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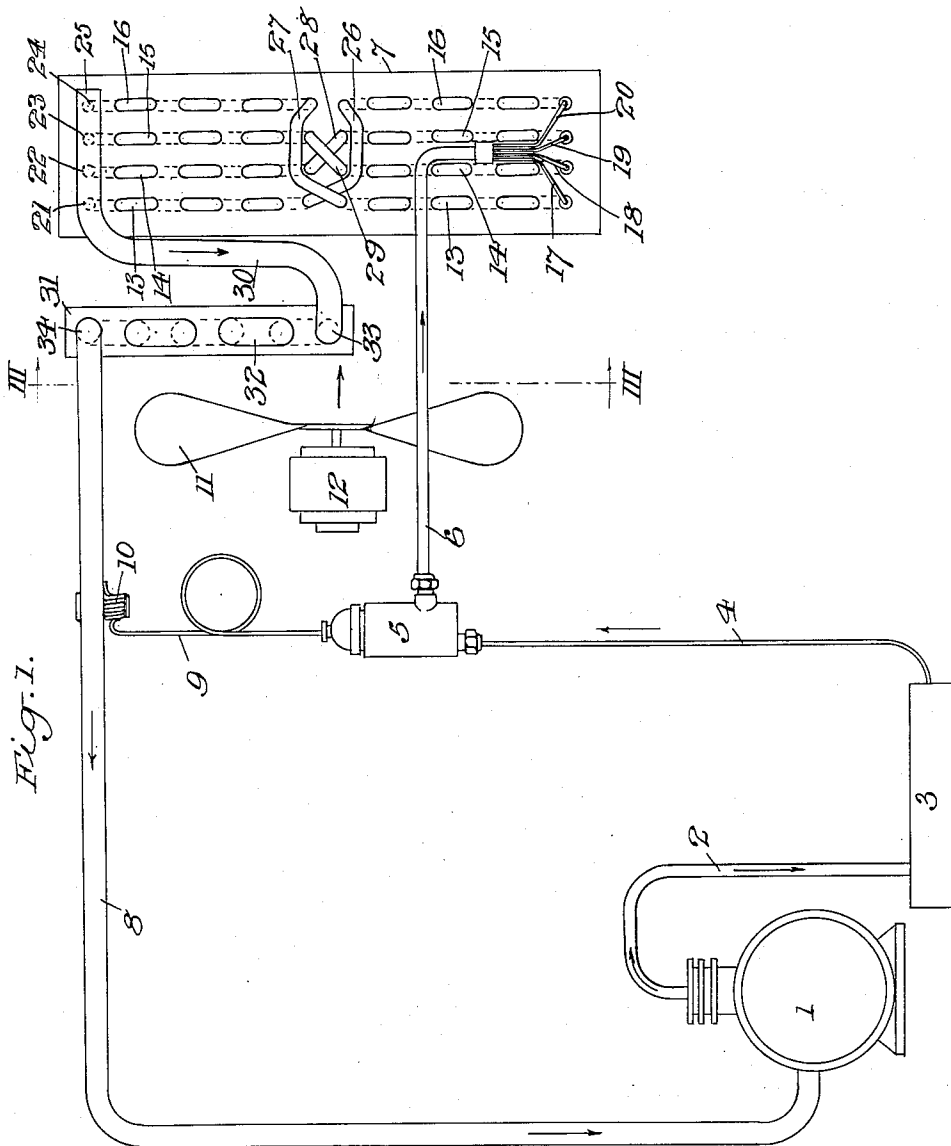
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EVAPORATOR CONSTRUCTION FOR HEAT EXCHANGE SYSTEMS

