June 26, 1945. W. E. DODSON 2,379,286

REFRIGERATING SYSTEM

Filed May 24, 1943 2 Sheets-Sheet 1

Fig. 1.

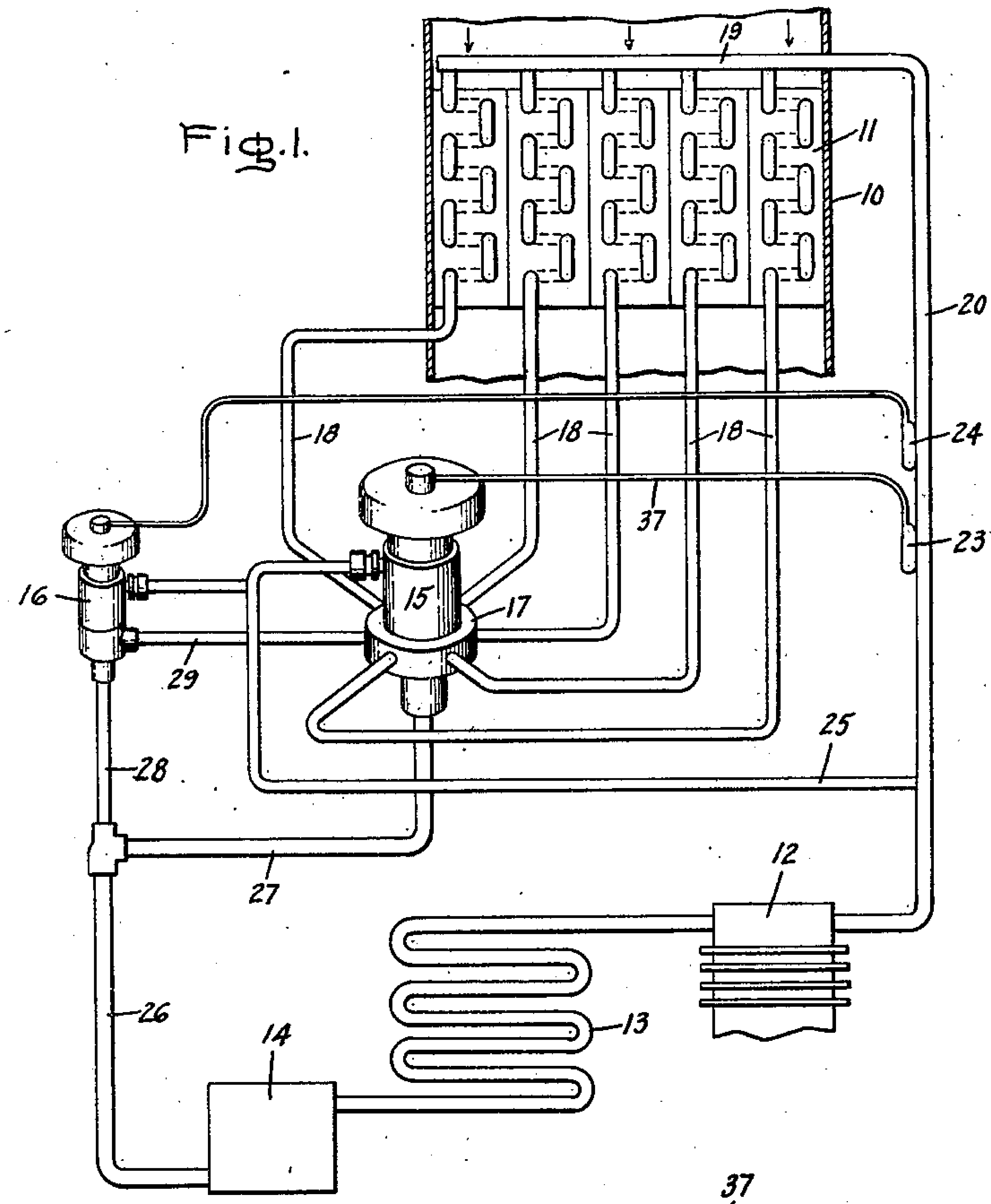
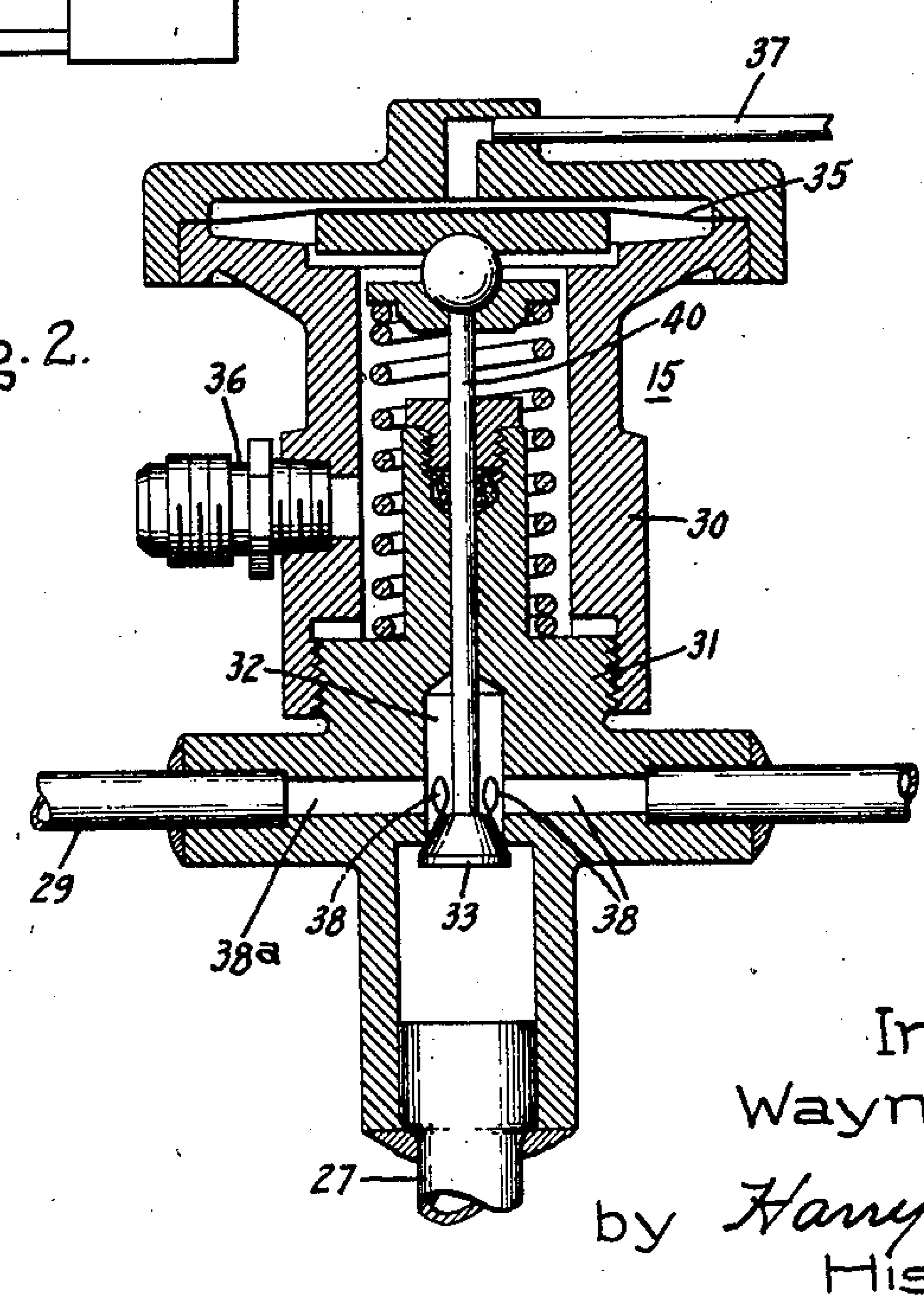


Fig. 2.



