July 14, 1936. C. A. RODMAN 2,047,799

AIR CONDITIONING APPARATUS

Filed Aug. 26, 1933 3 Sheets-Sheet 1

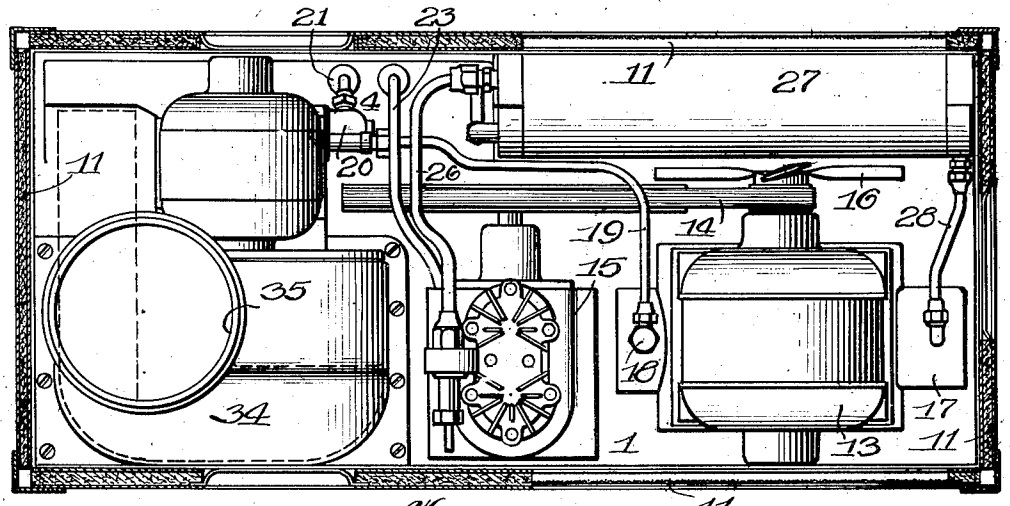



Fig. 1

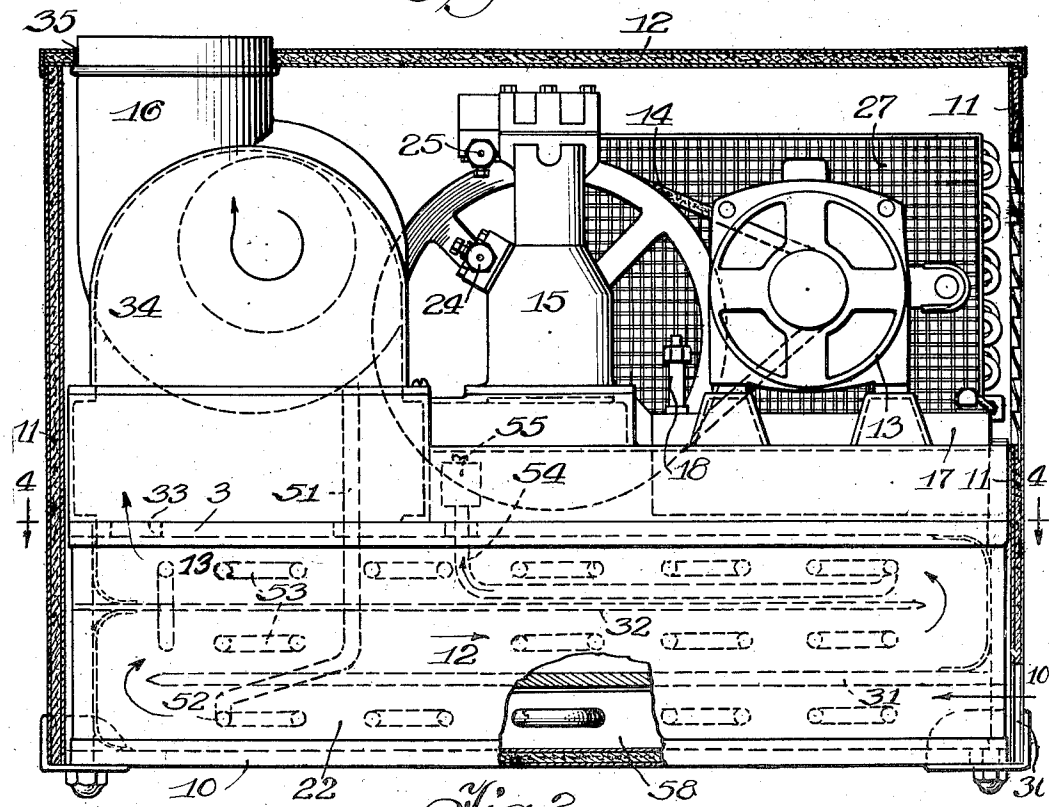



Fig. 2

Witness:
Chas. R. Kourse.

