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Morgan

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[54] **AIR CONDITIONING SYSTEM WITH PROVISION FOR REHEATING**

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[52] **U.S. Cl.** **62/173,** 62/90
[51] **Int. Cl.** **F25b 29/00**
[58] **Field of Search** 62/90, 173, 428, 429

[56] **References Cited**

UNITED STATES PATENTS

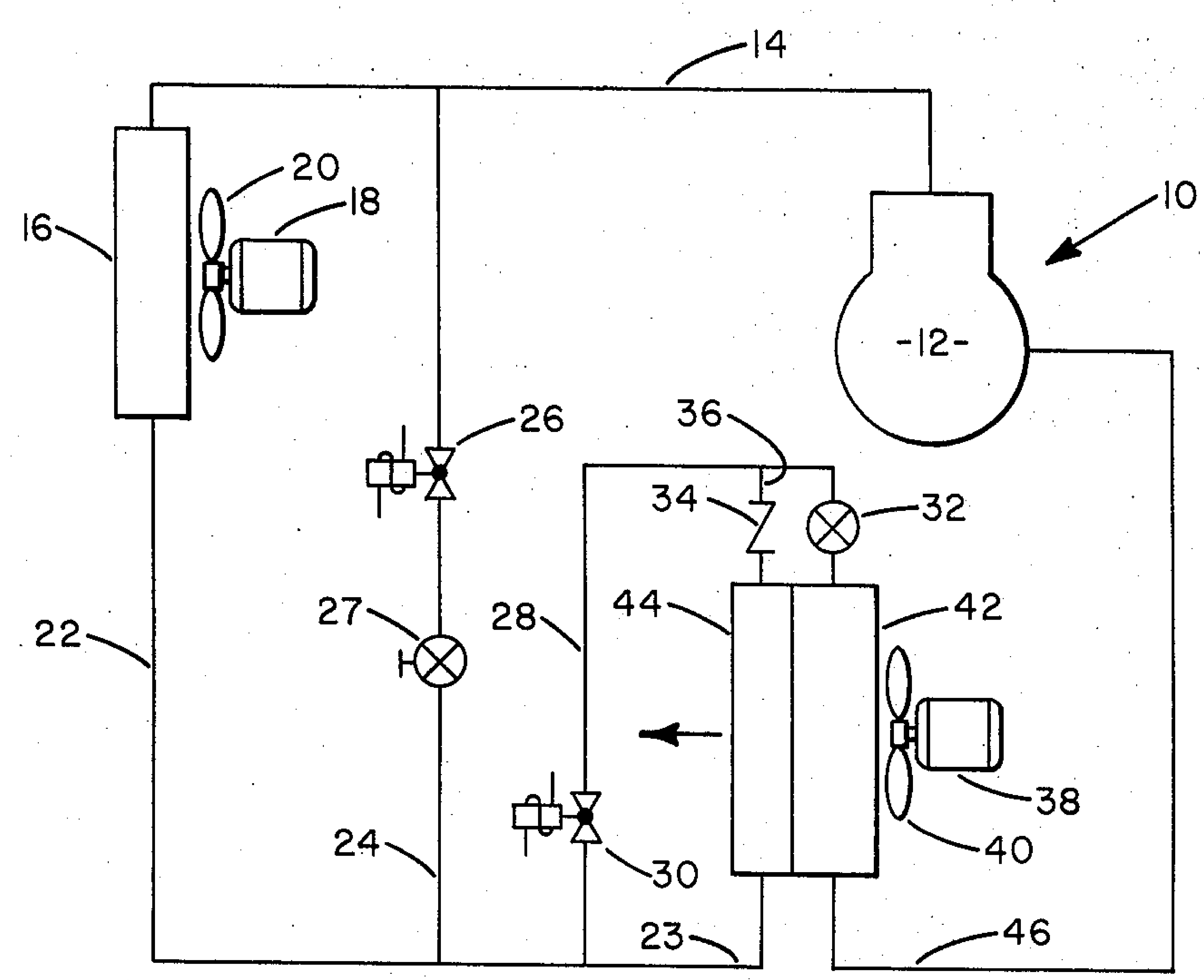
2,679,142 5/1954 McGrath 62/173
3,402,564 9/1968 Nussbaum 62/173

