March 4, 1941. S. M. ANDERSON 2,233,827

REFRIGERATION APPARATUS

Filed Dec. 16, 1939 3 Sheets-Sheet 1

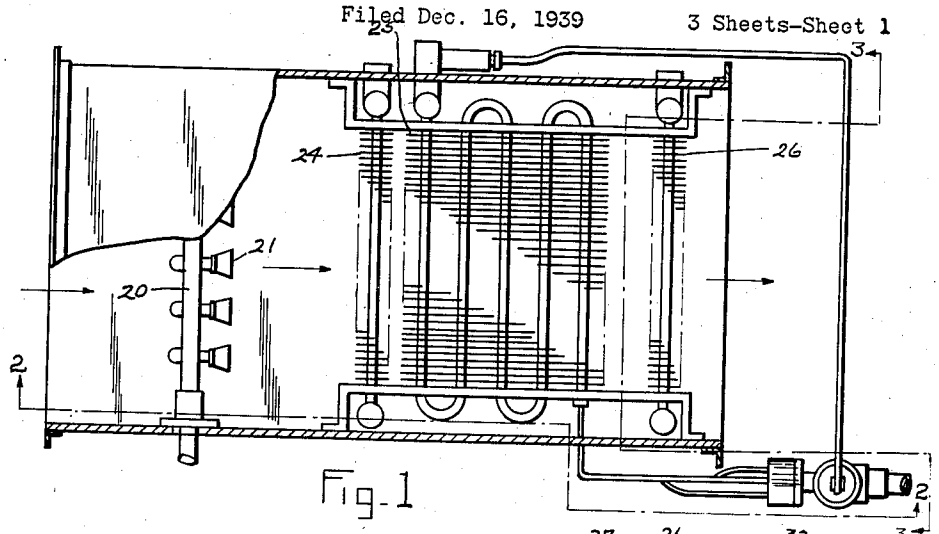

Fig-1

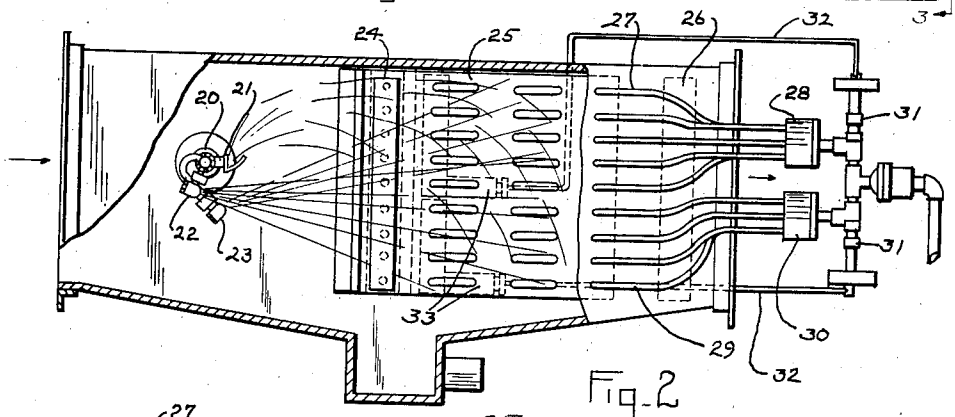

Fig-2

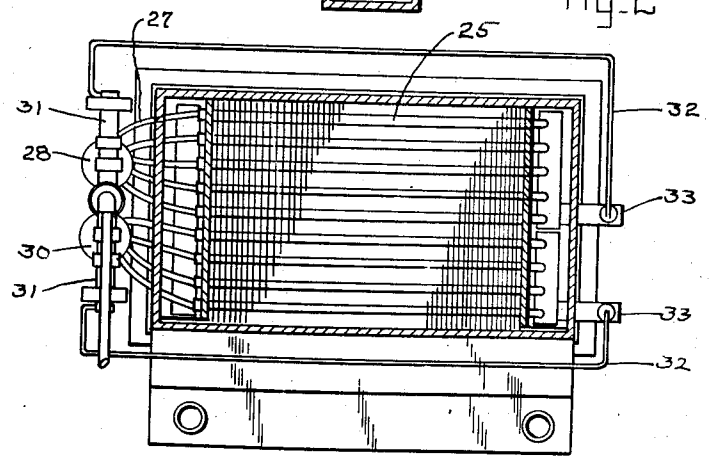

Fig-3

INVENTOR.
SAMUEL M. ANDERSON
BY
Robert T. Palmer
ATTORNEY.

