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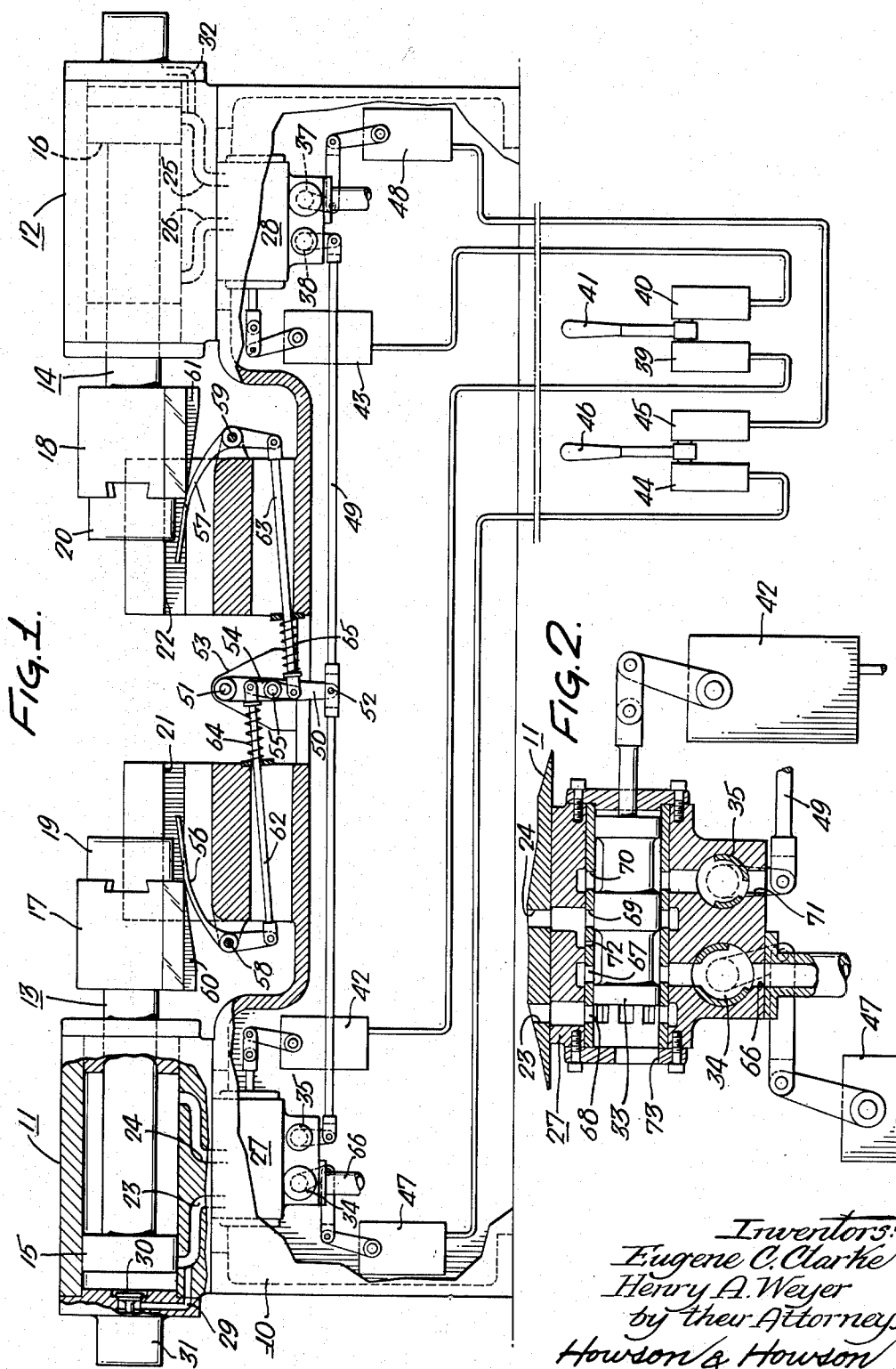
E. C. CLARKE ET AL

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FLUID-PRESSURE-ACTUATED APPARATUS

