Feb. 4, 1941. E. M. MAY 2,230,842

REFRIGERATING APPARATUS

Filed Sept. 8, 1939 2 Sheets-Sheet 1

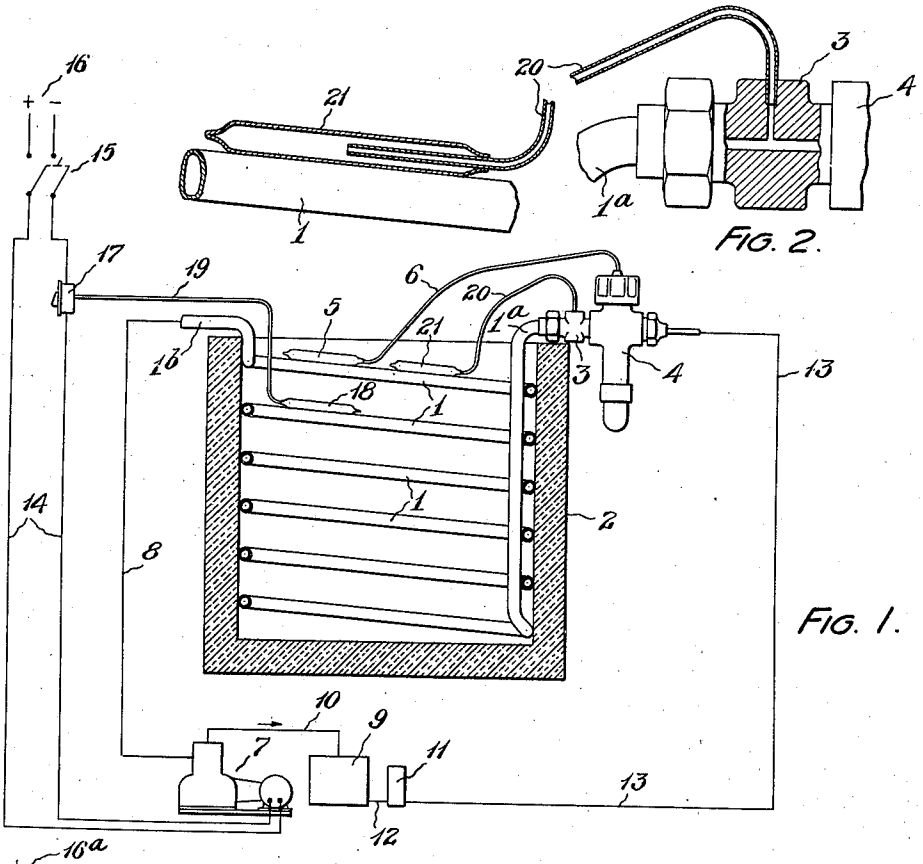


FIG. 1.

FIG. 2.

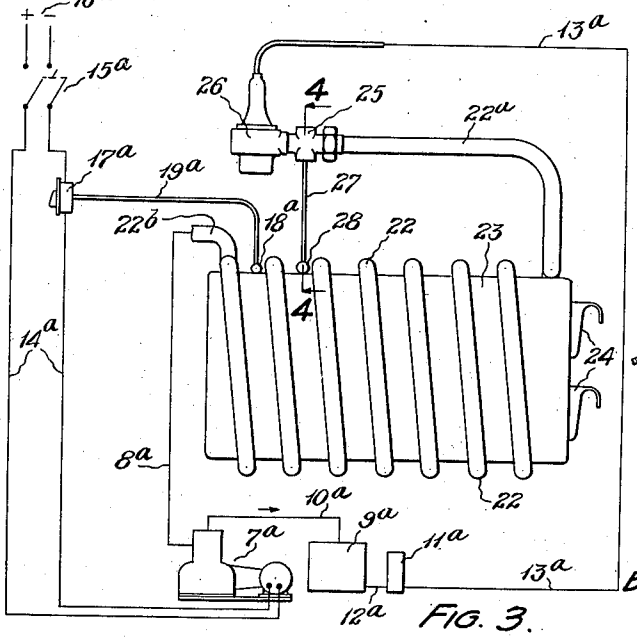


FIG. 3.

