

May 12, 1953

A. B. NEWTON

2,638,265

COMPRESSOR UNLOADING APPARATUS

Filed Jan. 3, 1948

3 Sheets-Sheet 1

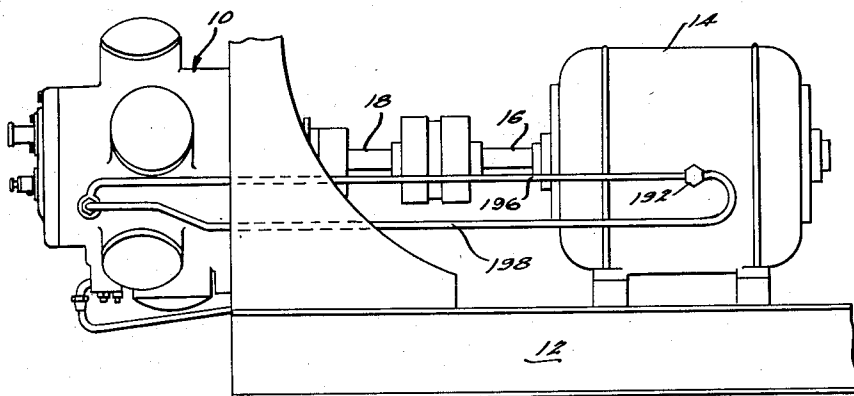


FIG. 1.

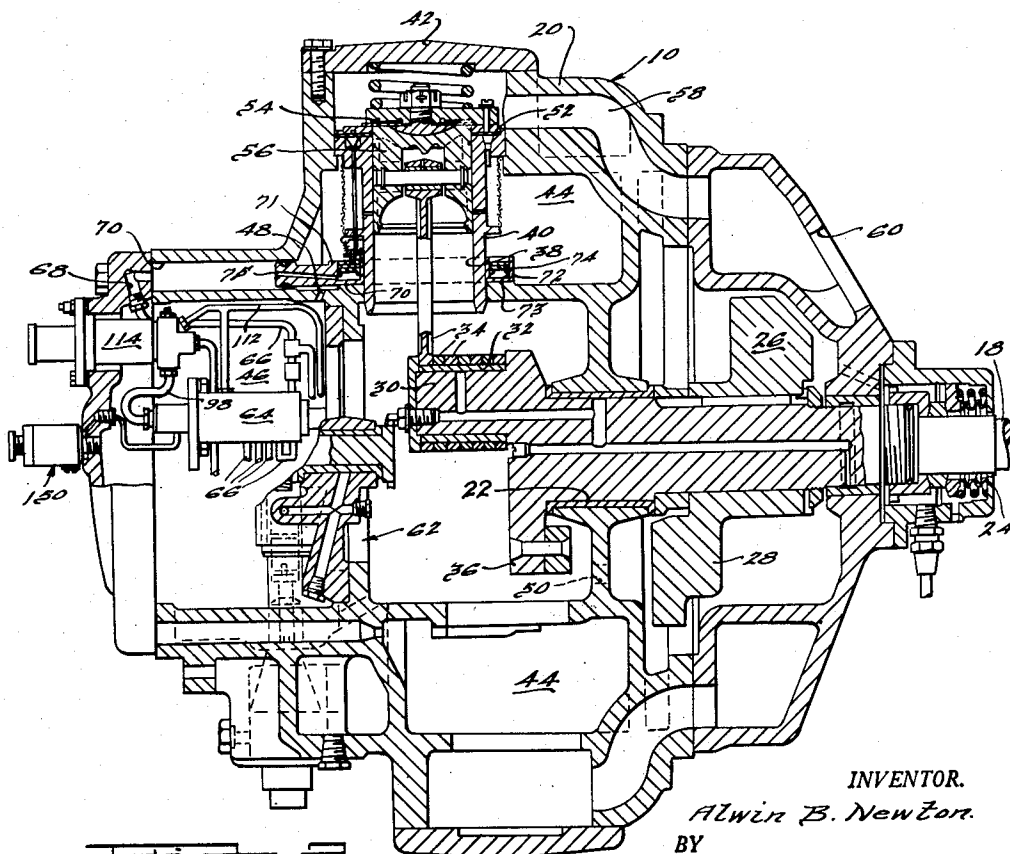


FIG. 2.

INVENTOR.
Alwin B. Newton.
BY
Harniss and Harris
ATTORNEYS.