Inventor,
Clarence A. Rodman,
George Bayard Jones, Atty.

July 14, 1936. C. A. RODMAN 2,047,799

AIR CONDITIONING APPARATUS

Filed Aug. 26, 1933 3 Sheets-Sheet 2

Fig. 4

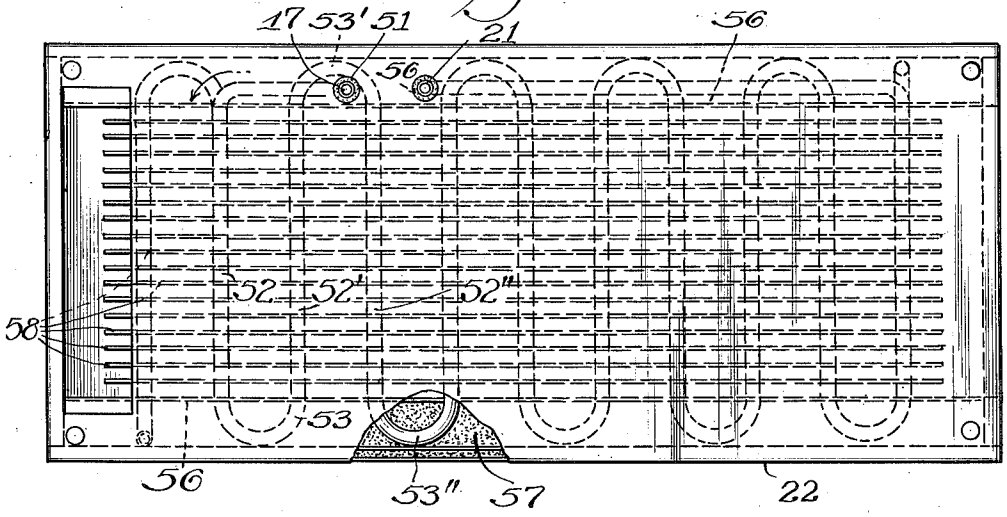



Fig. 3

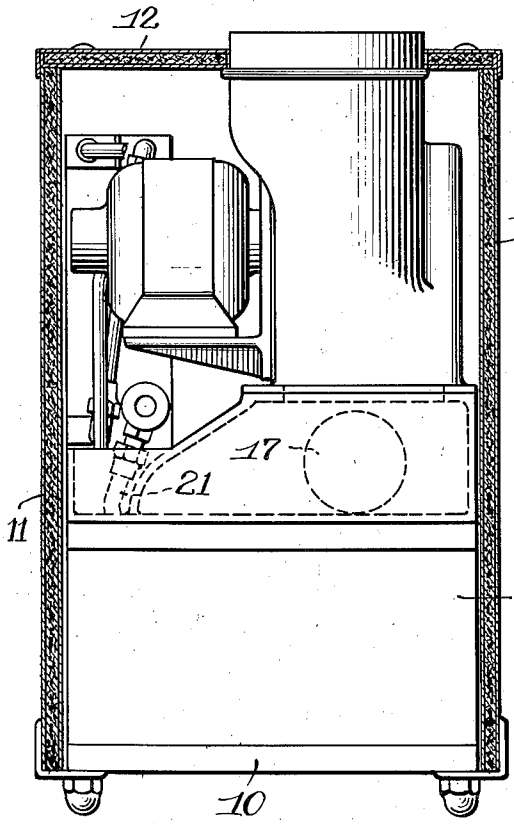
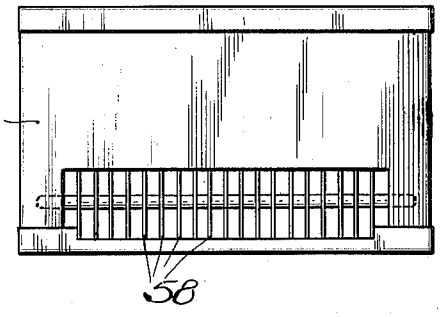



Fig. 5




Witness:
Chas. R. Kourse.

