

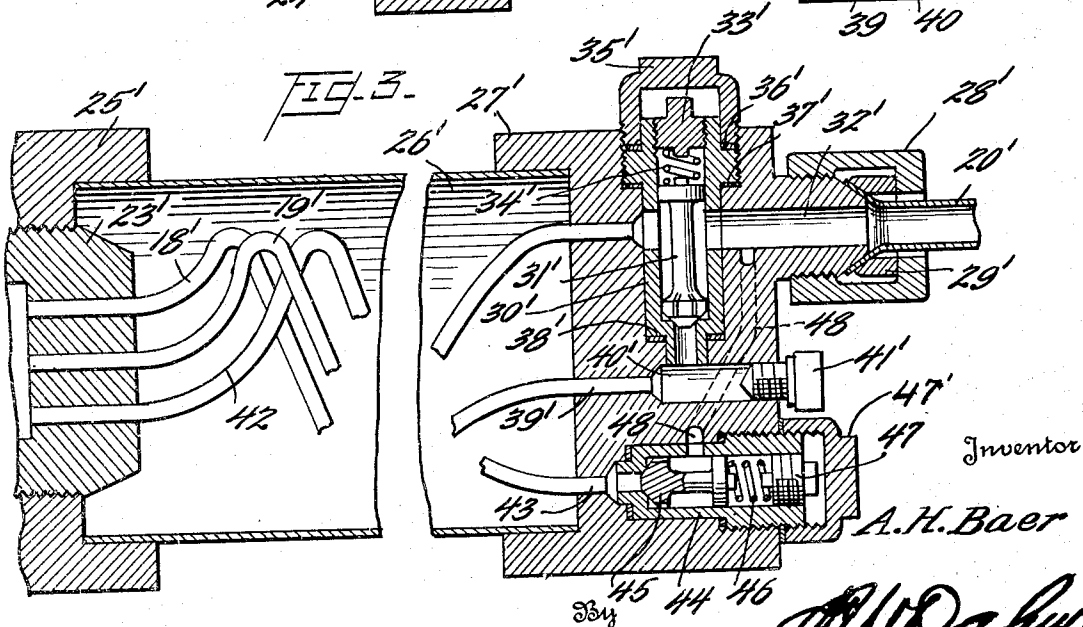
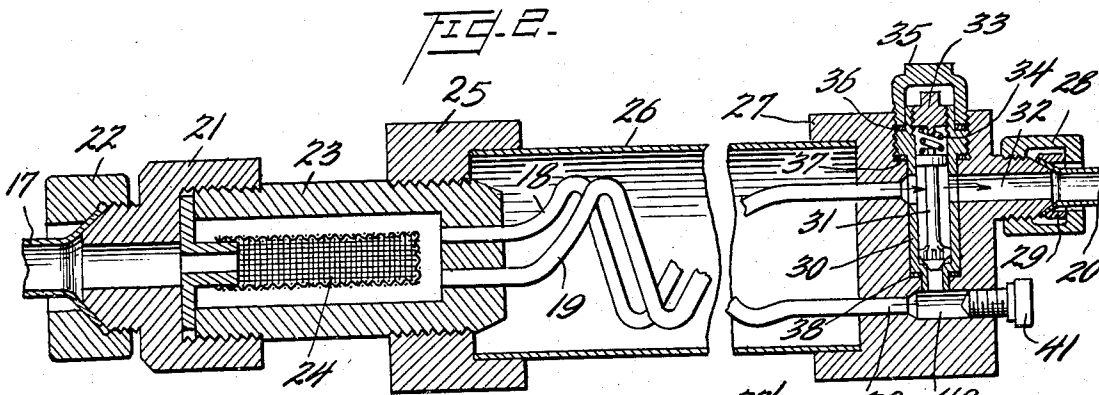
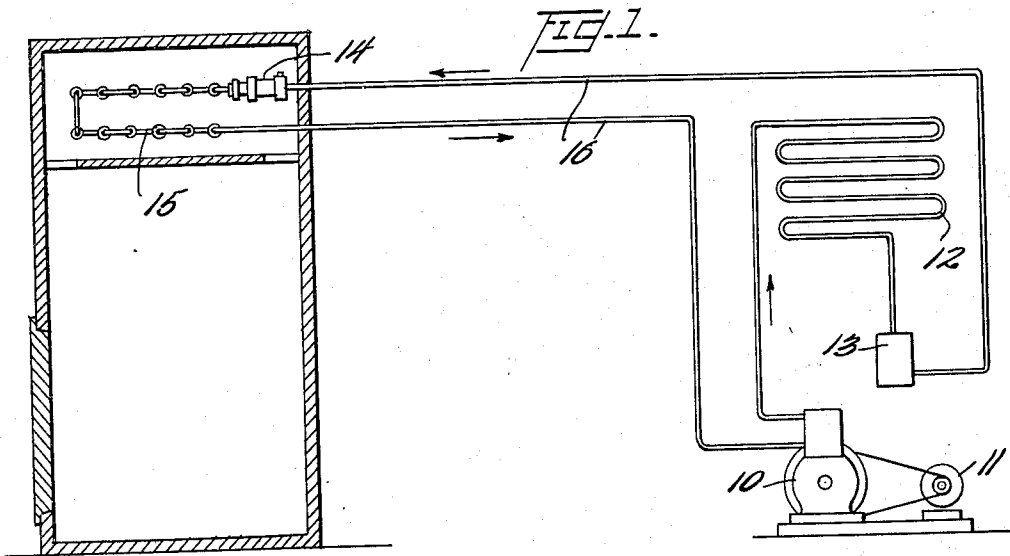
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LIQUID PRESSURE REDUCING MEANS

