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2,154,136

FLUID CIRCULATION SYSTEM

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Fig. 1.

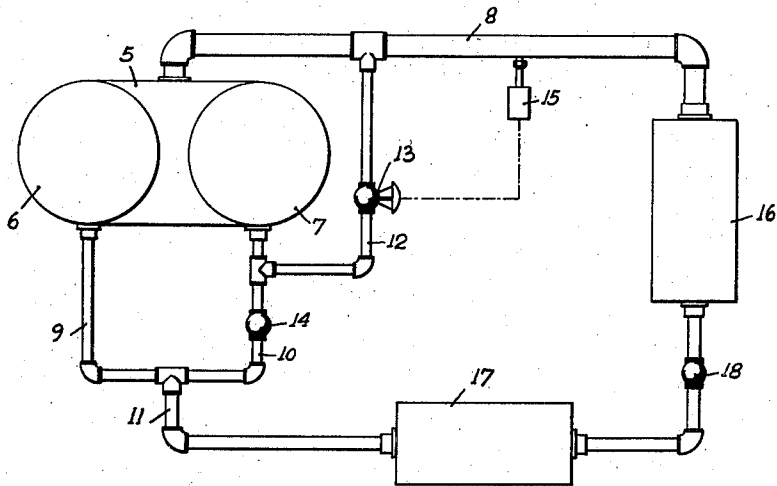


Fig. 2.

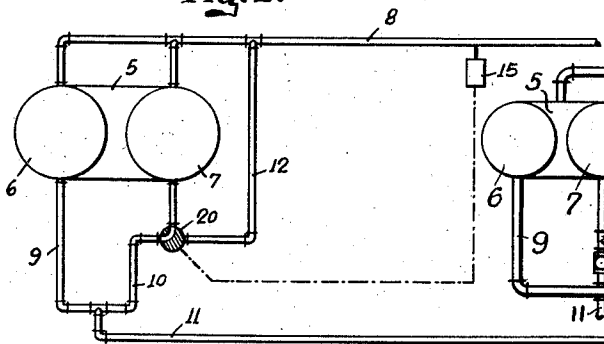


Fig. 4.

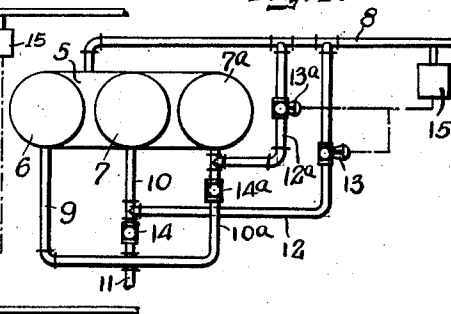
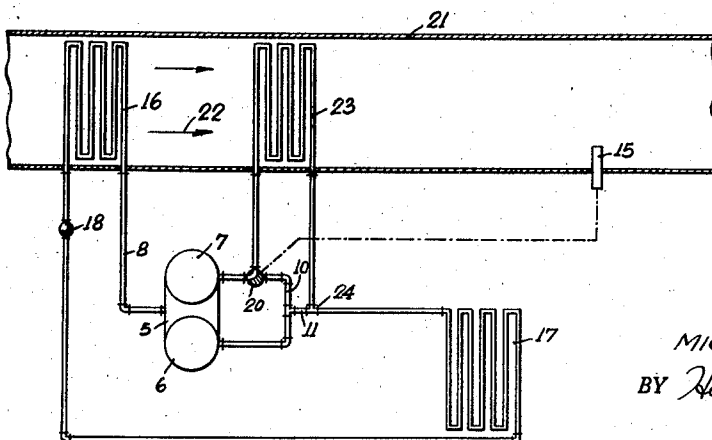


Fig. 3.



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FLUID CIRCULATION SYSTEM

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7 Claims. (Cl. 62-115)

This invention relates to fluid circulation, and more particularly to the flow of fluid through refrigerating systems.

The general object of the invention is to provide an improved method of and means for controlling the capacity of fluid compressors.

Another object of the invention is to provide for the reduction of the capacity of a compressor in such manner that the power input to the compressor is correspondingly reduced.

In the past, various devices and methods have been devised for reducing compressor capacity. However, they have quite generally proven unsatisfactory, either because of high cost, unreliability, or the setting up of inefficient operating conditions.