Inventor
Clarence A. Rodman,
George Bagar Jones Atty.

July 14, 1936. C. A. RODMAN 2,047,799

AIR CONDITIONING APPARATUS

Filed Aug. 26, 1933 3 Sheets-Sheet 3

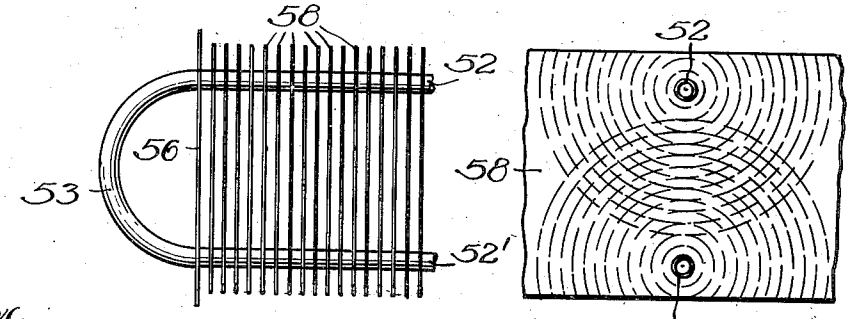



Fig. 6

FINS .025" THICK

Fig. 7

FINS .008" THICK

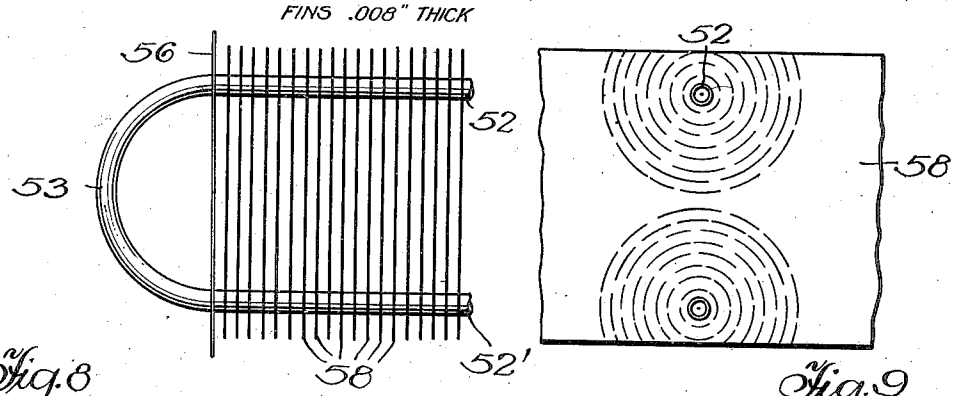



Fig. 8

Fig. 9

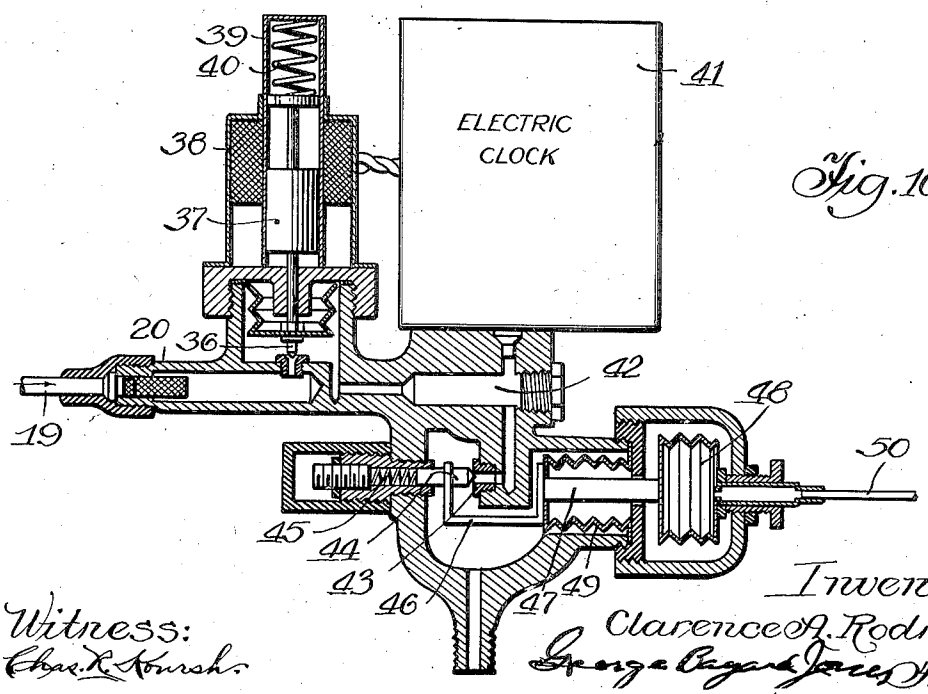



Fig. 10

Witness:
Chas. K. Kourish.

Inventor
Clarence A. Rodman,
George Page and James Abby.

Patented July 14, 1936

2,047,799

# UNITED STATES PATENT OFFICE

2,047,799

## AIR CONDITIONING APPARATUS

Clarence A. Rodman, Fort Wayne, Ind., assignor to Justin W. Macklin, Cleveland, Ohio, trustee

Application August 26, 1933, Serial No. 687,070

10 Claims. (Cl. 62—126)

My invention relates to improvements in air conditioning apparatus and methods of operating the same.

One object of the invention is to provide means for controlling the flow of refrigerant to the evaporator or expansion coil in such manner as to cause the latter to operate at or near the dew point without causing precipitation of moisture on the surfaces of said evaporator or expansion coil.

A contributory object is to cause the flow of refrigerant to take place intermittently or in impulses and provide means for positively controlling the length of time that the expansion valve is opened and closed.

Another object is to provide an improved valve for accomplishing the foregoing results, said valve having one part operated electrically, at predetermined time intervals, and another part under thermal control.

Another object is to provide a valve in which the orifice is automatically changed to compensate for variations in the load impressed upon the evaporator.

A further object is to provide equipment of this character which may be adjusted to maintain the air in humid condition or to dehydrate the air, as may be desired.

An additional object is to provide equipment of this character in which the valve may be used in inverse refrigeration for heating purposes.

In the accompanying drawings I have illustrated one embodiment of the invention which will serve to illustrate its advantages.

Fig. 1 is a top plan view of the mechanism mounted in a suitable container but with the top removed;

Fig. 2 is an elevation thereof with part of the side removed;

