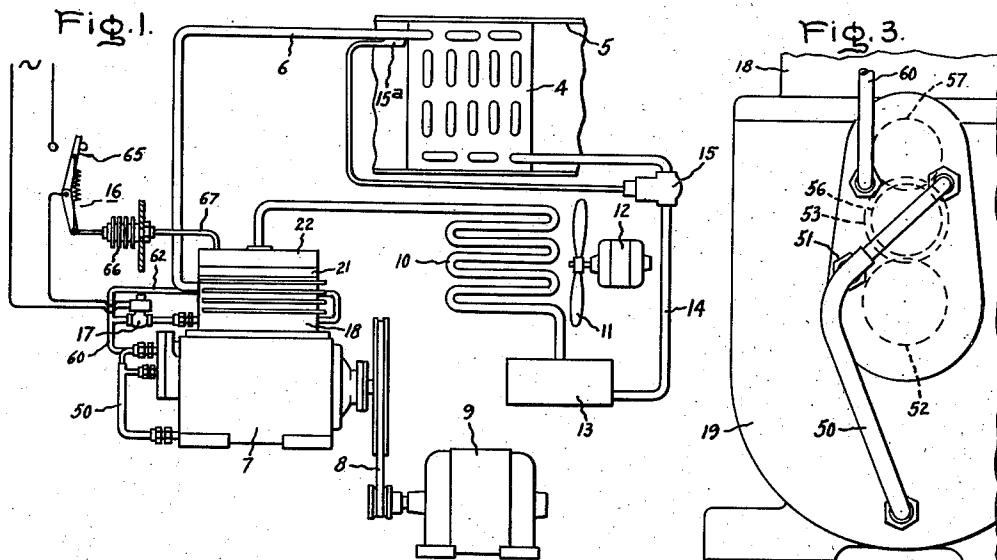
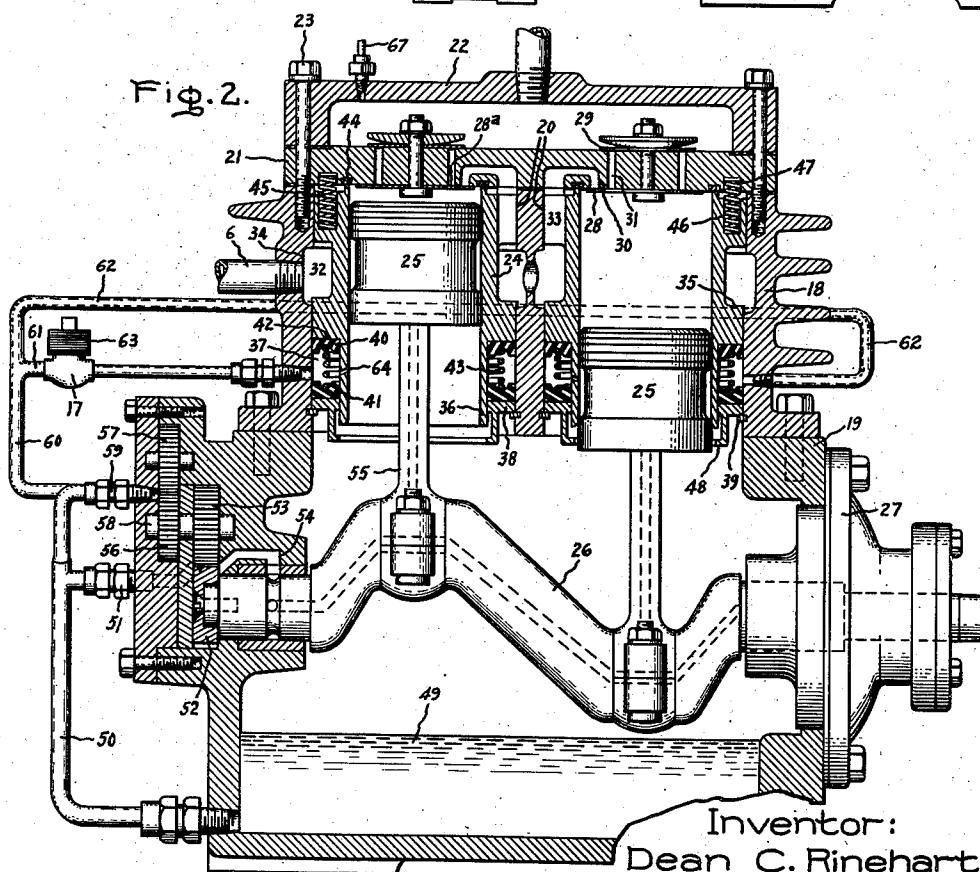


