Jan. 22, 1963 R. W. HUGHES ET AL 3,074,434

COMPRESSOR CONTROL

Filed Nov. 28, 1958

FIG. 1.

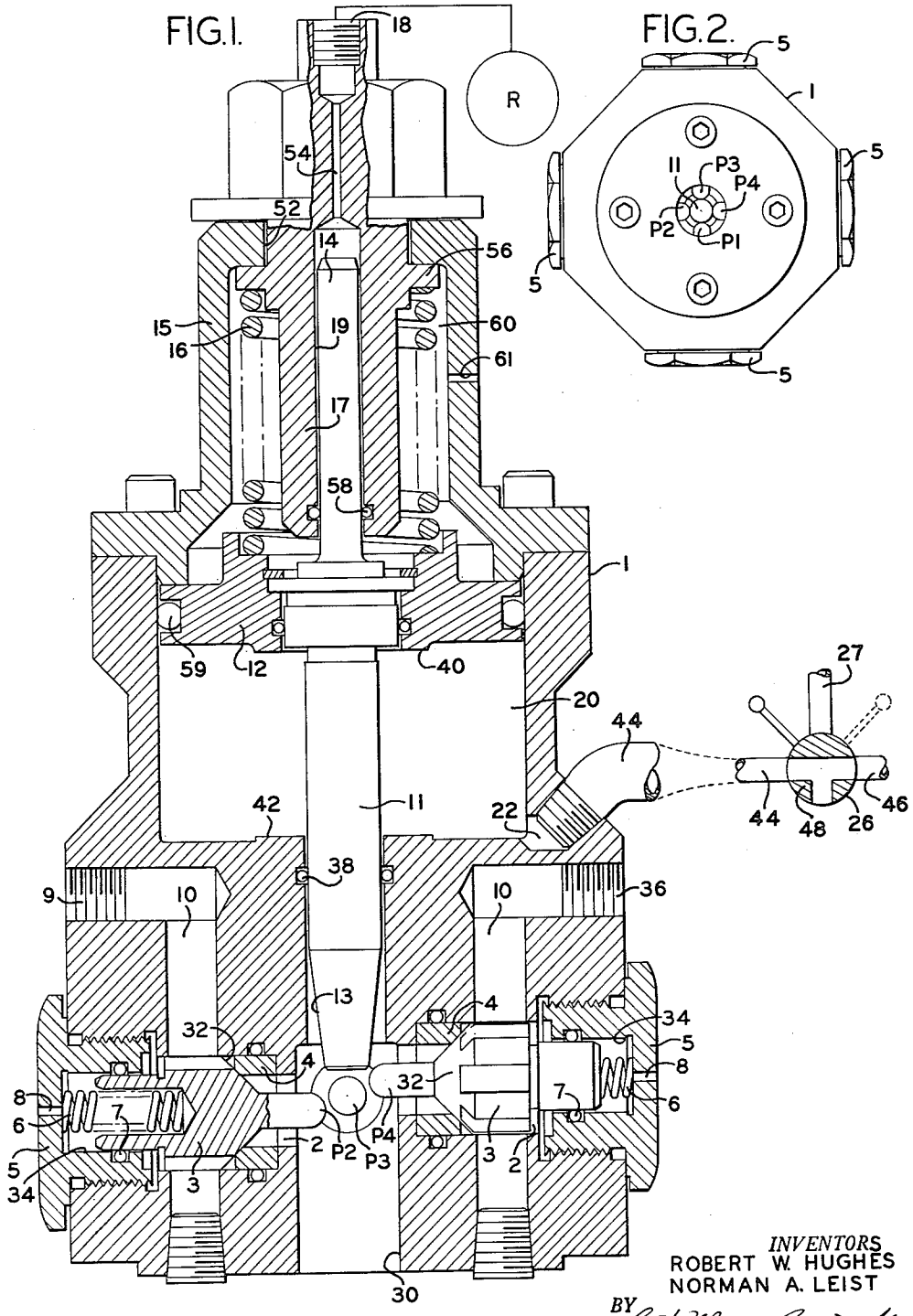


FIG. 2.

INVENTORS
ROBERT W. HUGHES
NORMAN A. LEIST

BY E. Wallace Breed

ATTORNEY

United States Patent Office 3,074,434 Patented Jan. 22, 1963

3,074,434

COMPRESSOR CONTROL

Robert W. Hughes and Norman A. Leist, Michigan City, Ind., assignors to Joy Manufacturing Company, Pittsburgh, Pa., a corporation of Pennsylvania

Filed Nov. 28, 1958, Ser. No. 776,900
6 Claims. (Cl. 137—628)

This invention relates to a compressor control and more particularly to a control for obtaining automatic sequential loading and unloading of a compressor.