It is another object of the invention to provide a system of compressor capacity control which is inexpensive and reliable, and which results in efficient operating conditions, thus overcoming the shortcomings of devices heretofore known.

It is another object of the invention to provide a system of compressor capacity control which may be applied to the various cylinders of a multi-cylinder compressor and/or to a plurality of compressors operating in parallel arrangement.

A feature of the invention resides in reducing the capacity of a multi-cylinder compressor by recirculating through the compressor gas passing from one or more cylinders of the compressor, while gas passing from the remaining cylinder or cylinders is disposed of in the normal way. The cylinders or compressors from which gas is recirculated cease to deliver high pressure gas to the discharge reservoir of the apparatus, but deliver gas at the suction pressure of the apparatus. These cylinders, therefore, do no work of compression. Accordingly, the power consumption of the entire apparatus varies very nearly in proportion to the number of cylinders functioning in the normal way. Thus, for example, if one cylinder of a two cylinder compressor is cut out of service (that is, if fluid from one cylinder is recirculated through the compressor), the power necessary to drive the compressor will approximate one-half of the power required when both of the cylinders are operating in the normal manner.

Another feature of the invention resides in the provision of means for preventing the recirculation to the compressor intake of high pressure gas delivered by a cylinder operating in the normal way, while low pressure gas delivered by another cylinder is returned to the compressor intake.

Another feature of the invention resides in automatically controlling the reduction of the capacity of a compressor. The control means may operate responsive to variations in the pressure or temperature of fluid supplied to the compressor, or in any other suitable manner.

Other objects, features and advantages of the invention will be more apparent from the following description to be read in connection with the accompanying drawing in which:

Fig. 1 illustrates a mechanical refrigeration system embodying the invention;

Fig. 2 illustrates a modification of the invention;

Fig. 3 illustrates a further modification of the invention; and

Fig. 4 illustrates a modified embodiment of the invention.

Referring now to the drawing, 5 designates a compressor having cylinders 6 and 7. A suction line 8 provides communication between the compressor 5 and the evaporator 16 of a refrigeration system including the compressor 5, condenser 17 and expansion valve 18. Fluid passing from cylinder 6 flows through pipe 9, and fluid passing from cylinder 7 flows through pipe 10. Pipes 9 and 10 communicate with line 11, leading to the condenser 17. A bypass line 12 connects pipe 10 and suction line 8. Bypass line 12 is provided with a valve 13. Pipe 10 is provided with a check valve 14, disposed beyond the connection of bypass line 12 in the line of normal fluid flow. Check valve 14 permits fluid to pass from cylinder 7 to line 11, but does not permit flow in a reverse direction.

Under normal load conditions, suction gas passes into cylinders 6 and 7 through suction line 8 and is discharged alternately into discharge lines 9 and 10, whence it passes to the condenser 17 through line 11. Under such conditions stop valve 13 in bypass line 12 is closed; check valve 14 offers no appreciable resistance to flow of gas through pipe 10 to line 11; and the operation of the apparatus is that of a conventional two-cylinder compressor.

When the load on the refrigerating system is reduced, the gas pressure in suction line 8 falls. When the pressure has reached a predetermined low point, pressurestat 15 in suction line 8 causes valve 13 to open, thus providing a free path for the gas discharged by each compression stroke of cylinder 7 to return to suction line 8. Check valve 14, by its self closing action, prevents high pressure gas from discharge lines 9 and 11 from entering bypass line 12.

Under low-load operating conditions, only cylinder 6 compresses gas from the suction pressure prevailing in line 8 to the condenser pressure prevailing in discharge lines 9 and 11. While gas is drawn into cylinder 7 and is delivered therefrom at approximately the normal rate of displacement of the cylinder 7, this gas is displaced at approximately the suction pressure prevailing in suction line 8. The cylinder 7 does practically no compression and therefore requires practically no power for its operation. Thus, while the capacity of the compression apparatus has been reduced by one-half, the power input has also been reduced to approximately the same extent, or in direct proportion to the reduction in compressor capacity.