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3 Sheets-Sheet 1



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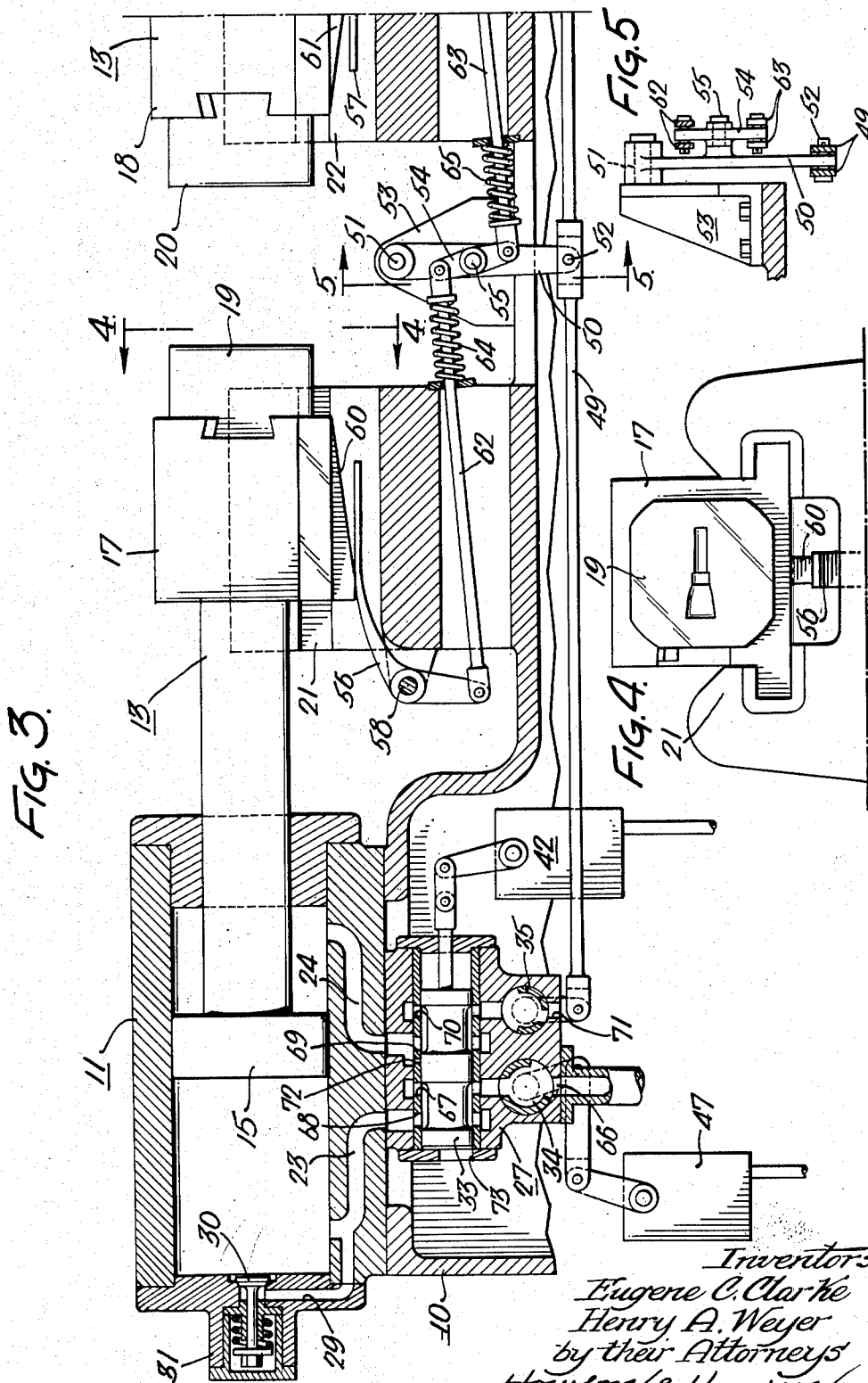