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RECIPROCATING COMPRESSOR WITH UNLOADING
AND CAPACITY MODULATING CONTROL
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RECIPROCATING COMPRESSOR WITH UNLOADING AND CAPACITY MODULATING CONTROL

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This invention relates to gas compressors of the reciprocating type and particularly to devices for unloading such compressors and for providing modulation of the compressor capacity.

In the operation of refrigerant compressors, for example, such as those employed in air conditioning systems, it is frequently desirable to provide a control which makes it possible to vary the capacity of the compressor in accordance with the demands of the system, and preferably such variation is effected over a relatively wide range in gradual steps. It is also desirable that a simple and effective unloading device be provided so that the compressor may be started under no-load conditions. Accordingly, it is an object of this invention to provide a compressor of the reciprocating type including an improved arrangement for unloading the compressor and for modulating the capacity thereof.

It is another object of the invention to provide a capacity modulating device for compressors of the reciprocating type which shall be of simple construction and readily controllable.

Further objects and advantages of this invention will become apparent as the following description proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention reference may be had to the accompanying drawing in which Fig. 1 is a diagrammatic view illustrating an air cooling system provided with a refrigerant compressor embodying the invention; Fig. 2 is an enlarged sectional view of the compressor shown in Fig. 1; and Fig. 3 is an end elevation view of the compressor.

The air cooling system shown in Fig. 1 comprises a refrigerant evaporator 4 arranged in a duct 5 through which air to be cooled is circulated by operation of a suitable blower (not shown). Liquid refrigerant in the evaporator is vaporized by the absorption of heat from the air circulated through the duct, and the vaporized refrigerant is withdrawn through a suction line 6 by operation of a reciprocating compressor 7 driven through a belt 8 by an electric motor 9. The refrigerant is compressed and discharged from the compressor and conducted to an air cooled condenser 10 having an air circulating fan 11 driven by a motor 12. The hot compressed refrigerant is cooled in the condenser and liquefied and flows to a liquid receiver 13 from which it is returned to the evaporator through a liquid line 14 under control of a thermostatic expan-

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sion valve 15. The valve 15 is provided with a temperature responsive bulb or feeler element 15a secured in heat exchange with the suction line 6 and operates to maintain a predetermined amount of superheat in the vaporized refrigerant withdrawn from the evaporator. During the operation of the air cooling system it is desirable that the motor compressor unit be operated at a relatively high coefficient of performance. The coefficient of performance may be improved by preventing short cycling of the motor 9, that is, by operating the compressor at a capacity such that under low-load conditions, for example, it will operate over an extended period to maintain the desired pressures in the system rather than operating at high capacity for short periods. Short cycling is objectionable because frequent starting and stopping of the electric motor tends to overheat the motor. In the system shown in Fig. 1 a control 16 responsive to the head pressure of the compressor 7 is arranged to actuate a solenoid valve 17 and vary the capacity of the compressor in a manner to be described below.