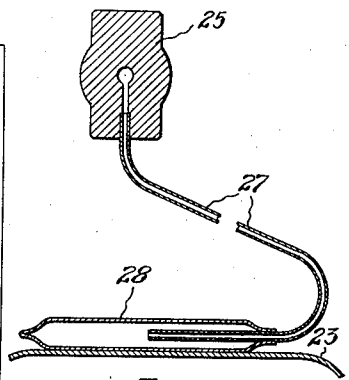


FIG. 4.

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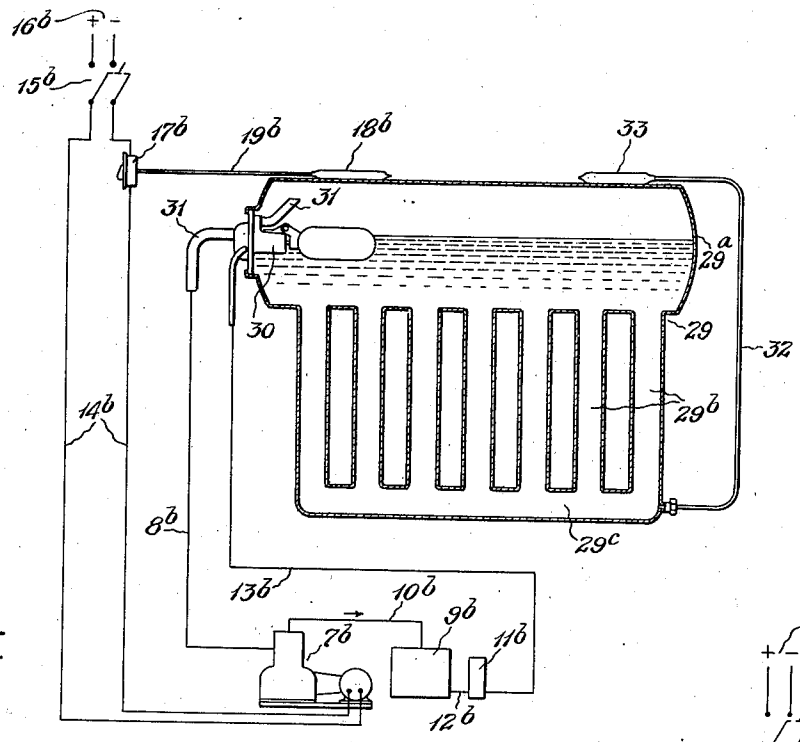


FIG. 5.

