May 22, 1945. W. A. EATON 2,376,588

FLUID PRESSURE MECHANISM

Filed Dec. 16, 1942 3 Sheets-Sheet 1

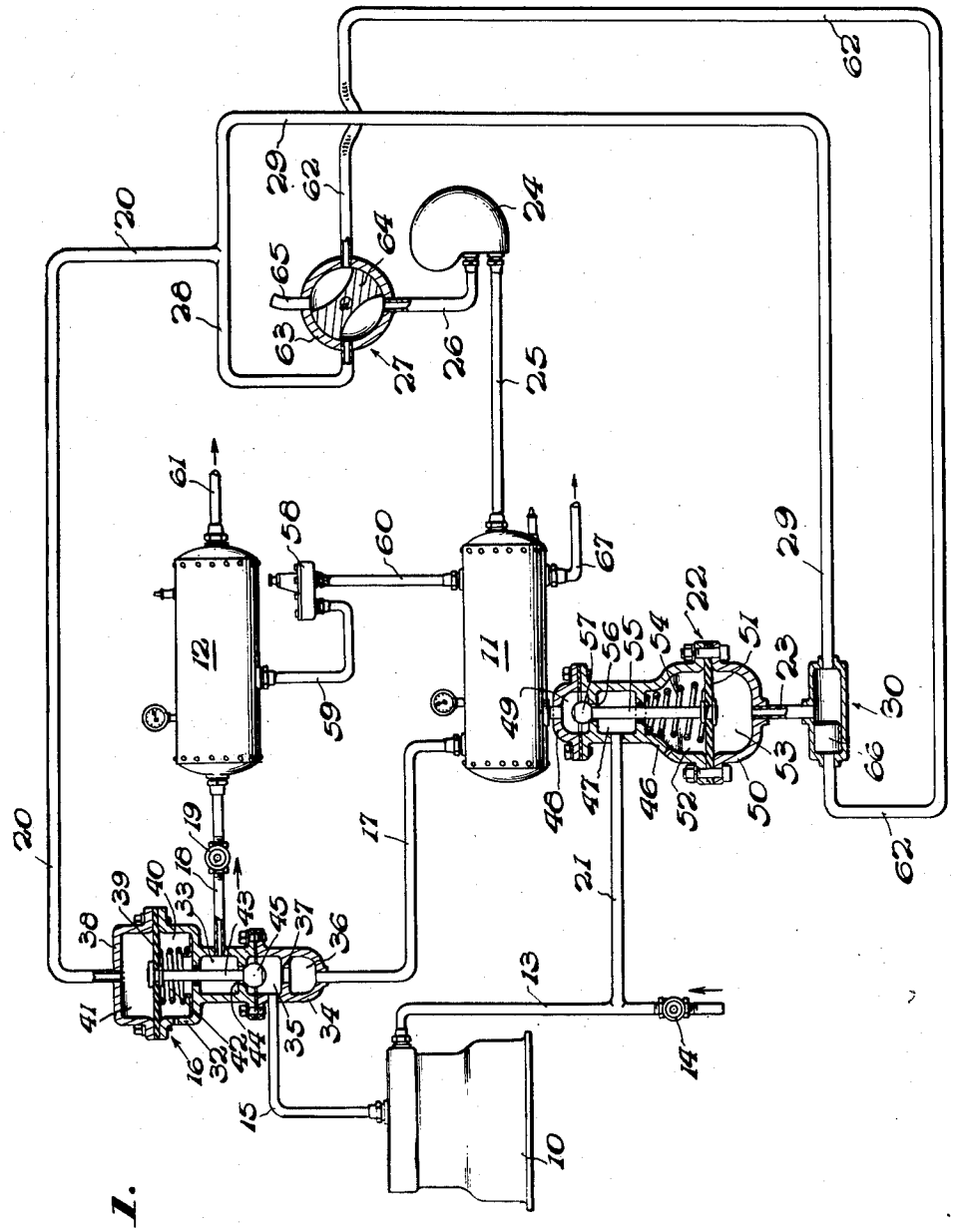


Fig. 1.

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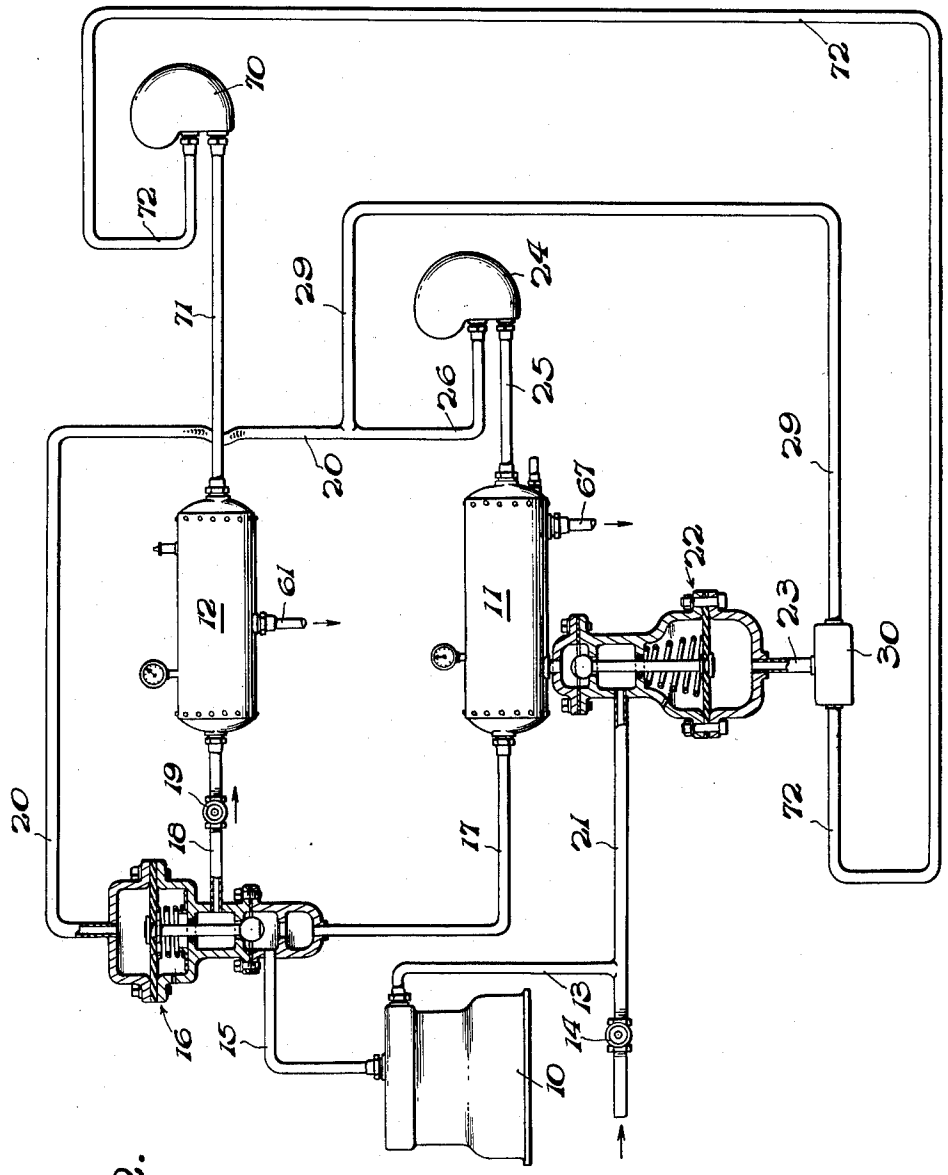


Fig. 2.

