Sept. 19, 1950 C. R. NEESON 2,522,762

COMPRESSOR UNLOADING MECHANISM

Filed Nov. 15, 1947 2 Sheets-Sheet 1

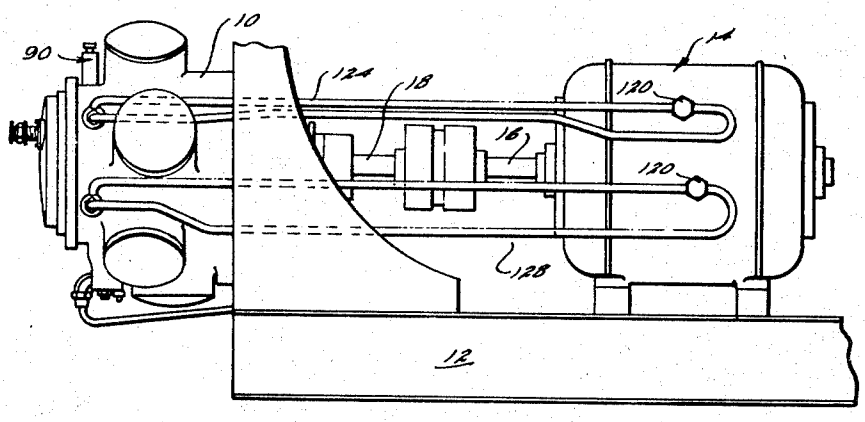


Fig. 1.

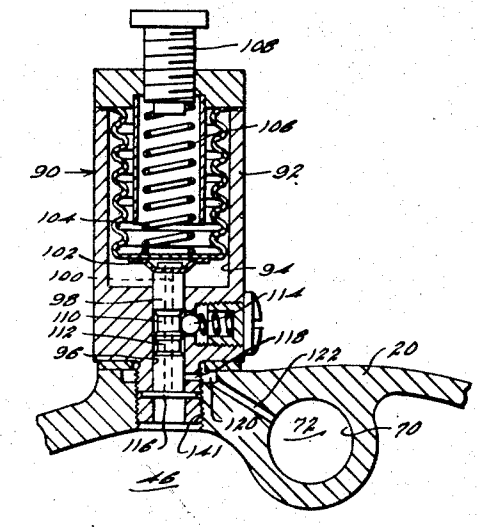


Fig. 3.

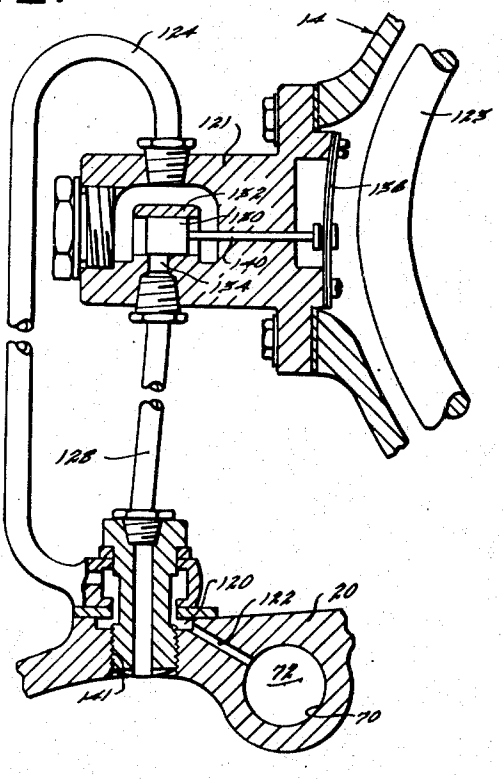


Fig. 4.

