May 22, 1928. 1,670,911

T. W. STONE ET AL

WATER GAS MACHINE VALVE CONTROLLING APPARATUS

Filed Jan. 31, 1923 4 Sheets-Sheet 1

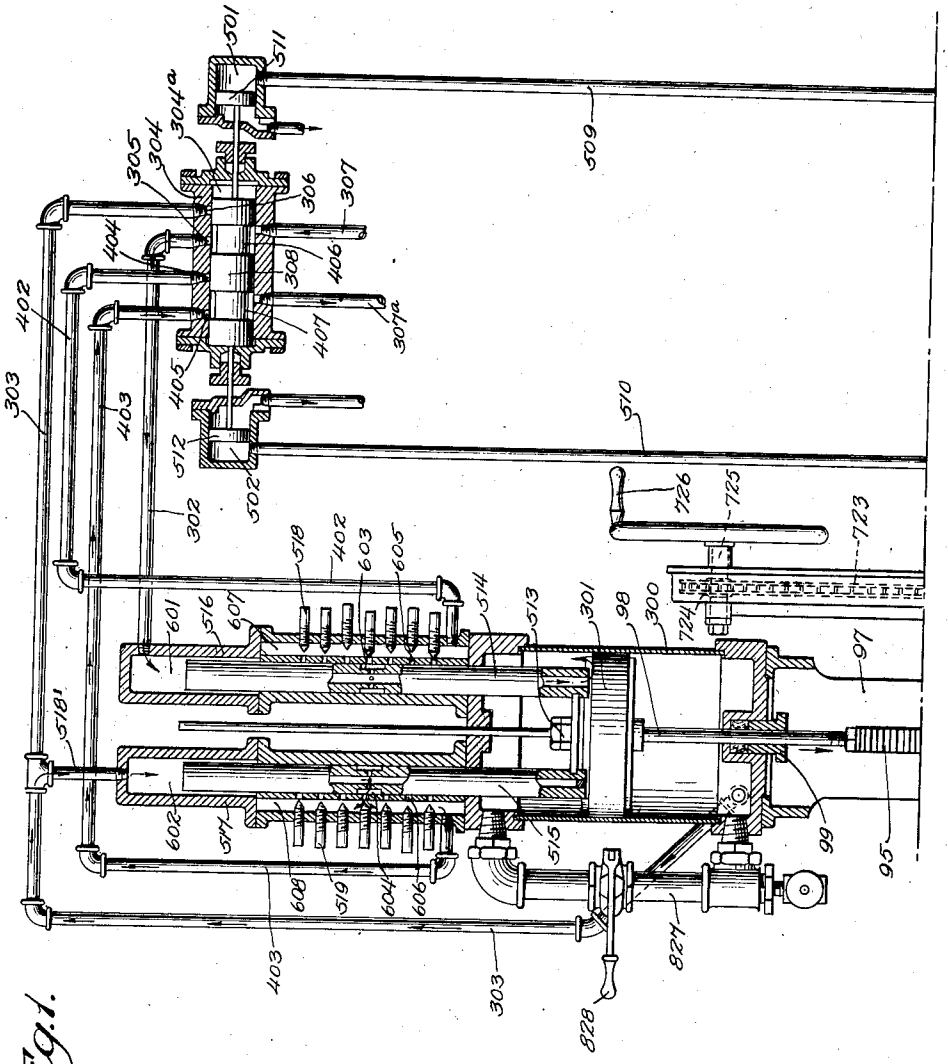


Fig. 1.

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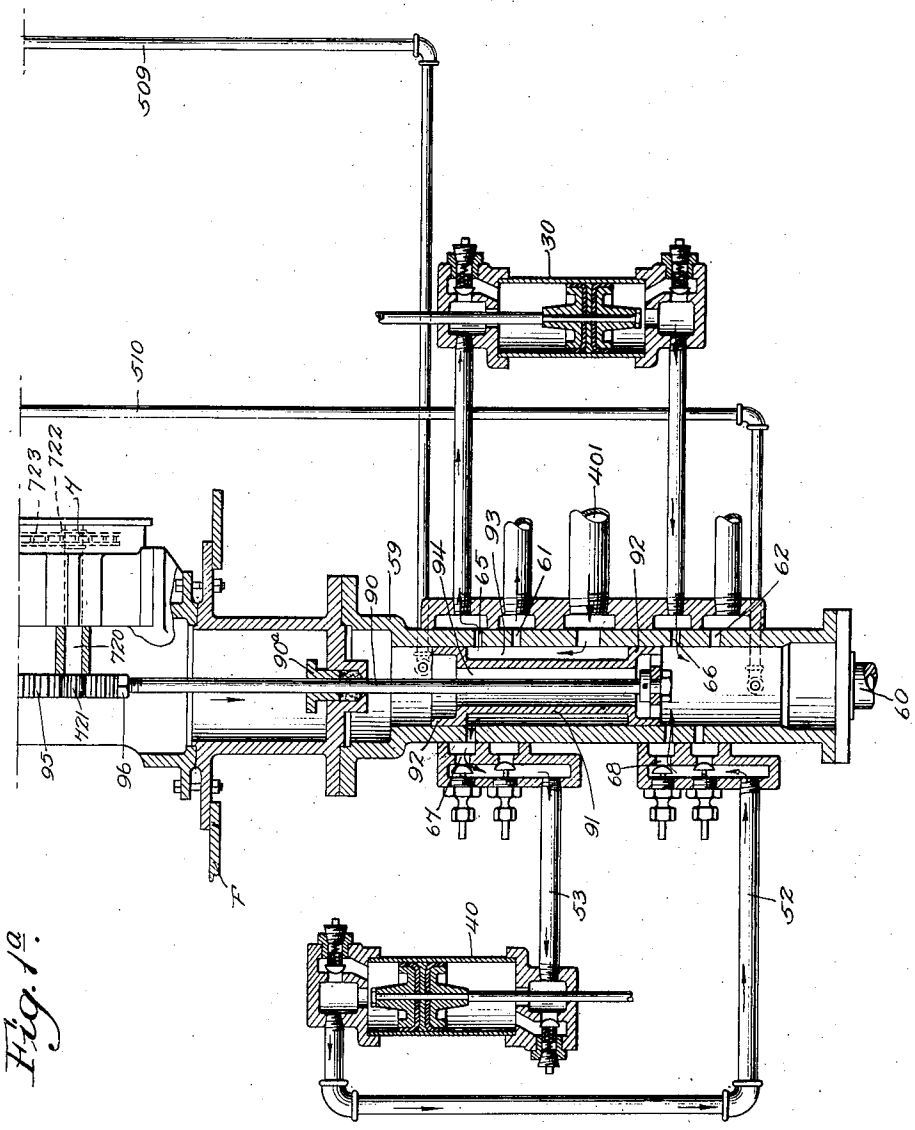


Fig. 1a.