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FLUID PRESSURE MECHANISM

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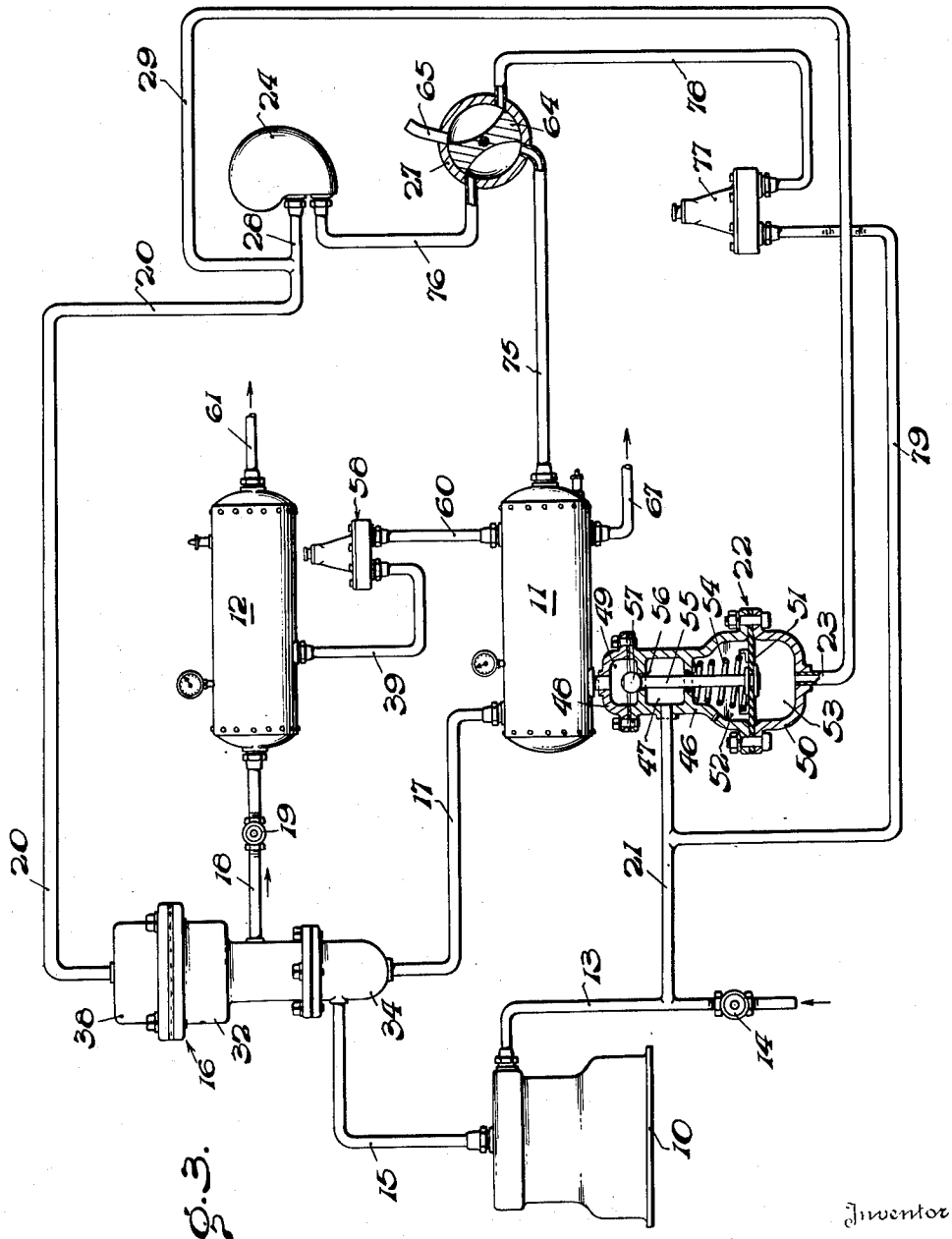


Fig. 3.

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Patented May 22, 1945 2,376,588

UNITED STATES PATENT OFFICE

2,376,588

FLUID PRESSURE MECHANISM

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Application December 16, 1942, Serial No. 469,259

20 Claims. (Cl. 230—2)

This invention relates to fluid compressing systems and more particularly to mechanism for producing fluid pressure under substantially high pressures.

It is well known by those skilled in the art that energy, in the form of heat, is generated when a fluid is compressed, with the temperatures produced corresponding to the increased pressure of the fluid. Since machines, such as fluid compressors, must be maintained below certain temperatures during operation thereof, the compression ratio of fluid compressors is limited. In view of the foregoing, it has become conventional practice to utilize multi-stage compressors for producing fluids under substantially high pressures. Conventional high pressure fluid compressors are therefore large bulky structures, of great mass, and of intricate design requiring extensive costs for the manufacture thereof. Compressors having the foregoing characteristics not only consume great energy during a short period of operation thereof but are also inadequate when employed in instances wherein weight of the equipment is of primary consideration, for example, in connection with systems for providing the energy medium to operate the controls of an aircraft.

It is, therefore, an object of the present invention to provide a novel fluid compressing system that overcomes the disadvantages enumerated heretofore.

Another object is to provide a novel fluid compressing system, employing a single stage compressor, for producing fluid under substantially higher pressures than the pressure of the fluid obtained upon operation of the single stage compressor alone.

Another object is to provide a fluid compressing system including a single stage fluid compressor and a novel arrangement for automatically intermittently supplying previously compressed fluid to the compressor for further increasing the pressure of such fluid.

Still another object of the present invention is to provide a fluid compressing system of the foregoing character including manually operable means for preventing further recompression of fluid pressure and with the system further characterized that the compressor automatically continually recirculates fluid pressure in a portion of the system to effectively unload the compressor.

