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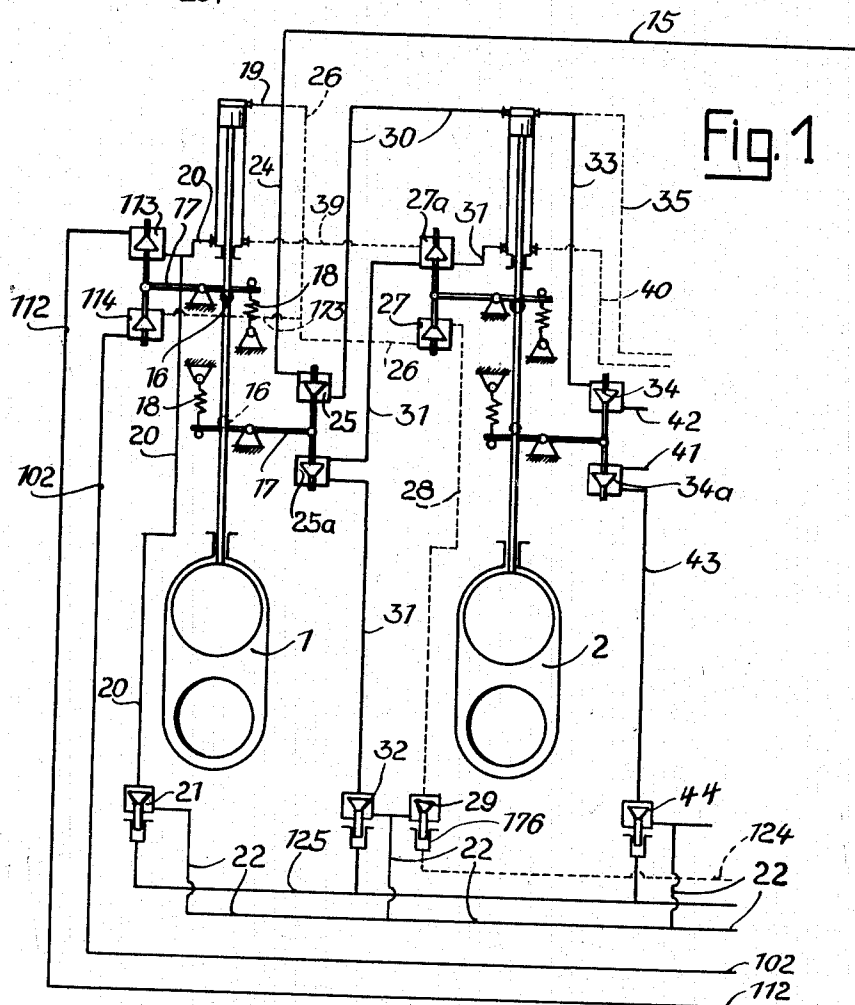
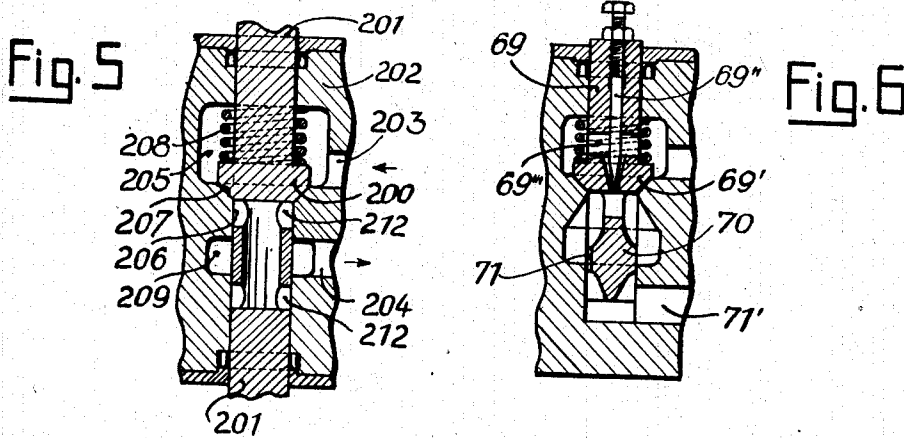
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2,252,800

OPERATING DEVICE FOR WATER-GAS PLANTS, BLAST-FURNACE STOVES, OR THE LIKE

Filed Feb. 7, 1938

4 Sheets-Sheet 1



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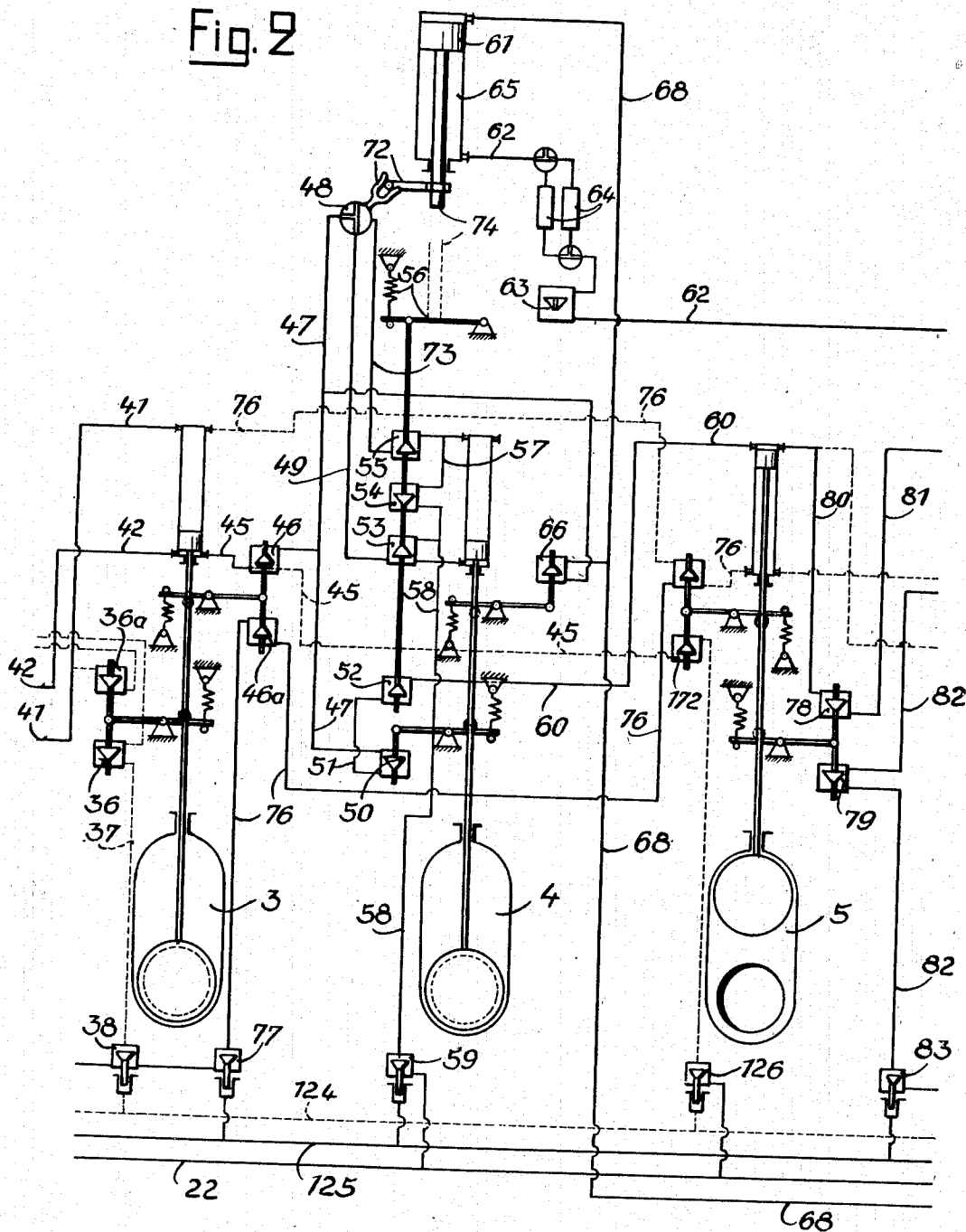
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OPERATING DEVICE FOR WATER-GAS PLANTS, BLAST-FURNACE STOVES, OR THE LIKE