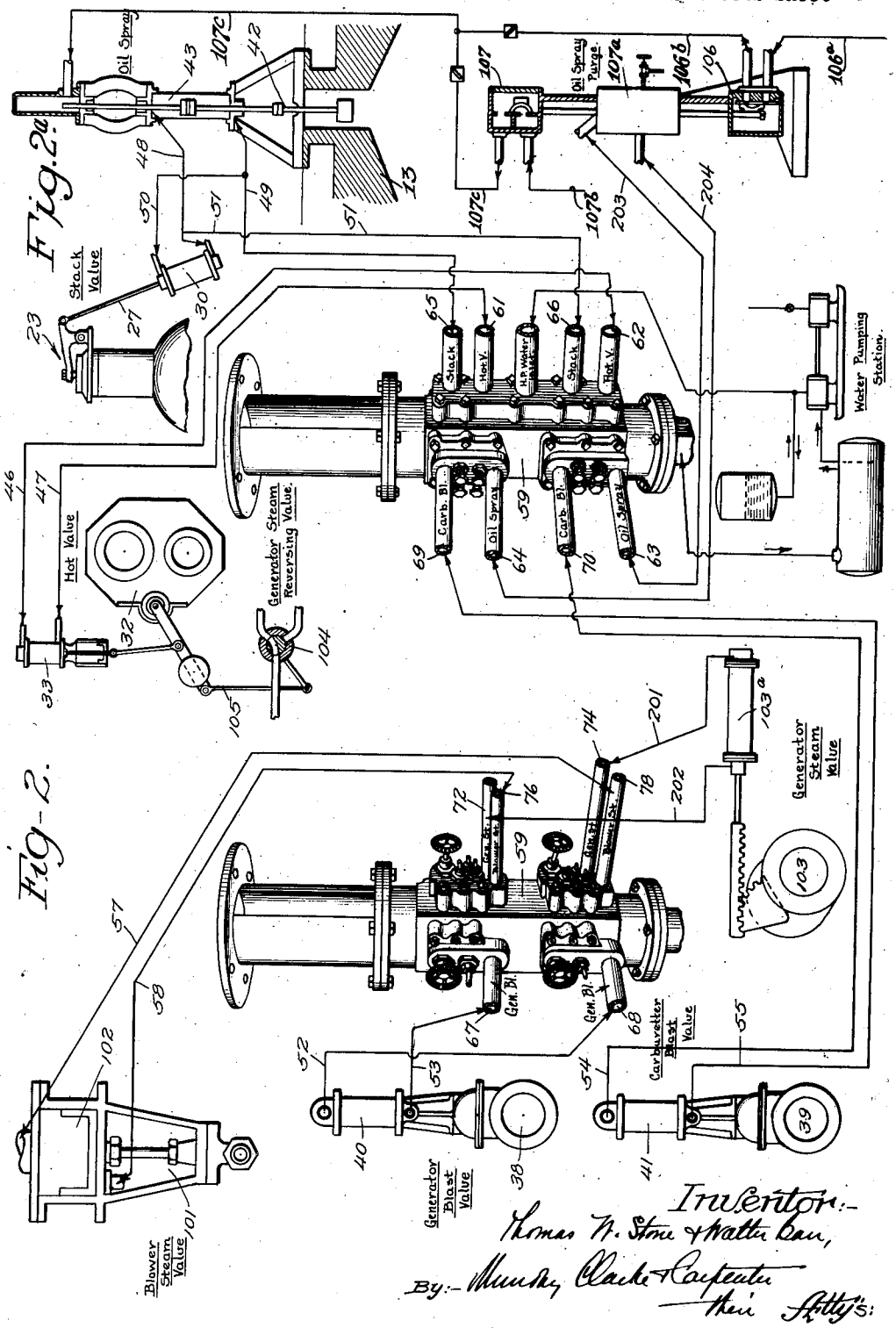
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WATER GAS MACHINE VALVE CONTROLLING APPARATUS

Filed Jan. 31, 1923 4 Sheets-Sheet 3



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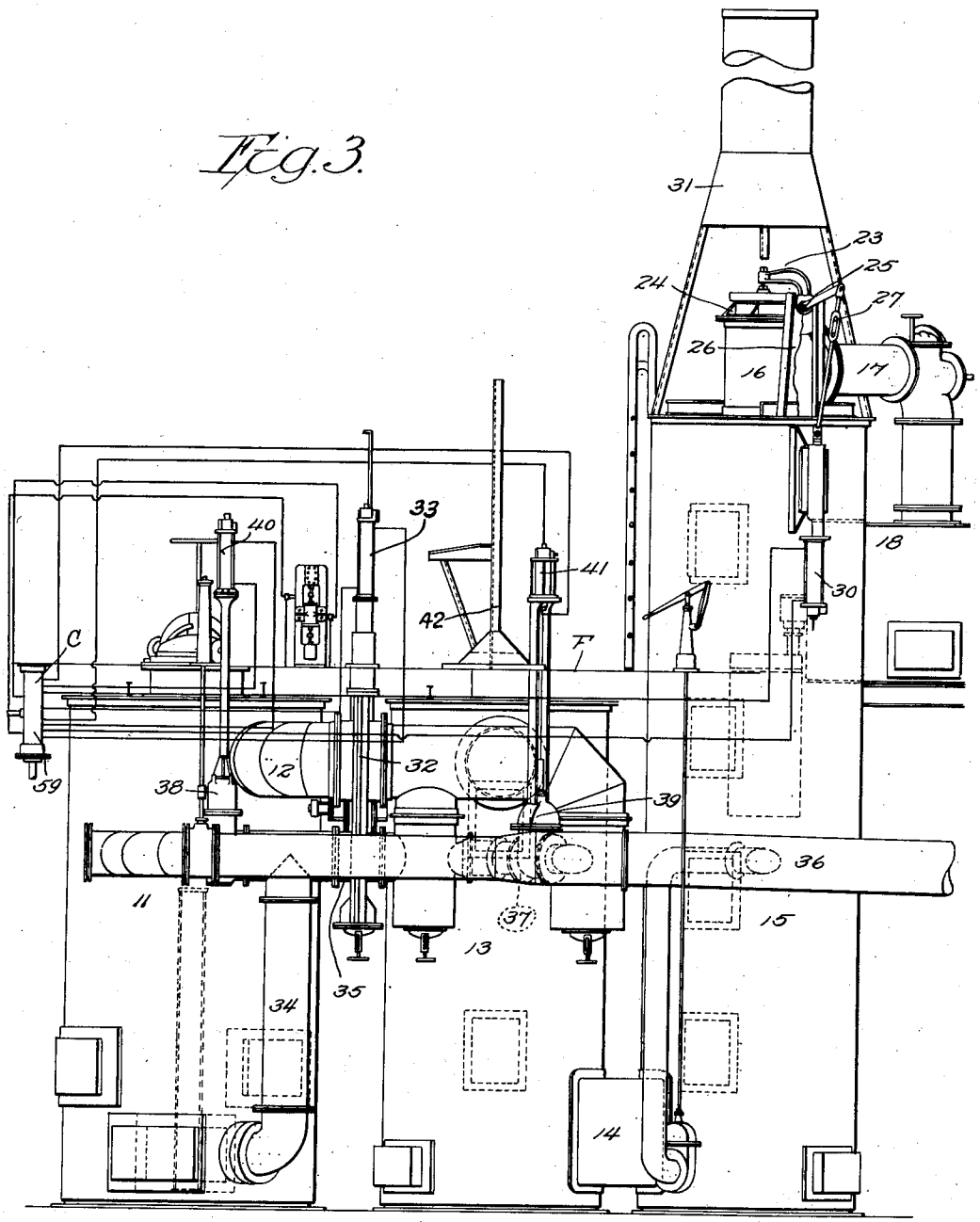
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WATER GAS MACHINE VALVE CONTROLLING APPARATUS

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Fig. 3.