May 12, 1953

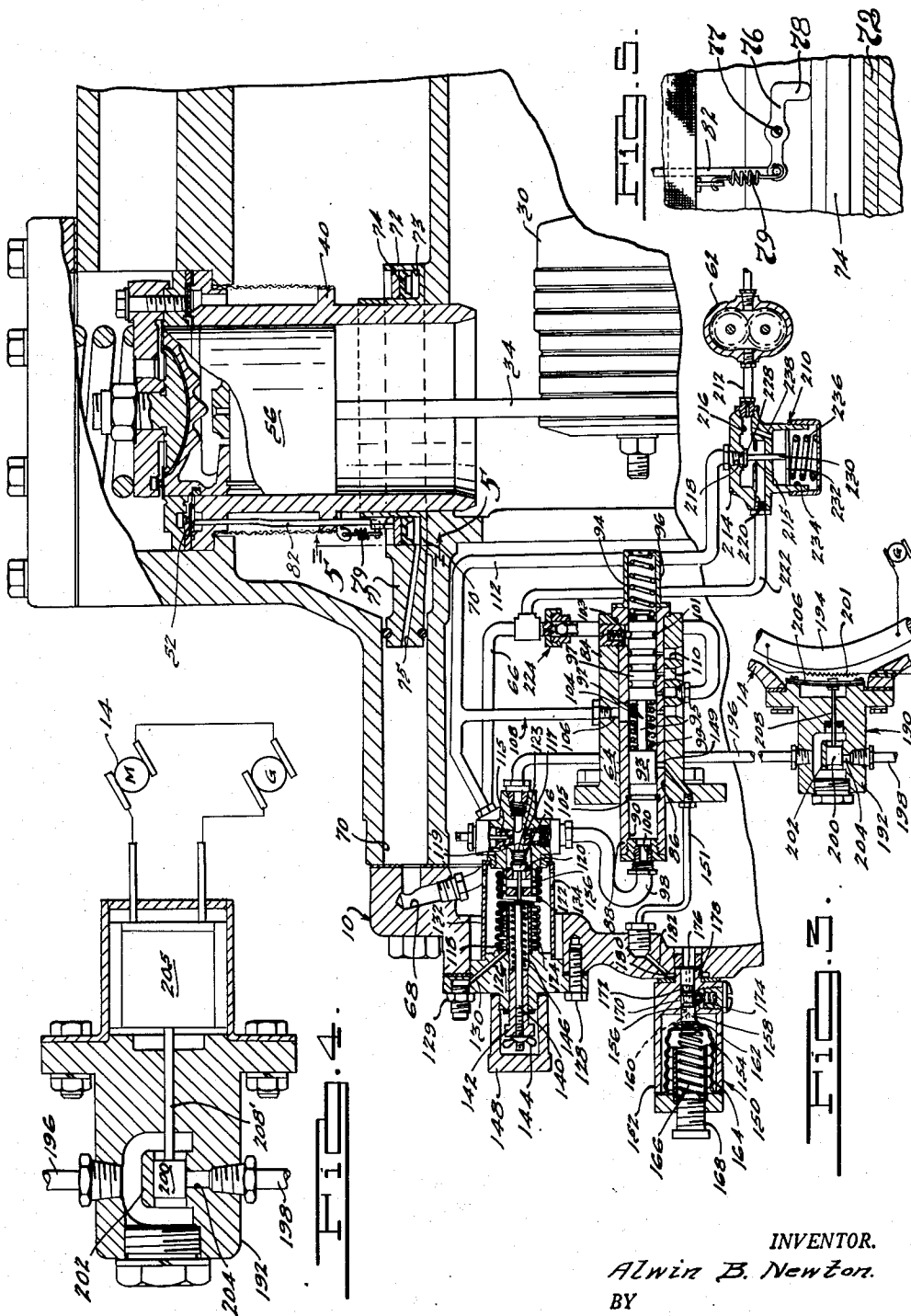
A. B. NEWTON

2,638,265

COMPRESSOR UNLOADING APPARATUS

Filed Jan. 3, 1948

3 Sheets-Sheet 2



INVENTOR.

Alwin B. Newton.

BY

Harness and Harris

ATTORNEYS.