At present various means have been provided to obtain gradual step unloading for compressors the most common being the provision of a plurality of spring biased valves which are opened in response to the pressure developed by the compressor. In general, however, the prior unloading systems have provided an individual means for each stage of the compressor. Such individual controls substantially increase the cost of the system and in the event of failure of any one control prevent the system from operating properly.

Accordingly one object of this invention is to provide a new and improved unitary control for sequential loading and unloading of a multi-stage compressor.

Another object of this invention is to provide a new and improved compressor control comprising a single plunger for sequentially actuating individual mechanisms controlling the loading and unloading of the stages of a multi-stage compressor.

A specific object of this invention is to provide a new and improved compressor control comprising individual valves for unloading and loading individual stages of a multi-stage compressor which valves have actuating portions spaced along the path of travel of an actuating member to obtain sequential operation thereof.

These and other objects of this invention will become more apparent upon consideration of the following detailed description of a preferred embodiment thereof, when taken in conjunction with the following drawings, in which:

FIG. 1 is an axial sectional view of a compressor control constructed in accordance with the principles of this invention, and

FIG. 2 is a reduced scale bottom plan view of the control as shown in FIG. 1.

Referring to the drawings it will be noted that a compressor control constructed in accordance with the principles of this invention comprises an elongated formed valve housing 1 having a central elongated bore 30 extending axially from the lower edge thereof to a cylindrical chamber 20 located intermediate the housing 1. A plurality of elongated valve cavities 2 are provided in the housing 1 which extend radially therethrough and are located upwardly from the lower end of the bore 30 with their central axes lying in parallel planes. As will become apparent hereinafter a valve cavity 2 is provided for each compressor stage of a multi-stage compressor which is to be controlled and, as a four stage compressor control is shown, four valve cavities 2 are provided in the housing 1 with their center axes being spaced 90° from each other with reference to a plane normal to the longitudinal axis of the bore 30. In FIG. 1 side views of the second and fourth stage control valves and an end view of the stage control valve have been shown. Of particular importance with reference to this invention is that the central axes of the valve cavities 2 are spaced from each other longitudinally of the axis of the bore 30.

Each valve cavity 2 is formed to receive an unloading valve means therein which valves are identical to each other. Each unloading valve comprises an annular valve seat 4 suitably rigidly located within a cavity 2 radially outwardly adjacent the bore 30, and an elongated valve body 3 having an annular seat portion 32 biased into engagement with the seat 4 by means of a suitable spring 6 extending between the valve body 3 and a valve cap 5 suitably secured to the housing 1 to enclose the outer end of the valve cavity 2. As shown, the cap 5 has a portion located inwardly of the cavity 2 which has a bore 34 therein which bore 34 extends outwardly from the inner end of the cap 5 and in which bore 34 the outer end of the valve body 3 is reciprocably received. The cap 5 is provided with an opening 8 to vent the outer end of the bore 34 and a suitable packing means such as an O-ring 7 is located in the cap 5 adjacent its inner end to seal the vented portion of the bore 34 from the rest of the cavity 2. By forming the open area of the valve body seat 4 equal to the area of the portion of the valve body 3 within the vented portion of the bore 34, atmospheric pressure is exerted on equal areas at opposite ends of the valve body 3 so that the valve body 3 is balanced regardless of the existing operating pressure.

Each of the control valve bodies 3 is provided at its inner end with an integral elongated plunger which extends radially from the seat portion 32 into the bore 30 of the housing 1. For the purpose of describing this invention the plunger for the fourth, third, second and first stages have been identified as P–4, P–3, P–2 and P–1, respectively. As shown the inner end of each plunger P–1, P–2, P–3 and P–4 is rounded and extends radially inwardly of the bore 30 with the rounded end being spaced radially outwardly from the central axis of the bore 30.

With reference to the second stage control valve it will be noted that a suitable passageway 10 is provided in the housing 1 which extends from the outer surface thereof to the cavity 2 therefor so as to be connected to the bore 30 upon movement of the seat portion 32 out of engagement with the seat 4. As shown the outer end of the passageway 10 is provided with suitable means such as threads 9 to permit a suitable transmission line (not shown) to be connected thereto which line is connected to the second stage of the compressor to be unloaded to atmosphere. The illustrated foruth stage is provided with a similar passageway 36 and the first and third stages are provided with similar passageways, not shown.