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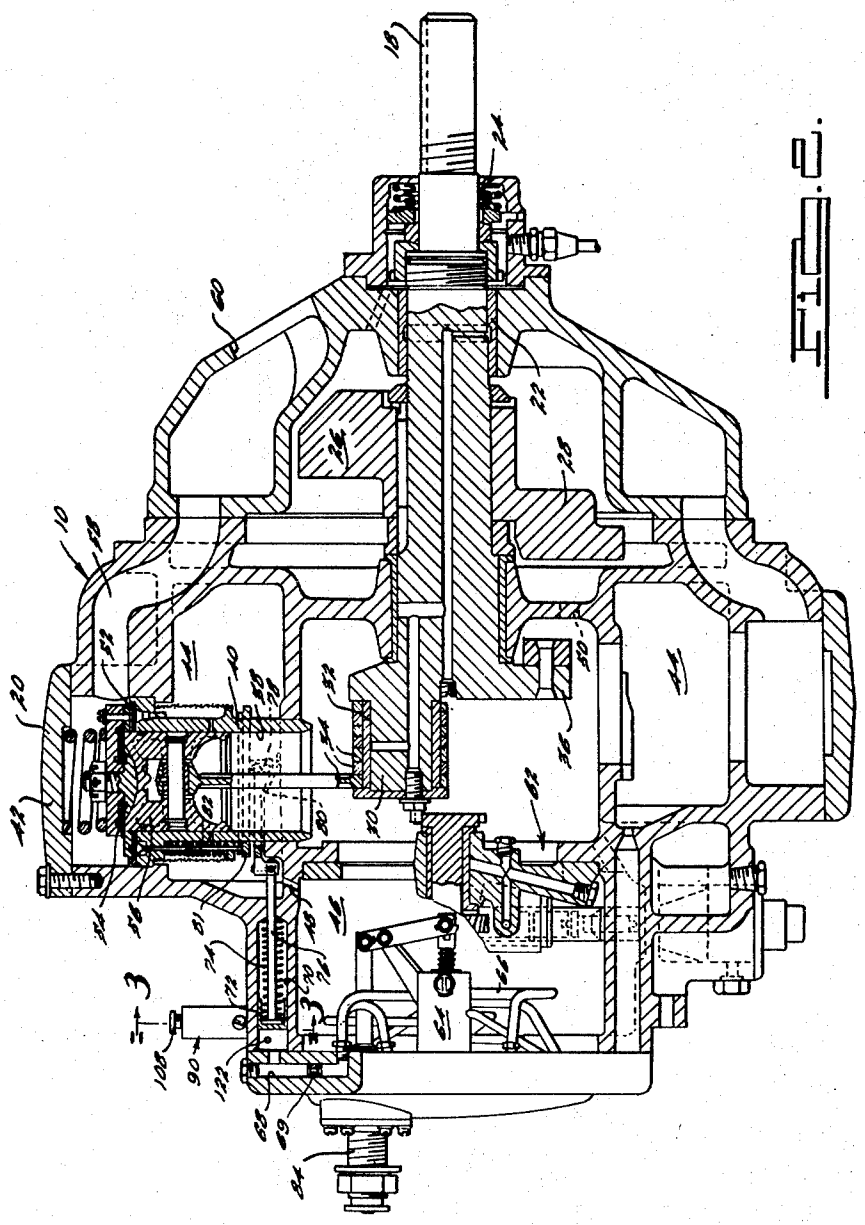


Fig. 1

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COMPRESSOR UNLOADING MECHANISM

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5 Claims. (Cl. 230—7)

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This invention relates to means for unloading individual cylinders of a motor driven multi-cylinder refrigerant compressor under selected conditions to prevent overloading of the motor.

The pressure existing on the suction side of a refrigerant compressor provides an indication of the load existing on the refrigerant system as an incident to the room and evaporator coil temperatures existing at that time. When this pressure is high the work required to compress a given volume of refrigerant is high. A means to prevent overloading of the motor driving the compressor is provided by apparatus to unload individual cylinders of the compressor and thereby reduce the volume of refrigerant compressed until its pressure lowers sufficiently to permit the volume of refrigerant handled by the compressor to be increased.

It is a principal object of this invention to combine means to unload some cylinders of a multi-cylinder compressor in response to high suction pressure thereof with means to unload additional cylinders of the compressor in response to overheating of the motor driving the compressor. The suction pressure responsive unloading apparatus is capable of determining that a predetermined number of cylinders should be unloaded for a given suction pressure. However, the length of time that the compressor must operate under abnormal pressure conditions is a factor which has heretofore been ignored by unloader mechanisms. While operation of the compressor with a given number of cylinders unloaded might prevent the motor from being injuriously overloaded this may only be true if the pressure drops within a reasonable length of time. Therefore, I have provided means responsive to motor temperature to unload additional cylinders when the motor temperature becomes excessive. This combined with a suction pressure responsive unloader mechanism provides a more accurate control of the volume of refrigerant handled by the compressor than has heretofore been obtainable and provides an adjustment of this volume in relation to rate of pressure drop.

