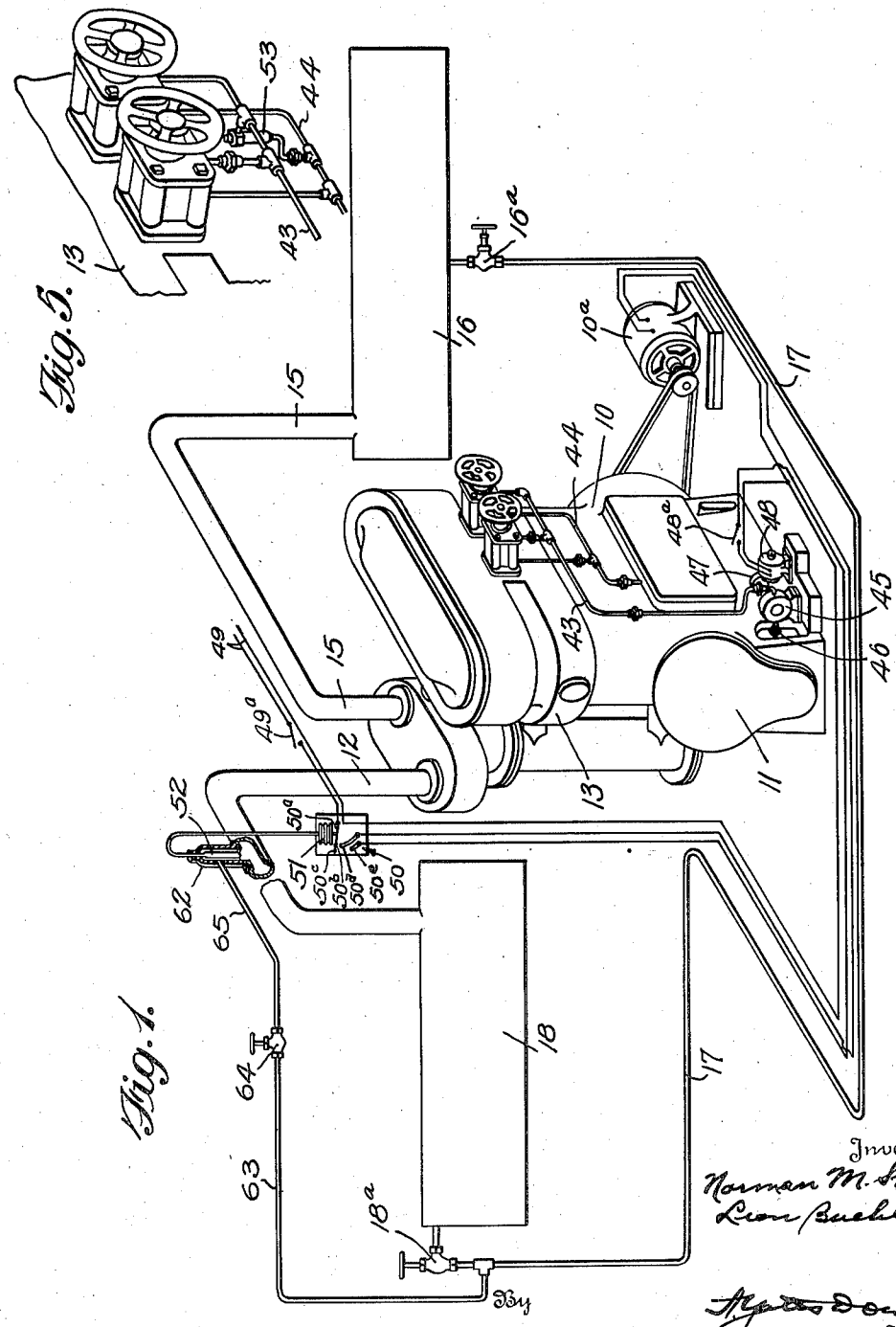
July 5, 1938. N. M. SMALL ET AL 2,123,123

REFRIGERATING SYSTEM CAPACITY CONTROL

Filed Jan. 16, 1937 2 Sheets-Sheet 1



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REFRIGERATING SYSTEM CAPACITY CONTROL

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Fig. 2.