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Patented May 22, 1928. 1,670,911

UNITED STATES PATENT OFFICE.

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WATER-GAS MACHINE VALVE-CONTROLLING APPARATUS.

Application filed January 31, 1923. Serial No. 616,139.

This invention relates to gas making apparatus, such as water gas machines; the invention has for objects to provide an improved and efficient mechanism for automatically effecting the operation in proper sequence of the various valves in the water gas set. As a further feature, the mechanism of the invention is operable alternatively by power or by hand, and may be rapidly shifted from power operation to manual operation or vice versa. Consequently the mechanism controlling the valves is always operable manually in the event of a break-down of the power, and accidents such as might result from a complete failure to operate the valves in the proper sequence are practically avoided.

Many of the valves, and especially each of the sequence operated apparatus valves, on a modern water gas set are operated by a hydraulic cylinder. To control these cylinders is to control the set. Such control is accomplished, according to the invention, in a very simple, direct manner, by the use of the master cylinder with its piston valve as hereinafter described. The piston valve is preferably constructed somewhat like a hollow dumb-bell. High pressure water surrounds the "handle" or neck of the piston, and is floated up and down. The spaces above and below the piston valve are connected to the waste pipe at the bottom. The piston rod extends up through the floor and may be operated by hand or by power. As the piston valve floats the zone of high pressure water upwardly, it uncovers one port after another which immediately sends high pressure water to the various hydraulic cylinders of the set which are thus operatively connected with the zone of high pressure water. At the same instant, the "mate" of each of these ports is being uncovered just under the bottom of the piston valve permitting water to flow freely into the exhaust space. The return trip of the piston valve will cause the reversal of each of these cylinders as the upper ports are one by one connected to the waste space and the lower ports at the same time connected with the zone of high pressure water.

The space within the hollow piston conducts water from the upper part of the master cylinder through to the waste pipe at the bottom. Any piping connected to the ports above or below the piston must necessarily contain low pressure water, while the "mate" from each of these pipes connecting to the central space occupied by high pressure water must carry high pressure water.

Consequently, the stem or piston rod is packed against practically no water pressure, thus reducing friction, wear and leakage. Another great advantage is that should the piston wear and some of the high pressure water leak out from around the "central neck", it will be carried away immediately into the waste with no danger of confusing the proper operation of the cylinders.

The ports are permanently cut in the master cylinder in proper sequence for operation of the water gas set. The motion of the piston valve, therefore, must necessarily open and close the valves in the proper sequence. There is no way in which it could open the wrong valve first.

Furthermore, there is provided an adjustable timing mechanism for controlling the rate of motion of the piston over the various parts of the stroke. This device permits the employment of operative cycles of different duration, each with gradual change of time, if desired. It also permits the division of each cycle into the blast time, up run time, and down run time with any desired percentage used in each step. Within the range of cycles per hour commonly used, it is possible to vary the length of the cycle without changing its make-up. For example, if using 35% blast time and a five minute cycle, the machine can be put on a four and a half minute cycle and the blast time will remain at 35% of the total. Moreover, within each cycle there is also complete flexibility. For example, fifteen seconds may be taken off the blast period, five seconds added to the up-run and ten seconds added to the down-run, or similar variations. All these changes are readily made by regulation of the timing mechanism. In order to modify the cycle to suit new operating conditions, it is only necessary to adjust the timing mechanism during one or two runs without interfering in any way with the continuous operation of the machine. The succeeding run immediately shows the effect of the slight adjustment made. In this way the machine can

be gradually brought up to the most effective operating condition.

In addition to the general objects recited above, the invention has for further objects such other improvements and advantages in construction and operation as are found to obtain in the structures and devices hereinafter described or claimed.

In the accompanying drawings forming a part of this specification and showing, for purposes of exemplification, a preferred form and manner in which the invention may be embodied and practiced, but without limiting the claimed invention to such illustrative instance or instances:

Figures 1 and 1ª collectively show in vertical section and elevation a valve operating mechanism constructed in accordance with the invention;

Fig. 2 is a diagrammatic side elevational view showing the connections between the control cylinder and the various apparatus valves, such as the blower steam-valve, generator steam-valve and generator blast-valve of a water gas set;

Fig. 2ª is a view similar to Fig. 2 illustrating the connections between the other side of the master or control cylinder and the various apparatus valves, such as the hot-valve, carburetter-blast valve, oil spray-valve, oil supply meter and oil spray-purge valve, stack-valve, and high pressure water valve, of a water gas set;

Fig. 3 is an elevational view of a water gas machine equipped with a valve operating mechanism such as illustrated in the preceding figures.

The same characters of reference designate the same parts in each of the several views of the drawings.

Referring to the drawings, and more particularly to Fig. 3, there is shown a water gas machine, or set, said apparatus embodying in its construction the following essential elements: The generator 11 provided with the usual chamber for carbonaceous fuel is connected by means of the discharge pipe section 12 with a carburetor 13. The latter in turn is connected at its bottom by the discharge passageway 14 with a superheater 15. The carburetor and superheater are of the well known constructions, embodying essentially two chambers filled with checkerbrick for storing up heat while the blast is on, the heat so stored in the checkerbrick being employed in the gas carburation and mixing in the subsequent run. At the top of the superheater 15 there is provided a discharge pipe 16 having a branch 17, the latter leading to a water seal 18, through which the gas passes to the usual scrubber and condenser (not shown).

The top of the discharge pipe 16 leading from the superheater may be opened and closed by the stack valve 23. Said stack valve consists essentially of a cover plate 24 adapted to fit over the top of the discharge pipe 16 and pivotally mounted at 25 in a suitable upright 26. Connected with the cover plate 24 at its pivotal point is an operating lever connection 27, the opposite end of which is attached to the upper end of a pressure-operated piston which works in the stack-valve cylinder 30 and responds to pressure supplied to the upper end of the cylinder 30 to open the stack valve and, reversely, to pressure supplied to the lower end of the cylinder to close the stack valve. Above the discharge pipe 16, is positioned a stack 31 through which the gases and products of combustion from the superheater pass when the stack valve 23 is open.

The water gas set is of the "up and down run" type, that is to say:—during the up run, the steam passes from the bottom of the generator through the mass of glowing fuel and the gas generated as a result of the chemical reaction between the steam and the glowing fuel discharges from the top; whereas, on the down run, the steam enters at the top of the generator and the resultant gas discharges from the bottom. This change in direction of flow of the gas in the generator is effected by means of the main or up-and-down run or "hot" valve 32. The up-and-down run valve 32 embodies in its construction a pressure cylinder 33 within which works the usual piston, not shown. The valve piston, it will be understood, controls ports in the piping 12, 34, and 35. When the piston in the cylinder 33 is in the "up" position, the hot valve is set to permit passage of the gases from the upper end of the generator into the carburetor, the operation at this time being an "up-run", and down-run connection 34, communicating with pipe 35, is closed by said valve. On reverse operation of the piston in the cylinder 33, the hot valve is set whereby the gaseous products pass from the lower end of the generator into the carburetor 13 through down-run connection 34 and pipe 35 which are now open, the operation at this time being a "down-run."

