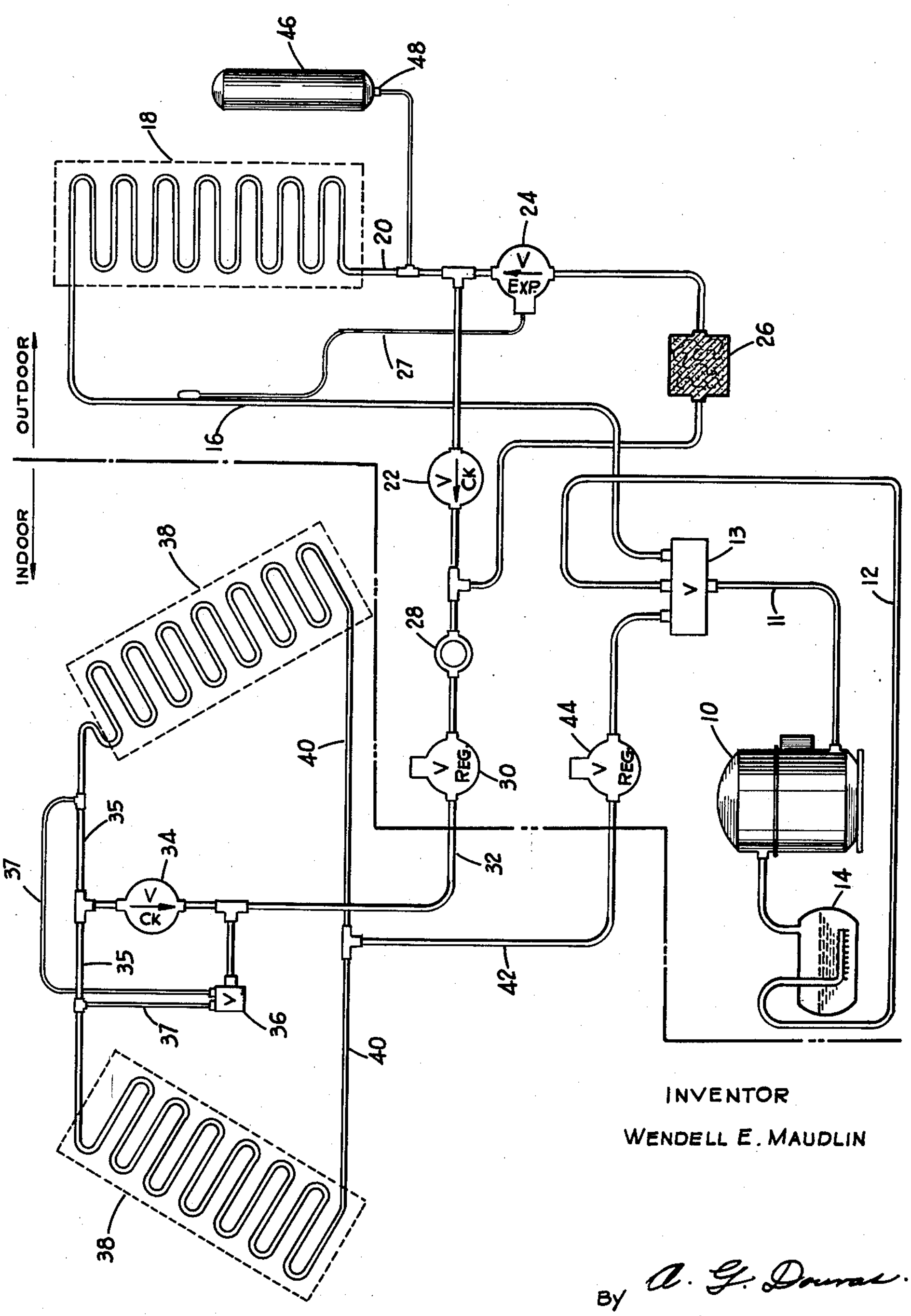
Nov. 27, 1962 W. E. MAUDLIN 3,065,610

CHARGE STABILIZER FOR HEAT PUMP

Filed Aug. 9, 1960



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3,065,610

CHARGE STABILIZER FOR HEAT PUMP

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Filed Aug. 9, 1960, Ser. No. 48,401
2 Claims. (Cl. 62—149)

This invention relates to heat pumps, and in particular, to means operable for adjusting the quantity of refrigerant in a heat pump circuit to achieve maximum efficiency of the heat pump during the heating and cooling cycles.