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LIQUID PRESSURE REDUCING MEANS

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15 Claims. (Cl. 62-8)

My invention relates to liquid pressure reducing means particularly intended for use in refrigerating apparatus of the compressor-condenser-evaporator type, i. e.; in refrigerating apparatus wherein pressure is reduced for the purpose of decreasing the temperature of a volatile refrigerating fluid, though not necessarily limited to such use. One of the known expedients for that purpose consists of a so-called capillary tube, which is a tube of small diameter through which refrigerant flows under pressure and wherein the pressure is reduced due to the resistance offered by the small tube, so that the pressure is much less at the outlet than at the inlet, the amount of pressure reduction varying with the length of the tube and the entering pressure, while the quantity of fluid passing through the tube is dependent on the diameter of the tube and the ratio of the inlet and outlet pressures. A device of this kind is illustrated in Patent No. 1,919,500 to Carpenter.

It is now well known that a restricted tube alone, such as the capillary tube illustrated in this patent, will be limited in its application to the particular refrigerating machine and the particular condensing pressure and evaporator pressure for which it is designed. If applied to a machine or system working with other pressures, its capacity will not suit that machine and system. Obviously, such a tube will pass a greater amount of liquid refrigerant when the ratio of the condenser pressure to the evaporator pressure is greater and a lesser amount when pressure ratios are less.

Now, the cooling capacity of a refrigerating machine becomes less as the ratio of the condenser pressure to the evaporator pressure becomes greater. Therefore, in practice, the capacity of a plain capillary tube will increase during a period when the operating pressures causes a decrease in the capacity of the refrigerating machine. There is, therefore, direct opposition, with respect to capacity changes, between the capillary tube and the refrigerating machine for which it is designed when that machine and system happens to be applied to cooling at a difference in pressures other than that for which the tube is made. What is more important, this same opposing situation exists when seasonal and weather changes create changing condensing pressures for the refrigerating machine.

Thus it becomes apparent that any refrigerating machine and system for which liquid refrigerant is supplied and controlled by means of the

so-called capillary tube, will require a different design of tube for every combination of pressures in the condenser and evaporator—the length of the tube would have to be greater for each increase in condenser pressure or each decrease in evaporator pressure and vice versa the tube would have to be shorter when the pressures change in the opposite directions. Thus a multitude of tube designs are required for each size of refrigerating machine if that machine is to operate according to the efficiency conditions for which it was designed.