Filed Dec. 29, 1950

3 Sheets-Sheet 1



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Feb. 16, 1954

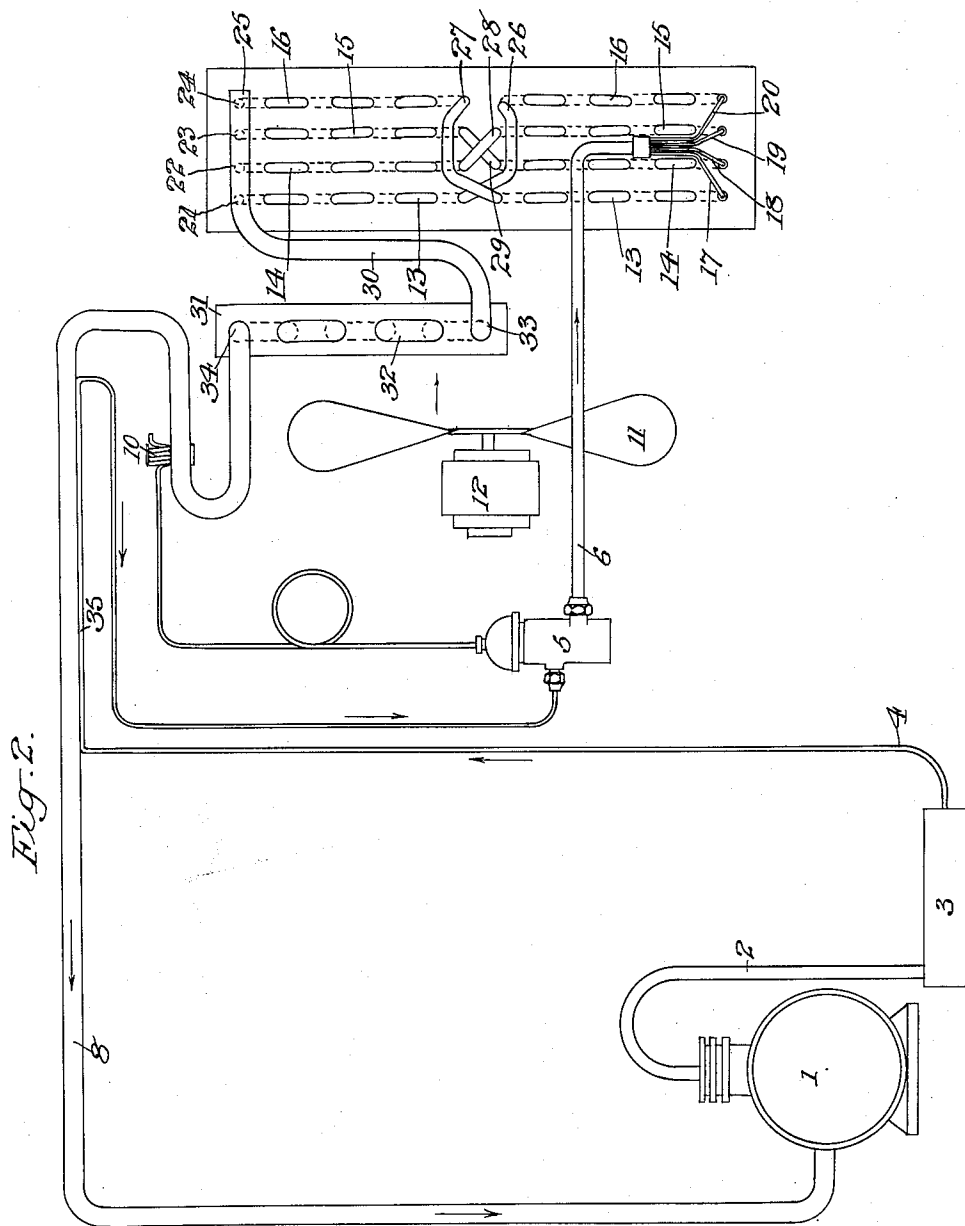
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

Fig. 4.