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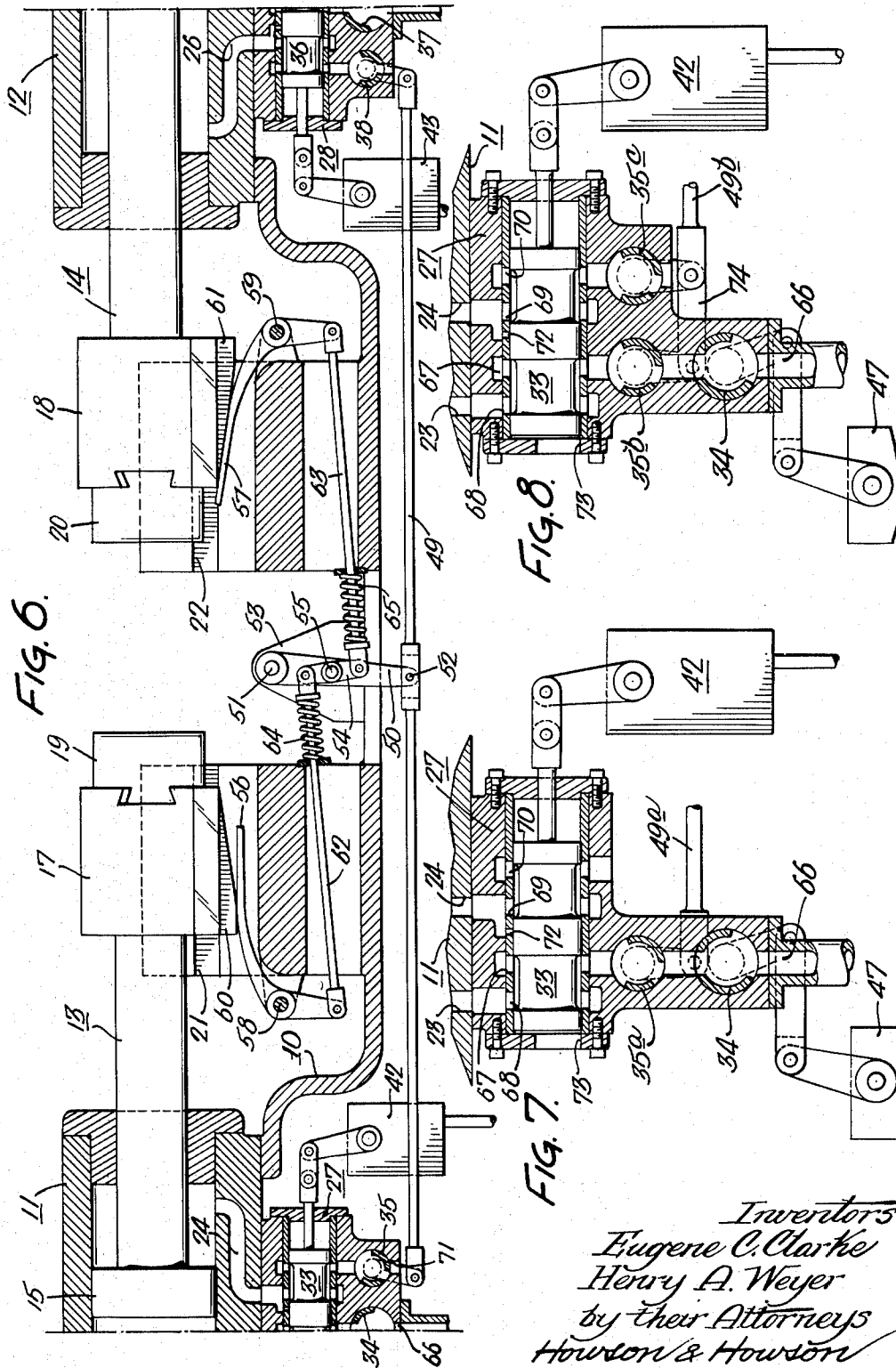
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FLUID-PRESSURE-ACTUATED APPARATUS