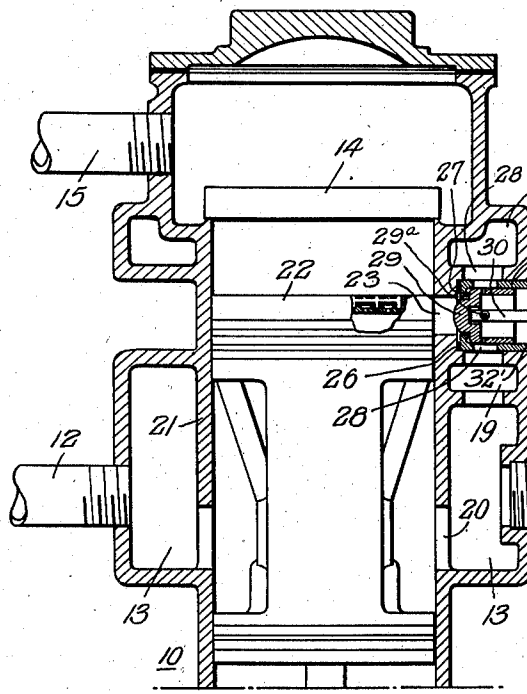
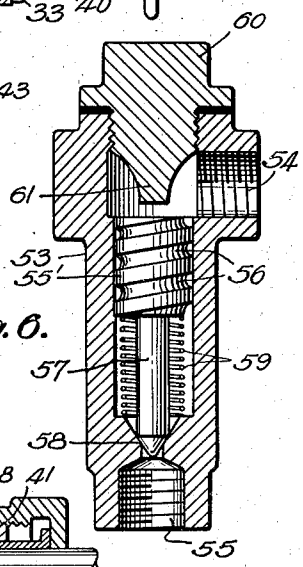


Fig. 6.



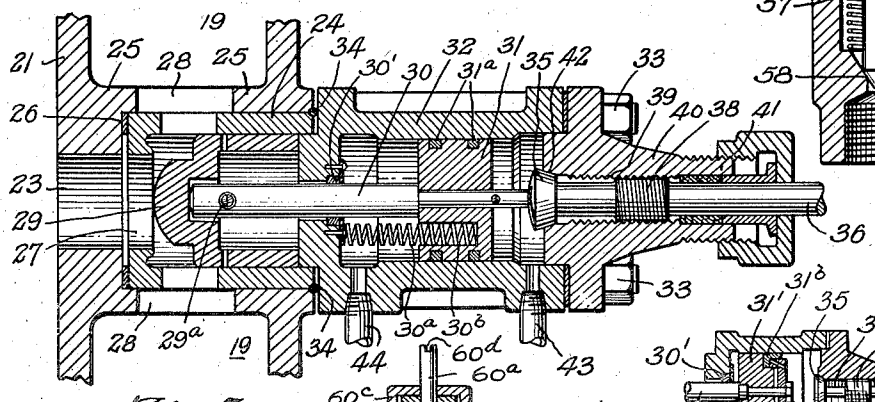


Fig. 3.

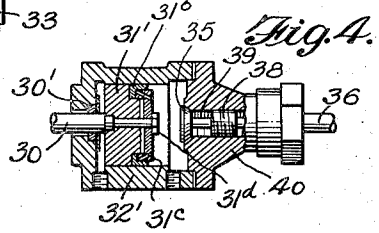


Fig. 4.

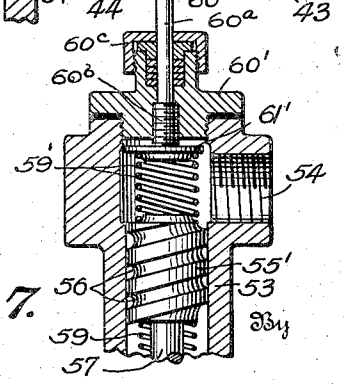


Fig. 7.

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UNITED STATES PATENT OFFICE

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REFRIGERATING SYSTEM CAPACITY CONTROL

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Application January 16, 1937, Serial No. 120,982

22 Claims. (Cl. 62—115)

This invention relates to refrigerating systems and more particularly to capacity control means for refrigerating compressors which are automatically operable in accordance with conditions in the refrigerating system.