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4 Sheets-Sheet 2

Fig. 2



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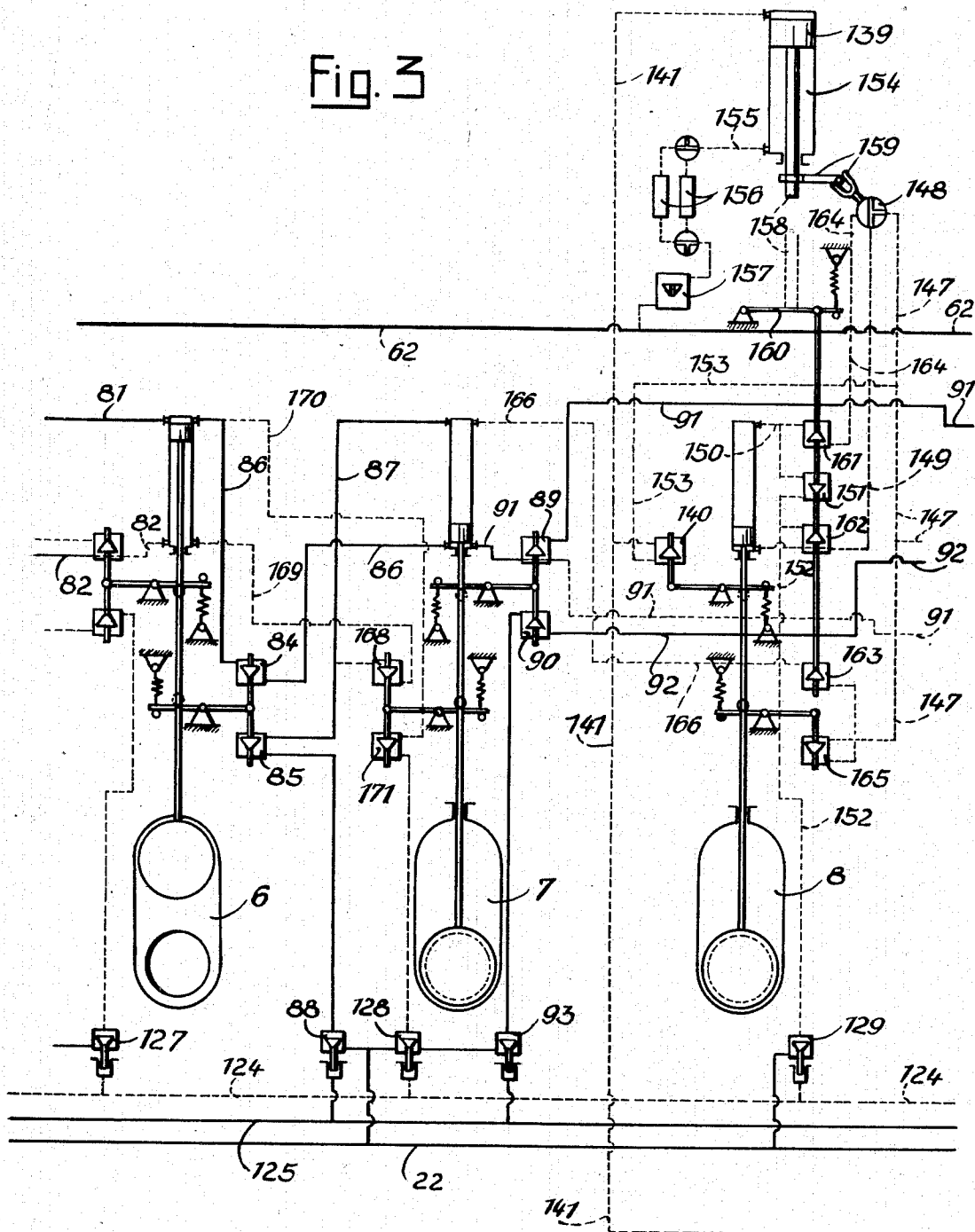
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OPERATING DEVICE FOR WATER-GAS PLANTS, BLAST-FURNACE STOVES, OR THE LIKE

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4 Sheets-Sheet 3

Fig. 3



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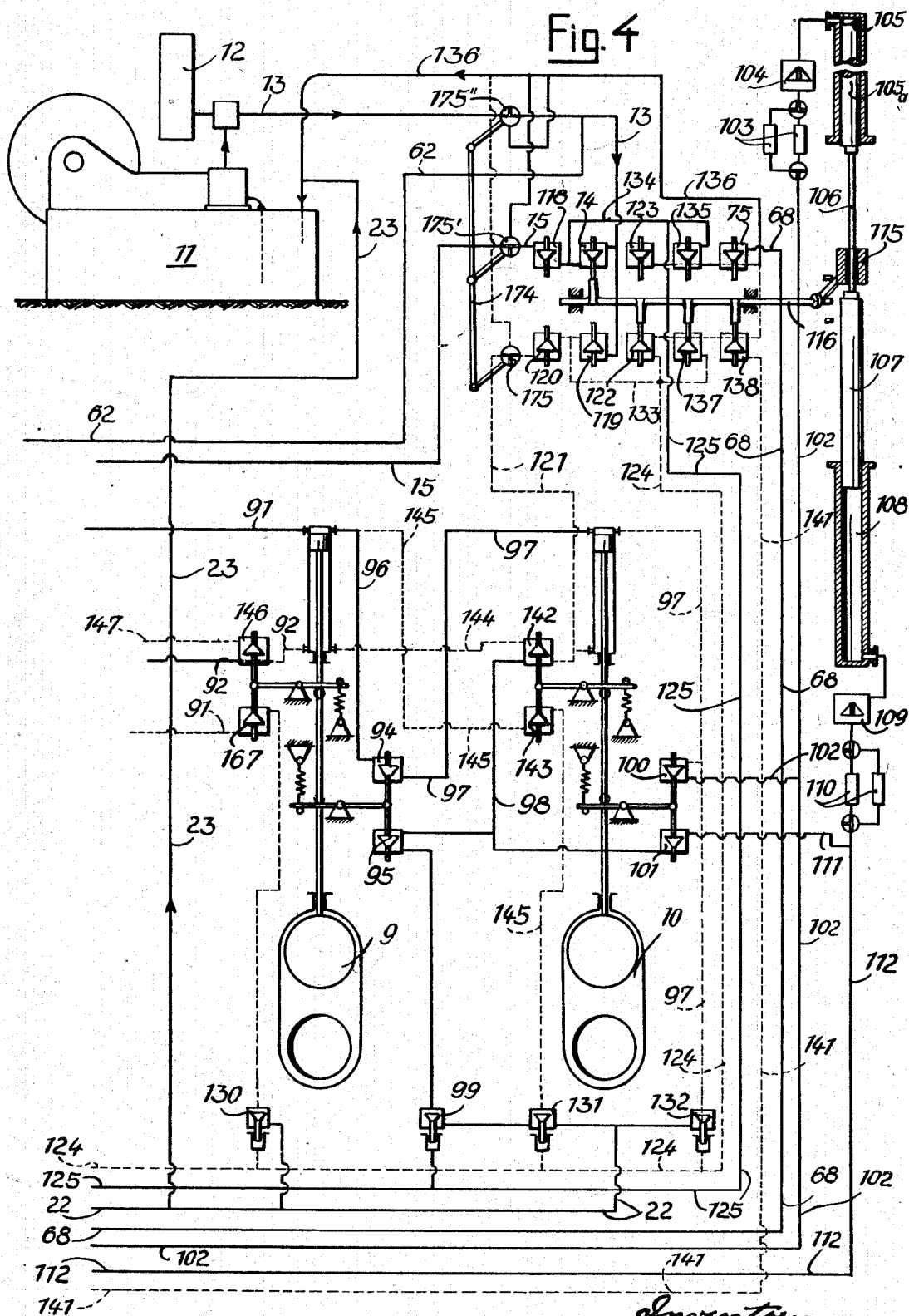
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OPERATING DEVICE FOR WATER-GAS PLANTS, BLAST-FURNACE STOVES, OR THE LIKE

