May 26, 1936. B. S. AIKMAN 2,042,085

COMPRESSOR UNLOADER

Filed Nov. 11, 1933 2 Sheets-Sheet 1

Fig. 1.

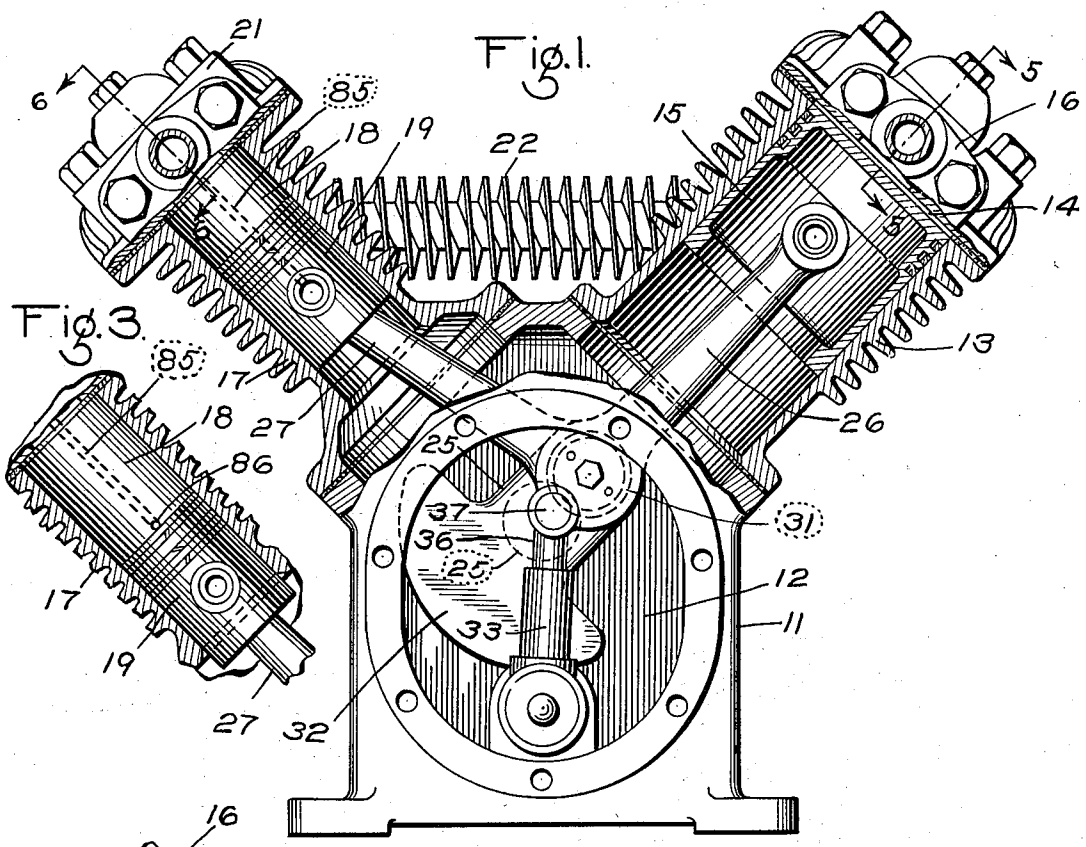
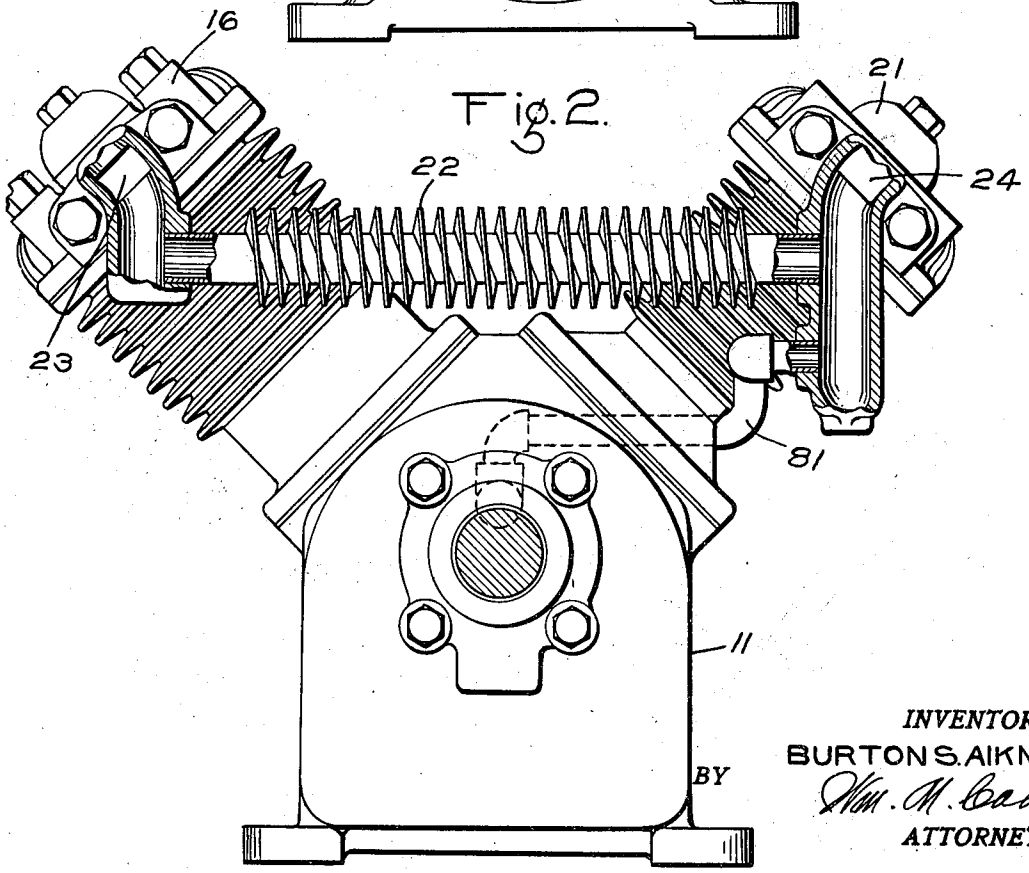