Operation of the control valves is obtained by actuating means such as an elongated cylindrical plunger 11 which is axially reciprocably or movably located within the bore 30. As shown, the upper end of the plunger 11 is suitably secured to a circular piston 12 which is closely received within the chamber 20. A suitable O-ring 59 may be provided on the outer edge surface of the piston 12 to engage the surface of the chamber 20 to prevent the leakage of air from the chamber 20. In FIG. 1 the piston 12 is shown in its full load operating position. It will be noted that the upper end of the housing 1 is formed by means of an axially elongated inverted cup shaped cap portion 15 having an elongated chamber 60 vented to the atmosphere through a radially extending opening 61 in the side thereof and in which an axially elongated suitable spring 16 is received. For the purposes of initially describing this invention it will be noted that the spring 16 is suitably received on the upper surface of the piston 12 and extends axially outwardly therefrom to bias the piston 12 towards the bottom of the chamber 20 at all times. When the piston 12 is in the illustrated full load position the plunger 11 is still closely received within the upper portion of the bore 30. The lower portion of the bore 30 is sealed from the chamber 20 in any suitable manner such as by providing a suitable O-ring 38 in the housing 1 which engages the outer surface of the plunger 11 at all times.

It will be noted that the lower surface of the piston 12 is provided with a central downwardly extending annular stop 40 outwardly adjacent the plunger 11 which engages a similar stop 42 formed in the housing 1 and which extends upwardly into the chamber 20 from the bottom thereof. Under no load conditions the spring 16 biases the piston 12 to the bottom of the chamber 20 until the stop 40 engages the stop 42 which functions to locate the undersurface of the piston 12 above the bottom of the chamber 20. One end of a suitable transmission line 44 is suitably secured to the outer end of a passageway 22 in the housing 1 which passageway 22 extends from the bottom of the chamber 20 and the other end of the line 44 is connected to a suitable T-valve 26 for controlling the operation of the compressor. Inasmuch as such T-valves are well known in the art the showing thereof is merely representative of the valve functions. As shown the valve 26 has a vent line 27 and an incoming line 46 which is connected to the first stage discharge pressure chamber of the compressor to be controlled. The valve 26 is also provided with a suitable rotor 48 having a T-shaped passageway therein whereby upon proper rotation thereof the line 44 may be connected to the line 46 or the vent 27.

Under the full load operating condition shown the line 46 is connected to the line 44 so that the discharge pressure from the first stage of the compressor causes the piston 12 to overcome the bias of the spring 16. To obtain manual unloading of the compressor the rotor 48 of the valve 26 is rotated so that the line 44 is connected to the vent 27 whereby the first stage pressure in the underside of the piston 12 is vented and the bias of the spring 16 causes the piston 12 to descend until the stops 40—42 are engaged. During such descent of the piston 12 the plunger 11 connected thereto also descends in the bore 30. It will be noted, however, that the lower end of the plunger 11 is tapered to provide a gradually increasing diameter cam surface 13 for the plungers P–1, P–2, P–3 and P–4 as the plunger 11 descends. As the plunger 11 starts to descend the cam surface 13 initially engages the outer rounded end of the plunger P–4 to start to displace the plunger P–4 laterally outwardly of the bore 30. Further descent of the plunger 11 causes the bias of the spring 6 of the fourth stage control valve to be overcome whereby the entire valve body 3 thereof moves outwardly of the valve cavity 2. When the seat portion 32 of the fourth stage control valve moves away from the seat 4 cooperable therewith the line 36 connected to the fourth stage is vented to atmosphere through the valve cavity 2 of the fourth stage control valve and the bore 30. Since the longitudinal axes of the plungers P–4, P–3, P–2 and P–1 are spaced greater distances, respectively, below the free end of the plunger the plunger will successively engage the plungers P–4, P–3, P–2 and P–1. Thus, each stage of the compressor will be unloaded in its proper sequence as in a seriatim manner. Once the cam surface 13 has descended past a plunger such as plunger P–4 the outer end of the plunger is held outwardly of the bore 30 by the engagement therewith with the outer surface of the plunger 11 above the cam surface 13.

