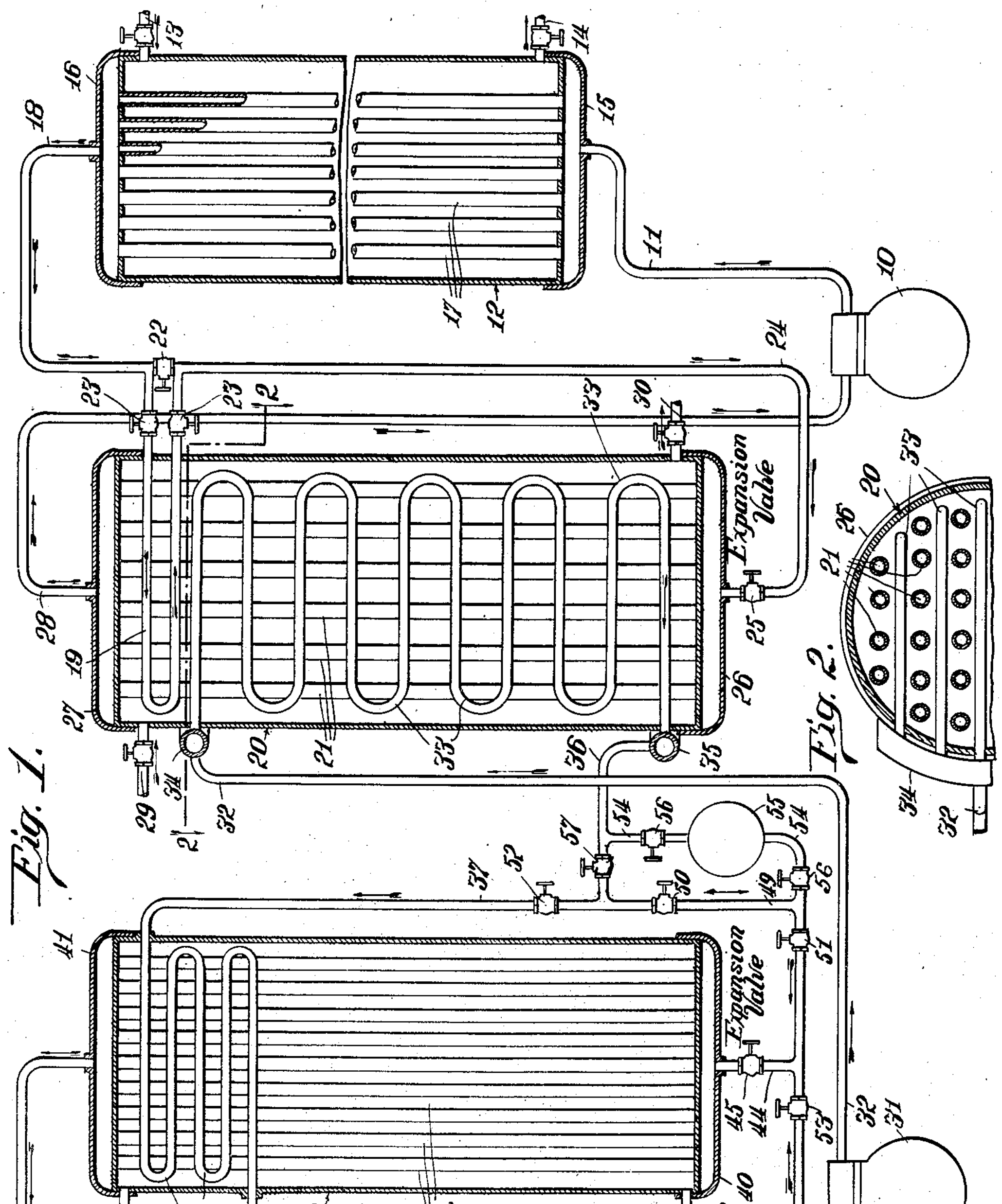
March 26, 1940. A. SCHWARZ 2,195,228

REFRIGERATING APPARATUS AND PROCESS

Original Filed May 7, 1934 3 Sheets-Sheet 1



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REFRIGERATING APPARATUS AND PROCESS

Original Filed May 7, 1934 3 Sheets-Sheet 2

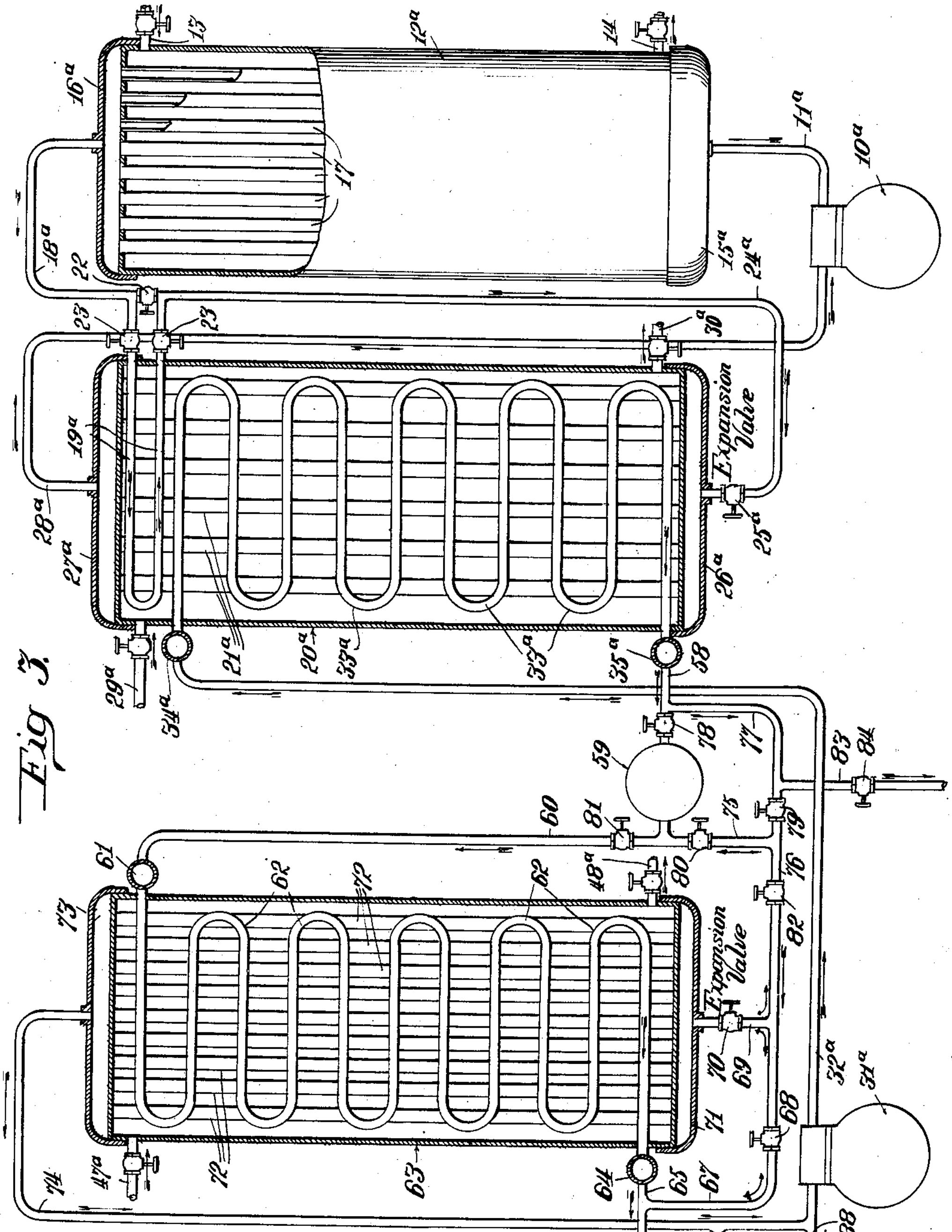

Fig. 3.

