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LOAD CONTROLLING APPARATUS

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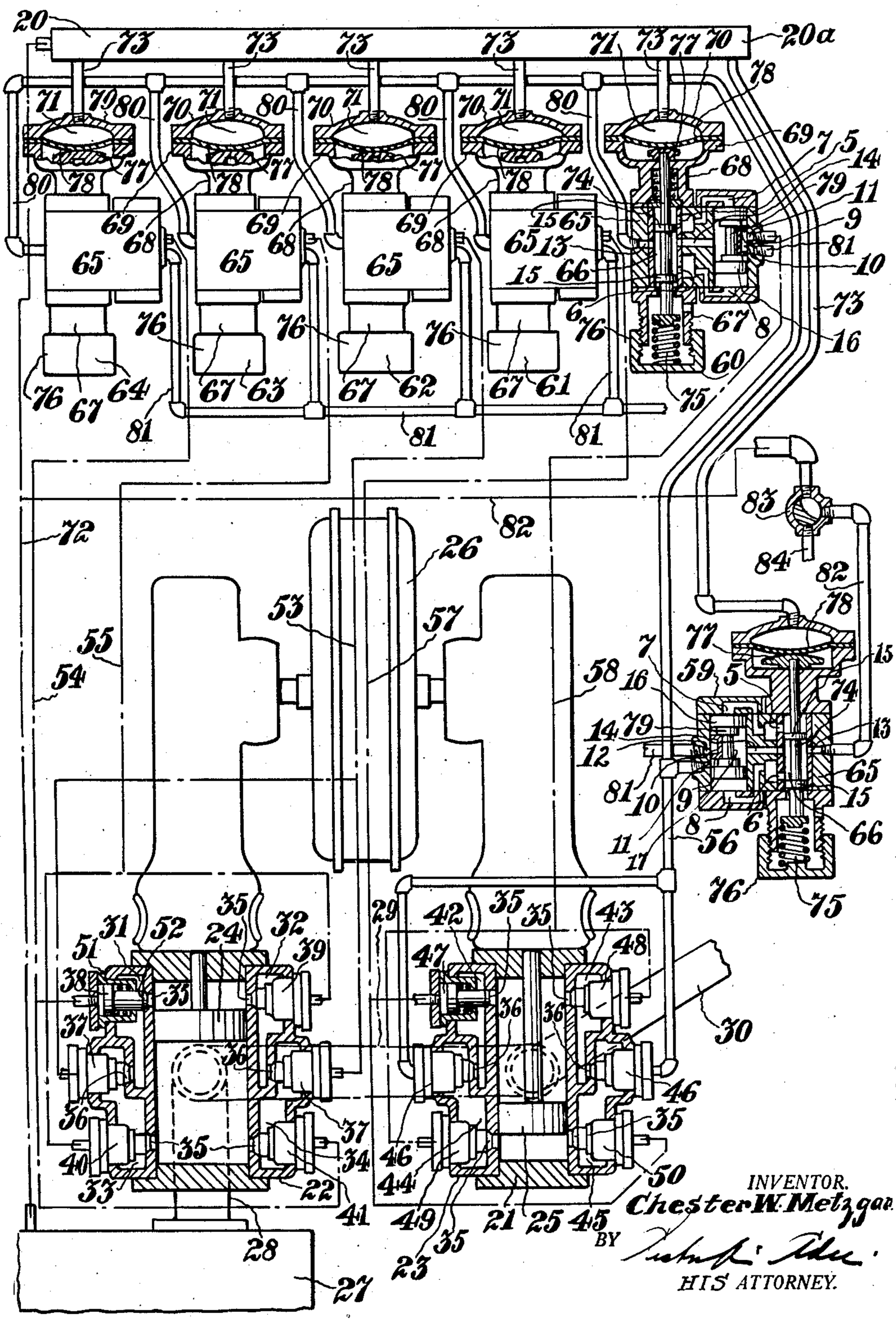

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LOAD CONTROLLING APPARATUS

Chester W. Metzgar, Easton, Pa., assignor to Ingersoll-Rand Company, Jersey City, N. J., a corporation of New Jersey

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15 Claims. (Cl. 230—21)

This invention relates to compressors, and more particularly to a load-controlling apparatus for machines of this character.