Still another object is to provide in a fluid compressing system having a single stage fluid compressor and a novel arrangement for automatically intermittently recompressing the fluid pressure, a novel construction for automatically terminating recompression of fluid pressure and for maintaining recirculation of fluid pressure throughout a portion of the system when fluid under a predetermined substantially high pressure is obtained.

A still further object of the invention is to provide a fluid compressing system which continually provides a source of fluid under a substantially high constant pressure and a source of fluid under a substantially lower constant pressure.

Other objects and novel features of the present invention will appear more fully hereinafter from the following detailed description when considered in connection with the accompanying drawings which illustrate several embodiments of the invention. It is to be expressly understood, however, that the drawings are employed for purposes of illustration only and are not designed as a definition of the limits of the invention, reference for the latter being had to the appended claims.

In the drawings, wherein similar reference characters denote corresponding elements throughout the several views:

Fig. 1 is a diagrammatic showing, partly in section, of a fluid compressing system embodying the principles of the present invention;

Fig. 2 is a diagrammatic illustration of a further embodiment of the invention, and

Fig. 3 is a diagrammatic showing of a still further embodiment of the invention.

With reference more particularly to Fig. 1 of the drawings, a fluid compressing system constructed in accordance with the principles of the present invention is disclosed therein including a single stage fluid compressor 10 driven by any suitable prime mover, not shown, and reservoirs 11 and 12 for receiving fluid pressure. The input valves of the compressor 10 are connected to atmosphere, or to any suitable source of fluid, through conduit 13 and one-way check valve 14. The discharge from the compressor 10 is fed to the reservoir 11 through conduit 15, a pressure responsive valvular device 16, the purpose of which will appear more fully hereinafter, and conduit 17. Upon operation of the compressor 10 the source of fluid applied thereto through the conduit 13 is compressed a number of times determined by the compression ratio of the compressor 10, while the fluid pressure discharged from the compressor is stored in the reservoir 11.

As mentioned heretofore, one of the objects of

the present invention is to provide a fluid compressing system, incorporating a single stage fluid compressor, of such construction that a source of fluid under a substantially high pressure, greater than the pressure of the fluid ordinarily produced upon operation of a single stage compressor, is obtained therefrom. In order to accomplish the foregoing, means are provided for periodically transferring the fluid pressure stored in the reservoir 11 to the input of the compressor 10 and for simultaneously periodically applying the fluid pressure discharged from the compressor to the reservoir 12 in accordance with the pressure of the fluid stored in the reservoir 11.

As shown, the foregoing means comprises the pressure responsive valvular device 16 which functions to close the fluid connection between the conduits 15 and 17 and to form fluid communication between the conduit 15 and the reservoir 12, by way of conduit 18 and one-way check valve 19, whenever a source of fluid pressure is applied thereto through conduit 20. The foregoing means also includes a connection between the reservoir 11 and the input of the compressor 10. The latter connection comprises the conduit 13, a conduit 21 connected to the conduit 13 between the compresser 10 and the check valve 14, and a pressure responsive valvular device 22 having connections with the reservoir 11 and the conduit 21. The valvular device 22 normally functions to prevent the flow of fluid pressure from the reservoir 11 to the conduit 21, however, upon application of fluid pressure thereto by way of conduit 23, the valvular device 22 is operated to form a connection between the reservoir 11 and the input of the compressor 10.

In order to control operation of the pressure responsive valvular devices 16 and 22 in accordance with the pressure of the fluid in the reservoir 11, a pressure responsive governor 24 is provided. The input of the governor 24 is connected to the reservoir 11 through conduit 25 while the output thereof is connected through conduit 26, manually operable valvular device 27 and conduit 28, to the conduit 20 and to conduit 29, the latter conduit being connected to the conduit 23 by way of a double check valve 30. The governor 24 includes means responsive to application of a predetermined pressure thereto, through the conduit 25, for forming a fluid connection between the conduits 25 and 26, and is constructed in such a manner as to maintain communication between the conduits 25 and 26 until the pressure of the fluid applied thereto drops to a second predetermined value, substantially less than the predetermined value previously mentioned. Therefore the pressure responsive governor 24 operates to form a fluid connection between the reservoir 11 and the conduits 20 and 29 whenever the pressure of the fluid in the reservoir 11 builds up to a predetermined value and to maintain such connection until the pressure of the fluid in the reservoir 11 drops to a substantially lower value. A device constructed in accordance with the principles disclosed in the U. S. patent to B. S. Aikman No. 1,754,218, dated April 15, 1930, adequately serves the purpose of the pressure responsive governor 24.

As previously mentioned, the pressure responsive valvular device 16 is constructed in such a manner to close the fluid connection between the conduits 15 and 17 and to form a fluid connection between the conduits 15 and 18 whenever fluid pressure is supplied thereto by way of the conduit 20. More particularly, the device 16 includes a cylindrical body portion 32 having an output chamber 33 formed therein which is in continuous communication with the conduit 18. A body portion 34 is secured to the lower end of the body portion 32 in such a manner to form an input chamber 35 into which the fluid pressure from the compressor 10 continuously discharges. The body portion 35 includes an output chamber 36 connected to the conduit 17. A circular opening 37 is provided in the body portion 34, between the chambers 35 and 36, for normally allowing fluid communication between the latter chambers. The valvular device 16 also includes a body portion 38 secured to the upper side thereof. A pressure responsive diaphragm 39 is clamped between the body portions 32 and 38 thus defining chambers 40 and 41. A spring 42 is included within the chamber 40 between the diaphragm 39 and the body portion 32 to urge the diaphragm 39 upwardly, as viewed in the drawings, while the chamber 41 is in communication with conduit 20. A valve stem 43 is mounted for movement within the body portion 32, having one end thereof rigidly secured to the diaphragm 39 while the other end extends through an opening 44, in the casing 32, and terminates within the chamber 35 in a ball valve 45. When the pressure responsive valvular device 16 is in the normal condition thereof as shown, that is, when fluid pressure is not applied thereto through the conduit 20, the diaphragm 39 and the valve stem 43 are urged upwardly as viewed in the drawings, by the tension of the spring 42, to maintain the ball valve 45 in contact with the periphery of the opening 44. With the foregoing conditions, fluid communication is maintained between the conduits 15 and 17 by way of chambers 35 and 36 while the flow of fluid pressure to the chamber 33 is blocked by the ball valve 45. Whenever fluid pressure is applied to the chamber 41 by way of the conduit 20, the diaphragm 39 is moved downwardly against the tension of the spring 42 to thus move the ball valve 45 away from the opening 44 and into engagement with the upper periphery of the opening 37. With the latter conditions, fluid communication is maintained between the conduits 15 and 18 while the connection between the conduits 15 and 17 is terminated.

