

Though, as above stated, the system is particularly adapted and useful for air heating purposes, it may be also arranged to produce a cooling effect on the air.

A further object of the invention is to produce a simple, inexpensive and flexible system and yet one which will be exceedingly effective for the purpose for which it is designed.

These objects I accomplish by means of such structure and relative arrangement of parts as will fully appear by a perusal of the following specification and claims.

The figure on the drawing is a diagrammatic plan of my improved air heating system.

My system operates on the principle of drawing in a supply of air from a relatively cool source, discharging it at its other end, and treating such air between its intake and discharge in a particular manner such that when discharged it will be considerably hotter than when taken into the system. The warmed air may be discharged directly into the area to be heated or into radiators or it may be given an additional heating by any other means if desirable before its use.

The air passage feature of the system comprises an air intake pipe 1 leading from the exterior of the building 2 to an air motor 3, with a screen 4 of suitable character preferably interposed in the passage between the atmosphere and the motor to keep dirt out of the system.

The exhaust pipe 5 from the motor leads to a heat transfer apparatus such as coil 6, there being a chamber 7 in the exhaust pipe in which moisture or congealed moisture may

collect and from which such moisture or congealed moisture would be drawn off when necessary through a port 8 in such chamber. From the coil 6 a pipe 9 leads to the intake of air pump 10, whose outlet pipe 11 discharges directly into the room to be heated or into a heating radiator.

From the above, it will be seen that the various pipes, together with the casings of the air motor, pump, and heat transfer device, form a continuous conduit in which said motor pump and device are interposed.

The air pump is connected in driving relation with a prime mover of any suitable character such as an electric motor 12, by means of a belt drive 13 from the motor to a countershaft 14, another belt drive 15 from the countershaft to one shaft of a change speed transmission 16, and another belt drive 17 from the other shaft of the transmission to the pump. The air motor aids the prime mover or electric motor in thus driving the air pump by means of a belt drive 18 from the air motor to one shaft of a change speed transmission 19 and another belt drive 20 from the other shaft of the transmission to the countershaft 14. I have here definitely called for and specified a number of belt drives, but it is to be understood that I do not wish to limit myself to this type of drive since any suitable form of driving connection between the various parts may be used as will be evident.

Also I specified a coiled pipe for a heat transfer apparatus, though reverse bends, aerofins or any suitable type of heat transfer apparatus could be used.

Also both the air motor and the air pump may be of rotary, reciprocating, turbine, centrifugal or any type suitable for the purpose which will withstand the temperature conditions imposed and work without excessive noise or odor.

The principle of operation of this system is that the air is drawn through the air motor by the operation of the air pump, driving said motor which causes the air to be automatically chilled below its original temperature after it leaves the motor, by reason of its thus expending power in driving the

motor. A certain amount of this heat is regained by the air as it passes through the heat transfer apparatus and a further heating is imparted adiabatically to the air as it is then compressed by the air pump and discharged into the room or radiator.

Or after leaving the system the air may be humidified or given additional heat by some other means or conditioned in other ways if desired.

The air pump is driven at such a speed relative to the speed of the air motor as to have a large volumetric displacement relative to the intake capacity of the air motor so that the air in the heat transfer apparatus and the discharge pipe of the motor will be maintained at a low pressure relative to the pressure of the air at the intake of the motor. This pressure difference actuates the air motor causing it to act as a prime mover, developing power from the air passing through it. This results in the temperature of such air being cooled to a certain extent below the temperature at which it entered the motor. The air is thus rendered capable of absorbing heat at a comparatively low temperature relative to the temperature at which it entered the air motor. The air is not only cooled at this time but by reason of the operation of the air motor and the driving connection of the same with the prime mover 12, such air in expanding through the air motor aids the prime mover in driving the air pump. It is however not absolutely necessary that the air motor shall thus aid the prime mover, since if desired the power developed by the air motor could be used for some other purpose and the necessary additional power to properly operate the air pump be supplied by the use of a larger prime mover.