May 12, 1953

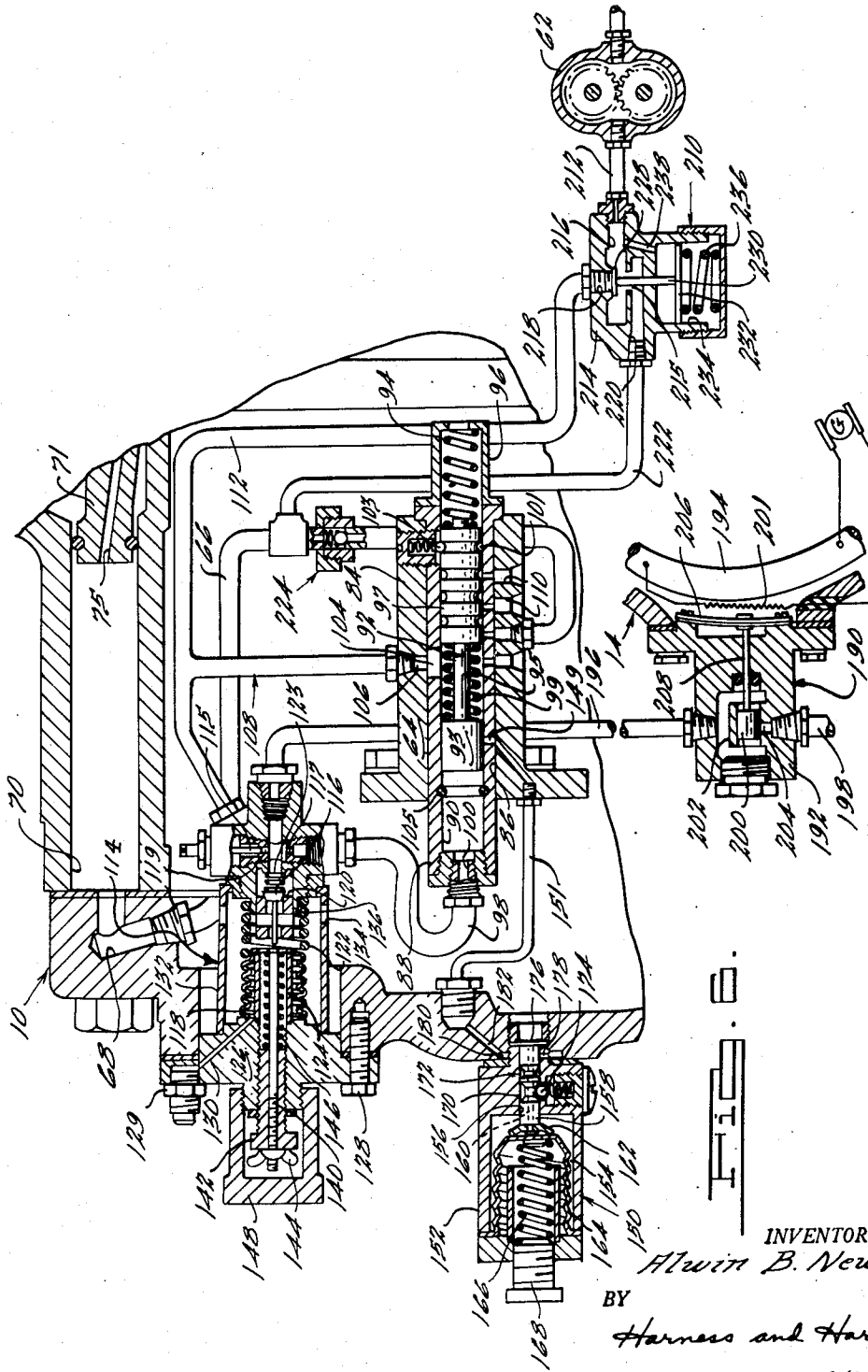
A. B. NEWTON

2,638,265

COMPRESSOR UNLOADING APPARATUS

Filed Jan. 3, 1948

3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,638,265

COMPRESSOR UNLOADING APPARATUS

Alwin B. Newton, Dayton, Ohio, assignor to
Chrysler Corporation, Highland Park, Mich., a
corporation of Delaware

Application January 3, 1948, Serial No. 444

8 Claims. (Cl. 230—31)

1

This invention relates to refrigerant compressors and more particularly to improved apparatus for selectively loading and unloading cylinders thereof in response to predetermined operating conditions.

Compressor unloading mechanisms and more particularly the unloading mechanism described in Patent No. 2,185,473, which issued to C. R. Neeson on January 2, 1947, are dependent upon mechanical linkages to operate a master control cylinder. It is an object of this invention to substitute a hydraulic means to control a master cylinder. A more sensitive control is possible with the hydraulic unloading mechanism than with the mechanism described in Patent No. 2,185,473. It has been observed that a change of approximately 2 pounds of suction pressure is required to cause the apparatus of the patent to move sufficiently to load one of the compressor cylinders. It is desirable to have a change of approximately 3 pounds in suction pressure produce a change from a complete loading to a minimum loading of the compressor or vice versa. Therefore, a mechanism is required which is sensitive enough to respond to a change in suction pressure equal to a small increment of the desired three pound spread. The size of the increment is determined by the number of cylinders to be controlled by the unloading mechanism. It is an object of this invention to provide a control with the required sensitivity.

It is a further object of the invention to provide a compressor unloading mechanism in which small forces and reduced movements of the component parts are sufficient to load or unload individual cylinders of the compressor.

It is a principal object of the invention to provide a control apparatus for unloading cylinders of a compressor where the control apparatus is particularly adaptable to being responsive to a plurality of operating conditions of a motor compressor set. It has been found that by hydraulically controlling the position of the master valve of a compressor unloader that various factors relating to suction pressure, motor overload and other factors, if desired, may be related to this principal hydraulic control so that the position assumed by the master valve of the unloader is the resultant of a plurality of controlling operating conditions existing in the motor compressor set. The composite control apparatus is thus capable of resolving a plurality of conditions to determine the optimum amount of compressor loading. The hydraulic means for controlling the position of the master valve of the

2

unloading apparatus is particularly adapted to be influenced by a multiplicity of control factors. A mechanical control of the master valve as described in Patent No. 2,185,473 does not lend itself readily to control in response to more than one operating condition.

It is an additional object of the invention to provide a means for interrupting the supply of oil to unloader pistons associated with the compressor cylinders where that means so operates that the oil supply line to an individual cylinder is either open or closed and is never partially closed with a throttled oil supply passing there-through.

It is a further object of the invention to associate with a hydraulically operated master control valve a means to dump the controlling oil from the valve when predetermined suction pressures are exceeded by the compressor. This provides a safety device which prevents overloading of the compressor.

It is an additional object of the invention to provide means to vary the pressure of oil delivered to a hydraulically operated master control valve in response to overheating of the motor driving the compressor and in response to the presence of an excessive amount of electric current in the field coil of the motor.

It is a further object of the invention to provide means to automatically load one compressor cylinder at the earliest possible moment after starting the compressor. This is accomplished by concentrating the entire output of the compressor oil pump on one unloader piston until the oil pressure is sufficiently high to indicate that enough oil is being supplied to operate through the normal unloader system involving all of the compressor unloader cylinders. The presence of refrigerant in the oil which occurs after a prolonged shutdown makes this feature of the unloader mechanism particularly desirable because a mixture of refrigerant such as Freon and oil cannot be pumped to as high a pressure as could oil itself. Thus, if even one cylinder can be loaded immediately after starting, the refrigerant can be pumped out of the oil and normal operation of the compressor can be obtained more quickly.