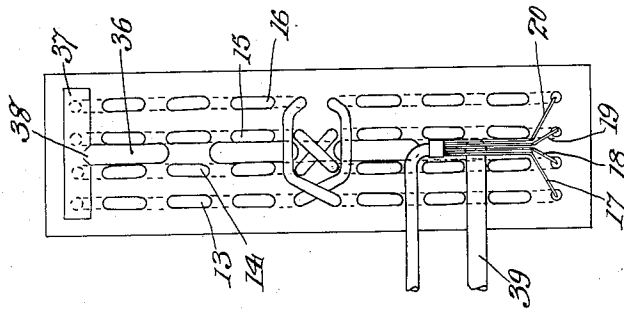
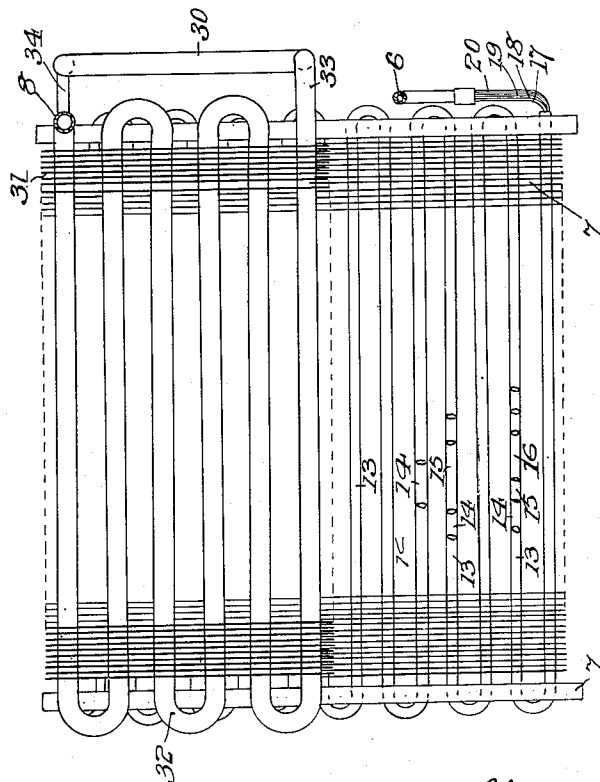


Fig. 3.



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UNITED STATES PATENT OFFICE

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EVAPORATOR CONSTRUCTION FOR HEAT EXCHANGE SYSTEMS

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6 Claims. (Cl. 62—126)

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This invention relates to heat exchange systems or apparatus and, more particularly, to the construction and arrangement of the evaporator portion thereof; and has for an object to provide a construction in which provision is made for evaporating refrigerant liquid that has failed to be evaporated during its passage through the evaporator due principally to lack of correct relationship between the amount of liquid refrigerant supplied to the individual conduits or passes of the evaporator and the heat load imposed thereupon by the air circulating means of the system.

Another object is to provide such a construction which embodies an auxiliary or after evaporator which receives refrigerant moving from the main evaporator and serves to evaporate the liquid portion of the same prior to the entry of the refrigerant into the suction line leading to the compressor of the system.

Another object is to provide such a construction in which the auxiliary or after evaporator is positioned in the path of the current generated by the air circulating means of the system and approaching the main evaporator.

Another object is to provide such a construction in which the auxiliary or after evaporator is positioned between the main evaporator and the air circulating means of the system.

Another object is to provide such a construction in which the after evaporator is positioned within the main evaporator.

Another object is to provide such a construction in which at least part of the conduits or passes of the main evaporator are so formed as to assist in causing the refrigerant to traverse the individual conduits or passes of the evaporator in accordance with the heat load demands imposed upon the said conduits or passes by the air circulating means of the system, with the result of increasing the effectiveness of the main evaporator and reducing the percentage of refrigerant that moves therefrom in liquid form.

Another object is to provide such a construction in which the refrigerant supply conduit or line leading from the condenser and receiver, if a receiver is included in the system, passes in heat exchange relationship with a portion of the suction conduit or line leading to the compressor, before the said supply conduit or line reaches the expansion valve of the system, for the purpose of providing heat to the said suction line and evaporating that portion, if any, of the refrigerant therein which may not have been thoroughly evaporated by the main and auxiliary or after evaporator.