The pressure responsive valvular device 22, as previously mentioned, is constructed in such a manner as to normally prevent the flow of fluid pressure from the reservoir 11 to the conduit 21 and is responsive to application of fluid pressure thereto, through the conduit 23, to allow fluid communication between the reservoir 11 and the conduit 21. As shown, the valvular device 22 comprises a cylindrical body portion 46 having a chamber 47 formed therein to which the conduit 21 is connected. The upper end of the body portion 46 is closed by a body portion 48 to thus form a chamber 49 that is in continuous communication with the reservoir 11. The valvular device 22 further includes a body portion 50 secured to the lower end of the body portion 46, with a pressure responsive diaphragm 51 clamped between the body portions 46 and 50, thus defining chambers 52 and 53. A spring 54 is included within the chamber 52, between the diaphragm 51 and the body portion 46, to continually urge the diaphragm downwardly as viewed in the drawings, while fluid pressure is supplied to the chamber 53 through the conduit 23 to move the diaphragm 51 upwardly against the tension of the spring 54. One end of a valve stem 55 is rigidly secured to the diaphragm 51 at the center there-

of while the other end of the valve stem extends through an opening 56 in the body portion 46 and terminates within the chamber 49. A ball valve 57 is secured to the terminating end of the valve stem 55, and is normally urged into contact with the periphery of the opening 56, due to the downward force applied to the diaphragm 51 and the valve stem 55 by the tension of the spring 54, to thus normally prevent the flow of fluid pressure between chambers 47 and 49. However, whenever fluid pressure is supplied to the chamber 53, the diaphragm 51 is moved upwardly against the tension of the spring 54 to thus move the ball valve 57 away from the opening 56 and to allow the flow of fluid pressure from the reservoir 11 to the conduit 21.

It is to be expressly understood, therefore, that the pressure responsive valvular devices 16 and 22 normally occupy the positions thereof shown in the drawings, in which case the input fluid to the compressor 10 is supplied by way of the check valve 14 while the fluid pressure discharged from the compressor is fed to the reservoir 11. When the pressure of the fluid stored in the reservoir 11 builds up to a predetermined value the pressure responsive governor 24 operates to form a fluid connection between the conduits 25 and 26. Whenever the manually operable valvular device 27 is in the position shown in the drawings, the fluid pressure from the conduit 26 may be supplied to the conduits 20 and 29 by way of the conduit 28. Fluid pressure is, therefore, simultaneously supplied to the chambers 41 and 53 of the valvular devices 16 and 22 respectively. The application of fluid pressure to the chambers 41 and 53 simultaneously operates the valvular devices 16 and 22 in a manner described heretofore. The valvular device 22 functions to open a fluid pressure communication between the reservoir 11 and the input valves of the compressor 10 while the valve device 16 operates to close the connection between the discharge of the compressor and the reservoir 11 and to form a connection between the conduit 15 and the reservoir 12. After the valvular devices 16 and 22 operate to form the foregoing connections the compressor 10 functions to recompress the fluid pressure stored in the reservoir 11. The fluid discharged from the compressor 10 under these conditions is at a pressure a number of times greater than the pressure of the fluid previously stored in the reservoir 11 by a degree corresponding to the compression ratio of the compressor 10. The compressor 10 continues to recompress the fluid stored in the reservoir 11 until the pressure of the fluid in the reservoir 11 is reduced to such a value that the pressure responsive governor 24 operates to close the fluid connection between the conduits 25 and 26 and to exhaust the conduit 26 to atmosphere. When the conduit 26 is exhausted to atmosphere the pressure of the fluid in the chambers 41 and 53 is reduced and the valve devices 16 and 22 return to normal positions thereof wherein the connection between the reservoir 11 and the conduit 21 is closed and wherein the fluid pressure discharged from the compressor 10 is fed to the reservoir 11. The compressor 10 thereafter functions to compress fluid received through the check valve 14 while the fluid pressure discharged therefrom is stored in the reservoir 11, until the pressure of the fluid in the latter reservoir attains a sufficient value to operate the pressure responsive governor 24 in a manner previously described. With the foregoing arrangement, fluid under extremely high pressures is built up in the reservoir 12 upon operation of the single stage compressor 10. It is to be expressly understood that the pressure of the fluid stored in the reservoir 12 is at a value greater than the pressure of the fluid fed to the reservoir 11 by a degree substantially equal to the compression ratio of the compressor 10.

In order to maintain the pressure of the fluid in the reservoir 12 at a predetermined, substantially constant value, the reservoirs 12 and 11 are interconnected through a suitable pressure regulating valve 58 by means of conduits 59 and 60. The pressure regulating valve 58 is of conventional construction and functions to prevent communication between the conduits 59 and 60 until the pressure of the fluid in the reservoir 12 builds up to a predetermined value, at which instant the valve 58 operates to form a connection between the conduits 59 and 60. With this arrangement, the fluid pressure stored in the reservoir 12 is maintained at a substantially constant, predetermined value determined by the adjustment of the pressure regulator valve 58. The fluid pressure in the reservoir 12 is fed, through conduit 61, to devices, not shown, for controlling the operation thereof.

Means are also provided in connection with the novel fluid compressing system previously described for preventing further energization of the reservoir 12 with fluid pressure after the pressure of the fluid in the reservoir 12 builds up to a desired value. When the above means is operated, the pressure of the fluid stored in the reservoir 11 builds up to a substantially constant value determined by the compression ratio of the fluid compressor 10. Such substantially constant fluid pressure may be employed for energizing the fluid pressure devices that operate upon application of fluid under substantially low pressures. A fluid compressing system incorporating the foregoing means is so characterized that the fluid pressure stored in the reservoir 11 is continually recirculated through the compressor 10, whenever the pressure of the fluid in the reservoir 11 builds up to a predetermined value, to thus effectively unload the compressor 10.

The foregoing means comprises the manually operable valvular device 27, the double check valve 30 and a conduit 62 forming a fluid connection between the valvular device 27 and the double check valve 30. More particularly, the valvular device 27 includes a cylindrical casing 63 having a valve member 64 mounted for rotation therein upon operation of a suitable manual control, not shown. The conduits 26 and 28 are connected, at substantially right angles with respect to each other, to the interior of the casing 63 while the conduit 62 and an exhaust conduit 65 are connected to the interior of the casing 63 at points substantially opposite the connected ends of the conduits 28 and 26, respectively. When the valve member 64 is in the position shown, fluid communication is maintained between the conduits 26 and 28 while the conduit 62 is exhausted to atmosphere through the conduit 65. However, when the valve member 64 is rotated to a position at right angles to the position shown, the conduit 28 is exhausted through the conduit 65 while a fluid connection is formed between the conduits 26 and 62. With the valve member 64 in the latter position, and whenever the pressure of the fluid in the reservoir 11 is of a sufficient value to operate the pressure responsive governor 24, a connection is maintained between the conduits 25 and 26, and the conduit

62 is therefore energized with fluid pressure. Energization of the conduit 62 with fluid pressure therefore moves the valve member 66 of the double check valve 30, to the right as viewed in the drawings, and the fluid pressure from the conduit 62 is applied to the chamber 53 of the pressure responsive valve device 22, by way of the conduit 23, thus operating the valvular device 22 in a manner described heretofore.