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;

3

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

Fig. 3 is a view partly in section and partly diagrammatic showing a portion of the compressor and the unloader controls associated therewith;

Fig. 4 is a view partly in section and partly diagrammatic showing a modified form of control responsive to the amount of current flowing in the motor of the motor compressor set;

Fig. 5 is a view taken on the line 5—5 of Fig. 3; and

Fig. 6 is an enlarged view of a portion of Fig. 3.

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. 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. Piston 56 is adapted to reciprocate in liner 40. The details and operation of the piston, seal, liner and valve assembly are more fully set forth in Neeson Patent No. 2,137,965, dated November 22, 1938. 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 Neeson Patent No. 2,185,473 a means for producing oil pressure is provided at 62. Oil pressure produced is used to lubricate

4

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 Figs. 2, 3 and 5 and comprises a passage 68, a bore 70 and a member 71 which has a portion sealed in bore 70 and has a ring portion 72 which surrounds liner 40. Ring portion 72 is provided with a channel 73 and ring piston 74 is adapted to reciprocate in channel 73. A port 75 connects channel 73 with bore 70 so that fluid admitted to bore 70 may enter channel 73 and raise piston 74. A plurality of circumferentially spaced unloader pins 82 extend longitudinally of liner 40 and are adapted to lift suction valve 52 so that the suction valve is held in its open position when piston 74 is not raised by fluid pressure. 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 usual work. A lever 76 is associated with each unloader pin 82. Each lever 76 is pivotally mounted at 77 and has one end thereof secured to a pin 82. The other end of each lever 76 is provided with a depending portion 78 which is adapted to engage the piston 74. A spring 79 is provided to retain portion 78 in contact with piston 74 and to raise pin 82 when fluid pressure is not present below piston 74. Pins 82 are adapted to open suction valve 52 and "unload" the cylinder when fluid pressure is not present below the piston 74.

When the system is at rest, the suction valves are held in open position due to the lack of oil pressure beneath the piston 74. When the motor is starting the reciprocation of the compressor pistons 56 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 74.

Control mechanisms are adapted to control the delivery of oil to the pistons 74 in response to predetermined motor and compressor operating conditions. The master valve 64 comprises a housing 84 having an axial bore 86 therein. A liner 88 which also contains an axial bore 90 is secured within bore 86 and adapted to receive a piston 92 therein. A spring 94 is contained within the bore 90 and acts upon one end of piston 92 to urge it to the left in Fig. 3. The other end of the spring 94 reacts upon a cap 96 secured to liner 88. A line 98 is adapted to deliver fluid to or receive fluid from a port 100 in that end of liner 88 which is opposite to the end carrying the spring 94. The relationship between the strength of spring 94 and the pressure of fluid delivered by line 98 will determine the position of piston 92 in bore 90. The central portion 95 of piston 92 is provided with a restricted diameter so that a space 104 is provided between the portion 95 and the wall of bore 90. Housing 84 and liner 88 are provided with cooperating aligned openings which form a port 106. A line 108 connects port 106 with a source of fluid under pressure. The housing 84 and liner 88 are provided with a plurality of aligned openings which cooperate to provide a number

of axially spaced discharge ports 110. Each discharge port 110 has a line 66 connected thereto so that fluid discharged from a port 110 will be transported to a passage 68 and a bore 70 associated with the unloader mechanism of one of the compressor cylinders. Fluid flow communication is provided in master cylinder 64 from line 108 through inlet port 106, space 104 to discharge ports 110 when piston 92 is positioned to accomplish this. Axial movement of piston 92 in bore 90 can effectively block one or more of the discharge ports 110 from the fluid delivered by line 108. When any discharge port 110 is so blocked oil is not delivered to the related bore 70 and the compressor cylinder associated with that particular port 110 becomes unloaded due to the action of the spring 79 in its unloader mechanism. The lines 98 and 108 are preferably joined to a common line 112 which is connected to a source of fluid under pressure.

Piston 92 is preferably so constructed that no partial throttling of the oil supply to any one of the lines 66 can occur. The piston 92 preferably comprises an assembly of a first piston element 93 having an axial rod 95 secured thereto and a second piston element 97 slidably mounted on the rod 95. The piston elements 93 and 97 are urged apart by a small spring 99 which is weaker than spring 94. The piston element 97 is provided with a plurality of circumferential grooves 101 adapted to cooperate with a spring loaded ball detent 103 mounted in liner 88 to positively position piston element 97 at a plurality of stations which will fully load or unload individual compressor cylinders. A stop 105 may be provided to assure the loading of at least a minimum number of cylinders.

To control the position of piston 92 in master valve 64 I have provided a control means 114 which is associated with line 98. The control means 114 is adapted to bleed fluid from line 98 under predetermined conditions. Control means 114 comprises a normally closed bleed valve 116 and cooperating valve seat 120 which are located in fluid flow communication with line 98. A bellows 118 contained within control means 114 is adapted to position valve 116. Valve 116 modulates or entirely restricts the flow of fluid from control means 114 to line 98. A spring 122 urges bellows 118 against a stop member 124 which corresponds to a position wherein valve 116 is positioned on seat 120 and the flow of fluid into control means 114 is completely interrupted. These components of the control means 114 are mounted upon a plate 126 which is attached to the compressor housing 10 by bolts 128. A port 130 connects the interior of bellows 118 with the atmosphere. If desired a fitting 129 may be provided to connect the interior of bellows 118 to an external control means similar to that shown in my Patent No. 2,581,329. A cover 132 for the control means 114 is provided with openings 134. As the suction pressure within the interior 46 of the compressor housing falls the bellows 118 extends to open valve 116. A fluid flow communication is provided from valve 116 to the compressor housing by the opening in valve seat 120 and openings 136 and 134. Oil thus bled from line 98 may fall by gravity to the sump in the bottom of the compressor housing and the pressure of the fluid in line 98 will be determined by the amount of relief provided by valve 116. The position of piston 92 is determined by the pressure of fluid in line 98. This