A further object consists in providing certain improvements in the form, construction and arrangement of the several parts whereby the above named and other objects inherent in the invention may be effectively attained.

Practical embodiments of the invention are represented in the accompanying drawings in which:

Fig. 1 represents, in part diagrammatically, a side elevation of a heat exchange system designed for refrigeration, and showing the auxiliary or after evaporator positioned between the air circulating fan and the main evaporator, as well as the formation of the conduits or passes of the main evaporator which assists in causing the refrigerant to traverse the individual conduits or passes of the evaporator in accordance with the heat load demands imposed thereupon;

Fig. 2 represents a similar view of a modified form of the invention in which a portion of the refrigerant supply conduit or line is arranged in heat exchange relationship with a portion of the suction conduit or line;

Fig. 3 represents a vertical section, partly in elevation, taken on the line III—III of Fig. 1, looking in the direction of the arrows; and

Fig. 4 represents an end elevation of a second modified form of the invention in which the auxiliary or after evaporator is positioned within the main evaporator.

The evaporators of heat exchange systems such, for instance, as refrigeration apparatus, frequently comprise a plurality of tubular conduits or passes which are traversed by the refrigerant coming from the expansion valve of the system mainly in liquid form and which, in performing their chilling or freezing function, vaporize or evaporate a large portion of the refrigerant coursing therethrough. The outer surface of the said conduits or passes of the evaporator are subjected to an air current flowing therethrough from one side to the other which is commonly generated by a fan or blower positioned at one side of the evaporator, or by suction means positioned at the opposite side; and this air current necessarily imposes a greater heat load upon the conduits or passes of the evaporator that are nearer to the side of the evaporator towards which the air current moves than those conduits or passes which are more distant therefrom, because the air current is progressively chilled as it flows through the evaporator. Consequently, the different conduits or passes of the evaporator do not render equal service in their chilling or freezing function because a greater percentage of the liquid

refrigerant is evaporated in some of the conduits or passes than in others owing to the above mentioned variation in heat load imposed thereupon by the air current. This reduces the efficiency of the evaporator as a whole, and an effort has been made to counteract this condition by supplying the refrigerant coming from the expansion valve in unequal amounts to the several conduits or passes of the evaporator so that a greater amount of the refrigerant is supplied to the conduits or passes in accordance with their proximity to the side of the evaporator towards which the air current flows, with the object of attaining that highly desirable practical condition in which the inner surface of each conduit or pass is constantly wet with liquid refrigerant while the refrigerant discharged therefrom is in vapor form and at a slightly superheated temperature, for instance, of five to eight degrees Fahrenheit.

The present invention is designed and calculated further to advance this aspect in the field of heat exchange systems by promoting the efficiency of the evaporator of the system and insuring the useful evaporation of any refrigerant which may be emitted therefrom in liquid form; thus not only heightening the value of the system as a whole with respect to its refrigerating function, but also preventing the return of liquid refrigerant to the compressor through the suction line.

Referring now to the form of the invention shown in Fig. 1, the compressor of the system is denoted by 1 and its discharge is connected by a conduit 2 with a unit 3 which may consist of a condenser and receiver or of a condenser only. A refrigerant supply line 4 connects the outlet of the unit 3 with the usual expansion valve 5 which, in turn, communicates by a conduit 6 with the inlet of the main evaporator that is denoted generally by 7 and the outlet of which is connected, in a manner which will hereinafter be described, to the suction conduit or line 8, which communicates with the inlet of the compressor 1. The action of the expansion valve 5 is controlled in the usual way through a capillary tube 9 that is connected with a feeler bulb 10 which is suitably clamped or otherwise fixed to the suction conduit 8. An air circulating fan 11 driven by an electric motor 12, that is connected in any appropriate way with a source of current (not shown) is mounted adjacent the evaporator 7 for the purpose of driving an air stream therethrough, as indicated by the arrow. As the compressor, condenser (with or without receiver), expansion valve, feeler bulb control therefor, and fan with its motor may be of any well known or approved form, and as their particular construction and arrangement constitute no part of the present invention, it is deemed unnecessary further to illustrate or describe the same.