The invention is particularly applicable to compressors having clearance chambers and suitable valve mechanisms whereby the load on the compressor cylinders may be gradually altered for either loading or unloading the compressor.

A specific utilization of the invention may be that of controlling the load of a compressor used for removing gas under pressure from a tank or chamber containing a definite volume of gas so that, as compression proceeds the pressure of the fluid supply is reduced. The several controlling elements of the apparatus may come into operation at predetermined pressure values to cause additions to the load on the compressor and in that way assure a constant discharge pressure, irrespective of the value of the pressure of the fluid constituting the source of supply.

One object of the invention is to effect a regulation of the load on a compressor cylinder or cylinders in response to variations in the value of the suction pressure.

A further object of the invention is to provide a compressor with load-changing devices each having a separate regulator or controller therefor.

Another object is to arrange such separate regulators for the load-changing devices so that one acts as a master regulator for the remaining ones.

Other objects will be in part obvious and in part pointed out hereinafter.

One purpose which the invention can serve is in regard to the cooling of petroleum and its distillates to cause the separation of the paraffin therein, preparatory to the recovery of the paraffin. The oil containing the paraffin, after such treatment as may be necessary, is conducted into a suitable vessel or reservoir, and then a cooling medium such as liquefied propane gas (C_3H_8) is mixed with it; the pressure and temperature within the reservoir containing the oil being so adjusted that the propane can readily be converted back into gaseous form. When the process of mixing is complete, the propane is allowed to vaporize in said vessel; and, in the course of vaporization, the propane takes from the oil an amount of heat corresponding to the specific heat of vaporization of the propane. This heat becomes latent and the oil is thus cooled to the required degree. During vaporization the propane bubbles out of the oil and collects above it, so that, by means of this invention, the propane can be pumped out. As a consequence of the cooling of the oil the paraffin wax separates, and when all of the propane has been recovered, the oil and paraffin are piped out of the reservoir, so that the paraffin can be extracted. The apparatus to be described includes devices for exhausting the propane from said vessel, and delivering it at constant pressure, as the pressure in the reservoir progressively drops.

The accompanying drawing illustrating one form which the invention may assume in practice, is a diagrammatic view partly in section of a load-controlling apparatus constructed in accordance with the practice of the invention and showing it connected to a compressor.

Referring more particularly to the drawing, the load-controlling apparatus, designated in general by **20**, is shown applied to a multi-stage compressor **21** comprising low and high pressure cylinders **22** and **23**, respectively. Within the cylinders **22** and **23** are double acting pistons **24** and **25** which are driven by a motor **26**.

The low pressure cylinder **22** is connected to a source of fluid supply, for example a tank or reservoir **27**, by a conduit **28** and the fluid passing from the cylinder **22** flows directly through a conduit **29** into the high pressure cylinder **23**. From the high pressure cylinder **23** the compressed fluid flows to the point of application through a discharge conduit **30**.

It is understood, of course, that the connection between the cylinder **22** and the conduits **28** and **29**, and between the cylinder **23** and the conduits **29** and **30** is shown diagrammatically only, and that suitable valves or the like will control the flow of the gas from the vessel **27** to the cylinder **22** and thence to the cylinder **23** and out through the pipe **30**.

In order to enable the load on the compressor cylinders to be altered, each cylinder is provided with suitable load-controlling devices. The low pressure cylinder accordingly has a plurality of clearance chambers, four being shown for illustrative purposes. Those adjacent the crank end are designated **31** and **32**, while those associated with the opposite end of the cylinder **22** are designated **33** and **34**. Each clearance chamber communicates with the adjacent end of the cylinder **22** through a port **35**, and communication is afforded between pairs of clearance chambers lying on each side of the cylinder through a by-pass port **36**.

The latter ports are controlled by pressure actuated spring-pressed clearance valves **37** which operate to control the by-passing of fluid between ends of the cylinder **22**. Similar valves designated **38**, **39**, **40** and **41** are arranged in the chambers **31**, **32**, **33** and **34**, respectively, to control the associated ports **35**.