With the foregoing arrangement therefore, whenever the valve member 64 is moved to a position at right angles to the position shown, the conduits 20 and 29 are exhausted to atmosphere through the conduit 65 and the pressure responsive valvular device 16 is maintained in the normal position thereof as shown, thus preventing the flow of fluid pressure to the reservoir 12. The fluid pressure discharged from the compressor 10 is therefore continually passed to the reservoir 11 at all times when the manually operable valvular device 27 is in the position referred to above. When the pressure of the fluid in the reservoir 11 is of a value insufficient to operate the pressure responsive governor 24 the compressor 10 receives fluid through the check valve 14. However, when the pressure of the fluid stored in the reservoir 11 builds up to a value so that the pressure responsive governor 24 operates to form a fluid connection between the conduits 25 and 26, fluid pressure is supplied to the chamber 53 by way of the conduit 62 thus operating the pressure responsive valvular device 22 to form a fluid connection between the reservoir 11 and the input of the compressor 10. Under these conditions, the compressor 10 merely functions to recirculate the fluid pressure stored in the reservoir 11. Since additional fluid is not supplied to the system, and furthermore, since no substantial changes in pressure occur throughout the system, substantially no load is applied to the compressor 10. Moreover, since the pressure responsive governor 24 functions when predetermined pressures are applied thereto, the pressure of the fluid in the reservoir 11 is maintained substantially constant. The fluid pressure in the reservoir 11 may therefore be fed through output conduit 67 to any pressure responsive devices requiring application of low pressures for the operation thereof.

Another embodiment of the invention is shown in Fig. 2 of the drawings. The fluid compressing system shown in this embodiment is somewhat similar to the system previously described and disclosed in Fig. 1 of the drawings, and includes novel means for automatically preventing further energization of the reservoir 12 whenever the pressure of the fluid stored in the latter reservoir builds up to a predetermined value, as well as means for automatically rendering the system in a condition wherein fluid pressure is only supplied to the reservoir 11, after the pressure of the fluid in the reservoir 12 builds up to such predetermined value, and for automatically recirculating the fluid stored in the reservoir 11 after the pressure of the fluid stored in the latter reservoir builds up to a predetermined value.

As shown, the fluid compressing system disclosed includes the fluid compressor 10 having discharge ports thereof connected through the conduit 15 to the pressure responsive valvular device 16. The pressure responsive device 16 functions in a manner described heretofore to normally maintain a connection between the conduit 15 and the reservoir 11 by way of the conduit 17 and is responsive to application of fluid pressure thereto by way of the conduit 20 to interrupt the fluid connection between the conduits 15 and 17 and to form a connection between the conduits 15 and 17 and to form a connection between the conduit 15 and the reservoir 11. The pressure responsive valvular device 22 is also included for forming a connection between the reservoir 11 and the input of the compressor 10 whenever fluid pressure is supplied thereto through the conduit 23. In order to control operation of the pressure responsive valvular devices 16 and 22 the pressure responsive governor 24 is provided. The governor 24 is responsive to the pressure of the fluid in the reservoir 11 for supplying fluid pressure to the conduit 26 whenever the pressure of the fluid stored in the reservoir 11 builds up to a predetermined value and for continually supplying fluid pressure to the conduit 26 until the pressure of the fluid in the reservoir 11 drops to a substantially lower value. In this embodiment, the conduit 26 is directly connected to the conduits 20 and 29 so that the pressure responsive devices 16 and 22 are operated whenever the pressure responsive governor 24 functions to form a fluid connection between the conduits 25 and 26. The portion of the fluid compressing system disclosed in Fig. 2 that has been described above operates in a manner similar to the arrangement disclosed in Fig. 1.

The aforementioned means for preventing further energization of the reservoir 12 after the pressure of the fluid in the latter reservoir builds up to a predetermined value includes a pressure responsive governor 70 constructed in a manner similar to the pressure responsive governor 24. The governor 70 is connected to the reservoir 12 through conduit 71 and therefore operates to from a fluid connection between the conduit 71 and an output conduit 72 whenever the pressure of the fluid in the reservoir 12 builds up to a predetermined value. It is to be expressly understood that the governor 70 is adjusted to respond to application of a predetermined pressure that is a number of times greater than the pressure required for operation of the governor 24. The conduit 72 is connected to the conduit 23 through the double check valve 30.

Whenever the pressure of the fluid in the reservoir 12 builds up to a sufficient value to operate the governor 70 fluid pressure is applied to the check valve 30 by way of the conduit 71. Since the pressure of the fluid applied to the check valve 30 through the conduit 72 is a number of times greater than the pressure of the fluid applied to the check valve 30 by way of the conduit 29, the fluid pressure from the conduit 72 is applied to the valvular mechanism 22 through the conduit 23 notwithstanding the presence of fluid pressure in the conduit 29. The valvular device 22 is therefore operated to form a connection between the reservoir 11 and the input of the compressor 10 whenever pressure in the reservoir 12 builds up to a sufficient value to operate the governor 70. At the instant the connection is formed between the reservoir 11 and the compressor 10 a substantial drop in pressure of the fluid stored in the latter reservoir occurs and the governor 24 functions to exhaust the conduit 20 to atmosphere to thereby operate the valvular device 16 and to terminate the fluid connection between the conduit 15 and the reservoir 12. The compressor 10 thereafter functions to recirculate the fluid pressure stored in the reservoir 11 in a manner heretofore described rel-

ative to the system disclosed in Fig. 1, until such time as the pressure of the fluid in the reservoir 12 is reduced a sufficient degree, upon utilization of the fluid pressure stored therein through the conduit 61, to allow the governor 70 to operate, thus terminating the connection between the conduits 71 and 72 and exhausting the latter conduit to atmosphere. The fluid compressing system then operates in a manner fully described heretofore to again intermittently supply fluid pressure to the reservoir 12 until the pressure stored therein builds up to a sufficient value to operate the governor 70. It is appreciated that the pressure of the fluid in the reservoir 11 may not immediately drop to a sufficient value to operate the governor 24, and consequently the valvular device 16, at the instant a fluid connection is formed between the reservoir 11 and the input of the compressor 10, upon application of fluid pressure to the valvular device 22 through the conduit 72. In view of the foregoing, fluid pressure may be supplied to the reservoir 12 after the governor 70 has operated to energize the conduit 72 and thus build up the pressure of the fluid stored in the reservoir 12 to some value higher than the predetermined value determined by the governor 70. However, in view of the differences in pressures between the fluid stored in reservoirs 12 and 11, the foregoing condition would only exist for a short period of time before the pressure of the fluid in the reservoir 11 would be reduced a sufficient degree to allow operation of the governor 24, during which time pressure of the fluid in the reservoir 12 will be only slightly increased.