The vapor-compression cycle of thermodynamics is quite well known. The basic cycle includes the cyclic steps of compressing a refrigerant gas, condensing the compressed gas to a compressed liquid, throttling the compressed liquid to vaporize the liquid and recompress the gas to repeat the cycle.

The latent heat of vaporization of the refrigerant either absorbs heat from the surroundings during the heat pump cooling cycle, or dissipates heat to the surroundings during the heat pump heating cycle.

Refrigerants commonly used in such a cycle are ammonia and a variety of Freons under the trade names of Freon 11, Freon 12, Freon 22, Freon 113 and Freon 114, as well as the common gases of carbon dioxide, sulphur dioxide, methyl chloride, and water vapor.

For cooling an enclosure, the vaporous refrigerant is compressed and directed to a coil located outside of the enclosure or an outdoor coil. The ambient temperature of the outdoor coil is below the condensing temperature of the compressed vapor. The vapor condenses to a liquid at approximately the same pressure. The compressed liquid is then directed to a coil located within the enclosure, or an indoor coil. The pressure of the compressed liquid is throttled and the liquid vaporizes or boils in the indoor coil absorbing heat from the surroundings approximately equal to the heat of vaporization of the refrigerant. The vapor from the indoor coil is then recompressed to repeat the cycle.

For the heating cycle the compressed vapor is directed to the indoor coil. This coil condenses the vaporous refrigerant to a compressed liquid. The condensation dissipates heat to the surroundings approximately equal to the heat of vaporization of the refrigerant. An expansion valve regulates the flow of liquid refrigerant to the outdoor coil where the heat of the outdoor air boils the refrigerant. The vapor is then recompressed to repeat the cycle.

Heating and cooling cycles of a closed heat pump circuit are controlled by a 4-way reversing valve operable to direct the compressed refrigerant gas to either the indoor coil or the outdoor coil. The outdoor coil acts as the condenser and the indoor coil acts as the evaporator during the cooling cycle, while the indoor coil acts as the condenser and the outdoor coil acts as the evaporator during the heating cycle.

For highest operating efficiency both the condensing and vaporizing sequences of the cycle should be totally completed before the refrigerant leaves the respective coils. In other words, the conveying lines leading to and from the condenser coil should contain all compressed vapor and compressed liquid, respectively, while the conveying lines leading to and from the evaporator coil should contain all compressed liquid and expanded low pressure vapor, respectively.

It has been found that a greater quantity of refrigerant is required for the heating cycle than for the cooling cycle. The quantity of refrigerant used in a prior art heat pump circuit has been a compromise based on the average conditions expected of the heat pump. Consequently, during the heating cycle the quantity of refrigerant has been insufficient. Vaporous refrigerant is then circulated without the process of complete condensation. This reduces the effectiveness of the heat transfer surface and requires compressor power input with little or no resultant heating effect derived from the uncondensed portion of refrigerant. Conversely, during the cooling cycle the quantity of refrigerant is excessive. The refrigerant then backs up through the condenser coil into the lines which reduces the available condensing surface thereby raising condensing temperatures causing increased compressor power input and reduced capacity. This comprising with the quantity of refrigerant in the circuit reduces the efficiency of the heat pump for both the heating and cooling cycles, since all of the refrigerant is not performing useful work.

Accordingly, a principal object of this invention is to provide means for adjusting the quantity of refrigerant in a heat pump circuit during the heating and cooling cycles to give optimum efficiency for both cycles.

A feature of this invention is a charge stabilizer communicating with the heat pump circuit. The circuit includes a circulating charge of refrigerant of such quantity to give optimum efficiency during the heating cycle. The charge stabilizer withdraws a portion of that charge during the cooling cycle for providing the lesser quantity of circulating refrigerant that ensures optimum efficiency during the cooling cycle. Such adjustment is automatically regulated by the varying vapor pressures of the refrigerant during the heating and cooling cycles.

