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COMPRESSOR CONTROL

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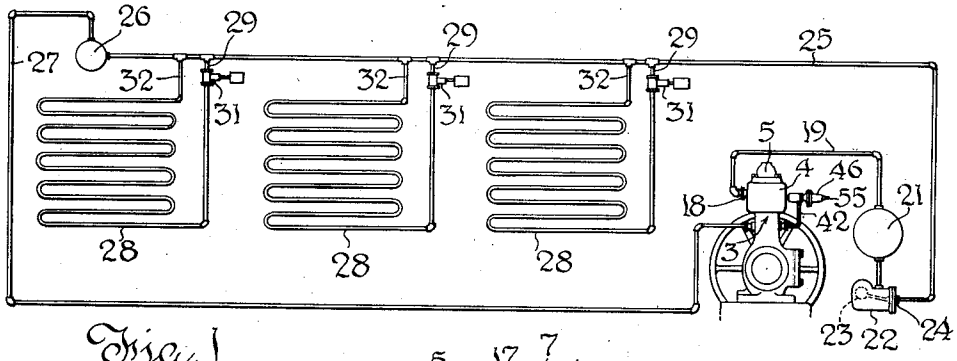


Fig. 1

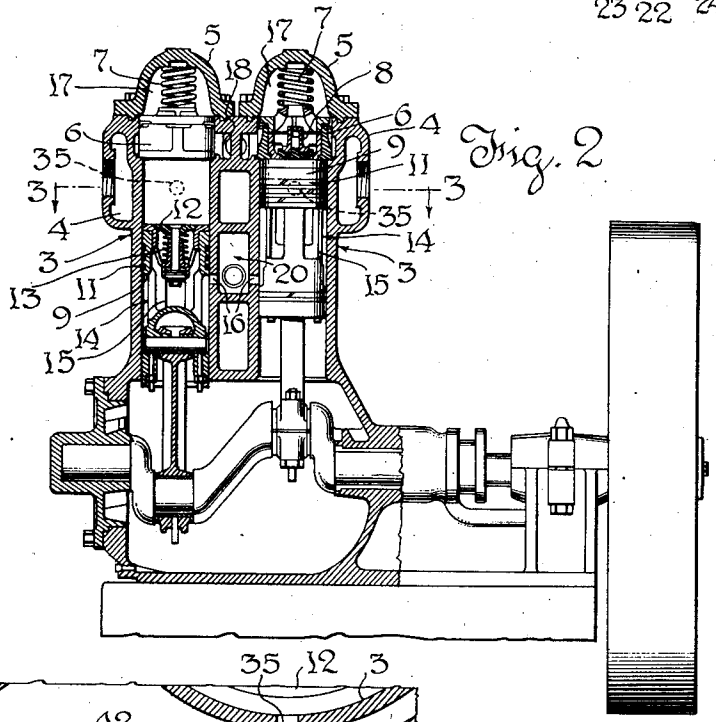


Fig. 2

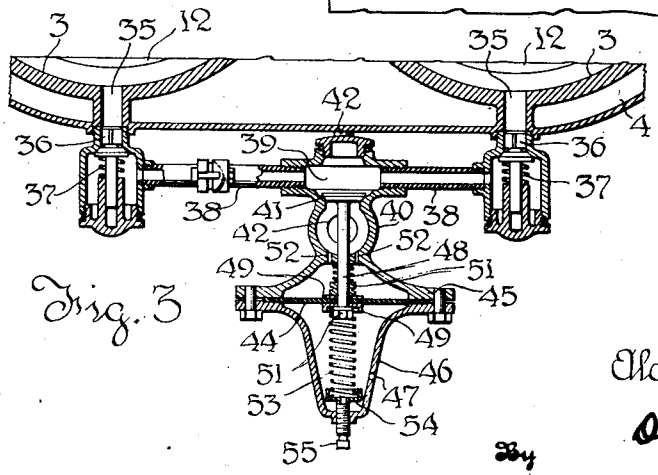


Fig. 3

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UNITED STATES PATENT OFFICE

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COMPRESSOR CONTROL

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This invention relates to refrigeration and particularly to the control of the compressor by an automatic unloading valve.