In addition, if a multitude of interchangeable tube units are to be used in order that the machine may operate at its full efficiency for each set of pressures, it will, of course, be necessary for one tube unit to be removed, and another substituted for it, each time the pressure ratios change a substantial amount. This, of course, is expensive and troublesome and it is also so inconvenient, in many cases, as to be almost impossible. Therefore the refrigerating machine, working with such capillary tube units, will in very many cases operate under a greater or less degree of impaired efficiency and capacity.

My invention provides a device that is able to utilize the advantages of the plain capillary tube—including the equalizing of pressures when the refrigerating compressor is idle—with a compensating means and adjusting means that controls the flow of liquid in such manner as to promote a substantially uniform pressure and temperature in the evaporator, regardless of the variations of weather and condensing pressures, and the resulting change of pressure ratios from hour to hour, or day to day.

I also provide a device that may automatically regulate the flow of liquid refrigerant between relatively wide maximum and minimum capacity limits in the refrigerating plant and system, regardless of weather changes and varying condenser pressures. Thus a give refrigerating machine and system may accommodate itself automatically to capacity changes as they occur.

Again, it is well known that the same refrigerating machine and system will in one case include an evaporator that is to function under lower pressures and temperatures, while in another case, or numerous other cases, the evaporator is to function under other pressures and temperatures. In either case the evaporator must operate at substantially uniform pressures and temperatures. My invention provides a means for accomplishing this.

Also, it is well known that many refrigerating

machines are constructed with means designed and built into their structures for changing capacity automatically from hour to hour, or day to day. Such variations of capacity frequently change one hundred per cent, that is, a given refrigerating compressor may at one moment operate at a rate of five tons capacity and at another moment at a rate of ten tons capacity. In such case the liquid refrigerant feed must also automatically adjust itself to the change. An example of this kind is found in many air conditioning plants.

My invention, together with the capillary tube, may operate to suit such changes in capacity by maintaining a given pressure and temperature within the evaporator and varying itself automatically to changes in the refrigerating machine, whether they be up or down. It is also adaptable for refrigerating systems of different characters, particularly systems of a commercial character and those that are of larger size than the standardized units, cabinets, etc., such as household refrigerators, ice cream cabinets, water coolers, and so on.

It is also very desirable that liquid feed devices of this class be capable of additional manual adjustment in order that they may be changed to operate with entirely different refrigerating machines and systems, or with different classes of refrigerant liquids, so that they may be used with one refrigerating system for a time, and then may be removed and applied to another system. Thus, the reconditioning of equipment and installation of new machines, or changes to the system, need not result in the rejection of perfectly good feed controls.

My invention includes fixed adjustment that enables the self-acting elements used with it to be changed to suit different operating pressure ratios, that is, their maximum and minimum limits are changed, and the scope of capacity changes that may be accomplished with it is thus enlarged.

It is also very desirable for devices of this class to be of such type that the customary refrigerating plant sizes with which they may be used can be served with the fewest possible unit sizes. Thus the manufacture of the units can be accomplished in quantity orders with resulting lower manufacturing costs that accompany such production. In addition, such a feature reduces the amount of stock to be carried by dealers, which of course is followed by less operating cost for the dealer. By reason of the wide scope of my self-acting adjustment I require only a very few unit sizes to cover all of the customary refrigerating machine sizes.

In constructing my device, I do not limit myself to any particular form of capillary tube arrangement. The tube may be a spiral coil or a parallel coil bent back and forth upon itself or it may be in any other convenient form. I do, however, use two or more tubes working in parallel, with at least one tube free of any separate control or restraint, and another tube or tubes provided with additional control devices, so that there may be one or more simple capillary tubes feeding liquid uniformly, and one or more other tubes that are under restraint, and therefore feed irregularly.

I do not require more than two tubes for the average control unit, but there may be more than two tubes required for some units. In such cases one or more tubes will be free of restraint; one or more other tubes may have adjustable self-act-

ing control devices; and a further tube or tubes may also have non-self-acting control, or a similar self-acting control with the other tube.