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REFRIGERATING APPARATUS AND PROCESS

Original Filed May 7, 1934 3 Sheets-Sheet 3

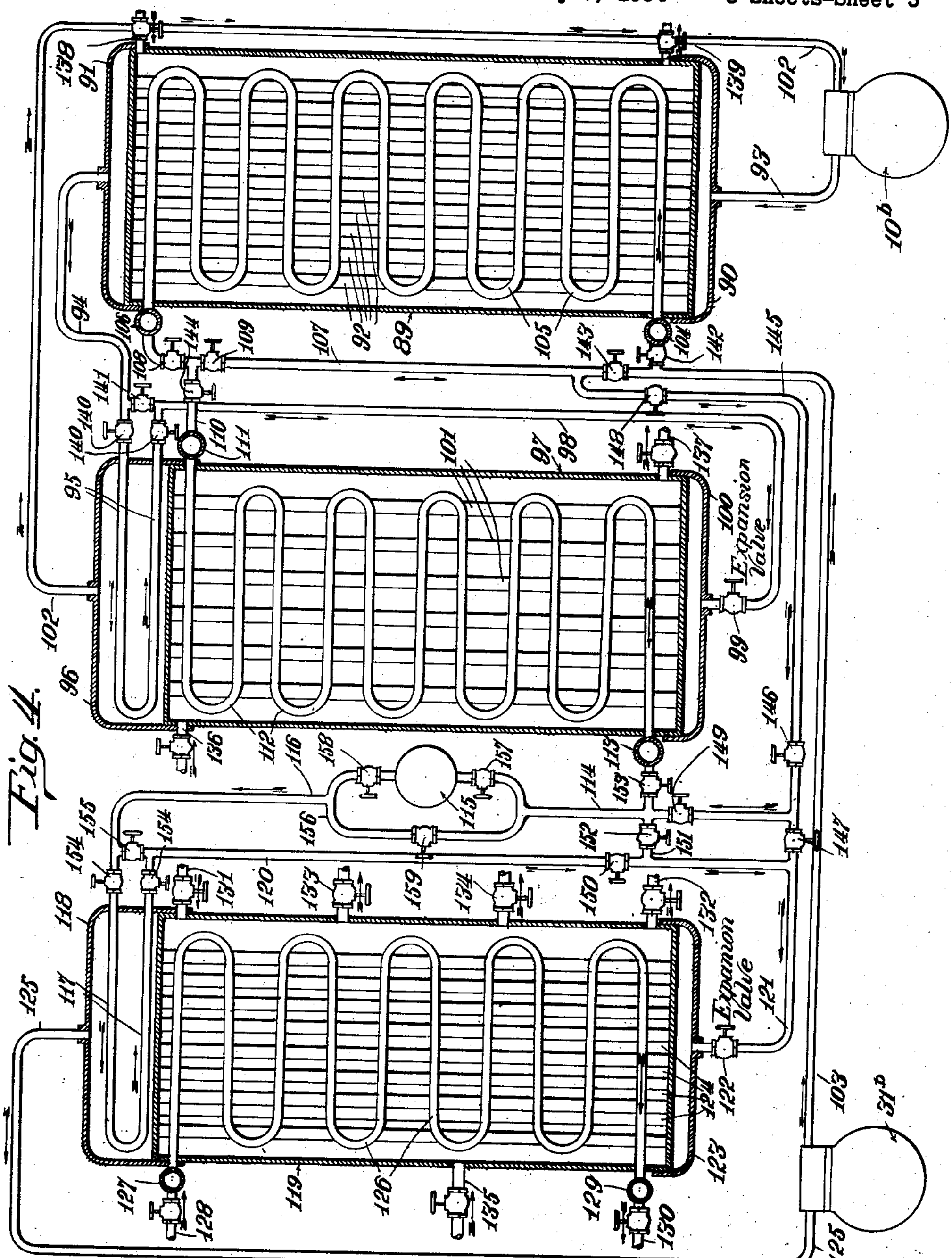

Fig. 4.

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2,195,228

REFRIGERATING APPARATUS AND PROCESS

August Schwarz, Chicago, Ill.

Refiled for abandoned application Serial No. 724,335, May 7, 1934. This application March 13, 1937, Serial No. 130,759

34 Claims. (Cl. 62—115)

My invention has for its object the provision of apparatus adapted for low temperature and quick freezing refrigeration; also for condensing the final refrigerant by low temperature and by low condenser pressure; including means whereby the low temperature and low pressure liquid may be boosted and further cooled under high pressure.

The invention involves what may be termed two single stage systems, namely apparatus so associated, but selectively operable, that a portion may be operatively disconnected from the other portion and each portion employed as a single phase system, one single phase system involving a compressor, a condenser, a pre-cooler, expansion means and evaporator means; while the other single phase system involves a compressor, a condenser, liquid pump, a pre-cooler, expansion means and evaporator element, together with means whereby the liquid pump, may, at the will of the operator, be operatively eliminated.

The invention also involves valve controlled means whereby the pre-coolers, either one or both, in both of said systems may be eliminated when desired.

The invention also involves a two stage condensing and refrigerating system whereby the carbon-dioxide refrigerant is condensed and cooled in two stages; the first stage including a low temperature and low pressure condenser cooled by the expansion of a volatile refrigerant; further whereby the pressure of the low temperature and low pressure carbon dioxide from said condenser may be boosted and the carbon dioxide further cooled under high pressure; and also means whereby a portion of the first mentioned liquid refrigerant commingled with a portion of the boosted and further cooled liquid carbon dioxide refrigerant before expansion, and further means whereby a portion of the low temperature and high pressure liquid carbon dioxide refrigerant may be utilized for making dry ice in connection with dry ice making apparatus.

The invention also involves means whereby high pressure and low temperature liquid is available for the same purpose; and means whereby low temperature and low pressure liquid is available for the purpose of further cooling the liquid in the ice making apparatus; with arrangements whereby the exhaust may be drawn off from the ice-making or cooling apparatus and arrangements whereby the spent carbon dioxide for ice-making or cooling may be conveyed into my improved apparatus; my improved apparatus for condensing and cooling under low and high pressure permitting use of the system as a single or a double stage refrigerating system.

My invention also involves a single unit which permits compressing and condensing a refrigerant; pre-cooling an oncoming liquid refrigerant in heat exchange relation with the vaporized refrigerant; the unit providing a path for a fluid medium to be heated or cooled therein, expansion means and evaporating elements in said unit.

My invention further involves an evaporator consisting of a vertically arranged shell divided by a wall in an upper and lower compartment, the lower compartment being provided with evaporating elements, the ends of said elements extending through said wall and communicating with said upper compartment, and a fluid conveying element, said lower compartment being also provided with a plurality of inlet conduits and outlet conduits, whereby a fluid cooled in said compartment may be introduced into said compartment at different levels and withdrawn therefrom at different levels, said upper compartment being provided with a liquid receiving and cooling element and in heat exchange relation with the discharge gas of said evaporating element.

My invention still further involves a refrigerating apparatus adapted either as a condenser or as an evaporator, said apparatus comprising a vertically arranged shell defining a chamber provided with a condenser element, an evaporating element and a liquid cooling element, the outlet end of said cooling element being connected with the inlet of said evaporating element, the shell being also provided with an inlet and an outlet conduit, whereby a fluid medium to be heated or cooled may be passed through the chamber of said shell in heat exchange relation with all of said elements.

This application covers new inventions which also represent novel improvements over the inventions of my Patent No. 1,951,447, reissue application for which is now being prosecuted, and also represents a refiling of my abandoned application, Ser. No. 724,335, filed May 7, 1934.

The accompanying drawings more or less schematically illustrate what I believe to be the best embodiments of my invention, although many variations and modifications of the systems are possible, and numerous arrangements of the relative positions may be made without departing in any way from my invention.

Fig. 1 is a vertical sectional view of my improved system, a portion of one of the units being broken away, while other portions are diagrammatically illustrated.

Fig. 2 is a detail sectional view taken substantially on the line 2—2 of Fig. 1, as viewed by the arrows.

Fig. 3 is a vertical sectional view of a modification of my improved system; certain portions being shown in section while other portions are diagrammatically illustrated.

Fig. 4 is a vertical sectional view of another modification of my improved system, with certain portions shown diagrammatically.

In the particular embodiment of the invention as shown in Figs. 1 and 2, a compressor is indicated at 10, connected by means of conduit 11 with a condenser 12, which may be water cooled or cooled by any other suitable medium; the medium may be introduced through inlet 13 and withdrawn by outlet 14.