In systems employing constant speed compressors, a reduction in the evaporating load, such as may occur when one or more of a plurality of evaporators are shut down, will cause a decided and rapid reduction of suction pressure, and will soon result in undesirable operating conditions unless some corrective measures be taken.

The harmful effects are various. The evaporator coil temperature is reduced and coils exposed to air are heavily frosted and the surrounding air unduly dried. The efficiency of the coils is impaired by the frost and the efficiency of the compressor is reduced by low suction pressure so that the cost of operation is increased. The tendency of air to leak into the system is increased, particularly if suction pressure should drop below atmospheric pressure and, in compressors having crank case suction, the oil in the crank case foams and tends to enter into circulation with the refrigerant.

Where there are several automatically controlled evaporators, the control of suction pressure should also be automatic.

The desired result is secured by using an automatic valve responsive to abnormally low suction pressures and operating to unload the compressor partially, but not wholly. The unloading is conveniently secured by shortening the effective working stroke of the pistons.

The results secured differ markedly from those secured in the prior art with devices which attempt to correct the difficulty by bleeding high pressure vapor to the suction line under the control of unduly low suction pressures. These prior art systems do not relieve the compressor of load and hence do not save power; also it has been found that the by pass valve repeatedly opens and closes with disturbing effects on operation which are so serious as to render the scheme impracticable.

The present invention will now be described, in its preferred embodiment, with reference to the accompanying drawing.

In the drawing,

Fig. 1 is an elevation, somewhat diagrammatic in character, showing a refrigeration circuit with the present invention applied;

Fig. 2 is a vertical axial section of a two cylinder compressor, showing the suction and discharge connections and the location of the unloading ports; and

Fig. 3 is a fragmentary section on the line 3—3 of Fig. 2 and illustrating the unloading valve mechanism in detail.

In the drawing the cylinders of an ordinary two cylinder single acting compressor are indicated at 3. The barrels of the two cylinders are enclosed by a water jacket 4 and the end of each cylinder is closed by head 5. The end of each working space is closed by safety head 6 held seated normally by a heavy spring 7. The discharge valves 8 are mounted in the safety head and are of the poppet type.

The pistons are shown at 9, and have the usual packing rings 11. The suction or inlet valve is in the upper face of each piston as indicated at 12, and consists of a poppet valve urged in an opening direction by the light spring 13. Below the packing rings, each piston is reduced to afford clearance as indicated at 14 and is provided with slots 15 which afford communication from the inlet port 16 which extends through the cylinder wall to the inlet valve 12, in all positions of the piston.

The compressed refrigerant flows from the chambers 17, between the head 5 and the safety head 6, through a connection 18 to the high pressure line 19 which leads to the condenser conventionally indicated at 21. This may be of any suitable type. In the smaller units it is commonly a horizontal shell and tube water cooled condenser.

From the condenser 21 the liquefied refrigerant flows to a float trap 22, of known form, whose float 23, upon the rise of liquid above a definite level, opens the valve 24 and allows refrigerant to flow into the liquid line 25. This liquid line terminates in an elevated separator trap 26 from which the suction line 27 leads to the suction ports 16 by way of chamber 20 in the cylinder casting.

Located below the connections with the liquid line 25 and fed with liquid therefrom by gravity are the evaporator units, three being shown. Each evaporator unit proper is indicated at 28 as a pipe coil and has two connections, a suction connection 29 controlled by an automatic valve 31 which may be of the automatic temperature regulating type or of any other suitable type, and a supply connection 32.

The above system is illustrated as an example of current practice, but is the invention of another and consequently is not herein claimed.