In refrigerating plants it is common practice to provide a plurality of compressors wherein one or more of the compressors can be shut down during cool or cold seasons and thus reduce the refrigerating capacity of the compression side of the plant. However, owners frequently desire to have all the compressor capacity in a single unit with means for varying the volumetric displacement, and the present invention relates to this type of installation.

Capacity control using the method of reducing the effective stroke of the compressor by by-passing part of the gas in the cylinder between the piston and discharge valves to the suction side of the compressor is old in the art and is not claimed as a part of this invention.

The present invention relates particularly to capacity control for refrigerating compressors although it may be used to equal advantage for air compressors, gas compressors and other types of fluid compressors.

An object of the invention is to provide means whereby the volumetric displacement of a compressor can be controlled either by hand or by automatic means.

Another object of the invention is to provide improved means for varying the volumetric displacement of a compressor, said means being automatically controlled by highly sensitive temperature responsive means.

A further object of the invention is to provide in a refrigerating system means for operating compressor capacity control means in accordance with the true saturated temperature of refrigerant in the low side of the system which corresponds to the back pressure of the expanded gas regardless of what the superheat temperature of the expanded gas in the low side of the system may be.

Another object of the invention is to provide in a refrigerating system means for operating a compressor in accordance with temperature conditions of the system in conjunction with a further means of controlling the capacity of the compressor during its operation.

A further object of the invention is to provide a varying capacity compressor controlled by temperature responsive means in accordance with the load requirements of the system and in conjunction with capacity control means for varying the compression within predetermined limits.

Another object of the invention is to provide in a refrigerating system a capacity control means which operates on the compressor to change from full capacity to partial capacity in accordance with load requirements of the system, the compressor at no time being completely unloaded while operating.

Other objects, details and advantages of our invention will be apparent from the following description of the embodiments thereof shown in the accompanying drawings, wherein:

Figure 1 is a perspective view of a refrigerating system showing a compressor provided with capacity control means automatically operated by fluid pressure in accordance with this invention.

Figure 2 is a vertical sectional view through a compressor cylinder and one of the capacity control ports in connection with fluid pressure operating mechanism.

Figure 3 is a sectional view of a spring mounting for operating the capacity control valve during inoperativeness of the pressure control means.

Figure 4 is a sectional view of a modified form of the fluid pressure operating mechanism for the capacity control ports.

Figure 5 is a fragmentary perspective view showing a modified form of the fluid pressure return means.

Figure 6 is a detailed view of the pressure operative return means shown in Figure 5.

Figure 7 is a fragmentary sectional view showing a modification of part of the pressure operative return means shown in Figure 6.

Referring to the drawings this invention is shown by way of example in Figure 1 applied to a two cylinder compressor 10 driven by motor 10a. However, the invention is applicable to a single cylinder compressor or of any number of cylinders. In the arrangement shown the compressor is provided with a crank case 11, and a suction conduit 12 communicates with the compressor intake chamber 13. The compressor is provided with the usual discharge valves located in the valve head 14 in the cylinder head as shown in Figure 2 and compressed gases are conducted through a discharge line 15 leading to a condenser and receiver 16. From the receiver refrigerant fluid is conducted through a hand control valve 16a and conduit 17 to an evaporator 18 which may be a cooler of any desired type, an expansion valve 18a controlling the discharge of liquid refrigerant thereinto. The gaseous refrig-

erant is then returned from the evaporator to the compressor through the suction conduit 12.

As shown in Figure 2 each cylinder is provided with a chamber 19 extending upwardly from the intake chamber 13 towards the head of the compressor and the intake chamber 13 is shown provided with an inlet port 20 communicating with the interior of the compressor cylinder 21 beneath the piston 22 therein; this piston is provided with the suitable types of sealing rings and valves as indicated. In order to vary the compressor capacity a port 23 communicating through the wall of the cylinder 21 with chamber 19 is positioned to provide the required capacity reduction of the compressor. This port provides communication with the cylinder 21 above piston 22 with the chamber 19 so as to permit gas to flow from the cylinder therethrough into the suction chamber 13 and through the suction port 20 during a portion of the upward stroke of the piston. As indicated, piston 22 has moved upwardly to the upper edge of port 23 to close the communication with chamber 19 and on further upward movement it operates to compress the remaining gas in the compressor cylinder 21.