In the illustration, the condenser is shown provided with headers 15 and 16 at opposite ends which are connected by a suitable number of tubes or coils as at 17.

The condensed refrigerant is conveyed from the outlet header 16 of the condenser by means of conduit 18.

In this particular embodiment of the invention, the conduit 18 is shown connected with a liquid receiver or liquid cooling element 19 which extends into or is located in a combined condenser, evaporator and liquid cooler unit 20, and preferably adjacent the discharge end of the evaporator element or elements 21 in said unit 20.

The flow of the liquid through the cooling element 19 is controlled by a suitable number of valves as at 22 and 23, 23. It is apparent from the arrangement shown that when valve 22 is closed and valves 23, 23 are open, the refrigerant or liquid in conduit 18 will be made to flow through element 19 and then returned to conduit 24. The liquid or refrigerant is conveyed by conduit 24 to the inlet end of unit 20 where the conduit is provided with an expansion valve 25. The liquid or refrigerant is evaporated or expanded into the header 26 of unit 20 and allowed to evaporate in tubes 21 by which it is conveyed to header 27, whence it is withdrawn by conduit 28 connected with the suction end of compressor 10, where the gas is recompressed and returned to condenser unit 12; said elements forming a primary refrigeration cycle.

The chamber in unit 20, intermediate of the headers 26 and 27, is provided with a valve controlled inlet 29 and valve controlled outlet 30, whereby any suitable liquid cooling medium may be circulated through the unit 20 in heat exchange relation with the evaporator elements 21.

A secondary or low temperature refrigeration cycle involves a compressor 31 provided with conduit 32 which conveys the compressed refrigerant to a condenser element or elements 33 arranged in unit 20 intermediate the headers 26 and 27. In the particular embodiment of my invention, I show the condenser elements in the nature of coils disposed intermediate the different rows of evaporating elements or tubes 21, as more clearly shown in Fig. 2. With this arrangement, the conduit 32 discharges the compressed refrigerant into a header or manifold 34 which connects with the inlet ends of all of the condenser coils 33, as shown in Fig. 2; while the discharge or outlet ends of these coils are connected with a similar header or manifold 35.

The condensed and low temperature liquid refrigerant coming from the condenser header 35 is conveyed by conduit 36 to a conduit 37 whereby the low temperature liquid refrigerant is conveyed into a liquid receiver or cooling element 38, shown in the nature of coils arranged preferably at the discharge end of an evaporator unit 39.

The unit 39 is preferably shown provided with headers 40 and 41 at opposite ends; and these headers are connected by means of a plurality of tubes or coils 42.

The low temperature liquid refrigerant is conveyed by element 38, into conduit 43 which is provided with a pipe connection 44 provided with expansion valve 45, whereby the refrigerant is expanded and vaporized into header 40, passing through tubes or coils 42 into discharge header 41, from whence the vaporized refrigerant is withdrawn by conduit 46 which connects with the suction side of compressor 31, where the refrigerant gas is recompressed and returned to condenser 33.

The chamber of unit 39 is shown provided with a valve controlled inlet 47 and a valve controlled outlet 48, whereby a suitable liquid cooling medium may be circulated through unit 39 and conveyed to any desirable place of use; the medium being made to flow in heat exchange relation with the tubes or coils in evaporator 39 and the liquid receiver or cooling element 38.

A conduit connection 49 is disposed intermediate of conduit 37 and pipe 44; and this connection 49 is shown provided with valves 50 and 51; while conduit 37 is shown provided with a valve 52 and conduit 43 is shown provided with a valve 53 adjacent to pipe 44.

It is apparent that when valve 52 and valve 53 are closed and valves 50 and 51 are opened, the liquid refrigerant coming from conduit 36 will be made to flow into pipe connection 49 and conveyed to pipe 44 and expanded into header 40 of unit 39.

Interposed between conduit 36 and pipe connection 49 is a by-pass line 54 provided with a liquid refrigerant pump 55. The by-pass 54, on opposite sides of pump 55 is shown provided with valves 56, 56, which must both be open when pump 55 is in use.

Conduit 36, at a point intermediate by-pass 54 and conduit 37, is shown provided with a valve 57. It is apparent that when valve 57 and valve 51 are closed, with valves 56, 56, 50, 52 and 53 open, the liquid refrigerant will be boosted by pump 55 and made to flow through conduits 54, 49, 37, cooling element 38, conduit 43 into pipe 44 and expanded through expansion valve 45.

On the other hand if the liquid refrigerant is not to be further cooled by element 38, valves 57 and 50 and 53 are closed, while valves 56, 56, 51 and expansion valve 45 are opened, thus causing the "boosted" liquid refrigerant to be discharged by pump 55 into by-pass 54 and into connections 49 and 44 and through expansion valve 45.

In Fig. 3 I show a modification of the system wherein the apparatus may be used as a double stage refrigeration system; or the apparatus may be used for condensing and cooling purposes of carbon dioxide gas or other refrigerants, under low and high pressures.

The apparatus of this modified system involves the compressor 10a which is connected by conduit 11a with a header 15a at one end of the condenser 12a; which condenser may be cooled by any suitable liquid cooling medium introduced through inlet 13 and withdrawn through outlet 14. The condenser 12ª may be horizontally disposed.

The condenser 12ª of Fig. 3, like the condenser shown in Fig. 1, is preferably provided at opposite ends with headers or manifolds which are connected to each other by suitable numbers of tubes or coils as indicated at 17 arranged in slightly spaced relation and disposed through the chamber within the condenser housing through which any suitable cooling medium may be circulated as heretofore stated.

The header 16ª receives the condensed refrigerant from coils or pipes 17 and discharges same into conduit 18ª. The conduit 18ª, like in the previously described construction, is shown connected with a liquid receiver or liquid cooler element 19ª which extends into and is located in the combined condenser, evaporator and liquid cooler unit 20ª and preferably adjacent the discharge end of the refrigerator element or elements 21ª. The flow of the liquid through the cooling element 19ª is controlled by the valves 22 and 23, 23. With this arrangement, when valve 22 is closed the liquid refrigerant from conduit 18ª will be made to flow through the element 19ª and then returned to the conduit 24ª by which it is conveyed to expansion valve 25ª arranged at the inlet end or header of the unit 20ª. The liquid or refrigerant is evaporated or expanded into the header 26ª and arranged to evaporate in tubes 21ª by which it is conveyed to header 27ª from whence it is withdrawn by a conduit 28ª which is connected with the suction side of compressor 10ª where the gas is recompressed and returned to condenser unit 12ª.

These elements, like in the previously described apparatus, constitute a primary refrigeration cycle.

The chamber in the unit 20ª, at points intermediate of the headers or manifolds 26ª and 27ª, is provided with valve controlled inlet 29ª and valve controlled outlet 30ª whereby any suitable medium may be circulated through the unit 20ª in heat exchange relation with the evaporating elements 21ª and the cooling element 19ª as well as the condensing element now to be referred to.

A secondary or low temperature refrigeration cycle, provided by my improved apparatus, involves a compressor 31ª provided with conduit 32ª which conveys the compressed refrigerant to a condenser element or elements 33ª located in unit 20ª. The unit 20ª is substantially similar to the construction shown in Fig. 2 with a plurality of condenser coils 33ª whose inlet ends communicate with the manifold or header 34ª while the outlets ends of said coils are connected with manifold or header 35ª which latter is connected with a conduit 58 which, in turn, connects with a liquid refrigerant pump 59 whose discharge end in turn is connected with conduit 60. Conduit 60 is shown connected with a manifold or header 61 of a series of liquid cooling tubes or coils 62 disposed throughout the length of a cooler and evaporator unit 63. The outlet ends of the liquid tubes or coils 62 are shown connected with a suitable manifold or header 64. The manifold or header 64 is shown provided with a valve controlled discharge conduit 65 whereby the cooled medium, for example carbon dioxide, coming from cooling coils 62, may be conveyed to distant points or to dry ice or solid carbon dioxide making apparatus. Conduit 65, intermediate the header or manifold 64 and the valve 66, is connected with a conduit 67 having a valve 68, and conduit 67 in turn is connected with pipe 69 provided with expansion valve 70 connected with the inlet header or manifold 71 at one end of unit 63. The expanded liquid is evaporated through tubes or coils 72 which extend from header 71 to the header 73 at the opposite end of the unit.

