

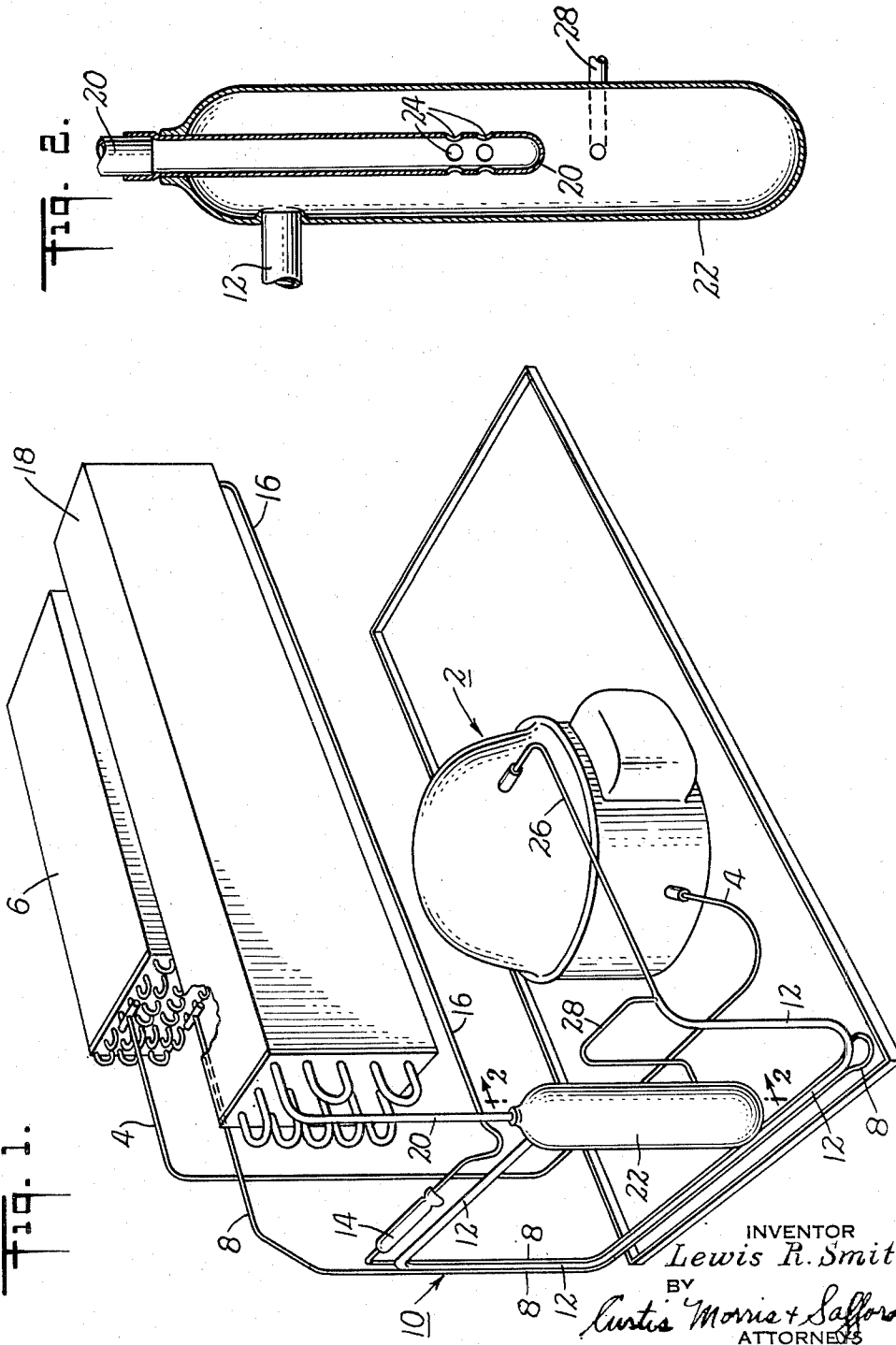
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AIR CONDITIONER

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AIR CONDITIONER

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This invention relates to refrigeration, and more particularly to self-contained air conditioning units and to obtaining improved operation over wide ranges of conditions of use.

In conventional types of refrigeration systems employing capillary tubes as to the restrictors or expansion elements between the condenser and the evaporator, the amount of refrigerant in the system may be somewhat critical. With some systems, proper operation is obtained only when substantially the optimum amount of refrigerant is in the system. It is commercially desirable to have a system that will operate efficiently with a wide refrigerant charge tolerance.