Referring to the drawing which is made a part of this application and in which similar reference characters indicate similar parts:

Fig. 1 is an elevation, partly diagrammatic, illustrating the method of embodying my invention in a refrigerating system,

Fig. 2, a longitudinal vertical section of one form of my invention, and

Fig. 3, a similar view of a modified form of the invention.

In the drawing, Figure 1 illustrates in diagrammatic form a compressor-condenser-evaporator type of refrigerating system in which 10 is the refrigerant gas compressor, 11 is a motor for driving the compressor, 12 is the refrigerant condenser, 13 is a liquid receiver sometimes used, 14 is my control unit, and 15 is a commonly used form of evaporator for cooling. All of these units, excepting 14, may be of any well-known type and they are connected by suitable pipes 16, the evaporator being shown as located in a refrigerator, though my invention may be used in connection with various types of cooling machinery.

In Figure 2, 17 is the common liquid inlet pipe which may be a part of the uppermost pipe 16, and 18 and 19 are each parallel tubes of restricted size, often referred to as capillary tubes, by means of which the pressure of the liquid flow is very much reduced. Numeral 20 indicates a common outlet pipe leading to the evaporator. Parts 21 and 22 constitute a head and clamping fitting for attaching tube 17 to the control unit, and 23 is a sleeve for enclosing a liquid screen 24 that is held in place by a flange clamped between parts 21 and 23, said sleeve 23 also having threaded thereon a casing head 25. Any of the well-known liquid screens may be used and this screen does not constitute a part of my invention.

A casing 26 connects the head 25 to another casing head 27 at the outlet end of tubes 18 and 19. Said casing encloses the tubes 18 and 19 and it may be used as the outer part of a heat exchanger if it is provided with an inlet and outlet at opposite ends for passing return gas from the evaporator to the compressor, but I prefer to use it as a protective enclosure for the tube. It may have flexible insulating filling around the tubes, or it may also be perforated when placed in a refrigerated space.

The outlet casing head 27 at the outlet end of casing 26 comprises a clamping nut 28 and a gland 29 for attaching the outlet pipe 20 to the head 27. A valve sleeve 30 is threaded at its upper end in a recess in the head 27 and a valve 31 is normally seated in the lower end of said sleeve. A conduit 32 leads from tube 18 through orifices in the sleeve 30 and past the reduced stem of valve 31 and so to outlet pipe 20. A plug 33 is threaded in the upper end of the valve sleeve 31, said plug serving to close the sleeve and also serving as a stop for a spring 34 bearing on the head of valve 31, adjustment of plug 33 serving to vary the pressure of the spring on the valve. A cap 35 is screwed into the top of the valve recess in the head 27 and must be removed before the plug can be adjusted. Gaskets 36, 37, and 38 of any suitable type are provided between opposed faces of the head, the sleeve, and the cap.

A conduit 39 leads from pipe 19 to a chamber 40 in head 27, connected to the open lower end

of valve sleeve 30, said chamber being closed at its outer end by a plug 41.

In the modified form of Fig. 3, the parts 18', 19', 20', 23', and 25' to 41' are or may be identical with parts 19, 20, 23, and 25 to 41 of Fig. 2. This form of the invention includes also a third restricted tube 42 leading from sleeve 23' to head 27' where it connects with a conduit 43. This conduit leads into the open end of an auxiliary valve sleeve 44, mounted in a horizontal recess in the head 27' and provided with a valve 45 held in closed position by a spring 46 that is adjustable by a plug 47 and is covered by a cap 47', all parts being generally similar to those of the main valve structure, but the valve sleeve having a side opening leading to a conduit 48 that connects at its upper end to passage 32'.

Preferably, I select units of the kind illustrated by Figure 2 for most of the refrigerating systems that operate under average conditions. However, there are numerous conditions that are handled more satisfactorily by a unit built according to Figure 3. Also, for certain future needs I will use tubes of differing sizes, i. e., tube 19' or 42 or both of them may be larger or smaller than tube 18' and, where it appears desirable, I will use any one of the tubes, or all of them, in multiple, i. e., two tubes 42 instead of one, and so on.