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

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OPERATING DEVICE FOR WATER-GAS
PLANTS, BLAST-FURNACE STOVES, OR
THE LIKEJoseph Daniels, Essen, Germany, assignor, by
mesne assignments, to Koppers Company,
Pittsburgh, Pa., a corporation of DelawareApplication February 7, 1938, Serial No. 189,241
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7 Claims. (Cl. 303—6)

The present invention relates to sequence control apparatus for the automatic operation or control of water gas plants, installations for heating-up the blast at blast furnaces, and the like, and in particular to apparatus in which the reversing valves of said plants, etc., are actuated by means of a pressure medium such as water, oil or air, and in which means are provided for insuring that the pressure medium at a certain moment always acts only on one of the series of shut-off valves and that the next reversing valve is only actuated after the preceding reversing valve has been actuated.

The reversing valves of water gas plants, hot blast stoves, and the like, have to be operated in a definite sequence. For instance at water gas plants, first of all the chimney damper is opened, after this the hot blast air valve is opened for a certain period, and then closed again, whereupon the valve for purging steam is opened for a short period and then closed again. Then the chimney damper must be closed, the waste gas valve must be opened, and finally the water-gas making steam valve is opened. After the gas generator has been cooled down, so that the production of water gas ceases, all valves must be adjusted again in such a manner that the run may begin all over again.

It has been usual hitherto to provide, in most cases, a central controller from which suitable valves, controlling the pressure-medium lines, or relay lines, leading to the working pistons of the individual reversing valves, are actuated by means of a cam shaft which is moved continuously so that individual cams, or the like, act in turn upon the reversing valves, by which they are closed or opened.

The great disadvantage of such controlling devices consists in that the reversing valves of the plant are opened or closed quite independently of the fact whether the preceding reversing valve is fully closed or opened.

In order to avoid any of the difficulties of the known controlling devices for water gas plants, or the like, it is usual to have the operation of the controller supervised. The supervisor may operate pushbuttons or other elements by hand in case of danger, and the controlling device is in this way set idle, or the position of the individual reversing valves may be altered independently of the controller. Such supervision of the control is, however, not reliable and at least partially renders delusive also the advantages of an automatic operation of the plant.

Interlocks for the various reversing valves, which hinder the movement of the controlling device so long until the corresponding valve has reached its proper final position, are only fully effective if they act through a mechanical gear or in a similar way such means can only be provided on smaller plants, when the valves and the control device are placed closely together.

Furthermore, it has been tried to interconnect the working pistons of the reversing valves in such a manner that the pressure medium, for instance water or oil, only flows to the working piston of a valve at such a moment when the piston of the preceding valve has reached the final position and has released a slot in the cylinder wall. The pressure medium may then flow through this slot to the next valve piston. This precaution fails, however, if one valve has to perform several movements, before the next damper is to be actuated. The many movements of the valves render it impossible to lead the stream of pressure medium from the one to the other valve, as soon as the first one has reached its final position. It is, therefore, necessary to provide special control apparatus for those valves which have to make several movements, by which unsafety is introduced again to the valve operating system.

Now, the principal object of my present invention is to provide such improvements in the control or operating devices of reversing valves of water gas plants, blast furnace hot stoves, or similar contrivances, by which an undesired manipulation of the valves is prevented, at any rate, before the valve to be operated previously has not reached properly its final position, notwithstanding whether the individual valve has to perform one or several movements, before the next valve is moved.

The essential feature according to my invention consists in providing adjustable control valves of short lift, preferably cone valves, within the moving range of the valves, or of any means connected therewith. Said cone control valves, control the supply of pressure medium to the subsequent reversing valve, and can be adjusted in such a way that the control valve is then actuated, only, if the corresponding reversing valve has obtained its proper final position.

Furthermore, the invention consists in providing within the moving range of the reversing valves, or of devices influenced or connected therewith, two control valves of short lift, of which one valve controls the supply of the pressure medium to one cylinder compartment and the other valve governs the discharge of the

pressure medium from the other cylinder compartment of the following valve. This arrangement of two adjustable valves offers the best safety against a faulty operation of the plant.

The present invention further consists in the provision for governing the outlets of the two cylinder compartments of the double-acting valve pistons of the reversing valve, by separate shut-off valves, controlled by the pressure medium, the control pistons of the stop-valves being connected with the pressure-medium line in such a manner that, at a given time, the outlet of the cylinder compartment to be filled-up with pressure medium is closed, whereas the outlet of the other cylinder compartment is opened.

Moreover, the invention provides mechanism whereby, in case of three reversing valves to be manipulated one after the other, of which the second reversing valve has to perform, for instance, two movements before actuating the third reversing valve, the pressure medium lines from the first valve lead to the two cylinder compartments of the second valve, through a reversing cock which is controlled from a time relay, put into action from the second reversing valve, on arriving at the final position, in such a way that after the expiration of the time relay, the pressure-medium line is connected with the other cylinder compartment of the second valve, and simultaneously, or after a certain period, with the third valve.

Many other essential objects and features of my present invention will be apparent from the following description of a preferred embodiment of my invention and may be taken therefrom and from the accompanying drawings, in which

Figures 1, 2, 3 and 4 show schematically a reversing arrangement for the sequential control of the valves of a water gas plant hot blast stove installation, or the like.

Figure 5 shows a section through a controlling valve according to the present invention and

Figure 6 is a section through a throttle valve.