It is often desirable in refrigeration systems to sub-cool the refrigerant below its condensing temperature in order to obtain a greater refrigerating effect for each pound of refrigerant circulated. It is also known that the fluid flow rate of refrigerant through a restrictor such as a capillary tube will increase with the amount of liquid sub-cooling. Liquid sub-cooling can be obtained in a number of ways which include the use of a suction line-to-capillary tube heat exchanger, a suction line-to-liquid line heat exchanger, and by designing the system in such a manner that the condenser will be partially filled with liquid refrigerant during normal operation.

The use of an accumulator or a refrigerant storage vessel between the outlet of the evaporator and the compressor may help to increase the tolerance in the amount of liquid refrigerant or charge in the system. In actual practice, however, the accumulator tends to fill with oil, and boiling tends to occur so that foam forms, and the full capacity of the accumulator is not available to permit the anticipated leeway in the amount of refrigerant in the system. Hence, with some conditions of operation, a situation will arise where any surplus refrigerant which flows from the evaporator into the accumulator will flow from the accumulator toward the compressor.

Under such circumstances, if a heat exchanger is used between the refrigerant gas flowing from the accumulator to the compressor and the liquid flowing to the capillary tube and thence to the evaporator, any liquid refrigerant flowing with the refrigerant gas from the accumulator will tend to evaporate. Any liquid refrigerant flowing with the refrigerant vapor through the heat exchanger will have a greater cooling effect upon the refrigerant flowing through that heat exchanger from the condenser toward the evaporator than would refrigerant vapor alone. As indicated above, any additional sub-cooling of the refrigerant causes a more rapid fluid flow through the restrictive device, such as a capillary tube, to the evaporator. An additional flow of refrigerant to the evaporator under such conditions will further increase the amount of liquid refrigerant leaving the evaporator and entering the suction line portion of the heat exchanger. The general condition in which liquid refrigerant is present in the returning suction vapor is referred to as "flood back."

With a system such as that referred to above, the size

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of the capillary tube and the refrigerant charge in the system are such that optimum conditions are obtained for certain predetermined conditions of operation. Under such conditions, the system may be designed to contain some liquid refrigerant stored in the condenser, so that the liquid refrigerant is sub-cooled prior to leaving the condenser. By sub-cooling the liquid refrigerant prior to leaving the condenser, a greater refrigeration effect is obtained from a given volume of refrigerant pumped by the compressor, and therefore the capacity of the refrigeration system is increased. This is particularly true with refrigerants which have a relatively high ratio of specific heat of liquid to latent heat of evaporation.

If such sub-cooling of the liquid refrigerant is provided in a refrigeration system such as described above, the "flooding back" condition wherein liquid refrigerant flows from the accumulator toward the compressor, creates a somewhat unstable condition. This condition is unstable because the "flooding back" increases the flow of liquid refrigerant to the evaporator so that the evaporator is receiving a greater amount of liquid refrigerant just at the time when some of the refrigerant is not being evaporated. Therefore, a greater quantity of liquid refrigerant passes from the evaporator to the accumulator. This results in increased "flooding back." A temporary "flood back", even when the load is heavy, may start a "flooding back" condition in an unstable system and because the system is unstable it will not recover unless there is a drastic change in the operating conditions.

It is an object of the present invention to provide an improved refrigeration system of a stable nature whereby any "flood back" will be momentary if the conditions creating that "flood back" have been removed.

It is a further object to provide for the above with a system which is particularly suited for unit-type refrigeration systems. It is a further object to provide an improved, self-contained, air conditioning unit. These and further objects will be in part obvious and in part pointed out below.

In the drawings:

Figure 1 is a somewhat schematic perspective view of a refrigeration system, constituting one embodiment of the invention, and,

Figure 2 is a vertical section of a special accumulator which is one element of the refrigeration system of Figure 1.

Referring to Figure 1 of the drawings, a motor driven compressor 2 discharges hot compressed refrigerant gas through a line 4 to a condenser 6. Here the refrigerant is condensed to a liquid, which passes through a line 8 to form a heat interchanger 10 with a cold refrigerant gas line 12 to be discussed below. This portion of line 8 extends along one side of line 12 to a U-bend, and thence back along the other side of line 12, and throughout this heat interchange lines 8 and 12 are bonded together to give a good heat exchange relationship. The liquid refrigerant passes from line 8 through a strainer 14 to a capillary tube 16, through which the liquid refrigerant flows to an evaporator 18. Capillary tube 16 acts as an expansion unit or restrictor, so as to produce a pressure drop and also so as to limit or meter the flow of refrigerant to the evaporator.