Extending horizontally of the machine is an air blast pipe 36 which leads to the vertical pipe 34 and is connected therewith to supply the blast to the lower end of the generator 11. Also connected with the main blast pipe 36 is a branch 37 leading to the carburetor 13. Separate valves are provided for controlling the blast supplied by the pipe 36 to the generator and to the carburetor, namely,—the generator blast valve 38 and the carburetor blast valve 39. These valves are preferably of the gate type respectively provided with cylinders 40 and 41, having pistons which in the up position operate to open the valves and in the down position operate to close the valves. For

supplying the oil to the carburetor during a run, there is provided an oil spray valve 42 operated by a similar piston which works in a cylinder 43. When the piston is in the down position in the cylinder 43, the oil spray valve is lowered into the carburetor for discharging its spray; on reverse operation of the piston, the oil spray valve is elevated out of the carburetor.

In addition to the apparatus valves above mentioned, the water gas set is provided with other valves, such as the following indicated diagrammatically in Fig. 2 and in Fig. 2[a]: The blower steam valve 101, which controls the supply of steam to the turbine that operates the blower, is provided with a hydraulic cylinder 102 having a piston for opening up or shutting off the supply of steam to the turbine. The generator steam valve 103 controlling the supply of steam to the generator 11 is opened or closed by a piston in a hydraulic cylinder 103[a]. The generator steam reversing valve 104 is operated by a direct lever connection 105 from the hot valve 32 in such manner that the steam is supplied to the top of the generator 11 when the hot valve is in the "down run" position but to the bottom of the generator when the hot valve is in the "up run" position. The oil spray purge valve 106 and the oil meter valve 107 which controls the supply of oil to the spray valve 42 are provided with a hydraulic cylinder 107[a] having the usual operating piston.

In a water gas machine or set, such as above briefly described, the cycle of operation is as follows: Assuming that the various parts of the machine be standing idle, the valves would have the following positions:

Generator blast valve 38,—closed.
Carburetor blast valve 39,—closed.
Hot valve 32,—up run position.
Blower steam valve 101,—closed.
Stack valve 23,—open.
Generator steam valve 103,—closed.
Oil spray 42,—in the up position with respect to the carburetor.
Oil spray purge 106 and cutoff valve 107,—closed.

In starting operation, the first move would be to put on the air blast. This is accomplished when the generator steam valve 103 is closed and by opening the blower steam valve 101 so that steam is admitted to the turbine that operates the blower. The generator blast valve 38 next opens to permit the air to pass into the bottom of the generator; shortly thereafter, the carburetor blast valve 39 is opened to permit the blast to enter the carburetor. The operation of the valves in the above stated sequence is known as "taking off the run and putting on the blast." During the blast cycle of operation the hot products of combustion from the generator pass out of the top of the generator into the carburetor, where any unconsumed, or partially consumed portion of the gas is burned in the secondary air supplied by the carburetor blast. The whole volume of the heated products of combustion passes through the checkerbrick in the carburetor and through the superheater to the stack thereby storing up in the carburetor and superheater a great amount of heat for the subsequent run. As soon as the blast cycle of operation is completed, the next operation of the cycle is carried out, this being known as "taking off the blast and putting on the run." The carburetor blast valve 39 is closed; the generator blast valve 38 is then closed; the stack valve is closed and the oil spray is concurrently lowered into the carburetor. Next the generator steam valve 103 is opened to admit steam to the bottom of the generator, the hot valve being still in the "up run position." The gas so produced passes out of the top of the generator into the carburetor. Just after the steam valve 103 is opened, the valve 107 is operated to supply the oil from line 107[b] to the spray 42 through the line 107[c] so that the gas is enriched by the oil sprayed into the carburetor. The enriched gas passes through the hot checkerbrick in the carburetor chamber and superheater chamber. Finally the gas discharges through the outlet 16 and branch 17 and through the water seal 18 from which the gas passes to the scrubber and condenser. On completion of the up run, the down run is commenced by next operating the main valve to the down run position, whereupon the steam reversing valve 104 is jointly operated to admit steam to the top of the generator, with the result that the water gas passes out of the lower end of the generator and subsequently into the upper end of the carburetor chamber. At the end of the down run, the main valve is again operated to the up run position for another up run. At the termination of the second up run of this cycle, the oil valve is closed and the shift of "taking off the run and putting on blast" is again made. Thereupon, the several valves are operated in the blast sequence hereinabove set forth.

In the operation of a water gas machine or set, according to the above cycle, it is important that the valves be operated substantially in the sequence described above, that is to say—when taking off the run and putting on the blast the up and down run or main valve must be first operated to the up run position, the oil valves must be closed, the stack valve must next be opened and followed in sequence by opening of the generator blast valve and the carburetor blast valve. It is also important that the stack valve be in the open position substantially concurrently with the opening of the

generator blast and that, in turn, the generator blast valve be in the open position before the carburetor blast valve is opened. When taking off the blast and putting on the run, it is important that the carburetor and generator blast valves be closed before the stack valve is closed. These considerations are absolutely essential to the safe manipulation of the machine for the obvious reason that, if any of the blast valves be opened to an appreciable extent while the stack valve is closed, the blast will be blown back into the scrubber and condenser where it will mix with the gas and form an explosive mixture.

According to the invention, there is provided an improved valve operating mechanism, operable either by power or by hand by a rapid switch from one type of operation to the other, which mechanism enforces operation of the various valves, in the proper sequence during both the blast and the run cycles.

Still referring to Fig. 2 and Fig. 2ª, the main up and down run or hot valve 32 is controlled in its operation by fluid pressure lines 46 and 47, the line 46 leading to the top of the cylinder 33 and the line 47 leading to the bottom of said cylinder; the oil spray valve 42 is controlled in its operation by fluid pressure lines 48 and 49 from the stack valve pressure lines, hereinafter described, the line 48 leading to the top of the cylinder 43 and the line 49 leading to the bottom of said cylinder. The stack valve 23 is controlled in its operation by fluid pressure lines 50 and 51, the line 50 leading to the top of the cylinder 30 and being connected with pressure line 49 and the line 51 leading to the bottom of said cylinder and being connected with pressure line 48. The generator blast valve is controlled in its operation by fluid pressure lines 52 and 53, the line 52 leading to the top of the cylinder 40 and the line 53 to the bottom of said cylinder; the carburetor blast valve 39 is controlled in its operation by fluid pressure lines 54 and 55, the line 54 leading to the top of the cylinder 41 and the line 55 to the bottom of said cylinder; the blower steam valve 101 is controlled in its operation by fluid pressure lines 57 and 58, the line 57 leading to the top of the cylinder 102 and the line 58 to the bottom of said cylinder. The generator steam valve 103 is controlled in its operation by fluid pressure lines 201 and 202, one line leading to one end and the other to the other end of the cylinder 103ª. The oil spray purge valve 106, which supplies steam from line 106ª to line 106ᵇ to purge the oil line 107ᶜ and oil spray 42, is controlled in its operation by fluid pressure lines 203 and 204, one line 203 leading to the top of the cylinder 107ª and the other 204 to a point below the top.