It will be observed that the recirculated gas is supplied to the feed line which serves both of the cylinders of the compressor. Thus the same gas is not continuously recirculated, as would be the case if the gas discharged from a cylinder were re-supplied to that cylinder only. Accordingly, excessive heating of the compressor, which would result from the continuous recirculation of the same gas, is avoided.

Although valve 13 is illustrated and described as being under the control of pressurestat 15, applicant does not restrict himself to this type of control. Valve 13 may be controlled manually, by a thermostat responsive to the suction temperature of the fluid to be compressed, by a thermostat responsive to temperatures created by the evaporator 16, or in any other suitable manner.

Although this description has been directed to a two cylinder compressor, it is to be understood that the invention may be used in connection with a compressor having three or more cylinders. In such case, two or more bypass lines 12 would be used, the valves in the different bypass lines operating successively to unload different cylinders of the compressor. Such an arrangement is illustrated in Fig. 4, in which a third cylinder designated 7a, is provided. Cylinder 7a is provided with a discharge line 10a, bypass line 12a, valve 13a and check valve 14a, respectively similar to the elements 10, 12, 13 and 14 associated with cylinder 7. The valves 13 and 13a operate successively, so that under different operating conditions different numbers of the cylinders will be functioning in the normal manner. Irrespective of the number of cylinders, the power input to the compressor will vary approximately in proportion to the actual work of compression done by the active cylinders. If it is desired to completely unload the compressor without interrupting the operation of the compressor driving means, each cylinder of the compressor may have a by-pass line associated therewith.

By the provision of by-pass lines and valves corresponding to elements 12, 13 and 14, the capacity of compressor apparatus comprising two or more compressors operating in parallel arrangement may be varied in accordance with load requirements.

In the modification of the invention illustrated in Fig. 2, valves 13 and 14 are replaced by a three way valve 20. Valve 20 is controlled by instrument 15 in substantially the same way that valve 13 of Fig. 1 is controlled by instrument 15. Valve 20 operates to discharge fluid passing from cylinder 7 into pipe 12 or into pipe 10. When the valve delivers fluid from cylinder 7 to pipe 12, it also prevents high pressure fluid from lines 9, 10

and 11 from entering into pipe 12. When valve 20 delivers fluid from cylinder 7 to pipes 10 and 11, it effectively prevents flow through pipe 12.

In operating air conditioning systems, it is sometimes desirable to cool or to cool and dehumidify air and then to reheat the air before supplying it to the enclosure served by the system. Such operation is frequently adopted where precise control of relative humidity is important. In the modification of the invention illustrated in Fig. 3, applicant provides a method of and a system for reheating cooled air by heat exchange with hot gases passing from a refrigerant compressor. In Fig. 3, air drawn through casing 21 in the direction indicated by the arrows 22, passes in contact with, and is cooled by, evaporator coils 16 of a refrigerating system. Refrigerant gas is drawn from the evaporator coils 16 and is delivered to the compressor 5 through suction line 8. Line 10, leading from the discharge side of compressor cylinder 7 is provided with a three way valve 20, corresponding to the valve 20 of Fig. 2. If desired, the stop valve and check valve arrangement of Fig. 1 may be substituted for the three way valve 20. As in Fig. 2, the valve 20 is under the control of a suitable control instrument 15. This may, for example, be a hygrostat or thermostat in the air stream, or in the enclosure served by the conditioning system, or any other instrument positioned at any point in the air conditioning system, or in the enclosure served by the system. Under certain operating conditions the valve 20 will cause fluid from cylinder 7 to pass to pipe 11 and thence to condenser 17. However, if the relative humidity of the air in the casing or in the enclosure is too high, or its temperature is too low, control instrument 15 will cause valve 20 to change its position so that fluid discharged from cylinder 7, instead of passing directly through pipes 10 and 11, will be routed through reheating coils 23. Since the refrigerant passing from the cylinder 7 is at a relatively high temperature, it is a satisfactory reheating medium. Fluid from heating coils 23 is returned to the main circuit at 24 and is then passed through the condenser in the normal manner. Although heating coils 23, as illustrated, receive fluid from only cylinder 7, it is apparent that fluid from both of the cylinders may be routed therethrough, if desired. The passage of gas from the different cylinders to the heating coils may be controlled by the same control instrument, or by different control instruments; and in the latter case the instruments may have the same or different settings. This system provides efficient and effective reheating without any increase in the cost of operating the system, and at comparatively small initial expense.