The header or manifold 73 is provided with a conduit 74 which connects with the suction side of compressor 31ª.

The discharge end of liquid pump 59 is also connected with a pipe line 75 which connects with pipe 76, one end of which communicates with the connection of pipes 67 and 69, thus permitting liquid to flow, under high pressure through pipes 75 and 76 and be commingled with the still lower temperature liquid coming through pipe 67 from the condenser coils 62 before passing through expansion valve 70. Conduit 58, in advance of its connection with pump 59, is shown provided with a by-pass conduit 77 which connects with the juncture between pipes 75 and 76. A portion of said liquid under relatively low pressure is conveyed through coils or tubes 62 while the other portion may be conveyed to the expansion valve 70 and the evaporated gas withdrawn as heretofore mentioned; while the low temperature and low pressure liquid coming from coils or tubes 62 may be discharged through conduit 65 and valve 66 (if the latter is open) for the purpose as heretofore mentioned.

In order to induce the liquid to flow in the manner as heretofore described, conduit 58, in advance of pump 59, is shown provided with a valve 78; by-pass 77 is provided with a valve 79; while conduit 75 is shown provided with a valve 80 and conduit 60 provided with a valve 81 and conduit 76 with a valve 82.

It is apparent that when it is desired to employ the liquid pump 59, valve 78 must be open, valve 79 closed while valves 80 and 81 are open, as well as valves 82 and 68, thus causing a portion of the liquid to flow through conduit 60 into cooling coil 62 while another portion of the liquid will flow directly through pipe 75 into pipe 76 and be commingled with the pre-cooled liquid from coil 62 coming through conduit 67 and the pre-cooled liquid expanded through valve 70 into unit 63.

With the arrangement just described, a portion of the liquid coming through by-pass 77 may be conveyed by connection 75 into conduit 60 and caused to pass through coils 62, while a portion of said liquid may be conveyed by connections 76 and 67 to discharge conduit 65 where the liquids of different temperatures are commingled and conveyed to the desired point of use.

Upon closing valves 80 and 68 with valves 78, 79, 82, and 81 open, a portion of the liquid coming from the manifold 35ª will flow under low pressure through by-pass 77, conduit 76 and pipe 69 into expansion valve 70 and be expanded into unit 63 from whence it is withdrawn through conduit 74 by compressor 31ª; while another portion of the liquid coming from pump 59 passes through conduit 60 into the cooling coil 62 and is conveyed through pipe 65 and valve 66 for purposes as heretofore mentioned.

The by-pass 77 is shown connected to a pipe 83 with a valve 84 whereby low temperature liquid under low pressure may be drawn off for use, for example, in dry ice making apparatus for refrigerating or freezing the high pressure low temperature liquid refrigerant coming from conduit 65. The gas, which is evaporated in the dry ice making machinery may be returned to my apparatus by means of valve 85 arranged in connection 86 of conduit 74. A new supply of gases for replenishing the refrigerant supply may be introduced by means of valve 87 arranged in a coupling or connection 88 on the suction side of compressor 31ª.

The unit 63 at opposite ends, like unit 39, is shown provided with a valve inlet 47ª and a valve controlled outlet 48ª, this inlet and outlet communicating with the chamber of the unit 63 to permit the introduction of any suitable medium, such as brine and the like, to be used as a heat exchange medium for the tubes or coils 62, because the medium introduced through inlet 47ª would surround the evaporation tubes 72 and the tubes or coils 62.

It is apparent that upon merely closing valves 68, 81, that unit 63 may then be transformed into a refrigerating unit of a single stage or double stage system; and brine or any suitable medium may be circulated through the refrigerating unit in contact with the evaporator tubes.

In Fig. 4 I illustrate a still further modification of my improved apparatus and method of operation, wherein 89 is a combination gas cooler and condenser unit for different refrigerants; the unit being provided at opposite ends with suitable manifolds or headers as at 90 and 91 connected with each other by a suitable number of coils or pipes 92. The gas is compressed by compressor 10ᵇ and introduced into header or manifold 90 by conduit 93 and into the tubes or coils 92 before being discharged into header 91 from whence the condensed liquid refrigerant is taken by conduit 94 which leads to a pre-cooler 95 arranged in the header 96 of a unit 97. The opposite end of pre-cooler 95 is connected with a conduit 98 which leads to an expansion valve 99 arranged at the inlet of header 100 at the opposite end of unit 97. The gas is evaporated through tubes or coils 101 in unit 97, conveyed into header 96 and taken off by conduit 102 which leads to the suction side of compressor 10ᵇ. The apparatus thus far described constitutes one cycle of operation.

A second closed refrigeration cycle involves compressor 31ᵇ which is provided with discharge conduit 103 whereby the compressed gas refrigerant is conveyed to a header or manifold 104 arranged at the inlet ends of the cooling tubes or coils 105 arranged in the combination gas cooler and condenser unit 89. The pre-cooled gas from the cooling coils 105 is discharged into a header or manifold 106 and thence into conduit 106 which is provided with valves 108 and 109.

The conduit 107, at a point intermediate of valves 108 and 109, is provided with a branch 110 which leads to a header or manifold 111 arranged at the inlet ends of the low temperature condenser tubes or coils 112 which are arranged in unit 97 disposed intermediate of the various sets of evaporating tubes 101 in said unit; the condenser coils 112 being arranged in the chamber of the unit 97 intermediate of the headers at opposite ends. The outlet ends of the condenser coils 112 are shown connected to a header or manifold 113 connected to a conduit 114 which leads to a liquid refrigerant pump 115 which, in turn, is provided with a discharge conduit 116 leading to a pre-cooler element 117 arranged in the header 118 of evaporator unit 119. The pre-cooler element 117 has its opposite end connected with a conduit 120 which leads to conduit 121 provided with expansion valve 122 arranged at the inlet end of header or manifold 123 of unit 119. The liquid gas discharging into header 123 is evaporated through the tubes or coils 124 arranged intermediate the two headers 123 and 118. The evaporated gas from header 118 is taken by conduit 125 to the suction side of compressor 31ᵇ. The evaporator unit 119 is provided with a plurality of tubes or coils 126 which are arranged intermediate the various sets of evaporator tubes 124 in unit 119; the inlet ends of the coils being shown provided with header or manifold 127 which is shown connected with a valve controlled inlet conduit 128; while the outlet ends of the coils 126 are shown connected with a manifold or header 129 which likewise is connected with a valve controlled outlet 130.

Any suitable medium to be condensed or liquid to be cooled is introduced through conduit 128 into manifold 127 and through the coils or tubes 126 from whence it is discharged into manifold or header 129 and take-off conduit 130 to any desired place of use.

The chamber of the unit 119, at spaced apart points throughout its length, is shown provided with valve controlled inlet 131 and a valve controlled outlet 132 whereby any suitable medium to be cooled, such as brine and the like, may be introduced into the chamber portion in heat exchange relation with the evaporator tubes and taken off by valve controlled conduit 132. At points intermediate the valve controlled inlet and outlet, the unit 119 is shown provided with valve controlled connections 133 and 134 whereby the medium, for example, brine, introduced through valve controlled inlet 131, may selectively be withdrawn from the chamber of unit 119 at various points, as for example either at outlet 133, 134 or 132, and brine, or any other fluid, of different temperatures, may be available depending upon the use to which the same is to be put. The unit 119 is also shown provided with a valve controlled inlet 135 preferably arranged closer to the coldest end of unit 119 than inlet 131. The inlet 135 is for the purpose of introducing brine from a point of use, but which is of a lower temperature than the brine entering through conduit 131 so as not to come into immediate contact with the discharge ends of the evaporator tubes or coils 124 and with the brine coming in through valved inlet 131, or to immediately mingle with the brine of higher temperature entering through inlet 131.

The pre-coolers 95 and 117, as shown and described, are both arranged in the discharge headers or units 97 and 119 respectively, where they are merely in heat exchange relation with the discharging evaporated gas and not in heat exchange relation with the cooling mediums in the chambers of said units and with the coils therein.

