Nov. 22, 1960 A. W. COURTNEY, JR 2,961,148

COMPRESSOR CYLINDER UNLOADERS

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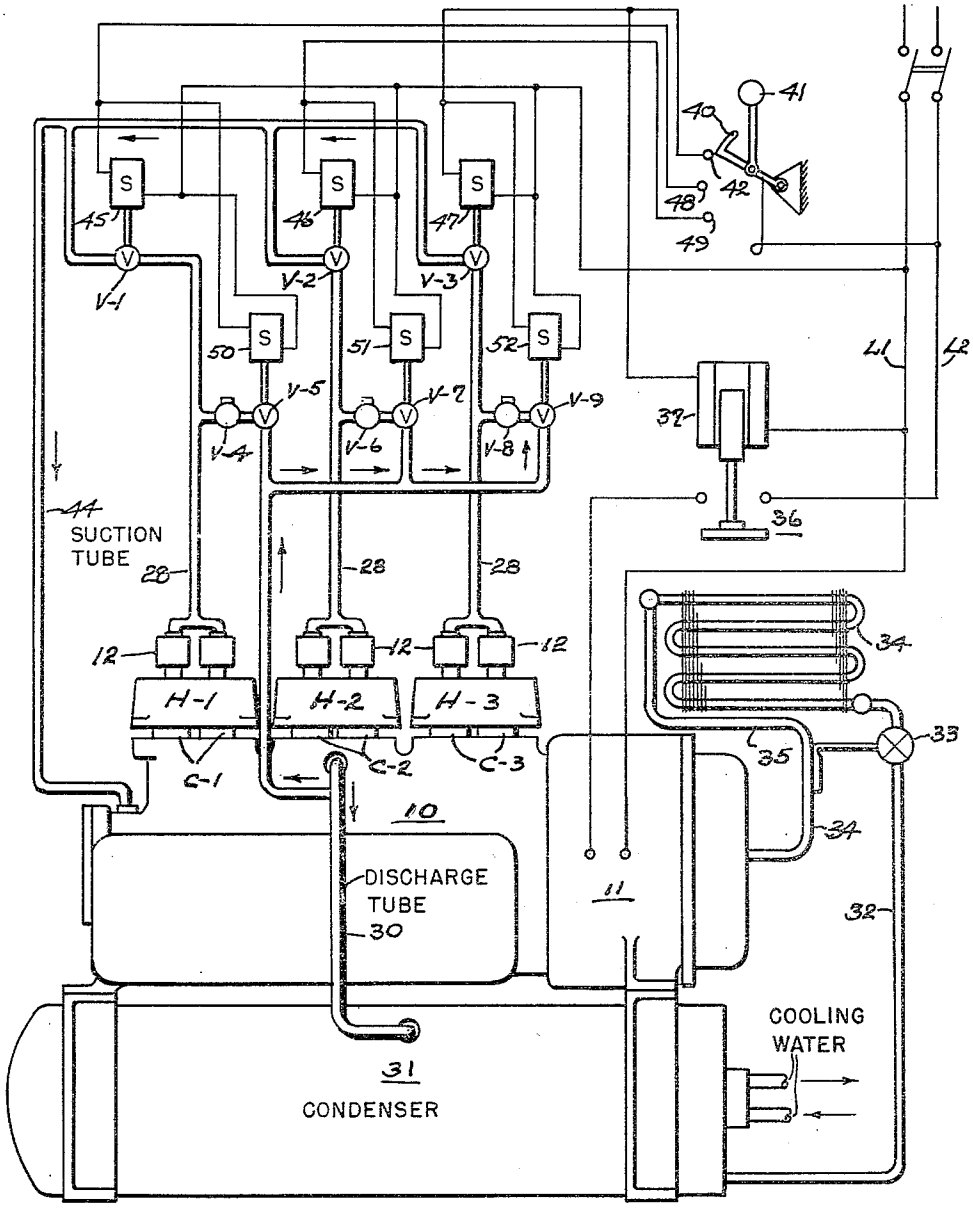