Primary Examiner—William J. Wye
Attorney, Agent, or Firm—Barry E. Deutsch

[57] **ABSTRACT**

An air conditioning system including a refrigeration unit comprising a compressor, a condenser, thermal expansion means and an evaporator are connected together to form a closed circuit. A reheat coil is provided downstream of the evaporator and upstream of the space being conditioned by the system. When reheat is required, a mixture of vaporous and liquid refrigerant is supplied to the reheat coil to pass in heat transfer relation with the conditioned air being supplied to the space so as to reheat the air subsequent to its having been cooled and dehumidified by passing in heat transfer relation with refrigerant flowing through the evaporator. Dehumidified air is provided at a temperature level that will not cause the space to be overcooled.

2 Claims, 2 Drawing Figures



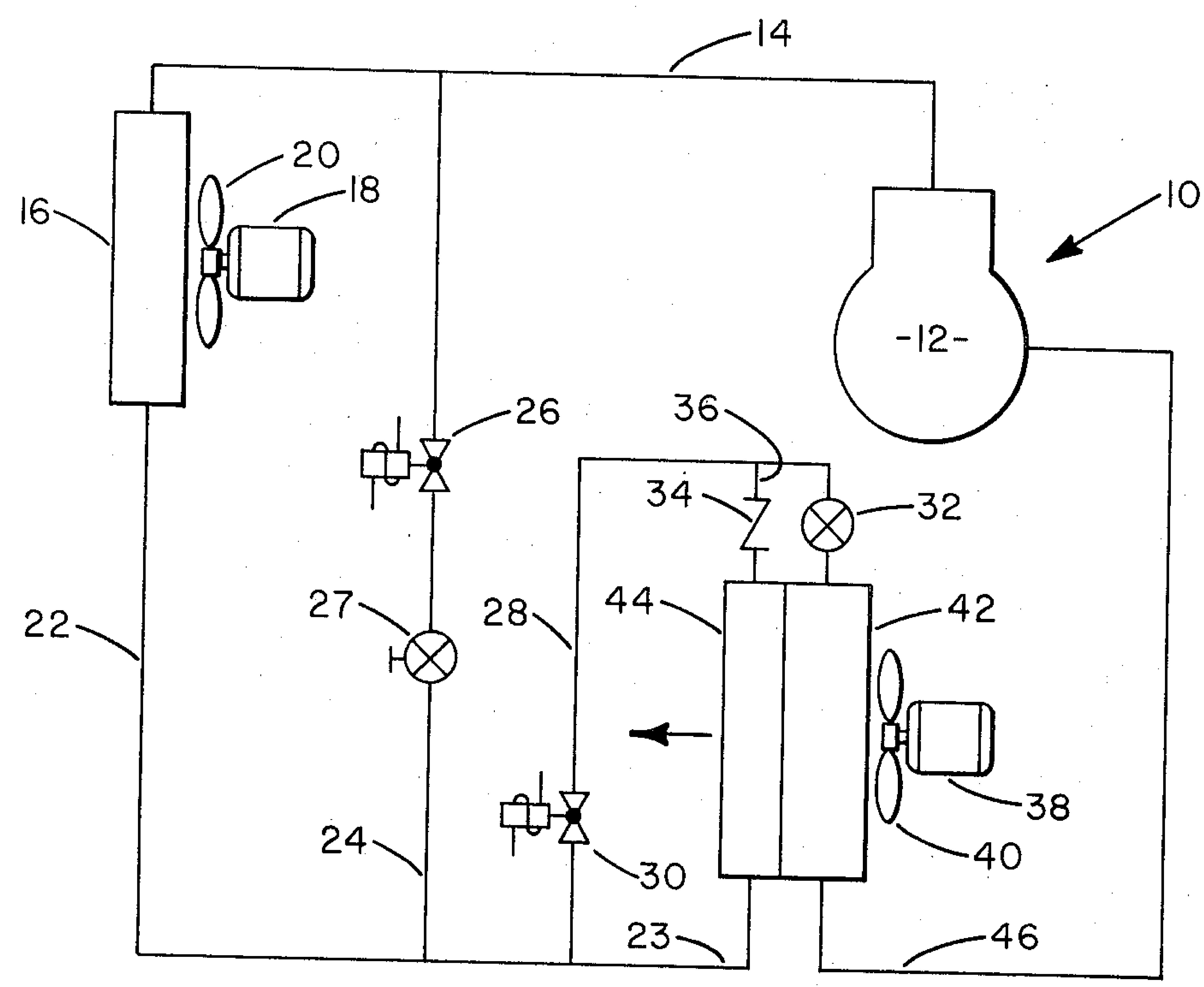

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FIG. 1

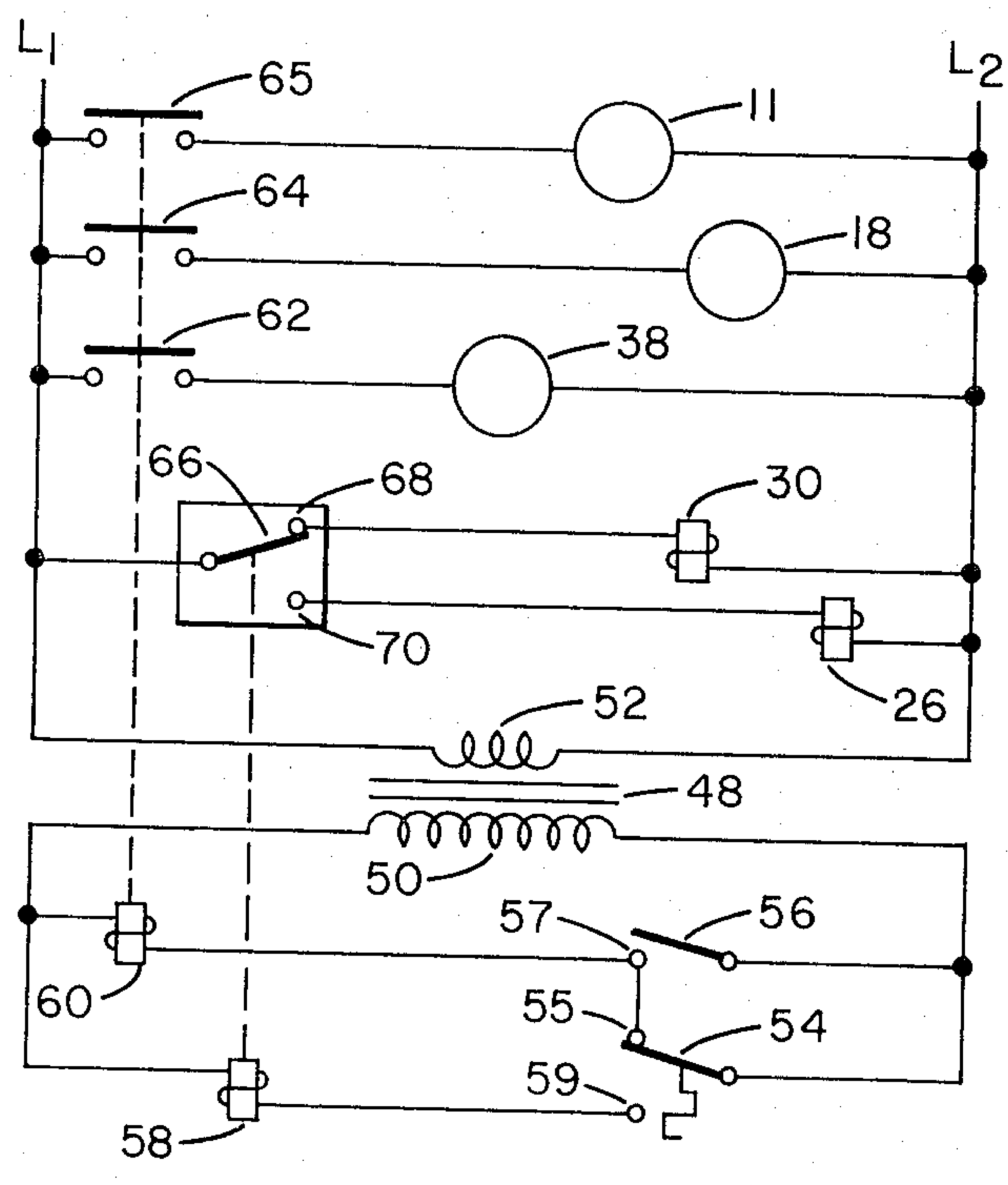
L1
L2
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FIG. 2