The unit 97 at opposite ends is shown provided with a valve controlled inlet 136 and a valve controlled outlet 137 for the purpose of introducing a suitable medium into the chamber of the unit, such as brine and the like, which may either act as a heat transfer medium; or the medium may be used as a cooling medium for the condenser elements 112, if said unit is merely employed as a condenser in a single stage system; or may be circulated therethrough for outside uses. In this instance, if brine is lead through unit 97, it will constitute a combined evaporator, low temperature condenser and cooler unit.

The chamber of unit 89, at opposite ends, is also shown provided with a valve controlled inlet 138 and a valve controlled outlet 139 whereby any suitable cooling medium may be introduced into the chamber of unit 89 in contact with the condenser tubes and gas cooling tubes or coils.

The liquid cooling element 95 is shown provided with valves 140, 140 for disconnecting the cooler 95; while conduit 98, intermediate the ends of the pre-cooler coil 95, is shown provided with a valve 141.

With this arrangement, it is apparent that with valves 140, 140, open and valve 141 closed, the liquid refrigerant from conduit 94 will be made to pass through the pre-cooler 95 before being discharged into conduit 98. On the other hand, with valves 140, 140 closed and valve 141 open, the liquid refrigerant from conduit 94 will be made to pass directly into conduit 98 and be delivered to expansion valve 99.

The gas cooler in unit 89 may be disconnected from the system by closing valve 142 and closing valve 108 at the outlet header 106; while with valves 143 and 109 in conduit 107 open and a valve 144 in branch pipe 110 open, the compressed gas coming from compressor 31^b will be caused to flow through conduit 103, conduit 107 and be delivered into header 111, into coil or tubes 112 where it is condensed and the liquid made to flow as heretofore described.

Conduit 107, at a point intermediate valves 109 and 143, is shown provided with a branch conduit 145 which is shown connected with conduit 114 and also with conduit 120; the branch conduit 145, in advance of its connection with conduit 114, having a suitable valve 146 and at a point intermediate the connection of conduits 114 and 120 provided with a valve 147. With this arrangement the coil or coils 105 in unit 89 may then function as a condenser and the liquid refrigerant then conveyed from discharge header 106 by conduit 107 to branch conduit 145 which connects with conduit 121 leading to expansion valve 122 of unit 119.

In order to induce this flow, valve 144 is closed, valve 109 opened and valve 143 closed; a valve 148 in branch conduit 145 opened, as are also valves 146 and 147; while a valve 149 in conduit 114 and a valve 150 in conduit 120 are closed. The condensed liquid refrigerant is expanded into header 123 of unit 119 and taken from the outlet header 118 by conduit 125 connected with the suction or low pressure side of compressor 31^b; the re-compressed refrigerant or gas being then conveyed by conduit 103 into header 104 connected with the coils or tubes 105 of unit 89.

Conduits 114 and 120 are shown connected by a branch pipe 151 provided with a valve 152; said connection being adjacent to the discharge header or manifold 113 of condenser coils 112 and unit 97; and the connection between the manifold or header 113 and conduit 114 is also shown provided with a valve 153. With this arrangement, the liquid refrigerant coming from coil or coils 105 in unit 89 will be conveyed from discharge header 106 by conduit 107 (assuming that valve 144 is closed) into branch pipe 145 and by closing valves 147, 152 and 153, the liquid refrigerant is made to flow upwardly through conduit 114 to pump 115 into conduit 116 which connects with pre-cooler element 117.

The inlet and outlet ends of pre-cooler 117 are provided with valves 154, 154 so that the pre-cooler unit 117 may be disconnected from the system by closing said valves and opening a valve 155 in conduit 120.

If the pre-cooler element 117 is not desired, the "boosted" refrigerant from pump 115 coming through conduit 116 will be made to flow down through conduit 120 which connects with conduit 121 leading to expansion valve 122 and the refrigerant expanded into header 123 of unit 119. The expanded refrigerant coming from discharge header 118 is conveyed by conduit 125 connected with the suction or flow pressure side of compressor 31^b and is then re-compressed and conveyed by conduit 103 to header 104; it being understood, of course, that valve 143 is closed.

Where it is not desired to "boost" the pressure of the liquid refrigerant, provision is made by means of a by-pass 156 around the pressure pump 115; the conduit 114 in advance of the pressure pump having a valve 157 and conduit 116 on the discharge side of the pump having a valve 158, while the by-pass is shown provided with a valve 159. With this arrangement, valves 157 and 158 may be closed and valve 159 opened, thus eliminating the pressure pump 115 and allowing the liquid coming from conduit 114 to flow through by-pass 156 into conduit 116 which connects with pre-cooler 117, and the pre-cooled liquid refrigerant to be conveyed by conduit 120 to conduit 121 which connects with expansion valve 122, allowing the liquid refrigerant to evaporate through the tubes or coils of unit 119 and be withdrawn therefrom by conduit 125 connected with the suction or low pressure side of compressor 31^b.

The cycle that has just been described constitutes a single stage system which comprises a compressor, a condenser, a liquid refrigerant pump, a pre-cooler, an expansion valve and evaporator element, all arranged substantially in the order named, the system also involving a by-pass whereby the liquid pump may be eliminated, together with arrangements whereby the pre-cooler may be eliminated, this single stage system as just defined involving elements 105, unit 89 and unit 119 with compressor 31^b.

A second single stage system, independent of the other mentioned system, is provided with my improved apparatus and involves compressor 10^b, condenser tubes or coils 92 of unit 89, pre-cooler 95, expansion valve 99 and evaporator tubes 101 of unit 97 with the discharge conduit 102 connected with the suction or low pressure side of compressor 10^b. The liquid to be cooled in unit 97 may be introduced into the chamber thereof through valve controlled inlet 136 and may be withdrawn therefrom through valve controlled outlet 137. In the case just mentioned, the tubes or coils 101 act as evaporator tubes and unit 97 therefore acts as a refrigerator only. The pre-cooler element 95 may be eliminated as heretofore described.

It will be noted that these two single stage systems just described work independently of each other and may work with different refrigerants; and that unit 89 acts as a double condenser for the different refrigerants of both systems. This condenser may be cooled by fresh water or any other suitable medium.

The apparatus shown also provides another single stage system which involves compressor 31^b, coils or tubes, constituting condenser tubes in this instance, arranged in unit 97, pre-cooler 117, expansion valve 122 and evaporator tubes in unit 119; the discharge ends of evaporator tubes in unit 119 having communication with the suction or low pressure side of compressor 31^b by conduit 125; the compressed refrigerant being conveyed by conduit 103 into the header 111 of condenser coils or tubes 112. In order to provide this path for the refrigerant, valves 142, 148, 108, 149, 152, 159, 155 and 147 are closed; while valves 143, 109, 144, 153, 157, 158, both valves 154 and 150 are open.

The condenser tubes or coils 112 in unit 97 may be cooled by any suitable medium introduced through valve controlled inlet 136 and the medium withdrawn from the chamber of unit 97 by means of valve controlled outlet 137. Where it is desired not to further "boost" the pressure of the liquid refrigerant, pump 115 may be eliminated through the closure of valves 157 and 158 and opening valve 159 in by-pass 156.

At the same time, pre-cooler 117 may be eliminated in this circuit by closing valves 154, 154 and opening valve 155, thus causing the "boosted" refrigerant to pass directly into conduit 120 from conduit 116.

Furthermore, the pressure pump 115 and the pre-cooler 117 may both be eliminated from this system so that the discharging liquid refrigerant coming from header 113 may be made to flow directly toward expansion valve 122 by closing valves 149, 157, 159, 150 and 147; while valves 153 and 151 are open.

This causes the liquid refrigerant to flow directly from the discharge header 113 into conduit 120 leading to conduit 121 and to expansion valve 122.

The single stage system just described provides a low pressure or normal phase and a high pressure phase, because the liquid is condensed under normal pressure in coils 112 and the oncoming "boosted" liquid then further cooled before expansion by the expanding gas in unit 119.