The main evaporator comprises four conduits or passes, 13, 14, 15, 16, which are preferably of the usual sinuous form, such as illustrated in Fig. 3, and are arranged in vertical parallelism. The conduit 6 leading from expansion valve 5 for feeding the expanded refrigerant fluid to the evaporator is fitted with four distributors, 17, 18, 19, 20, that communicate with the inlet ends of the conduits or passes 13, 14, 15, 16, respectively; while the outlet ends of the said conduits or passes are connected as indicated at 21, 22, 23, 24, with an outlet manifold 25 that is disposed transversely of the said conduits or passes.

It will be observed that, as the inlet conduit 6

running from the expansion valve to the main evaporator supplies the four conduits or passes of the evaporator, the distributors 17, 18, 19, 20 are of smaller cross sectional size than the conduit 6; and, conversely, as the outlet manifold 25 receives the refrigerant from all four conduits or passes of the evaporator, it is substantially larger in cross section than the individual passes of the evaporator.

For the purpose of supplying the incoming liquid refrigerant to the passes 13, 14, 15, 16, of the main evaporator 7, in accordance with the needs of the individual passes, a criss-cross formation of the said passes is provided at about the center of the main evaporator, the arrangement being such that conduit or pass 16 is connected by a cross-over 26 with conduit 13. As pass 16 is furthest from the side of the evaporator towards which the air current from fan 11 flows, it is subjected to the lightest heat load of all the passes; while pass 13, being nearest to the side of the evaporator towards which the air stream moves, is subjected to the heaviest heat load. Consequently, the liquid refrigerant which has been supplied through distributors 17, 18, 19, 20, in substantially equal amounts to the passes of the evaporator, will be vaporized to a greater extent in pass 13 than in pass 16 when the refrigerant has traversed or flowed through the lower half of the said passes; and the provision of cross-over 26 which connects pass 16 with pass 13 will supply an added amount of liquid refrigerant to the upper half of pass 13 to assist in meeting the requirements of the heavy heat load imposed upon the said pass by the air current. For the same reason, but with a converse application, pass 13 is formed with a cross-over 27 which connects it with pass 16 so that the upper portion of the latter pass will be supplied with an increased amount of vaporized refrigerant in consonance with the relatively light heat load imposed upon it. Similarly, pass 15 is formed with a cross-over 28 connecting it with pass 14 to increase the supply of liquid refrigerant in the upper half of the latter; while pass 14 has a cross-over 29 connecting it with pass 15 to increase the supply of vaporized refrigerant in the upper half of the latter. While this criss-crossing of the branch connections of the evaporator passes is shown and described as positioned substantially at the middle of the evaporator, it could be positioned nearer the inlet or nearer the outlet of the evaporator passes, in accordance with engineering desires or requirements and/or in accordance with the needs of particular installations; and, furthermore, part of the cross-over connections could be nearer the evaporator inlet and part nearer the evaporator outlet; or, finally, only some of the evaporator passes, instead of all, could be connected with another or others. Thus, by way of illustration and without limitation, cross-overs 28 and 29 could be omitted; or cross-overs 26 and 27 could be omitted; or pass 13 could be cross connected with pass 14 or 15, and pass 16 could be cross connected with pass 14 or 15; since the principle of this feature of the invention involves recognition of the inequality in heat load imposed upon the several passes of the evaporator as they are spaced further and further from the side thereof towards which the air current flows, and makes provision for equalizing, at least in large part, the functioning of the individual passes and increasing the efficiency of the evaporator as a whole by causing the passes having the

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lighter heat load to share a portion of their unused liquid refrigerant with the passes having the greater heat load, so that the output of refrigerant from each evaporator pass into the outlet manifold 25 will be comparable and substantially alike in respect to relative percentage of liquid and gaseous refrigerant and also with respect to temperature, such as the slight superheat hereinabove mentioned.

