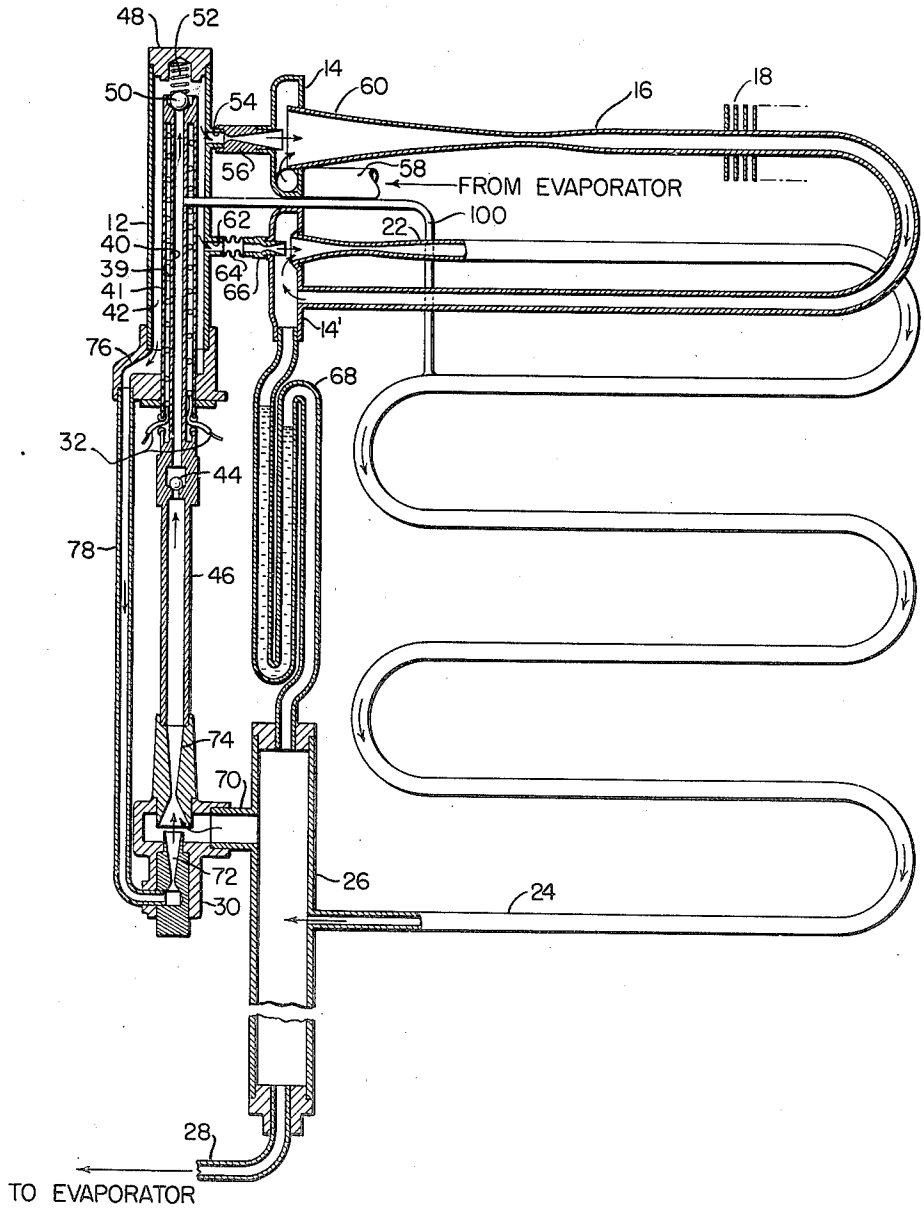
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JET PUMP REFRIGERATION SYSTEM

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JET PUMP REFRIGERATION SYSTEM

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This invention relates to refrigeration apparatus and in particular to systems wherein a refrigerant is moved through its cycle by a pressurized motive fluid. In one aspect the present invention comprises an improvement upon the system disclosed in our copending application for Letters Patent of the United States, Serial No. 235,278, filed July 5, 1951, now Patent No. 2,658,356, November 10, 1953.

The primary object of the present invention is to eliminate malfunctions of an injector-fed boiler employed to provide pressurized vapor of the motive fluid.

Another object of the invention is to render the boiler operation less directly responsive to the dimensions of the injector employed to feed it, thus facilitating the design of the system and reducing the cost of constructing the injector.

An important feature of the invention resides in the combination of a boiler fed by an injector and feeding an ejector coupled to drive refrigerant under compression into a condenser and a capillary tube connected between the boiler and the condenser, the capillary serving to drain the boiler above a predetermined level and prevent stoppage due to excessive feeding.