Referring now more particularly to Fig. 3 and to Figs. 1 and 1ª, inclusive, there is provided at a suitable control station, indicated at C in Fig. 3, a vertical cylinder 59 to which the several fluid pressure lines herein above set forth, as well as others lead. The cylinder 59 is located below the floor line F of the plant and functions as a central power station from which hydraulic pressure is released through the several fluid pressure line connections from a source of fluid pressure supply, to operate the several valves in proper sequence during each cycle of operation of the gas making machine. As shown in Fig. 1ª, a discharge pipe 60 communicates with the bottom of the cylinder 59 and receives the discharged fluid from those pipe lines which are operating on the exhaust sides of their respective valve-operating-cylinders. The fluid pressure line 47 to the bottom of the main up-and-down run or hot valve 32 leads from and is communicably connected with the top of the control cylinder 59, as shown at 61 (Fig. 2); the fluid pressure line 46 to the top of the main up and down run or hot valve cylinder 33 leads from and is communicably connected with the bottom of the control cylinder 59, as shown at 62. The fluid pressure line 203 to the top of the oil spray purge valve cylinder 107ª leads from and is communicably connected with the bottom of the control cylinder 59, as shown at 63; the fluid pressure line 204 to the middle portion of said oil spray valve cylinder 107ª leads from and is communicably connected with the top of the control cylinder 59, as shown at 64. The fluid pressure line 50 to the top of the stack valve cylinder 30 leads from and is communicably connected with the top of the control cylinder 59, as shown at 65; the fluid pressure line 51 to the bottom of the stack valve cylinder 30 leads from and is communicably connected with the bottom of the control cylinder 59, as shown at 66. The fluid pressure line 53 to the bottom of the generator blast cylinder 40 leads from and is communicably connected with the top of the control cylinder 59, as shown at 67; the fluid pressure line 52 to the top of the generator blast cylinder 40 leads from and is communicably connected with the bottom of the control cylinder 59, as shown at 68. The fluid pressure line 55 to the bottom of the carburetor blast cylinder 41 leads from and is communicably connected with the top of the control cylinder 59, as shown at 69; the fluid pressure line 54 to the top of the carburetor blast cylinder 41 leads from and is communicably connected with the bottom of the control cylinder 59, as shown at 70. The fluid pressure line 202 leading to the generator steam valve cylinder 103ª to close the valve is communicably connected with the top of the cylinder 59, as shown at 72; the fluid

pressure line 201 leading to the said cylinder 103[a] to open the generator steam valve is communicably connected with the bottom of the cylinder 59, as shown at 74. The fluid pressure line 57 leading to the top of the blower steam valve cylinder 102 is communicably connected with the bottom of the control cylinder 59, as shown at 78; the fluid pressure line 58 leading to the bottom of the blower steam valve cylinder is communicably connected with the top of the control cylinder 59, as shown at 76.

The order in which the several fluid pressure lines to the various valves, hereinabove mentioned are connected to the cylinder 59, is that which will accomplish the operation of the several apparatus valves to effect the blast and run cycles hereinbefore described. Extended within the cylinder 59 is a piston rod 90 to the lower end of which is secured the control piston 91. The control piston 91 is provided with top and bottom flanges 92 which fit closely the wall of the cylinder 59 and provide between them a chamber or space 93 surrounding the mediate portion of the piston and from which the high pressure operating fluid supplied from the port 401 is distributed to the various fluid pressure lines hereinabove described. The distribution of the high pressure fluid is, of course, determined by the position of the piston 91 in the control cylinder 59. As shown in Fig. 1[a] the piston 91 is made hollow to provide an interior chamber or space 94 open at top and bottom for the free circulation of the discharged fluid from the exhaust lines of the various valve cylinders. As the piston 91 moves one way in the control cylinder 59, the various hydraulic valves are progressively operated in proper sequence, and when the piston travels in the opposite direction, the operation of said valves is reversed, also in proper sequence. With this construction the downward and return movement of the single piston 91 in the cylinder 59 will distribute the operating fluid progressively to the several hydraulic valve cylinders with reversal in direction of the flow of the fluid in such manner as to effect the operation of the various valves through a complete blast and run cycle of the water gas machine.

The piston rod 90 extends through a gland 90[a] in the head of the cylinder 59 and thence upwardly to a rack 95 with which it is detachably connected, as shown at 96. The rack 95 is located in the frame casting 97. Detachably secured to the upper end of the rack 95 is the power piston rod 98 which projects through a gland 99 into the power cylinder 300. Mounted on the upper end of the piston rod 98 is a piston 301 which responds to fluid pressure, such as oil fed alternately to the top and bottom of the power cylinder 300 to lower and elevate the power piston 301 and with it the control piston 91. While it is not absolutely essential to employ oil as a motive power, the use of oil is preferable on account of its lubricating effect on the parts of the valve operating mechanism, with the result that little, if any, wear will take place in the operation of the device. The fluid pressure is supplied to the top of the cylinder 300 through a supply pipe 302 and alternately to the bottom of the power cylinder through a supply pipe 303.

The control of the flow of the motive power alternately to the supply pipes 302 and 303 is effected by means of a controlling or pilot valve mechanism 304, see Fig. 1, said controlling valve mechanism being reversed concurrently with the termination of a full one-way stroke of the control piston 91. The fluid pressure supply to the top of the power cylinder 300 is maintained through the pipe 302 by a supply port 305 in the pilot valve cylinder 304[a] and with which pipe 302 is connected. The fluid pressure supply to the bottom of the cylinder 300 is maintained through the pipe 303, after reversal of the pilot valve from a supply port 306 in said cylinder 304[a]. The high pressure fluid to operate the piston 301 is supplied to the valve chamber 304[a] by a supply main 307, and the exhaust from the valve chamber passes out through an exhaust pipe 307[a]. When the piston 301 is traveling upwardly, the exhaust from above the piston passes to the valve chamber 304[a] through a pipe 402 which is connected with the latter by a port 404. The exhaust from below piston 301, when the latter is traveling downwardly passes to valve chamber 304[a] through 403, connected with said chamber by a port 405.

Working within the valve chamber 304[a] is a valve body 308 which when moved in one direction will admit fluid pressure from main 307 to the supply pipe 302 and concurrently place the cylinder exhaust pipe 403 in communication with the exhaust main 307[a], and, when moved in the opposite direction, will place the supply pipe 303 to the bottom of the cylinder in communication with the fluid pressure supply, and concurrently the exhaust pipe 402 from the top of the cylinder in communication with the exhaust. For this purpose the valve body 308 is provided with a high pressure groove 406 and with an exhaust groove 407. In the operation of the valve body the supply and exhaust grooves are always in communication with the respective mains 307 and 307[a], but are only in communication respectively with one cylinder supply or exhaust port at a time.

The movement of the control piston 91 into its extreme upper and lower positions is employed for throwing the valve 308 to

reverse the flow of (oil, water, etc.) power supplied to the piston 301. As shown, the top and bottom of the control cylinder 59 are respectively connected with piston chambers 501 and 502 located at the right and left hand ends of the valve mechanism 304 by fluid (oil, water, etc.) supply pipes 509, 510. At its extreme right and left ends the valve body 308 is provided with piston heads 511 and 512 which work within the chambers 501 and 502. With this construction, as the control piston 91 travels to either its extreme top or bottom position, it will, according to the direction of its travel, place either the pipe 509 or 510 in communication with the high pressure zone 93 so that the high pressure will be delivered to either one or the other of the pipes 509, 510. Consequently the fluid pressure will be permitted to flow against one of the piston heads 511, 512, with the result that the position of the valve body 308 will be reversed, as the control piston 91 arrives in either of its extreme upper or lower positions. When one pipe 509 or 510 is in communication with the high pressure space, the other is in communication with the exhaust pipe 60.