The high pressure cylinder **23** is likewise provided with a plurality of clearance chambers, two designated **42** and **43** being located at the crank end of the cylinder and a like number designated **44** and **45** at the opposite end of the cylinder. As in the low pressure cylinder the clearance chambers lying on a side of the cylinder **23** also

communicate with each other through ports 36 which are controlled by pressure actuated valve devices 46. Each clearance chamber in the high pressure cylinder has a port 35 which opens into the adjacent end of the cylinder and said ports are controlled by pressure actuated valve mechanisms 47, 48, 49 and 50 arranged in the clearance chambers 42, 43, 44 and 45, respectively.

The valve mechanisms controlling the ports 35 and 36 may be of a well known type comprising a casing 51 and a pressure actuated spring-opposed plunger 52 adapted to seat into the ends of the ports 35. The valve mechanisms are preferably operated in pairs, that is, the pressure fluid whereby the plungers 52 are actuated is simultaneously supplied to or exhausted from two valve mechanisms of a cylinder. The valves 37 controlling the by-pass ports 36 of the low pressure cylinder are accordingly connected to a common conduit 53. In like manner the valve mechanisms 38 and 41 are connected to a conduit 54 while the pressure fluid is simultaneously supplied to and discharged from the valve mechanisms 39 and 40 through a conduit 55.

The valve mechanisms controlling the loading of the high pressure cylinder 23 are similarly operated, the valve mechanisms 46 controlling the by-pass ports 36 being connected to receive pressure fluid from a common supply conduit 56. In order to simultaneously effect partial loading or unloading of each end of the high pressure cylinder one valve mechanism at each end of the cylinder 23, as for instance those designated 47 and 50, are connected to a supply conduit 57 and the valve mechanisms 48 and 49 are connected to a supply conduit 58.

In accordance with the practice of the invention each supply conduit is connected to an individual controlling device whereby the supply of pressure fluid to the valve mechanisms associated with the clearance chambers is controlled. These controlling devices designated 59, 60, 61, 62, 63 and 64 are connected to the conduits 56, 58, 57, 53, 55 and 54, respectively.

Structurally the controlling devices are substantially identical so that a description of one will suffice for all. Each controlling device comprises a main casing 65 having a valve chamber 66 closed at its lower and upper ends by heads 67 and 68, respectively. The head 68 has a flared portion 69 and a cover 70 cooperates therewith to form a pressure chamber 71 which is in free communication with a source of suction pressure, in this instance the tank 27, through a conduit 72, the header 20a and a branch pipe 73.

The valve chamber 66 contains a pilot valve 74 of which the lower end extends into the head 67 and is seated upon a spring 75 supported by a cap 76 threaded on the head 67 for adjusting the force of the spring 75. The opposite end of the valve 74 extends into the flared portion 69 of the head 68 and has affixed thereto a head 77 which seats against a diaphragm 78 clamped between the flared portion 69 of the head 68 and the cover 70.

The valve 74 serves as a pilot valve for controlling the admission of pressure fluid to a main valve 79 reciprocable in the casing 65. Such pressure fluid is supplied to the valve chambers 66 by the supply conduit 56 which is connected to the valve chambers 65 by branch conduits 80. The pilot valve 74 admits pressure fluid selectively to the ends of the main valve 79 for connecting the valve chamber 66 with a supply conduit leading to the clearance valve mechanisms or for connecting a supply conduit with discharge pipe 81 connected to the valve casing 65.

As has been previously intimated, the head 77 of each controlling device is constantly subjected to the pressure existing in the tank 27 and in order that the valves 74 wherewith they are associated may came into action at different suction pressures said heads are of different diameters. Thus with the head 77 of the controlling device 59 of larger area than the other heads 77 it will yield to a lower suction pressure, at equal pressures of the springs 75, than will the heads of smaller diameter. Conversely, upon a reduction in the pressure acting against the head 77 the valve 74 of the controlling device 59 remains depressed until all the other valves have been restored to their initial positions by their springs.

In the present arrangement, and with the head 77 of the controlling device 59 of maximum area, the heads of the other controlling devices are of increasing areas from that of the controlling device 60 to the head 77 of the controlling device 64 which latter head constitutes that of maximum area of the group of controlling devices 60 to 64, inclusive.