In operation of my device the liquid supply from condenser 12 flows into all capillary tubes alike, having first passed through screen 24. By reason of their very small size, the tubes cause a great deal of pressure loss which is the desired result. Therefore, the volatile refrigerant liquid flows from the opposite end of all tubes at much lower pressure and at a correspondingly lower temperature. The diameter of the tubes is such as to pass a stream of liquid of predetermined cross section at the entrance end. The length is made such as to create a given pressure reduction with a given entering pressure.

Tube 18 will have a constant flow whenever the refrigerating compressor 10 is operating and taking the vapor away from the evaporator 15. If tube 18 is designed to pass less than the quantity of liquid required for the refrigerating compressor then the pressure in the evaporator will soon be reduced. Up to this time tube 19 has remained closed at its outlet end because of the spring pressure on the valve 31.

However, when the evaporator pressure and, of course, the pressure in pipe 20, conduit 32 and in the space over valve 31 is reduced just enough to offset the spring pressure (say from $\frac{1}{4}$ to 1 pound per square inch) the valve will lift and liquid will then flow from tube 19 to join that flowing from tube 18. This will very soon become an over-supply and raise the evaporator pressure to the top limit permitted and will unbalance the pressure over valve 31 so that the spring pressure will close this valve. Then tube 18 again becomes the sole supply for the evaporator. This procedure will be repeated as frequently as the evaporator and refrigerating compressor require it.

In practice many refrigerating systems (compressor, condenser, evaporator and associated parts through which refrigerant flows) have to meet varying capacity conditions. And this requires that the liquid feed, or control, shall have a varying capacity, also that it must meet such variations frequently—sometimes every hour.

In some cases the load variations will be those

due to weather and condensing pressure changes and in other cases to actual mechanical devices on the refrigerating machine that change its capacity while operating. The changes due to the former causes will generally be between minimum and maximum limits not too far apart, while those due to the latter causes will sometimes have moderate limits and at other times will have minimum and maximum limits widely separated.

For the former cases I generally use devices in which all tubes are of the same diameter and length and thus provide devices that may vary in capacity as much as 100%, i. e., tube 18 alone could have a capacity equaling two tons refrigeration and both tubes 18 and 19 would then have a capacity equaling four tons refrigeration, when working together. In this case the device could adjust itself to load changes of that scope.

For other cases where the load changes vary between wider limits I generally use a device in which tube 18 will be of smaller size while the other tube or tubes will be of larger size or in lieu of this there will be two of the tubes 19 functioning together at one such tube. Thus, if tube 18 was of a capacity for 2 tons refrigeration the larger tube 19 or the pair of smaller tubes having the function of tube 19 could have a capacity of 4 tons and the total capacity of both would then be 6 tons.

If a device be made wherein tube 18 equals 2 tons and tube 19 equal 2 tons, I will preferably apply the device to a refrigerating machine in which the capacity may vary from $2\frac{1}{4}$ tons to $3\frac{3}{4}$ tons. The condenser pressure changes due to weather and seasons will hardly ever reach such wide limits. They will generally be confined to 25 per cent variation. I therefore have ample margin.

In like manner, if tube 18 equal 2 tons refrigeration and tube 19 equals 4 tons I will preferably apply the device to a refrigerating machine having a minimum capacity of $2\frac{1}{4}$ tons and a maximum capacity of $5\frac{3}{4}$ tons. And I may also use it with one size refrigerating machine having moderate capacity limits from $2\frac{1}{4}$ tons to 3 tons or with another size having moderate limits from 3 to $3\frac{3}{4}$ tons or another size having moderate limits from 4 tons to 5 tons or thereabouts.

I preferably use wider capacity limits when designing my devices so as to broaden the operating scope of each device and thus reduce the number of devices that are needed to satisfy the requirements of the usual line of refrigerating machine sizes. This leads to the use of three tubes for some devices such as tubes 18', 19', and 42, shown in Figure 3. In this case tube 42 may be opened to operate jointly with tube 19' or it may remain closed and be inoperative. This is to provide for wider scope of operation and also for the transfer of the same device from one machine to another having somewhat different capacity and other characteristics.