The distance the edge of the port 23 is located from the head of the compressor depends upon the amount of capacity reduction desired, for example, in Figure 2 it is located at fifty percent of the stroke of the piston which gives approximately fifty percent capacity reduction. If a greater capacity reduction is desired the upper edge of port 23 must be closer to the head of the compressor, and for a less capacity reduction the port must be lower in the cylinder. The position of the port in accordance with the required capacity reduction is preferably determined and fixed at the time the compressor is constructed.

As shown in Figure 3 a valve cage 24 is mounted in flanges 25 formed in chamber 19 and it extends through an aperture in the exterior wall thereof. The inner end of cage 24 seats on a gas tight gasket 26 between it and the compressor cylinder wall. Cage 24 is provided with a port 27 communicating with port 23 into the interior of the cylinder and ports 28 communicating with chamber 19 which ports provide passageways through which gas may be permitted to flow as stated above. This cage 24 acts as a guide for a valve 29 slidingly mounted therein and which is operable to close the passageway into the compressor cylinder, thus causing the compressor to operate under full capacity.

As shown valve 29 is held in open position by a plunger 30 connected to the valve by the pin 29*a* and extending from a differentially pressure actuated piston 31 slidingly mounted in an operating cylinder casing 32 which is secured by means of bolts 33 to the outer wall of chamber 19 with a gasket 34 of circular cross section between the end of the cylinder member 32 and the wall of the chamber. This gasket forms a gas tight seal and permits easier alignment of the cylinder with the valve cage chamber for the valve 29. Piston 31 may be held in the valve closing position by the engagement of the head 35 on a stem 36 which is provided with manual operating hand wheel 37.

Hand wheel stem 36 is provided with threads 38 engaging corresponding threads 39 in a cylinder closing head 40, and the outer end of head 40 is provided with a packing member 41. It will be noted that when hand wheel 37 is turned to disengage the head 35 from piston 31 and is moved outwardly therefrom the rear of the head 35 which has a seating surface makes contact with a complementary seat 42 formed in head 40 making a gas tight joint therewith whereby the packing element 41 may be inserted or removed.

When hand wheel stem 36 is turned to disengage the head 35 from piston 31 and the pressure operating means is released the spring members 30*a* positioned between the piston 31 and end wall 32' hold the valve open and displace the fluid when the pressure supply is discontinued. Preferably these springs are placed in a recess 30*b* at angles of 120° about the plunger 30 to obtain a more even distribution of force in opening the valve 29.

Referring to Fig. 4 an operating cylinder casing 32', of the same construction as shown in Fig. 3, is shown with a modified form of a differentially pressure actuated piston 31' and other slight changes; with the exception of these modifications, the parts are the same as those illustrated in Figure 3 but the stem 36 is shown in its outer position with the head 35 seated in the seating surface in head 40 are previously described. In this structure piston 31' is provided with a piston packing 31*b*, in the form of a molded cup packing instead of piston rings 31*a* such as provided for piston 31. This cup packing is secured to piston by means of a cup retainer 31*c*. This in turn is held in place by a nut 31*d* on the end of plunger 30 extending through piston 31' which also maintains piston elements assembled on this plunger. The casing 32' is also provided with a closure seal 30' surrounding plunger 30 which seal as shown includes a flexible packing ring and a retainer ring cooperating therewith and may be secured to the end wall of casing 32' by means of screws or the like shown in Figure 2. The spring members 30*a* in indentations or recesses 30*b* as shown in Figures 2 and 3, positioned by piston 31 against wall end 32' of fluid chamber 32, are not included in this view as the compression pressure may serve to hold the valve in open position, though preferably the spring members are to be used.