It is a further object of this invention to provide mechanisms which may be associated with individual cylinder unloading apparatus without requiring that an entirely new unloading apparatus be substituted in a compressor to obtain the added features of unloading in response to excessive suction pressure and motor overheating.

It is an additional object of the invention to

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provide an improved apparatus which may be associated with the unloader mechanism of individual compressor cylinders to unload these cylinders when predetermined compressor suction pressures are exceeded.

It is a further object of the invention to provide apparatus which may be associated with the unloader mechanism of individual compressor cylinders to unload these cylinders when predetermined motor temperatures are exceeded.

The apparatus to be described herein is adapted to supplement the unloading apparatus described in my Patents No. 2,185,473 and 2,369,841 and reference may be had thereto for a more detailed description of that apparatus which will be briefly referred to herein.

Other objects and advantages will become more apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a side elevation of a refrigerant compressor coupled to a motor;

Fig. 2 is a vertical section taken through the compressor of Fig. 1;

Fig. 3 is a section on the line 3—3 of Fig. 2; and

Fig. 4 is a sectional view of apparatus adapted to unload compressor cylinders in response to motor temperature.

In Fig. 1 a motor compressor set incorporating my invention is illustrated. A compressor 10 is supported by a base 12 and adapted to be driven by an electric motor 14. The armature 16 of motor 14 is coupled to the main shaft 18 of the compressor. The compressor is illustrated in more detail in Fig. 2 and a substantial portion of its construction and attachments are as described in my Patent No. 2,185,473. The compressor illustrated in Fig. 2 comprises a housing 20 provided with a bearing 22 in which the shaft 18 is journaled. A conventional seal 24 may be employed between the shaft 18 and housing 20 in order to prevent the escape of refrigerant from the compressor housing.

The shaft 18 includes a pair of counterbalances 26 and 28 which are located thereon and which tend to smooth vibration by acting as flywheels. The front end of the shaft beyond the bearing 22 is provided with a crank pin 30 which is surrounded by a bearing ring 32 forming the bearing surface for a plurality of piston rods 34. The number of piston rods corresponds to the number of cylinders in the compressor. The weight of the crank pin is counterbalanced by a balance weight 36.

Each piston rod 34 extends radially towards its associated cylinder 38. The cylinders are radially, equally spaced about the center lines of the compressor. Each cylinder is offset longitudinally of the compressor by an amount equal to the distance between centers of the piston rods 34. Each cylinder comprises a liner 40 which is inserted through the outer end of the cylinder when a cylinder head 42 is removed. A suction manifold 44 surrounds the liners and communicates with a refrigerating system (not shown) through a suction port provided in the housing 20 and not illustrated herein. The suction manifold 44 communicates with the interior 46 of the compressor housing through a plurality of openings 48. The suction manifold is also in communication with the interior of the rear or right hand portion of the compressor of Fig. 2 through one or more openings 50. The entire interior of the compressor is therefore subjected to pressure equal to the suction pressure of the refrigerating system with which it is associated.

The refrigerant entering the compressor through the suction manifold 44 is admitted to each cylinder space through suction valves 52. The gas is admitted upon raising of the suction valve 52 and discharged from the cylinder upon the raising of a discharge valve 54. The details and operation of the piston, seal, liner and valve assembly are more fully set forth in my Patent 2,137,965 dated November 22, 1938. Discharge ports 58 are associated with each cylinder. Each of the discharge ports 58 extends through the main housing 20 and passes from the compressor through a main discharge port 60.