Preferably the pressure fluid supplied to the controlling devices 60 to 64 and distributed thereby to the valve mechanisms wherewith they are associated passes through the controlling device 59 which is, in effect, the master controller. To this end the controlling device 59 is connected to the conduit 72 and reservoir 27 by a conduit 82 having interposed therein a manually operable valve 83. The valve 83 is of the two-way type and serves to establish communication between the several sections of the conduit 82 connected to the valve 83 or between that section of the conduit 82 leading from the valve casing 65 to the valve 83 and an exhaust pipe 84.

The operation of the device is as follows: Let it be assumed that it is intended to remove gas under pressure, as say 125 pounds, from the tank 27 and compress it to a final discharge pressure of 200 pounds and that it be desired to maintain a predetermined load on the compressor throughout the compression period. As a first step of operation intended to meet these conditions the valve 83 is opened to supply pressure fluid from the vessel 27 to the valve chamber 66 of the controlling device 59. It is, of course, understood that each pilot valve 74 of the various controlling devices is depressed, those of the group of controlling devices 60 to 64 being in a position to admit pressure fluid to the main valves 79 for positioning them so that the main conduits which they control are connected with the adjacent discharge pipes 81.

With the several valves of the controlling devices 60 to 64 in the position described, and the valves 74 depressed, and before valve 83 connects the device 59 to the tank 27 no pressure fluid will, therefore, pass to the associated valve mechanisms in the compressor cylinders and the valve mechanisms will, in consequence, remain open to connect the ends of the cylinders with the clearance chambers. Upon the admission of pressure fluid into the controlling device 59, however, its main valve 79 rises and assumes a position to pass pressure fluid through the pipe 56 to the valve chambers 66 of the other controlling devices and also to the valve mechanisms 46 in the high pressure cylinder. The valve mechanisms 46 will then close the ports 36 to prevent the by-passing of fluid and the high

pressure cylinder 23 will thereby become partially loaded.

The valve chamber 66 of the device 59 has an upper port 5 and a lower port 6 with passages 7 and 8 respectively, connecting these ports to the top and bottom of the space containing the main valve 79. This valve moves a sliding valve 9 having a recess 10 which is capable of connecting ports 11 and 12 leading respectively to the pipe 56 and the exhaust pipe 81, so as to put these pipes into communication with each other. The supply pipe 82 connects with the inside of the chamber 66 through a port 13 and a duct 14 connects this chamber to the middle of the space containing the valve 79. The valve 74 has two heads 15 thereon to control the ports 5 and 6, and the valve 79 has at its ends heads 16 connected by a reduced part 17. Hence, when the diaphragm 78 is depressed, the upper port 5 will be cut off by the upper head 15 of the valve 74 while the lower head 15 will expose the port 6. Fluid from the pipe 82 passing into the chamber 66 flows through the port 6 and passage 8 to lift the valve 79. The slide valve 9 then exposes port 11 to the pipe 56, but closes the outlet port 12 to exhaust pipe 81. Pressure fluid then flows past the portion 17 of the valve 79 into the pipe 56, while the outlet 12 to the pipe 81 is closed.

The fluid intended to be compressed passes directly through the low pressure cylinder and the conduit 29 into the high pressure cylinder 23 and, with the various valve mechanisms of the low pressure cylinder occupying their open positions, the pressure of the fluid passing through the low pressure cylinder will not be increased.

The compressor will continue to operate in this manner until the suction pressure drops to a value at which it no longer predominates over that exerted by the spring 75 of the controlling device 60. The said spring will then raise the associated pilot valve 74 to admit pressure fluid to the main valve 79 and said main valve will then be dropped to connect the conduit 58 with the valve chamber 66.

This operation takes place in the same manner as described above in connection with the controlling device 59, because the arrangement of ports, passages and valves is the same.

In the new position of the valve 79 of the controlling device 60 pressure fluid flows through the conduit 58 to the valve mechanisms 48 and 49 to close them, thus increasing the load of the compressor by, say one-quarter, depending upon the capacities of the clearance chambers.