Fig. 3 is an end elevation with part of the end wall removed;

Fig. 4 is a section on the line 4—4 of Fig. 2 showing the evaporator;

Fig. 5 is an end view thereof;

Fig. 6 is a plan view of part of one of the evaporator coils;

Fig. 7 is a section thereof;

Fig. 8 is a plan view of part of a modified construction of evaporator coil;

Fig. 9 is a section thereof; and

Fig. 10 is a sectional elevation of a form of expansion valve.

The mechanism is mounted on a suitable base 10 which may form part of a housing having side walls 11 and a top 12. The compressor unit may be of any suitable construction and may comprise a motor 13 having a belt drive 14 for operating the compressor 15. The motor shaft has a fan 16 thereon. Beneath the motor is a tank 17 which contains the refrigerant, which latter may be methyl chloride, dichlorodifluormethene, or any other well known or suitable compound.

Tracing first the flow of the refrigerant, the same passes from the receiver tank 17 through an outlet 18 and a pipe 19 to a suitable expansion valve 20. This valve, as hereinafter pointed out, operates to deliver the refrigerant intermittently, in impulses which may be adjusted as to their rapidity and duration. It may be any suitable valve structure, intermittently operated by proper mechanism, but is preferably of special design and of the form shown in Fig. 8, and operated by an electric clock, as hereinafter explained more fully. From the expansion valve the refrigerant passes through a pipe 21 and is expanded into the evaporator 22, which may be conveniently located in any desired relation with reference to the compressor and other mechanism. In the form shown in the drawings it is located in a compartment below the one in which the compressor is located. It is understood, of course, that the air to be cooled is passed through the evaporator compartment around or through the evaporator coils and fins, as will be hereinafter explained. From the evaporator the refrigerant is returned through pipe 23 to the inlet 24 of the compressor 15 and after being compressed is discharged through the outlet 25 and pipe 26 to the condenser 27 where the heat is removed in the usual way and the liquid refrigerant is returned through pipe 28 to the tank 17.