Still another embodiment of the invention is shown in Fig. 3 of the drawings. The fluid compressing system disclosed in this embodiment is also similar to the system shown in Fig. 1 of the drawings and includes other novel means for controlling the pressure of the fluid stored in the reservoir 11 after the fluid pressure in the reservoir 12 is built up to some desired value. As shown, the system disclosed in Fig. 3 includes the fluid compressor 10, the reservoirs 11 and 12, and the pressure responsive valvular devices 16 and 22 interconnected in a manner similar to the arrangement shown in Fig. 1. Moreover, the reservoirs 12 and 11 are interconnected through the pressure regulator valve 58 by means of conduits 59 and 60 in a manner similar to the connection between the reservoirs 11 and 12 of Fig. 1.

The reservoir 11 is connected, by way of conduit 75, the manually operable valvular mechanism 27 and the conduit 76 to the pressure responsive governor 24, whenever the valve member 64 of the valvular device 27 is in the position shown. The governor 24 is also connected through the conduit 28 to the conduits 20 and 29 and is responsive to a predetermined pressure of the fluid in the reservoir 11 to form a fluid connection between the latter reservoir and the pressure responsive valvular devices 16 and 22 in a manner similar to the arrangements previously described. The portion of the fluid compressing system shown in Fig. 3, that has been described above, therefore operates in such a manner to alternately feed the output of the compressor 10 to the reservoirs 11 and 12, thus storing fluid at substantially high pressure in the latter reservoir. When the pressure of the fluid in the reservoir 12 builds up to a value that corresponds to the adjustments of the pressure regulator valve 58, the pressure in excess of such value is fed to the reservoir 11 through the conduit 60.

A pressure regulator valve 77, constructed in a manner similar to the pressure regulator valve 58, is connected to the valvular mechanism 27, through the conduit 78, and to the conduit 21 by way of conduit 79. Whenever the valve member 64 is moved to a position at right angles to that shown in the drawings, the conduit 76 is exhausted to atmosphere through the conduit 65 and a fluid connection is formed between the conduits 75 and 78. When the valve member 64 is moved to the latter position the conduits 20 and 29 are exhausted to atmosphere, through the governor 24, and the valvular mechanisms 16 and 22 move to the normal positions thereof wherein the output of the compressor 10 is fed to the reservoir 11 and the connection between the latter reservoir and the input of the compressor 10 is closed. The pressure regulator valve 77 is responsive to a predetermined pressure of the fluid in the reservoir 11 to form a connection between the latter reservoir and the conduit 21. Whenever the pressure of the fluid in the reservoir 11 is below a sufficient value to operate the valve 77 the compressor 10 operates to compress fluid supplied through the check valve 14 which is discharged to the reservoir 11. Whenever the pressure of the fluid in the reservoir 11 builds up to a value greater than the pressure required to operate the valve 77, the latter valve operates to form a connection between the reservoir 11 and the conduit 21. The compressor 10 therefore merely functions to recirculate the fluid pressure in excess of the predetermined value determined by the valve 77, thus substantially reducing the load on the compressor. Since the valve 77 operates to close the connection between the reservoir 11 and the conduit 21 whenever the pressure of the fluid in the latter reservoir drops to a predetermined value, fluid under substantially constant pressure is maintained in the reservoir 11.

Operation of the fluid compressing system disclosed in Fig. 1 of the drawings may be more readily understood by assuming that no fluid pressure is present within the system and that the compressor 10 is not operated. Under these conditions, the pressure responsive valvular devices 16 and 22 are in the position shown in the drawings and the output of the compressor 10 is connected to the reservoir 11. Upon operation of the compressor 10 fluid is drawn through the check valve 14 and compressed a number of times equal to the compression ratio of the compressor 10, while the fluid pressure discharged from the compressor 10 is fed through the conduits 15 and 17 to the reservoir 11. The foregoing operation continues until the pressure of the fluid stored in the reservoir 11 builds up to a sufficient value to operate the pressure responsive governor 24 at which instant the conduits 20 and 29 are energized with fluid pressure to simultaneously operate the pressure responsive valvular devices 16 and 22. When the valvular device 16 is energized with fluid pressure, a fluid communication between the conduits 15 and 18 is formed and the fluid connection between the conduit 15 and the reservoir 11 is closed, while the pressure responsive valvular device 22 functions to form a fluid connection between the reservoir 11 and the input of the compressor 10 by way of the conduits 13 and 21. After the valvular devices 16 and 22 operate in the foregoing manner the fluid pressure previously stored in the reservoir 11 is supplied to the input of the compressor 10, wherein the pressure of the fluid is increased by an

amount substantially equal to the compression ratio of the compressor. The fluid under high pressure discharged in the compressor 10 is supplied to the reservoir 12 through the conduits 15 and 18. The compressor 10 continues to recompress the pressure stored in the reservoir 11 until the pressure of the fluid therein drops to a predetermined value at which instant the governor 24 operates to terminate the fluid connection between the conduits 25 and 26 thus exhausting the conduits 20 and 29 to atmosphere through the governor 24. The pressure responsive valvular devicese 16 and 22 then return to the normal positions shown, terminating the connections between the reservoir 11 and the input of the compressor 10 and between the discharge port of the compressor 10 and the reservoir 12 and to form a fluid connection between the discharge of the compressor 10 and the reservoir 11. The check valve 19 functions to prevent the fluid pressure stored in the reservoir 12 from flowing to the valvular device 16 and hence to the reservoir 11 during the time the valvular device 16 is operating.

The fluid compressing system continues to charge the reservoir 11 with fluid pressure and to automatically recompress the fluid stored in the latter reservoir and to store the recompressed fluid in the reservoir 12 until the pressure of the fluid in the latter reservoir builds up to a predetermined value determined by the pressure regulator valve 58.

