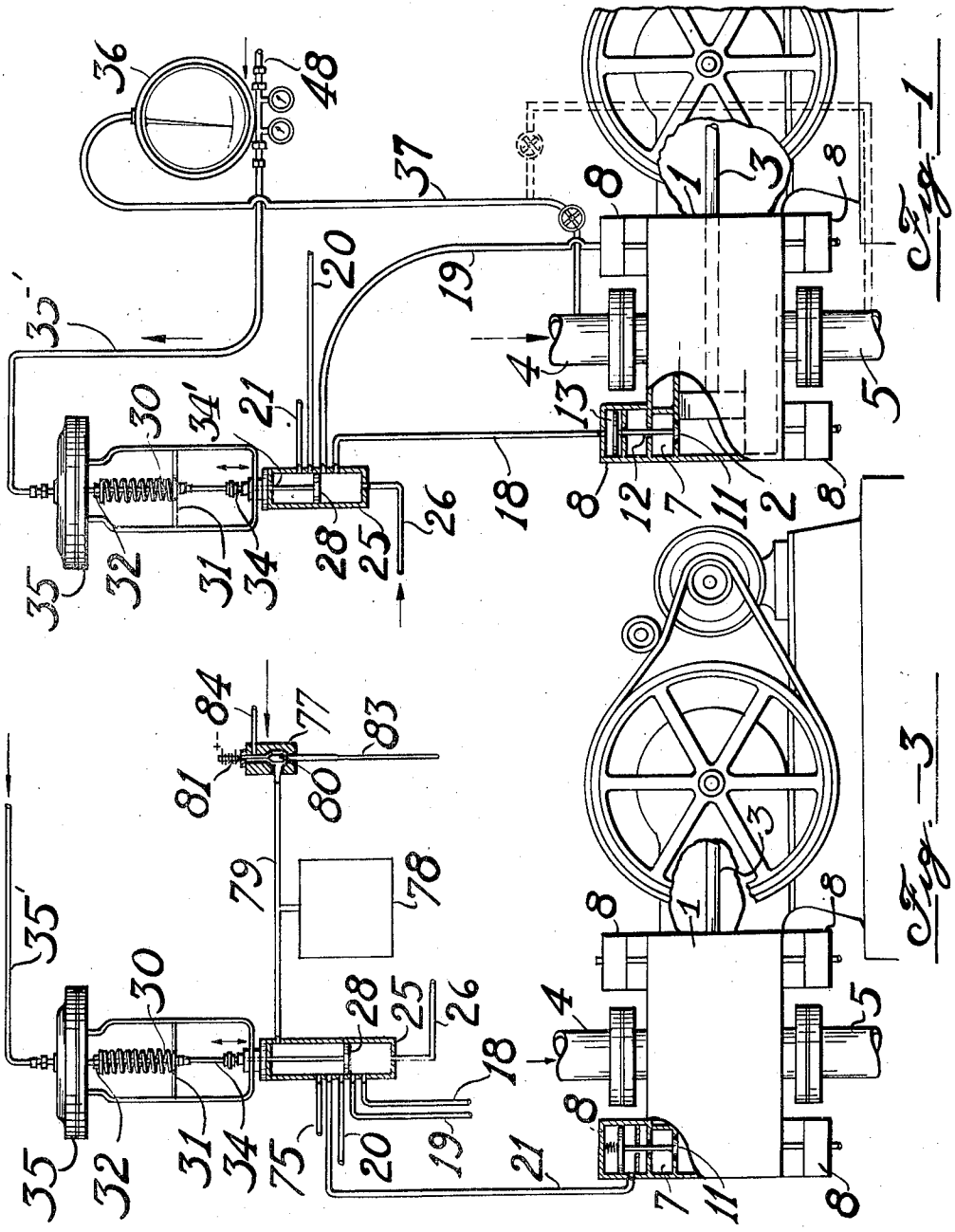
April 28, 1936. P. E. KUHL 2,038,577

REGULATOR FOR VARIABLE CAPACITY COMPRESSORS

Filed March 11, 1932 2 Sheets-Sheet 1



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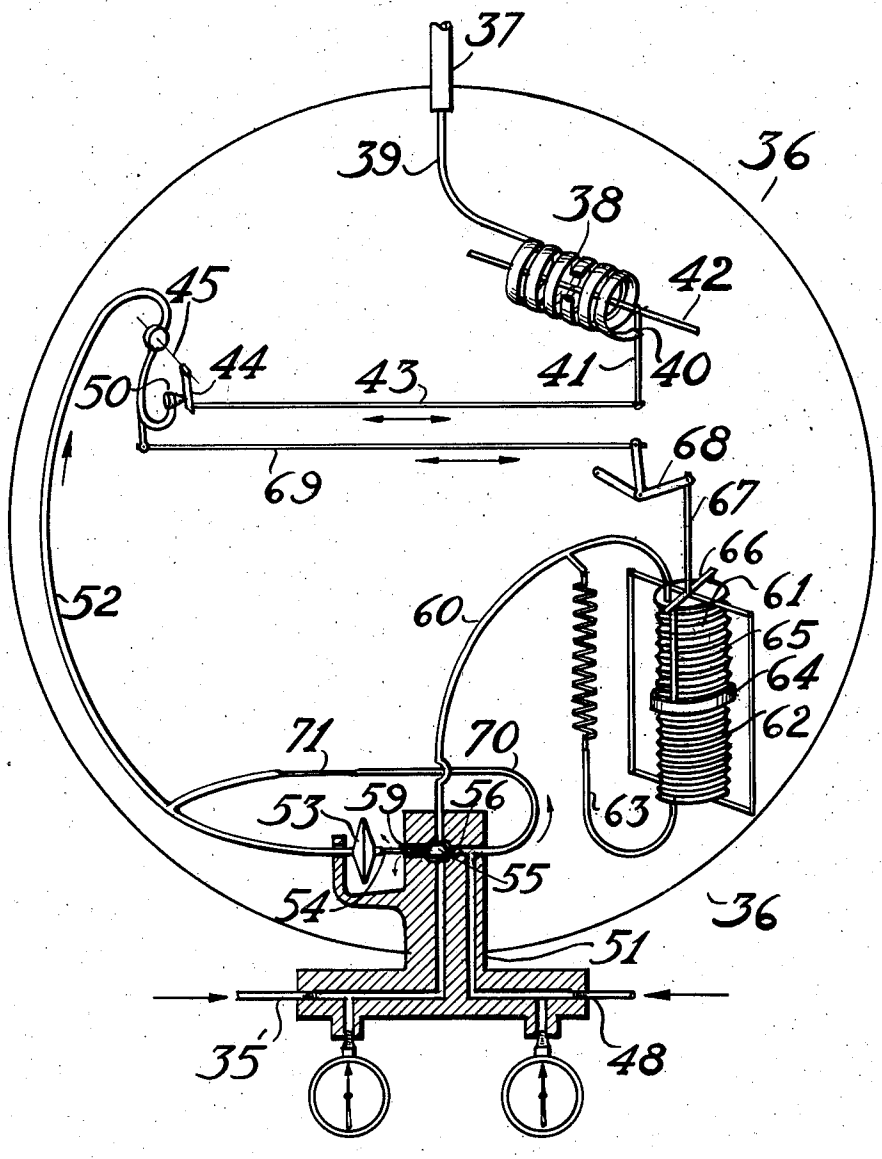

Fig.-2

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REGULATOR FOR VARIABLE CAPACITY COMPRESSORS

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17 Claims. (Cl. 230—21)

This invention relates to improvements in the regulation of the suction or discharge pressure of fluid compressors.

The invention will be fully understood from the following description taken in connection with the accompanying drawings in which latter—

Fig. 1 is a diagrammatic view showing the improved regulator connected to a constant speed variable capacity compressor of approved construction, the compressor being shown in side elevation with parts broken away.

Fig. 2 is a diagrammatic view of a stabilizer pressure controller, and

Fig. 3 is a diagrammatic view of a modified form of compressor control.

Referring particularly to Fig. 1, reference numeral 1 designates the cylinder of a compressor pump having a piston 2 actuated by a piston rod 3. The cylinder is disposed in a tube which constitutes an intake 4 and an outlet 5. Clearance pockets 7 open into the cylinder at opposite ends of the cylinder and are governed by pocket controls 8. Valves 11 control the opening of the clearance pockets into the cylinder. Each valve 11 is provided with a stem 12 connecting the valve 11 and control piston 13 for reciprocation in the pocket and pocket control respectively. Leakage from the clearance pockets 7 to the atmosphere along the stem 12 is prevented by means of a stuffing box. The pistons 13 are pneumatically or hydraulically operated by means of fluid introduced into the head of each pocket control 8 through lines 18, 19, 20 and 21 respectively.