In the present case, the reversing valves of the blast furnace air-heating plant are marked 1-10. The reversing valves may be of any suitable design. In the drawings, valves of the so-called sliding type, with sealing discs or plates radially movable, are illustrated by way of example. Various reversing valves have been shown on the drawings in closed and others in opened position. The operating pistons and the cylinders for actuating the reversing valves are illustrated accordingly. The actuation of the valves is done by means of oil under pressure which is forced by a pump 11 to an accumulator 12, thence into the main supply line 13. The line 13 leads to a hydraulic reversing arrangement which has been shown schematically in Figure 4. This reversing arrangement according to the drawings, is so adjusted that compressed oil (oil under pressure) from the line 13 is led through the open valve 14 and then through the line 15 to the upper end of the cylinder of valve 1. The reversing valve rods are provided with pins such as 16, which open or close the control valve pairs in the upper and lower position of the reversing valve by means of levers 17. The levers 17 are normally drawn by springs 18 in such a manner that the control valves are urged toward closing position. Only by the action of the pin 16 provided for the reversing valve rods, are the valves opened.

The compressed oil flows from the line 15 through the inlet 19 of the cylinder into the up-

per cylinder compartment of the reversing valve 1. The piston of the reversing valve 1 is pushed downwards and the oil from the lower cylinder compartment is forced through the line 20 over a pressure operated valve 21, the pressure being derived through line 125, which valve 21 is at present open, to permit oil to drain from the lower compartment to enable the piston to move, and thence into the waste(liquor)-oil line 22, being in direct contact with a line 23, which goes freely into the oil tank 11' for the pump 11, said tank being shown in Fig. 4 on the drawings. The compressed oil flowing through the line 15 also flows through the line 24 to the upper part of a valve 25 which is still closed at this moment. Moreover, the oil may penetrate into the line 26 as shown on the drawings. It further flows through the valve 27 which is open resulting from the position of the pin 16 provided on the rod of the reversing valve 2, and then enters the line 28. A valve 29 which at the present position of connections is commonly closed together with a multitude of other similar valves, hampers the flowing on of the compressed oil.

The reversing valve 1 has meanwhile reached its closing position and has opened the pair of valves 25 and 25a by means of pin 16 and the lever 17. The lever position of the pin 16 is shown in dotted lines. At this moment, the compressed oil may flow through the valve 25 and through the line 30 entering the upper cylinder compartment of the reversing valve 2. The oil to be discharged from the lower compartment of the cylinder of valve 2 then flows through the line 31, the open valve 25a, further through the discharging valve 32, which is open similarly to valve 21, thus reaching the waste oil line 22. As is the case with valve 1, the compressed oil entering the upper compartment for the cylinder of the reversing valve 2 through the line 30, may also pass through the line 33 to the valve 34, which is still in closing position as long as the reversal of the reversing valve 2 is not completed. Moreover, the compressed oil may flow through the line 35, through the valve 36 which is still open, then through the line 37 to the valve 38, which similarly to valve 29 is closed.

Already, when operating the first two reversing valves, it will be found that a manipulation of the second reversing valve is impossible until the first reversing valve has completed its way and has opened the control valve pair 25 and 25a which governs the flow of the pressure medium to the actuating piston of the second reversing valve. Also, the pressure upon the upper cylinder compartment continues to remain from the beginning of the reversal, thus forcing the reversing valves, under all circumstances, into their proper closing position. In order to avoid all dangerous dead ways for the operation of the control valves, cone valves have been provided to replace the cocks. It is known that these cone valves only require a small lift.

A suitable hydraulic control valve is shown in Figure 5. The illustrated valve has a conical sealing member 200 provided on a shaft 201. The shaft 201 is arranged slidably in a casing 202 in such a manner that it may be moved up and down. The casing 202 has an inlet 203 and an outlet 204. Inlet 203 leads to a valve chamber 205 in which may move the conical sealing member 200. On the bottom of the chamber 205 is provided an opening 206 surrounded by a conical seat 207 for the sealing member 200. A spring 208 is arranged on the

shaft 201 between casing 202 and conical member 200, the latter conical member 200 being pressed against its seat 207 by said spring.

The opening 206 leads to another chamber 209 to which is connected the outlet 204. The opening 206 is substantially cylindrical and a lower projection 210 of the member 200 fits into the cylindrical part of the opening 206. The projection 210 is formed with a channel 211, an opening 212 at both the upper and lower end, the arrangement being such that in case shaft 201 and member 200 be lifted a few millimeters, the liquid or gaseous medium may flow from the chamber 205 through opening 212 and channel 211 to the lower chamber 209, the inlet 203 and the outlet 204 of the valve being interconnected in this manner. Thereby it is impossible for the pressure liquid to escape even if the conical seating face does not make a perfectly tight seat. The conical sealing face may easily be reground to tightly seal by turning the shaft 201 of the valve.

A further safeguard against any undesired passage of pressure oil, for instance through the line 24, valve 25 and line 30 to the cylinder of the reversing valve 2, before the reaching of the final position of the reversing valve 1, is likewise obtained in that the oil that must be withdrawn from the lower part of the reversing valve 2, for displacement of the piston, cannot be forced through the valve 25a. Only in case both of the valves 25, 25a have become leaky, is the pressure liquid able to continue its flow to the next reversing valve, before the preceding reversing valve, has reached its final position.

If either of the valves 29, 38, etc., charged with pressure oil, does not fit tightly, then at worst, pressure oil flows from the upper cylinder compartment, for instance through the line 26, valve 27, line 28 directly into the waste oil line 22, which is always open. From this it may only result that the reversal is slightly delayed, and that a reversing valve will need more time for arriving at its final position, but in no case it will happen that the compressed oil will actuate any valve in an undesired manner.

Finally, the oil to be discharged from the lower compartment of the cylinder, piston which has to flow, for instance out of the lower piston compartment of the reversing valve 1, through the line 20, being under pressure through the reversing valve may instead alternatively enter the opposite line 39, thence flow through the valve 27a which is open at that moment. From here, the oil flows through one branch of the line 31 until it reaches just before the valve 25a, which is still closed, and then through the other branch of the line 31 into the lower cylinder compartment of the reversing valve 2, and so forth through the line 40, valve 36a, line 41 into the lower cylinder space of the reversing valve 3, etc. Consequently, all these cylinder compartments are favourably charged during the reversing period by the oil which has been removed from the cylinders operated beforehand and which is under a certain pressure, by means of the movement of the reversing valve pistons. The reversing valves are thus maintained in their actual position.

Now, the further run of the automatic control is as follows:

After the pin 16 of the reversing valve 1 has opened the control valves 25, 25a, the compressed oil flows through the line 30 into the upper cylinder compartment of the reversing valve 2 and 75

simultaneously through the line 33 reaching the valve 34 which is still closed. When the reversing valve 2 reaches its lowest final position, the valves 34 and 34a are opened and the compressed oil is led through the line 42 into the cylinder of the reversing valve 3. The oil to be withdrawn flows from the line 41 through the valve 34a, the line 43, the open valve 44 into the discharging line. The oil under pressure that is introduced through the line 42 into the cylinder of the reversing valve 3, flows through the line 45 leading into the valve 46. At this point, a special reversing valve 4 for steaming is now interconnected in order to be able to carry out the purging process mentioned before. The purging process is continued for a definite period and then is stopped again by opening and closing one and the same reversing valve 4. It is, of course, understood that no further actuation of any reversing valve can take place until this purging process is completed. The requirement of performing a definite operating process for a certain period within the whole apparatus, with a simultaneous safeguard against any further connection of the remaining elements, before the elapse of the intermediate working period, is fulfilled, when the apparatus is once adjusted and when only one outlet line is adopted, by making use of the following contrivances with careful consideration of the precautions given below:

After the reversing valve 3 has reached in the present case its upper final position, the control valves 46, 46a are opened, the compressed oil flowing through the valve 46 to the line 47, thence through the cock 48 to the line 49. The down-going branch of the line 47 leads the compressed oil to a valve 50 which at this moment is open, thence through the line 51 up to a valve 52 which is closed just now. The valve 52 is coupled commonly to a series of other valves 53, 54, and 55 and is maintained in closing position by means of rods and springs 56. If the spring 56 is able to exert its pulling stress, the valve 52 is closed to line 60, 55 closed to line 73, and 53 kept in closed position, whereas the valve 54 is open to drain line 58, and line 49 is open to the lower cylinder compartment for valve 4 through the other line leading thereto from the lower part of valve 53.

