This invention relates to refrigeration evaporators and relates more particularly to variable surface evaporators for use with refrigerant compressors.

The railroads prefer mechanical refrigeration systems for their air conditioned passenger cars and they usually specify over-sized evaporators for use as air coolers. They usually make the contractor responsible for the proper balance between the compressor-condenser equipment and the evaporator, and for the overall performance of the complete equipment.

With an evaporator too large for the cooling load, excessive back pressure develops so that the compressor cannot deliver its tonnage without excessive pressure. It is desirable therefore, to adjust the evaporator surface to maintain the proper balance between tonnage, refrigerant temperature, superheat, pressure and compressor horsepower. This is satisfactorily accomplished in the present invention.

An object of the invention is to adjust the surface of an air cooling, refrigerant evaporator, conformably with load requirements.

Other objects of the invention will be apparent from the following description and from the drawing.

The invention will now be described with reference to the drawing which illustrates diagrammatically one embodiment of the invention.

The evaporator is shown in the embodiment illustrated, ten horizontal rows of finned tubes, each horizontal row containing nine tubes connected together by the return bends. The tubes of the upper five rows are connected by the tubes to the return header, and the tubes of the lower five rows are connected by the tubes to a similar header.

The upper five rows of tubes are connected by the distributor tubes to the refrigerant distributor. The lower five rows of tubes are connected by the distributor tubes to the refrigerant distributor. The lower five rows are similarly tapped at the third tubes from the right hand end of the evaporator and are connected by the distributor tubes to the refrigerant distributor.

The refrigerant distributors A, B, C, and D are similar and are each attached to the similar thermostatic expansion valves. The distributors and their valves are preferably of the type shown by the U. S. Patent No. Re. 20,964 to Harry F. Morton.

In operation, when serving as an air cooler, it is intended that the air to be cooled, enter the evaporator at its left hand end (facing the drawing) and leave at its right hand end.

The valve controls the supply of refrigerant to the distributor A. The similar valve controls the supply of refrigerant to the distributor B. The similar valve in the refrigerant supply line controls the supply of refrigerant to the distributor C. The similar valve in the refrigerant supply line controls the supply of refrigerant to the distributor D.

With the valves 17 and 18 open and the valves 21 and 22 closed, the evaporator 5 will be supplied by the distributors A and B at full capacity. The ten rows of nine tubes per row, ninety tubes in all, will then be supplied with refrigerant.

With the valves 17 and 18 closed and the valves 21 and 22 open, the distributors C and D will supply refrigerant to the ten rows of tubes, each row containing seven tubes, a total of seventy tubes, the minimum capacity of the evaporator.

With one of the valves A or B open, and the other closed and with one of the valves C or D open and the other closed, five rows of tubes with seven tubes per row, plus five rows of tubes with nine tubes per row, will be served with refrigerant, a total of eighty tubes, the mid-capacity of the evaporator.

Experience has shown that a railroad company, specifying an evaporator for an air conditioned passenger car would usually specify the maximum capacity evaporator corresponding to the ninety tube one above described, even though it is expected that such an evaporator will be too large for proper operation, at least for the majority of air conditioned cars. Since the size of the evaporator for efficient operation is closely related to the air conditioning load, compressor capacity, power, refrigerant temperature and pressure, and other factors, the above described variable surface evaporator has been devised for providing the proper evaporator surface for different conditions, yet complying with the specifications for over-sized surface.

Although the valves 17, 18, 21 and 23 could be adjusted manually to provide the proper evaporator surface for a given operation condition, in the embodiment illustrated, a suitable automatic control has been provided as will now be described.

Calculations based upon experience have shown that in an evaporator of the type illustrated, the suction temperature of the refrigerant should normally be about 40°F., with the evaporator operating at mid-capacity, with eighty tubes in service. Then if the temperature of the gas rises above 40°F. to say 45°F., less surface is required, and proper operation may be had with only seventy tubes. If on the other
hand, the suction temperature falls below 40°F., more surface is required, and all of the ninety tubes should be in.