The distance between the pressure line ports in the control cylinder 59 initially determines the interval between the operations of any successively operated valves. In the present embodiment of the invention, provision is made for effecting wide adjustments of the several intervening intervals between valve operations, in accordance with the principle disclosed and claimed in the copending application of Thomas W. Stone for Letters Patent of the United States for gas making apparatus, filed August 5, 1921, Serial No. 490,088, by adjustably varying the rate of movement of the piston 91 between any pair of adjacent ports independently of the rate of movement of said piston between any other pairs of adjacent ports. As shown, the operating piston rod 98 is provided at its upper end with a crosshead 513 to which is secured right and left hand stems 514 and 515. These stems 514, 515, respectively project into vertical chambers 601 and 602, the chambers being provided in extensions 516 and 517 mounted on top of the power cylinder 300, the right hand hollow stem 514 is open to the space above the piston 301 but the left hand stem 515 is closed to the space above the piston 301 and open to the space below said piston by means of a pipe connection 518′ leading from chamber 602 to the pipe 303. During the downward travel of the piston 301, as shown in Fig. 1, the exhaust from the space below the piston is discharged through pipes 303, 518′, and the hollow stem 515; but, during the upward travel of said piston 301 the exhaust from the space above said piston is discharged through the hollow stem 514. The stems 514, 515, are respectively provided with exhaust ports 603, 604, adapted, during the travel of the piston 301 to communicate successively with a series of exhaust ports 605, 606, leading to exhaust chambers 607, 608, and controlled by needle valves 518 for the right hand cylinder extension and needle valves 519 for the left hand cylinder extension. The exhaust chamber 607 is connected with exhaust pipe 402, and exhaust chamber 608 with exhaust pipe 403. The needle valves 518 adjustably control the upward movement of the piston 301 and the needle valves 519 adjustably control the downward movement of said piston 301. Each needle valve provides an individual adjustment of the area of its respective port. Consequently, the rate of discharge of the exhaust in the different stages of travel of the piston 301 may be controlled, to the end that the rate of movement of the control piston 91 in each stage, i. e., between any two valve operations, may be varied independently of the rate of movement between other stages. The result is that simple adjustments of the needle valves 518, 519, are effective to vary the times between the operation of the several apparatus valves, and also control the duration of the entire cycle by any desired progressive change. When the piston 301 is traveling downwardly the supply of high pressure oil is maintained through the hollow stem 514, the pipe 302 being connected to chamber 601.

In accordance with the invention, provision is made for rapidly switching the operation of the control piston 91 from the power mode of operation hereinabove described to manual operation, or vice versa. Mounted in bearings supported by the frame casting 97 is a shaft 720 provided with a pinion 721 in mesh with the rack 95. A sprocket 722 is also mounted on the shaft 720, said sprocket 722 being connected by a sprocket chain 723 with a sprocket 724 on the hand wheel shaft 725 carrying the hand wheel 726. With the gearing connections just described, by operating the hand wheel 726 the rod 90 and piston 91 may be moved up and down in the controlling valve cylinder 59 to reverse the various apparatus valves. It will be noted that the upper power cylinder 300 with its attendant operating parts constitutes an operating unit which may be entirely detached from the lower control cylinder 59 and the control piston 91, it being preferable to bolt the parts together through the intermediary casting 97. This construction permits an entire removal of the devices for operating the control piston by power, leaving if desired only the manual operating devices hereinafter described, or making it entirely practicable to substitute other operating devices without at all disturbing the adjustment of the control piston 91. There is

no possibility of getting operations "mixed-up" in making any substitution of power device for operating the piston 91 inasmuch as the ports in the cylinder 59 are all fixed and the correct sequence of operation of the various apparatus valves must inevitably result, whatever be the device employed for moving the piston 91 up and down.

In order to reduce the labor incident to hand operation, with the construction herein described, provision is made for equalizing the pressure on the top and bottom of the piston 301 which moves with the rack 95 and other parts. Connected with the top and bottom of the power cylinder 300 is a by-pass pipe 827 provided with a manually operable valve 828. By opening the valve 828 the top and bottom of the cylinder 300 are mutually interconnected, with the result that the pressure is equalized above and below the piston head 301. As the piston head 301 travels up and down in the cylinder 300 during the manual operation, the fluid passes freely back and forth through the by-pass so that the piston 301 is practically unobstructed in its travel. In operating the apparatus by power the valve 828 is of course closed. With the construction just described, the apparatus is instantly convertible from power to manual operation, by the simple expedient of opening the valve 828 thereby rendering it possible to manually operate the hand wheel 726. By closing valve 828 the apparatus is reconverted to power operation.

In order to make the invention clear, there will be given a description of one cycle of operation of the piston 91. As it starts upwards the high pressure area 93, due to high pressure fluid (oil, water, etc., under pressure) applied through port 401 substantially continuously, is floated upwardly and the piston 91 uncovers first, the lower generator blast port 68 to the discharge area 94 and the upper generator blast port 67 to the area 93 forcing the generator blast up and open; second, the piston uncovers the lower carburetor blast port 70 to area 94 and the upper carburetor blast port 69 to area 93 passing water to the bottom of the carburetor blast valve cylinder and opening the air blast valve. The air blast is now on. This continues for some time, for example approximately three minutes. During this period the piston inside the control cylinder 59 has reached the top of the stroke and uncovered the port of line 509 to the high pressure area and forcing the head 511, with the result that the position of the valve body 308 is reversed, and the piston inside the control cylinder 59 has automatically reversed and is now traveling downwardly until it is time to take off the blast and put on the steam run.

As the piston is moving downwardly, the high pressure area 93 will be uncovered to the lower sets of ports while the upper set of ports are uncovered to the discharge area 94. First the lower carburetor blast port 70 will receive high pressure water which enters the carburetor blast valve cylinder at the top, forcing the valve downward and closed. Next, the lower generator blast port 68 will receive water, pass it to the top of the generator blast cylinder, to force the valve downwardly and closed. Next, the stack valve lower port 66 will receive water pressure, pass it to the bottom of the stack valve cylinder, forcing the stack valve closed. The lower generator steam port 74 will receive water and pass it to the right end of its cylinder forcing the piston to the left and opening generator valve admitting steam for making gas. Next, the lower blower steam port 78 will send water to the top of the blower steam valve cylinder, closing off the steam from the turbine and shutting down the blower. Next, the high pressure water will be passed through the lower oil spray port 63 to the top of the control for the oil spray purge, forcing the piston down opening the oil cutoff valve and so admit oil from line 107^b through the meter 107 and out through line 107^c to the oil spray 42 and into the carburetor. The steam up run is now on. This up run continues for a minute or a minute and a half, for example, after which the down run should be put on.

