United States Patent [19]

Brown

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[54] **AIR CONDITIONING PROCESS**

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Related U.S. Application Data

[60] Division of Ser. No. 359,368, May 11, 1973, Pat. No. 3,812,685, which is a continuation-in-part of Ser. No. 172,968, Aug. 19, 1971, abandoned.

[52] **U.S. Cl.** **62/91,** 62/311, 62/314, 62/93

[51] **Int. Cl.** **F25d 17/06**

[58] **Field of Search** 62/311, 314, 91, 93

[56] **References Cited**

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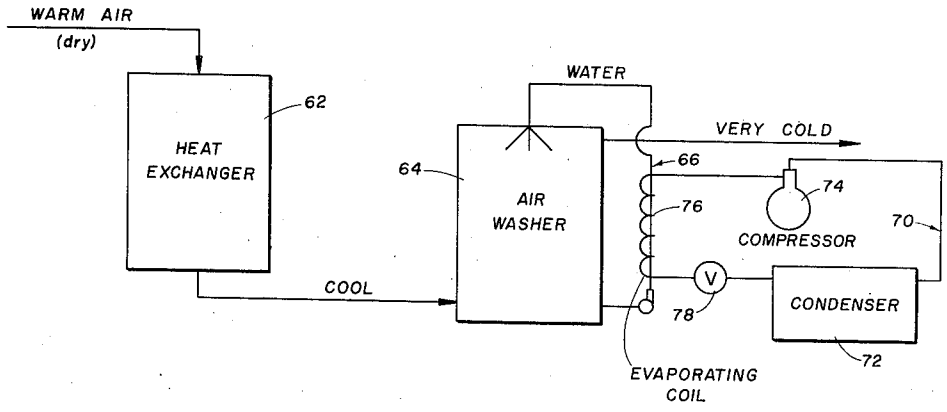
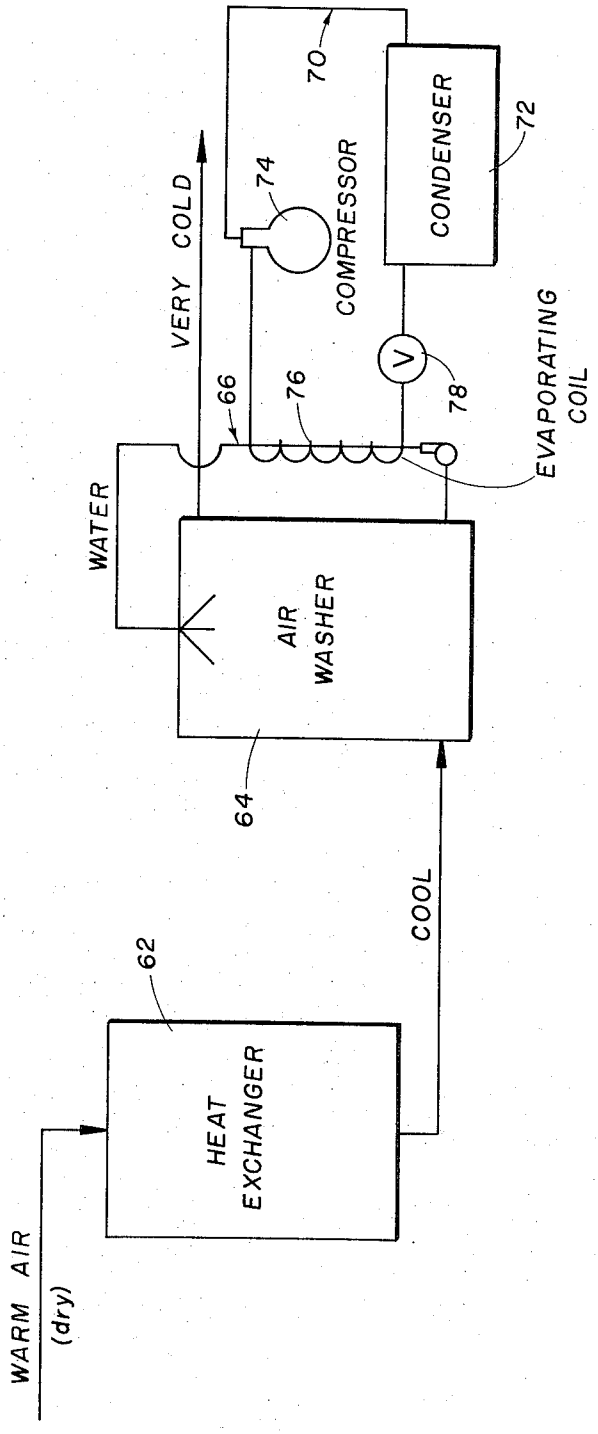
[57] **ABSTRACT**

A process for efficiently conditioning air for beneficial use by sequentially cooling dry air in three distinct steps, e.g., pre-cooling the air out of the presence of moisture, adiabatically cooling the air with recirculating cooling liquid, and refrigerating the recirculating cooling liquid to assure that the temperature of the cooling liquid is low enough to make the air cold.