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REFRIGERATION APPARATUS

Filed Dec. 16, 1939 3 Sheets-Sheet 2

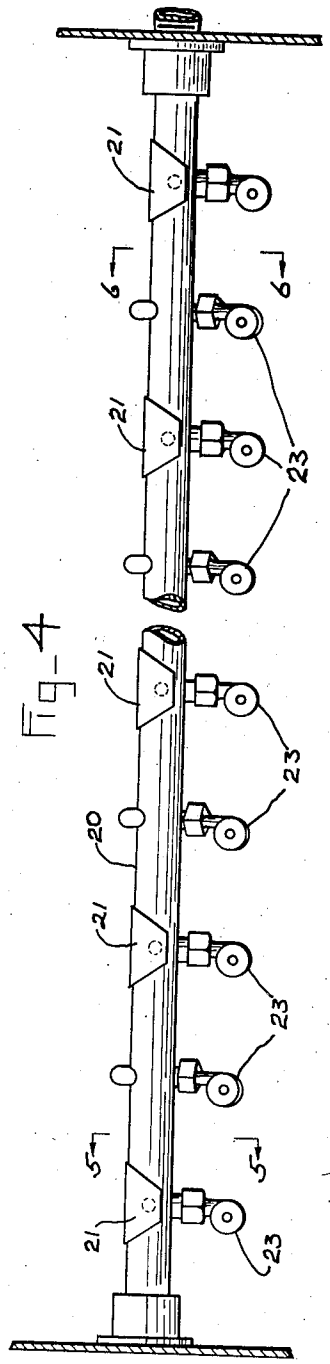

Fig-4

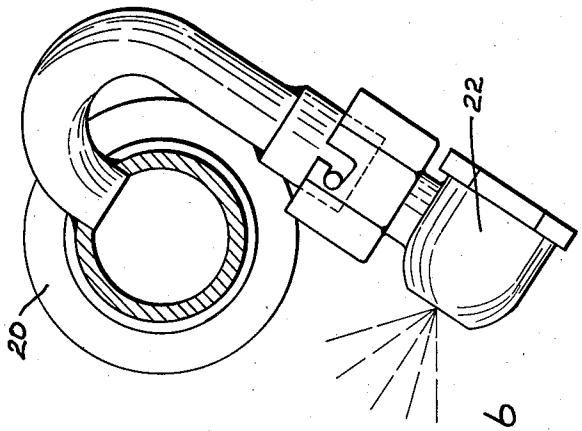

Fig-6

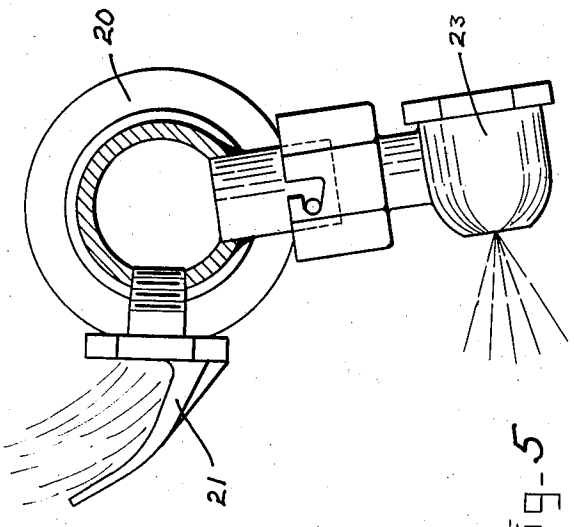

Fig-5

INVENTOR.