In connection with the immediately foregoing description, it seems desirable to explain that, as is plainly evident from the drawings, the conduit marked 13 in fact has its inlet at the bottom left hand side of the main evaporator, as viewed in Figs. 1, 2 and 4, and its outlet at the upper right hand side; while the conduit marked 16 has its inlet at the lower right hand side of the main evaporator and its outlet at the upper left hand side; the two said conduits being crossed intermediate their inlets and outlets. The same fact is true with respect to the conduits marked 14 and 15. Hence, the foregoing description relating to the criss-crossing of the conduits or passes of the main evaporator could have recited that the lower portion of the conduit 13 is nearest the side of the evaporator toward which the air current moves while its upper portion is furthest therefrom; and that the lower portion of conduit 16 is furthest from the said side of the evaporator while its upper portion is nearest thereto. Corresponding language could also have been used with respect to conduits 14 and 15. However, inasmuch as the conduits or passes of evaporators are commonly arranged in spaced vertical planes side by side, it has seemed easier to consider and mark the several conduits as in such a side by side sequential arrangement, and to describe their intermediate portions as criss-cross connected, since the functioning is the same regardless of whether one form of description or the other be adopted.

The outlet manifold 25 of the main evaporator 7 is connected by a conduit 30, which may be an integral part of the said manifold or coupled thereto, with the inlet of the auxiliary or after evaporator that is denoted generally by 31. The said auxiliary evaporator comprises, in the form shown, a single pass or conduit 32 (although there could be more, if desired) which pass, like those of the main evaporator, is preferably sinuous in form, but is relatively large in cross section because it receives the output from all four passes of the main evaporator. The auxiliary evaporator 31 is positioned intermediate the fan 11 and the main evaporator 7 and it is shown as substantially one-half the height of the main evaporator, although its dimension in this respect, as well as the size and number of its pass or passes, can be varied as occasion may dictate. The inlet of the auxiliary evaporator is preferably at the lower part thereof, as indicated by 33, and its outlet at the upper part thereof, as indicated at 34; the said outlet being connected by the suction conduit or line 8 with the inlet of the compressor 1.

The function of the auxiliary or after evaporator 31 is to evaporate that portion of the refrigerant emitted from the passes of the main evaporator which has remained in liquid form; which function not only serves to increase the refrigerating effect of the system, but also insures that the refrigerant flowing back to the compressor will be entirely, or at least approximately entirely, in gaseous rather than liquid

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form, thus facilitating the operation of the compressor and avoiding possible injury thereto arising from the slugging of liquid refrigerant through its suction port. This elimination of liquid refrigerant from the suction line also prevents it from so affecting the feeler bulb 10 as to cause the latter to throttle the expansion valve 5 with the result of diminishing the supply of refrigerant to, and so to speak, starving the main evaporator. The location of the auxiliary evaporator intermediate the fan and the main evaporator causes it to receive a heavier heat load from the air current than is received by any of the passes of the main evaporator, which fact enhances the evaporating effect of the auxiliary evaporator upon the refrigerant passing there-through and thus improves its functional effects just mentioned, as well as permitting it to be of comparatively small size.