The details of construction of the compressor and the arrangement of the capacity modulating and unloading device are clearly shown in Figs. 2 and 3. The compressor comprises a cylinder block 18 mounted on a crankcase 19. Cylinders 20 are formed within the block 18 and are closed by a compressor head structure including a valve plate 21 and a head 22 secured to the block by bolts 23. Within the cylinders 20 there are mounted cylinder sleeves 24 which are vertically slidable within the cylinders and within which pistons 25 are reciprocated by operation of a crankshaft 26 journaled in bearings in the crankcase 19, the right-hand bearing being mounted in a removable end plate 27. The valve plate 21 is provided with intake valves including flexible disks 28 and discharge valves including flexible disks 29 for controlling intake ports 30 and discharge ports 31 respectively. The intake valve disks 28 are provided with suitable openings 28a so that the discharge ports 31 communicate directly with the cylinder space within the sleeves 24. The intake ports 30 are connected in communication with the suction line 6 through annular intake passages 32 formed between the sleeves 24 and the block 18 and connected to the passages 30 by upright passages 33 formed as grooves in the sleeves 24. The annular passages 32 are formed by grooves 34 in the walls of the cylinders 20 and annular grooves 35 in the external walls of the sleeves 24. The lower ends

36 of the sleeves 24 are of reduced external diameter and cooperate with the walls of the cylinders 20 to form annular chambers 37 which are closed by collars 38 rigidly secured in the lower ends of the cylinders 20 by retaining rings 39. The annular chambers 37 are sealed by upper and lower resilient rings or gaskets 40 and 41. The upper gasket 40 is seated on a downwardly facing shoulder 42 formed by the reduced portion of the sleeve 24, and the lower gasket is seated on the collars 38. The gaskets are pressed apart and retained in sealing engagement with the cylinder walls by a helical spring 43 surrounding the sleeve, the gaskets being provided with annular grooves forming seats for the spring.

In the drawing the cylinder sleeves 24 have been shown in engagement with sealing rings or gaskets 44 embedded in the lower side of the valve plate 21. The sleeves are held in this position by fluid pressure within the chambers 37 which opposes the force of a plurality of springs 45 arranged in rings around the sleeves and seated in recesses 47 in the valve plate and in recesses 46 in the sleeves. Only two of the springs 45 have been shown in the drawing, it being unnecessary for an understanding of the invention that the remaining springs be illustrated. The combined force of the springs 45 is such that these springs overcome the springs 43 and bias the sleeves 24 to their lower position so that bypasses are provided around the intake valves at the tops of the sleeves and the compressor is normally unloaded. The lowermost position of the sleeves is determined by stop rings 48 formed as internal flanges on the collars 38.

A body of lubricating oil 49 is maintained in a sump formed by the bottom of the crankcase 13 and is circulated from the sump through a conduit 50 and a connection 51 to a gear pump comprising a gear 52 mounted on the end of the crankshaft 26 and a meshing gear 53, these gears being arranged in a housing to provide a gear pump in a manner well known in the art and which discharges the oil through a duct 54 to oil circulating passages indicated generally by dotted lines in the crank 26 and in the connecting rods indicated at 55. The lubricant is also employed as the pressure fluid for actuating the sleeves 24, and although the same pump may be employed it is preferred, as shown in the drawing, to provide a separate pump comprising intermeshing gears 56 and 57, the gear 56 being connected directly by a stub shaft 58 to the gear 53. Oil from the conduit 50 enters the second pump through a connection 59 and, by operation of the gears 56 and 57, is pumped through a discharge conduit 60 and enters branch conduits 61 and 62 leading to the annular chambers 37 of the left-hand and right-hand cylinders respectively. The valve 17 is arranged to control the flow of oil through the branch conduit 61. This valve is normally open but may be closed by energization of a solenoid 63 to cut off the supply of oil under pressure to the left-hand chamber 37. Bleeder passages 64 are provided in the walls of the sleeves 24 between the passages 37 and the inside walls of the cylinder sleeves so that a minimum flow of oil is permitted and provides lubrication for the pistons. A minimum opening may be provided in the valve 17 so that even when the valve is in its closed position there is a flow of oil through bleeders 64 for lubricating purposes. These bleeder passages also limit the back pressure on the gear pump.