The piston in the control cylinder is still moving the high pressure water area downward and uncovers the lower hot valve port 62 passing water through the lower port valve pipe to the top of the hot valve cylinder, moving the piston downward, but the disc upward, so that the down run port is opened and the up run port is closed. At the same time the three-way valve 104 in the steam line to the generator is reversed so that steam now passes to the top of the generator instead of the bottom, making a steam down run.

The down run is now on and continues for two or to two and a half minutes, for example. During this period the water piston in the master cylinder 59 has moved to the bottom of its stroke, has automatically reversed and is traveling upward. At the end of the down run period, it is time to reverse the hot valve back to the final up run period. The water piston passing upward moves the high pressure water area over the upper hot valve port 61 and passes high pressure water through the upper hot valve pipe to the bottom of the hot valve cylinder, moving the hot valve disc down to cover the down run port and open the up run port, at the same time reversing the three-way generator steam valve 104 so as to pass steam to the bottom of the generator instead of to the top of the generator. The up run is now on

and continues for three quarters to one minute.

About half way in this final up run the oil spray is shut off. This is accomplished by the water piston moving upward and uncovering the upper oil spray port 64 passing high pressure water through the upper oil spray pipe to the bottom of the piston in the cylinder 107ª for the oil meter 107 and the oil spray purge 106, moving the piston upward and shutting off the oil. Further about half way in this up run period it is advisable to start the turbine blower so that the blower will be up to speed by the time the blast valves are to be opened. The piston still moving upward admits high pressure water to the upper blower steam port 76 and through the upper pipe connects to the bottom of the cylinder on the blower steam valve, forcing it upward and opening the valve admitting steam to the turbine and bringing up the blast pressure in the blast lines.

It is now time to take off the steam run and put on the blow.

The piston moving upward admits high pressure water to the upper generator steam port 72 and through the upper pipe connects to the left hand end of the generator steam valve cylinder forcing the piston to the right and closing the generator steam valve and so shutting off steam from the bottom of the machine and stopping the gase production. At almost the same time high pressure water is admitted through the upper stack valve port 65 to the upper end of the stack valve cylinder, the piston in this cylinder is forced downward and the stack valve is raised. Almost immediately high pressure water is admitted to the upper generator blast port 67 and through the upper generator blast pipe is conducted to the bottom of the generator blast cylinder, the piston moving upward opening the generator blast. Very shortly thereafter the same action takes place in reference to the carburetor blast port 69 which has been previously described, and the cycle has been completed and the second blast is on the machine.

The invention hereinabove set forth may be variously embodied within the scope of the claims hereinafter made.

We claim:

1. In a sequence control device for gas making apparatus valves and their operating mechanisms, in combination: a source of fluid pressure adapted to be connected with a plurality of fluid pressure lines respectively leading to and operating respective valve operating mechanisms: a sequence control device, itself operated by fluid pressure, directly inserted in the flow-paths from said source to said lines respectively and having a plurality of different operative positions for releasing fluid pressure intermittently from said source to said lines leading to said valve operating mechanisms in their predetermined order as said sequence control device is adjusted back and forth through its different positions; means for effecting manual operation of said control device; and means for equalizing the fluid pressure on said control device for such manual operation; substantially as specified.

2. In a sequence control apparatus for gas making apparatus valves and their operating mechanisms, in combination: a source of fluid pressure adapted to be connected with a plurality of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a unitary sequence-control device directly inserted in the flow-paths from said source to said lines respectively and having a plurality of different operative positions for directly releasing fluid pressure intermittently from said source to said lines leading to said valve operating mechanisms in their predetermined order as said unitary control device is adjusted back and forth through its different positions; and switch controlled means for effecting alternatively manual or power operation of said sequence-control device; substantially as specified.

3. In a sequence control apparatus for gas making apparatus valves and their operating mechansims, in combination: a source of fluid pressure adapted to be connected with a plurality of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a unitary control device, itself operated by fluid pressure, directly inserted in the flow-paths from said source to said lines respectively and having a plurality of different operative positions for directly releasing fluid pressure intermittently from said source to said lines leading to said valve operating mechanisms in their predetermined order as said unitary control device is adjusted back and forth through its different positions; and valve controlled means for effecting alternatively manual or fluid pressure operation of said unitary-control device; substantially as specified.

4. In a sequence control device for gas making apparatus valves, in combination: a power transmission device adapted to be connected with a series of power lines respectively leading to and operating a plurality of such valves; a unitary control member adapted to traverse said transmission device and successively and directly admit and intercept the flow of power through said transmission device directly to said power lines; a manual drive and a power drive for said unitary control member for effecting alternatively manual or power operation of said unitary control device; substantially as specified.

5. In a control device for effecting the op-

eration of a plurality of independent valve operating mechanisms operable in predetermined order, in combination: a source of fluid pressure for supplying motive power to operate the respective valve operating mechanisms; a sequence controlling valve directly inserted in the flow-paths from said source to the respective valve operating mechanisms and having a plurality of different operating positions for releasing fluid pressure intermittently from said source to said valve operating mechanisms in their predetermined order as said controlling valve is adjusted through the flow-paths to several of said valve operating mechanisms; a piston for effecting the operation of said controlling valve; manually-operated gearing connections for effecting the operation of said piston; means for supplying fluid pressure to effect an alternative operation of said piston; and means for equalizing the fluid pressure on said piston for manual operation by said gearing connections; substantially as specified.

6. In a control device for effecting the operation of a plurality of independent valve operating mechanisms operable in predetermined order, in combination: a source of fluid pressure for supplying motive power to operate the respective valve operating mechanisms; a sequence controlling valve inserted in the flow paths from said source to the respective valve operating mechanisms and having a plurality of different operative positions for releasing fluid pressure intermittently from said source to said valve operating mechanisms in their predetermined order as said sequence controlling valve is adjusted through the flow-paths to several of said valve operating mechanisms; a power cylinder; a piston movable within said power cylinder and operatively connected with said controlling valve; means for supplying fluid pressure to said power cylinder on both sides of the piston; means for effecting manual operation of said piston to operate said piston; and a valve controlled by-pass for mutually interconnecting the cylinder spaces on both sides of said piston during manual operation of the latter; substantially as specified.

7. In a control device for effecting the operation of a plurality of independent valve operating mechanisms operable in predetermined order, in combination: a cylinder provided with two sets of ports, the ports of one set being mates of the ports of the other set, each pair of mated ports having fluid pressure connections for operating a hydraulic valve operating mechanism; a fluid pressure exhaust pipe connected with one end of said cylinder; a high pressure fluid supply main leading to the mediate portion of said cylinder; and a hollow piston within the cylinder for releasing pressure from said high pressure supply to the ports of one set of said sets of ports and for exhaust to said exhaust pipe of fluid pressure from the ports of the other set of said sets of ports in predetermined order, said hollow piston being provided with a mediate high pressure chamber, the latter being in communication with the high pressure fluid supply main and the hollow interior of the piston being in communication with the exhaust pipe, whereby on movement of the piston in either direction in the cylinder one set of hydraulic valve ports are brought into communication with the high pressure main while the mates of said ports in the other set are brought into communication with the exhaust pipe; substantially as specified.