Fig. 1

Arthur W. Courtney, Jr.
Inventor
by Robert J. Palmer
Attorney

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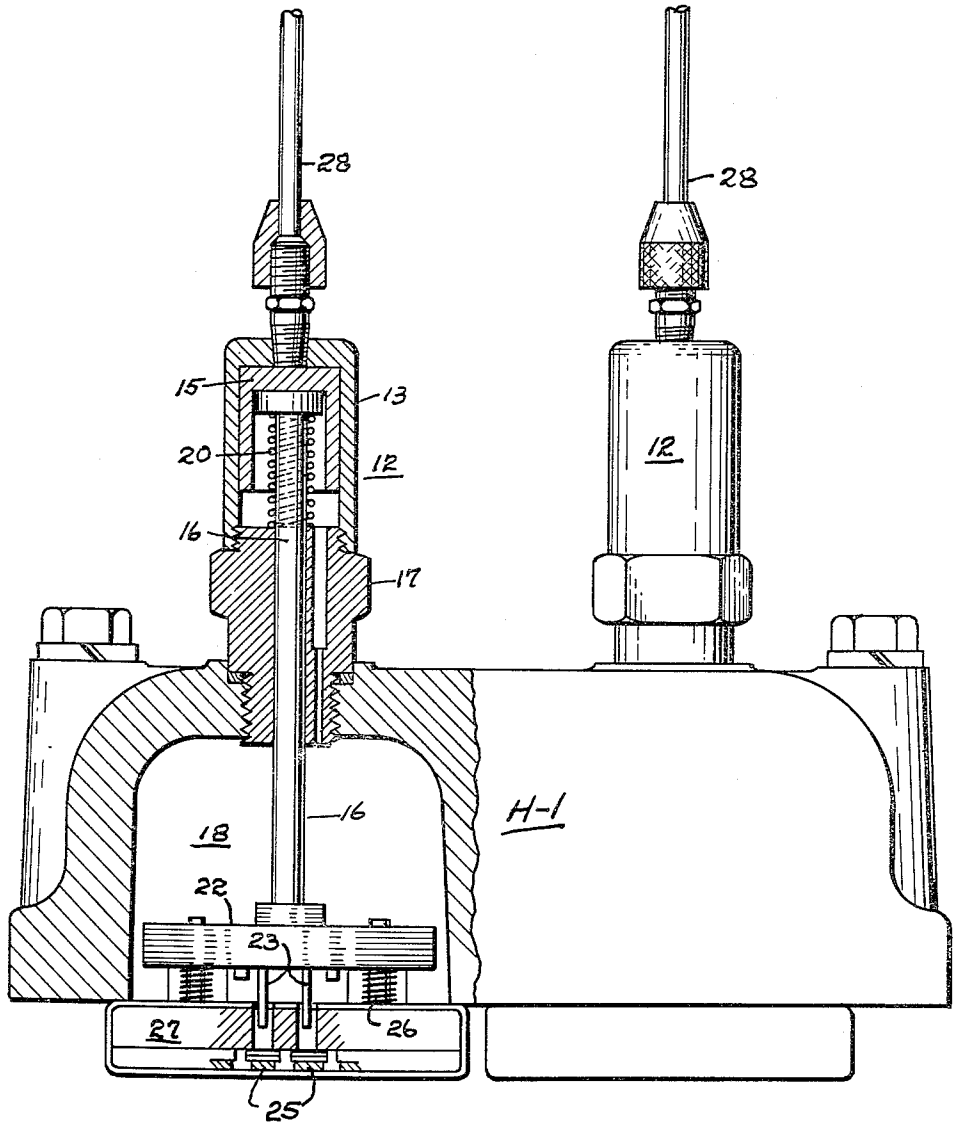


Fig. 2

Arthur W. Courtney, Jr.
Inventor
by Robert J. Palmer
Attorney

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COMPRESSOR CYLINDER UNLOADERS

Arthur W. Courtney, Jr., Grottoes, Va., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates to refrigerant compressors, and has as an object to improve the mechanisms for unloading such compressors.

In many refrigerant compressors, unloading mechanisms are provided for reducing the starting power and for reducing the capacity as load reductions take place. The E. R. Wolfert Patent No. 2,296,304 discloses a widely used form of unloader in which unloading is accomplished by depressing suction valve reeds so that they do not act as check valves as they ordinarily do during the compression strokes of the pistons in their respective cylinders. A toothed bar called a "comb" is used to hold a set of suction reeds down, the comb being forced down by refrigerant discharge pressure acting on a piston in an unloader cylinder located over the comb. The comb is returned from the depressed (unloading) position by relieving the pressure in the unloader cylinder and allowing return springs and the spring action of the valve reeds to lift the comb to its inoperative (loading) position.

The pressure difference which is required to operate an unloader of this type varies with the gas drag on the suction reeds. This, in turn, is a function of the density of the suction gas. The result is that the pressure required at low suction pressure is small. At high suction pressure, the necessary pressure difference is larger. If the pressure available is not sufficient, experience has shown that the unloader will chatter. That is, it will repeatedly open and close accompanied by a great deal of noise and some damage to the unloader parts. At such times, unloading is not complete.