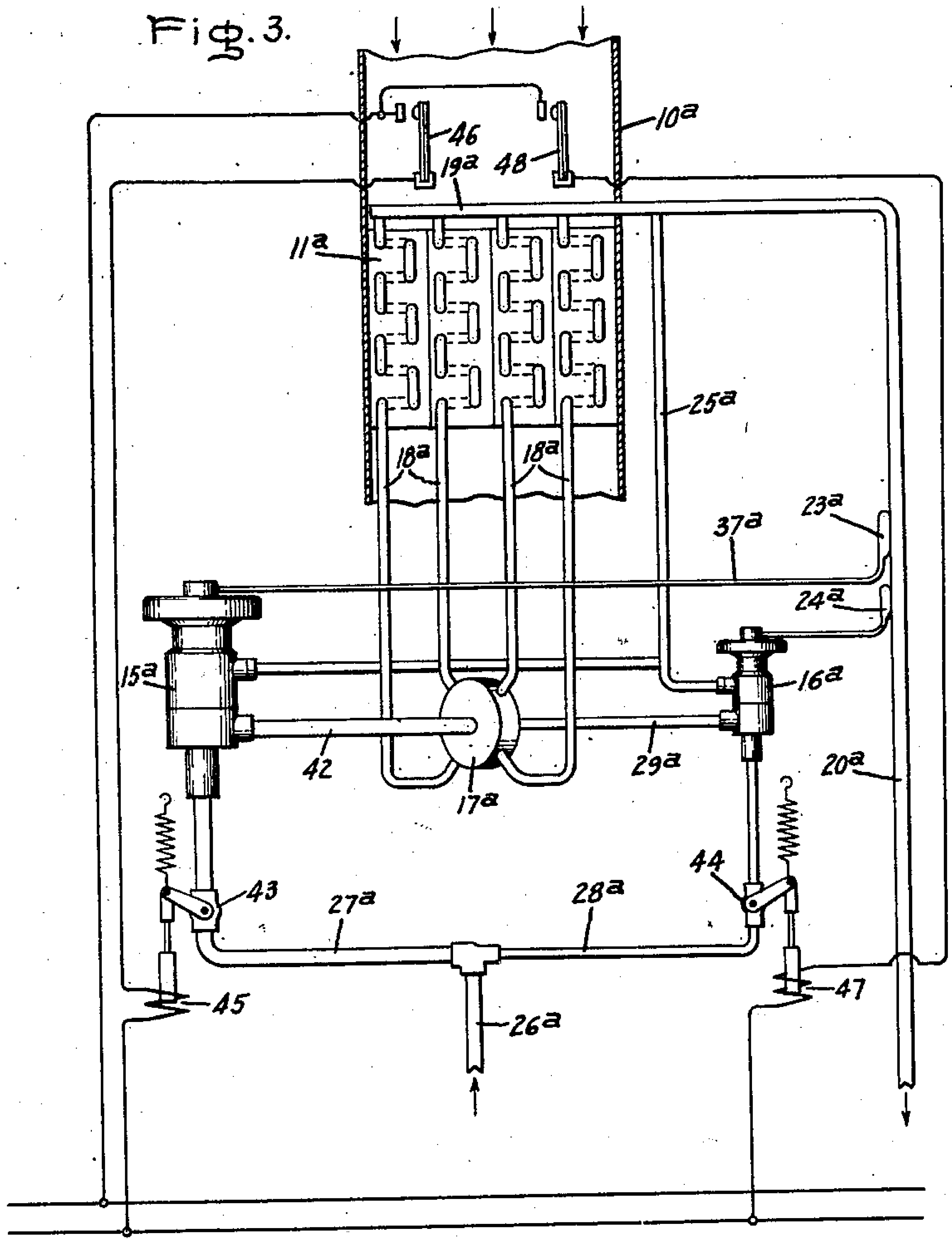
Inventor:
Wayne E. Dodson,
by Harry E. Dunham
His Attorney.