A multi-port distributor is provided which opens or closes the clearance pockets successively by introducing or withdrawing the control fluid such as air or water or the like from the clearance pockets. The distributor valve includes a barrel 25. An inlet line 26 opens into one end of the barrel 25 for introducing air or water or the like under pressure from a suitable source of pressure not shown. Preferably the fluid is introduced from line 26 under a pressure of approximately eighty pounds per square inch. Lines 18, 19, 20 and 21 open through ports into the barrel in spaced relation at spaced intervals longitudinally of the barrel at successively progressively increasing distances from the inlet line 26. Communication of the inlet line 26 with the lines 18, 19, 20 and 21 is controlled by means of a piston 28 which is mounted for reciprocation longitudinally of the barrel. The force of a spring 30 normally maintains the piston 28 in retracted position whereby all of the lines 18, 19, 20 and 21 are in communication with the line 26. This movement of the piston 28 to retracted position is partially assisted by the force of the compressed fluid entering the barrel through line 26. One end of the spring 30 is affixed to a suitable support 31. The other end is compressed by the nut 32 which operates on a threaded piston rod 34. The piston rod 34 is secured to the piston 28 and passes into the barrel through a vent 34', as clearly shown in Fig. 1. The opposite end of the piston rod is affixed to a diaphragm 35.

The multi-port diaphragm valve is actuated to determine the communication between inlet 26 and the lines 18, 19, 20 and 21 by means of fluid such as air under pressure which is introduced above the diaphragm through a line 35' from a suitable control mechanism 36. The compressed fluid from line 35' opposes the spring 30 to reciprocate the piston 28 to open or close communication of the lines 18, 19, 20 and 21 with the line 26 as desired. The position of the piston is determined by the air pressure developed on the diaphragm by a pilot operated pressure controller 36, preferably a stabilized control instrument. The controller communicates with the line 35' as shown and with the inlet 4 of the compressor cylinder 1 through a line 37. Alternatively the line 37 can connect the controller with the outlet of the compressor cylinder.

The pressure controller shown in Fig. 2 comprises a tubular helical spring 38 which is connected through a tube 39 and the line 37 with the pressure which is to be controlled. Variation in the fluid pressure within the line 37 causes the tubular helical spring 38 to either contract or expand. The end of the spring 38 is connected at 40 to a link 41 which is pivotally supported by a rod 42 on the axis of the spring. The link 41 is pivotally connected to a rod 43 which in turn is connected to a flapper 44. The flapper 44 is mounted for rotation upon a shaft 45. By this construction should the pressure being controlled rise, the helical spring 38 will expand thus moving the connecting rod 43 to the left as viewed in Fig. 2, thereby causing the flapper 44 to be moved in a clockwise direction.

Compressed air from a line 48 is passed through the stabilizer 36 where it is delivered through a nozzle 50 in a manner to be later described, and the flow of the compressed air through the nozzle is controlled by means of the flapper 44. The flapper is continuously held in a balanced position with respect to the nozzle. The variation in the obstruction to the compressed air issuing

from the nozzle 50 is caused to influence a pilot valve 51 by the following arrangement of parts: A flexible conduit 52 leading from the nozzle 50 opens through one of the plates of a bellows 53. The other plate is connected to the valve stem 54 of the pilot valve control head 51. The valve stem 54 carries a valve head 55 which is adapted to be reciprocated in a valve chamber 56 to alternatively open communication between the air inlet 48 or an air outlet 59 and the valve chamber which in turn is connected to the conduit 35'. The compressed air is preferably introduced through the line 48 under a pressure of approximately 15 pounds per square inch above atmospheric pressure. The bellows 53 is so mounted that alteration in the pressure of the fluid within the bellows with resultant collapse or expansion of the bellows causes change in position of the valve stem 54. When the instrument is in operation controlling the pressure, the nozzle and flapper are substantially in contact. The position of the nozzle 50 is determined by the air pressure within a line 60 which opens into the valve chamber 56 and which communicates with a chamber 61 of a sylphon bellows. A chamber 62 of another sylphon bellows communicates through a capillary tube 63 with the line 60. A disc 64 separates the chambers 61 and 62 and is connected through links 65, 66 and 67 with an arm of a bell crank 68. The other arm of the bell crank is connected by a link 69 with the nozzle 50.