The suction or return tube 25 is connected to the thermostat 26 which may contain the ther-

\[ \text{mometer 27. The bulb 28 of the thermometer 27 is connected by the wire 29 to the wire 30 and to one side of the electric source 36. The same side of the electric source is connected to the wires 30 and 31, and by the branch wires 32, 33, 34, and 35 to one of the two terminals of each of the electrical solenoids operating the valves 23, 19, 17 and 21 respectively.} \]

Imbedded in the stem of the thermometer 27 are the contact 37 at the 40°F. division, and the contact 38 at the 43°F. division. When the suction temperature is at 40° or between 40° and 43°, the relay indicated generally by 39 is energized to close contacts closing the circuits energizing the solenoids of the valves 19 and 21 and opening the circuits energizing other valves with the result that the distributors B and C serve eighty tubes of the evaporator 5. If the suction temperature falls below 40°F., the energizing circuits of the solenoids of the valves 18 and 21 are opened and the energizing circuits of the valves 17 and 19 are closed, causing the dis-

\[ \text{tributors A and B to serve ninety tubes. If on the other hand, the suction temperature goes up to 43°F., the relay indicated generally by 40 is energized, causing the relay 39 to become deenergized, the solenoids of the valves 17 and 19 to become deenergized and the solenoids of the valves 21 and 23 to become energized, causing the distributors C and D to serve seventy tubes.} \]

The relay 40 contains the control solenoid 41 which is included in the electric circuit includ-

\[ \text{ing the wire 42, the thermistor contact 43, the wire 44, the electric source 45, the wires 46,} \]

and 47, and the temperature bulb 28. When the suction temperature reaches 43°F., the circuit is closed, and the solenoid 41 is energized to pull up its armature 45 causing it to strike the contacts 51 and 52. This closes one circuit including the armature 50, the wire 53, the electric source 36, the wires 30, 31 and 33, and the solenoid of the valve 21, the wires 54 and 55, and the contacts 56 and 57 causing the solenoid of the valve 21 to open the valve to permit the distributor C to serve thirty-five tubes of the evaporator 5. At the same time, the circuit including the armature 50, the wire 53, the electric source 36, the wires 30, 31 and 33, and the solenoid of the valve 21, the wires 54 and 55, and the contacts 56 and 57 causing the solenoid of the valve 23 to open the valve and to permit the distributor D to serve an additional thirty-five tubes of the distributor 5. The two distributors C and D thus serve seventy evaporator tubes when the suction temperature reaches 43°F.

When the solenoid 41 is energized as described for suction temperatures at and above 43°F., its armature 50 is pulled up and carries with it the insulated armature 45 and separates the armature 45 from the contacts 44. This opens the circuit connecting the relay 39 to the electric source 36 and prevents the solenoids of the other valves 17 and 19 from being energized through operation of the relay 39.

When the suction temperature falls below 43°F., but remains about 40°F., the energizing circuit of the relay 39 will be closed as will now be described. The solenoid 41 is now deenergized and the armature 45 strikes the contacts 44. The circuit including the thermosto-

\[ \text{tect 37, the wire 42, the solenoid 41, the wires 51 and 43, the contacts 44, the armature 45, the wire 46, the electric source 36, the wires 30 and 31, and the thermometer bulb 28, is closed causing the solenoid 41 to pull up its armature 50 and strike the contacts 59 and 60. This causes the closing of one circuit including the armature 50, the wires 61 and 43, the contacts 44, the armature 45, the wire 46, the electric source 36, the wires 30 and 31, and the solenoid of the valve 21, the wires 54 and 52, and the contact 59. This causes the solenoid of the valve 21 to become energized to open the valve and to cause the distributor C to serve thirty-five tubes of the evaporator 5. At the same time, a second circuit including the armature 50, the wires 61 and 43, the contacts 44, the armature 45, the wire 46, the electric source 36, the wires 30, 31 and 33, the solenoid of the valve 19, the wire 63 and the contact 59, causing the solenoid of the valve 19 to become energized and the valve to open to cause the distributor B to serve 45 tubes of the evaporator 5. At this time, when the suction temperature is between 40°F. and 43°F., the distributors B and C serve a total of eighty tubes of the evaporator.

When the suction temperature falls below 40°F., the above described circuit of the solenoid is energized, its armature 50 is released, the last two described circuits including the contacts 59 and 60 are opened causing the solenoids of the valves 19 and 21 to become deenergized causing these valves to close.