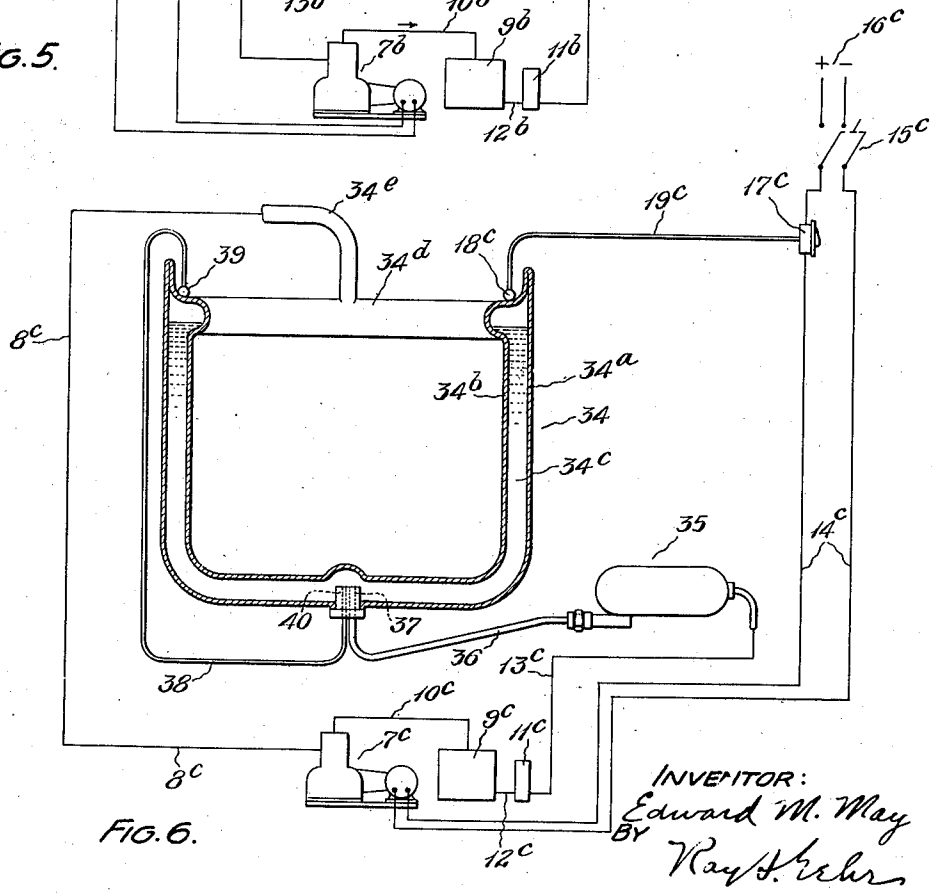


FIG. 6.

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REFRIGERATING APPARATUS

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Application September 8, 1939, Serial No. 293,938

3 Claims. (Cl. 62—115)

The invention relates to refrigerating apparatus and particularly to such apparatus of the automatic intermittently cycling type.

In automatic refrigerating apparatus now in common use, such for example as that of the common household refrigerator, the system comprises an evaporator in which liquid refrigerant is evaporated to produce the desired cooling effect and refrigerant condensing means which withdraws the refrigerant vapor from the evaporator and restores it to the liquid state for reuse in the evaporator, variations of the temperature or pressure within the evaporator, or other part of the "low side" of the system being utilized to control the operation of the condensing means and usually to start and stop it. Now, the heat load to which such refrigerating apparatus is subjected in service may vary widely, and it has been found that under a light heat load the operation of the evaporator of such a system is sluggish, it being necessary to reduce the pressure in the evaporator to a relatively low value in order to initiate ebullition; and the production of this necessary low pressure lowers the over-all efficiency of the apparatus.

The general object of the present invention is to provide refrigerating apparatus of the character in question in which the evaporator is more responsive to the suction effect of the condensing means under light heat loads, with resultant improvement in the efficiency of operation.

More specifically, it is an object of the invention to provide refrigerating apparatus of the character in question having means for automatically agitating the liquid refrigerant in the evaporator when the refrigerant condensing means is in operation and especially during the first part of such operation.

Another specific object of the invention is to effect the agitation of the liquid refrigerant referred to above by introducing refrigerant vapor into the liquid refrigerant in the evaporator.

And a still further object of the invention is to provide refrigerating apparatus having simple, inexpensive and effective means for the introduction of refrigerant vapor into the liquid refrigerant space of the evaporator to stimulate ebullition.

With the above objects and others more or less incidental or ancillary thereto in view the invention consists in certain combinations of parts and features of construction which will appear in the following description of certain specific embodiments of the invention shown in the accompanying drawings.

In the drawings,

Fig. 1 is a view partly in sectional elevation and partly diagrammatic of a refrigerating system embodying the invention.

Fig. 2 is an enlarged view partly in section and partly in elevation of fragmentary parts of the apparatus shown in Fig. 1.

Fig. 3 is a view partly in elevation and partly diagrammatic of a refrigeration system similar to that shown in Fig. 1 but with the invention applied to a different type of refrigerant evaporator.

Fig. 4 is an enlarged section on the line 4—4 of Fig. 3.

Fig. 5 is a view partly in sectional elevation and partly diagrammatic of a refrigeration system embodying the invention as applied to an evaporator of the flooded type with low side float valve.

Fig. 6 is a view partly in sectional elevation and partly diagrammatic of a refrigeration system showing the invention as applied to another form of flooded evaporator with high side float valve.

Referring in detail to the construction shown in Figs. 1 and 2, 1 designates a refrigerant evaporator in the form of an upright continuous coil designed to cool a refrigerator or container 2 of the top-opening box type, only the side and bottom walls of the refrigerator being indicated. The inlet arm 1*a* of the evaporator coil 1 is connected to a T coupling 3 to which in turn is connected a thermostatic expansion valve 4 designed to be automatically operated by pressure generated in a thermostatic bulb 5 which has heat-transmitting engagement with the outlet end of the evaporator coil 1 and which is connected with the valve 4 by means of a small bore tube 6. The internal construction of the valve 4 is not shown as any known thermostatic expansion valve can be used.