Briefly stated, the liquid line 25 contains liquid refrigerant which boils under suction pressure until it reaches the temperature corresponding to suction pressure. The pipe 25 thus is a combined liquid and vapor line and is large enough to permit partial separation of the liquid and vapor to occur in the line. The final separation occurs in trap 26. Refrigerant vaporized in the coils 28 flows by way of connection 31 to the line 25 and thence to the trap 26 from which vapor only flows through the suction line 27 to the compressor. If any valve 31 is closed partially or wholly, the evaporation of refrigerant in the coil 28 will displace the liquid refrigerant partially or wholly thus reducing or suspending the refrigerative action of the coil.

Any other arrangement involving the use of independent evaporators, whether their control be automatic or manual may be used with my invention, it being understood that no novelty is herein claimed for the parts so far described. They are to be regarded as representative or permissible practice.

The features characteristic of the present invention will now be described.

Each of the cylinders 3 is formed with an unloading port 35 which is shown located as indicated in dotted lines in Fig. 2 at or about mid-stroke, but which may be located at other points in the stroke depending on the degree of unloading desired. Ports 35 are shown in dotted lines in Fig. 2 because they are in front of the plane of section. Each of these ports 35 is controlled by a check valve 36 which opens to permit outflow from the cylinder and closes against inflow. These valves are seated by coil springs 37.

Outflowing gas passing either valve is led by a corresponding pipe connection 38 to a valve chamber 39 formed in a casting 40 whose form is clearly shown in the drawing. A poppet valve 41 controls flow from the chamber 39 and is seated by pressure in said chamber. Vapor flowing from the chamber 39 past the valve 41 flows by way of pipe connection 42 to chamber 20; that is, to the compressor suction.

It follows that if the valve 41 be held open, refrigerant vapor displaced in the first portion of the stroke will flow through the unloading ports 35 past the check valves 36, past valve 41, and by way of pipe 42 back to the compressor suction. Vapor compressed after the pistons overtravel the ports 35, will be discharged through the discharge valves 8 and flow to the condenser in the usual way.

The valve 41 is controlled by a pressure-actuated movable abutment. In the structure illustrated this abutment takes the form of a diaphragm 44, which is clamped between a flange 45, forming part of the casting 40, and a cap 46. Cap 46 is vented to atmosphere as indicated at 47. The stem 48 of the valve 41 passes through the center of the diaphragm 44 and is mechanically connected and sealed gastight thereto by the discs 49 and nuts 51.

The ports 52 serve as means of communication between the suction connecting pipe 42 and the inner face of diaphragm 44, and compression spring 53 is seated on the outer disc 49 and on a spring seat 54 which is adjustable by means of a thrust screw 55 threaded in cap 46. The spring 53 acts to urge the valve 41 open, in opposition to the suction pressure, it being assumed that, as is the usual practice, the suction pressure is higher than atmospheric pressure. By turning the screw 55 the stress on spring 53 is adjusted to determine the suction pressure at which the valve 41 will open and partially unload the compressor.

It will be observed that the top of the valve 41 when closed is subject to the pressure developed in the cylinders at the time when the pistons 9 overtravel the unloading ports 35. The other side of the valve is subject to suction pressure. Thus the valve 41 is held closed both by pressure in the chamber 39 acting on the valve and by suction pressure acting on the diaphragm 44. When, however, the valve 41 opens, pressure on the two faces of valve 41 equalizes and the closing tendency is exerted solely by the diaphragm 44. In this way it is possible to give quite a broad range of pressure response to the unloading valve, the valve 41 acting as a biasing device to cause the valve to open and close at different suction pressures.

For example: The parts may be so dimensioned that the unloading valve will not open until the suction pressure drops to a relatively low value, say 5 pounds per square inch gage. At such pressure the spring 53 will overcome the pressures exerted on the diaphragm 44 and on the head of the valve 41. As soon as the valve 41 starts to open, it will open wide because of equalization of the pressure acting on the valve and the closing tendency will thereafter be that exerted by the diaphragm 44. It follows that the valve 41 will remain open until the suction pressure rises to a value much higher than that at which the valve 41 opened, say for example 15 pounds gage. At such higher

pressure the diaphragm 44 will close the valve 41 and will thereafter maintain it closed until the suction pressure drops to the predetermined low pressure here suggested as five pounds gage.