June 26, 1945. W. E. DODSON 2,379,286

REFRIGERATING SYSTEM

Filed May 24, 1943 2 Sheets-Sheet 2

Fig. 3.



Inventor:
Wayne E. Dodson,
by Harry E. Dunham
His Attorney.

Patented June 26, 1945

2,379,286

UNITED STATES PATENT OFFICE

2,379,286

REFRIGERATING SYSTEM

Wayne E. Dodson, Bloomfield, N. J., assignor to General Electric Company, a corporation of New York

Application May 24, 1943, Serial No. 488,187

5 Claims. (Cl. 62—8)

My invention relates to refrigerating systems and particularly to such systems which include evaporators of the multiple conduit type.

Refrigerating systems such as those employed for air conditioning frequently include evaporators or cooling units which comprise a plurality of refrigerant tubes or conduits connected through a manifold to receive refrigerant in parallel from a common condensing unit. These systems commonly employ refrigerant expansion valves of the thermostatic type which operate to maintain a predetermined degree of superheat of the vaporized refrigerant withdrawn from the evaporator. In multiple conduit evaporator systems, it is necessary to insure equal distribution of the refrigerant to the several conduits so that each conduit carries its proportionate share of the cooling load. A distribution header comprising a chamber having a plurality of symmetrically located radial outlets is one form of load equalizing device. The header is located between the expansion valve and the evaporator and frequently is built into the valve as an integral part thereof.

When an air conditioning system, for example, is required to operate over a wide range of refrigerant demand caused by changes of load, or of refrigerant temperatures, or of air temperatures, or of a combination of such conditions, it is difficult to provide an expansion valve which will regulate the flow of refrigerant satisfactorily throughout the entire range. A thermostatic expansion valve sufficietly large to control the system during the heaviest refrigerant demand may provide poor regulation during low demands and produce "overshooting" and "hunting" so that the operation of the evaporator is irregular in the low demand range. Irregularities may be caused, for example, by the inability of the high capacity valve to move with sufficient precision to produce regular and proportionate flow of refrigerant at greatly reduced rates so that the valve upon opening may introduce too much liquid refrigerant which must then be compensated by closing the valve. It is obvious, for example, that a given lift or movement from the closed position of a large diameter valve provides a much greater flow cross section than the same movement in a small diameter valve. Accordingly, it is an object of my invention to provide a refrigerating system including an improved arrangement for insuring the maintenance of predetermined conditions in the evaporator over a wide range of operating conditions.

It is another object of my invention to provide a refrigerating system including a multiple conduit evaporator and an improved control for maintaining predetermined operating characteristics throughout a wide range of operating conditions and for insuring even distribution of the refrigerant among the several conduits.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention reference may be had to the accompanying drawings in which Fig. 1 represents diagrammatically an air cooling system including a refgrigerating machine embodying my invention; Fig. 2 is a sectional elevation view of the main expansion valve shown in Fig. 1; and Fig. 3 is an illustration similar to Fig. 1 showing another embodiment of my invention.

Briefly, the refrigerating system shown in the drawings comprises a refrigerant condensing unit, a multiple conduit evaporator, and an expansion valve provided with an arrangement for conducting equal amounts of refrigerant to each of the multiple conduits of the evaporator. A main thermostatic expansion valve is provided which supplies liquid refrigerant to a distributing header having connections for leading the refrigerant in equal quantities to the several evaporator conduits. In order to provide even distribution and control of the flow of refrigerant under conditions prevailing in the portion of the operating range in which there is the least refrigerant demand, a second valve having much smaller capacity is connected in parallel with the main valve to control the passage of a small amount of refrigerant from the condensing unit to the distributing header. Both valves are controlled, for example, to maintain substantially the same degree of superheat of the vaporized refrigerant withdrawn from the evaporator. The main valve provides correct control during normal and high refrigerant demands, and the small valve acting in parallel with the main valve cooperates with the main valve to extend the low demand range of the system by insuring evenly controlled refrigerant expansion at the lowest refrigerant requirements of the range. When the main valve is provided with an integrally constructed distributing header, the auxiliary valve may be connectel to supply refrigerant to the header chamber through one of the radial outlet connections, the remaining outlets being employed as the refrigerant distributing outlets.