When acting to heat air it is essential that the heat transfer apparatus be in thermal contact with an environment which is warmer than the air passing through it. Said apparatus may be heated by waste heat from an industry, exhaust steam, flue gases, or by heated air from ventilation. It will usually be sufficient however to locate said apparatus outside the building to receive heat from the sun and atmosphere. In general however it may be stated that as long as this apparatus is located where the surrounding air is warmer than that passing through it will function for its purpose.

After passing through the heat transfer apparatus the air is compressed by the pump which of course heats the air. The more heat absorbed by the air in passing through the system, the greater is its efficiency in heating the air. This efficiency would be a maximum if the expansion in the air motor were isothermal, but that is impossible in practice for obvious reasons. It will usually be sufficient to expand the air almost

adiabatically in the air motor, letting it absorb heat in the heat transfer apparatus after expansion.

To show the operation of the system let us consider as an example a case in which the system is operating to heat air for a building, admitting air to the air motor at a temperature of 40° F. (which is 500° R. or absolute temperature) and at an absolute pressure of 1 atmosphere. Suppose the pressure at the discharge of the air motor is maintained at 0.750 atmosphere absolute pressure by the air pump. Also assume adiabatic expansion in the air motor. The temperature of the air discharging from the air motor is therefore

$$500 \times \left( \frac{0.750}{1} \right)^{.29} = 459^\circ \text{ R. or } -1.0^\circ \text{ F.,}$$

which is 41° colder than the air outside the building. The heat transfer apparatus is also considered as being located outside the building where it is in thermal contact with the atmosphere at the temperature of 40° F. And suppose the area or length of the heat transfer apparatus is such that in this case the air passing through the same is heated from -1° F. to 30° F., or 490° R.; an increase of 31° F. in temperature.

Taking the heat capacity of air at constant pressure as 0.242 B. t. u. per lb. per degree, the heat absorbed is  $31 \times 0.242 = 7.50$  B. t. u. per lb. Suppose also that due to air friction in the heat transfer apparatus the air pressure on arriving at the intake to the air pump is only 0.70 atmosphere absolute pressure instead of 0.75. After the air is recompressed adiabatically in the air pump back to 1 atmosphere pressure its final temperature will then be

$$490 \times \left( \frac{1}{0.70} \right)^{.29} = 542^\circ \text{ R., or } 82^\circ \text{ F.}$$

at which temperature the air goes directly into the room as warm air. The air in passing through the system has therefore increased in temperature from 40° F. to 82° F., or a total of 42°. The total heating effect is  $42 \times .242 = 10.16$  B. t. u. per lb. of air heated. The theoretical net power consumed by the operation of the electric prime mover 12 is the electrical equivalent of  $10.16 - 7.50 = 2.66$  B. t. u. per lb. It will thus be seen that even allowing for an actual inefficiency due to mechanical and heat losses the efficiency of my system is considerably greater than when heat from the customary electrical resistance wires or similar heat alone is relied on to heat the air.

While in the above case certain compression and expansion ratios and temperature changes were specified, still these and other factors may be varied to suit the conditions met in practice. Thermometers, pressure gauges and throttling valves, besides the change speed drives, may be suitably located

in the system, so the system can be adjusted to changing temperature conditions outside the building to deliver air at the required pressure, quantity and temperature desired inside the building.

If the same system is to be used for both heating and cooling air it is only necessary that the air pump and the air motor be of reversible types or that their relative speeds be changed by means of the change speed devices. If the air motor 3 is speeded up it acts as an air pump and the pump 10 when slowed down acts as an air motor. The system then discharges air at the outlet 11 which will then be lower in temperature than the air temperature at the intake 1.

Another way in which this might be accomplished is by having the machines of types that can be reversed in direction of rotation, leaving the device 10 to act as an air pump, but taking in air through the member 11; the cooled air being discharged through pipe 1 from air motor 3.