As described in Patent No. 2,185,473, a means for producing oil pressure is provided at 62. Oil pressure produced is used to lubricate moving parts of the compressor and to operate an unloader mechanism to be described. A master valve 64 is associated with the unloader mechanism and is adapted to control the delivery of oil pressure to unloader mechanisms associated with each compressor cylinder. Oil is delivered under pressure from means 62 to master valve 64. A plurality of tubes 66 connect the master valve 64 to individual unloader mechanisms associated with each compressor cylinder. One such unloader mechanism is illustrated in Fig. 2 and comprises a passage 68, a bore 70 and a piston 72 contained in the bore and urged toward the left in Fig. 2 by a spring 74. The strength of spring 74 is such as to be overcome by the pressure of the oil from means 62 which is selectively transmitted thereto through master valve 64, tube 66, passage 68 and bore 70. When the piston 72 is in the position illustrated in Fig. 2 the cylinder is "loaded" and when the piston is forced to the left by spring 74 the cylinder is "unloaded." The piston 72 is provided with a rod 76 carrying a roller mechanism 78. A stationary cam 80 is associated with each liner 40. A ring 81 is slidably mounted upon the cylinder liner 40. A plurality of circumferentially spaced unloader pins 82 are fastened to the ring 81 and extend longitudinally of liner 40 and are adapted to lift suction valve 52 so that the suction valve is continuously held in its open position. In such case gas entering the cylinder space through the suction valve is forced back into suction manifold 44. Since the discharge valve remains seated the net effect is an accomplishment of no useful work. Pins 82 are adapted to so open suction valve 52 and "unload" the cylinder when the spring 74 moves the roller mechanism 78 to the left in Fig. 2 so that the roller mechanism climbs the cam 80 and lifts ring 81 and pins 82.

In order to operate the master valve 64 and the unloading mechanisms there is provided an unloader control means 84 as described in Patent No. 2,185,473. The control means 84 is responsive to the suction pressure of the refrigerant existing within the compressor housing and is adapted to position the master valve 64 in accordance therewith to thereby selectively expose individual pistons 72 to the oil pressure capable of loading these cylinders.

When the system is at rest, the suction valves are held in open position due to the lack of oil pressure against the pistons 72 which means that the roller mechanism 78 will have climbed the incline of cam 80. When the motor is starting the reciprocation of the pistons will result in no compression being performed. However, as the motor reaches a higher speed and oil pressure is built up sufficient pressure will be available to load the compressor cylinders by movement of pistons 72.

Supplemental control mechanisms which form a part of my invention will control the delivery of oil to the pistons 72. Some of the cylinders of a multi-cylinder compressor in accordance with my invention are provided with a suction pressure responsive apparatus designated by the numeral 90 herein. The control means 84 previously discussed herein is adapted to cut off the supply of oil to pistons 72 and is responsive to low suction pressure thereby permitting individual cylinders to be unloaded when the suction pressure is low. The control means 90 is adapted to dump oil from bore 70 into the interior 46 of the compressor housing when the suction pressure becomes high. Control means 90 may be associated with some, though preferably not all, of the cylinders of a multi-cylinder compressor.

A restriction 69 is preferably provided in each passage 68 so that when oil is delivered to passage 68 by the master valve 64 then the restriction 69 will permit the dumping of oil by control means 90 or a valve means 121 to be described herein to be effective in lowering the pressure ahead of piston 72. Without the use of restriction 69 oil might be delivered sufficiently fast to retract piston 72 even though some of the oil was being dumped.

The control means 90 comprises a housing 92 having a cylinder 94 therein and a bore 96 extending axially of the housing 92 through one end thereof. A valve element 98 is adapted to reciprocate in bore 96. Valve element 98 has an axial opening 100 extending therethrough which is exposed to the suction pressure existing in the interior 46 in the compressor housing. Legs 102 secure the valve element 98 to the end portion of a collapsible bellows 104. The other end of the bellows 104 is sealed by the top of the casing 92. A spring 106 is provided within the bellows 104 and adapted to react against an adjusting screw 108 threaded through the top of the casing 92. Adjustment of the screw 108 preselects the compression of spring 106. Spring 106 resists collapsing of the bellows 104. Suction pressure transmitted from the interior 46 of the compressor through axial opening 100 to the cylinder 94 tends to compress bellows 104 thereby producing linear movement of piston element 98 in accordance with variations in suction pressure within the compressor. When the suction pressure is greatest the valve element 98 is moved