The refrigeration system or cycle just described does not include unit 89. On the other hand, unit 97 may be entirely disconnected from the system, and one set of tubes or coils in unit 89 used as a condenser in connection with the evaporator elements of unit 119 and compressor 31^b; this circuit involving compressor 31^b, conduit 103, header 104, coil or coils 105, discharge header 106, conduit 107, branch pipe 145 and expansion valve 122 of the evaporator unit 119. In this instance, of course, valves 143, 144, 149 and 150 are closed. Should it be desired to further "boost" and pre-cool the liquid refrigerant, valves 153, 159, 155 and 152 are closed, while valves 142, 108, 109, 148, 146, 149, 157, 158, 154 and 150 are open.

If it is desired to pre-cool and not to "boost" the liquid refrigerant, then valves 157 and 158 are closed and valve 159 opened allowing the liquid refrigerant to by-pass the pump.

On the other hand, if it is desired to "boost" the pressure and not to pre-cool this liquid, then valve 159 and valves 154, 154 are closed and valve 155 opened, causing the "boosted" liquid refrigerant to be discharged into conduit 120, 121 connected with expansion valve 122.

Another single stage system is provided which may eliminate the use of unit 119; this system involving compressor 10^b, tubes or coils 92 of unit 89, discharge 94, pre-cooler 95, conduit 98, expansion valve 99, evaporator tubes or coils 101 and discharge conduit 102, connected with the suction or lower pressure side of compressor 10^b. The medium to be cooled may be conveyed into the chamber of unit 97 through valve controlled inlet 136 and discharged through valve controlled outlet 137. In order to provide this circuit for the refrigerant, it is apparent that valve 141 is closed, while valves 140, 140 are open with expansion valve 99 being also open. If the pre-cooler 95 is to be eliminated, then valves 140, 140 are closed and valve 144 opened.

When the entire system is in operation, different refrigerants may be employed, as for example ammonia, or similar refrigerants condensing under relatively low condenser pressure, employed in the first or primary cycle, and carbon dioxide, or similar refrigerants of low boiling point condensing under relatively high pressure under normal temperature, may be employed in the second or low temperature cycle; or ammonia or similar refrigerants may be employed in both cycles, depending upon the work to be accomplished or conditions under which the system is being operated; as set forth in my previously filed applications.

It is understood that if the entire system is in operation the high boiling point refrigerant is condensed in tubes 92 of unit 89 and expanded in tubes 101 of unit 97; while the low boiling point gas refrigerant may first be cooled in coils 105 of unit 89, further cooled in coils 112 of unit 97 and evaporated in the tubes of unit 119. The initial gas cooler 105 may be disconnected from this circuit so that the low temperature exhaust from unit 119 may be directly conveyed into coil 112 of unit 97.

It is to be understood that I do not limit myself to the use of a volatile refrigerant, but any other refrigerant may be used including one which condenses under atmospheric pressure and temperature, especially where the apparatus is intended to be used as a single phase system and in smaller units.

While I have shown and described my invention and the arrangements of elements in the separate units, I do not wish to limit myself to the arrangements as shown. If the separate systems are, however, constructed and operated and no brine or other fluids are passed through the chambers of units 20, 20*a*, 97 and 119, the vertically arranged tubes may be eliminated and the liquid refrigerant may be directly vaporized in the chambers of said units.

Furthermore, if the systems are constructed, however, to cool fluids in said chambers, coils of any desired form, shape or make may be used and substituted and arranged in any desired manner in place of the vertically arranged tubes and liquid refrigerant vaporized in said coils. Since I have shown coils and tubes in my condenser 98, Fig. 4, I do not wish to be limited to this construction because coils may be substituted for the vertically arranged tubes either in intermingled relation with the other coils, or the coils of both circuits may be arranged one above the other or in any other desired manner.

It will be obvious to those skilled in the art that various changes may be made in my devices without departing from the spirit of the invention and I therefore do not limit myself to what is shown in the drawings and described in the specification, but only as set forth in the appended claims.

I claim:

1. A refrigerating system comprising, in combination, a primary refrigerating circuit including a compressor, a condenser, an expansion valve and an evaporating element connected in a closed circuit, and a second lower boiling point refrigerant circuit including a compressor, a condenser cooled by said primary circuit, a liquid receiving and cooling element and an expansion valve and an evaporator connected in a closed circuit, said cooling element and said evaporator being located in a housing, and means for circulating a medium to be cooled over said cooling element and said evaporating elements.

2. A refrigerating system comprising, in combination, a primary refrigerating circuit includ-

ing a compressor, a condenser, an expansion valve and an evaporator connected in a closed circuit, and a second circuit employing a refrigerant of lower boiling point, including a compressor, a condenser cooled by said primary circuit and an evaporator unit connected in a closed circuit, said last mentioned evaporator unit comprising a housing, a liquid receiving and cooling element, an expansion valve and evaporating elements closely adjacent to said cooling element, the cooling element and said evaporating elements being located in said housing and having communication with the discharge of the second mentioned condenser and the expansion valve, valve controlled connections at the inlet and outlet ends of said cooling element whereby the lower boiling point refrigerant from the second-mentioned condenser may be conveyed directly to the expansion valve of the second-mentioned evaporator unit, and means for circulating a medium to be cooled over said cooling element and said evaporating elements.

3. A refrigerating system comprising, in combination, a primary circuit employing a refrigerant of high boiling point and including a compressor, a condenser, a liquid cooling element, an expansion valve and evaporating elements connected in a closed circuit in the order named; and a second circuit employing a refrigerant of lower boiling point and including a compressor, a condenser cooled by said primary circuit, an expansion valve and an evaporator connected in a closed circuit in the order named; the liquid cooling element of said primary circuit and the condenser of said second circuit and the evaporating elements of the primary circuit being incorporated in a single closed housing and in heat exchange relation.

4. A refrigerating system comprising, in combination, a primary circuit employing a refrigerant of high boiling point and including a compressor, a condenser, a liquid receiving and cooling element, an expansion valve and evaporating elements connected in a closed circuit in the order named; and a second circuit employing a refrigerant of lower boiling point and including a compressor, a condenser cooled by said primary circuit, a liquid receiving and cooling element, an expansion valve and evaporating elements connected in a closed circuit in the order named; the liquid receiving and cooling element of said primary circuit, the condenser of the second circuit and the evaporating elements of the primary circuit being incorporated in a single closed housing and in heat exchange relation, while the liquid receiving and cooling element of the second circuit and the evaporating elements of the second circuit are incorporated in a single closed housing and in heat exchange relation.

5. A refrigerating system for low temperature and quick freezing refrigeration involving a compressor, a condenser, liquid refrigerant pressure boosting means, a liquid receiving and cooling element, an expansion valve and an evaporating element arranged in a closed circuit in the order named, means for further cooling the liquid in said cooling element; valved controlled connections intermediate of the condenser, said liquid refrigerant pressure boosting means, said cooling element and said expansion valve whereby the direction of flow of the refrigerant relative to said means, cooling element and said expansion valve may be controlled; and a closed refrigerating circuit adapted to cool said condenser.

6. A refrigerating system comprising, in combination, a primary circuit employing a refrigerant of high boiling point and including a compressor, a condenser, an expansion valve and evaporating elements connected in a closed circuit in the order named; and a second circuit employing a refrigerant of lower boiling point and including a compressor, a condenser cooled by said primary circuit, liquid pressure boosting means, a liquid receiving and cooling element, an expansion valve and evaporating elements connected in a closed circuit in the order named, the liquid cooling element and the evaporating elements being incorporated in a single housing and in heat exchange relation.

7. A refrigerating system comprising, in combination, a primary circuit adapted to employ a refrigerant of high boiling point and involving a compressor, a condenser, an expansion valve and evaporating elements connected in a closed circuit in the order named; and a second circuit adapted to employ a refrigerant of lower boiling point and including a compressor, a condenser cooled by said primary circuit, liquid pressure boosting means, a liquid receiving and cooling element, an expansion valve and evaporating elements connected in a closed circuit in the order named, means arranged for further cooling the liquid in said cooling element; and a valve controlled by-pass whereby said liquid pressure boosting means may be operatively disconnected from said second circuit.