The numeral 7 designates as an entirety a motor-driven refrigerant compressor having its suction inlet connected by a pipe 8 with the discharge branch 1*b* of the evaporator coil 1. A condenser 9 is connected by a pipe 10 to the discharge of compressor 7 and the condenser in turn is connected to a liquid refrigerant receiver 11 by pipe 12. Receiver 11 is connected by a liquid refrigerant line 13 with the inlet of the expansion valve 4, thus completing the closed circuit of the system. The motor of the compressor set is connected by suitable conductors 14 and manual switch 15 with a current source 16 and a pressure-actuated switch 17 is provided to auto-

matically control the compressor motor, said switch being actuated by fluid pressure generated in a thermostatic bulb 18 having heat-conducting contact with the outlet portion of the evaporator and being connected by small bore tube 19 with the pressure chamber of the switch 17.

All of the above described parts of the apparatus are of well known type and construction. In the operation of such systems the absorption of heat by the evaporator coil 1 raises the temperature of thermostatic bulb 18 which results in the closing of switch 17 and the starting of the motor-driven compressor 7. The suction of the compressor in the first part of the period of its operation reduces the pressure in the evaporator coil 1 while the valve bulb 5 remains relatively warm. This permits expansion valve 4 to open and admit liquid refrigerant through the T connection 3 into inlet section 1a of the evaporator. Meanwhile liquid refrigerant in the bottom turn or turns of the evaporator coil 1 tends to lie quiescent and in prior apparatus of this kind, as was indicated at the outset, it has been necessary to carry the suction pressure of the evaporator to a relatively low value before active ebullition of the liquid refrigerant in the lower part of the coil would begin, this being especially true where the heat load on the evaporator was relatively low. Furthermore, while the liquid remains quiescent in the coil the valve bulb will continue warm, thus causing the valve temporarily to pass too much liquid into the evaporator. I have discovered that these adverse operating conditions can be effectively overcome by mechanically agitating the otherwise quiescent body of liquid refrigerant in the lower part of the coil and furthermore that it is possible to accomplish this by means of the exceedingly simple expedient of introducing refrigerant vapor into the body of liquid refrigerant. This I accomplish in the apparatus illustrated by means now to be described.

In the apparatus shown in Fig. 1, the upper branch or passage of the T coupling 3 is connected by means of a small bore tube 20 with a liquid refrigerant container 21 in the form of a tubular bulb which is arranged in heat transmitting connection with the upper, outlet turn of the coil 1. As is shown in Fig. 2, the end of the tube 20 projects well into the chamber of the container 21.

In the operation of the apparatus the tube 20 and container 21, connected as described to coupling 3, function in the following manner. Toward the end of a running period of the apparatus the temperature throughout the evaporator coil 1 is lowered, the outlet portion of the coil being slightly colder than the inlet part thereof. Under these conditions condensation of refrigerant vapor occurs in bulb 21 and some of the liquid refrigerant admitted to the T coupling by the expansion valve is drawn through tube 20 into bulb 21 where at least some of it is trapped. When the temperature of the evaporator has been reduced to a predetermined point, the condensing means is shut off and the usual off or idle period follows. During the idle period a converse condition of the evaporator develops; that is, the outlet part of the evaporator becomes warmer than its inlet part. This causes refrigerant trapped in the bulb 21 to evaporate with the result that the gaseous refrigerant is forced back through tube 20 and T coupling 3 into and through the evaporator. This action is especially marked when the compressor first starts at the beginning of the operating period due to the marked drop in the suction pressure at that time. The liquid in the refrigerant bulb 21 evaporates before the liquid refrigerant in the coils of the evaporator because it is warmer. The passage of the gaseous refrigerant from the bulb 21 into the lower inlet coils of the evaporator agitates the liquid refrigerant in said coils and thus greatly stimulates ebullition and evaporation. Because of this action I call the bulb 21 an ebullator.

The above described mechanical agitation of the liquid refrigerant at the beginning of the working period of the cycle of operation increases the overall efficiency of the apparatus because the suction pressure of the system does not have to be carried as low, to attain a given evaporator temperature, as when such agitation is not supplied. This advantage, as has been indicated, is especially marked when the heat load on the evaporator is relatively low or moderate.