Fig. 3.

Fig. 2.



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Filed Nov. 11, 1933 2 Sheets-Sheet 2

Fig. 4

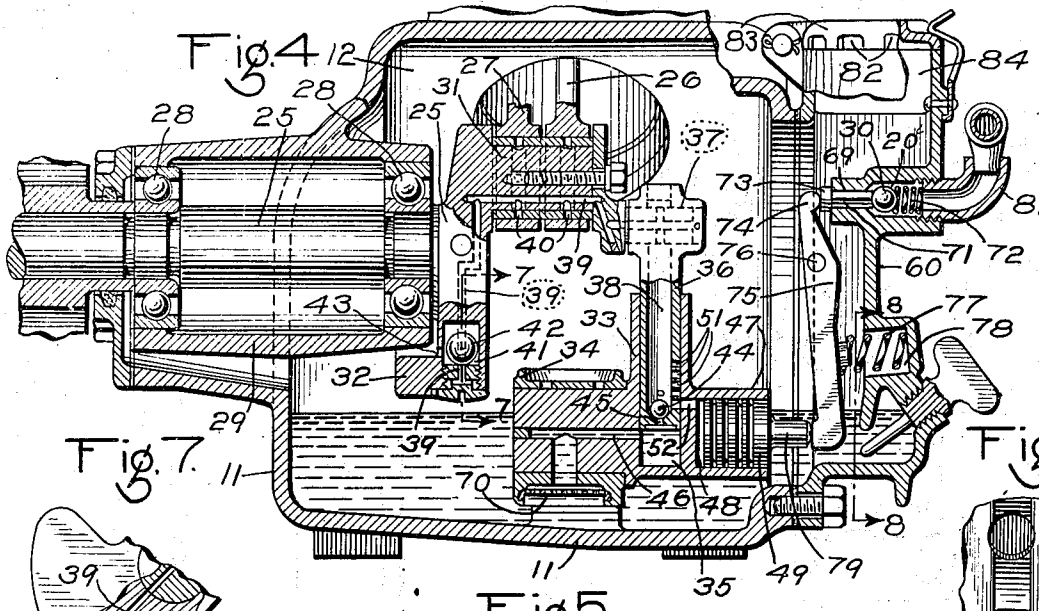


Fig. 7.

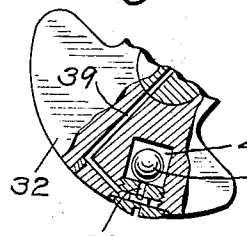


Fig. 8.