position will determine which of the compressor cylinders are loaded. Continued operation of the compressor with certain cylinders loaded will alter the suction pressure within the interior of the compressor housing which in turn will relocate bellows 118 and reposition valve 116 to reflect this change in suction pressure in the position of piston 92. The new position of piston 92 will load additional compressor cylinders thereby repeating the cycle of increasing the suction pressure and repositioning the piston 92. Control means 114 loads cylinders as the suction pressure increases and unloads cylinders with decrease in suction pressure.

A pair of orifices 117 and 119 are provided in fluid flow communication with line 98. An adjustable needle valve 115 controls the discharge of oil from line 112 through orifice 119 and thereby provides means for varying the sensitivity of the system. Orifice 117 controls the rate of change of position of piston 92 for any given change in the opening of valve 116.

A manual control may be associated with the control means 114 if desired to provide a means for wedging the system to a loaded position. This manual control includes an adjusting screw 140 which is slidably locked in a nut 142 carried by plate 126. A lock nut 144 is threaded on screw 140. A spring 146 is provided to extend adjusting screw 140. A threaded cap 148 may be provided to cover this apparatus. The operator by removing cap 148 and turning lock nut 144 may retract screw 140 and permit spring 123 to seat valve 116 on seat 120 thereby rendering control means 114 inoperative and preventing its interference with the loading of compressor cylinders. During periods of normal automatic operation the lock nut 144 is removed so that screw 140 is not restricted in its axial movement in response to movement of bellows 118.

Supplemental controls may also be provided to unload compressor cylinders by bleeding oil from line 98 and bore 90 in response to other operating conditions of the compressor or motor. The copending application of C. R. Neeson, Serial No. 786,273, filed November 15, 1947, which has matured into Patent No. 2,522,762, describes an improved mechanism for bleeding oil from an unloader apparatus in response to increased suction pressure in a compressor thereby permitting springs 79 to unload compressor cylinders. The hydraulic control means described herein for master cylinder 64 is particularly adapted to operate in conjunction with the high suction pressure bleeding device described in the Neeson application. This device is generally designated by the numeral 150 and is adapted to bleed fluid from bore 90 in master valve 64. A port 149 is provided in liner 88 and operatively connected by a line 151 to control means 150. Port 149 is preferably located axially in liner 88 in such a position that piston element 93 will block this port until a predetermined minimum number of compressor cylinders are loaded. The control means 150 comprises a housing 152 having a cylinder 154 therein and a bore 156 extending axially of the housing 152 through one end thereof. A valve element 158 is adapted to reciprocate in bore 156. Valve element 158 has an axial opening 160 extending therethrough and exposed to the suction pressure existing in the interior 154 in the compressor housing. Legs 162 secure the valve element 158 to the end portion of a collapsible bellows 164. The other end of the bellows 164 is sealed by the top of the casing 152.

7

A spring 166 is provided within the bellows 164 and adapted to react against an adjusting screw 168 threaded through the top of the casing 152. Adjustment of the screw 168 preselects the compression of spring 166. Spring 166 resists collapsing of the bellows 164. Suction pressure transmitted from the interior 46 of the compressor through axial opening 160 to the cylinder 154 tends to compress bellows 164 thereby producing linear movement of valve element 158 in accordance with variations in suction pressure within the compressor. When the suction pressure is greatest the valve element 158 is moved inwardly in housing 152 and when the suction pressure is low spring 166 moves valve element 158 outwardly. Valve element 158 is provided with a pair of adjacent recessed portions 170 and 172 in its surface. A spring pressed ball detent 174 is adapted to enter recessed portion 170 or recessed portion 172 depending on the position of the valve element 158. A pin 176 in housing 152 limits outward movement of valve element 158. Valve element 158 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 178 provided in housing 152 adjacent the outer end of valve element 158 communicates with a chamber 180 and a passage 182. The passage 182 is in fluid flow communication with line 151 and port 149 which, as explained above is in fluid flow communication with bore 98 and line 98 unless port 149 is blocked by piston element 92. When valve element 158 is in the position shown in Fig. 3 the port 178 is blocked thereby and the fluid pressure in line 98 is unaffected by control 150. However, when the suction pressure existing in the interior 46 of the compressor becomes excessive the bellows 164 is collapsed and the valve element 158 retracted until ball 174 drops into recessed portion 172 therein. This provides a fluid flow communication from line 98 through passage 182, chamber 180, port 178 and bore 156 to the interior 46 of the compressor. This provides a relief for oil pressure in line 98 so that the number of discharge ports 110 blocked by piston 92 is increased and more cylinders are unloaded. It is to be understood, however, that if desired control 150 could be made responsible to discharge pressure or to both discharge pressure and suction pressure.