The present invention is not limited to apparatus having evaporators of the particular type illustrated in Fig. 1. As indicative of some of the other possible applications of the invention I have shown such applications in other figures of the drawing to several forms or types of evaporator.

In Fig. 3 the parts 7a, 8a, 9a, 10a, 11a, 12a, 13a, 14a, 15a, 16a, 17a, 18a and 19a are respectively substantially identical with the corresponding parts 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19 of the system shown in Fig. 1. But in lieu of the vertical coil type of evaporator shown in Fig. 1 the apparatus in Fig. 3 has an evaporator comprising a horizontally disposed expansion coil 22 and a metal shell 23 with the exterior of which coil 22 has heat transmitting connection. The shell 23 is of the type provided with ice or food trays such as are shown at 24. The coil 22 has its inlet arm 22a connected to a T coupling 25, which in turn is connected to an automatic expansion valve 26 which may be of the known types of construction suitable for use in connection with such evaporators. The inlet of the valve 26 is connected with the liquid line 13a of the system, and the outlet 22b of the evaporator coil is connected with the suction line 8a of the system. Thermal bulb 18a operatively connected with control switch 17a is arranged in heat transmitting connection with the evaporator shell 23 at or near the outlet end of the evaporator.

In this apparatus the T coupling 25, as best shown in Fig. 4, is connected by tube 27 to an ebullator bulb 28 which is in heat transmitting engagement with the evaporator shell 23 near the outlet end of the evaporator.

Except for the automatic action of the expansion valve 26 the system of Fig. 3 is substantially the same in operation as that of Fig. 1. The operation of the ebullator 28 in Fig. 3 also is similar to the operation of the ebullator in Fig. 1 and it is believed it will be clear without further description.

In Fig. 5 of the drawings, the invention is shown applied to a refrigeration system having an evaporator of the flooded type fitted with a low side float valve for controlling the admission of liquid refrigerant. Here the parts 7b, 8b, 9b, 10b, 11b, 12b, 13b, 14b, 15b, 16b, 17b, 18b and 19b are substantially identical with the corresponding parts 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19 of Fig. 1. The evaporator, indicated in its entirety by the numeral 29, comprises an upper cylindrical header 29a, a series of tubes 29b depending from the header, and a lower header 29c to which the lower ends of tubes 29b are connected. The evaporator is fitted with a float-controlled inlet

valve 30 to which the liquid refrigerant supply line 13b is connected, and with a suction outlet tube 31 to which the suction line 8b is connected.

In the operation of a system having a flooded evaporator such as is shown, the float valve 30 admits liquid refrigerant to the evaporator as refrigerant is evaporated therein so as to maintain the refrigerant at a substantially constant level as indicated in Fig. 5, the open upper end of the suction tube 31 being thus disposed in the vapor space of the evaporator. In an evaporator of the flooded type the top wall thereof, during the off or idle period, is the warmest part of the evaporator because it is not in direct contact with liquid refrigerant. Accordingly the top wall of the header 29a corresponds to the outlet portion of the evaporator coil 1 in Fig. 1 and the switch bulb 18b is arranged in contact with the top wall of the header.

The ebullator in Fig. 5 is substantially the same as that in the above described systems and comprises a small bore tube 32 which is connected with the lower header 29c as shown, and an ebullator bulb 33 which is similar in construction to the bulb 21 shown in Fig. 2, having the end of tube 32 projecting into the chamber of the bulb so as to trap liquid refrigerant therein as explained in connection with the first described system.

In the operation of the apparatus in Fig. 5 all parts of the evaporator are lowered in temperature during the working period of the cycle and this results in condensation in the ebullator bulb 33, causing liquid refrigerant to be drawn from the lower header 29c into the ebullator bulb 33. Later, during the idle period of the compressor, the temperature of the evaporator rises, evaporation occurs in the ebullator and refrigerant vapor is forced into the lower header 29c so as to rise through the liquid refrigerant and agitate it and stimulate ebullition as explained in connection with the first described system.

In Fig. 6 of the drawings, the invention is shown applied to a flooded evaporator with high side float valve. Here the parts 7c, 8c, 9c, 10c, 11c, 12c, 13c, 14c, 15c, 16c, 17c, 18c and 19c are substantially the same as the corresponding parts 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19 of the system shown in Fig. 1.