When the pressure of the fluid in the reservoir 12 builds up to a desired value, such as the predetermined pressure determined by the pressure regulator valve 58, or when it is desired to maintain a source of fluid pressure of a substantially low value, the valve member 64 of the manually operable valvular device 27 is moved to a position at right angles to that shown in the drawings, thus exhausting the conduits 20 and 29 to atmosphere, through the conduit 65, to form a fluid connection between the conduits 26 and 62. When the valvular device 27 is operated in the foregoing manner, the reservoir 12 is eliminated from the system and the fluid pressure discharged from the compressor 10 is continually supplied to the reservoir 11. In the event that the pressure of the fluid in the reservoir 11 is of an insufficient value to operate the governor 24 fluid is supplied to the input of the compressor 10 by way of the check valve 14. However, when the pressure of the fluid in the reservoir 11 builds up to a sufficient value to operate the governor 24, a connection is formed between the reservoir 11 and the input of the compressor 10. The compressor thereafter merely functions to recirculate the fluid pressure stored in the reservoir 11.

The fluid compressing system disclosed in Fig. 2 of the drawings operates in a manner similar to that disclosed in Fig. 1 to store fluid under high pressure in the reservoir 12. When the pressure of the fluid in the reservoir 12 builds up to a predetermined value the pressure responsive governor 70 operates to energize the conduit 72 with fluid pressure to thus operate the pressure responsive valvular device 22 independently of the fluid pressure supplied thereto through the conduit 29. The connection between the reservoir 11 and the input of the compressor 10 is maintained open whenever the pressure of the fluid in the reservoir 12 exceeds the predetermined value determined by the adjustment of the pressure responsive governor 70. The compressor 10 therefore continually recompresses the fluid pressure stored in the reservoir 11. A drop in pressure of the fluid in the reservoir 11 immediately occurs and the governor 24 functions to exhaust the conduit 26 to atmosphere, thus allowing the pressure responsive valvular device 16 to return to the normal position as shown. The pressure of the fluid in the reservoir 11 is therefore continually recirculated until the pressure of the fluid in the reservoir 12 drops below a predetermined value in which case the governor 70 functions to exhaust the conduit 72 to atmosphere and thus allowing the system to operate in a manner described heretofore to again charge the reservoir 12 with fluid pressure.

Operation of the embodiment of the invention disclosed in Fig. 3 of the drawings is similar to the operation of the system disclosed in Fig. 1, whenever the valve member 64 of the manually operable valvular device 27 is in a position as shown in the drawings. However, when the pressure of the fluid in the reservoir 12 builds up to a desired value or whenever a source of fluid of substantially constant pressure is desired, the valve member 64 is moved to a position at substantially right angles to the position shown. When the valve member 64 is moved in the foregoing manner the conduits 20 and 29 are exhausted to atmosphere and the pressure responsive valvular devices 16 and 22 return to the normal positions thereof wherein the conduit 15 is connected to the reservoir 11. The compressor 10 then compresses fluid derived by way of check valve 14 until the pressure of the fluid stored in the reservoir 11 builds up to a sufficient value to operate the pressure regulator valve 77. When the pressure regulator valve 77 operates, a connection is formed between the reservoir 11 and the input of the compressor 10 so that the compressor functions to recirculate the fluid pressure in the system and no additional fluid is supplied thereto by way of the check valve 14.

There is thus provided by the present invention a novel fluid compressing system, employing a single stage, light-weight, fluid compressor, that is capable of producing fluid under substantially high pressures, substantially equal to the pressure of fluid obtained from conventional multistage fluid compressors. Furthermore, the fluid compressing systems disclosed in the several embodiments of the present invention are not only capable of producing a source of fluid under substantially high pressures but also are so characterized to continually maintain a source of fluid under a substantially lower pressure. Moreover, automatic as well as manually operable arrangements have been disclosed herein for controlling operation of fluid compressing systems of the above character in such a manner that the fluid compressor functions to recirculate fluid pressure throughout a portion of the system, thus effectively unloading the compressor, when a source of fluid under a predetermined pressure is built up in the system or when fluid under a desired pressure is obtained.

Although several embodiments of the present invention have been illustrated and described in detail herein it is to be expressly understood that various changes and substitutions may be made therein without departing from the spirit of the invention as well understood by those skilled in the art. Reference, therefore, will be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. A system for compressing fluid comprising a fluid compressor, means supplying a source of fluid to said compressor, a first reservoir, means normally charging said first reservoir with fluid pressure from said compressor, a second reservoir, and means responsive to a predetermined value of the pressure of the fluid in said first reservoir for automatically supplying the fluid pressure in said first reservoir to said compressor and for charging said second reservoir with fluid pressure from said compressor.

2. A system for compressing fluid comprising a fluid compressor having input and output conduits, means connecting a source of fluid to said input conduit, a plurality of reservoirs, a normally open connection between said output conduit and one of said reservoirs, a normally closed connection between said output conduit and another of said reservoirs, a normally closed connection between said one reservoir and said input conduit, and means responsive to a predetermined pressure of the fluid in said one reservoir for simultaneously closing said normally open connection and opening said normally closed connections.

3. A system for compressing fluid comprising a fluid compressor, means connecting a source of fluid to said compressor, a first reservoir, means normally charging said first reservoir with fluid pressure from said compressor, a second reservoir, and automatic means for periodically supplying the fluid pressure in said first reservoir to said compressor and for charging said second reservoir with fluid pressure from said compressor, whereby charging of the first reservoir is prevented and the second reservoir is charged to a pressure greater than that in the first reservoir.

4. A system for compressing fluid comprising a fluid compressor, means connecting a source of fluid to said compressor, a first reservoir, means normally charging said first reservoir with fluid pressure from said compressor, a second reservoir, means responsive to a predetermined pressure of the fluid in said first reservoir for supplying the fluid pressure in said first reservoir to said compressor, and other means responsive to said predetermined pressure of the fluid in said first reservoir for charging said second reservoir with fluid pressure from said compressor.

5. A system for compressing fluid comprising a fluid compressor, means connecting a source of fluid to said compressor, a first reservoir, means normally charging said first reservoir with fluid pressure from said compressor, a second reservoir, and means responsive to a predetermined pressure of the fluid in said first reservoir for automatically simultaneously supplying the fluid pressure in said first reservoir to said compressor and for charging said second reservoir with fluid pressure from said compressor.

6. A system for compressing fluid comprising a source of fluid, a fluid compressor, a plurality of reservoirs, means normally operative for supplying fluid pressure from said source to the input of said compressor and for transferring the fluid pressure discharged from said compressor to one of said reservoirs and means responsive to the pressure of the fluid in said one reservoir for supplying the fluid pressure in said one reservoir to said compressor and for transferring the fluid pressure discharged from said compressor to another of said reservoirs.