AIR CONDITIONING SYSTEM WITH PROVISION FOR REHEATING

BACKGROUND OF THE INVENTION

This invention relates to air conditioning systems operable to provide relatively cool and dehumidified air to a space being conditioned. In particular, this invention relates to such a system having a reheat coil provided therein and being solely operable to provide dehumidified air to the space when the temperature level in such space does not require cooling, but the humidity level therein requires dehumidified air.

It has now been recognized that maintaining comfortable conditions within a space or room adapted for human occupancy requires not only that the temperature of the air be controlled, but, in addition thereto, the moisture content or humidity of the air be similarly controlled. Many internal environments or spaces typically have air conditioning systems which provide conditioned air to regulate the temperature of the space. When relatively cool air is provided to the space, not only is the temperature level therein reduced but, in addition, the humidity level is also lowered since the removal of heat from air will dehumidify the same by lowering the air's dew point.

However, there are many times when the temperature level in the room or space does not require cooling, albeit human discomfort may still be experienced due to a relatively high humidity level within such space. Such temperature generally falls within the range of 70° to 75°F. If cool air were to be provided to dehumidify the space, uncomfortably cool temperatures would be obtained, thereby causing discomfort to the occupants.

In the past, it has been proposed to cool the air in a conventional manner and then reheat the same prior to its being supplied to the space. The cooling of the air will remove the moisture or dehumidify the same and the reheating of the air will raise the temperature thereof so the space will not be overcooled. Examples of prior art illustrating air conditioning systems having reheat capabilities are disclosed in U.S. Pat. Nos. 2,515,842; 2,679,142; and 2,940,281. Each of the arrangements disclosed in the cited patents suffer from a common failure.

When reheating is required, vaporous refrigerant is provided to a heat exchange coil functioning as a reheat coil. The ambient air which has been cooled and dehumidified by passing in heat transfer relation with refrigerant flowing through the evaporator of the refrigeration unit is thence passed in heat transfer relation with the vaporous refrigerant flowing through the reheat coil. The air is thus warmed prior to its delivery to the space. However, as noted hereinbefore, the temperature conditions at which solely dehumidified air is required generally falls within the range of 70° to 75°F. Therefore, by passing the cooled and dehumidified air in heat transfer relation with vaporous refrigerant, the air has generally been reheated to an excessively high level, thus elevating the temperature in the space to an uncomfortable level. In addition, the vaporous refrigerant supplied to the reheat coil has generally been unregulated. As is obvious, the prior art defects caused such reheat systems to be generally unsatisfactory.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to reheat conditioned air to acceptable levels without overheating the same.

It is a further object of this invention to discharge conditioned air into a space that requires solely dehumidified air without overheating such space.

It is a further object of this invention to provide an air conditioning system having a conventional refrigeration unit operable to supply solely dehumidified air when the space being conditioned requires dehumidification, without lowering or raising the temperature in such space to an unacceptable level.