In order to obtain manual loading of the compressor the rotor 48 of the valve 26 is rotated (as shown) to connect the first stage pressure discharge line 46 to the line 44. When so connected and with the compressor running the undersurface of the piston 12 is subjected to the first stage discharge pressure. As such first stage pressure starts to increase the piston 12 is forced upwardly so that the plunger 11 is gradually elevated in the bore 30. Due to such upward movement of the plunger 11 and the cam surface 13, and the fact that the first stage plunger P–1 is the most remote from the piston 12, the plunger P–1 of the first stage control valve will be biased by the spring 6 thereof and force the seat portion 32 thereof into engagement with its cooperable seat 4. Upon closing of the first stage control valve the line therefrom connected

to the compressor (that is the line similar to line 10 for the second stage control valve) is closed so that the compressor load starts to increase and consequently the first stage discharge pressure starts to increase. Such increase in first stage discharge pressure causes the piston to move further upwardly whereby the second control valve is closed, so that the first stage pressure discharge again increases whereby the third control valve is closed so that the first pressure discharge pressure again increases and the fourth stage control valve is closed. Thus it will be noted that by the disclosed structure the compressor is automatically properly sequentially loaded and unloaded.

It is believed obvious in view of the state of the art that if desired an automatic control may be substituted for the manual T-valve 26 described which is properly actuated to unload the compressor in response to various temperature or pressure conditions. In addition it will be noted that upon stopping the compressor the proper sequence of unloading is automatically obtained as the first stage discharge pressure in the chamber 20 bleeds off to atmosphere and the spring 16 forces the piston 12 downwardly to engage the stop 42.

Operation of the control valves may also be obtained by a suitable high pressure air connection 18 suitably connected to the upper end of the cup portion 15 of the housing 1. The connection 18 may be connected to the compressor receiver which is at a higher pressure than the first stage discharge pressure or any other source of sufficient pressure to cause the hereinafter described operation of the piston 12. As shown, an elongated plunger 14 extends axially upwardly from the piston 12 and is received within an elongated bore 19 of a cylinder 17 which extends centrally through the spring 16. The upper end of the cylinder 17 is closely received within an opening 52 in the upper end of the cup portion 15 so that the bore 19 therein is directly connected to an elongated passageway 54 extending axially through the connection 18. The cylinder 17 has an integral annular flange 56 extending outwardly therefrom adjacent its outer end the lower side of which is engaged by the spring 16 to be biased by the spring 16 into engagement with the bottom surface of the cup shaped portion 15. The plunger 14 is suitably secured to the piston 12 and if desired may be formed integral with the plunger 11. A suitable O-ring 58 may also be provided in the cylinder 17 to engage the outer surface of the plunger 14 to prevent leakage of air from the chamber 19.

With the above described structure and with the piston 12 in the position shown, when the high pressure medium, such as air, which is admitted to the upper surface of the plunger 14 is of sufficient magnitude to overcome the force of the first stage discharge pressure on the undersurface of the piston 12, the piston 12 will be forced downwardly in the chamber 20 so that the compressor is properly sequentially unloaded as heretofore described. When the pressure which is admitted to the upper surface of the plunger 14 is relieved the compressor is properly sequentially loaded as heretofore described. It is believed obvious that any suitable type of control as is well known in the art may be employed to control the admission and venting of high pressure air from the connection 18.

Having described a preferred embodiment of this invention in accordance with the patent statutes, it is to be realized that modifications thereof may be made without departing from the broad spirit and scope of the invention. Accordingly it is respectfully requested that this invention be interpreted as broadly as possible and be limited only by the prior art.

What we claim as new and desire to secure by Letters Patent is:

1. A control for obtaining sequential operation of a multi-stage compressor comprising, a housing having an elongated passageway with an opening connected to atmosphere therein, a plunger supported within said passageway for movement along a path in said passageway,

control devices mounted in said housing having movable actuating means extending into said passageway and the path of movement of said plunger respectively, said actuating means being spaced longitudinally with respect to each other along said path of movement, and said plunger having a portion engageable with each of said actuating means to hold all of said control devices in one operating position which portion is movable out of engagement with said actuating means to permit said actuating means to assume another operating position sequentially with reference to the longitudinal spacing of said actuating means to each other and to said path.