2 Claims, 1 Drawing Figure




70
CONDENSER
72
74
COMPRESSOR
VERY COLD
66
76
78
EVAPORATING COIL
WATER
AIR WASHER
64
COOL
62
HEAT EXCHANGER
WARM AIR
(dry)

AIR CONDITIONING PROCESS

This invention is a division of my copending application Ser No. 359,368, filed May 11, 1973, now U.S. Pat. No. 3,812,685 which is in turn a continuation-in-part of my copending application Ser No. 172,968, filed Aug. 19, 1971 (now abandoned).

BACKGROUND

1. Field of the Invention

The present invention relates to the production of low temperature gases such as air for beneficial use in air conditioning.

2. The Prior Art

It is well-known that the efficiency of air conditioning systems is highly dependent upon the temperature of ambient air. In summer months, where the ambient air temperature is high, usually refrigerated air conditioning systems are employed to produce consistently cold air. This is particularly true where high temperatures are accompanied by relatively high humidity levels. So-called "swamp cooler" type air conditioning systems become of almost negligible value when both the temperature and humidity of ambient air are high.

Because of the great difficulty with which air is reduced to a very low temperature in hot summer months, most air conditioning systems have been engineered so as to recirculate and recool the conditioned air instead of continuously cooling fresh air. This procedure has been found necessary to keep the size and attendant costs of air conditioning systems from becoming prohibitive. Until this present invention, an economical and efficient way of substantially reducing the temperature of air or other gas for cooling purposes year-round without refrigeration has not been known.

It is also well-known to condition air by successive cooling, humidifying, drying and recooling steps which are inefficient, complicated and expensive. See, for example, U.S. Pat. No. 1,863,578.

BRIEF SUMMARY AND OBJECTS OF THE INVENTION

The present invention relates to conditioning fresh air by sequentially (1) pre-cooling dry air out of the presence of moisture, (2) adiabatically cooling the air, and (3) refrigerating the adiabatic cooling liquid to assure that the temperature of the cooling liquid is low enough to produce cold air. Surprising efficiency and cooling results from this process using a total fresh air system and treatment of the air in quantities between 400 and 600 cubic feet per minute per ton of net sensible in-space cooling.

It is, therefore, a primary object to efficiently provide air having controlled temperature and humidity for air conditioning.

It is another important object to provide a process for effecting sensible cooling using a total fresh air system.

These and other objects of the present invention will become more fully apparent from the following description and appended claims taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE is a schematic flow diagram illustrating a fluid circuit and apparatus for reducing air temperature according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

General

Heat exchange processes such as used in air conditioning systems have always been required to have increased capacity in order to adequately cool air when the temperature and/or the humidity of external air climbs as in summer months and on hot days.

While it is relatively easy and comparatively inexpensive to remove heat from gases when the temperature of the gas is high, the difficulty with which heat is removed increases at an astonishing rate when the temperture of the gas is already low. Thus, generally speaking, it is much easier and less expensive to make hot air cool than to make cool air cold using prior art techniques. Historically, the approach used to make cool air cold was to increase the size and capacity of cooling systems.

The present invention includes treating dry warm air out of the presence of moisture to reduce its wet bulb temperature. Air most efficiently used with the illustrated embodiment has a dew point of not more than 57° which is low compared to the dry bulb temperature of the warm air. This treatment can be performed by pre-cooling in a conventional heat exchanger.

According to the present invention, the temperature of the pre-cooled gas is then adiabatically reduced so that the gas is cold. Adiabatic processes are defined as those processes carried out in such a manner that heat is not exchanged between the system and its surroundings. Thus, the adiabatic cooling step does not require an energy input to reduce the temperature. When the gas is adiabatically cooled according to the present invention, heat is not actually removed from the cooling system but is reduced psychrometrically.

If a stream of gas is intimately mixed with a quantity of recirculating liquid at a given temperature in an adiabatic system, the temperature of the gas will drop and its humidity will increase. Furthermore, the temperature of the recirculating liquid will approach the wet bulb temperature of the gas. The low temperature liquid which is used for adiabatic cooling is subjected to refrigeration which further cools the liquid and therefore the air which contacts it and coincidentally produces further sensible cooling of the air. In this specification, refrigeration is defined to include cooling with mechanically or chemically refrigerated fluids.