BY SAMUEL M. ANDERSON

Robert J. Palmer

ATTORNEY.

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REFRIGERATION APPARATUS

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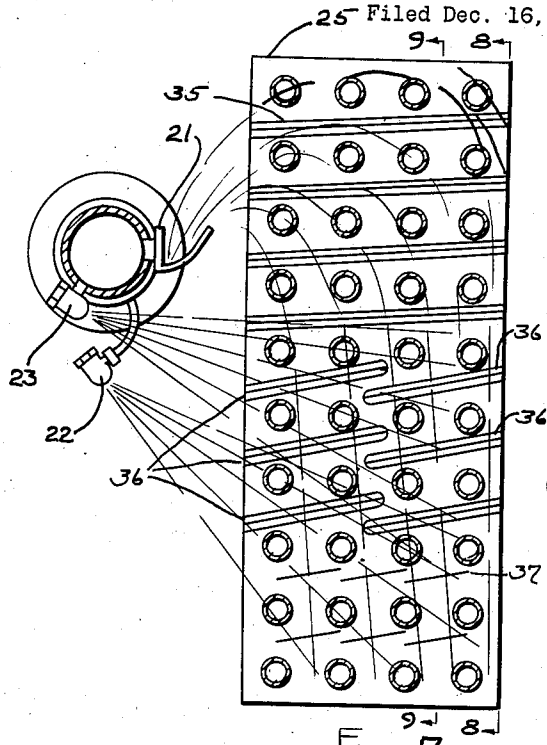