The evaporator will now be described. The air to be cooled is drawn into the evaporator chamber through an opening 30, along one of the side walls 11, near the bottom of the structure and follows a circuitous course, horizontally to the other end of the housing and then back and forth at successively higher levels through superimposed horizontal chambers formed by horizontal partitions 31 and 32, arranged in staggered relation and each extending from one end of the housing almost to the other end thereof, as shown in Fig. 2. During this back and forth flow, heat is extracted from the air by the evaporator fins and coils and the cooled air is then drawn upwardly through the outlet 33 to the inlet side of the blower 34, and, passing through the rotor of the blower, is discharged from the outlet 35, shown as an opening in the cover 12. Where the structure is installed in

an ornamental cabinet, the cooled air may of course be discharged into the room through horizontal louvers in a horizontal direction or in any desired direction.

A preferred form of expansion valve shown in Fig. 8 will now be described. Another form of expansion valve is shown, described and claimed in my co-pending application filed May 31, 1935, Serial No. 24,381. Said valve may be called an electro-thermal expansion valve and it provides means for controlling the flow of refrigerant through the evaporator or expansion coils so as to permit the operation of the latter at or near the dew point without causing the precipitation of moisture on the surface of the evaporator, or, if such a condition is desired it may also be adjusted to cause dehydration of the air passing through said evaporator by precipitating the moisture on the surface of the evaporator. The valve housing contains two valves, the first of which is opened and shut intermittently and the second of which remains open for a considerable interval of time, although the effective size of the opening is varied in accordance with conditions. The relative arrangement of said two valves may be reversed, however, i. e. with the electrically operated valve located between the thermal valve and the evaporator. The chamber of the electrically operated valve, through which the gas flows, has a port or seat from which the valve stem **36** may be lifted by the core **37** of a solenoid coil **38** when the latter is energized. The upper part of the structure is formed as a dash pot **39** having a spring **40** resisting said upward movement and serving to hold the valve on its seat when the coil is deenergized. Said coil may be actuated by any suitable source of electric impulses such as a "Telechron" timer **41**, which is adjustable so as to regulate the opening and closing of the valve for any predetermined lengths of time and at any desired intervals, thus causing the refrigerant to be released in impulses which may be long or short, as desired. The remainder of the valve is designed to release the proper amount of refrigerant to the evaporator or expansion coils in accordance with the load impressed on the same. From the electrically controlled valve the refrigerant flows through the passage **42** and through an opening in the valve seat **43**, the stem of the valve **44** being normally pressed toward its seat by a spring **45**, the tension of which may be adjusted. The valve stem is mounted in a suitable bracket **46** whereby it may be moved away from its valve seat by a rod **47** under the influence of a "Sylphon" **48** constituting the power element of the thermostatic part of the valve and which may be filled with the same refrigerant as is used in the rest of the system.

The rod **47** is surrounded by an additional bellows or "Sylphon" **49** to prevent leakage through the opening through which the rod **47** slides. The "Sylphon" **48** is connected by a suitable tube **50** to the outlet pipe from the evaporator, as hereinafter explained.

The refrigerant, after leaving the expansion valve in a short impulse, travels downwardly through tube **51** and then horizontally across the evaporator through a transverse tube **52** to the first return bend **53** and then back through another transverse tube **52'**, preferably parallel to the first one, and then through another return bend **53'** and so on back and forth through the entire series of parallel tubes in the lower one of three layers of such tubes. From the lower layer the flow continues back and forth through a second and similar layer above the first layer and so on through successive superimposed layers. In the form illustrated there are three such layers, the outlet end of the pipe being indicated at **54**. Surrounding said outlet end or otherwise closely associated with it is a closed container **55** containing the same refrigerant used in the rest of the system, said container having the tube **50** connected thereto whereby the variations in temperature of said container are communicated to the sylphon **48** of the valve previously described in the form of a variable pressure which actuates said "Sylphon".