As the operation of compression proceeds and the pressure value of the fluid in the tank 27, in consequence, decreases, the spring 75 of the controlling device 61 will raise its associated valve 74 and cause the valve 79 of that controlling device to be shifted. Pressure fluid then flows through the supply conduit 57 to the valve mechanisms 47 and 50 for closing them. The high pressure cylinder 23 will then be fully loaded. When the suction pressure drops sufficiently to allow the spring 75 of the controlling device 62 to lift its valve 74 pressure fluid is admitted to the valve mechanisms 37 of the low pressure cylinder to close the ports 36 and thus cause the low pressure cylinder to operate at part load. Thereafter, as the value of the suction pressure decreases the controlling devices 63 and 64 will come successively into action to close the valve mechanisms wherewith they are connected through the supply conduits 55 and 54, respectively. The compressor will then be completely loaded.

In order to prevent the creation of a sub-atmospheric pressure in the tank 27 the spring 75 of the controlling device 59 is adjusted to act at approximately atmospheric pressure. Thus when the pressure in the tank 27 reaches that value the valve 74 is raised to exhaust the holding pressure from the adjacent valve 79. Hence, the lower head 15 on this valve rises above the lower port 6 and associated passage 8 and the upper head 15 uncovers the upper port 5. Pressure fluid from the pipe 82 now passes through the passage 7 and reaches the top of the valve 79, and depresses it. The fluid below this valve then flows through the passage 8 and the port 6 into the lower portion of the casing 65, whence it may escape to the atmosphere through a suitable port in the casing 65. The valve 79 will then move down to connect the conduit 56 with the discharge pipe 81 through the valve 9. All the valve mechanisms in the compressor are then connected through their respective supply conduits and controlling devices with the discharge pipe 81 of the controlling device 59, thereby completely unloading the compressor. The valve 83 may then be placed in the position for connecting the pipes 82 and 84 with each other and incidentally cutting off communication between the tank 27 and the valve chest 66 of the controlling device 59.

From the foregoing it will be apparent to those skilled in the art that the device will operate to compensate for the decrease in suction pressure resulting upon removal of gas at a definite rate from the tank 27 and that the load on the compressor will thus become gradually increased until the pressure in the tank 27 has been reduced to approximately atmospheric pressure, whereupon the master controller will act to effect complete unloading of the compressor.

When the invention is employed in the manner above described, to extract propane from paraffin bearing oil, the propane can be removed from the reservoir at a uniform rate and the entire quantity can be exhausted in a given time. Also, with the suction pressure high at the start and gradually dropping, and the compression pressure maintained constant by the pumping mechanism, there is a considerable saving in power over what would be required if the gas in the tank 27 were first allowed to decrease in pressure and then supplied through suitable appliances at a constant suction pressure to the cylinders 22 and 23. From the compressor the propane can be conducted to a condenser to be again liquefied.

Of course, the invention can be put to use to extract and compress other gases than propane, and the description herein is for purposes of explanation only. In practice many changes in structural details and mode of proceeding might be made and the scope of the invention is set forth in the broad terms in which the claims appended hereto are expressed.

I claim:

1. The combination of a compressor, a plurality of clearance chambers, clearance valves for each chamber connected to operate in pairs, a plurality of control devices each directly controlling operation of a pair of clearance valves and each acting in response to a different predetermined pressure, and a master control device directly controlling operation of one pair of clearance valves and indirectly controlling operation of the remaining clearance valves by controlling

operation of their respective controlling devices.

2. The combination of a compressor, a plurality of clearance chambers, clearance valves for the chambers, by-pass valves to control communication between the chambers, a plurality of devices for controlling the clearance valves and connected to act one after another in response to decrements in the value of the suction pressure for effecting gradual loading of the compressor, and a controlling device for the by-pass valves connected to act responsively to suction pressure to effect closing of the by-pass valves and to a predetermined minimum suction pressure to effect opening of the by-pass valves.

3. The combination of a compressor, a plurality of clearance chambers, clearance valves for the chambers, by-pass valves to control communication between the chambers, a plurality of devices for controlling the clearance valves and connected to act one after another in response to decrements in the value of the suction pressure for effecting gradual loading of the compressor, and a controlling device for the by-pass valves connected to act responsively to suction pressure for effecting closing of the by-pass valves and to supply pressure fluid to the first mentioned controlling devices for closing the clearance valves, said last mentioned controlling device connected to act responsively to a predetermined minimum suction pressure for effecting complete unloading of the compressor.