The dimensions of the boiler in a system designed for ordinary household use are relatively small, a fact which would in return require a very small injector, so small as to introduce grave difficulties in forming and assembling its parts. However, by providing a capillary drain from the boiler, it becomes possible to employ an oversize injector without flooding the boiler. A capillary will accept a satisfactorily large flow of liquid but only a negligible flow of gas. Hence the presence of the capillary does not result in any serious drop in boiler pressure.

These and other objects and features of the invention will be more readily understood and appreciated from the following detailed description of a preferred embodiment thereof selected for purposes of illustration and shown in the accompanying drawing, in which the figure is a diagrammatic view partly in cross-section through the boiler, injector, and jet pump assembly.

In advance of a discussion of the details of the embodiments herein shown it will be helpful first to consider the general organization of the system. There is provided a conventional evaporator of standard construction (not shown) and a boiler 12 of elongated tubular form. The boiler 12 serves a pair of jet pumps contained in housings 14 and 14' and connected in series by a pipe

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16 having cooling fins 18 secured thereto. Refrigerant gas from the evaporator is pumped and compressed by the jet pumps working in tandem, the effluent therefrom being thereafter passed through a condenser 22 in which it yields heat and liquefies.

From the condenser 22 the liquid refrigerant, together with the motive fluid injected from the boiler 12, passes through a tube 24 and into a gravity separating chamber 26. As shown the connections are established for operation with a heavier refrigerant and a lighter motive fluid. Hence the former collects at the bottom of the separator 26 and is drawn off through a pipe 28 and returned to the evaporator through a conventional expansion valve (not shown).

The lighter motive fluid fills the upper portion of the separator and is drawn off through an injector contained in a housing 30 and thereby pumped back to the boiler 12. The injector in the housing 30 is powered by vapor exhausted from the boiler 12 and conducted to the injector through an external tube 78. Heat for the boiler is supplied by electricity through a resistance element in the form of nichrome windings served by a supply line 32.

In operation the liquid refrigerant passes from the separator 26 into the evaporator where it is expanded and heated. From the evaporator the gaseous refrigerant is drawn by the upper jet pump in the housing 14 into the tube 16 where it is given preliminary compression and wherein part of its heat is extracted and radiated to the atmosphere by the cooling fins 18. The partially compressed refrigerant then passes through the tube 16 into the second jet pump into the housing 14' where it is further compressed and then discharged into the condenser 22 where additional heat is given up and wherein the gaseous refrigerant condenses to the liquid state and then passes into the tubular separating chamber 26 where it settles to the bottom readily to pass again through the refrigerating cycle. On the other hand, the motive fluid is withdrawn from the top of the separating chamber 26 by the jet pump in the housing 30, by means of which the liquid is injected into the boiler 12 and therein heated until it vaporizes and leaves the top of the boiler under pressure to serve as the motive fluid for the two stage jet pump. Also a portion of the vapor from the boiler passes through the tube 78 and serves as the motive fluid to operate the injector 72 in the pump 30 and thus to feed the boiler 12.

With the foregoing general remarks in mind

the details of the boiler and jet pump assembly can more easily be understood. As shown the boiler comprises an outer tube or shell 12 within which and concentrically arranged is a tube 40 around which is wrapped a spiral of nichrome wire 39, the latter being protected in turn by a casing 41. There is thus formed an elongated annular chamber 42 lying between the casing 41 and the shell 12. At the bottom of the tube 40 there is disposed a ball check valve 44 serving to prevent the draining of liquid from the bottom of the boiler. At the top of the tube 40 there is a second ball check valve 50 working against a spring 52 set in a socket formed in a plug 48 serving to close the top of the shell 12. Adjacent the upper end of the boiler shell 12 is an outlet 54 which is coupled to an injector nozzle 56 having its inner passage so shaped that vapor leaving the boiler shell 12 first encounters a converging wall portion in which the pressure of the vapor is raised and then a diverging or diffuser portion which discharges into the housing 14. Refrigerant gas is admitted into the housing 14 through a pipe 58 connected into the exhaust end of the evaporator. One end of the tube 16 is enlarged as shown at 60 and projected within the housing 14 opposite the injector nozzle 56.

The rush of vapor through the nozzle 56 and into the tube 60 carries with it refrigerant gas entering the housing 14 through the pipe 58 and the refrigerant gas thus entrained is compressed to a preliminary extent in the tube 16; another result, of course, is to create suction in the line 58 leading from the evaporator. Disposed below the outlet 54 is a second outlet 62 receiving one end of a bellows connection 64 which is coupled at its outer end to the housing 14' and to a second and smaller jet nozzle 66. The condenser tube 22 has an enlarged head projected into the housing 14' opposite the diffuser end of the nozzle 66, the result being that partially compressed refrigerant together with motive fluid introduced into the tube 16 is discharged into the housing 14' and then entrained in the rush of vapor through the nozzle 66 and dispatched through the condenser tube 22 where the refrigerant will condense to a liquid as it passes through the condenser 22. As a matter of fact, most of the motive fluid will be condensed by the time it reaches the bottom of the housing 14', and we provide a trapped drain 68 leading from the bottom of the housing 14' to the top of the separator 26, the drain 68 having a U-shaped loop portion effective to provide a head of pressure sufficient to prevent liquid in the separator from blowing back into the housing 14' through the drain 68.