The compressed oil arriving through the line 49 enters the lower cylinder compartment of the reversing valve 4 through the lower line of valve 53 and the oil present above the piston is forced through the line 57, the open valve 54, the line 58 and the opened waste-oil valve 59 into the discharging lines 22 and 23. Immediately after the piston rod of the reversing valve 4 has been lifted by several millimeters, the valve 50 is closed, so that practically in case of an eventual leakage of the valve 52, no compressed oil may enter through the line 60 into the upper cylinder compartment of the reversing valve 5. With respect to valve 4, it will be noted that two lines lead from valve 53. The upper line connects with line 58 for outlet, whereas the lower line connects with the base of the piston cylinder for valve 4, to feed the upper leading to line 58 during outflow, and to receive fluid from line 49 during inflow. Line 49 is controlled by valve 48 and not by valve 53.

The supply of compressed oil to the reversing valve cylinder 5 is, therefore, interrupted by two separate valves. In practical operation, it is also possible to construct the valves along the lines of Fig. 5 but so as to have the opening of the

valve 46a when opened by the operation of the rods of the reversing valve 3 follow the opening of valve 46 so that first of all compressed oil may be introduced into the reversing valve cylinder 4 before the outlet valve 46a, acting for the reversing valve cylinder 5, is opened. A little advance of the valve 46 will be sufficient to lift the reversing valve 4 for a few millimeters and to close the valve 50 before opening the valve 46a. Whilst the before described reversing valves 1 to 3 are safeguarded against any further movement by the closed inlet valve 25 and the outlet valve 25a, an inlet valve, for instance the valve 52, and the outlet valve 46a are closed, when starting with the operation of the reversing valve 4. During the following course of the upward movement of the reversing valve 4, the closed valve 50 instead of the outlet valve 46a, which meanwhile is open, undertakes to perform the double interlock against a too early opening of the reversing valve 5.

As soon as the compressed oil enters the lower cylinder compartment of the reversing valve 4, the latter is lifted into the open position. As may be seen from the drawing, the reversing valve 4 now remains in lifted position. No further movement of the reversing valve 4 or of any other reversing valve will take place until the purging period is completed. During this period, the generator is purged out by means of steam. The duration of the purging period is determined by a differential piston 61, which is fitted with a suitable throttling device. The smaller cylinder face of the differential piston 61 is now charged with compressed oil from line 62 being kept under a constant pressure. The compressed oil from this line 62 flows in a full stream through a non-return valve 63 and a small filter 64 and from there it reaches the differential cylinder compartment 65. The compressed oil in the lower cylinder compartment 65 tends to keep the piston 61 always in its upper final position. In the upper position of the steam valve 4, i. e. at the beginning of the purging period, the valve 66 is opened. Now compressed oil flows from the line 47 through the line 67 and further through the line 68 to the cylinder compartment above the differential piston 61. The piston 61, the larger face of which being now charged with compressed oil, goes downwards and forces the compressed oil from the cylinder compartment 65 through the filter 64 and through a throttle in the regulating valve 63 into the pressure line 62, i. e. back into the accumulator 12. The speed of the downward movement of the differential piston 61 determines the duration of the purging period. It is adjusted by means of the throttle in the regulating valve 63.

The regulating valve 63 is illustrated in an enlarged scale in Figure 6. The general assembly of the valve 63 is similar to that of the valve illustrated in Figure 5 of the drawings. In the shafts 69 of the conical valve member 69' is arranged an adjustable pin 69'', which engages a hole provided therefor in the member 69'. Furthermore, openings 69''' are arranged in the shaft 69, said openings connecting the upper valve chamber with the hole of the member 69'. By varying the position of the pin 69'', the free section of the hole in the member 69' may be adjusted in such a manner that the medium may flow with a determined speed from the upper valve chamber through said hole into the outlet chamber 71'. Consequently, the downward movement of the differential piston 61 is varied

and by adjusting the pin 69'', the time may be adjusted which is needed for moving the piston 61 from its upper to its lower final position, the latter being illustrated in Figure 2 in dotted lines. Also the regulating valve 63 still has in addition to its conical sealing member a piston sealing face 70 which, being fitted with small recesses 71, allows the compressed oil entering from above to pass through the hole in the member 69'. The recess 71 is of course of the size of the largest possible free diameter of the throttle determined by the adjusting pin 69''. A filter 64 serves for the removal of small impurities from the compressed oil, in order to prevent the throttle and the regulating valve 63 from being blocked-up. The cleaning of the throttle opening may, however, be effected during the course of operation easily by varying the position of the pin 69''. The filter 64 consists of two units which may be reversed if one of the two filters has to be cleaned-out.

During the downwards movement of the differential piston 61, the cock 48 is reversed by means of the control pin and the fork lever 72 in such a manner that the compressed oil may penetrate from the line 47 into the line 73, instead of entering the line 49, and is able to flow as far as in front of the valve 55 which is still closed at this moment. If the differential piston 61 has completed its downwards movement and the purging period is finished, the piston rod 74 operates the spring tensioned lever 56 and thus opens the valves 55, 53 and 52 and closes the valve 54. Since the valve 50 at this moment is still closed, the compressed oil from the line 47 cannot yet flow through the line 51 and 60 into the reversing valve cylinder 5. The compressed oil from the line 73 which has been supplied with compressed oil by the reversal of the cock 48, first of all flows through the now opened valve 55 into the upper piston compartment of the reversing valve 4. The reversing valve 4 goes back into its closing position and the oil underneath the piston of the reversing valve 4 is forced through the opened valve 53, through the line 58 and through the opened outlet valve 59 into the discharging lines 22 and 23. By the downwards movement of the reversing valve piston 4, the valve 66 is again closed so that the oil pressure can be eliminated from the line 68 and from the cylinder compartment above the differential piston 61. A continued flow of the oil which is still contained in the cylinder compartment above the piston 61, which oil remains under pressure due to the constant oil pressure on the lower differential piston face can, however, not yet be led off through the line 68, since the respective outlet valve 75 (Figure 4) is closed at this time. The valve 75 is only opened during the subsequent reversing period if the operation of the reversing valves takes place in an opposite sequence, and during this period, the differential cylinder compartment 65 is filled up again and the piston lifted into its upper final position. On withdrawing the differential piston 61, the cock 48 may also be brought back again into the position shown on the drawing by means of the levers 72.