Assuming the instrument to be in operating equilibrium, the air pressure on top of the diaphragm 35, see Fig. 1, will be the same as the air pressure within the line 35', line 60 connecting the sylphon bellows 61 to the valve chamber 56, and the sylphon bellows 62. Should the pressure being controlled rise, the helical spring 38 will expand thus moving the connecting link 43 to the left as viewed in Fig. 2 which causes the flapper 44 to be moved clockwise as viewed in Fig. 2.

Air under pressure enters the control head 51 and passes through a by-pass 70 with its restriction 71 and the line 52 and blows out of the nozzle 50 against the flapper 44. As the flapper 44 moves to the left it restricts the flow of air from the nozzle 50 and builds pressure within the bellows 53. The bellows 53 therefore expands thereby moving the pilot valve 55 to the right, as viewed in Fig. 2, shutting off the air entering the valve chamber and permitting the air to leak away from the diaphragm valve and sylphon bellows 61 at 59. The sylphon bellows are actuated by springs, not shown, of equal strength inside the bellows. Since the pressure in chamber 61 is reduced the greater pressure in chamber 62 functions to cause the disc 64 with its attached links to be moved upwardly thereby rotating the bell crank 68 counter-clockwise as viewed in Fig. 2 and in turn withdrawing the nozzle 50 to the left as viewed in Fig. 2. This produces an opposite effect with respect to the compression of the air issuing from the nozzle 50 from that produced when the flapper is moved to the left, as viewed in Fig. 2, and thereby tends to minimize the effect of moving the flapper. The mechanism thereby seeks a balanced position.

A relationship is established between the movement of the main valve which is a function of the pressure in line 35' and the magnitude of the change in pressure in line 37 which it is desired to control. Since the sylphon 62 is connected to sylphon 61 through the capillary tube 63, the pressure in sylphons 61 and 62 becomes balanced at a rate depending upon the length and diameter of the capillary tube. The lever system 67, 68 and 69 is thus brought back to a mid-position. While a particular form of stabilizer pressure controller has been described, it will be understood that other devices for this purpose can be used within the scope of this invention.

Referring particularly to Fig. 3, a modified form of compressor control is illustrated adapted to remove the load from the compressor at once when there is a dip in voltage as when synchronous motors are used, in order to avoid getting the motor out of step and causing it to stop. Like reference numerals refer to like parts as described in the preceding figures. The compressor 1 is provided with clearance pockets 7 having valves 11 which open when fluid pressure is applied through lines 18, 19, 20 and 21, and which close when air pressure thus supplied is released. Similarly a by-pass is provided from the head end to crank end which opens when air pressure is applied in line 75. It is understood that air pressure in line 75 could be used to operate any of the usual compressor unloaders such as by-pass from suction to discharge or hold the suction valves open.

A three-way solenoid valve 77 is connected through relays to the field circuit of the motor, not shown. This valve communicates with the multi-port valve 25 and with a capacity tank 78 by means of a line 79. A valve head 80 of the solenoid valve is actuated by a solenoid 81. The solenoid is connected to the motor circuit in the customary manner whereby on voltage dips or failure of power the solenoid 81 is de-energized thereby permitting the valve head 80 to close communication of a vent 83 with the line 79, whereby fluid such as air under pressure admitted through a line 84 rapidly enters the capacity tank 78 and clearance pocket controls 8 and by-pass valve control (not shown) thereby unloading the compressor. Upon return of voltage, or when the motor reaches synchronous speed on starting, the solenoid valve 80 is withdrawn from the vent 83 thereby releasing the fluid such as air from above the piston 28 and permitting the compressor 1 to operate under load.

It will be understood that small tubing, orifices, or similar devices may be inserted in the vent line 83 and air inlet lines 35 and 84 to permit in conjunction with the capacity tank the regulation of the rate at which the compressor is loaded or unloaded.

The capacity tank being large as compared with the volume of the clearance pocket controls etc., will not affect the speed at which the control in normal operation can open or close clearance pockets.

Fluid from the multi-port valve can be used to control devices other than a compressor such as heating devices, flow control devices, or the like, in which case a temperature controller or rate of flow controller would be substituted for the pressure controller 36.

Various changes may be made within the scope of the appended claims in which it is desired to claim all novelty inherent in the invention as broadly as the prior art permits.