Fig-7

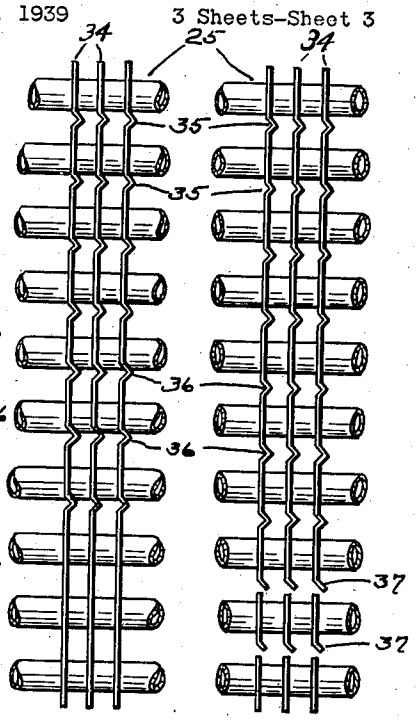

Fig-8

Fig-9

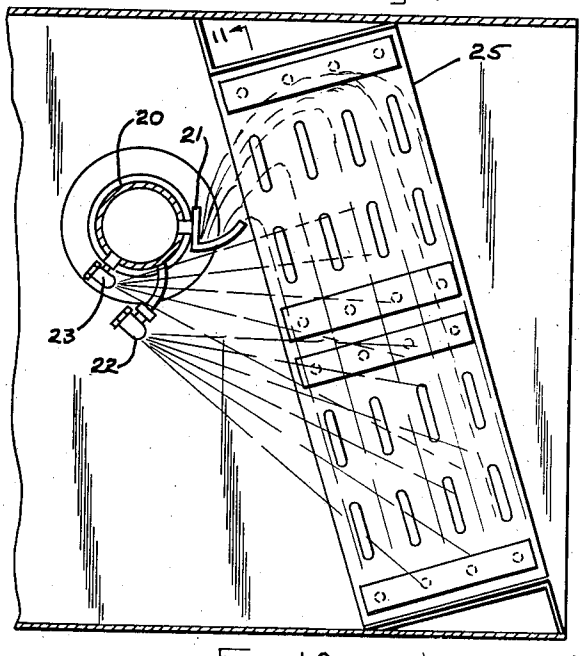

Fig-10

11

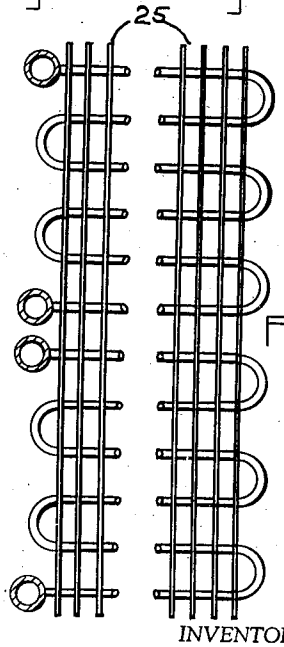

Fig11

INVENTOR.
SAMUEL M. ANDERSON
BY Robert J. Palmer
ATTORNEY.

Patented Mar. 4, 1941

2,233,827

UNITED STATES PATENT OFFICE

2,233,827

REFRIGERATION APPARATUS

Samuel M. Anderson, Sharon, Mass., assignor to B. F. Sturtevant Company, Hyde Park, Boston, Mass.

Application December 16, 1939, Serial No. 309,600

8 Claims. (Cl. 261—10)

This invention relates to refrigeration apparatus and relates more particularly to air cooling evaporators.

It is generally recognized that air washers supplied with refrigerated water are to be preferred for cooling air in air conditioning systems. Among the advantages are the cleaning and effective sterilizing of the air, the removal of odors, and the freshening of the air, all in addition to the air cooling and the exact control of temperature and humidity. But, heretofore, such large quantities of water have been required together with large air washers and large evaporator water chillers that most air conditioning systems, especially air conditioning for railway passenger cars where space is limited, have had to forego the advantage of washed air and to use dry coil evaporators for cooling the air.

This invention eliminates the need for a separate evaporator water chiller and produces a small compact air washer in which evaporator tubes extend across the air stream and are sprayed with water.

A feature of this invention resides in providing a plurality of sets of spray nozzles, differently directed for projecting spray over a plurality of portions of the evaporator, simultaneously.

Another feature of the invention resides in providing upper flooding nozzles and lower spray nozzles, in advance with respect to air flow, of the evaporators, the flooding nozzles projecting upwardly and forwardly upon the upper rows of evaporator tubes and the spray nozzles projecting water upon lower tubes.

Other features of the invention reside in projecting water in relatively coarse droplets at low pressure upon evaporator tubes and arranging the surfaces of the tubes for obtaining prolonged water to surface contact.

Objects of the invention are to reduce the size of air washers and to reduce the quantity of water required therein, by utilizing improved forms of sprayed evaporators.

The invention will now be described with reference to the drawings, of which:

Fig. 1 is a plan view, looking downwardly, with a portion of the cover removed, of an air washer embodying this invention;

Fig. 2 is a sectional view along the lines 2—2 of Fig. 1;

Fig. 3 is a sectional view along the lines 3—3 of Fig. 1;

Fig. 4 is an enlarged plan view looking downwardly upon the spray nozzle assembly of Figs. 1–3;

Fig. 5 is an enlarged sectional view along the lines 5—5 of Fig. 4;

Fig. 6 is an enlarged sectional view along the lines 6—6 of Fig. 4;

Fig. 7 is an enlarged elevation view illustrating one embodiment of an evaporator which may be used in the air washer of Figs. 1–3;

Fig. 8 is a sectional view along the lines 8—8 of Fig. 7;

Fig. 9 is a sectional view along the lines 9—9 of Fig. 7;

Fig. 10 is an enlarged elevation view of an alternative form of evaporator which may be used instead of that of Figs. 7–9, and

Fig. 11 is a sectional view along the lines 11—11 of Fig. 10.

Figs. 1–3 inclusive illustrate a complete air conditioning system including spray header 20, flooding nozzles 21, spray nozzles 22 and 23, preheater 24, evaporator 25 and reheater 26.