The transverse tubes **52**, **52'**, **52''** are supported in the parallel metal walls **56** passing through openings therein with the connecting bends **53** outside of the enclosure formed by said walls. These bends are surrounded by suitable insulating material **57** whereby they are completely insulated from the relatively warm stream of air flowing through said evaporator. Consequently said bends have a lower temperature than the rest of the evaporator. As a result, the refrigerant flowing through the condenser pipe is condensed somewhat in these bends. For example, the first quantity of refrigerant gas released by the valve condenses in part in the first bend at the end of tube **52**. Immediately thereafter a new charge or impulse of refrigerant is discharged into said tube **52** which picks up in part the small amount of condensate left in the first bend **53**. This process of partial condensation and reevaporation in the bends repeats itself throughout all of the transverse tubes in each of the three layers of tubing in the evaporator.

The pressure of these conflicting impulses may be varied within desired limits and may be changed over the entire range of the possible operating field of the machine, according to the temperature desired for operation. The time intervals of said impulses are in accordance with the setting of the valve, which is electrically controlled.

Considering the various tubes **52**, **52'**, **52''**, etc., during any particular impulse the tubes are alternately cooler and warmer throughout the evaporator and on the succeeding charge they are the reverse.

Said tubes **52** are also provided with fins **58** made of good heat conducting material, preferably strips of metal, which are long enough to extend throughout the entire length of the evaporator, each strip having a series of openings therein through which the heat conducting tubes **52** pass. These strips, arranged vertically and in spaced parallel relation, are shown in Fig. 4. The thickness of the fins has an important bearing on the function performed by the apparatus. In Figs. 6 and 7, for example, said fins may be assumed to have a thickness of .025 inch which is thick enough to result in a substantial transfer of heat from one of the tubes **52** to its adjacent parallel tube. The tubes themselves may be assumed to be ⅜ inch copper tubes spaced three inches apart. In other words, the temperature of each tube is affected by the temperature of the preceding tube and the temperature of the succeeding tube, i. e. the transfer of heat may be said to balance off. This is intended to be illustrated by the dotted line circles in Fig. 7.

If the thickness of the fins is substantially less, as for example .008 inch, as indicated in Fig. 8 where also ⅜ inch copper tubes are intended to

be shown, but spaced 5 inches apart, there is substantially no transfer of heat by conduction between adjacent tubes when the temperature thereof becomes alternately cooler and warmer. This is intended to be represented by the dotted circles surrounding each tube in Fig. 9.

When it is desired to operate the apparatus so as to dehydrate the air flowing through it the heavier, continuous fins are used to insure the overlapping of the heat transfer from one tube to another. When it is desired to construct apparatus to condition air by leaving considerable moisture in it, i. e. with a minimum amount of dehydration, the thin, continuous strips are used. It is evident that the operations described are based on the use of continuous fins as distinguished from small individual fins out of contact with the fins on adjacent tubes, although under some conditions the latter may be used.

The relationship between the number of square feet of the superficial area of the evaporator compared to the cubic feet of air handled with either the thick or the thin fins, is an important feature. This ratio of evaporator area to cubic feet of air handled is approximately two and a quarter to one, or, otherwise expressed, one square foot of evaporator area will properly condition two and a half cubic feet of air per minute. If substantially this ratio is obtained, satisfactory operation of the evaporator will take place between temperatures slightly below freezing and up to approximately 90° F. In the construction of the device any number of tubes may be used in conjunction with any number of fins as long as the relationship just referred to is maintained. The evaporator may be constructed in any shape necessary to meet any given requirements and yet made to handle the number of cubic feet of air for which it is designed. The insulated portions of the evaporator may be located in any practical or convenient place. Although the insulation is shown as applied to the return bends, it is evident that such insulated sections may be otherwise located, as for example in a path down the center of the evaporator, or elsewhere, as the location of the insulation is not a governing factor as long as it produces portions isolated from the stream of warm air flowing through the evaporator for cooling purposes.

As previously stated, the power element of the thermostatic part of the valve is located in good thermal contact with the return line of the evaporator or expansion coil so that as the load increases on the evaporator it will cause a rise in temperature of the return line, which in turn will cause a rise in temperature of the power element of said thermostatic element, causing the valve to open and release more refrigerant on each impulse. When the load on the evaporator decreases, there is a drop in temperature on the return line, resulting in a restriction of the valve orifice and thus compensating for the reduction in the load. It will also be understood that in a given construction of pipes and fins, the valve may be used to regulate the apparatus so that it will operate at or near the dew point without causing the precipitation of moisture, or on the contrary the valve may be adjusted to cause dehydration of the air by precipitating its moisture on the surface of the evaporator.