inwardly in housing 92 and when the suction pressure is low spring 106 moves valve element 98 outwardly. Valve element 98 is provided with a pair of adjacent recessed portions 110 and 112 in its surface. A spring pressed ball detent 114 is adapted to enter recessed portion 110 or recessed portion 112 depending on the position of the valve element 98. A pin 116 in housing 92 limits outward movement of valve element 98. Valve element 98 is therefore provided with a first extended position as shown in Fig. 3 when the suction pressure is low and a second retracted position when the suction pressure is high. A port 118 provided in housing 92 adjacent the outer end of valve element 98 communicates with a chamber 120 and a passage 122. The passage 122 is in fluid flow communication with bore 70 ahead of piston 72 as shown in Fig. 2. When valve element 98 is in the position shown in Fig. 3 the port 118 is blocked thereby and the loaded or unloaded condition of the associated compressor cylinder is determined by means 84. However, when the suction pressure existing in the interior 46 of the compressor becomes excessive the bellows 104 is collapsed and the valve element 98 retracted until ball 114 drops into recessed portion 112 therein. This provides a fluid flow communication from bore 70 through passage 122, chamber 120, port 118 and bore 96 to the interior 46 of the compressor. This provides a relief for any oil pressure attempting to act upon piston 72 to maintain the associated cylinder in a loaded condition. Since the dumping of the oil from bore 70 relieves all pressure on piston 72 except that provided by spring 74 the cylinder will be unloaded by means of pins 82 as previously described herein. The control means 90 associated with different cylinders of the multi-cylinder compressor may be adjusted to be operative at different high suction pressures so that, for example, when a given suction pressure is obtained a certain cylinder is unloaded and when a still higher suction pressure is obtained an additional cylinder is unloaded and so on. Means are thus provided to prevent the operation of portions of the compressor when the suction pressure becomes sufficiently great to require a decrease in the volume of refrigerant handled to prevent overloading of motor 14. The control means 90 provides a means for determining which cylinders of a multi-cylinder compressor will be operative at high suction pressures.

The control means 90 attempts to classify the optimum number of compressor cylinders corresponding to the suction pressures which may be encountered. However the classification is limited by the number of cylinders provided with control means 90 and although the optimum condition may be approached it is unlikely that it will be exactly obtained. Thus, instead of severely overloading the motor 14 it is probable that the overloading will be reduced to a relatively minor and usually harmless amount due to the operation of the control means 90 associated with various cylinders. However, even a slight overloading if maintained for a sufficient interval of time could produce a gradual overheating of motor 14. The time during which the overloading occurs is determined by the load upon the evaporator of the refrigerating system. Therefore, even though means are provided to unload individual cylinders of the compressor when the suction pressure reaches predetermined values it is possible that the motor 14 could be overloaded.

I have found that the control means 90 should be combined with an additional unloading mechanism preferably associated with other cylinders of the compressor and adapted to unload these other cylinders when the temperature of the motor 14 becomes excessive.

Fig. 4 illustrates the control which I desire to combine with control means 90. This control comprises a means to dump oil from bore 70 of certain of the compressor cylinders back through passage 122 and chamber 120 to the interior 46 of the compressor housing. A temperature responsive valve 121 is secured to the housing of the motor 14. The usual field coil 123 of motor 14 is illustrated in Fig. 4 and it is the temperature thereof which will determine the operation of the valve 121. Valve 121 is connected by a line 124 to chamber 120 provided in compressor housing 20. The port 122 communicates with the bore 70 ahead of the most advanced position of piston 72. Line 124 delivers oil from bore 70 to valve 121. A line 128 returns oil from valve 121 to the interior 46 of the compressor housing 20. The valve 121 is provided with a hollow interior portion and a slidable element 130. The slidable element 130 is adapted for linear movement within a guide 132. A port 134 operatively connects the interior of the valve 121 to the line 128. Slidable element 130 is adapted to selectively open and close port 134. The position of slidable element 130 is determined by the deformation of a bimetallic disk 136 located within valve mem- 121 in close proximity to field coil 123 of motor 14. A rod 140 operatively connects bimetallic element 136 and slidable element 130. When the temperature of coil 123 becomes excessive bimetallic element 136 deflects to the right in Fig. 4 thereby opening port 134 and permitting oil to be dumped from bore 70 to the interior 46 of the compressor housing.

The fittings for control means 90 and valve means 121 are preferably interchangeable so that the same threaded opening 141 in the compressor housing may be either closed by a plug or have the control means 90 or valve means 121 associated therewith.