An additional control adapted to bleed fluid from line 98 and which is responsive to operating conditions of motor 14 may be provided. This control has been designated by the numeral 190. The control 190 consists of a temperature responsive valve 192 which is secured to the housing of the motor 14. The usual field coil 194 of motor 14 is diagrammatically illustrated and it is the temperature thereof which will determine the operation of the valve 192. Valve 192 is connected by a line 196 to line 98 which is the source of fluid under pressure to master valve 64. Line 196 bleeds oil from line 98 to valve 192. A line 198 returns oil from valve 192 to the interior 46 of the compressor housing 20. The valve 192 is provided with a hollow interior portion and a slidable element 200. The slidable element 200 is adapted for linear movement within a guide 202. A port 204 operatively connects the interior of the valve 192 to the line 198. Slidable element 200 is adapted to selectively open and close port 204. The position of slidable element 200 is determined by the deformation of a bimetallic disk

8

206 located within valve member 192 in close proximity to field coil 194 of motor 14. A rod 208 operatively connects bimetallic element 206 and slidable element 200. When the temperature of coil 194 becomes excessive bimetallic element 206 deflects to the right in Fig. 3 thereby opening port 204 and permitting oil to be bled from line 98 to the interior 46 of the compressor housing.

A resistance wire 201 may be placed in close proximity to the bimetallic element 206, if desired. The resistance wire 201 is connected in series with the field coil 194 of motor 14 and adapted to heat the bimetallic element 206 when an excessive amount of electric current is present in the field coil 194. The resistance wire 201 possesses an advantage over the use of direct motor heat to actuate bimetallic element 206 in that the response is quicker. In the event of motor overload an interval of time is required for the entire motor to heat up. Resistance 201 heats up much faster.

A modified form of control responsive to motor overload is illustrated in Fig. 4. A valve 192 which is similar to the valve illustrated in Fig. 3 is provided with a rod 208' which comprises the movable portion of a solenoid 205 and operates within a sealed tube in solenoid 205 as is common in solenoid valve construction. The solenoid 205 is connected in series with the field coil 194 of motor 14 and is adapted to be actuated to move element 200 to a position providing a fluid flow communication between lines 196 and 198 when a predetermined excessive amount of current passes through field coil 194 of motor 14.

One or all of these means for bleeding oil through line 196 in response to motor overload may be used in an installation.

Operation

In the operation of the control device herein described it will be seen that fluid under pressure such as oil is delivered to line 112 by lubricating pump 62 and that line 112 divides to form lines 98 and 108 with the line 108 serving as the source of fluid to be selectively delivered to a plurality of lines 66 under the control of a master valve 64. Each of the lines 66 is connected to a port 110 and the ports 110 are spaced axially along master valve 64 so that the position of piston 92 determines which ports 110 are in communication with fluid supplied by line 108. Each of the lines 66 is adapted to deliver fluid to the unloading mechanism described herein and associated with individual cylinders to load these cylinders when oil is delivered thereto. The position of the piston 92 in the master valve is determined by the fluid pressure supplied to the master valve through branch line 98 and the modulating valve 114 is adapted to bleed oil from line 98 thereby reducing the pressure on piston 92 as the suction pressure decreases. In other words, as the suction pressure increases the modulating valve 114 bleeds less fluid from line 98 thereby increasing the oil pressure on piston 92 and forcing piston 92 to the right in Figs. 3 and 6 to expose additional ports 110 to oil delivered by line 108 to load more of the cylinders.

The control device 150 is provided to bleed fluid from master valve 64 and permit spring 94 to move piston 92 to the left to unload additional cylinders when the suction pressure exceeds a predetermined value and piston 92 is located in a position corresponding to the loading of a predetermined number of compressor cylinders so

that port 149 is uncovered. It will be noted that modulating valve 114 bleeds the greatest amount of oil from line 98 when the compressor suction pressure is low while device 150 does not become operative until port 149 is uncovered by piston 92 which indicates that a predetermined number of compressor cylinders are loaded and then device 150 operates to bleed oil through orifice 149 when the suction pressure is great enough to collapse bellows 164.

An additional control 190 is provided to bleed fluid from line 98 and cause cylinders to be unloaded when the operating conditions of the motor 14 indicate that this would be desirable by opening the temperature responsive valve 192. The temperature responsive valve 192 is opened when the motor temperature becomes excessive or when the amount of electric current present in the field coil 194 becomes excessive. An additional supplementary control which assures the initial loading of one or more compressor cylinders is hereinafter described.