I have determined that this chattering action occurs because of the resiliency of the gas in an unloader cylinder and in tubing connecting it to the compressor. During the compression strokes of the piston in a compressor cylinder, discharge gas is applied directly against the undersides of the downwardly depressed suction valve reeds, forcing them upwardly. This reed lifting action is opposed by the discharge gas in the tubing connecting the unloader cylinder to the discharge gas side of the compressor. Since the gas in such tubing is resilient, it is compressed by the up movements of the suction reeds during the compress-strokes. I have found that such chattering can be prevented by placing a check valve in the high pressure tubing which supplies operating pressure to the unloader cylinder, and using an auxiliary tube for relieving this pressure when re-loading is desired. The check valve reduces the volume in the system and thereby reduces the capacitance. This results in increased stiffness so that there will be less tendency for the unloader assembly to lift during that portion of the compressor cylinder pumping cycle when the gas velocities are high enough through the suction valve to cause compression of the gas in the unloader cylinder. An additional advantage is that two simple relatively inexpensive solenoid operated valves will be required instead of the relatively expensive, three-way solenoid operated valve now used.

Another object of this invention is to prevent the chattering of unloading mechanism.

This invention will now be described with reference to the annexed drawings, of which:

Fig. 1 is a diagrammatic view of a refrigeration system embodying this invention, and

Fig. 2 is an enlarged side view, partially in section, of one of the heads of the compressor of Fig. 1, and shows the details of one of the unloading mechanisms.

A conventional refrigerant compressor **10** driven by a hermetically sealed electric motor **11**, has three pairs of cylinders C–1, C–2 and C–3 with their associated cylinder heads H–1, H–2 and H–3. Each cylinder head contains two unloading mechanisms, indicated generally by the reference character **12**, one for each of its cylinders, the details of the unloading mechanisms being shown by Fig. 2.

Each unloading mechanism **12** consists of an unloader cylinder **13** having therein a piston **15**, and which has a piston rod **16** which extends through a fitting **17** into a cavity **18** above a compressor cylinder. A coiled spring **20** around the rod **16** between the piston **15** and fitting **17** urges the piston upwardly.

The lower end of the rod **16** has a comb **22** attached thereto, and which has the small rods or teeth **23** which, when the comb is in its unloading position, depresses the suction valve reeds **25**. Coiled springs **26** between the valve plate **27** and the comb **22** urge the comb upwardly. Discharge or suction pressure as the case may be, is supplied through a tube **28** into the unloader cylinder against the top of the piston **15**.

The discharge side of the compressor **10** is connected by a discharge tube **30** to a conventional condenser **31**, which is connected by a tube **32** and expansion valve **33** to an air cooling evaporator **34**, the outlet of the evaporator being connected by a suction tube **35** to the suction side of the compressor.

A starter switch **36** is connected in series with the motor **11** and the electric supply lines L1 and L2, and is opened and closed by a solenoid **37** which is adapted to be connected to the lines L1 and L2 by the contact arm **40** of a room thermostat **41** touching a starter contact **42**.

The construction described so far in connection with the drawings is conventional and shown by said Wolfert patent. This invention adds a two-way, suction control valve V–1 connected to the tube **28** which is connected to the unloader cylinders **12** of the head H–1, and to another suction tube **44**; adds a similar two-way, suction control valve V–2 connected to the tube **28** which is connected to the unloader cylinder **12** of the head H–2, and to the suction tube **44**, and adds a similar two-way, suction control valve V–3 connected to the tube **28** which is connected to the unloader cylinders **12** of the head H–3.

This invention also adds a check valve V–4 and a two-way, pressure control valve V–5 connected to the tube **28** which is connected to the unloader cylinder **12** of the head H–1, and to the discharge tube **30**; adds a check valve V–6 and a two-way, pressure control valve V–7 connected to the tube **28** which is connected to the unloader cylinder **12** of the head H–2, and to the discharge tube **30**, and adds a check valve V–8 and a two-way, pressure control valve V–9 connected to the tube **28** which is connected to the unloader cylinders **12** of the head H–3, and to the discharge tube **30**.

The pressure control valves V–1, V–2 and V–3 are opened and closed by solenoids **45**, **46** and **47** respectively which are adapted to be energized when the control means contact arm **40** touches the control means contacts **48**, **49** and **42** respectively. When the solenoids **45**, **46** and **47** are energized, they open their valves V–1, V–2 and V–3 respectively.

The suction control valves V–5, V–7 and V–9 are opened and closed by solenoids 50, 51 and 52 respectively, which are connected across the solenoids 45, 46 and 47 respectively, and which are energized when the solenoids 45, 46 and 47 respectively, are energized. When the solenoids 50, 51 and 52 are energized, they close their valves V–5, V–7 and V–9 respectively.