7. A system for compressing fluid comprising a source of fluid, a fluid compressor, a plurality of reservoirs, means normally operative for supplying fluid pressure from said source to the input of said compressor and for transferring the fluid pressure discharged from said compressor to one of said reservoirs, normally inoperative means for supplying fluid pressure in said one reservoir to said compressor and for transferring the fluid pressure discharged from said compressor to another of said reservoirs, and means responsive to the pressure of the fluid in said one reservoir for simultaneously rendering said normally operative means inoperative and said normally inoperative means operative.

8. A system for compressing fluid comprising a source of fluid, a fluid compressor, a plurality of reservoirs, means normally operative for supplying fluid pressure from said source to the input of said compressor and for transferring the fluid pressure discharged from said compressor to one of said reservoirs, normally inoperative means for supplying fluid pressure in said one reservoir to said compressor and for transferring the fluid pressure discharged from said compressor to another of said reservoirs, and means responsive to the pressure of the fluid in said one reservoir for intermittently synchronously rendering said normally operative means inoperative and said normally inoperative means operative.

9. A system for compressing fluid comprising a fluid compressor, means supplying a source of fluid to said compressor, a first reservoir, means normally charging said first reservoir with fluid pressure from said compressor, a second reservoir, and means responsive to a predetermined value of the pressure of the fluid in said first reservoir for automatically supplying the fluid pressure in said first reservoir to said compressor and for charging said second reservoir with fluid pressure from said compressor until the pressure of the fluid in said first reservoir drops to a second predetermined value substantially less than said predetermined value.

10. A system for compressing fluid comprising a fluid compressor having input and output conduits, means connecting a source of fluid to said input conduit, a plurality of reservoirs, a normally open connection between said output conduit and one of said reservoirs, a normally closed connection between said output conduit and another of said reservoirs, a normally closed connection between said one reservoir and said input conduit, and means responsive to a predetermined value of the pressure of the fluid in said one reservoir for simultaneously closing said normally open connection and opening said normally closed connections until the pressure of the fluid in said first reservoir drops to a second predetermined value substantially less than said predetermined value.

11. A system for compressing fluid comprising a source of fluid, a fluid compressor, a plurality of reservoirs, normally operative means for supplying fluid pressure from said source to the input of said compressor and for transferring the fluid pressure discharged from said compressor to one of said reservoirs, normally inoperative means for supplying fluid pressure in said one reservoir to said compressor and for transferring the fluid pressure discharged from said compressor to another of said reservoirs, and means operative when the pressure of the fluid in said one reservoir is between predetermined limits for maintaining said normally operative means in an inoperative state and said normally inoperative means in an operative state.

12. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and for opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pressure thereto for opening the last-named normally closed connection, and means responsive to the pressure of the fluid in said one reservoir for simultaneously applying fluid pressure to said first and said second valvular means.

13. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pressure thereto for opening the last-named normally closed connection, and means responsive to a predetermined pressure of the fluid in said one reservoir for simultaneously supplying fluid pressure to said first and said second valvular means, the last-named means operable upon a predetermined drop in pressure of the fluid in said one reservoir for simultaneously exhausting said first and said second valvular means to atmosphere.

14. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and for opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pressure thereto for opening the last-named normally closed connection, and means responsive to the pressure of the fluid in said one reservoir for periodcally simultaneously supplying fluid pressure to said first and said second valvular means and for simultaneously periodically exhausting said first and said second valvular means to atmosphere.

15. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and for opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pressure thereto for opening the last-named normally closed connection, means responsive to the pressure of the fluid in said one reservoir for simultaneously applying fluid pressure to said first and said second valvular means, and manually operable valve means for exhausting said first valvular means to atmosphere and for only supplying the output of the last-named means to said second valvular means.

16. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and for opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pressure thereto for opening the last-named normally closed connection, means responsive to the pressure of the fluid in said one reservoir for simultaneously supplying fluid pressure to said first and said second valvular means, and means responsive to the pressure of the fluid in said another reservoir for supplying fluid pressure to said second valvular means independently of the last-named means.

17. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and for opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pressure thereto for opening the last-named normally closed connection, means responsive to a predetermined pressure of the fluid in said one reservoir for simultaneously supplying fluid pressure to said first and said second valvular means and for exhausting said first and said second valvular means to atmosphere after the pressure of the fluid in said one reservoir drops a predetermined degree, and means responsive to the pressure of the fluid in said another reservoir for supplying fluid pressure to said second valvular means independently of the last-named means.

18. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and for opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pres-

sure thereto for opening the last-named normally closed connection, means responsive to a predetermined pressure of the fluid in said one reservoir for simultaneously supplying fluid pressure to said first and said second valvular means and for exhausting said first and said second valvular means to atmosphere after the pressure of the fluid in said one revervoir drops a predetermined degree, and means responsive to a predetermined pressure of the fluid in said another reservoir for supplying fluid pressure to said second valvular means independently of the last-named means and for allowing the last-named means to supply fluid pressure to said second valvular means when the pressure of the fluid in said another reservoir drops a predetermined degree.

19. In a system for compressing fluid, a fluid compressor, a plurality of reservoirs, a source of fluid connected to the input of said compressor, a normally open connection between the output of said compressor and one of said reservoirs, a normally closed connection between the output of said compressor and another of said reservoirs, first valvular means operable upon application of fluid pressure thereto for simultaneously closing said normally open connection and for opening said normally closed connection, a normally closed connection between said one reservoir and the input of said compressor, second valvular means operable upon application of fluid pressure thereto for opening the last-named normally closed connection, means responsive to a predetermined pressure of the fluid in said one reservoir for simultaneously supplying fluid pressure to said first and said second valvular means and for exhausting said first and said second valvular means to atmosphere after the pressure of the fluid in said one reservoir drops a predetermined degree, means responsive to the pressure of the fluid in said one reservoir for simultaneously supplying fluid pressure to said first and said second valvular means, a second normally closed connection between said one reservoir and the input of said compressor, a valve device responsive to a predetermined pressure of the fluid in said one reservoir for opening the last-named connection and manually operable valve means for disconnecting the last-named means from said one reservoir and for forming a connection between said one reservoir and said valve device.

20. A system for compressing fluid comprising a source of fluid, a fluid compressor, a plurality of reservoirs, means normally operative for supplying fluid pressure from said source to the input of said compressor and for transferring the fluid pressure discharged from said compressor to one of said reservoirs, normally inoperative means for supplying fluid pressure in said one reservoir to said compressor and for transferring the fluid pressure discharged from said compressor to another of said reservoirs, means responsive to the pressure of the fluid in said one reservoir for simultaneously rendering said normally operative means inoperative and said normally inoperative means operative, and means including a valve for transferring fluid from said another reservoir to said one reservoir when the pressure of the fluid in said another reservoir exceeds a predetermined value.

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