The liquid refrigerant evaporates in the evaporator, and the gas refrigerant leaves the top of the evaporator through a line 20 which extends downwardly into an accumulator 22. Line 20 has its lower end extending to the central portion of accumulator 22, and this lower end is closed. (See Figure 2.) The gas refrigerant is discharged from the tube into the accumulator through eight holes 24 positioned in pairs on four sides of the tube. Hence, the refrigerant, together with oil carried into the

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evaporator with the refrigerant, is discharged horizontally, i. e., radially of the axis of the accumulator. The oil and any liquid refrigerant drop to the bottom of the accumulator and the refrigerant gas flows upwardly (see Figure 1) and returns to the compressor through the cold refrigerant gas line 12 referred to above.

During the passage to the compressor, the refrigerant gas passes through the portion of line 12 which forms part of the heat interchanger 10, and the cool refrigerant tends to cool the liquid refrigerant passing through line 8 from the condenser. Line 12 terminates at the compressor in a horizontal portion 26 to which is joined a liquid bypass line 28 connected also to the accumulator 22. The connection of line 28 to the accumulator is below the level of the bottom end of the line 20 through which the refrigerant and oil pass to the accumulator from the evaporator. Line 28 is a much smaller size than line 12 so that line 28 has a much higher resistance to fluid flow. Thus there is a tendency for substantially all of the flow to be through line 12 and for there to be only a limited flow through line 28.

During operation, when the oil and the liquid refrigerant accumulate in the bottom of the accumulator 22, the level rises to that of the end of line 28, at which time this oil and any liquid refrigerant present tend to flow through line 28 into the portion 26 of line 12. Thus there is no substantial tendency for an excessive amount of oil or refrigerant to collect in the accumulator beyond that contained below the opening of line 28. The liquid refrigerant and the oil pass from the accumulator through line 28 without passing through the heat interchanger 10, and the evaporation of the liquid refrigerant does not tend to cool the liquid refrigerant passing to the evaporator. The positioning of the inlet to line 28 below the bottom end of line 22 permits the gas to flow upwardly into the top of the accumulator and the liquid refrigerant and oil drop freely. This avoids the violent agitation and boiling which would occur if the liquid line in the accumulator were to rise above the outlet openings 24, from which the gas refrigerant is discharged into the accumulator.

With the arrangement herein disclosed, the objectionable "flooding back" conditions referred to above are avoided. The by-pass line 28 carries the liquid refrigerant and the oil from the bottom of the accumulator, and only gas refrigerant passes back through line 12 in heat exchange relationship with the liquid refrigerant. Line 28 is sufficiently small that it carries only a small percentage of the refrigerant gas when no liquid is passing through it. Hence, a steady stream of refrigerant gas passes through line 12 so as to produce a rather stable cooling effect upon the liquid refrigerant.

If the by-pass line 28 were not used, the liquid refrigerant entering line 12 would materially increase the cooling effect to which the liquid refrigerant is subjected, because the evaporating refrigerant liquid has a much greater capacity to absorb heat from the liquid refrigerant than the refrigerant gas. Hence, at such times as liquid refrigerant were to pass from the evaporator to the accumulator, the liquid refrigerant would be cooled to a much lower temperature than at times when no liquid refrigerant passed from the evaporator. As indicated above, this would cause more refrigerant to flow to the evaporator at such times as the load were insufficient to evaporate all of the liquid refrigerant in the evaporator. Hence, even more refrigerant would be passed to the evaporator when conditions are such as to not require the full amount which was flowing through the capillary tube to the evaporator. With these assumed conditions, i. e., some liquid refrigerant is leaving the evaporator to start the "flooding back" condition and that the evaporator thereby receives refrigerant at a higher rate so that the amount of unevaporated refrigerant is increased, and with the elimination of line 28, the "flooding back" con-

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dition would become increasingly worse because of the additional cooling of the liquid refrigerant passing to the evaporator. However, with the bypass arrangement of the present invention, the sealed or hermetic refrigerant system will deliver the proper amount of refrigerant to the evaporator under a very wide range of load conditions. Furthermore, the accumulator performs its function of separating the oil from the refrigerant gas and returning the oil directly to the compressor. Also any liquid refrigerant which in the return gas is separated and is withdrawn from the lower portion of the accumulator to the portion 26 of line 12 where it tends to evaporate while passing to the compressor.