While the invention has been described in conjunction with a refrigerating system, it is to be understood that its application is not restricted thereto, but that the invention may be used in a great variety of ways. It may, for example, be used in conjunction with liquid pumping systems, gas engines and other types of displacement apparatus.

The term "compressor element" in the claims shall be understood to refer to individual cylinders or the like of compressors, pumps or other displacement apparatus, and also to complete assemblages of compressors, pumps or displacement apparatus. Applicant does not restrict himself to compressors, pumps, or displacement apparatus of any particular type, and these may

be of the reciprocating, centrifugal or any other desired type.

Since many modifications may be made in the invention without departing from its scope, it is to be understood that the above description and accompanying drawing shall be interpreted as illustrative only, and not in a limiting sense, applicant limiting himself only as indicated in the accompanying claims.

I claim:

1. In a refrigerating system of the character described, in combination a plurality of compressor elements in parallel, feed means for supplying fluid to the elements, a plurality of discharge pipes for receiving fluid discharged by the compressor elements, a by-pass line connecting the feed means and at least one of the discharge pipes, a valve for controlling the flow of fluid through said by-pass line, said valve being normally closed, means for opening said valve whenever the load on said apparatus falls below a predetermined point, and means for preventing the flow of fluid from another of the discharge pipes to said by-pass line.

2. In a refrigerating system of the character described, in combination a plurality of compressor elements in parallel, feed means for supplying fluid to said elements, a plurality of discharge pipes for receiving fluid discharged from said elements, and means for recirculating to said feed means from said discharge pipes fluid discharged from different numbers of said elements under different operating conditions, said recirculating means being adapted to recirculate to said feed means fluid from a relatively large number of discharge pipes in response to a relatively low load on said apparatus and to recirculate fluid from a lesser number of said discharge pipes in response to a relatively higher load on said apparatus.

3. In a refrigerating system of the character described, a plurality of compressor elements connected in parallel arrangement, feed means for supplying fluid to said elements, means for receiving fluid discharged by said elements, and means for recirculating through at least one of said elements fluid discharged by at least one of said elements in response to decrease of the fluid pressure in said feed means below a predetermined point while delivering fluid discharged from at least another of the elements from the compressor in normal manner.

4. In a refrigerating system of the character described, a plurality of compressor elements connected in parallel arrangement, feed means for supplying fluid to said elements, means for

receiving fluid discharged by said elements, means for recirculating through at least one of said elements fluid discharged by at least one of said elements whenever the fluid temperature in said feed means falls below a predetermined point, and means for preventing recirculation through said compressor of fluid discharged from at least another of said elements.

5. In a refrigerating system of the character described, in combination, compressor apparatus including a plurality of compressor elements, said elements being connected in parallel arrangement, feed means for supplying fluid to said apparatus, means for discharging fluid from said elements, means for delivering fluid discharged from at least one of said elements to the suction side of at least one of said elements in response to decrease of the load on the apparatus below a predetermined point, and means for directly discharging from said compressor apparatus fluid discharged from at least one of said elements.

6. The combination with a refrigerating system including an evaporator and a condenser, of a compressor apparatus including a plurality of compressor elements in parallel arrangement, feed means for supplying evaporated refrigerant from said evaporator to said compressor apparatus, means for discharging fluid from said elements, means for recirculating fluid discharged from at least one of said elements whenever the heat load on said evaporator falls below a predetermined point, and means delivering fluid discharged from at least another of said elements directly to said condenser from said compressor apparatus at all times during operation of said compressor apparatus, said fluid recirculating means being arranged to supply fluid to at least one of said last-mentioned elements.

7. The combination with a refrigerating system including an evaporator and a condenser, of a compressor apparatus including a plurality of compressor elements connected in parallel arrangement, feed means for supplying evaporated refrigerant from said evaporator to said compressor apparatus, means for discharging compressed refrigerant fluid from said elements, means for recirculating through said compressor apparatus fluid discharged from at least one of said elements in response to decrease of the heat load on said evaporator below a predetermined point, and means for delivering fluid discharged from at least another of said elements directly to said condenser from said compressor apparatus at all times during operation of said compressor apparatus.

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