8. In a control device for effecting the operation of a plurality of independent valve operating mechanisms operable in predetermined order, in combination: a cylinder provided with two sets of ports, the ports of one set being mates of the ports of the other set, each pair of mated ports having fluid pressure connections for operating a hydraulic valve operating mechanism; a fluid pressure exhaust pipe connected with said cylinder; a high pressure fluid supply main leading to said cylinder; and a hollow piston within the cylinder for releasing pressure from said high pressure supply to the ports of one set of said sets of ports and for exhaust to said exhaust pipe of fluid pressure from the ports of the other set of said sets of ports in predetermined order, said hollow piston being provided with a mediate high pressure chamber, the latter being in communication with the high pressure fluid supply main and the hollow interior of the piston being in communication with the exhaust pipe, whereby on movement of piston in either direction in the cylinder one set of hydraulic valve ports are brought into communication with the high pressure main while the mates of said ports in the other set are brought into communication with the exhaust pipe; substantially as specified.

9. In a control device for effecting the operation of a plurality of independent valve operating mechanisms operable in predetermined order, in combination: a vertical control cylinder provided with ports for fluid pressure lines that respectively lead from said control cylinder to respective valve operating mechanisms; a sequence control piston within said cylinder and operable to control the flow of an operating fluid through the ports for a plurality of valve operating mechanisms; a power cylinder located above the control cylinder and provided with a power operated piston to effect timed operation of the sequence control piston; and a device for effecting manual operation of said sequence control piston, said device being interposed between the power

cylinder and the control cylinder and having detachable connections with both the power piston and the control piston; substantially as specified.

10. In a control device for effecting the operation of a plurality of independent valve operating mechanisms operable in predetermined order, in combination: a vertical control cylinder provided with ports for fluid pressure lines that respectively lead from said control cylinder to respective valve operating mechanisms; a sequence control piston within said cylinder and operable to control the flow of an operating fluid through the ports for a plurality of valve operating mechanisms; and a power cylinder located above the control cylinder and provided with a power operated piston to effect timed operation of the sequence control piston; the power piston and its cylinder having detachable connections with the control piston and its cylinder; substantially as specified.

11. In a control device for effecting the operation of a plurality of independent valve operating mechanisms operable in predetermined order, in combination: a control cylinder provided with ports for fluid pressure lines that respectively lead from said control cylinder to respective valve operating mechanisms; a piston within said cylinder and operable to control the flow of an operating fluid through the ports for a plurality of valve operating mechanisms; and a separate power cylinder located at one end of the control cylinder and provided with a power operated piston to effect timed operation of the control piston, the power piston and its cylinder having detachable connections with the control piston and its cylinder; substantially as specified.

12. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in combination: a substantially vertical fluid-pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve-operating mechanisms; a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above said substantially vertical supply connection; a power piston movable within said power cylinder and operatively connected with said control device; means for supplying fluid pressure to and for exhausting fluid pressure from each of the cylinder spaces on opposite sides of said power piston for fluid pressure operation of said power piston; a liquid exhaust chamber having a series of orifices through which exhaust liquid flows in succession for flow of liquid from each of said cylinder spaces to control the rate of movement of said power piston in each direction; an auxiliary cylinder having a piston therein to automatically regulate the direction of flow of fluid pressure to and from said cylinder spaces; and fluid pressure lines leading from said supply connections to said auxiliary cylinder and controlled by said control device for supply of fluid pressure to the piston within said auxiliary cylinder, whereby said control device automatically operates the piston in said auxiliary cylinder to automatically regulate the direction of flow of fluid pressure to operate the power piston in the power cylinder.

13. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermind sequence, in combination: a substantially vertical fluid-pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve-operating mechanisms; a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above said substantially vertical supply connection; a power piston movable within said power cylinder and operatively connected with said control device; means for supplying fluid pressure to and for exhausting fluid pressure from each of the cylinder spaces on opposite sides of said power piston for fluid pressure operation of said power piston; a liquid exhaust chamber having a series of orifices through which exhaust liquid flows in succession for flow of liquid from each of said cylinder spaces to control the rate of movement of said power piston in each direction; an auxiliary cylinder having a device therein to automatically regulate the direction of flow of fluid pressure to and from said cylinder spaces.

14. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in combination; a substantially vertical fluid pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a

control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above said substantially vertical supply connection; a piston movable within said power cylinder and operatively connected with said control device; means for supplying fluid pressure to and for exhausting fluid pressure from each of the cylinder spaces on the opposite sides of said power piston for effecting fluid pressure operation of said power piston; an auxiliary cylinder having a piston therein to automatically regulate the direction of flow of fluid pressure to and from said cylinder spaces, and fluid pressure lines leading to said auxiliary cylinder for fluid operation of the piston therein, said fluid pressure lines being controlled by said control device, whereby said control device automatically controls said auxiliary piston.

15. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in combination: a substantially vertical fluid pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above said substantially vertical supply connection; a piston movable within said power cylinder and operatively connected with said control device; means for supplying fluid pressure to and for exhausting fluid pressure from each of the cylinder spaces on the opposite sides of said power piston for effecting fluid pressure operation of said power piston; and an auxiliary cylinder having a piston therein to automatically regulate the direction of flow of fluid pressure to and from said cylinder spaces.

16. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in combination: a substantially vertical fluid pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve operating mechanisms, a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above said substantially vertical supply connection; a piston movable within said power cylinder and operatively connected with said control device; valve controlled means for supplying fluid pressure to and for exhausting fluid pressure from each of the cylinder spaces on the opposite sides of said power piston for effecting fluid pressure operation of said power piston; a liquid exhaust chamber having a series of orifices through which exhaust liquid flows in succession for flow of liquid from each of said cylinder spaces to control the rate of movement in each direction; and manually operated needle valves for controlling the flow through said orifices.

17. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in combination: a substantially vertical fluid pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above said substantially vertical supply connection; a piston movable within said power cylinder and operatively connected with said control device; valve controlled means for supplying fluid pressure to and for exhausting fluid pressure from each of the cylinder spaces on the opposite sides of said power piston for effecting fluid pressure operation of said power piston; and a liquid exhaust chamber having a series of orifices through which exhaust liquid flows in succession for flow of liquid from each of said cylinder spaces to control the rate of movement in each direction.

18. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in com-

bination: a fluid pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; and means for effecting said movement of the control device by fluid pressure medium separate from the fluid pressure medium supply connection.

19. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in combination: a fluid pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above the said fluid pressure medium supply connection; a power piston movable within said power cylinder and operatively connected with the control device in the said fluid pressure medium supply connection to move said control device as a unit in relation to the said lines.

20. In a sequence control apparatus for a plurality of independent valve mechanisms operable in predetermined sequence, in combination: a fluid pressure medium supply connection adapted to be connected with a series of fluid pressure lines respectively leading to and operating respective valve operating mechanisms; a control device that is directly inserted in the flow-path from said supply connection to said lines respectively and that itself admits and intercepts the flow of said pressure medium through it to said lines in predetermined sequence and is movable as a unit in relation to said lines and by its movement in relation to said lines, itself determines the sequence in which respective valve operating mechanisms are operated by fluid pressure in said lines; a power cylinder located above the said fluid pressure medium supply connection; a power piston movable within said power cylinder and operatively connected with the control device in the said fluid pressure medium supply connection to move said control device as a unit in relation to the said lines; and means for effecting movement of said power piston by fluid pressure separate from the said fluid pressure medium supply connection.

In testimony whereof we have hereunto set our hands.

THOMAS W. STONE.
WALTER BARR.