I claim:

1. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, of a distributor valve including a barrel

having lines leading to the control devices and including a reciprocable piston controlling admission of pressure fluid to the lines and release therefrom, an inlet for introducing fluid under pressure into the barrel in spaced relation to the piston, the barrel having a vent for releasing fluid from the end of the barrel opposite the inlet, a conduit adapted to contain fluid under pressure leading to the distributor valve to actuate the piston, and a pilot valve having fluid communication with the gas compressor operable by fluid pressure generated by the compressor to control flow of fluid through the conduit.

2. A distributor valve, comprising a barrel having ports disposed in spaced relation longitudinally of the barrel, a piston mounted for reciprocation within the barrel to control admission to or release of fluid from the ports, an inlet for introducing fluid under pressure into the barrel in spaced relation to the piston, a flexible diaphragm associated with the piston, means for passing fluid under pressure against the diaphragm whereby the position of the piston is varied, a capacity tank communicating with the barrel on the opposite side of the piston from the inlet, and a valve controlling flow of fluid under pressure to or from the capacity tank.

3. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, of a distributor valve including a barrel having ports disposed in spaced relation longitudinally of the barrel and communicating with successive control devices, a piston mounted for reciprocation within the barrel to control admission to and release of fluid from the ports, an inlet for introducing fluid into the barrel in spaced relation to the piston, means for controlling the position of the piston, a capacity tank opening into the barrel on the opposite side of the piston from the inlet, a motor for actuating the compressor, an electrically operated valve connected to the electric circuit of the motor, the electrically operated valve controlling admission of fluid under pressure to the capacity tank and release therefrom.

4. A multi-port distributor valve, comprising floating reciprocable means for controlling admission to or release of fluid from the ports, means for normally resiliently forcing said reciprocable means in one direction and means of low frictional and inertia values for controlling reciprocation in the opposite direction by use of fluid pressure subject to fluctuation, said fluid pressure being independent of the fluid passing to and from the ports.

5. A multi-port distributor valve, comprising floating reciprocable means for controlling admission to or release of fluid from the ports, means for normally resiliently forcing said reciprocable means in one direction, fluid-pressure-opposing means attached directly to the reciprocable means adapted to withstand fluid pressure from the opposite direction over a relatively wide area and means for maintaining fluid under pressure against said pressure-opposing means, whereby the position of the reciprocable means is varied according to fluctuations in the pressure of said fluid.

6. A distributor valve, comprising a plurality of ports, reciprocable means for controlling admission to or release of fluid from said ports, a flexible diaphragm connected directly to said reciprocable means and means for maintaining fluid under pressure against the diaphragm, whereby the position of the reciprocable means is varied according to fluctuations in the pressure of said fluid.

7. The combination with a gas compressor having pressure operated control devices for controlling the loading and unloading of the compressor, of a multi-port distributor valve comprising floating reciprocable means for controlling admission to or release of fluid from the ports, means for normally resiliently forcing said reciprocable means in one direction and pressure responsive means operatively connected to the intake or discharge of the compressor operating through an air pilot valve controlling reciprocation in the opposite direction whereby sensitivity of control of floating action of the reciprocable means is obtained.

8. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, of a distributor valve including a barrel having ports disposed in spaced relation longitudinally of the barrel communicating with the successive control devices, a piston mounted for reciprocation in the barrel to control the admission to or release of fluid from the ports, an inlet for introducing fluid under pressure into the barrel in spaced relation to the piston, the barrel having a vent for releasing fluid from the end of the barrel opposite the inlet, a flexible diaphragm associated with the piston, a motor for actuating the gas compressor, an electrically operated valve connected to the electrical circuit of the motor, the electrically operated valve controlling the admission of fluid under pressure to the distributor valve on the opposite side of the plunger from the inlet, a fluid pressure line opening against one side only of the diaphragm whereby the diaphragm is actuated, a pressure responsive means having fluid communication with the intake or outlet of the gas compressor operated by the pressure within the intake or outlet to control flow of fluid through the fluid pressure line.

9. A distributor valve according to claim 2 in which the valve is an electrical valve controlled from the motor circuit operating the compressor.

10. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, a distributor valve including a barrel having lines leading to the control devices and including a reciprocable piston controlling admission of pressure fluid to the lines of release therefrom, an inlet for introducing fluid under pressure into the barrel in spaced relation to the piston, the barrel having a vent for releasing fluid from the end of the barrel opposite the inlet, a conduit adapted to contain fluid under pressure leading to the distributor valve to actuate the piston, and a pilot valve operatively connected with the pressure being controlled to control flow of fluid through the conduit.