Referring now to the drawings, the air cooling system illustrated in Fig. 1 comprises an air circulating duct 10 within which is arranged a multiple conduit evaporator 11. The evaporator 11 is supplied with refrigerant from a condensing unit comprising a compressor 12, a condenser 13, and a liquid receiver 14. The control of liquid refrigerant flowing from the receiver 14 to the evaporator 11 is accomplished through the operation of thermostatic expansion valves 15 and 16. A refrigerant distributor 17 is provided to supply the refrigerant in substantially equal quantities to a plurality of conduits 18 each connected to a separate conduit or pass of the evaporator 11. During the operation of the refrigerating system, liquid refrigerant within the evaporator 11 is vaporized by the absorption of heat from the air flowing through the duct 10, and the vaporized refrigerant is withdrawn from the evaporator 11 through a manifold 19 connected to the several multiple conduits of the evaporator and flows through a suction line 20 to the compressor 12. The vaporized refrigerant is compressed and discharged into the condenser 13 where it is cooled and liquefied and from which it flows to the liquid receiver 14. The liquid refrigerant is returned to the evaporator through the operation of valves 15 and 16 having thermal bulbs 23 and 24, respectively, both secured in heat exchange relation with the suction line 20 and responsive to the temperature of the vaporized refrigerant withdrawn from the evaporator. Valves 15 and 16 are also connected to be responsive to the pressure in the suction line through a so-called "equalizer conduit" 25 which is connected to pressure responsive elements in both valves.

The thermostatic expansion valve operates in accordance with the difference between forces produced by the pressure and by the temperature of the vaporized refrigerant withdrawn from the evaporator, the valve tending to open upon an increase in temperature and to close upon an increase in pressure. The differential action of the temperature and pressure responsive elements provides a measure of the superheat in the withdrawn vaporized refrigerant, and the valve, therefore, controls the operation of the system to maintain a predetermined substantially constant degree of superheat. This type of valve prevents the return of slugs of liquid refrigerant to the compressor.

An air conditioning system such as that illustrated may be required to operate over a wide range of conditions such as load, air temperature, and refrigerant temperature, and while a single thermostatic expansion valve may be sufficient to provide accurate control of the superheat over a limited range, difficulty may be encountered when it is attempted to extend the range, because the characteristics of the valve make it difficult to handle both high and low loads with equal precision of control. For example, the valve may upon opening introduce too much refrigerant for a required low refrigerant demand and the valve must then remain closed until sufficient refrigerant has been vaporized, and as a result the superheat of the vaporized refrigerant may vary cyclically instead of being maintained at a substantially constant value.

In order to extend the effective range of operating conditions of the refrigerating system within which the admission of refrigerant to the evaporator may be controlled accurately, the valve 16 is connected in parallel with the valve 15. The valve 16 is a relatively small capacity valve having smaller parts and which can accurately control the admission of small quantities of refrigerant to the evaporator in such manner as to maintain steady superheat conditions at minimum refrigerant demands. Valve 16 then operates to maintain the required superheat of the vaporized refrigerant at the outlet of the evaporator and this prevents operation of the high capacity valve 15 such that amounts of liquid refrigerant in excess of that required are not admitted to the evaporator. While the valve 16 operates throughout the entire range of operating conditions, its operation is effective to control the superheat of the withdrawn refrigerant substantially only when the system is operating under conditions resulting in refrigerant demands in the lowermost portion of the range. Liquid refrigerant flows from the receiver 14 through a liquid line 26 having a main branch 27 for conducting liquid refrigerant to the valve 15 and an auxiliary branch 28 for conducting the refrigerant to the valve 16. The expanded refrigerant flowing from the outlet of the valve 16 passes through a connection 29 to the refrigerant distributing header 17.