Operation

In operation, when the thermostat 41 calls for cooling, its contact arm 40 touches the contact 42 and energizes the motor 11, starting the compressor 10. The solenoids 47 and 52 are energized at this time. The valve V–3 is opened and the valve V–9 is closed so that the unloader cylinder 12 of the head H–3 is connected to the suction tube 44 and disconnected from the discharge tube 30. Suction pressure aided by the springs 20 and 26 lifts the unloader comb 22 permitting the suction valve reeds 25 of the head H–3 to close and to load the compressor cylinders of the head H–3. However, an appreciable period of time, such as two seconds, is required for sufficient flow of gas through the tubing before the cylinders are actually loaded, and this period is greater than the period of time required for starting so that at the start of the motor 11, all cylinders are unloaded.

If the thermostat calls for additional cooling by moving its contact arm 40 against the contact 48, the solenoids 45 and 50 will be energized, causing the unloader cylinders of the head H–1 to be connected to the suction tube 44, and disconnected from the discharge tube 30, and the cylinders of the head H–1 to be loaded. Upon further increase in temperature, the contact arm 40 will touch the contact 49, energizing solenoids 46 and 51, causing the unloader cylinder of the head H–2 to be connected to the suction tube 44, and to be disconnected from the discharge tube 30, causing the cylinders of the head H–2 to be loaded.

Assuming that the sequence of operations described in the foregoing has taken place so that all cylinders of the compressor are loaded, then when the room temperature drops the contact arm 40 of the thermostat will move away from the contact 49, deenergizing the solenoids 46 and 51, causing the unloader cylinders of the head H–2 to be disconnected from the suction tube 44 and to be connected to the discharge tube 30 so that discharge pressure will act against the unloader pistons of the head H–2 and force the unloader assembly of the head H–2 to unloaded position.

When the room temperature drops further the contact arm will move away from the contact 48, deenergizing the solenoids 45 and 50 and causing the cylinder of the head H–2 to become unloaded. Upon further drop in temperature, the contact arm will move away from the contact 42, causing the solenoids 46 and 51 to become deenergized, causing the cylinders of the head H–3 to become unloaded, and causing the solenoid 37 to become deenergized and open the switch 36 to stop the compressor motor 11.

The check valves V–4, V–6 and V–8 are one-way valves permitting the passage of gas under discharge pressure for unloading but preventing the passage of gas from their associated unloader cylinders into the tubing connecting the latter to their associated discharge pressure controlling valves V–5, V–7 and V–9 respectively, during the compression strokes of the pistons in the compressor cylinders. The suction control valves V–1, V–2 and V–3 release the pressure in the unloader

cylinders when reloading is required, permitting the unloader assembly to lift and the suction valve reeds to close. The check valves reduce the volume of gas in the control system, and thereby reduce its capacitance, providing increased stiffness so that there will be less tendency for the unloader assembly to lift during that portion of the compressor cylinder pumping cycle when the gas velocities through the open suction valve reeds are high enough to cause compression of the gas in the unloader.

While one embodiment of this invention has been described for the purpose of illustration, it should be understood that the invention is not limited to the exact apparatus and arrangement of apparatus illustrated, since modifications thereof may be suggested by those skilled in the art, without departure from the essence of the invention.

What is claimed is:

1. A control system for a cylinder of a refrigerant compressor, said compressor having a suction tube connected to its suction side, and having a discharge tube connected to its discharge side, said cylinder having a suction valve reeds, having an unloader cylinder, and having a piston in said unloader cylinder connected to said reeds, said piston being movable in one direction to move said reeds to open position, and being movable in the opposite direction to permit said reeds to move to closed position, comprising: a two-way, pressure control valve connected to said discharge tube, a check valve connected to and between said control valve and unloader cylinder, a two-way, suction control valve connected to and between said suction tube and unloader cylinder, pressure control valve opening and closing means connected to said pressure control valve, suction control valve opening and closing means connected to said suction control valve, and control means connected to said pressure control valve opening and closing means and to said suction control valve opening and closing means for actuating said pressure control valve opening and closing means to open said pressure control valve to supply discharge gas from said discharge tube through said pressure control valve and said check valve into said unloader cylinder to move said piston in said one direction, and simultaneously actuating said suction control valve opening and closing means to close said suction control valve, or for actuating said pressure control valve opening and closing means to close said pressure control valve, and simultaneously actuating said suction control valve opening and closing means to open said suction control valve to apply suction from said suction tube through said suction control valve to said unloader cylinder to move said piston in said opposite direction, said check valve preventing gas from flowing from said unloader cylinder into said pressure control valve.

2. A control system as claimed in claim 1 in which said valve opening and closing means are electric solenoids, and in which said control means includes electric switches for energizing and deenergizing said solenoids.

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