If the valve 75 (Figure 4) would, however, not fit tightly, the compressed oil which is introduced through the valve 66 would not only pass to the piston 61, but a larger quantity of such oil would escape through the outlet valve 75. Consequently, the lowering period for the piston 61 would be increased and the steaming period would be prolonged. If this delay should not be

noticed and the piston 61 should finally complete its path, closing the steam valve 4 and also the control valve 66, then in case of need the compressed oil above the piston 61 might be discharged already during this operating period through the line 68 and the valve 75, thus effecting an early withdrawal of the piston 61 and a too early reversal of the cock. Such a difficulty would, however, do no harm to the operation and to the sequence of the complete control. At the worst, the steam valve 4 would become opened again if the cock 48 would be turned back into the position shown on the drawing early enough so that the compressed oil could flow through the line 49 again into the lower cylinder compartment of the reversing valve 4. The purging process would, therefore, be repeated in the described sequence. However, no compressed oil can enter the reversing valve cylinder 5 through the line 60 until the steam reversing valve piston has reached again its lower position, i. e. until the valve 50 as well as the valve 52 are opened at the same time. The position of the valve 52 is, however, only dependent on the position of the differential piston and its piston rod 74. Only in the lower position of the differential piston, when the piston rod 74 presses the spring-tensioned lever 56 downwards, and the compressed oil valve 52 be opened.

In this way, the compressed oil can only continue its flow through the line 60 to the reversing valve cylinder 5 and actuate the latter if the valve 75 is tight and no compressed oil can escape from the cylinder compartment over the differential piston 61.

In order to avoid at any rate a sticking of the control valves whereby, in spite of the auxiliary sealing piston (see Figure 5) a leakage might be caused so that compressed oil may pass the valve, the valve shafts are also pulled downwards during the closing movement by means of suitable springs 208.

Now, assuming that the purging period through the steam reversing valve 4 has completed and that both valves 50 and 52 are opened the former (50) by the pin arranged on the operating rod of the steam valve 4 and engaging a suitable actuating lever (as shown), in the lower final position of the valve 50, and the valve 52 held open by means of piston rod 74 and the operation of valve 75 until the subsequent reversal of valve 75 as described aforesaid, that likewise the outlet valve 46a which has already been opened by the reversing valve 3, is open, and the operation of the plant may then be carried on. Similarly to the reversing valves 1 to 3, the reversing valves 5 to 7 are also now reversed one after the other. The compressed oil on entering through the line 60 into the upper cylinder compartment of the reversing valve 5, presses downwards the piston for valve 5. The oil to be driven from the lower cylinder compartment flows through the line 76, through the valve 46a and finally through the open valve 77 into the discharge line 22 and 23. In its lowest position, the pin 16 on the operating rod of the reversing valve 5 opens the control valves 78 and 79, and the compressed oil which has already passed the line 80 up to the control valve 78 flows through the line 81 further on into the upper cylinder compartment of the reversing valve 6. The oil to be led-off from beneath the piston for valve 6 flows through the line 82 and through the valve 79 as well as 83 into the outlet line. Also in the final position of the reversing valve 6, the valves 84 and 85 are

opened so that the compressed oil may come through the line 86 into the corresponding lower cylinder compartment of the reversing valve 7 and the oil to be extracted from the upper cylinder compartment of the reversing valve 7 may escape through the line 87, through the valve 85 and the open outlet valve 88 into the outlet line 22.

Also a steam reversing valve 8 is inserted in connection with the reversing valve 7. As shown, however, this steam reversing valve while provided with the system of connections described hitherto, in which the arrangement is for the elements to be operated in the direction from the left to the right of the drawings, is not actuated during this operating period. Therefore, in the final position, the reversing valve 7, also only opens the valves 89 and 90 belonging to the reversing valve 9 in order to lead the compressed oil through the upper line 91 to the cylinder of the reversing valve 9 and to discharge the oil to be driven-off through the line 92, the valves 90 and 93 into the line 22.

Finally, the reversing valve 9 opens, in its final position, the pair of valves 94, 95. The compressed oil may flow from the line 96 through the line 97 into the cylinder compartment of the last reversing valve 10. The oil to be discharged flows through the line 98 and through the valve 95 and 99 into the line 22.

Now the operation proper of the control device is finished. Since the installation is not to be influenced by any independently driven control apparatus or the like, but as the installation itself has to influence the controller, after the final step of the operating cycle has completed, another operating cycle has now to be started in such a manner that, without any help by hand or the like, a reversal of the reversing valves into the position illustrated on this drawing, may take place, and this by a fully automatic operation.

In the present case, such a new cycle is introduced for instance in such a manner that the reversing valve 10 in its lowest position opens a pair of valves 100, 101. The valve 100 has already been charged with compressed oil through the line 97. The compressed oil after opening of the valve 100 flows through the line 102 and further through a filter 103 and throttle valve 104 into the cylinder compartment 105. The non-return valve 104 is of similar design as the valve illustrated in Figure 6. The valve 104 is so adjusted that the compressed oil only passes the opening drop by drop.

By adjusting the free section of the throttle opening, the time of the operating period of the plant is fixed, i. e. that period of a hot blast stove during which air is heated-up.

The piston 105a in the cylinder 105 (Fig. 4) passes downwards only slowly, and since it is connected with an equally large piston 107 situated opposite through the piston rod 106, which piston dips into the cylinder compartment 108, the piston 105a presses the compressed oil from this cylinder 108 through the valve 109, the filter 110 and the line 111, through the opened valves 101, 95 and 99 into the line 22.

From the branch of the line 111 another line 112 leads to the control valve 113 for the reversing valve on the other end of the reversing valve arrangement. Since the reversing valve 1 has been adjusted downwards according to the connecting or operating method just before described, the valve 113 necessary for the line 112

is closed, thus preventing an outflow of the compressed oil. Moreover, no compressed oil from the down-going extension of the line 102 can enter through the valve 114 at the reversing valve 1, since also this valve is still closed.

If so much compressed oil from the line 102 has come through the throttle valve 104 into the impulse cylinder 105 (Figure 4) that the end of the piston 105a has reached a fall-weight 115, this weight is taken at the same velocity at which the piston first of all goes downwards, down to its dead point, i. e. over the controlling cam axis 116. All valve cams 117 now remain in the position shown on the drawing. If the free face edge of the piston 105a rests against the face of the weight 115, the free length of the piston rod 106 has already moved to the other side for instance to the cylinder 108. After surpassing the dead point, the heavy weight 115 falls by its own gravity under the same angle to the other side of the axis and thus sets into operation the controlling cams 117 in opposite position.

At this moment, the operating period of the plant has been finished and the closing valves of the plant now have to be reversed again commencing with the reversing valve 10 which previously has been connected as the last one.

According to Figure 4, the valve 14 is now closed. The compressed oil present in the line 15 cannot escape through the immediately adjacent non-return valve 118. The inlet valve 119 it, however, open and the compressed oil coming from the pump 11 flows now through the line 13, valve 119, non-return valve 120 into the line 121, leading directly to the lower cylinder compartment of the reversing valve 10. Simultaneously, when reversing the main valve block of Figure 4, also the valve 122 is closed and the valve 123 is open. Thereby, the compressed oil formerly present in the common line 125 is discharged, which oil has maintained the various valves 21, 32, 44, 77, 59, 83, 88, 93 and 99 in lifted position. The line 124 is set under pressure. The outlet valves 29, 38, 126, 127, 128, 129, 130, 131 and 132 are now open. The line 124 gets the compressed oil through an auxiliary line 133 provided for within the valve block, said auxiliary line 133 being connected with the opening of the pressure valve 119.