The evaporator 25 includes as shown by Figs. 2 and 3, nine vertical rows of finned tubes, one group of upper five rows of tubes being supplied with refrigerant through the tubes 27 from the refrigerant distributor 28, and another group of the lower four rows being supplied with refrigerant through the tubes 29 from the distributor 30.

The refrigerant distributors are preferably of the type of the Morton Reissue Patent No. 20,964 and are supplied with refrigerant through the expansion valves 31, which in turn are automatically controlled through the tubes 32 connected to the thermostats 33 at the suction side of the two groups of evaporator tubes.

The flooding nozzles 21 are arranged above the spray nozzles 22 and 23 and are adapted to project relatively coarse droplets at an upward angle as illustrated, upon the evaporator tubes. The relatively large droplets are not carried by the air stream through the unit, but fall downwardly by gravity into the sump of the washer.

The auxiliary spray nozzles 22 and 23 are arranged to project finer droplets of water but at low pressure onto the front sides of the tubes in the area missed by the spray from the flooding nozzles 21, due to its angular upward projection. The nozzles 22 serve the mid-area of the tubes, and the nozzles 23 serve the lower area. All nozzles cooperate to intimately contact the entire evaporator surface with spray water and without any of the spray being carried by the

air stream, from the unit, thus eliminating the necessity for the usual zig-zag eliminators.

While the placing of the flooding nozzles as described with the cooperation of the spray nozzles provides more intimate metal to water contact than has been provided in the past, Figs. 7–9 and 10–11 illustrate two preferred evaporator arrangements for increasing the time of water to metal contact for increasing heat transfer and efficiency.

In the embodiment of the evaporator illustrated by Figs. 7–9, the vertical fins **34** are provided with the projections **35, 36 and 37** which angle downwardly in a direction counter-flow to the air stream. These projections form breaks in the continuity of the fin surface and the water droplets striking them, instead of flowing straight downwardly, flow counter-flow to the air. The air slows them up, and their path is extended. These two factors cause greatly increased time of contact between the fins and the water and result not only in increased heat transfer but in less water required.

Three forms of breaks in the fin surface are illustrated. Any one of these forms could be used throughout or other forms such as punched dummy holes could be used for providing the increased time of contact.

The embodiment of Figs. 10 and 11 provides prolonged contact by arranging the evaporator at the angle the spray from the flooding nozzles follows after turning downwardly. This provides for more complete and for longer contact between the water and the metal. This embodiment is suitable for sprayed refrigerant condensers as well as for sprayed evaporators.

In a cooling unit designed for railway passenger cars, embodying this invention, it was found that only three gallons of water were required for satisfactory air washing and cooling as compared to about forty gallons previously required. The three gallons of water were recirculated ten times per minute. Not only is far less water required than formerly, but the size of the complete unit is but a small fraction of those formerly giving equivalent performance.

While several embodiments of the invention have been described for the purpose of illustration, it should be understood that the invention is not limited to the exact apparatus and arrangement of apparatus illustrated as departures therefrom may be suggested by those skilled in the art without departing from the essence of the invention.

What is claimed is:

1. Refrigeration apparatus comprising an air washer, a plurality of tubes adapted to receive a volatile refrigerant, extending crosswise the downstream end of said washer, a liquid supply header extending across the upstream end of said washer, a plurality of substantially horizontally aligned flooding nozzles connected to said header and being positioned to project spray in an upwardly extending arc upon said tubes, a first plurality of spray nozzles arranged below said flooding nozzles and being connected to said header and positioned to project spray directly upon said tubes, and a second plurality of spray nozzles below said flooding nozzles and connected to said header and positioned to project spray directly upon said tubes.

2. Refrigeration apparatus comprising an air washer, a plurality of tubes adapted to receive a volatile refrigerant, extending crosswise the downstream end of said washer, a liquid supply header extending across the upstream end of said washer, a plurality of substantially horizontally aligned flooding nozzles connected to said header and being positioned to project spray in an upwardly extending arc upon said tubes, a first plurality of spray nozzles arranged below said flooding nozzles and being connected to said header and positioned to project spray directly upon said tubes, and a second plurality of spray nozzles below said flooding nozzles and connected to said header and positioned to project spray directly upon said tubes.