When the compressor is at a standstill there is

no oil pressure in the chambers 37 and the sleeves 24 are pressed downwardly by the springs 45 to open the bypasses over the tops of the sleeves, this being the unloaded position. When the compressor is started, oil pressure is gradually built up in both chambers 37, the valve 17 being normally open, and when a predetermined speed has been reached the pressure is sufficient to force the sleeves against the gaskets 44 and maintain them in this position to seal off the bypass and load the compressor. As the conditions of operation change it may become desirable to decrease the total compressor capacity and this may be done by closing the valve 17 to open the bypass in the left-hand cylinder and unload that cylinder. In order to control the valve 17 the control 16 is arranged to actuate a snap-acting switch 65 upon expansion of a bellows 66 connected through a duct 67 in communication with the discharge chamber in the head 22 of the compressor. When the head pressure reaches a predetermined high value the bellows expands and moves the switch 65 to its closed position thereby energizing the solenoid 63 and closing the valve 17. This cuts off the main supply of oil to the left-hand chamber 37 and unloads the left-hand cylinder by allowing the springs 45 to move the sleeve 24 away from its seat. The actuation of the control 16 to effect loading and unloading of the left-hand cylinder provides modulation of the capacity of the compressor, the cylinder being loaded again as soon as the head pressure falls to a predetermined value at which the snap-acting switch is moved to its open position and deenergizes the solenoid. Whenever the compressor is stopped the oil pressure falls because of the stopping of the operation of the oil pumps, and the pressure in the chambers 37 drops to allow the springs 45 to force both cylinder sleeves 24 away from their seats and unload the compressor. Obviously the control 16 may be actuated in accordance with any condition of operation of the refrigerating system which is indicative of the required compressor capacity so that modulation of the compressor may be effected in accordance with changes in the selected condition, the control in response to head pressure having been selected merely by way of illustration. It is also obvious that although a two-cylinder compressor has been illustrated the invention is applicable to multi-cylinder compressors regardless of the number of cylinders and that with more than two cylinders the modulating control may be arranged for successive operation of the bypass control of the cylinders, a plurality of the cylinders being provided with valves for controlling the flow of oil thereto.

Although this invention has been described in connection with a two-cylinder compressor having capacity modulation control of only one of the cylinders, various modifications will occur to those skilled in the art. It is not, therefore, desired that the invention be limited to the particular details illustrated and described and it is intended by the appended claims to cover all modifications within the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A compressor of the reciprocating type comprising a cylinder block having a cylinder therein, a piston mounted for reciprocation in said cylinder, intake and exhaust valves for said cylinder, a sleeve valve surrounding said piston and movable between open and closed positions, said

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sleeve valve in its open position providing a bypass around said intake valve, means biasing said sleeve valve toward its open position, means including an annular shoulder on said sleeve valve for forming an annular chamber surrounding said piston whereby said chamber expands upon movement of said sleeve valve toward its closed position, and means for supplying to said chamber a fluid under pressure for expanding said chamber and moving said sleeve valve toward its closed position to close said bypass and control the loading of said cylinder.

2. A compressor of the reciprocating type comprising a cylinder block, means providing a head for said block, a cylinder sleeve cooperating with said head to form a closed cylinder and mounted in said block for movement toward and away from said head, a piston in said cylinder, means for driving said piston, intake and exhaust valves for said cylinder, an annular seat on said head for limiting the movement of said sleeve toward said head and for sealing said cylinder, means for urging said sleeve away from said seat to provide a bypass around said intake valve, an expansible chamber device for moving said sleeve toward said seat, and means including a pump driven by said driving means for supplying fluid under pressure to said device to move said sleeve toward said seat and close said bypass to control the loading of said cylinder.

3. A compressor of the reciprocating type comprising a cylinder block, means providing a head for said block, a cylinder sleeve cooperating with said head to form a closed cylinder and mounted in said block for movement toward and away from said head, a piston in said cylinder, means for driving said piston, intake and exhaust valves for said cylinder, an annular seat on said head for limiting the movement of said sleeve toward said head and for sealing said cylinder, means for urging said sleeve away from said seat to provide a bypass around said intake valve, means providing an annular chamber expansible longitudinally of said cylinder for moving said sleeve toward said seat, and means including a pump driven by said driving means for supplying a fluid under pressure to said chamber to move said sleeve toward said seat and close said bypass to control the loading of said cylinder.