While a device having a given length of tube will have a given pressure drop when the entering liquid pressure from the condenser is at a given pressure I am able to apply my device to machines having several evaporator pressures and yet retain the self-adjusting ability for meeting ordinary variations of condenser pressure due to weather and seasonal changes. One method of accomplishing this result is by tightening the screw plug 33 over the spring 34 so that greater pressure is exerted against valve 31.

Thus, for example, if one of my devices is to

be operated in control of an evaporator in which the pressure is 5 pounds per square inch less than the pressure under which it has been operating, the spring may be set down so that it holds the valve closed until such lower evaporator pressure has been reached under the limited supply from tube 18 after which tube 19 opens. But it will remain open only until the evaporator pressure has increased a small amount and it then closes. Thus it functions in open and closed positions at the lower pressure levels just as it did at the higher levels.

The same method may be used when a unit is to be transferred from one evaporator to another. Of course, for any of these cases it is also possible to apply a unit having tubes of smaller diameter, thus offsetting to some extent the effect of the greater pressure ratio to push more liquid through the unrestrained tube 18. However, I prefer to use a unit having longer tubes when there is a substantially large change of pressure ratio.

In order to further spread the scope of pressure limits within which my device is able to function and exert its control, I will, for some cases, use an additional valve like valve 45 (Fig. 3) and its related parts, for controlling the outlet end of tube 42. In such a case the outlet from this additional valve will be independent of valve 31 and will send its supply directly to passage 32' and pipe 20'. In that case tube 18' will feed without restraint, just as in any other case, and if the inlet pressure is higher or the outlet pressure is lower, or if any combination of these creates a greater pressure ratio than the unit has been handling there will be some increase of liquid flow through it.

When such conditions are to be met I select a unit in which the capacity of tube 18' for the initial conditions will not be over $\frac{2}{3}$ of the compressor capacity so that its capacity under the later conditions will still be less than that of the compressor. Then tube 18' cannot supply all capacity that the evaporator demands and the pressure in the evaporator will soon drop as before. Now by setting the plug, or stop 33', so as to further compress spring 34' the valve 31' that controls the outlet of tube 19' will not open until the pressure (and temperature) in the evaporator has been reduced to the desired level.

At this point the increased pressure difference affecting valve 31' and spring 34' will cause tube 19' to flow. However, tube 19' will only flow until the over-supply of liquid raises the evaporator pressure a small amount when it will close. Thus it will function intermittently as before but at the lower pressure levels. Obviously, I can combine tube sizes that will provide a considerable range of pressure ratios to be handled by one unit.

I may combine a tube 42 with a tube 18' and a tube 19' so that for an increase over the initial pressure conditions plus larger capacity increases or for similar capacity under much lower pressure ratios, I may set the adjustment on tube 19' so that it functions with tube 18 and then tube 42 will be adjusted to provide the intermittent control.

It will be apparent that my device lends itself to a great variety of applications and may be selected so as to provide self-acting control for any of them. Therefore, I do not confine myself to the device as illustrated in the drawing and described in the specification, but only as indicated in the appended claims.

Having thus fully described my invention, what I claim is:

1. In a mechanical refrigerator, the combination of a compressor, a condenser, and an evaporator, pipe connections between them in the order specified, the pipe connections between the condenser and the evaporator including pressure reducing means having a series of restrictor tubes leading from the condenser to the evaporator, one or more of said restrictor tubes being unobstructed and having a capacity short of that necessary for maintaining the desired pressure at the outlet end of the attachment, and a valve in each of one or more other tubes of the series, said valve being opened automatically to admit additional refrigerant to the evaporator when the difference in pressures at the inlet and outlet ends of said pressure reducing means exceeds a predetermined value.

2. In a refrigerating mechanism, a source of vaporizable refrigerant under pressure, an evaporator, and a plurality of restrictor pipes connecting said source to said evaporator, at least one of said restrictor pipes having a pressure-operated automatic valve therein normally serving to prevent refrigerant from passing through said pipe, and means for opening said valve when the difference in pressures at opposite ends of said last-named pipe exceeds a predetermined value.