Adjacent the upper end of the separator there is provided an outlet pipe 70 leading to a housing 30 in which is contained a jet nozzle 72 disposed opposite an injector nozzle 74 leading to a vertical pipe 46 which is connected into the bottom of the tube 40 below the ball check valve 44. Adjacent the bottom of the boiler shell 12 there is provided an annular housing enclosing a conduit 76 leading to a tube 78 which in turn terminates in the nozzle 72.

For a discussion of the operation of the elements thus far described, the reader is referred to our copending application identified above. Coming now to the improvement with which the present application is concerned, it will be evident that a thin capillary tube 100 has a horizontal leg connected to the interior boiler tube

40 at a point about three quarters of the distance from the lower check valve 44 to the upper check valve 50, or wherever it is desired to establish the maximum height of the level of liquid in the boiler. The other end of the capillary tube 100 comprises a vertical leg connected to the condenser tube 22 at a point substantially below the first connection.

In operating the system the injection system 72, 74 may be dimensioned to feed a small excess of liquid to the boiler, that is to say an amount exceeding that which is normally vaporized in the boiler. When the liquid level rises to the end of the tube 100, it begins to drain through the tube 100, an effect which is assisted by the pressure within the boiler and by the suction of the liquid column formed in the vertical leg of the tube 100. However, when the level of the liquid in the boiler drops below the end of the tube 100, the flow of gas through the tube is negligible, since the mass flow through a capillary is much less for a gas than for a liquid. Although a capillary tube is quite satisfactory, a larger tube with a constriction or restricted orifice may be substituted therefor with no loss of efficiency. The actual diameter of the tube will depend upon the size of the boiler and other elements of the system, and those skilled in the art will readily understand what dimensions will be applicable.

The advantages resulting from the employment of the improvements herein disclosed include not only the elimination of malfunction due to flooding of the boiler but also the feasibility of injector nozzles of larger dimensions and cheaper cost, since very difficult machining problems are encountered in the fabrication of very small nozzles.

Having now disclosed and illustrated a preferred embodiment of the invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. In a refrigeration system including a boiler, a condenser, a jet pump connected to said boiler and to said condenser, the combination of an injector driven by a portion of the exhaust from said boiler and connected to the inlet of said boiler and said condenser for entraining liquid from said condenser into said boiler, and a relatively small tube connecting said boiler at a predetermined height therein to said condenser.

2. In a refrigeration system including a boiler, a condenser, a jet pump connected to said boiler and to said condenser, the combination of an injector driven by a portion of the exhaust from said boiler and connected to the inlet of said boiler and said condenser for entraining liquid from said condenser into said boiler, and a capillary tube connecting said boiler at a predetermined height therein to said condenser.

3. Apparatus of the class described, comprising a boiler, a condenser, a jet pump connecting the exhaust of the boiler to the condenser, an injector receiving vapor from said boiler and connected to pump liquid from the condenser to the boiler, and a tube having a horizontal leg connected to the boiler a predetermined distance above its base and a vertical leg depending from the level of the horizontal leg and connected to the condenser for passing directly to said condenser liquid in said boiler above the level of the horizontal leg of said tube.

4. Apparatus of the class described, comprising a boiler, a condenser, a jet pump connecting the exhaust of the boiler to the condenser, an

injector receiving vapor from said boiler and connected to pump liquid from the condenser to the boiler, and a capillary tube having a horizontal leg connected to the boiler a predetermined distance above its base and a vertical leg depending from the level of the horizontal leg and connected to the condenser for passing directly to said condenser liquid in said boiler above the level of the horizontal leg of said tube.

5. Apparatus of the class described, comprising a boiler having an inlet for liquid and an exhaust passage for vapor, pressure responsive check valves controlling the inlet and the exhaust passage, a pair of jet pumps connected in parallel to said exhaust passage, a condenser connected to said jet pumps, a tank connected to said condenser, a capillary tube connected between an intermediate point of the boiler and said condenser, an injector connected to said exhaust passage and to said tank, and walls forming a chamber connected at one end to said

boiler inlet and at the other end to said injector.

6. Apparatus of the class described, comprising a boiler having an inlet for liquid and an exhaust passage for vapor, pressure responsive check valves controlling the inlet and the exhaust passage, a pair of jet pumps connected in parallel to said exhaust passage, a condenser connected to said jet pumps, a capillary connected between said condenser and said boiler, a tank connected to said condenser, an injector connected to said exhaust passage and to said tank, and walls forming a chamber interconnecting said injector and said boiler inlet.

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