In the operation of this form of the invention represented in Fig. 1 of the drawings which has been hereinabove described, the refrigerant compressed by the compressor and condensed by the condenser travels from the latter, or from a receiver associated therewith, to the expansion valve, and from it to the main evaporator 7 in a manner well understood by those in this industrial field. The refrigerant flows through the passes of the main evaporator, that may be criss-cross connected, as previously described; thence to the outlet manifold 25, through conduit 30, through pass 32 of the auxiliary evaporator 31, and finally through suction conduit or line 8 back to the compressor 1. The construction and arrangement of the invention is such that, as already indicated in the description thereof, all the passes of the main evaporator 7 function with a high degree of efficiency, each pass being fully wetted with liquid refrigerant, while the refrigerant flowing from the main evaporator through auxiliary evaporator 31 causes the latter to increase the refrigerating effect of the system and to insure that the refrigerant flowing back to the compressor has been entirely or approximately entirely exhausted with respect to its refrigerating value and is in proper condition to be received and recompressed by the compressor.

The modified form of the invention represented in Fig. 2 of the drawings is the same in construction, arrangement and mode of operation as that shown in Fig. 1, except that the refrigerant supply conduit or line 4 leading from the condenser, or condenser and receiver, 3, to expansion valve 5, has a part thereof marked 35 in juxtaposition and heat exchange relation with a portion of the suction conduit or line 8. This serves to elevate the temperature of the said portion of the line 8, because the refrigerant in line 4 is warm, and thereby further to insure the complete evaporation of the refrigerant flowing back to the compressor in case by any chance the auxiliary or after evaporator 31 has failed completely to evaporate or gasify all the liquid refrigerant passing therethrough. The shape of the suction line 8 and of the expansion valve control tube 9 in this modified form of the invention shown in Fig. 2 differs somewhat from the shape shown in Fig. 1, but this difference is for engineering or installation purposes and is not functional except that the U-shaped part of the suction line 8 provides a convenient place for positioning the feeler bulb 10 intermediate the auxiliary evaporator 31 and the zone 35 in which

the supply line 4 and suction line 8 are in heat exchange relation.

Fig. 3, as noted in the description of the figures of the drawings at the outset of this specification, shows a vertical section taken in the plane of the line III—III of Fig. 1; and it illustrates the general appearance and arrangement of the parts of the main evaporator 7 and auxiliary evaporator 31 when viewed at right angles to the representation of these parts in Figs. 1 and 2. This Fig. 3 also shows the fin plates on the auxiliary evaporator which are denoted by 31 because it is to such a fin plate that the leader line from the numeral 31 in Figs. 1 and 2 runs when designating the auxiliary evaporator as a whole. Similar fin plates are also provided on the main evaporator as also shown in Fig. 3. If desired, the same fin plates could be used for both the main and auxiliary evaporators, i. e., an integral construction.

Fig. 4 shows a second modified form of the invention in which the auxiliary or after evaporator is embodied within the main evaporator, all other parts of the system being the same as illustrated in either Fig. 1 or Fig. 2. In this Fig. 4, the auxiliary evaporator conduit or pass, here marked 36, is positioned intermediate passes 14 and 15 of the main evaporator, and pass 36 is somewhat greater in length than in the forms of Figs. 1 and 2, which increase in length is indicated by its greater height in Fig. 4. The said pass 36 is connected at the center of the outlet manifold, here marked 37, of the main evaporator, as indicated at 38, and its other end communicates through a conduit 39 with the suction line 8. The greater length of the auxiliary evaporator in the form of Fig. 4 is called for mainly by the fact that it is not interposed between the main evaporator and the incoming air current so as to receive the greatest heat load as is the case with the forms of the invention shown in Figs. 1 and 2. Consequently, the evaporating effect of the auxiliary or after evaporator of Fig. 4 is, per unit of size and other factors being equal, less than in the case of the arrangement of Figs. 1 and 2. On the other hand, the form of Fig. 4 has advantages because of its compactness and unitary character which are important in connection with transportation and installation. The auxiliary evaporator pass 38 of Fig. 4 is not provided with its own fins, but shares the fin plates of the main evaporator.

As the mode of operation of the form of invention shown in Fig. 4 is like that of the other forms, there is deemed to be no occasion here to repeat the same other than to note, as already pointed out, that the pass of the auxiliary evaporator receives the refrigerant from a point intermediate the ends of the outlet manifold 37 rather than from one end thereof, and that it is nested within the conduits or passes of the main evaporator so that it does not directly receive the impingement of the air stream prior to the entry thereof into the latter.