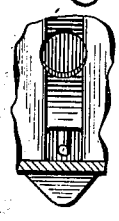


Fig. 5.

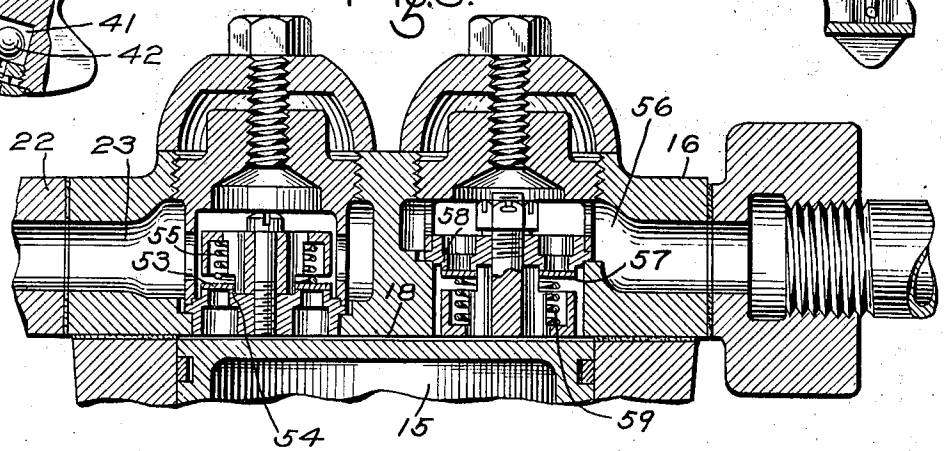
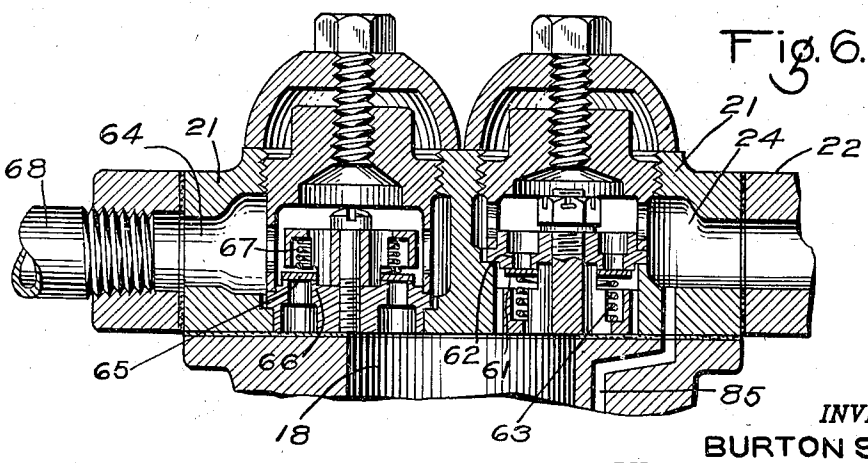


Fig. 6.



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COMPRESSOR UNLOADER

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Application November 11, 1933, Serial No. 697,669

19 Claims. (Cl. 230—27)

This invention relates to compressors and particularly to multi-stage compressors and unloading mechanism therefor.

It is an object of this invention to provide a multi-stage compressor with an unloader that is adapted to unload the compressor when the speed thereof falls below a predetermined value, and to maintain the compressor unloaded while starting, until such speed has been attained as will render it safe to impose a load on the driving unit, which may be either an electric motor or an internal combustion engine, or any preferred prime mover.

Another object of the invention is to provide a multi-stage compressor and unloader therefor, wherein unloading is automatically accomplished when the compressor is stopped, by opening communication from the intercooler to the atmosphere and opening communication from the high pressure compression chamber to the intercooler, and wherein the intercooler is maintained at atmospheric pressure while starting, until the compressor has attained such speed that the full load may be safely assumed thereby.

A further object of the invention is to provide an unloader for a multi-stage compressor, wherein the unloader valve is actuated by the fluid lubricant of the lubricating system and is responsive to variations in pressure of the fluid lubricant, and wherein the pressure of the fluid lubricant is regulated by a centrifugally controlled means, so that loading of the compressor is accomplished when the speed of the compressor attains a predetermined value.