The construction of the main expansion valve 15 is shown in Fig. 2. This valve comprises a casing 30 closed by a block 31 constituting the distributor 17 and provided with a refrigerant distributing chamber 32. Liquid refrigerant from the line 27 flows to the chamber 32 through a valve opening controlled by a valve member 33. The operation of the valve 33 is dependent upon the amount of superheat in the refrigerant withdrawn through the suction line 20. In order to accomplish this operation a diaphragm 35 is provided in the valve, the lower side of the diaphragm being subject to the pressure of the withdrawn refrigerant and the upper side being subject to a pressure dependent upon the temperature of the withdrawn refrigerant. The lower side of the diaphragm is connected to the pressure conduit 25 through a fixture 36. The upper side of the valve is connected by a capillary tube 37 to receive the pressure dependent upon the temperature of the withdrawn refrigerant as determined by the thermal bulb 23 which is partially filled with a vaporizable liquid. The pressure of the vaporizable liquid is, of course, dependent upon the temperature of the suction line 20. It will be evident that this valve operates in the conventional manner so that it tends to open upon an increase in suction line temperature and to close upon an increase in evaporator pressure. The valve 16 is of similar construction but smaller and is not provided with the distributing header 17 but instead has a single outlet connected to the connection 29. The several evaporator inlet conduits 18 are placed in communication with the chamber 32 through radial outlets 38 in the block 31. In order that a single distributing header may be employed, one of the outlets 38, which has been indicated at 38a, is arranged to serve instead as an auxiliary for refrigerant flowing from the valve 16 through the connection 29. It will be noted that the valve 33 is actuated by movement of the diaphragm 35 transmitted through a valve operating rod 40. When the auxiliary inlet 38a is in operation, refrigerant entering the chamber from this inlet is directed against the valve stem 40 which minimizes any direct flow of refrigerant from the inlet **38a** into the one of the outlets **38** diametrically opposite. It has been found that under low load conditions refrigerant is substantially equally divided among the several conduits, even though the inlet **38a** enters the chamber **32** at right angles to the main inlet through the valve **33**. The arrangement of the valves **15** and **16** employing the single liquid distributor **17**, integrally formed with the valve **15**, provides a refrigerant distributing arrangement having a minimum number of parts and affording effective operation over a wide range of refrigerant demands. The valves **15** and **16** may be calibrated to provide operation of the system with predetermined desired characteristics; for example, the two valves may be arranged to maintain substantially the same number of degrees of superheat over the entire range of operating conditions of the system. Under other conditions of operation, it may be desirable to calibrate the valve **16** to maintain a lower amount of superheat than the valve **15** so that it may operate to control the flow of refrigerant through the evaporator although there is not sufficient superheat to operate the main valve **15**.

In Fig. 3, there is illustrated an arrangement similar to that of Fig. 1, and corresponding parts have been designated by the same numerals with the addition of the letter *a*. In this system, the distributing header **17a** is separate from the valve **15a**, the valve **15a** being of the same type as the valve **16a** and the valve **16** in that it is provided with a single outlet connection. The outlet connection of the valve **15a** communicates with the header **17a** through an outlet conduit **42**. Solenoid operated valves **43** and **44** are provided in the liquid lines **27a** and **28a**, respectively. Valve **43** is provided with a solneoid **45** controlled by a thermostat **46** in the duct **10a**. This thermostat is arranged to close when the temperature of the air flowing through the duct indicates that normal or heavy refrigerant demand conditions prevail. The valve **44** is controlled by a solenoid **47** operated by a thermostatic switch **48** which closes whenever there is a demand for cooling. It will, therefore, be evident that the valve **15a** is operated only when there is a refrigerant demand sufficient to require the larger valve. Obviously, control valves corresponding to the valves **43** and **44** may be employed also in the system of Fig. 1.

From the foregoing, it is apparent that I have provided a simple and effective arrangement making possible the operation of a refrigerating system over a wide range of loads or other conditions and which provides predetermined operating characteristics throughout the entire operating range.