In this way, the valve 41 is kept from hunting, and the compressor operates with reasonable efficiency either fully loaded or partially unloaded as conditions may require. The suction pressure is not allowed to become unduly low, and because the compressor operates with good mechanical efficiency, the horse power per ton of refrigeration is kept at a reasonable value.

The invention obviously may be embodied in various specifically different structures, and may be used with specifically different refrigerative circuits without departure from the invention.

What is claimed is:

1. A suction pressure control device for a compressor, comprising in combination with such compressor, means for partially unloading said compressor; and means responsive to suction pressure and serving upon abnormal reduction thereof to render said unloading means effective.

2. A suction pressure control device for a compressor, comprising in combination with such compressor, means for varying the effective working stroke of said compressor; and means responsive to suction pressure for actuating said stroke varying means.

3. A suction pressure control device for a compressor, comprising in combination with such compressor, means for varying the effective working stroke of said compressor; and means responsive to suction pressure for actuating said stroke varying means, and serving to reduce the effective stroke upon an abnormal reduction of suction pressure.

4. The combination of a compressor having an unloading passage which connects the compression space with the suction connection during a part of the working stroke, and pressure actuated valve means responsive to suction pressure and controlling said passage.

5. The combination of a compressor having an unloading passage which connects the compression space with the suction connection during a part of the working stroke; and pressure actuated valve means responsive to suction pressure and controlling said passage, the last named means normally closing said passage and serving upon abnormal reduction of suction pressure to open said passage.

6. A suction pressure control device for a compressor comprising in combination with such compressor, means for partially unloading said compressor, means responsive to suction pressure serving to operate said unloading means, and a biasing device associated with the last named means, serving to cause unloading to occur at a substantially lower suction pressure than loading.

7. A suction pressure control device for a compressor comprising in combination with such compressor, means for partially unloading said compressor, means responsive to suction pressure serving to operate said unloading means upon abnormal reduction of suction pressure, and a biasing device associated with the last named means, serving to cause unloading to occur at a substantially lower suction pressure than loading.

8. A suction pressure control device for a compressor, comprising in combination with such compressor; means for varying the effective working stroke of said compressor; means responsive to suction pressure for actuating said stroke varying means; and a biasing device associated with the last named means and serving to cause shortening of the effective stroke to occur at a substantially lower suction pressure than lengthening thereof.

9. The combination of a compressor having an unloading passage which connects the compression space with the suction connection during a part of the working stroke; pressure actuated valve means responsive to suction pressure and controlling said passage; and a biasing device associated with the last named means and serving to cause opening of said passage to occur at a substantially lower suction pressure than closing thereof.

10. The combination of a compressor having an unloading passage which connects the compression space with the suction connection during a part of the working stroke; a check valve preventing back flow through said passage to the compression space; a normally unbalanced valve controlling said passage and urged in a closing direction when closed by pressure developed in said compression space; a movable abutment subject to suction pressure and urging the unbalanced valve in a closing direction; and yielding means urging said unbalanced valve in an opening direction.

11. The combination of a compressor having an unloading passage which connects the compression space with the suction connection during a part of the working stroke; a check valve preventing back flow through said passage to the compression space; a normally unbalanced valve controlling said passage and urged in a closing direction when closed by pressure developed in said compression space; a movable abutment subject to suction pressure and urging the unbalanced valve in a closing direction; yielding means urging said unbalanced valve in an opening direction; and means for adjusting the force exerted by said yielding means.

12. The combination of a compressor having an unloading passage leading from the

compression space to the suction connection and overtraveled by the piston; a check valve adjacent the entrance to said passage from the compression space and closed against back flow toward the compression space; a normally closed unbalanced valve controlling flow in said passage and urged in a closing direction when closed by pressure fluid passing said check valve; a movable abutment subject to suction pressure operatively connected with said unbalanced valve to urge the latter in a closing direction; and yielding means urging said unbalanced valve in an opening direction.

In testimony whereof I have signed my name to this specification.

ALONZO W. RUFF.