The line 125 is discharged by the auxiliary line 134, which is connected with the just opened valve 135 and thus with the main waste-oil line 136. The auxiliary line 134 also serves to make ineffective any leakages of the inlet valve 14 in order to prevent the compressed oil from entering the line 15 during this actuating period. During the first described operating period, the auxiliary channel 133 had to prevent the flow of compressed oil to the line 121 in case the valve 119 had become leaky.

Under certain circumstances, the valves 135 and 137 may be replaced by the valves 123 and 122 since these valves are opened and closed respectively at the same time as the valves 135 and 137 and, moreover, they have the same inlet and outlet connections.

When changing-over the main control block of Figure 4 by means of the weight 115, the valve 75 is also opened and the valve 138 is closed. Hereby, the compressed oil still contained in the upper cylinder compartment of the differential piston 61 and in the line 68 may escape into the outlet line 136. The upper cylinder compartment of the differential piston 139 illustrated in Figure 3 may be charged with compressed oil if

the correct inlet valve 140 has been opened at a given time by the steam reversing valve 8, that means the compressed oil introduced into the line 141 cannot escape through the valve 138.

At the beginning of the new operating cycle, the compressed oil entering through the line 121 into the lower cylinder compartment of the reversing valve 10 moves said valve upwards. The oil to be removed over the piston is passed through the line 97 and the opened valve 132 to the discharge line. When the reversing valve 10 reaches its upper position, illustrated on the drawing, the valves 142 and 143 are opened, the compressed oil flows through the valve 142 and line 144 into the reversing valve cylinder 9 and the removed oil through the line 145, valve 143 and open outlet valve 131 into the decompressed oil line 22. After the reversing valve 9 has again been brought into the position illustrated, there takes place a steam purging of the apparatus and for this purpose, the steam reversing valve 8 which during the previously described cycle (reversal of the valves from the left to the right of the drawings) has not been actuated, is opened. The operation of the steam reversing valve 8 is similar to that of the steam reversing valve 4. The compressed oil flows through the valve 146 which is open at the lifted position of the reversing valve 9 into the line 147 and further-on through the cock 148, the line 149 into the lower cylinder compartment of the reversing valve 8. The oil to be removed goes through the line 150 and the open valve 151, as well as through the line 152 and valve 129 into the decompressed oil line 22. If the piston of the reversing valve 8 has reached its upper position, it opens the valve 140 and the compressed oil from the line 147 flows first through the lines 153 and 141 into the cylinder compartment over the differential piston 139, illustrated in Figure 3. The oil to be discharged from the lower cylinder compartment 154 of the differential piston flows in throttled condition through the line 155, filter 156, valve 157 back again into the pressure line 62. If the piston rod 158 has reached its lowest position and touches the lever 160, the valves 161, 162 and 163 are opened, whereas the valve 151 is closed.

Meanwhile, the differential piston has reversed the cock 148 during the downward movement of the rods and of the fork lever 159 in such a manner that the compressed oil from the line 147 may enter the line 164. From the line 164, the compressed oil flows through the open valve 161 and the line 150 into the upper cylinder compartment of the steam valve 8 and closes it again. The oil contained in the lower cylinder compartment of the reversing valve 8 is discharged through the valve 162, through the line 152 and through the open valve 129.

Now the steam valve has again reached its final position as shown on the drawings. The purging cycle is completed and the valve 165 is opened. Since the valve 163 is still kept open through the piston rod 158 of the differential piston, the compressed oil may flow through the open valve 146 and the lower part of the line 147, through the valves 165 and 163 and furthermore through the line 166 into the upper cylinder compartment of the reversing valve 7 in order to move the latter back into the final position, shown on the drawings. The oil to be discharged from the lower cylinder compartment flows through the line 91 and the valve 167 which was opened by means of the previously actuated reversing valve 9, through

the outlet valve 130 into the decompressed oil line 22.

After closing the reversing valve 7, the compressed oil flows through the line 87 over the valve 168 opened by the reversing valve 7 and through the line 169 into the lower cylinder compartment of the reversing valve 6 and the oil to be removed goes through the line 170, through the opened valve 171 and the valve 128 into the oil line 22.

In a similar manner, the other sealing valves 5, 3, 2, 1 also are actuated one after the other. It should be noted that during the present operating cycle from the right to the left of the drawing, the purging steam reversing valve 4 is not actuated since no-purging has to take place. The direct connection of the compressed oil line 76 from the reversing valve 5 to the upper cylinder compartment of the reversing valve 3 shows this very clearly, also the direct connection of the compressed oil line 45 from the reversing valve 3 to the reversing valve 5, in order to allow the oil to be discharged from the lower cylinder compartment of the reversing valve 3 to flow freely through the opened valve 172 and 126 into the decompressed oil line 22.

If the reversing valve 1 has finished its upwards movement and if the oil to be removed through the piston of this valve is led through the line 26, valve 27, 29 with the intermediate line 28 to said oil line 22, this reversing valve by means of its pin 16 opens the valves 113 and 114, thus giving the new impulse for the start of the time counting device for the following operating period of the plant which has to take place after the last mentioned operating cycle of the reversing valves has been completed.

When opening the valves 113 and 114, the compressed oil from the lower cylinder compartment of the reversing valve 1 is led through the line 20, the valve 113 and the line 112, through the throttle valve 109 into the cylinder 108 being controlled from the side and the oil in the cylinder 105a is transferred through the line 102, valve 114, through the line 173 and valve 27, line 28, outlet valve 29 to the decompressed oil line 22. The piston 107 according to the drawing now moves upwards until it causes the fall weight 115 again to throw-over into the position illustrated on the drawing, thus effecting a reversal of the impulse apparatus of the control.

All reversing valves may be balanced by counterweights so that no undesired movement of the reversing valves can take place if any pressure lines should break-down or become leaky. The manipulation of the reversing valves may be effected by hand in case any special precautions or repairs have to be done. In such a case, the whole system can be released from the pressure whilst still working, by actuating a rod 174 (Figure 4), fitted with hand levers. On actuating the rod 174, the three-way cocks 175, 175', 175'', each in the lines 13, 15 and 121 respectively, for instance on lifting it out of the position shown in Figure 4 may be reversed in such a manner that all three mentioned lines are connected with the decompressed oil line 136. The whole apparatus then stands idle and no further stage of operating cycle can take place, all lines are connected to the discharge lines and the reversing valves may be easily moved by hand.

In order to prevent the oil, when being removed from the operating of the reversing valves, from passing through all cylinders, additional three-way cocks may be inserted into each of the

lines 124 and 125, and after opening of such cocks, all outlet valves 21, 32, 29, 44, 38, 77, 59, 126, etc., are put under pressure, i. e. they are opened. In this connection it may be pointed out that the special operating pistons of the outlet valves 21, 32, 29, 44, 38, etc., dip into the cylinders 176 which are connected to the lines 124 and 125.

I have above described the present invention on the lines of a preferred embodiment thereof, but my invention is not limited in all its aspects to the mode of carrying it out as described and shown, since the invention may be variously embodied within the scope of the following claims.

I claim:

1. An apparatus unit for sequential control of a series thereof comprising: an hydraulic cylinder and piston therein having a connection for operating an operating element; hydraulic fluid pressure conduits for supply to and exhaust from each of the opposite ends of the cylinder; interlocking control means for control of the fluid pressure for the hydraulic cylinder of another of the apparatus units; and means operable by the connection for the piston of the unit, in predetermined position thereof, for actuating the interlocking control means of the unit for controlling the fluid pressure of the other apparatus unit for which the interlocking means is provided; and in which the interlocking control means of the apparatus unit comprises a pair of valves operable to close and open in unison, with one valve of a pair controlling the supply to one end and the other valve controlling the exhaust from the opposite end of the hydraulic cylinder of the other apparatus unit.