An additional supplementary control may be provided to assure the initial loading of one or more compressor cylinders and after a minimum predetermined oil pressure is established to operate the unloader mechanism master valve 64. This concentrates the entire output of the oil pump on the one or more unloader pistons until the oil pressure is sufficiently high to indicate that enough oil is being supplied to operate through the normal unloader system involving all of the cylinders. This device is generally designated by the numeral 210 and is interposed in the fluid supply line 112 between the fuel pump 62 and the master valve 64. A line 212 connects the fuel pump 62 with the device 210. The device 210 is provided with a housing 214 having an inlet 216 to which the line 212 is connected and having a first discharge port 218 to which the line 112 is connected and a second discharge port 220 to which a line 222 is connected. The line 222 is connected to one of the lines 66 extending between the master valve 64 and the unloader mechanism of an individual cylinder. More than one line 222 could be provided if desired and in that event each line 222 would be connected to a different line 66. The line 66 is provided with a one-way valve 224 which prevents oil delivered by line 222 from traveling to the master valve 64 although it permits oil to travel from the master valve through line 66. The housing 214 of device 210 is provided with a port 215 which connects inlet port 216 and discharge port 220. A valve element 228 is adapted to selectively seal discharge port 218 and port 215 and carries a valve stem 230 which is secured to a piston 232. The piston 232 is adapted to reciprocate in a cylinder 234 provided in housing 214. A spring 236 urges piston 232 to seat the valve 228 across discharge opening 218. A port 238 provides a fluid flow communication between inlet port 216 and cylinder 234 above piston 232 so that the oil pressure existing in passage 226 exerts a force upon piston 232 tending to unseat valve element 228 from opening 218 and to seat it across port 215. It will thus be seen that when the compressor is initially started the pump 62 will deliver oil through line 212, passage 226, line 222, line 66, and passage 68 to bore 70 thereby loading the cylinder associated with the line 66 to which oil is delivered. After the compressor operates for a limited time interval the oil pressure will increase and the piston 232 will be forced downwardly against spring 236 thereby unseating valve ele-

ment 228. This opens discharge port 218 and closes port 215 so that subsequently the oil delivered by pump 62 will be transported by lines 112, 108 and 98 to the master valve 64 thereby permitting the operation of the compressor cylinders to be controlled by the mechanism previously described herein.

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. In a motor driven multi-cylinder compressor set having a first means for unloading individual cylinders thereof, a fluid pressure responsive 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, means to deliver fluid under pressure to said fluid pressure responsive means including a source of fluid under pressure and a master valve adapted to be positioned by said fluid, said valve comprising a fixed member and a relatively movable member, one of said members being provided with a plurality of discharge ports and a first inlet port, said movable member being adapted to control the communication of fluid from said inlet port to said individual discharge ports in relation to its position relative to said fixed member, said one member having a second inlet port for the admission of fluid to position said movable member relative to said fixed member, means operatively connecting said discharge ports with their respective fluid pressure responsive means, means to deliver fluid from said source to said first inlet port and means to deliver fluid from said source to said second inlet port, said last mentioned means including a suction pressure responsive valve of the modulating type adapted to regulate the delivery of fluid to said second inlet port in response to suction pressure in said compressor.

2. In a motor driven multi-cylinder compressor set, unloading means in conjunction with individual cylinders operable to unload these cylinders 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 whereby to load all of the cylinders, and unloading control means responsive to the pressure in said compressor to connect or disconnect said fluid pressure creating means successively to or from individual cylinder unloading means, said control means comprising a master valve having a fluid flow connection with said fluid pressure creating means and adapted to be positioned by fluid pressure at different positions to connect or disconnect different cylinders with said fluid pressure creating means and a suction pressure responsive valve of the modulating type interposed in said fluid flow connection to control the position of said master valve by metering fluid to said master valve in response to predetermined suction pressure operating conditions of said set.

3. In a motor driven multi-cylinder compressor set having a first means for unloading individual cylinders thereof, a fluid pressure responsive 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, means to deliver fluid under pressure to said fluid

pressure responsive means including a source of fluid under pressure and a master valve adapted to be positioned by said fluid, said valve comprising a fixed member and a relatively movable member, one of said members being provided with a plurality of discharge ports and a first inlet port, said movable member being adapted to control the communication of fluid from said inlet port to said individual discharge ports in relation to its position relative to said fixed member, said one member having a second inlet port for the admission of fluid to position said movable member relative to said fixed member, means operatively connecting said discharge ports with their respective fluid pressure responsive means, means to deliver fluid from said source to said first inlet port and means to deliver fluid from said source to said second inlet port, said last mentioned means including a suction pressure responsive valve of the modulating type adapted to bleed fluid from said master valve and means forming a fluid flow connection between said master valve and said suction pressure responsive valve including a port in said fixed member positioned to be obstructed by said movable member until said movable member assumes a position corresponding to the loading of a predetermined number of compressor cylinders.

4. In a motor driven multi-cylinder compressor set having a first means for unloading individual cylinders thereof, a fluid pressure responsive 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, means to deliver fluid under pressure to said fluid pressure responsive means including a source of fluid under pressure and a master valve adapted to be positioned by said fluid, said valve comprising a fixed member and a relatively movable member, one of said members being provided with a plurality of discharge ports and a first inlet port, said movable member being adapted to control the communication of fluid from said inlet port to said individual discharge ports in relation to its position relative to said fixed member, said one member having a second inlet port for the admission of fluid to position said movable member relative to said fixed member, means operatively connecting said discharge ports with their respective fluid pressure responsive means, means to deliver fluid from said source to said first inlet port, means to deliver fluid from said source to said second inlet port, apparatus adapted to bleed fluid from said last mentioned means in response to predetermined operating conditions of said set to thereby regulate the pressure of fluid delivered to said second inlet port, and means to deliver all of the fluid from said source to the fluid pressure responsive means associated with at least one of the compressor cylinders and to by-pass said master valve until a predetermined fluid pressure is exceeded.