These and other objects of the invention that will be made apparent throughout the further description thereof are attained by means of the compressor and unloader apparatus hereinafter described and illustrated in the accompanying drawings; wherein

Fig. 1 is an elevational view, partly in section, of a compressor embodying features of the invention;

Fig. 2 is an elevational view of the side of the compressor opposite to that shown in Fig. 1;

Fig. 3 is a fragmental sectional view of a portion of the high compression cylinder showing the piston at the bottom of its stroke;

Fig. 4 is a sectional view of the crank case of the compressor shown in Fig. 1;

Figs. 5 and 6 are sectional views of the valve heads of the low and high pressure cylinders, respectively;

Fig. 7 is a fragmental sectional view taken on the line 7—7 of Fig. 4; and

Fig. 8 is a view partly in elevation and partly in section, of a detail of the apparatus, the section being taken on the line 8—8 of Fig. 4, in the direction of the arrows.

Referring to the drawings, and particularly to Figs. 1 and 4, the compressor apparatus comprises a crank case 11 having a crank chamber 12, a low pressure cylinder casing 13 having a compression chamber 14 containing a low pressure piston 15, a low pressure valve head 16 closing the low pressure compression chamber 14, a high pressure cylinder casing 17 having a high pressure compression chamber 18 containing a high pressure piston 19, a high pressure valve head 21 and an intercooler 22 which serves to connect the outlet chamber 23 of the low pressure valve head 16 with the inlet chamber 24 of the high pressure valve head 21, as indicated in Fig. 2.

The pistons 15 and 19 are connected in the usual manner to a crank shaft 25 by connecting rods 26 and 27 respectively, the crank shaft being journaled in anti-friction bearings 28 mounted in a bearing housing 29 that is integral with the crank case 11. The crank shaft 25 is adapted to be connected to a prime mover, such as an electric motor or an internal combustion engine, and is provided with a crank arm 31 upon which the connecting rods 26 and 27 are journaled. The crank arm is counterbalanced by a counterweight arm 32 that is integral with the crank shaft 25.

The fluid lubricating system of the compressor comprises a pump cylinder casing 33 that is journaled for oscillation in a fixed bearing 34 that is integral with the crank case 11, and which contains a compression chamber 35 in which the pump plunger 36, which is journaled upon a crank pin 37 carried by the crank arm 31, is adapted to reciprocate when the crank shaft 25 is rotated. The pump plunger 36 is hollow and is provided with a chamber 38 which communicates at its upper end with a lubricant passage 39 which extends through the crank pin 37 and the crank arm 31 and into the counterweight arm 32. The counterweight arm is provided with a valve chamber 41 containing a ball check valve 42 which serves to close the passage 39 when the ball check valve 42 is thrown outwardly by centrifugal force with sufficient force to overcome the pressure of the lubricant within the passage 39. A port 43 establishes communication from the valve chamber 41 to the crank case chamber 12 and through which fluid lubricant may flow from the valve chamber 41 to the crank case chamber 12 when sufficient fluid pressure is gen-

erated within the passage 39 by the plunger 36 to unseat the ball check valve 42. Passages 40 conduct fluid lubricant from the passage 39 to the connecting rod bearings.

The chamber 38 in the pump plunger 36 contains a ball check valve 44 that is adapted to close a port 45 in the end wall of the plunger 36 during the suction stroke of the plunger, and which is adapted to be forced from the closed position, shown in Fig. 4, during the compression stroke of the plunger, to permit fluid within the chamber 35 to be forced into the chamber 38 of the plunger. An inlet passage 46 establishes communication from the crank case chamber 12 to the compression chamber 35 and is protected by a screen 47 for preventing the entrance of foreign particles into the pump chamber 35. The inlet passage 46 is adapted to be closed by the plunger 36 upon initial movement of the plunger 36 in its compression or downward stroke.

As the crank shaft 25 is rotated during the operation of the compressor, the pump plunger 36 is reciprocated within the compression chamber 35, and fluid lubricant is forced past the ball check valve 44 when the plunger is moved into the compression chamber 35. The lubricant thus forced into the chamber 38 is conducted to the bearings of the connecting rods 26 and 27 and to the valve chamber 41 containing the ball check valve 42. Fluid lubricant flows past the ball check valve 42 until the speed of rotation of the crank shaft is sufficient to cause the bell check valve 42 to be forced by centrifugal force into the closed position, shown in Fig. 4, against the pressure of the fluid lubricant in the passage 39. Until the ball check valve 42 closes the passage 39, the fluid lubricant will be circulated by the pump, which draws it into the inlet passage 46 and discharges it through the port 43 in the counterweight arm 32.