The principle of this invention will be better understood by reference to the following disclosure and drawing, wherein the only FIGURE of the drawing is a schematic circuit diagram of a heat pump disclosing a preferred embodiment of this invention.

The compressor **10** is connected in a loop by lines **11** and **12** to a 4-way reversing valve **13** and an accumulator **14**. Line **16** connects the reversing valve to one end of outdoor coil **18**. The coil **18** is located outside of the enclosure to be conditioned in heat exchange relationship with the outdoor air. Line **20** connects the other end of coil **18** to a parallel juncture having check valve **22** comprising one leg, and expansion valve **24** and filter drier **26** comprising the other leg. A valve control **27** extends between the expansion valve to the outdoor coil.

Line **32** including liquid indicator **28** and service valve **30** communicates the rejoined parallel juncture with another parallel juncture. The second parallel juncture has check valve **34** and lines **35** comprising one leg, and a distributor and strainer **36** and capillary tubes **37** comprising the other leg. Lines **35** and **37** join and communicate with corresponding ends of indoor coils **38**. Coils **38** are located within the enclosure to be conditioned in heat exchange relationship with the indoor air. Lines **40** from corresponding ends of coils **38** unite and communicate through line **42** and service valve **44** with the reversing valve **13**. The circuit is thus completely enclosed at all times. Service valves **30** and **44** are for servicemen to gain access to the circuit for evacuating, adding refrigerant or reading pressures. The valves also serve as shut-off valves so that the outdoor section can be shipped sealed. Liquid indicator **28** gives visual indication of the liquid refrigerant at the outlet of the condenser coil. If bubbles are present, insufficient refrigerant charge is generally indicated.

This invention provides a charge stabilizer **46** which is preferably located on line **20**. Line **20** is the inlet of coil **18** for the heating cycle and the outlet of coil **18** for the cooling cycle. The charge stabilizer **46** is a hollow fluid-tight tank constructed of material with sufficient strength to withstand the high side operating pressures of the heat pump cycle. The charge stabilizer is in an inverted position and has a port 48 communicating with line **20**. Port **48** preferably is lower than the remainder of the tank so that any liquid collected in the tank can be quickly dumped by gravity to line **20**. The charge stabilizer is in heat exchange relationship with the outdoor air.

With the heat pump circuit as shown in the FIGURE, the quantity of refrigerant required during the heating and cooling cycles is automatically adjusted to give the optimum performance for both cycles. A specific quantity or charge of refrigerant can be included in the circuit for the heating cycle to give optimum efficiency for the designed conditions. Similarly, the cooling cycle employing the same circuit would require a different specific quantity or charge of refrigerant to give optimum efficiency for given design conditions. The difference in the quantity of refrigerant required to give optimum efficiency during the heating and cooling cycles can then be determined. This difference represents the quantity of refrigerant which the charge stabilizer must accommodate. The volume of the charge stabilizer to accommodate this difference thus is determined.

During the cooling cycle, vaporous refrigerant is compressed and directed through 4-way valve **13** and line **16** to the outdoor coil. The compressed vaporous refrigerant then condenses to a compressed liquid and flows through line **20**, check valve **22**, and line **32** to distributor and strainer **36**. The capillary tubes then throttle the high pressure liquid causing the liquid to vaporize. The refrigerant vaporizes within the indoor coils **38** cooling the coils and absorbing heat from the indoor air flowing over the coils. The vapor then flows through lines **40** and **42** to 4-way valve **13** and by line **12** to the accumulator **14**. Accumulator **14** separates any remaining liquid droplets from the vapor mixture before the vapor is recompressed to repeat the cycle, thus preventing damage to the compressor.