These and other objects of the present invention are obtained by providing an air conditioning system including a refrigeration unit having a heat exchange coil provided in the path of flow of the conditioned air downstream from the evaporator and upstream from the space being conditioned. When the humidity in the space is at an uncomfortable level and the temperature in such space does not require cooling, a mixture of vaporous and liquid refrigerant is passed through the heat exchange coil.

Ambient air, which has been cooled and dehumidified by passing in heat transfer relation with refrigerant flowing through the evaporator is thence passed in heat transfer relation with the mixture of vaporous and liquid refrigerant flowing through the coil. The relatively cold air absorbs heat from the vaporous refrigerant and thereby condenses the same. Regulating means is provided to regulate the quantity of vaporous refrigerant supplied to form the mixture of vaporous and liquid refrigerant. Thus, dehumidified air may be supplied to a space when such space solely requires dehumidified air, without overheating the space.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of an air conditioning system embodying the present invention; and

FIG. 2 illustrates a control arrangement which may be employed with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing and in particular to FIG. 1 thereof, there is schematically shown a preferred embodiment of the present invention. An air conditioning system **10** employing a refrigeration unit incorporating the reheat means of the present invention is illustrated. The refrigeration unit may be of a type typically utilized in "split systems," that is air conditioning systems having the evaporator coil disposed in the furnace or supply duct and the condenser and compressor mounted outside of or remote from the space being conditioned.

An outdoor heat exchange coil or condenser **16** is connected by means of line **14** to the discharge side of a suitable refrigeration compression mechanism, for example a reciprocating type compressor **12.** The gaseous refrigerant produced in compressor **12** flows to condenser **16** and is condensed by ambient air routed over the surface of the condenser by an outdoor fan **20** which is suitably connected to a motor or other prime mover **18.** Liquid refrigerant formed in condenser **16** flows via line **22,** thermal expansion valve **32** and line **28** to indoor heat exchange coil or evaporator **42.** It is understood that other suitable expansion devices, such as a capillary tube, may be employed in place of expansion valve **32**.

Liquid refrigerant in evaporator **42** is converted to vaporous refrigerant as it extracts heat from the medium, for example, air passed over its surface by fan **40** which is suitably connected to a prime mover such as electric motor **38**. The cooled air is discharged into the area being conditioned through a suitable outlet (not shown). Vaporous refrigerant from evaporator **42** flows via line **46** to compressor **12** to complete the refrigerant flow cycle. The foregoing describes a refrigeration unit of the conventional type employed in air conditioning systems as is well known to those skilled in the art.

A conduit **24** having first solenoid valve **26** and throttle valve **27** disposed therein connects line **14** to line **22**. A second solenoid valve **30** is disposed in line **28**. The manner in which valves **26** and **30** are controlled shall be described in detail hereinafter.

A second heat transfer coil **44** is provided in the path of flow of the conditioned air being discharged into the space or room in the enclosure. Preferably coil **44** is disposed in the path of conditioned air flow downstream of evaporator **42**. Branch line **23** connects line **22** with the inlet to heat exchange coil **44**. A line **36** connects the outlet from heat exchange coil **44** to line **28**. Line **36** has a check valve **34** disposed therein. The check valve only permits the refrigerant to flow from coil **44** through line **36** and thence into line **28**.

Referring now to FIG. **2**, a preferred form of control, suitable for use with the air conditioning system hereinabove described, is schematically shown. A suitable source of electric power, represented by lines L1 and L2, is connected to primary winding **52** of transformer **48**. It is understood, a polyphase source of electric power may be employed if the circuit is suitably modified.