I claim:

1. Air conditioning apparatus comprising a container for the refrigerant, an evaporator, an expansion valve between the two and means for opening said valve at short intervals whereby said refrigerant is delivered to said evaporator in short impulses, said means being adjustable to vary the frequency and the length of said intervals.

2. Air conditioning apparatus comprising a container for the refrigerant, an evaporator having a conduit bent back and forth with its bends thermally insulated and the intermediate spans in heat exchange with air, an expansion valve between said container and said evaporator and means for opening said valve at intervals whereby said refrigerant is delivered to said evaporator in impulses, resulting in partial, temporary condensation of said refrigerant in said bends.

3. Air conditioning apparatus comprising a compressor, a condenser, a tank, an expansion valve and an evaporator connected to form a closed circuit, said expansion valve comprising an intermittently actuated time controlled valve and a thermostatic valve responsive to the temperature of the outlet end of said evaporator, to regulate the flow to said evaporator in accordance with the load on the latter.

4. In air conditioning equipment comprising a supply tank and an evaporator with a supply pipe and a return pipe, an electro-thermal expansion valve in said supply pipe, comprising a valve member actuated at intervals with means to retard its action, a second valve member associated therewith, and a power element associated with said return line to permit increased flow of refrigerant as the load and hence the temperature increase.

5. Air conditioning apparatus comprising a container for the refrigerant, an evaporator having a conduit with portions of less heat conductivity than the remainder thereof, an expansion valve between said container and said evaporator and means for opening said valve at intervals whereby said refrigerant is delivered to said evaporator in impulses, resulting in partial temporary condensation of said refrigerant in said portions.

6. Air conditioning apparatus comprising a container for the refrigerant, an evaporator having a conduit with portions of less heat conductivity than the remainder thereof, an expansion valve between said container and said evaporator, means for opening said valve at intervals whereby said refrigerant is delivered to said evaporator in impulses, resulting in partial temperorary condensation of said refrigerant in said portions and heat conducting members in contact with said remaining portions and with each other, to equalize temperature differences in said remaining portions.

7. Air conditioning apparatus comprising a container for the refrigerant, an evaporator having a conduit surrounded at intervals by heat insulating material with the intermediate spans exposed, an expansion valve between said container and said evaporator and means for opening said valve at intervals whereby said refrigerant is delivered to said evaporator in impulses, resulting in partial, temporary condensation of said refrigerant in said insulated portions.

8. Air conditioning apparatus comprising a container for the refrigerant, an evaporator having a conduit surrounded at intervals by heat insulating material with the intermediate spans exposed, an expansion valve between said container and said evaporator, means for opening

said valve at intervals whereby said refrigerant is delivered to said evaporator in impulses, resulting in partial, temporary condensation of said refrigerant in said insulated portions and additional means controlled by variations in the temperature of the outlet end of said conduit, for regulating the quantity of refrigeration delivered to said conduit.

9. The combination with the expansion coil of a mechanical refrigerator, of a source of supply for the refrigerant, connections therefrom to the inlet end of said coil, a pair of valves arranged in series in said connections, temperature responsive means associated with the outlet end of said expansion coil, power means controlled by said temperature responsive means for regulating the flow of refrigerant through one of said valves and means for opening and closing the other of said valves at intervals to deliver said refrigerant in impulses.

10. The combination with a supply container for refrigerant, an evaporator connected thereto and consisting of a plurality of substantially parallel spaced heat conducting strips having perforations therein, heat conducting tubes passing through the openings in said strips at substantially right angles thereto, parallel side walls having openings therein through which the ends of said tubes protrude, means connecting the ends of certain adjacent tubes to provide for the flow of refrigerant back and forth throughout the series of tubes, heat insulation surrounding the ends of the tubes outside of said side walls, and means for supplying the refrigerant to said tubes in impulses, whereby alternate tubes are first warmer and then cooler than the remaining tubes, and means for causing the air to be treated to flow over said tubes.

CLARENCE A. RODMAN.