The armature 50 at this time strikes the contacts 64 and 65. This causes the completion of a circuit including the armature 50, the wires 61 and 43, the contacts 44, the armature 45, the wire 46, the electric source 36, the wires 30, 31 and 33, the solenoid of the valve 19, the wire 63 and the contact 64 causing the solenoid of the valve 19 to become energized to open the valve and causing the distributor B to serve forty-five tubes of the evaporator 5.

At the same time, another circuit including the armature 45, the wire 46, the electric source 36, the wires 30, 31 and 34, the solenoid of the valve 17, the wire 66 and the contact 65 is closed causing the solenoid of the valve 17 to become energized to open the valve 17 and causing the distributor A to serve the other forty-five tubes of the evaporator. Thus for suction temperatures below 40°F., the full ninety tubes of the evaporator are placed in service.

The suction tube 25 contains the usual thermo-

\[ \text{static elements 67 connected by the tubes 68 indicated by the dash-dot lines on the drawing, to the thermostatic expansion valves 66 for controlling as shown by said Morton patent, the rate of flow of the refrigerant.} \]

Regardless of whether the evaporator is operating at maximum capacity, mid-capacity or minimum capacity, the effective air cooling tubes extend in multiple across the entire face of the air stream being cooled, so that the effect is the same as if three separate, independent evaporators were provided.

While an evaporator adjustable to provide three surface areas has been described, two or more than three surface areas could be provided.

In the claims the term “tubes” does not refer to the refrigerant conduits running from the re-

\[ \text{frigerant distributor tubes to the header, but refers to separate, transversely extending, sub-
}

\[ \text{stantially parallel tubes such as the tubes 6, with} \]
adjacent tubes being interconnected at their ends as by the return bends 7.

While one embodiment of the invention has been described for the purpose of illustration, it should be understood that other apparatus and arrangements of apparatus may be suggested by those skilled in the art without departure from the essence of the invention.

What is claimed is:

1. An air cooler comprising a plurality of rows of tubes, each row containing a plurality of tubes, means including a plurality of distributors connected to the tubes of said rows at one end thereof and another plurality of distributors connected to tubes of said rows between the ends thereof for supplying refrigerant to said tubes, means including a plurality of valves for supplying refrigerant to said distributors, and means for selectively adjusting said valves for varying the number of said tubes supplied with refrigerant.

2. An air cooler comprising a plurality of rows of tubes, each row containing a plurality of tubes, means including a plurality of refrigerant distributors for supplying refrigerant to all of said tubes with refrigerant, means including a second plurality of refrigerant distributors for supplying a portion of said tubes with refrigerant, means including valves for supplying refrigerant to said distributors, and means including means responsive to changes in the temperature of the refrigerant leaving said cooler for selectively adjusting said valves for supplying refrigerant to all of said tubes or to a portion of said tubes.

3. An air cooler comprising a plurality of rows of tubes, each row containing a plurality of tubes, means including a plurality of distributors connected to the tubes at one end of said rows for supplying refrigerant to all of said tubes, means including a distributor connected to the tubes of a plurality of said rows at points intermediate the ends thereof for supplying refrigerant to a portion of said tubes, means including a plurality of valves for supplying refrigerant to said distributors, and means including means responsive to changes in the temperature of the refrigerant leaving said rows for selectively adjusting said valves for varying the number of said tubes supplied with refrigerant.

4. An air cooler comprising a plurality of rows of tubes, each row containing a plurality of tubes, means including a plurality of distributors connected to the tubes of said rows at one end thereof and other distributors connected to the tubes of said rows between the ends thereof for supplying refrigerant to said tubes, means including a plurality of valves for supplying refrigerant to said distributors, and means including means responsive to changes in the temperature of the refrigerant leaving said rows for selectively adjusting said valves for varying the number of said tubes supplied with refrigerant.

5. An air cooler comprising a plurality of rows of tubes, each row containing a plurality of tubes, refrigerant distributor means connected to tubes of refrigerant distributor thereto, and means for selectively adjusting said valves for varying the number of tubes supplied with refrigerant.

6. An air cooler comprising a plurality of rows of tubes, each row containing a plurality of tubes, refrigerant distributor means connected to tubes of said rows at one end thereof, refrigerant dis-