The pump cylinder casing 33 is provided with a cylinder 47 having a chamber 48 containing a plunger 49 that is adapted to operate an unloader valve device to be hereinafter described. The chamber 48 is adapted to be supplied with fluid lubricant under pressure from the chamber 38 though a series of ports 51 which are adapted to successively register, as the plunger 36 is reciprocated, with a slightly larger port 52 leading from the chamber 35 to the chamber 48. It is apparent from the foregoing that as the pump plunger 36 is reciprocated, fluid under pressure forced into the plunger chamber 38 is also forced through the passages 51 and 52 into the chamber 48, thereby causing fluid under pressure to act on the plunger 49, the pressure of the lubricant being determined by the centrifugally controlled ball valve 42.

Referring to Fig. 5, the valve head 16 of the low pressure cylinder contains an outlet chamber 23 which is adapted to receive fluid under pressure compressed in the low pressure compression chamber 18 and which is forced past the discharge valve disc 53 which is yieldingly pressed against the valve seat 54 by means of a spring 55. The valve head 16 also is provided with an inlet chamber 56 from which air is drawn at atmospheric pressure past the inlet valve 57 into the compression chamber 18, upon the suction stroke of the piston 15. The inlet valve disc 57 is yieldingly retained upon its seat 58 by means of a spring 59.

The discharge or outlet chamber 23 is connected to the intercooler 22, which in turn is connected to the inlet chamber 24 of the high pressure cylinder valve head 21. Referring to Fig. 6, fluid under pressure within the intercooler 22 is drawn from the inlet chamber 24 into the high pressure compression chamber 18 past the inlet valve disc 61, which valve is yieldingly retained on its seat 62 by a spring 63. The fluid compressed within the high pressure compression chamber 18 is forced into the outlet chamber 64 of the high compression cylinder valve head 21, past the discharge valve disc 65, which valve is yieldingly retained seated upon the seat 66 by a spring 67, the fluid under pressure forced into the outlet chamber 64 being conducted to a receiver, not shown, through a pipe 68.

Referring to Figs. 1 and 4 particularly, the unloader mechanism comprises a valve chamber 20 in the crank case cover 60 and containing a ball check valve 30 that is adapted to close a port 69, through which a fluted operating stem 71 extends from the crank case chamber 12 into the valve chamber 20, so that when the stem is in its extreme right position, it holds the ball check valve 30 unseated. A spring 72 within the valve chamber 20 serves to yieldingly bias the ball check valve toward its seat. The valve operating stem 71 is provided with an enlarged head 73 that is adapted to be engaged by an arm 74 of the rocking lever 75 which is pivotally mounted upon a shaft 76 carried by the crank case cover 60. The lower end of the lever 75 is normally biased toward the left, or valve open position, by means of a spring 77 mounted in a recess 78 in the cover 60 and which engages the lower end of the lever 75. As indicated in Fig. 4, the lever 75 is shown in the valve open position, wherein the arm 74 thereof retains the valve stem 71 in its extreme right position, with the ball check valve 30 held unseated against the action of the spring 72.

The unloader plunger 49 is provided with a stem 79 that is adapted to engage the lower end of the lever 75 and rotate the lever in a counterclockwise direction when the pressure of the fluid acting on the plunger 49 is sufficient to overcome the tension of the spring 77, in which event the lever 75 is turned in a counter-clockwise direction, thus permitting the spring 72 to seat the ball check valve 30.

The valve chamber 20 is connected to the intercooler 22 and to the inlet chamber 24 of the high pressure cylinder head 21 by means of a pipe 81, so that when the ball check valve 30 is unseated, communication is established from the intercooler to the crank case chamber 12 through the inlet chamber 24, pipe 81, valve chamber 20, past the ball check valve 30 and port 69. The crank case chamber 12 is open to the atmosphere through openings 82 provided in the cover 83 for the oil filling inlet 84 in the cover 60. Accordingly, when the ball check valve 30 is unseated, the intercooler is in communication with the atmosphere through the passages above defined.