It will be noted in the foregoing valve equipment, which is a preferred construction although other forms can be employed for the purpose of this invention, that with the hand control moved to the extreme inward position from that shown in Figures 2 and 3 the valve 29 closes port 23 for the full volumetric capacity of the compressor, but when the hand wheel is in the position shown in Figures 2 and 3 the valve 29 will be forced to an open position by the compression in the cylinder and the springs 30*a* compressed by piston 31 in its cylinder casing 32, the springs 30*a* maintaining the valve open during inoperation of either the compressing fluid or the hand valve. Cylinder 32 is also provided with a fluid return conduit 44 as shown in Figure 1 and Figure 5 to conduct the seepage or pressure fluid to the source of fluid supply which in this case is the compressor crank case, although any suitable source of fluid supply may be employed other than the crank case if desired. The fluid conduits 43 of the cylinders 32 are interconnected and coupled with a fluid pump 45 which has a supply conduit 46 leading to it from the source of fluid supply,—as shown the crank case 11 of the compressor.

Fluid pump 45 is shown operatively connected by means of a coupling 47 with an electric motor 48 and the compressor 10 is shown operatively connected with an electric motor 10*a*, which motors 10*a* and 48 receive their operating current from a suitable source of electric power supply indicated by electrical conductors 49 having a

positive cut-out switch 49a and the thermostatically actuated switch 50 in the circuit for controlling the current flow.

The switch 49a is placed in the power supply line to render the switch 50 inoperative when no power supply to the electric motors is desired. In the power supply line between the switch control 50 and fluid motor 48 is placed the switch 48a which may be used to cut out the power supplied to the fluid motor when the compressor is desired to be operated at full capacity by mechanical closure of the outlet ports in the cylinder wall, or if the compressor is to be operated at a capacity less than full, by allowing the port to remain open and the closure means inoperative. While the switch 49a and 48a are manually operable any substitution of an automatic or mechanically actuated switch means could obviously be used for cutting in or out the power supply.

Switch 50 controlling the operation of the motors 48 and 10a is actuated by a bellows 51 which may be controlled by temperature or pressure conditions directly or indirectly of a storage room, or any part of a plant in which the temperature or pressure is to be maintained within close limits. As shown in Figure 1 this bellows is controlled by a thermal element 52 cooperating with suction conduit 12 of the compressor.

In this arrangement of switch control 50 the operation of the electric driving motors 48 and 10a are automatically controlled so that their cutting in and out is in accordance with the temperature of the refrigerant in the suction line. The bellows 51 actuates the switch arm 50a on which are contact points 50b and 50c properly insulated from one another and adapted to have sliding engagement with the contact points 50d and 50c for controlling the electric motors 10a and 48 respectively. The operation of the electric motors is in accordance with the load requirements of the system and the switch contact is arranged to operate the motors in accordance with the required conditions of the system.

When a system is required to operate at full capacity bellows 51 is expanded to engage the contacts 50b and 50c with 50d and 50e respectively, the contact 50d controlling the compressor motor 10a, the contact 50e controlling the fluid motor 48. When the compressor is adapted to be operated at a reduced capacity the bellows 51 is contracted to disengage the contact 50c from 50e controlling the fluid motor 48. The contact 50b remains in engagement with the contact 50d controlling the operation of motor 10a and allowing it to complete the compression desired at half capacity until at such time that when sufficient refrigeration is produced the compressor motor control switch is disengaged to interrupt the current supply. If desired the control of the capacity and the operation of the compressor may be produced by individual thermostats situated at different points in the system as the particular situation demands.

The operation of the motor driven pump 48 is automatically controlled so that its operation is in accordance with the temperature or pressure of the refrigerant in the suction line, and in accordance with the conditions required the piston 31 is operated to close port 23 by valve 29 without using the hand control wheel 37, the hand control wheel being operated to its outermost position to allow piston 31 to reciprocate in its cylinder for the automatic operation thereof. Thus the automatic operation of the compressor will take place irrespective of atmospheric conditions such as temperature and humidity or pressure which normally have a decided effect on the compressor capacity, and the compressor will operate at full discharge capacity or at its intermediate discharge capacity in accordance with the refrigerating requirements within the system and which may be determined by temperature or pressure.