5. In a motor driven multi-cylinder compressor set having a first means for unloading individual cylinders thereof, a fluid pressure responsive 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, means to deliver fluid under pressure to said fluid pressure responsive means including a source of fluid under pressure and a master valve adapted to be positioned by said fluid, said valve comprising a fixed member and a relatively movable member, one of said members being provided with a plurality of discharge ports and a first inlet port, said movable member being adapted to control the communication of fluid from said inlet port to said individual discharge ports in relation to its position relative to said fixed member, said one member having a second inlet port for the admission of fluid to position said movable member relative to said fixed member, means operatively connecting said discharge ports with their respective fluid pressure responsive means, means to deliver fluid from said source to said first inlet port, means to deliver fluid from said source to said second inlet port, a first apparatus adapted to reduce the pressure of fluid delivered to said second inlet port when the suction pressure in said compressor is less than a predetermined minimum, a second apparatus adapted to reduce the pressure of fluid delivered to said second inlet port when the suction pressure in said compressor exceeds a predetermined maximum, and means to deliver all of the fluid from said source to the fluid pressure responsive means associated with at least one of the compressor cylinders and to by-pass said master valve until a predetermined fluid pressure is exceeded.

able member, one of said members being provided with a plurality of discharge ports and a first inlet port, said movable member being adapted to control the communication of fluid from said inlet port to said individual discharge ports in relation to its position relative to said fixed member, said one member having a second inlet port for the admission of fluid to position said movable member relative to said fixed member, means operatively connecting said discharge ports with their respective fluid pressure responsive means, means to deliver fluid from said source to said first inlet port, means to deliver fluid from said source to said second inlet port, apparatus adapted to bleed fluid from said last mentioned means in response to predetermined operating conditions of said set to thereby regulate the pressure of fluid delivered to said second inlet port, a fluid pressure responsive valve interposed in the path of fluid from said source to said master valve and adapted to prevent the delivery of fluid to said master valve until a predetermined fluid pressure is obtained and means forming a direct fluid flow communication between said source and the fluid pressure responsive means associated with one of said cylinders and adapted to concentrate all available fluid pressure thereon until a predetermined fluid pressure is exceeded and said fluid pressure responsive valve is opened.

6. In a motor driven multi-cylinder compressor set having a first means for unloading individual cylinders thereof, a fluid pressure responsive 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, means to deliver fluid under pressure to said fluid pressure responsive means including a source of fluid under pressure and a master valve adapted to be positioned by said fluid, said valve comprising a fixed member and a relatively movable member, one of said members being provided with a plurality of discharge ports and a first inlet port, said movable member being adapted to control the communication of fluid from said inlet port to said individual discharge ports in relation to its position relative to said fixed member, said one member having a second inlet port for the admission of fluid to position said movable member relative to said fixed member, means operatively connecting said discharge ports with their respective fluid pressure responsive means, means to deliver fluid from said source to said first inlet port, means to deliver fluid from said source to said second inlet port, a first apparatus adapted to reduce the pressure of fluid delivered to said second inlet port when the suction pressure in said compressor is less than a predetermined minimum, a second apparatus adapted to reduce the pressure of fluid delivered to said second inlet port when the suction pressure in said compressor exceeds a predetermined maximum, and means to deliver all of the fluid from said source to the fluid pressure responsive means associated with at least one of the compressor cylinders and to by-pass said master valve until a predetermined fluid pressure is exceeded.

7. In a motor driven multi-cylinder compressor set having a first means for unloading individual cylinders thereof, a fluid pressure responsive means adapted to selectively overrule the action of said first means with respect to individual cylinders to load said individual cylinders under

13

predetermined operating conditions, means to deliver fluid under pressure to said fluid pressure responsive means including a source of fluid under pressure and a master valve adapted to be positioned by said fluid, said valve comprising a fixed member and a relatively movable member, one of said members being provided with a plurality of discharge ports and a first inlet port, said movable member being adapted to control the communication of fluid from said inlet port to said individual discharge ports in relation to its position relative to said fixed member, said one member having a second inlet port for the admission of fluid to position said movable member relative to said fixed member, means operatively connecting said discharge ports with their respective fluid pressure responsive means, means to deliver fluid from said source to said first inlet port, means to deliver fluid from said source to said second inlet port, said fixed member being provided with a port so located that under certain conditions it is covered by said movable member and under other conditions it is exposed to fluid delivered by said last mentioned means and apparatus adapted to control the disposition of fluid entering said last mentioned port by bleeding increasing amounts of fluid from said fixed member through said last mentioned port when the suction pressure in said compressor increases above a predetermined maximum, the covering of said last mentioned port by said movable member assuring that a predetermined minimum number of compressor cylinders will be loaded.

14

8. In a motor driven multi-cylinder compressor set having a first means for unloading cylinders thereof, a fluid pressure responsive means adapted to selectively overrule the action of said first means with respect to individual cylinders under predetermined operating conditions, means defining a first circuit to deliver fluid under pressure to said fluid pressure responsive means including a source of fluid under pressure and a master valve adapted to be positioned by said fluid and to selectively connect said source with the fluid pressure responsive means of individual cylinders, means defining a second circuit to deliver fluid directly from said source to the fluid pressure responsive means of one cylinder and to by-pass said master valve as an incident to starting of the compressor to thereby concentrate the full pressure of said source on the fluid pressure responsive means of said one cylinder and means to render said second circuit inoperative and said first circuit operative after initial starting of the compressor.

ALWIN B. NEWTON.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,786,791	Terry	Dec. 30, 1930
2,137,219	Aikman	Nov. 22, 1938
2,169,554	Buchanan	Aug. 15, 1939
2,185,473	Neeson	Jan. 2, 1940
2,304,999	Gonzales	Dec. 15, 1942
2,387,117	Buehler	Oct. 16, 1945