When the compressor is at rest, the fluid pressure acting on the left face of the plunger 49 is substantially zero, and consequently, the spring 77 holds the operating lever 75 in the valve open position shown in Fig. 4, so that, at this time, the intercooler is open to atmosphere. In order to unload the high pressure compression chamber when the compressor is at rest, a passage 85 is provided in the high pressure cylinder casing

17, which, as indicated in Figs. 1 and 3, communicates at one end with a port 86 which opens into the high compression chamber 18 at a point just above the upper face of the piston 19 when the latter is in its lowermost position, as when it is at the bottom of its stroke. The other end of the passage 85 opens into the inlet chamber 24 of the high pressure head 21, as shown in Fig. 6, and therefore communicates with the intercooler 22.

When the compressor is stopped, the fluid under high compression within the compression chamber 18 forces the piston 19 to its lowermost position, as shown in Fig. 3, wherein the port 86 is uncovered, so that the fluid under pressure within the compression chamber 18 may then flow to the intercooler, which is at this time open to atmosphere in the manner above described. Thus, the compression chamber 18 is unloaded when the compressor is brought to rest, and since the port 86 remains open while the compressor is at rest, fluid under pressure leaking past the discharge valve disc 65 will flow to atmosphere through the compression chamber 18, uncovered port 86, passage 85, inlet chamber 24, intercooler 22, pipe 81, valve chamber 20, past the ball check valve 30, port 69, crank case chamber 12, oil filling inlet 84, and passages 82 in the cover 83.

It is apparent from the foregoing, that when the compressor is brought to rest, the high compression chamber 18 and the intercooler 22 are opened to the atmosphere. Therefore, upon initial starting of the compressor and so long as the intercooler is maintained open to the atmosphere, the only load upon the compressor will be the compression of the fluid at atmospheric pressure within the high pressure compression chamber 18 which is initially at atmospheric pressure. This load, because of the relatively small area of the high pressure piston, is insufficient to offer any difficulty in starting of the compressor unit.

When the crank shaft 25 is initially rotated in starting, the oil pump plunger 36 pumps oil from the crank case chamber 12 through the oil passage 39 and past the ball check valve 42, which is at the time unseated, because insufficient centrifugal force has been developed to cause the ball valve to seat. As the speed of the crank shaft 25 increases, the fluid lubricant pressure within the compression chamber 35 of the lubricant pump and in the lubricant passage 39 does not materially increase so long as the ball valve 42 is unseated. When the crank shaft 25 has attained a predetermined speed found to be desirable for assuming the load of the compressor, the ball valve 42 is forced centrifugally to its seated position, wherein the passage 39 is held closed against the pressure of the fluid lubricant generated in the passage by the pump plunger 36. As the ball valve 42 closes, the pressure within the chamber 38 of the plunger 36 increases and the fluid lubricant supplied to the piston chamber 48 through the ports 51 and 52 forces the piston 49 to the right against the action of the spring 77, thereby turning the lever 75 in a counter-clockwise direction and permitting the spring 72 to close the unloader ball valve 30 and to thereby permit pressure to build up in the intercooler and to thus load the compressor.

While the compressor is normally operating, the passage 85 performs functions in addition to that of unloading the high compression chamber 18 when the compressor is at rest. During the operation of the compressor, compressed fluid at the pressure of the fluid in the intercooler, is forced between the skirt of the piston 19 and the cylinder wall and causes any excess lubricant to be forced back into the crank case chamber. Further, the passage 85 permits air at intercooler pressure to flow from the intercooler into the compression chamber 18 when the piston is at the bottom of its suction stroke, thereby permitting more air to flow into the compression chamber than can ordinarily enter through the spring loaded inlet valve.

The speed of rotation of the compressor crank shaft 25 at which the compressor is loaded is determined by the weight of the ball valve 42, which may be selected in accordance with the design of the compressor, so that the compressor may be loaded at any desired speed of operation. Since the loading of the compressor is dependent upon the pressure of the fluid lubricant while the compressor is operating, it is apparent that in the event of failure of the circulating pump or leaks in the system, such as would occasion an abnormal fall in fluid lubricant pressure, the pressure acting on the plunger 49 falls correspondingly, so that the spring 77 may operate the lever 75 to unseat the ball check valve 30 and thereby unload the compressor.

From the foregoing, it is apparent that a simple and effective unloading mechanism is provided that may be applied to multi-stage compressors and controlled by the fluid lubricant of the lubricant system.