It will be seen that I have provided a means for unloading compressor cylinders in response to high suction pressure and for unloading additional compressor cylinders in response to the maintenance of a high suction pressure for an abnormal length of time.

Although but one specific embodiment of the invention is herein shown and described, it will be understood that various changes may be made without departing from the spirit of the invention.

I claim:

1. A motor driven multi-cylinder compressor set having a first means for unloading individual cylinders thereof, fluid pressure means adapted to selectively overrule the action of said first means with respect to individual cylinders to load said individual cylinders under predetermined operating conditions, a mechanism associated with one of said cylinders and operable to relieve the effect of said fluid pressure on said first means with respect to said one cylinder in response to excessive suction pressure in said compressor and a temperature responsive device including a valve associated with a second of said cylinders, said device being operable to open said valve to relieve the effect of said fluid pressure on said first means with respect to said second cylinder in response to an excessive temperature of said motor.

2. A motor driven compressor set having a plurality of cylinders, means forming a common suction chamber, unloading means in conjunction with each cylinder operable to unload each cylinder when the compressor is at rest, fluid pressure creating means operating in unison with said compressor and creating sufficient pressure at a minimum speed to overcome said unloading means after the compressor has attained said minimum speed, a suction pressure responsive device comprising a valve associated with the unloading means of at least one of said cylinders, said valve having an open and a closed position, suction pressure responsive apparatus associated with said valve and adapted to open said valve when the pressure in said suction chamber exceeds a predetermined value, said valve when open being adapted to relieve the fluid pressure on the unloading means of said one cylinder, a motor temperature responsive device comprising a second valve associated with the unloading means of another of said cylinders, said second valve having an open and a closed position and a motor temperature responsive apparatus associated with said second valve and adapted to open said second valve when a predetermined temperature of said motor is exceeded, said second valve being adapted when open to relieve the fluid pressure on the unloading means of said last-mentioned cylinder.

3. A motor driven compressor set having a plurality of cylinders, means forming a common suction chamber, unloading means in conjunction with each cylinder operable to unload each cylinder when the compressor is at rest, fluid pressure creating means operating in unison with said compressor and creating sufficient pressure at a minimum speed to overcome said unloading means after the compressor has attained said minimum speed and a suction pressure responsive device comprising a valve associated with the unloading means of at least one of said cylinders, said valve having an open and a closed position, and suction pressure responsive apparatus associated with said valve and adapted to open said valve when a predetermined suction pressure is exceeded in said compressor, said valve being adapted when open to relieve the fluid pressure on the unloading means of said one cylinder.

4. A motor driven compressor set having a plurality of cylinders, means forming a common suction chamber, unloading means in conjunction with each cylinder operable to unload each cylinder when the compressor is at rest, fluid pressure creating means operating in unison with said compressor and creating sufficient pressure at a minimum speed to overcome said unloading means after the compressor has attained said

minimum speed, a master valve having an element movable to a plurality of stations and operable to selectively admit said fluid pressure to the unloading means of individual cylinders in response to movement of said element to different stations, suction pressure responsive means to move said element to said stations in response to variations in the pressure in said suction chamber, a plurality of supplemental valves each associated with the unloading means of one of said cylinders, each supplemental valve having an open and a closed position and being operable when open to relieve the fluid pressure on the unloading means of its associated cylinder and means to open said supplemental valves in response to predetermined operating conditions of said motor compressor set.

5. A motor driven compressor set having a plurality of cylinders, means forming a common suction chamber, unloading means in conjunction with each cylinder operable to unload each cylinder when the compressor is at rest, fluid pressure creating means operating in unison with said compressor and creating sufficient pressure at a minimum speed to overcome said unloading means after the compressor has attained said minimum speed, and a plurality of valves respectively associated with the unloading means of individual cylinders, each of said valves having an open and a closed position and having suction pressure responsive apparatus associated therewith adapted to open its associated valve when a predetermined suction pressure is exceeded in said compressor, each of said valves being adapted when open to relieve the fluid pressure on the unloading means of its associated cylinder and each of said valves being provided with adjusting apparatus independent of the other valves by means of which the predetermined suction pressure at which each of said valves will open may be preselected.

CHARLES R. NEESON.

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