8. A refrigerating system for low temperature and quick freezing refrigeration involving a compressor, a condenser, liquid pressure boosting means, a liquid receiving and cooling element, an expansion valve and evaporating elements arranged in a closed circuit in the order named, the cooling element and the evaporating elements being arranged in heat exchange relation, valve controlled arrangements whereby the liquid cooling element may be operatively disconnected from said circuit and the refrigerant made to flow directly to said expansion valve; and a closed refrigeration circuit adapted to cool said condenser.

9. A refrigerating system comprising a compressor, a condenser, a liquid pressure pump for boosting the pressure of the liquid refrigerant, a liquid receiving and cooling element, an expansion valve, an evaporating element arranged in a closed circuit in the order named, the cooling element and said evaporating elements are arranged in heat exchange relation, and valve controlled connections whereby the liquid pressure pump and the liquid cooling element may be either singly or jointly operatively disconnected from said circuit at the will of the operator.

10. In a refrigerating system, a housing defining a chamber, an evaporating element arranged in said chamber, an expansion valve communicating with the inlet of said evaporating element, a condenser element arranged in said chamber, means for introducing and withdrawing a fluid medium into and from said element, a liquid receiving and cooling element arranged in said chamber, the discharge end of said element communicating with the expansion valve intermediate of said evaporating element, and means for circulating a fluid medium through the chamber of said housing in heat exchange relation with all of said elements.

11. A refrigerating system involving, in combination, a refrigerating circuit employing a refrigerant of low boiling point and comprising a

compressor, a low pressure and low temperature condenser, a liquid pressure pump, liquid receiving and cooling means, an expansion valve, and evaporating elements arranged in the order named to form a closed refrigerating circuit, the cooling means and said evaporating elements being arranged in a housing in heat exchange relation with each other; a valve controlled connection intermediate of said condenser and the pump whereby liquid under low pressure and of low temperature from said condenser is available for other purposes; a valve controlled connection at the discharge end of said cooling means whereby liquid under high pressure and at a lower temperature is available for other purposes; and a closed refrigeration circuit employing a refrigerant of higher boiling point adapted to cool said condenser.

12. A refrigerating system involving, in combination, a refrigerating circuit employing a refrigerant of low boiling point and comprising a compressor, a gas-cooled condenser, a liquid pressure pump, liquid receiving and cooling means, an expansion valve, a refrigerating evaporator connected in a closed circuit, the cooling means and said evaporator being arranged in a single closed housing in heat exchange relation with each other, a valve controlled connection intermediate of said condenser and said pump whereby liquid under low pressure and low temperature from said condenser is available for other purposes, a valve controlled connection between the pump and said expansion valve whereby the path of the boosted liquid may be determined, a valve controlled connection at the discharge end of said cooling means whereby liquid under high pressure and at a lower temperature is available for other purposes, and valve controlled connections communicating with the inlet side of said compressor whereby evaporated refrigerant and additional refrigerant may be conveyed to the compressor.

13. In a refrigerating system, a housing defining a chamber comprising headers at opposite ends, a plurality of evaporating elements connecting the headers at opposite ends, an expansion valve communicating with the inlet header, a plurality of cooling elements arranged in said chamber in heat exchange with said evaporating elements, valve controlled means whereby said cooling elements may be operatively disconnected, a liquid receiving and cooling element arranged in the header at the discharge ends of the evaporating elements, valved connections between said element and the expansion valve, and means for circulating a fluid medium through said cooling chamber.

14. The process of refrigeration which consists in compressing, condensing and vaporizing a refrigerant of relatively high boiling point in a continuous cycle, compressing, condensing and liquefying a refrigerant of low boiling point at relatively low condenser pressure by utilizing the refrigerating action of the high boiling point refrigerant for condensing the refrigerant of low boiling point, boosting the pressure of the cold liquid refrigerant of low boiling point, vaporizing said liquid refrigerant of low boiling point and utilizing the expanding refrigerant of low boiling point to pre-cool oncoming liquid refrigerant of low boiling point before expansion, returning the vaporized refrigerant for recompression and recondensing under low condenser pressure, and circulating a fluid medium to be cooled in heat exchange relation with the vaporized and pre-cooled high pressure liquid refrigerant.

15. A two stage refrigerating system involving, in combination, a primary circuit comprising a compressor, a condenser, liquid cooler, expansion valve and an evaporator, arranged in the order named to form a closed refrigeration circuit; a second circuit comprising a compressor, a gas cooler, a condenser, a liquid cooler, an expansion valve and an evaporator, arranged in the order named to form a closed refrigeration circuit; said gas cooler of the second circuit and the condenser of the primary circuit being incorporated in a closed housing, means whereby a cooling medium may be circulated through said housing; the condenser of the second circuit and the liquid cooler and the evaporator of the primary circuit being incorporated in a closed housing; the liquid cooler and the evaporator of the second circuit being incorporated in a closed housing.

16. A two stage refrigerating system involving, in combination, a primary circuit comprising a compressor, a condenser, a liquid cooling element, an expansion valve and an evaporator provided with headers at opposite ends, all of the elements being arranged in the order named to form a closed refrigeration circuit; a second circuit using low boiling point refrigerant and comprising a compressor, a condenser, a liquid cooler, a liquid cooling element, an expansion valve and an evaporator provided with headers at opposite ends, said elements being arranged in the order named to form a closed refrigerating circuit; the condensers of the primary and of the second circuits being enclosed in a single closed housing and permitting operation with different refrigerants; the liquid cooler of the second circuit and the evaporator of the primary circuit being enclosed in a single housing; the first mentioned liquid cooling element being arranged in one of the headers of the evaporator of the primary circuit; and the second liquid cooling element being arranged in one of the headers of the evaporator of the second circuit.

17. In a refrigerating apparatus, a housing, defining a chamber and provided with headers at opposite ends, evaporating elements, tubes or coils disposed through the chamber and communicating with both of said headers, and a liquid refrigerant receiving and cooling element arranged in one of the headers of said housing and having valve controlled communication with the other header.

18. A refrigerating apparatus comprising a vertically arranged closed housing defining a chamber provided with a header at the upper end, an exhaust discharge conduit connected to said header and communicating with the interior of said header, evaporating elements disposed through the chamber and communicating with said header, expansion means adjacent the inlet of said evaporating elements, a liquid refrigerant receiving and cooling element arranged in said header of said housing, and means whereby a fluid medium may be circulated through the chamber of said housing.

19. In a refrigerating apparatus, a housing, provided with headers at opposite ends, evaporating elements disposed through the chamber and communicating with both of said headers, a liquid refrigerant receiving and cooling element arranged in one of the headers of said housing, valve controlled means for introducing a fluid medium into said chamber adjacent the discharge ends of the evaporating elements, valve controlled means arranged at spaced apart intervals in communication with said chamber whereby the

fluid medium may be withdrawn from said chamber at points of different temperatures, and valve controlled means whereby the fluid medium, which is withdrawn through one of the first mentioned valve controlled means at the point of lowest temperature of said chamber, may be returned into said chamber at a point removed from the initial introduction of said fluid medium if of a temperature lower than the initially incoming fluid medium.

20. A two stage refrigerating system consisting of two refrigerating systems cooperating with each other, one of said systems comprising a compressor, a condenser, expansion valve and an evaporator arranged in the order named to form a closed refrigeration circuit; the other system comprising a compressor, a condenser, a liquid receiving and cooling element, expansion valve and an evaporator arranged in the order named to form a closed refrigeration circuit; the condensers of the first and second system being arranged in a closed housing which is provided with valve controlled inlets and outlets for circulating a cooling medium through said housing in contact with both of said condensers; valve controlled elements whereby the liquid cooling element of the second system may be operatively disconnected from the condenser and evaporator of said second system and the discharge of the condenser of the second system directly connected with the expansion valve of said second system, the liquid cooling element of the second mentioned system and the evaporator of the first system being arranged in a closed housing, valve controlled means for circulating a fluid medium through said last mentioned housing in contact with said liquid cooling element and evaporator, whereby said systems may be converted into two independently operated systems.