When 100% fresh (unrecirculated) air is used for cooling, air quantities treated according to the preferred embodiment of the invention must necessarily be limited to a rather narrow range in order to efficiently produce desired cooling to within a range of 53°F to 60°F without imposing larger than necessary pre-cooling and refrigeration loads on the air cooling process.

It has been found according to the present invention that approximately 400 to 600 cubic feet of fresh air per minute per ton (CFM/ton) of net sensible in-space cooling is an adequate amount to develop conditioned air at a desirable temperature of between 53°F and 60°F. The surprising efficiency of this system can be recognized by observing that conventional fresh air swamp coolers require about 1,000 CFM/ton even with very dry fresh air. The efficiency of the system using this air volume range presumes 100% fresh (unrecirculated) air having a dew point of not more than 57°F

coincident with dry bulb temperatures of not less than 90°F. Under these climatic conditions, the presently preferred embodiment of the invention produces 53°F to 60°F moisture conditioned air with surprising efficiency and without requiring intermediate drying steps.

Referring more particularly to the FIGURE, warm dry air is first obtained from a fresh air source, e.g., ambient. To maximize the efficiency of the system, the dew point of the air should be at least as low as 57°F when air having a dry bulb temperature of not less than 90°F is used.

The warm air is first pre-cooled in a heat exchanger **62.** The heat exchanger **62** may be any one of a variety of heat exchangers which will not add moisture to the air, one suitable type being the fin-coil heat exchanger often called an extended surface heat exchanger. This type of heat exchanger is very inexpensive to acquire and operate and is very efficient at high temperatures.

Therefore, according to the illustrated embodiment of the invention, the pre-cooled dry air emerging from the heat exchanger **62** is conducted to an air washer **64** which scrubs the air with water or, if desired, other cooling liquid. The water used to scrub the pre-cooled dry air is recirculated through an external circuit **66** continuously.

The recirculated water in the circuit **66** is treated with a conventional refrigeration circuit generally designated **70.** The refrigeration circuit conventionally comprises a condenser **72** and a compressor **74** with an evaporating coil **76** interposed therebetween. A conventional expansion valve **78** admits refrigerant fluid into the evaporating coil **76.** Accordingly, the temperature of the recirculation water is reduced sufficiently by evaporator **76** so that both adiabatic and sensible cooling of the air results. The refrigeration system **70** is specfically limited to avoid exclusive refrigerated cooling in the air washer **64** to insure that effluent air is within the range of 53°F to 60°F.

It should be observed that if the temperature of the air were not adiabatically reduced in the air washer **64,** a far larger and more expensive coil **76** and larger refrigeration system **70** would be necessary to obtain the same very cold air temperature developed according to the conventional methods.

The system of the FIGURE is designed to transport and condition about 400 to 600 CFM/ton net sensible cooling. Using the air having a 57° dew point, temperatures as low as 53° to 60°F may be economically and efficiently achieved. Accordingly, the effluent conditioned air has a surprisingly low temperature and controlled humidity without requiring expensive dehumidifying (warming) and recooling steps.

Using the embodiment of the FIGURE cold air in the range of 53°F to 60°F for air conditioning or any other desired beneficial use can be obtained with surprising efficiency using a 100% fresh air system at maximum outdoor temperatures. Thus, the need for recirculating the same air in order to reduce the costs of cooling is unnecessary. Furthermore, cold air can be obtained without using large and expensive refrigeration systems. The refrigeration system **70** required for this combination of cooling steps has been found to be approximately one-third the size required conventional conventinal recirculating air refrigeration systems are employed. Accordingly, the advantages of a complete fresh air system can be substituted for the lower quality, more expensive recirculating air systems.

The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiment is to be considered in all respects only as illustrative and not restrictive and the scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed and desired to be secured by United States Letters Patent is:

1. A process for controlling the temperature and moisture content of air having a dew point of not more than 57°F corresponding to at least 90°F dry bulb temperature, sequentially

preparing an air flow path accommodating 400–600 CFM/ton net sensible cooling;

drawing fresh dry air exclusively from a fresh air source and through the flow path in the amounts of 400 to 600 CFM/ton net sensible cooling;

pre-cooling the fresh air with a heat exchanger without altering its moisture content;

scrubbing the air with recirculating water to adiabatically cool the air; and

refrigerating the recirculated water to further cool the air to within a range of 53°F to 60°F.

2. A process for conditioning air comprising (a) precooling 100% fresh air having a dew point of not more than 57°F corresponding to at least 90°F dry bulb temperature without altering its moisture content; (b) adiabatically cooling the air by scrubbing the air with recirculating water; (c) cooling the recirculating water with refrigeration to control the moisture content of the effluent air and to the extent that the effluent air has a temperature between 53°F and 60°F.

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