3. Refrigeration apparatus comprising an air washer, a plurality of tubes adapted to receive a volatile refrigerant, extending horizontally crosswise the downstream end of said washer, a plurality of vertical fins extending crosswise said tubes, a plurality of spray nozzles extending crosswise the upstream side of said washer and positioned to spray liquid upon said tubes, and means forming breaks in the continuity of said fins for causing water droplets draining down same, to flow upstream.

4. Refrigeration apparatus comprising an air washer, a plurality of tubes adapted to receive a volatile refrigerant, extending horizontally crosswise the downstream end of said washer, a plurality of vertical fins extending crosswise said tubes, a plurality of flooding nozzles extending crosswise the upstream side of said washer and positioned to spray liquid in an upwardly extending arc upon said tubes, a plurality of spray nozzles arranged below said flooding nozzles and positioned to spray liquid directly upon said tubes, and means forming breaks in the continuity of said fins for causing water droplets draining down same, to flow upstream.

5. Refrigeration apparatus comprising an air washer, a plurality of tubes adapted to receive a volatile refrigerant, extending horizontally crosswise the downstream end of said washer, a plurality of vertical fins extending crosswise said tubes, a plurality of flooding nozzles extending crosswise the upstream side of said washer and positioned to spray liquid in an upwardly extending arc upon said tubes, a plurality of spray nozzles arranged below said flooding nozzles and positioned to spray liquid directly upon said tubes, and another plurality of spray nozzles below said first mentioned spray nozzles and positioned to project spray directly upon said tubes, and means forming breaks in the continuity of said fins for causing water droplets draining down same, to flow upstream.

6. Refrigeration apparatus comprising an air washer, a tube unit containing a plurality of rows of tubes adapted to receive a volatile refrigerant extending horizontally across the downstream side of said washer, and a plurality of substantially horizontally aligned flooding nozzles extending crosswise the upstream side of said washer and positioned to project spray in an upwardly extending arc upon said tubes, said unit being so tilted forwardly with upper end upstream and lower end downstream that it lies in and substantially parallel to the path of the downwardly moving spray from said nozzles as positioned by the force of the air stream and the force of projection from said nozzles so as to provide longer contact between the spray droplets and the surface of said unit than were it mounted vertically in said washer.

7. Refrigeration apparatus comprising an air washer, a tube unit containing a plurality of rows of tubes adapted to receive a volatile refrigerant extending horizontally across the downstream side of said washer, a plurality of substantially horizontally aligned flooding nozzles

extending crosswise the upstream side of said washer and positioned to project spray in an upwardly extending arc upon said tubes, said unit being tilted forwardly with upper end upstream and lower end downstream whereby it lies in the path of the downwardly moving spray from said nozzles as positioned by the force of the air stream and the force of projection from said nozzles, and a plurality of spray nozzles below said flooding nozzles and positioned to project spray directly upon the tubes of said unit.

8. Refrigeration apparatus comprising an air washer, a tube unit containing a plurality of rows of tubes adapted to receive a volatile refrigerant extending horizontally across the downstream side of said washer, a plurality of substantially horizontally aligned flooding nozzles extending crosswise the upstream side of said washer and positioned to project spray in an upwardly extending arc upon said tubes, said unit being tilted forwardly with upper end upstream and lower end downstream whereby it lies in the path of the downwardly moving spray from said nozzles as positioned by the force of the air stream and the force of projection from said nozzles, a plurality of spray nozzles below said flooding nozzles and positioned to project spray directly upon the tubes of said unit, and a second plurality of spray nozzles below said first mentioned spray nozzles and adapted to project spray upon the tubes of said unit.

SAMUEL M. ANDERSON.