With respect to all forms of the invention, it should be stated that the criss-crossed interconnection of the conduits or passes of the main evaporator is not a necessary feature, because the auxiliary or after evaporator can perform its function even though the effects of the individual passes of the main evaporator are not brought towards equalization by the fact of their criss-crossed interconnection. Indeed, it is practical deliberately to supply an excess of liquid refrigerant to the main evaporator so that the

passes thereof nearer to the side of the evaporator towards which the air current flows may be assured of having an adequate amount of liquid refrigerant to perform at peak efficiency, even though this causes an excess of liquid to be emitted from the passes more distant from the said side of the evaporator, because the auxiliary or after evaporator will vaporize this excess. But the criss-cross arrangement permits reduction in the size of the auxiliary evaporator.

It will be understood that various changes may be resorted to in the form, construction and arrangement of the parts without departing from the spirit or scope of the invention, and hence I do not intend to be limited to details herein shown or described except as they may be included in the claims or be required by disclosure of the prior art.

What I claim is:

1. An evaporator assembly designed and adapted to cool a single air stream in heat exchange systems comprising, a main evaporator having a plurality of conduits provided with refrigerant inlets and outlets, an auxiliary after evaporator having an inlet connected with the outlets of the main evaporator conduits, and means for generating an air stream, the parts being so constructed and arranged that the after evaporator is adapted to augment the cooling effect of the main evaporator on the air stream and itself to evaporate the liquid portion of refrigerant supplied to the main evaporator which is not evaporated during its passage through said main evaporator, the said auxiliary after evaporator including a conduit of relatively large cross sectional size as compared with the conduits of the main evaporator to adapt the auxiliary after evaporator to receive the combined output of all conduits of the main evaporator, and the means for generating an air stream being arranged to force the air stream directly through the auxiliary after evaporator and the main evaporator.

2. An evaporator assembly designed and adapted to cool a single air stream in heat exchange systems comprising, a main evaporator having a plurality of conduits provided with refrigerant inlets and outlets, an auxiliary after evaporator having an inlet connected with the outlets of the main evaporator conduits, and means for generating an air stream, the parts being so constructed and arranged that the after evaporator is adapted to augment the cooling effect of the main evaporator on the air stream and itself to evaporate the liquid portion of refrigerant supplied to the main evaporator which is not evaporated during its passage through said main evaporator, the conduits of the said main evaporator being arranged in substantially parallel relationship and at least one of said conduits located further from the side of the main evaporator toward which the air current moves being connected by a refrigerant conducting cross-over with at least one other conduit located nearer the said side of the main evaporator, the points of connection being between the inlets and outlets of said conduits connected by the cross-over.

3. An evaporator assembly as defined in claim 2, which also includes individual refrigerant distributors connected with the inlets of the main evaporator conduits.

4. An evaporator assembly as defined in claim 3, which also includes an outlet manifold interconnecting the outlets of the main evaporator conduits and the inlet of the auxiliary after evaporator.

5. An evaporator assembly designed and adapted to cool a single air stream in heat exchange systems comprising, a main evaporator having a plurality of conduits provided with refrigerant inlets and outlets, an auxiliary after evaporator having an inlet connected with the outlets of the main evaporator conduits, and means for generating an air stream, the parts being so constructed and arranged that the after evaporator is adapted to augment the cooling effect of the main evaporator on the air stream and itself to evaporate the liquid portion of refrigerant supplied to the main evaporator which is not evaporated during its passage through said main evaporator, the said auxiliary after evaporator being positioned between two of the main evaporator conduits.

6. An evaporator assembly as defined in claim 5, which also includes a manifold for the outlets

of the main evaporator conduits to which manifold the inlet of the said auxiliary after evaporator is connected at a point within the main evaporator.

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