While I have illustrated my invention in connection with an air conditioning system, other applications will readily be apparent to those skilled in the art. I do not, therefore, desire my invention to be limited to the particular arrangements shown and described, and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A refrigerating system including a refrigerant condensing unit and a refrigerant evaporator, a high capacity thermostatic expansion valve and a low capacity thermostatic expansion valve connected in parallel between said unit and said evaporator for controlling the flow of refrigerant to said evaporator throughout the operation of said system, each of said valves including an individual control element responsive to the temperature of the vaporized refrigerant withdrawn from said evaporator, both of said control elements being set to operate their respective valves independently for maintaining substantially the same predetermined amount of superheat of the vaporized refrigerant withdrawn from said evaporator, said low capacity valve acting to extend the range within which the operation of said evaporator may be controlled effectively to maintain said predetermined superheat beyond the range of effective control obtainable with said high capacity valve alone.

2. A refrigerating system including a refrigerant condensing unit and a refrigerant evaporator, said evaporator comprising a plurality of refrigerant conduits arranged in parallel, a liquid refrigerant distributing header having separate outlet connections for each of said conduits for dividing the liquid refrigerant equally among said conduits, a thermostatic expansion valve connected between said unit and said header for maintaining a predetermined amount of superheat of the vaporized refrigerant withdrawn from said evaporator during normal refrigerant demands on said system, and a relatively small capacity thermostatic expansion valve connected in parallel with said first mentioned valve for maintaining substantially said predetermined amount of superheat at low refrigerant demands on said system, said small capacity valve cooperating with said first mentioned valve to extend the effective range of operation of said system.

3. A refrigerating system including a refrigerant condensing unit and a refrigerant evaporator, said evaporator comprising a plurality of refrigerant conduits arranged in parallel, a thermostatic expansion valve of the type provided with an outlet chamber having a plurality of distributing outlets and a main inlet, said chamber also having an auxiliary inlet, means for connecting each of said conduits to a corresponding one of said outlets whereby refrigerant is divided equally among said conduits, a second expansion valve having a substantially lower capacity than that of said first mentioned valve and connected between said condensing unit and said auxiliary inlet whereby said second valve discharges refrigerant into said chamber and said valves are connected in parallel, and means for controlling said valves to maintain predetermined conditions within said evaporator over a desired range of operating conditions of said system.

4. A refrigerating system including a refrigerant condensing unit and a refrigerant evaporator, said evaporator comprising a plurality of refrigerant conduits arranged in parallel, a thermostatic expansion valve for maintaining a predetermined amount of superheat of the vaporized refrigerant withdrawn from said evaporating unit during normal refrigerant demand conditions, said valve being connected between said unit and said evaporator and including an outlet chamber having a plurality of outlets and a main inlet and an auxiliary inlet, means connecting said refrigerant conduits to corresponding ones of said outlets whereby refrigerant is distributed equally to said conduits, a second thermostatic expansion valve having a capacity relatively small with rerespect to that of said first mentioned valve and connected between said condensing unit and said outlet chamber through said auxiliary inlet for maintaining substantially the same amount of

superheat during low refrigerant demand conditions.

5. A refrigerating system including a refrigerant condensing unit, a refrigerant evaporator, a high capacity thermostatic expansion valve and a low capacity thermostatic expansion valve connected in parallel between said unit and said evaporator for controlling the flow of refrigerant to said evaporator throughout the operation of said system, each of said valves including an individual control element responsive to the temperature of the vaporized refrigerant withdrawn from said evaporator, both of said control elements being set to operate their respective valves independently for maintaining substantially the same predetermined amount of superheat of the vaporized refrigerant withdrawn from said evaporator, and means dependent upon the refrigerant demand on said system for preventing the operation of said high capacity expansion valve to control said system during the lower portion of the range of refrigerant demands on said system, said low capacity valve acting to extend the range within which the operation of said evaporator may be controlled effectively to maintain said predetermined superheat beyond the range of effective control obtainable with said high capacity valve alone.

WAYNE E. DODSON.