3. In a refrigerating mechanism, a source of vaporizable refrigerant under pressure, an evaporator, and a plurality of restrictor pipes connecting said source to said evaporator, at least one of said pipes being continuously open from end to end, and means normally closing at least one of said pipes while a normal ratio is maintained between the pressures at the inlet and outlet ends of said open pipes, said closing means being so constructed as to open when the pressure at said outlet end falls below a predetermined amount.

4. The combination of a source of fluid under pressure, an evaporator, a plurality of restrictor tubes leading from said source to said receiver, at least one of said tubes having an automatically releasable valve biased toward closed position, said valve being constructed to open upon change of pressure at opposite sides thereof beyond a predetermined value, and at least one of said tubes being continuously open.

5. The combination of a source of fluid under pressure, a chamber, a plurality of restrictor tubes leading from said source to said chamber, and a valve normally closing at least one of said tubes, said valve being constructed to open when the pressure in said chamber falls below a predetermined minimum.

6. The combination of a source of fluid under pressure, a chamber, an attachment comprising a plurality of restrictor tubes leading from said source to said chamber, at least one of said tubes being constantly open to permit fluid to pass to said chamber, and at least one other of said tubes having a normally-closed valve arranged to be opened by the pressure of fluid from said source when the pressure in said chamber falls below a predetermined minimum.

7. In a refrigerating mechanism of the kind that successively compresses, condenses, expands, and evaporates a volatile substance, a feed control for the evaporator having two or more restrictive tubes arranged for parallel flow of the substance, at least one of said tubes having a pressure actuated closing valve at its outlet end

functioning according to the pressure in the evaporator.

8. In a refrigerating plant, an evaporator, a gas compressor, a gas condenser, and an expander in the liquid pipe leading to the evaporator, said expander including at least two restrictive tubes arranged to work in parallel, with a pressure actuated stop for the outlet of at least one of said tubes, said stop being constructed and arranged to function according to evaporator pressure.

9. An expansion device for a compressor-condenser-evaporator type of refrigerating mechanism including two or more parallel restrictive tubes adapted to receive refrigerant liquid from the condenser, and a yieldable pressure operated throttling stop in at least one of said tubes for controlling the flow of refrigerant to the evaporator.

10. A pressure reducing device for liquid refrigerant including a plurality of restrictive tubes adapted to be connected to a common higher pressure liquid supply and a common lower pressure receptacle, and flow controlling means in at least one of said tubes, said flow controlling means being arranged to open when the pressure in said lower pressure receptacle falls below a predetermined point.

11. In a control for a refrigerating mechanism employing a volatile refrigerant, a control throat comprising a series of two or more restrictive tubes, at least one of said tubes being constantly open, and a restraining means for each of one or more of the other tubes of the series, said restraining means being arranged to be relieved upon lowering of the pressure of refrigerant beyond said throat.

12. A liquid feed control for refrigerant evaporators, including a plurality of restrictive tubes adapted to receive liquid at a higher pressure and to deliver it to an evaporator at a lower pressure, in combination with closing devices for only part of the tubes, and means arranged to open said closing means upon undue decrease in such lower pressure.

13. A device as in claim 12, including yieldable means for normally holding said closing means in position to shut off the flow through their tubes, and adjusting means for varying the action of said yieldable means.

14. An expansion device for a compressor-condenser-evaporator type of refrigerating cycle including two or more parallel restrictive tubes for receiving refrigerant liquid from the condenser, at least one of said tubes having therein a yieldable throttling stop arranged between the inlet and outlet of the tube for controlling the flow of refrigerant to the evaporator, and adjustable means for varying the throttling action of said stop.

15. In a refrigerating mechanism, a source of vaporizable refrigerant under pressure, an evaporator, a plurality of restrictor pipes connecting said source to said evaporator, at least one of said restrictor pipes having a pressure-operated automatic valve therein normally serving to prevent refrigerant from passing through said pipe, means for opening said valve when the difference in pressures at opposite ends of said last-named pipe exceeds a predetermined value, and adjustable means for acting on said valve to alter the point at which it is opened.

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