While but one embodiment of the invention is disclosed herein, it is obvious that omissions, additions, and other changes may be made in the apparatus without departing from the spirit of the invention.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and containing a piston, and an intercooler connecting the said outlet and said inlet, of an unloader comprising a passage controlled by said piston for establishing communication from said high pressure chamber to said intercooler and a speed responsive means for opening said intercooler to the atmosphere.

2. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and containing a piston, and an intercooler connecting the said outlet and said inlet, of an unloader comprising a passage establishing communication from said high pressure compression chamber to said intercooler adapted to be closed by said piston except when the piston is adjacent the bottom of its stroke, and a speed responsive means for opening said intercooler to the atmosphere when the compressor speed falls below a predetermined value.

3. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and containing a piston, and an intercooler connecting the said outlet and said inlet, of an unloader comprising a passage establishing communication from said high pressure compression chamber to said intercooler adapted to be closed by said piston except when the piston is adjacent the bottom of its stroke, a lubricant pump actuated by the compressor for circulating fluid lubricant under

pressure, and means responsive to variations in the pressure of said fluid lubricant for opening said intercooler to atmosphere when the pressure of said lubricant falls below a predetermined value.

4. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and containing a piston, and an intercooler connecting the said outlet and said inlet, of an unloader comprising a passage establishing communication from said high pressure compression chamber to said intercooler adapted to be closed by said piston except when the piston is adjacent the bottom of its stroke, means establishing communication from said intercooler to atmosphere and a speed responsive means for effecting the closing of said last mentioned communication when the speed of the compressor exceeds a predetermined value.

5. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and containing a piston, and an intercooler connecting the said outlet and said inlet, of an unloader comprising a passage controlled by said piston for establishing communication from said high pressure chamber to said intercooler, means establishing communication from said intercooler to atmosphere and a speed responsive means for effecting the closing of said last mentioned communication when the speed of the compressor exceeds a predetermined value.

6. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and containing a piston, and an intercooler connecting the said outlet and said inlet, of an unloader comprising a passage controlled by said piston for establishing communication from said high pressure chamber to said intercooler, a lubricant pump actuated by the compressor for circulating fluid lubricant under pressure, and means responsive to variations in the pressure of said fluid lubricant for opening said intercooler to atmosphere when the pressure of said lubricant falls below a predetermined value.

7. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and an intercooler connecting the said outlet and said inlet, of an unloader comprising valve means responsive to variations in speed of the compressor for opening said intercooler to atmosphere when the speed of the compressor falls below a predetermined value.

8. The combination with a multi-stage compressor having a low pressure compression chamber having an outlet, a high pressure compression chamber having an inlet and an intercooler connecting the said outlet and said inlet, of an unloader comprising a pump for circulating lubricant under pressure, a centrifugally controlled valve for regulating the pressure of the fluid lubricant, and a valve means responsive to variations of the pressure of the fluid lubricant for opening said intercooler to atmosphere when the pressure of said lubricant falls below a predetermined value.

9. An unloader for a compressor having a compression chamber containing a piston and a crank shaft for operating the piston, comprising an unloader valve, a fluid pressure actuated abutment for effecting the operation of said valve, a pump actuated by the crank shaft for supplying fluid lubricant under pressure adapted to act on said abutment, and a centrifugally controlled valve mounted eccentrically on said crank shaft for regulating the pressure of said fluid lubricant acting on said abutment.

10. An unloader for a compressor having a crank shaft provided with a fluid lubricant passage, comprising an unloader valve, a fluid pressure actuated abutment for effecting the operation of said valve, a pump actuated by said crank shaft for supplying fluid lubricant under pressure to said abutment and said passage, and a centrifugally controlled valve in said passage for regulating the pressure of said fluid lubricant within said passage and acting on said abutment.

11. An unloader for a compressor having a crank shaft provided with a fluid lubricant passage, comprising an unloader valve, a fluid actuated abutment for operating said valve, a pump chamber having an inlet port, a hollow pump plunger operating in said pump chamber and actuated by said crank shaft and having a chamber therein communicating with said passage, said abutment and said pump chamber and adapted to close said inlet port upon the compression stroke and to force fluid lubricant into the chamber in said plunger, a check valve in said pump plunger chamber for closing communication from said plunger chamber to said pump chamber upon the suction stroke of said plunger and means for regulating the pressure of the fluid in said passage and acting on said abutment.