Accordingly in the operation of the control mechanism when the temperature drops below a predetermined point the switch opens and breaks the current to motor 48 thereby stopping it. The fluid supply is consequently stopped and the fluid in the piston cylinder is released through conduits 43, returning directly back to its source of supply. This allows the springs 30a aided by the compressor to force valves 29 to open position and consequently unload the compressor to the predetermined degree (fifty per cent or in accordance with the position of port 22 with respect to the compressor cylinder head) through the various ports back to the suction of the compressor.

A modified pressure relief connection particularly applicable when a fluid pressure pump is used which is inapt for return of fluid therethrough is shown in Figure 5 for the return of fluid through conduit 44 to its source by means of valve 53 which is placed in the by-pass between the pressure supply source conduit and the relief conduit 44. Check valve 53 is closed by fluid pressure in the conduit 43. This valve as shown in Figure 6 comprises a casing which includes an inlet port 54 and outlet port 55 which ports are connected to conduits 43 and 44 respectively. Inside the casing is a reciprocable valve member 55' having an elongated spirally grooved passageway 56 extending from its upper face to the lower portion thereof whereby fluid may escape from the inlet or high pressure side to the outlet or low pressure side when the pump is inoperative. This valve member has a plunger 57, the end of which seats in a valve seat 58 in the casing, and a spring 59 therein tends to force the valve upwardly to open the port through valve seat 58. In the upper portion of the valve casing is an abutment member 60 having a projection 61 thereon within the casing against which the movable valve member 55' is adapted to engage when forced upwardly by the spring 59. The position of the projection 61 in the valve casing determines the upper limit of the movement of valve member 55'.

A check valve 53 with modifications is shown in Figure 7. Due to inequalities of tension of spring 59, a compensating spring 59' is positioned above valve member 55' and in this arrangement the abutment member 60 with its projection are replaced by a head 60' threaded into the check valve casing in place of the member 60. This head carries a stem 60a having a threaded engagement therewith at 60b and a packing member 60c forms a fluid tight seal around stem 60a. Stem 60a has an enlarged spring engaging member 61' on its inner end for engaging spring 59' and its upper end is formed for receiving an operating tool such as a kerf 60d for receiving the blade of a screw driver. By turning stem 60a in or out tension on spring 59' may be varied and by such adjustment compensation for inequalities of spring 59 is provided.

When the temperature rises switch 50 is automatically closed, starting motor 48 so that pump

45 is operated to start the circulation of fluid through conduit 43 to the cylinders of piston 31. This puts pressure through the branch conduits 43 leading to the piston chambers for each compressor cylinder and against the pistons 31 which are forced inwardly compressing the springs 30a and closing the ports 23 by engagement of the valves 29 therewith, the compressor then operates at full capacity. When the check valve 53 connection is used valve member 55' is closed against the spring 59 by the fluid pressure on account of the resistance of the fluid passing through the valve. This in turn puts pressure through the branch conduits 43 leading to the piston chambers for operation of the valves as heretofore described.

Referring again to the thermal element 52 which cooperates with suction line 12 of the compressor, it will be noted that this element is preferably positioned in a small chamber 62 which is closed at its upper end where the thermostatic bulb screws into it but is in open communication at its lower end with the suction line. A small liquid refrigerant line 63 conducting refrigerant from receiver 16, shown connected with conduit 17, connected with an expansion valve 64 which in turn discharges through a connecting pipe 65 into chamber 62 around thermal element 52.

It will be noted that with valve 64 fluid refrigerant is discharged and expanded into this chamber surrounding the thermal bulb. This is for the purpose of giving a saturated temperature around the bulb regardless what the superheat temperature may be in the suction line itself. Accordingly, a true saturated temperature corresponding to the back pressure is obtained because the temperature of the gas expanded must correspond to the back pressure in the suction line, and this true saturated temperature is obtained because the gas so expanded does not mix with the superheated gas until it passes down to the suction line. However when valve 64 is closed the capacity control of the refrigerating system will operate in accordance with the temperature of the gas in the suction line from the evaporator instead of the saturated gas temperature. Thus the system may be operated under either condition by operating with valve 64 opened or closed as desired.

This application is a continuation in part of our copending application now Patent No. 2,112,791.