2. A control for obtaining sequential operation of a multi-stage compressor comprising, a housing having an elongated passageway with an opening connected to atmosphere, a plunger supported within said passageway for movement along a rectilinear path in said passageway, control devices mounted in said housing having means for biasing movable actuating means into said passageway along the path of movement of said plunger respectively, said actuating means being spaced longitudinally with respect to each other along said passageway, said actuating means being spaced circumferentially with respect to each other, said actuating means located in respective bores in said housing wherein said bores have their one ends communicating with separate inlet lines respectively and their other ends connected with said passageway, said plunger having a cammed portion engageable with each of said actuating means to overcome the bias of said means and hold all of said control devices in one operating position, and means operatively connected to said plunger for moving said portion of said plunger out of engagement with said actuating means to permit said biasing means to move said actuating means to another operating position of said control devices sequentially with reference to the longitudinal spacing of said actuating means wherein said sequential operation is determined by said cammed portion.

3. A control for obtaining sequential loading and unloading of a multi-stage compressor comprising, a housing having an elongated passageway with an opening connected to atmosphere, a plunger supported within said passageway for movement along a rectilinear path in said passageway, a plurality of control devices mounted in said housing having movable actuating means with portions thereof extending into said passageway for engagement by said plunger respectively, said actuating means being spaced longitudinally with respect to each other along said passageway, said actuating means being spaced circumferentially with respect to each other, said plunger having a tapering cammed portion engageable with each of said actuating means sequentially to hold all of said control devices in one operating position, said plunger being operatively connected to a piston of a cooperable piston and cylinder assembly, means operatively connected to said cylinder for moving said piston and said portion of said plunger in one direction in said passageway along said path out of engagement with said actuating means to permit said actuating means to assume another operating position sequentially with reference to the longitudinal spacing of said actuating means to each other, and other means operatively connected to said cylinder for moving said piston and said portion of said plunger in the direction opposite said one direction to return said control devices to said one operating position sequentially with reference to the longitudinal spacing of said actuating means with respect to each other.

4. A control for obtaining sequential operation of a multi-stage compressor comprising, a housing having an

elongated bore therein with one end being open to the atmosphere, a member supported within said bore for movement towards and away from said one end of said bore, said housing having passageways extending from said bore with control devices therein for selective opening and closing of said passageways respectively, said control devices having movable actuating means extending into and spaced longitudinally with respect to each other along the path of movement of said member, said member having a portion engageable with each of said actuating means to hold said control devices in a passageway-open-position, and said member being movable out of engagement with said actuating means to permit said actuating means to close said passageways sequentially with reference to the longitudinal spacing of said actuating means with respect to each other.

5. A control for obtaining sequential operation of a multi-stage compressor comprising, an elongated housing having an elongated chamber extending axially thereof, an axially movable piston within said chamber, an elongated opening extending axially through said housing into one end of said chamber, an elongated plunger secured to said piston and extending into said opening, a plurality of control devices having movable actuating means extending radially into said opening into the path of movement of said plunger, said actuating means being spaced longitudinally with respect to each other in said opening, means for biasing said piston towards said one end of said chamber with said plunger engaging all of said actuating means to hold said control devices in one operating position, a passageway in said housing connected to said chamber to cause movement of said piston away from said one end of said chamber and said plunger out of engagement with said actuating means when said passageway is connected to a pressurized medium sufficient to overcome the bias of said biasing means, and means for exerting a force on said piston to cause movement thereof towards said one end of said chamber.

6. A control device for obtaining sequential loading and unloading of a compressor comprising, a housing having a plurality of passageways connected to an elongated discharge bore and wherein said passageways are adapted to be connected to the respective several stages of a multi-stage compressor, valve means located in said passageways respectively for opening and closing the respective said passageways, said valve means and their rsepective said passageway being located in longitudinally spaced seriatim relationship with respect to each other, and actuating means engaging the valve means in sequential order due to said longitudinally spaced relationship for opening and closing said respective valve means in sequential order to load and unload the stages of a compressor.

References Cited in the file of this patent

UNITED STATES PATENTS

1,678,905	Goldberg	July 31, 1928
2,116,456	Wainwright	May 3, 1938
2,170,358	Wainwright	Aug. 22, 1939
2,177,544	Warner	Oct. 24, 1939
2,192,193	Johnson	Mar. 5, 1940
2,247,261	Towler et al.	June 24, 1941
2,301,439	Moen	Nov. 10, 1942
2,338,451	McCoy	Jan. 4, 1944
2,401,545	Briggs	June 4, 1946
2,478,213	Towler et al.	Aug. 9, 1949
2,899,168	Kleczek	Aug. 11, 1959

FOREIGN PATENTS

232,331	Switzerland	of 1944