4. A compressor of the reciprocating type comprising a cylinder block having a cylinder therein, a head for said block arranged to close said cylinder, a cylinder sleeve slidably mounted in said cylinder for movement toward and away from said head, a piston mounted in said sleeve, said sleeve being formed with an external annular shoulder facing away from said head and forming an annular chamber between said sleeve and the wall of said cylinder, annular closure means spaced from said shoulder for closing said chamber, intake and discharge valves communicating with the interior of said sleeve, means for urging said sleeve away from said head to provide a bypass around said intake valve, and means for admitting fluid under pressure to said chamber for moving said sleeve toward said head to close said bypass and control the loading of the compressor.

5. A compressor of the reciprocating type comprising a cylinder block having a cylinder therein, a head for said block arranged to close said cylinder, a cylinder sleeve slidably mounted in said cylinder for movement toward and away from said head, a piston mounted in said sleeve,

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said sleeve being formed with an external annular shoulder facing away from said head and forming an annular chamber between said sleeve and the wall of said cylinder, annular closure means spaced from said shoulder for closing said chamber, a pair of resilient annular gaskets one seated against said shoulder and the other seated against said closure means, a spring engaging said gaskets for urging said gaskets apart and for maintaining said gaskets seated on said shoulder and closure means regardless of movement of said sleeve, intake and discharge valves communicating with the interior of said sleeve, means for urging said sleeve away from said head to provide a bypass around said intake valve, and means for admitting fluid under pressure to said chamber for moving said sleeve toward said head to close said bypass and control the loading of the compressor.

6. A compressor of the reciprocating type comprising a cylinder block having a cylinder therein, a valve plate for closing said cylinder, a cylinder sleeve slidably mounted in said cylinder for movement toward and away from said plate, a piston mounted in said sleeve, means providing an intake passage for said compressor extending about said sleeve, intake and exhaust valves in said plate communicating with the interior of said sleeve, said plate having a passage therein connecting said intake valve and said intake passage, means for urging said sleeve away from said valve plate to provide a bypass around said intake valve, and fluid pressure means for moving said sleeve toward said valve plate to control said bypass and effect the loading and unloading of the compressor.

7. A compressor of the reciprocating type comprising a cylinder block having a cylinder therein, a head for said block arranged to close said cylinder, a cylinder sleeve slidably mounted in said cylinder for movement toward and away from said head, a piston mounted in said sleeve, said sleeve being formed with an external annular shoulder facing away from said head and forming an annular chamber between said sleeve and the wall of said cylinder, annular closure means spaced from said shoulder for closing said chamber, intake and discharge valves communicating with the interior of said sleeve, means for urging said sleeve away from said head to provide a bypass around said intake valve, means for retaining a body of liquid lubricant for the compressor, a pump for supplying lubricant under pressure from said body to said annular chamber, and means dependent upon the load on the compressor for controlling the supply of lubricant to said chamber to close said bypass and effect the loading of the compressor.

8. A compressor of the reciprocating type comprising a cylinder block having a cylinder therein, a head for said block arranged to close said cylinder, a cylinder sleeve slidably mounted in said cylinder for movement toward and away from said head, a piston mounted in said sleeve, said sleeve being formed with an external annular shoulder facing away from said head and forming an annular chamber between said sleeve and the wall of said cylinder, annular closure means spaced from said shoulder for closing said chamber, intake and discharge valves communicating with the interior of said sleeve, means for urging said sleeve away from said head to provide a bypass around said intake valve, means for retaining a body of liquid lubricant for the compressor, a pump for supplying liquid lubricant

cant from said body to said annular chamber, and means responsive to the pressure of the discharged gas in said head for controlling the supply of lubricant to said chamber to move said sleeve and control the loading of the compressor.

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