During the heating cycles the compressed vapor is directed by the reversing valve **13** through lines **42** and **40** to the indoor coil. Indoor coil condenses the compressed vapor to a compressed liquid. The condensation dissipates heat through the coil to heat the indoor air flowing over the coils. The compressed liquid is then directed through check valve **34**, line **32** to the filter drier **26**. The filter drier removes dirt or foreign matter and dries the refrigerant of water by chemical action. Expansion valve **24** then throttles the liquid refrigerant to the outdoor coil where it is boiled by the heat of the outdoor air to vaporous refrigerant. Valve control **27** regulates the expansion valve by temperature or pressure sensing means as is well known in the art. The vapor is returned by line **16** to 4-way valve **13** and by line **12** through the accumulator to the compressor **10** for recompression.

Thus the heating and cooling cycles utilize the same circuit varying only the direction of refrigerant flow which is regulated by 4-way reversing valve **13**.

During the heating cycle all of the refrigerant will be used effectively within the circuit. The refrigerant will be a low pressure vapor in the outdoor coil and the charge stabilizer. When reversing valve **13** is actuated to the cooling cycle, the refrigerant entering the outdoor coil is a high-pressure vapor. The outdoor coil condenses the refrigerant, and the charge stabilizer withdraws the excess liquid refrigerant from the active heat pump circuit. The pressure of the refrigeration line **20** is sufficient to maintain the liquid refrigerant in the charge stabilizer against the vapor pressure of the refrigerant. During the cooling cycle the charge stabilizer would be filled with condensed refrigerant.

The charge stabilizer also regulates the quantity of refrigerant used during an automatic defrosting cycle. During the heating cycle, frost can accumulate on the outdoor coil if the temperature of the outdoor air is below freezing. The accumulated frost can be defrosted by interrupting the heating cycle and temporarily reversing the flow of the refrigerant with reversing valve **13**. The compressed vapor is thus directed by line **16** to outdoor coil **18**. Since the temperature of the air surrounding the outdoor coil and the charge stabilizer is substantially below the vaporization temperature of the compressed refrigerant, the refrigerant readily condenses within the coil and charge stabilizer. The heat given off by the refrigerant condensing melts the frost on the outdoor coil. The excess refrigerant during the defrost cycle is effectively withdrawn from the active circuit and stored in the charge stabilizer until the defrost cycle is completed and valve **13** is reversed to resume the heating cycle. The pressure of the refrigerant in the charge stabilizer then drops below the vaporization pressure and the refrigerant boils to a vapor. Thus the proper quantity of refrigerant is insured for all operations of a heat pump to give optimum efficiency.

What is claimed is:

1. In a heat pump operable to air-condition an enclosure, the heat pump having a refrigerant circulating in a closed circuit including a compressor, an indoor coil located within the enclosure, an outdoor coil located outside of the enclosure, a reversing valve for selectively controlling the flow direction of the refrigerant for the heating and cooling cycle, and pressure throttling means between the indoor and outdoor coils operable to reduce the pressure of the refrigerant flowing therethrough to below the vapor pressure of the refrigerant corresponding to the ambient temperature of the respective coil acting as the evaporator coil, the improvement comprising a charge stabilizer consisting of a fluid-tight tank located outside of the enclosure and having a refrigerant communicating connection substantially at its lowest point with the circuit between the throttling means and the outdoor coil, said charge stabilizer being operable to withdraw automatically a portion of the refrigerant from the active circuit during the cooling cycle by the varying vapor pressures of the refrigerant during the heating and cooling cycles, respectively.

2. A heat pump for an enclosure, comprising an indoor coil within the enclosure, an outdoor coil outside of the enclosure, pressure throttling means interconnecting one end of each coil, a compressor, a 4-way valve interconnecting the other end of each coil and the compressor and completing a closed heat pump circuit, said 4-way valve being operable to connect the output of the compressor directly to the indoor and outdoor coils respectively during the heating and cooling cycles of the heat pump, a given charge of refrigerant in the heat pump circuit to render optimum performance for the heating cycle, and a charge stabilizer of volume comparable to the refrigerant in the liquid state excessive from the given charge to render optimum performance for the cooling cycle, said charge stabilizer being disposed outside of the enclosure and having a communicating connection with the heat pump circuit between the 4-way valve and the pressure throttling means in the portion of the circuit including the outdoor coil.

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