It will be obvious to those skilled in the art that various changes may be made in my device without departing from the spirit of the invention and therefore we do not limit ourselves to what is shown in the drawings and described in the specification but only as indicated in the appended claims.

We claim:

1. A refrigerating system including a compressor, an evaporator and suction line for returning refrigerant from the evaporator to the compressor and capacity control means for controlling the effective volumetric displacement of the compressor for varying the effective refrigerating capacity of the system, and means for controlling said capacity control means and for controlling said system in accordance with refrigerant temperature on the low side of the system.

2. In a refrigerating system, a compressor including a compression cylinder and piston therein, capacity control means for varying the refrigerating capacity of the system, comprising a port in the cylinder wall and a valve for closing said port, a pressure actuated piston for operating said valve, temperature responsive means for operating said valve and piston to close the port and to permit the valve to open, manual control means for closing said valve, and spring means for opening said valve during inoperation of the closing means.

3. In a refrigerating system, a compressor including a compression cylinder and piston therein, capacity control means including a housing for controlling the volumetric displacement of the compressor for varying the refrigerating capacity of the system comprising a port in the cylinder wall and a valve biased into open position for closing said port, manual control means for closing said valve including a stem movable inwardly to and outwardly from its valve closing position, a head on the end of said stem having a valve seat on one side, a packer in said housing through which said stem operates, and said housing having a cooperating valve seat adapted to be engaged by said stem head valve seat and forming a seal therewith when the stem is in its outermost position.

4. In a refrigerating system, a compressor including a compression cylinder and piston therein, capacity control means controlling the volumetric displacement of the compressor for varying the refrigerating capacity of the system comprising a port in the cylinder wall and a valve for closing said port, a ported cylinder in which said valve is slidingly mounted, a piston reciprocably mounted behind said valve and having means interconnecting it and said valve to operate the latter to its open or closed position, a source of fluid supply, a pump for supplying said fluid behind said piston for closing said valve, a conductor for returning fluid therefrom to said source of supply, and a check valve therein operable to return the fluid therethrough to the source of fluid supply when said pump is inoperative.

5. In a refrigerating system, a compressor, capacity control means for varying the refrigerating capacity of the compressor, a fluid supply source, means for placing the fluid under pressure for operating said capacity control means to cause the refrigerating system to operate at full capacity, manually operable electrical means for controlling the effectiveness of said capacity control means independently of the system operation, a conductor for returning fluid therefrom to said source of supply, and a check valve therein operable to return the fluid therethrough to the fluid supply source when said fluid pressure means is inoperative.

6. In a refrigerating system, including a compressor with fluid pressure operated capacity control means, a source of fluid supply and means for supplying fluid therefrom under pressure to said pressure operated control means, a conductor for returning fluid from said control means to said source of supply, and a check valve therein for unloading the operating fluid therethrough comprising a valve casing having a cylindrical interior and inlet and outlet ports at opposite ends thereof, a valve member therein operable to close the communication with the outlet port, said valve including a piston portion slidable in said casing, a spring under said valve member, tending to move it from its closing position, and said piston portion having a restricted spiral passageway therethrough permitting the passage of fluid when the pressure of the fluid is reduced.

7. In a refrigerating system including a com-

pressor with fluid pressure operated capacity control means, a source of fluid supply and means for supplying fluid therefrom under pressure to said pressure operated control means, manually operable electrical means for controlling the effectiveness of said capacity control means independently of the system operation, a conductor for returning fluid from said control means to said source of supply, and a check valve therein for unloading the operating fluid therethrough comprising a valve casing having a cylindrical interior and inlet and outlet ports at opposite ends thereof, a valve member therein operable to close the communication with the outlet port, said valve including a piston portion slidable in said casing, a spring under said valve member tending to move it from its closing position, a spring over said valve tending to move in the reverse direction, means for adjusting the tension of the last said spring, and said piston portion having a restricted passageway therethrough permitting the passage of fluid therethrough when the pressure of the fluid is reduced.

8. In a compressor condenser evaporator system an unloading mechanism for the compressor, temperature responsive means controlling said unloader and for controlling said system, said temperature responsive means being constructed and arranged for actuation in accordance with the temperature corresponding to the pressure within the said evaporator.