4. The combination of a plurality of compressors, a plurality of load controlling devices for each compressor, a plurality of devices for enabling the load controlling devices to be operated and connected to act one after the other in response to variations in the value of the suction pressure for effecting gradual loading of the compressors according as the value of the suction pressure decreases, one of said second mentioned devices operating to effect complete unloading of all the compressors.

5. The combination of a plurality of compressors, a plurality of load-controlling devices for each compressor, a plurality of devices for enabling the load controlling devices to be operated and connected to act one after the other in response to decrements in the value of the suction pressure for effecting first a gradual loading of one compressor and subsequently a gradual loading of another compressor according as the value of the suction pressure decreases, one of said second mentioned devices operating at a predetermined minimum suction pressure to effect complete unloading of all the compressors.

6. A load controlling apparatus for a compressor having a plurality of clearance chambers, clearance valves for said chambers, by-pass clearance valves for controlling communication between the clearance chambers, and a plurality of controlling means each controlling a pair of said valves, one of said controlling means acting as a master controlling means to control actuation of the remainder of the said controlling means, one of said controlling devices serving to control actuation of the remaining controlling devices by the pressure medium while controlling its respective loading device.

7. The combination with a compressor and loading means therefor of a plurality of controlling devices each controlling a loading device, and a common source of pressure medium connected to said controlling devices through which said loading devices are actuated.

8. The combination of a compressor having loading devices, a plurality of controlling devices connected individually to certain of the loading devices and one of which controlling devices is a master controlling device and serves to control the remaining controlling devices, each controlling device comprising a separate casing containing a main valve and a pilot valve, and a source of pressure medium connected to said casings to actuate said loading devices, said connection including means for passing said medium through the casing of the master controlling device to the casings of the remaining controlling devices.

9. The combination of a compressor having loading devices, a plurality of controlling devices for the loading devices, connections for conveying pressure medium from each controlling device to a loading device, and connections for conveying pressure medium from one of said controlling devices to the remaining controlling devices.

10. The combination of a compressor having loading devices, a plurality of controlling devices for the loading devices, connections connecting each controlling device with a pair of loading devices to convey pressure medium thereto, a master controlling device, and connections to convey pressure medium from the master controlling device to the first mentioned controlling devices and to a pair of loading devices.

11. The combination of a compressor having loading devices, a plurality of controlling devices each controlling a pair of loading devices, and a master controlling device controlling operation of said plurality of controlling devices while controlling a pair of loading devices.

12. The combination of a compressor having loading devices, a plurality of controlling devices each controlling a loading device, and a master controlling device controlling said plurality of devices and a loading device substantially simultaneously.

13. The combination of a compressor having loading means, separate means each controlling a loading means, and master means controlling said separate means and a loading means substantially simultaneously.

14. The combination of a compressor having loading means, a plurality of means each controlling a loading means, and master means controlling a plurality of means and a loading means substantially simultaneously, said master means and each said separate means being actuated by a different pressure.

15. A compressor comprising loading devices, controlling devices for the respective loading devices to increase the load on the compressor step-by-step as the compressor discharge pressure decreases, each of said controlling devices comprising a casing having a pilot valve therein and an additional mechanism to enable the respective loading devices to be actuated, a head affixed to said valve, a diaphragm to engage the head, means for subjecting the diaphragm to the pressure of a fluid medium, and a spring to oppose the force of the pressure fluid acting against the diaphragm, said head for each controlling device being of a different size whereby different pressures actuate each device to affect step-by-step loading of the compressor.

CHESTER W. METZGAR.

CERTIFICATE OF CORRECTION.

Patent No. 2,125,355. August 2, 1938.

CHESTER W. METZGAR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, first column, lines 64 to 68 inclusive, claim 6, strike out the comma and words ", one of said controlling devices serving to control actuation of the remaining controlling devices by the pressure medium while controlling its respective loading device" and insert the same after "actuated" and before the period in second column, line 2, claim 7; line 26-27, claim 10, for "devides" read devices; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of November, A. D. 1938.

Henry Van Arsdale

(Seal) Acting Commissioner of Patents.