2. An apparatus unit for sequential control of a series thereof comprising: an hydraulic cylinder and piston therein having a connection for operating an operating element; hydraulic fluid pressure conduits for supply to and exhaust from each of the opposite ends of the cylinder; interlocking control means for control of the fluid pressure for the hydraulic cylinder of another of the apparatus units; and means operable by the connection for the piston of the unit, in predetermined position thereof for actuating the interlocking control means of the unit for controlling the fluid pressure of the other apparatus unit for which the interlocking means is provided; and in which the apparatus unit is designed and adapted to constitute the unit for one end of the series, and is provided with a reversing mechanism for connection of said unit with the unit that is to constitute the unit for the other end of the series, and in which said reversing mechanism comprises a device operable by movement to reverse a central control for the hydraulic fluid conduits of the series of units, means movable in opposite directions to actuate said device, two impulse cylinders on opposite sides of said means for moving the same, an impulse cylinder hydraulic conduit leading from each impulse cylinder, one to the control valve at one end of the series, and the other to the control valve at the other end of the series, a throttle valve for each impulse cylinder conduit, and means adapted to be controlled by connections at each of the opposite ends of the series of units, for controlling the exhaust of hydraulic fluid from the respective impulse cylinders.

3. An apparatus unit for sequential control of a series thereof comprising: an hydraulic cylinder and piston therein having a connection for operating an operating element; hydraulic fluid

pressure conduits for supply to and exhaust from each of the opposite ends of the cylinder; interlocking control means for control of the fluid pressure for the hydraulic cylinder of another of the apparatus units; and means operable by the connection for the piston of the unit, in predetermined position thereof, for actuating the interlocking control means of the unit for controlling the fluid pressure of the other apparatus unit for which the interlocking means is provided; and in which the interlocking control means of the apparatus unit comprises two pairs of control valves operatively connected with the aforesaid connection, the valves of a pair being operable to close and open in unison, one pair being operable on the stroke of the connection in one direction, and the other pair being operable on the stroke of the connection in the opposite direction, one valve of each pair being operable to supply hydraulic to one end of the cylinder of the other apparatus unit it is to control, and the other valve of the same pair being operable to control the exhaust of hydraulic fluid from the opposite end of the cylinder of the other apparatus unit to which the supply control valve of its pair supplies hydraulic fluid.

4. An apparatus unit for sequential control of a series thereof comprising: an hydraulic cylinder and piston therein having a connection for operating an operating element; hydraulic fluid pressure conduits for supply to and exhaust from each of the opposite ends of the cylinder; interlocking control means for control of the fluid pressure for the hydraulic cylinder of another of the apparatus units; and means operable by the connection for the piston of the unit, in predetermined position thereof, for actuating the interlocking control means of the unit for controlling the fluid pressure of the other apparatus unit for which the interlocking means is provided; and in which the interlocking control means of the apparatus unit comprises a pair of control valves of the cone-valve type having a conical seat and a conical sealing member therefor movable into and out of sealing relation relative to the seat by a short lift of the conical sealing member, the valves of the pair being operable to be opened and closed in unison by the aforesaid connection, one valve being operable to supply hydraulic fluid to one end and the other valve being operable to control the exhaust of hydraulic fluid pressure from the opposite end of the cylinder of the other apparatus unit to be controlled by the pair of valves, with flow of the pressure medium into and out of the valves, while open, around the open conical sealing member and over the seat therefor in the direction of closing movement of the sealing member.

5. An apparatus unit for sequential control of a series thereof comprising: an hydraulic cylinder and piston therein having a connection for operating an operating element; hydraulic fluid pressure conduits for supply to and exhaust from each of the opposite ends of the cylinder; interlocking control means for control of the fluid pressure for the hydraulic cylinder of another of the apparatus units; and means operable by the connection for the piston of the unit, in predetermined position thereof, for actuating the interlocking control means of the unit for controlling the fluid pressure of the other apparatus unit for which the interlocking means is provided; and in which the interlocking control means of the apparatus unit comprises a pair of control valves of the cone-valve type having a conical

seat and a conical sealing member therefor, movable into and out of sealing relation relative to the seat by a short lift of the conical sealing member, the valves of the pair being operable to be opened and closed in unison by the aforesaid connection, one valve being operable to supply hydraulic fluid to one end and the other valve being operable to control the exhaust of hydraulic fluid pressure from the opposite end of the cylinder of the other apparatus unit to be controlled by the pair of valves, each valve of the pair having its inlet over the top conical sealing member and its outlet beyond the seat therefor, for exertion of the pressure of the hydraulic fluid on the conical sealing member in its direction of closing of the valve, and a spring between the casing of the valve and the conical sealing member, normally tending to press the latter into sealing relation with its seat.

6. An apparatus unit for sequential control of a series thereof comprising: an hydraulic cylinder and piston therein having a connection for operating an operating element; hydraulic fluid pressure conduits for supply to and exhaust from each of the opposite ends of the cylinder; interlocking control means for control of the fluid pressure for the hydraulic cylinder of another of the apparatus units; and means operable by the connection for the piston of the unit, in predetermined position thereof, for actuating the interlocking control means of the unit for controlling the fluid pressure of the other apparatus unit for which the interlocking means is provided; and in which the interlocking control means of the apparatus unit comprises a pair of control valves of the cone-valve type having a conical seat and a conical sealing member therefor movable into and out of sealing relation relative to the seat by a short lift of the conical sealing member, the valves of the pair being operable to be opened and closed in unison by the aforesaid connection, one valve being operable to supply hydraulic fluid to one end and the other valve being operable to control the exhaust of hydraulic fluid pressure from the opposite end of the cylinder of the other apparatus unit to be controlled by the pair of valves, each valve of the pair having an inlet chamber surrounding the top of the conical sealing member and an outlet chamber beyond the seat for the sealing member, for exertion of the pressure of the hydraulic fluid on the conical sealing member in the direction of its closing, and each conical sealing member being provided with a channeled extension having ports for inlet and outlet thereto, said extension and ports being located between the aforesaid chambers with the ports, in closed position of the valve, out of register with the chambers and also sealed from one of the chambers by the seating of the conical sealing member on its conical seat.

7. Apparatus for sequential control of a series of three units to be actuated one after the other, and the second to perform two movements before the third is actuated, comprising: a series of three units each comprising an hydraulic cylinder and piston therein having a connection for operating an operating element, and hydraulic fluid pressure conduits for supply to and exhaust from each of the opposite ends of the cylinder; interlocking control means operable by the first unit for control of the fluid pressure to the cylinders of the second and third units; pressure-medium conduit-means leading from the interlocking control means to the supply conduits for the cylinders of the second and third units; valve means in the

portion of the conduit-means that leads to the third unit; branch conduits in the portion of the conduit-means for the second unit and leading to the opposite ends of the cylinder thereof, a reversing cock in the branch conduits, time relay means, operable by the second unit upon one movement thereof, and adapted, when so oper-

ated, to reverse the reversing cock to institute the second movement after the expiration of the time of relay, and at the same time actuate the valve means in the portion of the conduit-means that leads to the third unit.

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