9. In a refrigerating system a compressor, a condenser and an evaporator connected in a closed circuit and in the order named, an unloading device for said compressor, a control for said unloading device, a by-pass connected in the circuit parallel to and short-circuiting the evaporator, a thermostat in functional relation to said by-pass for selectively actuating said control or the system.

10. A compression refrigeration system having a variable capacity compressor, a motor for driving said compressor, means for controlling the capacity of the compressor including an unloader, means for stopping and starting operation of the system, and common thermostatic means for actuating both the compressor capacity control and said last named means.

11. In a compressor condenser evaporator system an unloading mechanism for the compressor, temperature responsive means controlling said unloader and for controlling said system, said temperature responsive means being located outside of said evaporator and constructed and arranged for actuation in accordance with the temperature corresponding to the pressure within the said evaporator.

12. In a compressor condenser evaporator system an unloading mechanism for the compressor, means controlling said unloader including a temperature responsive element, said temperature responsive element being constructed and arranged for actuation in accordance with the temperature corresponding to the pressure within said evaporator, and thermostatic means including said element for stopping and starting said system.

13. In a refrigeration system having a compressor, condenser and evaporator, an unloading mechanism for the compressor, means controlling said unloader including a temperature responsive element, means remote from said evaporator but responsive to pressure conditions interiorly of said evaporator, said temperature responsive element being located outside said evaporator in said last named means but constructed and arranged for actuation in accordance with the temperature corresponding to the pressure within the said evaporator, and thermostatic means including said temperature responsive element for stopping and starting said system and selectively rendering said unloader control effective or ineffective.

14. In a compressor condenser evaporator system an unloading mechanism for the compressor, temperature responsive means controlling said unloader, said temperature responsive means being constructed and arranged for actuation in accordance with the temperature corresponding to the pressure within the said evaporator, and means for stopping and starting said system, said last named means being responsive to said temperature responsive means.

15. In a compressor condenser evaporator system an unloading mechanism for the compressor, temperature responsive means controlling said unloader, said temperature responsive means being located outside of said evaporator and constructed and arranged for actuation in accordance with the temperature corresponding to the pressure within the said evaporator, and means for stopping and starting said system, said last named means being responsive to said temperature responsive means.

16. In a refrigerating system a compressor, a condenser and an evaporator connected in a closed circuit and in the order named, an unloading device for said compressor, a control for said unloading device, a by-pass connected in the circuit parallel to and short-circuiting the evaporator, a thermostat in functional relation to said by-pass for actuating said control, and thermostatic means for stopping and starting said system.

17. In a refrigerating system a compressor, a condenser and an evaporator connected in a closed circuit and in the order named, an unloading device for said compressor, a control for said unloading device, a by-pass connected in the circuit parallel to and short-circuiting the evaporator, a thermostat in functional relation to said by-pass for actuating said control, and means for stopping and starting said system, said last named means being responsive to said thermostat.

18. A compression refrigeration system having a variable capacity compressor, a motor for driving said compressor, means for controlling the capacity of the compressor including an unloader, means for stopping and starting operation of the system, and single thermostatic means for actuating both the compressor capacity control and said last named means.

19. A compressor condenser evaporator system, an unloader for said compressor, manual means for operating said unloader, fluid pressure means for operating said unloader, a circulating pump for causing an under pressure to operate said unloader, and means for controlling said circulating pump.

20. A compressor condenser evaporator system, an unloader for said compressor, manual means for operating said unloader, fluid pressure means for operating said unloader, a circulating pump for causing fluid under pressure to operate said unloader, and thermostatic means for controlling said circulating pump.

21. A compressor condenser evaporator system, an unloader for said compressor, manual means for operating said unloader, fluid pressure

means including a fluid circulating pump for operating said unloader, means for controlling said circulating pump, and thermosatic means for starting and stopping said system.

22. A compressor condenser evaporator system, an unloader for said compressor, manual means for operating said unloader, fluid pressure means including a fluid circulating pump for operating said unloader, means for controlling said circulating pump, and single thermostatic means for starting and stopping said system and for controlling said circulating pump.

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