21. A refrigerating apparatus comprising a vertical arranged shell provided with an evaporating element for vaporizing a refrigerant therein to cool brine in said shell, a plurality of cooling elements arranged in said shell for introducing a liquid to be cooled into said elements and means for withdrawing said liquid therefrom, said shell being provided with a plurality of inlets and outlets, all said inlets and outlets being arranged at different levels, said inlets and outlets providing means for withdrawing brine of different temperatures at different levels from the shell and returning said brine of different temperatures to the shell at different levels whereby an equal temperature may be maintained of the liquid to be cooled in said cooling elements.

22. A refrigerating apparatus consisting of a vertical arranged shell defining a chamber, provided with a plurality of inlets and a plurality of outlets, all said inlets and outlets being arranged at different levels, means for introducing brine into the chamber of the shell and for withdrawing the brine therefrom; evaporating element arranged in the chamber and forming part of a closed refrigerating circuit for cooling said brine, a plurality of cooling elements arranged in the chamber of said shell, means for introducing a liquid to be cooled into said elements, means for withdrawing the cooled liquid therefrom; the brine introduced at higher levels into the chamber being withdrawable from the chamber at lower levels or vice versa, whereby the temperature of the liquid to be cooled in said elements may be controlled and equalized.

23. The process of obtaining a liquid refrigerant of low boiling point under high pressure and low temperature in economical manner which consists in compressing, condensing, and vaporizing a volatile refrigerant in a continuous cycle, compressing, condensing and liquefying a gaseous refrigerant of low boiling point at relatively low condensor pressure by utilizing the low temperature of the vaporized volatile refrigerant, boosting the pressure of a portion of the low boiling point liquid refrigerant and utilizing the remaining portion of said low boiling point refrigerant at said relatively low condenser pressure for vaporization to further cool the boosted portion of said low boiling point refrigerant.

24. In a refrigerating apparatus, a suitable chamber, a refrigerating element disposed in said chamber, expansion means at the inlet of said element, a plurality of inlet and a plurality of outlet valved connections communicating with said chamber at different points whereby a medium cooled in said chamber may be withdrawn at different temperatures and returned to the chamber at different levels and at different temperatures.

25. Refrigerating apparatus of the character described comprising three units, one of said units comprising two cooling elements with fluid passages therebetween, a second unit comprising an evaporator element and a condenser element with fluid passages therebetween, while the third unit comprises an evaporator, a compressor connected with the first and second unit, an expansion valve for the second unit; valve controlled connections between said first and second units and said compressor whereby a closed refrigeration circuit is established; an expansion valve for the third mentioned unit, a compressor connected to the discharge of the third unit and connected with the first unit; valve controlled connections between all of said units whereby the refrigerant may circulate through all of the units; and valve controlled connections whereby the units may be operatively disconnected into separate independent systems wherein one system involves the first mentioned compressor, first mentioned unit and second mentioned unit, while the other system involves the second mentioned compressor, the first mentioned unit and the third mentioned unit.

26. In a mechanical refrigerating apparatus of the character described, a suitable housing, an evaporating element, a liquid refrigerant receiving and cooling element arranged in heat exchange relation with the discharge of the evaporating element, and communicating with the entrance of said evaporating element, an expansion valve associated with said evaporating element, and a separate closed fluid conveying passage for introducing and withdrawing a fluid to be cooled, arranged in the housing, free passages intermediate of said elements, separate means whereby different mediums may be circulated through said elements, a conduit for introducing a medium to be cooled in the housing to pass in counterflow to the refrigerant in the evaporating element, and a plurality of valved connections whereby a medium may be withdrawn from the housing at different points and different temperatures.

27. A refrigerating system comprising a compressor, a condenser, a liquid receiving and cooling element, an expansion valve, and an evaporator consisting of a vertically arranged shell with the liquid receiving and cooling element arranged in the upper part in the interior of said shell arranged in the order named to form a closed refrigerating circuit, a cooling element ar-

ranged in the lower part in the interior of said shell; means for introducing and withdrawing a fluid to be cooled into and from said element whereby the refrigerant circulated in said closed circuit will be successively in heat exchange relation first with said last mentioned cooling element and then with said first mentioned cooling element.

28. In a two stage refrigerating system involving two refrigerating systems cooperating with each other, the first system consisting of a compressor, a condenser, a liquid receiving and cooling element, an expansion valve, and an evaporating element; the second system consisting of a compressor, a brine cooled condenser consisting of a shell provided with a condenser element and brine inlets and outlets, a liquid receiving and cooling element, and an evaporator; the liquid receiving and cooling element and the evaporating element of the first system being arranged in said brine cooled condenser, the liquid receiving and cooling element of the second system being arranged in heat exchange relation in the path of the vaporized refrigerant of the same system; the first system being adapted to cool the brine for said brine cooled condenser of the second system.

29. The process of refrigeration which consists in compressing and condensing a volatile refrigerant gas in a plurality of stages, utilizing a cooling medium of atmospheric temperature to cool the compressed refrigerant gas in the first stage, and utilizing a cooling medium lower than atmospheric temperature to further cool the liquid refrigerant in the second stage as the cooling medium; boosting the pressure of a volatile liquid refrigerant, utilizing the vaporized refrigerant in a third stage as a cooling medium for further cooling the boosted volatile liquid refrigerant before vaporization, and recompressing the vaporized volatile refrigerant in a continuous cycle.

30. A two stage refrigerating system comprising two systems cooperating with each other, one system comprising a compressor, a condenser element, a liquid cooling element, a liquid control valve and an evaporating element, all arranged to form a closed refrigerating cycle, the cooling element being arranged in heat exchange relation with the exhaust gas of the evaporating element; the other system comprising a compressor, a condenser element, a liquid cooling element, a liquid control valve, and an evaporating element, all arranged in the order named to form a closed refrigerating circuit the evaporating element of the first system and the condenser element of the second system being arranged in heat exchange relation, the second mentioned cooling element and the second mentioned evaporating element being arranged in closed housing with free passages between all of said elements; and means for conveying a fluid medium to be cooled through said housing in heat exchange relation with all of said elements.

31. The process of refrigeration which consists in compressing, cooling, condensing and liquefying a volatile refrigerant gas at relatively low pressure and low temperature, utilizing a second vaporized volatile refrigerant preferably of higher boiling point than said first mentioned refrigerant to cool, condense, and liquefy said first mentioned refrigerant gas at said low pressure and low temperature, boosting the pressure of the volatile liquid refrigerant, vaporizing the high pressure liquid refrigerant to obtain a low refrigerating temperature, recompressing and recooling the volatile gaseous refrigerant at said relatively low pressure and low temperature.

32. In a refrigerating system for low temperature work, a compressor, a condenser element, a liquid refrigerant pump, a liquid receiving and cooling element for cooling the liquid refrigerant of increased pressure introduced thereinto, an expansion valve, and an evaporating element, connected in the order named to form a closed refrigeration circuit; said refrigerant pump being connected so that the pressure of the liquid refrigerant in the liquid receiving and cooling element may be increased as desired and to thereby increase the pressure drop between the evaporator and the liquid receiving and cooling element and to simultaneously increase the efficiency thereof; said liquid receiving element being arranged in heat exchange relation with the discharge of said evaporating element.

33. A refrigerating system for low temperature and quick freezing refrigeration, comprising a compressor, a condenser, a liquid receiving and cooling element, an expansion valve and an evaporator arranged in a closed circuit in the order named, means for further cooling the liquid refrigerant in said liquid cooling element, a valve controlled connection intermediate of said condenser and said liquid receiving and cooling element whereby the direction of flow of the refrigerant relative to the said expansion valve and the liquid receiving and cooling element may be controlled; and a closed refrigeration cycle arranged for cooling said condenser.

34. In a mechanical refrigerating apparatus of the character described, comprising a vertical arranged housing, an evaporating element arranged in the housing for introducing and withdrawing a refrigerant and a separate closed fluid conveying passage for introducing and withdrawing a fluid to be cooled arranged in the housing, a conduit arranged on the upper end of the housing for introducing a fluid medium to be cooled to pass in counter flow to the vaporized refrigerant in the evaporating element, means for introducing a medium to be cooled into the housing and a plurality of valve controlled conduits connected to the housing and communicating with the interior of the housing whereby said medium may be withdrawn from the housing at different levels and at different temperatures.

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