11. The combination with a variable capacity gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, a multi-port distributor valve, lines leading from the ports to the control devices, the valve comprising fluid reciprocable means for controlling admission to or release of fluid from the ports, means for normally resiliently forcing said reciprocable means in one direction, fluid pressure opposing means attached directly to the reciprocable means adapted to withstand fluid pressure from

the opposite direction over a relatively wide area, and a pilot valve having fluid communication with the gas compressor operable by fluid pressure generated by the compressor for maintaining fluid under pressure against said pressure opposing means whereby the position of the reciprocable means is varied according to fluctuations in the pressure of said fluid.

12. The combination with a variable capacity gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, a multi-port distributor valve, lines leading from the ports to the control devices, the valve comprising fluid reciprocable means for controlling admission to or release of fluid from the ports, means for normally resiliently forcing said reciprocable means in one direction, and a pilot valve having fluid communication with the gas compressor operated by fluid pressure generated by the compressor for controlling reciprocation in the opposite direction to control flow of fluid through the conduit.

13. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, a multi-port distributor valve, lines leading from the ports to the control devices, a valve comprising floating reciprocable means for controlling admission to or release of fluid from the ports, means for normally resiliently forcing said reciprocable means in one direction, and pressure responsive means including a pilot valve having fluid communication with the intake or outlet of the gas compressor operated by the pressure within the intake or outlet for controlling reciprocation in the opposite direction, the last mentioned fluid being independent of the fluid being compressed by the compressor.

14. The combination with a variable capacity gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, a multi-port distributor valve, lines leading from the ports to the control devices, the valve comprising floating reciprocable means for controlling admission to or release of fluid from the ports, means for normally resiliently forcing said reciprocable means in one direction, fluid pressure opposing means attached directly to the reciprocable means adapted to withstand fluid pressure from the opposite direction over a relatively wide area, and pressure responsive means including a pilot valve having fluid communication with the intake or outlet of the gas compressor operated by the pressure within the intake or outlet to control flow of fluid against said pressure opposing means, the fluid being independent of the fluid being compressed by the compressor.

15. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, the compressor being disposed in a tube which constitutes the inlet and outlet of the compressor, a distributor valve including a barrel having ports disposed in spaced relation longitudinally of the barrel communicating with successively operable control devices, a piston mounted for reciprocation within the barrel to control admission to or release of fluid from the ports, an inlet for introducing fluid into the barrel in spaced relation to the piston, a flexible diaphragm associated with the piston, means for passing fluid under pressure against the diaphragm whereby the position of the piston is varied, and stabilized control means operatively connected with the tube for automatically controlling the pressure of said fluid against the diaphragm according to fluctuations in the pressure within the tube.

16. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, the gas compressor being disposed in a tube which constitutes the inlet and outlet for the compressor, of a distributor valve including a barrel having ports disposed in spaced relation longitudinally of the barrel communicating with the successive control devices, a piston mounted for reciprocation in the barrel to control admission to or release of fluid from the ports, an inlet for introducing fluid under pressure into the barrel in spaced relation to the piston, the barrel having a vent for releasing fluid from the end of the barrel opposite the inlet, a flexible diaphragm associated with the piston, a fluid pressure conduit opening against one side only of the diaphragm whereby the diaphragm is controlled, and pressure responsive means including a pilot valve in the fluid pressure conduit and a pressure controller connected to the tube and responsive to variations in pressure in the tube and operatively connected to the pilot valve to control the pilot valve, the fluid in the fluid pressure conduit being independent of the fluid being compressed by the compressor.

17. The combination with a gas compressor having pressure operated control devices for controlling the unloading and loading of the compressor, the gas compressor being disposed in a tube which constitutes the inlet and outlet from the compressor, of a distributor valve including a barrel having a line leading to the control devices and including a reciprocable piston controlling admission of fluid pressure to the line and release therefrom, an inlet for introducing fluid under pressure into the barrel in spaced relation to the piston, the barrel having a vent for releasing fluid from the end of the barrel opposite the inlet, a conduit adapted to contain fluid under pressure leading to the distributor valve to actuate the piston, a pilot valve in the conduit operated to control flow of fluid through the conduit, and means operatively associated with the tube responsive to variations in pressure in the tube for actuating the valve.

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