If these parts are not reversible the same effect can be accomplished by interchanging various ones of the pipe connections so that the air pump draws in fresh air to be cooled, while the air as it is cooled is discharged from the air motor.

When the system is acting to cool air it is essential that the air pump be driven by the prime mover at such a speed relative to that of the air motor as to have a large volumetric intake capacity relative to the intake capacity of the air motor so that the air is compressed by the air pump which, at the same time, heats the air.

The heat transfer apparatus must be in thermal contact with a medium which is cooler than the air passing through it, such medium may consist of cold water or of evaporating water, tho it will usually be sufficient to place said apparatus outside the building to dissipate heat by radiation and contact with the atmosphere. A further cooling of the air is effected when the air expands thru the air motor developing power which power may be used to assist the prime mover in driving the air pump. The air is discharged from the air motor as cooled air. It will generally be used as it is discharged, tho it can be humidified, further cooled by some other means, or otherwise conditioned to meet special requirements.

For an example of the operation of the system to cool air for a room assume that atmospheric air at a temperature of 100° F. enters the intake of the air pump. After adiabatic compression by the air pump to say 1.5 atmospheres absolute pressure its temperature is

$$(100 + 460) \left( \frac{1.5}{1} \right)^{.29} - 460 = 210^{\circ} \text{ F.}$$

Suppose it is then cooled from 210° F.

down to 150° F. in the heat transfer apparatus and is then expanded adiabatically in the air motor back to atmospheric pressure. Its final temperature is

$$(150 + 460) \left( \frac{1}{1.5} \right)^{.29} - 460 = 82^{\circ} \text{ F.}$$

And it goes at that temperature directly into the room where cooled air is desired. The theoretical net power consumed by the prime mover is the mechanical equivalent of  $0.242 (210 - 150) - 0.242 (100 - 83) = 10.12$  B. t. u. per pound of air cooled.

Still another way in which the system can be used to cool air for a room is to cool the air for the room by passing it over the outside of the heat transfer apparatus, or the heat transfer apparatus can be located inside the room to cool the air in the room. Air, other than that for the room, is used as the medium that is cooled by expansion through air motor 3, and is drawn through heat transfer apparatus 6 where it absorbs heat from the air to be cooled for the room. The air medium is finally compressed and rejected from the system by means of the power driven air pump 10. In this case the parts have the same relative arrangement as shown in the drawing and the air pump must be of larger volumetric intake capacity than the air motor.

From the foregoing description it will readily be seen that I have produced such a device as substantially fulfills the objects of the invention as set forth herein.

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

1. A system to alter air temperature comprising an air motor, an air pump, a heat transfer device, air conduits between the outlet of the motor and device and between said device and the intake of the pump, a prime mover to operate the pump, separate driving connections between the pump and prime mover and between said prime mover and the air motor, and independent speed change devices in said driving connections whereby the relative speed of the air motor and air pump may be altered.

2. A system to alter air temperature comprising an air motor, an air pump, a heat transfer device, air conduits between the outlet of the motor and device and between said device and the intake of the pump, means to drive the pump, means to mechanically maintain the speed of the air motor at a definite ratio to that of the air pump, and means to alter such ratio at will.

3. A system for altering air temperature comprising air compressing means, a heat transfer device for altering the temperature of the air while compressed, an air actuated device through which said air then passes, means to maintain the speed of said air ac-

tuated device at a definite ratio to that of said compressing means, and means to alter such ratio at will.

4. A system for altering air temperature comprising separate mechanical air circulating devices, a conduit connecting said devices, a heat transfer device interposed in the conduit between the devices, means to maintain said devices operating at a definite speed ratio, and means to reverse such ratio at will.

5. A system for altering air temperature comprising separate mechanical air circulating devices, a conduit connecting said devices, a heat transfer device interposed in the conduit between the devices, means to maintain said devices operating at a definite speed ratio, and means to alter such ratio at will.

In testimony whereof I affix my signature.

FRANK M. DARROW.

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