A secondary winding **50** of transformer **48** is connected to first control relay **58** and second control relay **60**. The first and second relays are connected in parallel with each other. Connected in series with relays **58** and **60** is a temperature responsive switch **54**. Switch **54** is movable between terminals **55** and **59** for a reason to be more fully explained hereinafter. Connected in series with second relay **60** is a humidity responsive switch **56**. Switch **56** in a closed position contacts terminal **57**. Terminals **55** and **57** are in parallel with each other. When either terminal **55** or **57** has switch **54** or **56** respectively in contact therewith, control relay **60** is energized. Control relay **58** is energized when switch **54** is moved into contact with terminal **59**.

When relay **60** is energized, switches **62, 64,** and **65** operatively connected thereto are closed. The closure of switch **62** energizes motor **38** which thereby causes fan **40** to route air over coil **42**. The closure of switch **64** energizes motor **18**, thereby causing fan **20** to route outdoor air over condenser **16**. The closure of switch **65** energizes motor **11** which is operatively connected to compressor **12**.

Operatively connected to first relay **58** is a switch **66**. The deenergization of relay **58** causes switch **66** to contact terminal **68**. Terminal **68** is in series with solenoid valve **30**. When switch **66** contacts terminal **68**, the solenoid is energized so that valve **30** is placed in an open position. The energization of control relay **58** causes switch **66** to disengage from terminal **68** and to engage terminal **70**. When switch **66** contacts terminal **70**, solenoid valve **26** is energized to an open position. When switch **66** disengages from terminal **68**, valve **30** is placed in a normally closed position.

The manner in which the present invention functions to provide dehumidified air without overcooling or overheating the area or space being conditioned shall now be explained.

Assume the space being conditioned requires cooled and dehumidified air. Temperature responsive switch **54** senses the requirement for cooled air and moves so it engages terminal **55** in the manner illustrated in FIG. **2**. Control relay **60** is thus energized. Control relay **58** remains deenergized since switch **54** is disengaged from terminal **59**.

When control relay **60** is energized, switches **62, 64,** and **65** close, thereby energizing motors **38, 18,** and **11** respectively.

With control relay **58** in its deenergized state, switch **66** remains in contact with terminal **68**. Solenoid valve **30** is thus energized into its open position. Since switch **66** is disengaged from terminal **70**, solenoid valve **26** remains deenergized and in a closed condition. Refrigerant flow through line **24** is thus prevented. Thus, all of the refrigerant discharged from compressor **12** passes through condenser coil **16**.

As solenoid valve **30** is energized, the liquid refrigerant flowing through line **22** is directed through line **28** to evaporator coil **42**. Check valve **34** prevents any of the refrigerant from flowing into heat exchange coil **44**. The refrigerant passing through coil **44** passes in heat transfer relation with ambient air, absorbing heat from such air and becoming vaporous. The cooled air is then delivered to the area or space requiring the same.

Assume now cooled air is no longer required in the area, but dehumidified air is still needed to obtain comfortable environmental conditions for the human occupants thereof. As noted before, if the supply of cooled air were to be continued, uncomfortable conditions would be created by the resultant overcooling of such space.

Temperature responsive switch **54** will disengage from terminal **55** and move into contact with terminal **59** when cooling is no longer required in the space. However, since the humidity level in such space is still above a desired value, switch **56** remains in contact with terminal **57**; thus control relay **60** remains energized. Control relay **58** is also energized since switch **54** now contacts terminal **59**.

The energization of control relay **58** causes switch **66** to become disengaged from terminal **68** and engaged with terminal **70**. Solenoid valve **30**, in series with terminal **68**, thereby becomes deenergized and the valve moves to a normally closed position. Simultaneously, solenoid valve **26**, which is in series with closed terminal **70**, becomes energized and thereby moves into an open condition, thus permitting vaporous refrigerant to flow from line **14** to line **22** about condenser coil **16**. Throttle valve **27** provides a restriction in line **24** to regulate the amount of vaporous refrigerant flowing through line **24** and simultaneously the amount of refrigerant passing through the condenser. Valve **27** may be manually or automatically operated; if automatically operated, the valve will regulate flow in accordance with temperature conditions in the space. As an alternative, since the operating conditions at which solely dehumidified air is required is generally from 70°–75°F, a suitably sized orifice may be provided as an integral part of solenoid valve **26**. A mixture of vaporous and liquid refrigerant is thereby obtained in line **22**.