As indicated above, the present invention is particularly suited for use in the refrigeration systems of unit-type air conditioning units. With such an arrangement, the components of the refrigeration system may be assembled and charged with refrigerant and oil upon a mass production basis, and greater leeway is permitted in the amount of refrigerant in the system. Furthermore, with wide variations in the load upon the air conditioning system, the system will operate efficiently and dependably. In the particular illustrative embodiment, which is a commercial unit, the suction line 12 running from the accumulator is connected into the casing or shell of the motor compressor, as in some such systems. However, it should be brought out that this connection could be made directly to the compressor, and certainly would be if the conditions of any particular system were such that there would not be apt to be sufficient "spill over" to cause difficulty because of excess liquid refrigerant passing to the compressor.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a refrigeration system, the combination of, a compressor, a condenser, a restrictor, an evaporator, a heat exchanger having separate paths of flow, and circuit lines interconnecting the above elements whereby the refrigerant is compressed in the compressor and flows to the condenser where it is condensed and then passes through one path of said heat exchanger and thence through said restrictor to the evaporator and in heat exchange with gas passing from the evaporator through the other path of said heat exchanger to the compressor, and means located between the evaporator and heat exchanger to separate liquid from the refrigerant gas passing from the evaporator and having a connecting line to divert any liquid to the compressor without passing in heat exchange with the liquid refrigerant passing from the condenser.

2. The system as described in claim 1, wherein said means to separate liquid from the refrigerant gas is an accumulator and the means to divert liquid is a bypass connection around the heat exchanger.

3. The system as described in claim 2 wherein said accumulator is a vertically positioned shell having a gas inlet tube extending from the evaporator axially downwardly into the accumulator and adapted to discharge the refrigerant and accompanying liquid horizontally within the accumulator, said accumulator having a gas outlet at its upper portion and a liquid outlet below the level of said inlet from the evaporator.

4. The system as described in claim 1, wherein at least a portion of said restrictor is a part of said heat exchanger.

5. The system as described in claim 1 wherein the restrictor is a capillary tube and at least a portion of said capillary tube is positioned in heat exchange relationship with the suction vapor returning to the compressor.

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6. A system as described in claim 1 wherein said refrigeration system is incorporated into a unit air conditioner.

7. A system as described in claim 1 wherein said restrictor is a capillary tube, and wherein said connecting line to divert liquid to the compressor is a line which offers high resistance to the flow of refrigerant vapor but is so positioned as to carry the major portion of any liquid returning to the compressor.

8. In an air conditioning system of the character described wherein it is desirable to provide for highly efficient operation over wide variations in load conditions, a refrigeration system having a compressor and an evaporator with conduits connected therebetween to provide separate paths for refrigerant flowing to and from said evaporator, means in one zone to cool the liquid refrigerant flowing to the evaporator by passing it in heat exchange relationship with cool refrigerant gas passing from the evaporator to the compressor, and means in a second zone between the evaporator and first zone to separate and bypass liquid accompanying said refrigerant gas to the compressor prior to its passage through the first zone whereby it does not pass in heat interchange relationship with the liquid refrigerant passing to the evaporator.

9. In an air conditioning system of the unitary type which includes a compressor, an evaporator, conduits connecting the compressor to the evaporator and including a capillary tube through which the liquid refrigerant flows to the evaporator, conduits connecting the evaporator and compressor to provide a path of flow from the evaporator to the compressor and including an accumulator con-

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nected to the outlet of the evaporator and within which refrigerant gas is separated from any accompanying liquid, heat interchange means located beyond the accumulator in the path of flow from the evaporator to the compressor to pass the liquid refrigerant flowing to the evaporator into heat exchange relationship with gas flowing from said accumulator, and bypass means in the path of flow from the evaporator to the compressor to divert liquid from said accumulator around the heat exchange means to the compressor without passing into heat exchange relationship with the liquid refrigerant flowing to the evaporator.

10. In the art of refrigeration, the steps of, carrying on a continuous refrigeration cycle during which refrigerant is compressed at a place of compression, liquified by condensation and evaporated at a place of evaporation, separating from the refrigerant gas flowing from the place of evaporation to the place of compression any liquid which is present therewith, passing said gas after said separation through one path to the place of compression into heat exchange relationship with liquid refrigerant flowing to said place of evaporation, and returning the separated liquid to the place of compression in a path separate from said one path and out of heat exchange relationship with said liquid refrigerant flowing to said place of evaporation.

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