The evaporator 34 is of the hollow shell type and comprises outer and inner walls 34a and 34b in the form of metal sheets bent into approximately U form and spaced apart to form refrigerant chamber 34c. The two upright branches of the chamber so formed are connected by at least one transverse tube 34d which is fitted with a suction outlet tube 34e to which the suction line 8c is connected. A high side float valve 35, which may be of any suitable known construction, has its inlet connected with the liquid refrigerant line 13c, and its outlet connected by tube 36 to the inlet 37 in the bottom of the evaporator 34. The high side float valve is adapted to maintain, in a well known manner, a body of liquid refrigerant in the evaporator, as indicated in Fig. 6, with a vapor space above the liquid level in the side chambers of the evaporator and in the transverse connector 34d.

In the operation of a system having an evaporator such as the evaporator 34, the high side float valve admits liquid refrigerant to the evaporator as refrigerant is withdrawn from the evaporator, condensed and returned to the float valve chamber, and thus maintains the refrigerant in the evaporator at a suitable level as indicated in Fig. 6. As in the case of the evaporator 29 of Fig. 5, the evaporator 34 has its wall parts above the liquid level warmer than other parts of the evaporator during the idle period of the apparatus, and the switch bulb 18c is arranged in heat conducting contact with the top wall of the evaporator 34 as shown.

The ebullator for the evaporator 34 comprises small bore tube 38 which is connected at one end with an ebullator bulb 39, and at its other end is connected to passage 40 formed in the same fitting as the refrigerant inlet 37, thus operatively connecting the ebullator bulb with the bottom part of the evaporator chamber 34c. The ebullator bulb 39 is secured in heat transmitting connection with the top wall of the evaporator and is of the same construction as the bulb 21 shown in Fig. 2, having the end of the tube 38 projecting into the bulb chamber.

In the operation of the last described apparatus all parts of the evaporator are lowered in temperature during the working period of the cycle. This results in condensation of refrigerant in the ebullator bulb 39 which in turn causes liquid refrigerant to be drawn from the bottom of the evaporator into the ebullator bulb. Later, during the idle period of the apparatus, the temperature of the evaporator rises and evaporation of refrigerant occurs in the ebullator so that refrigerant vapor is forced therefrom into the bottom of the evaporator causing agitation of the liquid refrigerant therein and stimulating ebullition as explained in connection with the systems already described.

It will be understood that means of various kinds can be employed to effect automatically a positive agitation of the liquid refrigerant in the evaporator at appropriate times in the operating cycle, but I prefer to accomplish this agitation by the introduction of refrigerant vapor into the liquid refrigerant and, furthermore, I especially prefer to accomplish this by means of a refrigerant bulb or trap operatively associated with the evaporator in ways such as have been shown in the drawings and described above, because of the extreme simplicity of said construction and its reliability and effectiveness in operation.

What I claim is:

1. In a refrigerating system, the combination with a refrigerant evaporator having an inlet for refrigerant liquid and an outlet for refrigerant vapor leading from the vapor space of the evaporator; refrigerant condensing means having its refrigerant vapor inlet connected with the said outlet of the evaporator and its refrigerant outlet connected with the said inlet of the evaporator; means for controlling admission of liquid refrigerant into the evaporator; and control means for the refrigerant condensing means causing the latter to operate intermittently to withdraw refrigerant from the said vapor space of the evaporator; of means for introducing refrigerant vapor into the lower part of the evaporator at a time when refrigerant is being withdrawn from the latter by the condensing means, the said means for introducing vapor comprising a refrigerant container having good heat-conducting connection with that part of the evaporator wall enclosing the said vapor space of the evaporator; and conduit means leading from the interior of the said container into a liquid-containing part of the evaporator, whereby liquid refrigerant is drawn into the container in the

latter part of the working period of the condensing means and refrigerant vapor is driven out of the container into the liquid space of the evaporator in the early part of the said working period.

2. A refrigerating system as claimed in claim 1 in which the evaporator is in the form of a continuous coil of pipe and an expansion valve serves to control admission of liquid refrigerant into it.

3. A refrigerating system as claimed in claim 1 in which the evaporator is of the flooded type and a float actuated valve serves to control admission of liquid refrigerant into it.

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