Since valve **30** is closed, the mixture of vaporous and liquid refrigerant passes from line **22** through line **23** and thence into heat exchange coil **44**. The refrigerant mixture exits from heat exchange coil **44** and then passes via line **36** and expansion valve **32** into evaporator coil **42**. Fan **40** operates in the conventional manner to pass air to be conditioned over coil **42** where the refrigerant passing therethrough absorbs heat from the air. The temperature of the air is thus reduced so that its ability to hold moisture is also reduced. Thus, cooled and dehumidified air is provided.

The cooled and dehumidified air is passed in heat transfer relation with coil **44** having the mixture of vaporous and liquid refrigerant passing therethrough. The air passing thereover absorbs heat from the mixture of vaporous and liquid refrigerant, thereby condensing the vaporous component of such refrigerant mixture and being warmed thereby. The air is subsequently supplied to the area or space being conditioned.

By passing the air in heat transfer relation with the mixture of liquid and vaporous refrigerant, the dehumidified air is reheated to a satisfactory temperature level.

By employing a mixture of liquid and vaporous refrigerant to reheat the air prior to its being discharged into the space being conditioned, the temperature of such conditioned air is neither below a satisfactory temperature level, nor above the same, so that desired temperature and humidity conditions may be readily obtained in the space.

It should be particularly understood that the position of the heat exchange coil relative to the evaporator may be altered without departing from the spirit and scope of this invention. For example, the reheat coil and evaporator may be arranged so that only a portion of the total ambient air being conditioned will pass over each heat exchange element. The separate air streams will thence be mixed together prior to their delivery into the space. Other variations that might readily occur to one skilled in the art may also be employed.

While I have described and illustrated a preferred embodiment of my invention, my invention should not be limited thereto, but may be otherwise embodied within the scope of the following claims.

I claim:

1. In an air conditioning system for providing cooled and dehumidified air to a space to be conditioned, a refrigeration unit comprising a compressor, a condenser, thermal expansion means, and an evaporator connected together in a closed circuit and having liquid refrigerant flowing in a first portion thereof, and vaporous refrigerant flowing in a second portion thereof, the improvement comprising:

A. means to pass a relatively cold heat exchange medium in heat transfer relation with vaporous refrigerant flowing through said condenser from said compressor, said heat exchange medium absorbing heat from said vaporous refrigerant to condense the refrigerant;

B. means to pass relatively warm air to be conditioned, for subsequent discharge into said space, in heat transfer relation with liquid refrigerant flowing through said evaporator, the refrigerant absorbing heat from said air, the air being cooled thereby;

C. heat exchange means disposed in the path of flow of said cooled air downstream of said evaporator and upstream from said space;

D. bypass means about said condenser to pass at least a portion of said vaporous refrigerant discharged from said compressor about said condenser;

E. first valve means operably associated with said bypass means and having first and second operating positions, said valve means in its first position passing vaporous refrigerant about said condenser to mix with liquid refrigerant flowing therefrom and in its second operating position passing all the vaporous refrigerant discharged from the compressor through said condenser;

F. second valve means disposed between said condenser and said evaporator and having first and second operating positions, said valve means when in its first operating position directing the refrigerant through said heat exchange means and thence through said evaporator and when in its second operating position directing the refrigerant about the heat exchange means and directly to the evaporator; and

G. control means operable to place said first valve means in its first operating position and said second valve means in its first operating position when dehumidified air is solely required in said space and being further operable to place said first and second valve means in their second operating positions when cooled and dehumidified air is required in said space.

2. An air conditioning system in accordance with claim 1 wherein said bypass means includes regulating means to control the amount of vaporous refrigerant in said mixture of vaporous and liquid refrigerant.

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