12. An unloader for a compressor having a crank shaft provided with a fluid lubricant passage, comprising an unloader valve, a fluid actuated abutment for operating said valve, a pump chamber having an inlet port, a hollow pump plunger operating in said pump chamber and actuated by said crank shaft and having a chamber therein communicating with said passage, said abutment and said pump chamber and adapted to close said inlet port upon the compression stroke and to force fluid lubricant into the chamber in said plunger, a check valve in said pump plunger chamber for closing communication from said plunger chamber to said pump chamber upon the suction stroke of said plunger and speed responsive means for regulating the pressure of the fluid in said passage and acting on said abutment.

13. An unloader for a compressor having a crank shaft provided with a fluid lubricant passage, comprising an unloader valve, a fluid actuated abutment for operating said valve, a pump chamber having an inlet port, a hollow pump plunger operating in said pump chamber and actuated by said crank shaft and having a chamber therein communicating with said passage, said abutment and said pump chamber and adapted to close said inlet port upon the compression stroke and to force fluid lubricant into the chamber in said plunger, a check valve in said pump plunger chamber for closing communication from said plunger chamber to said pump chamber upon the suction stroke of said plunger and a centrifugally controlled valve means in said passage for regulating the pressure of the fluid in said passage and acting on said abutment.

14. An unloader for a compressor having a

crank shaft provided with a fluid lubricant passage, comprising an unloader valve, a fluid actuated abutment for operating said valve, a pump chamber having an inlet port, a hollow pump plunger operating in said pump chamber and actuated by said crank shaft and having a chamber therein communicating with said passage, said abutment and said pump chamber and adapted to close said inlet port upon the compression stroke and to force fluid lubricant into the chamber in said plunger, a check valve in said pump plunger chamber for closing communication from said plunger chamber to said pump chamber upon the suction stroke of said plunger and a ball check valve mounted in said passage eccentric to the center of rotation of said crank shaft and centrifugally controlled for regulating the pressure of the fluid in said passage and acting on said abutment.

15. The combination with a multi-stage compressor having a high pressure compression chamber, a low pressure compression chamber and an intercooler, of an unloader comprising speed responsive means for opening said intercooler to atmosphere and means actuated by the fluid under pressure in the high compression chamber for opening the high pressure chamber to the intercooler.

16. An unloading device for a compressor having a compression chamber, a piston operative therein and a crank shaft for operating the piston, comprising means providing a communication through which fluid may be vented from the compression chamber, the communication being closed by the piston except when the piston is adjacent the extremity of its intake stroke, and means responsive to the speed of rotation of the crank shaft for causing said communication to be opened to atmosphere when the speed of rotation of the crank shaft decreases below a certain degree.

17. An unloader for a compressor having a crank shaft provided with a fluid lubricant passage, comprising an unloader valve, a fluid pressure actuated abutment for effecting the operation of said valve, a pump driven by the crank shaft for supplying fluid lubricant to the passage and to said abutment, and means responsive to the speed of rotation of the crank shaft for regulating the pressure of the fluid lubricant within the passage and acting on the said abutment.

18. Mechanism for loading or unloading a compressor having a crank shaft, comprising a valve effective in one position to cause loading of the compressor and operative out of said one position to cause unloading of the compressor, a pump driven by the crank shaft for supplying fluid lubricant under pressure to moving parts of the compressor, a movable abutment subject to the pressure of the fluid lubricant supplied by the said pump and responsive to variations in the pressure of the fluid lubricant for effecting the operation of the said valve, and means responsive to the speed of rotation of the crank shaft for effecting variations in the pressure of the fluid lubricant supplied by the pump.

19. Mechanism for loading or unloading a compressor having a crank shaft, comprising a valve effective in one position to cause loading of the compressor and operative out of said one position to cause unloading of the compressor, a pump driven by the crank shaft for supplying fluid lubricant under pressure to moving parts of the compressor, a movable abutment subject to the pressure of fluid lubricant supplied by the said pump for causing said valve to be maintained in said one position as long as the fluid lubricant pressure exceeds a certain degree and for causing said valve to be operated out of the said one position when the fluid lubricant pressure decreases below the said certain degree, and means responsive to the speed of rotation of the crank shaft for effecting variations in the fluid lubricant pressure above or below said certain degree.

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