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13 Claims. (Cl. 60—97)

This invention relates to fluid pressure-actuated devices, and more particularly to devices employing two movable members which are moved toward and away from one another in work and return strokes. An example of such a device is a forging apparatus in which two forging rams or impacters are arranged horizontally in opposed relation to each other and are moved toward each other to engage an interposed work piece to forge the same.

In such an apparatus, it is important that the impacters move through their work stroke in precise synchronism in order that they will simultaneously impact the work piece. The impacters should move through their work stroke in synchronism both as to position and as to speed, but it is inevitable that they will at times get out of step with one another and, therefore, it is desirable to provide some means for bringing about a correcting action to restore the desired synchronous condition.

One object of the present invention is to provide an apparatus of the character above-mentioned including an arrangement for effecting the desired correcting action.

Another object of the invention is to provide in such an apparatus a mechanical correcting arrangement by which the correcting action is effected by mechanical operation of correcting valves that vary the fluid flow in a manner to bring about the desired correction.

A further object of the invention is to provide a remote-controlled manually-operated apparatus embodying a mechanical correcting arrangement as above-mentioned.

Other objects and features of the invention will be apparent from the following detailed description with reference to the accompanying drawings, in which

Fig. 1 is a view, partly in elevation and partly in section, of an apparatus embodying the present invention, such apparatus being adapted for remote manual control;

Fig. 2 is a fragmentary sectional view showing the condition of the valves in Fig. 1;

Fig. 3 is a fragmentary sectional view, similar to Fig. 1, showing the parts at a different time in the operating cycle;

Fig. 4 is a view taken on line 4—4 of Fig. 3;

Fig. 5 is a sectional view taken on line 5—5 of Fig. 3;

Fig. 6 is a sectional view, similar to Fig. 1, illustrating a condition in which the correcting arrangement becomes effective;

Fig. 7 is a fragmentary sectional illustration of a modified form of the apparatus; and

Fig. 8 is a fragmentary sectional illustration of another modified form of the apparatus.

Referring first to Fig. 1, the apparatus comprises a supporting frame 10 on which there are provided a pair or horizontally aligned and spaced fluid cylinders 11 and 12. A pair of movable members 13 and 14 extend respectively from the inner ends of the cylinders 11 and 12 and have pistons 15 and 16 within the cylinders for operation of said members toward and away from each other by pressurized fluid, e. g. compressed air, supplied to the cylinders. The illustrated apparatus is a forging appara-

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tus and, therefore, the members 13 and 14 are in the form of impacters having die-carrying heads 17 and 18 on which the forging dies 19 and 20 are carried. Guides 21 and 22 serve to accommodate the moving heads of the impacters.

Cylinder 11 is provided with fluid ports 23 and 24, and cylinder 12 is similarly provided with ports 25 and 26. The flow of pressurized fluid to and from the cylinders via the ports is controlled through the valve chests 27 and 28 as hereinafter described. At its outer end cylinder 11 has a by-pass port 29 which communicates with port 23 and with the end of the cylinder chamber, and a spring-biased valve 30 is provided within a casing 31 in association with the by-pass port 29, the valve being biased to closed position. Similarly, cylinder 12 has a by-pass port 32 and an associated spring-biased valve (not visible). The purpose of this is to provide for cushioning of the impacters at the end of their return stroke and to enable initiation of the work or power stroke as hereinafter described.

The valve chests 27 and 28 are identical with one another and have corresponding components. Valve chest 27, as shown in Fig. 2, comprises a control valve 33, a throttle valve 34 and a correcting valve 35. Valve chest 28, partially shown in Fig. 6, similarly comprises a control valve 36, a throttle valve 37 and a correcting valve 38. The control valves 33 and 36 are slide valves, while the throttle valves and the correcting valves are rotary valves. The control valves serve to control the operation of the impacters 13 and 14 in response to operation of these valves. The throttle valves serve to adjust the fluid flow to the cylinders according to the setting of these valves, thereby determining the speed of operation of the impacters. The correcting valves serve to correct a non-synchronous condition of the impacters as hereinafter described.

In the illustrated apparatus, provision is made for remote manual control of the operation, as shown in Fig. 1. At the remote control point there are two transmitters 39 and 40 which are jointly controlled by a manual lever 41, and these transmitters are connected respectively to receivers 42 and 43 to which the control valves 33 and 36 are respectively connected. Also at the remote control position there are two transmitters 44 and 45, jointly controlled by throttle lever 46, which transmitters are connected respectively to receivers 47 and 48 to which the throttle valves 34 and 37 are respectively connected. The present invention is not concerned with the details of the remote control system employed. Such system is shown diagrammatically as a hydraulic system, but it may be an electrical system employing Selsyn transmitters and receivers as will be well understood. It suffices to note that the throttle valves 34 and 37 are set by placing the throttle lever 46 in a desired position, and operation of the impacters through their work and return strokes is effected by moving the control lever 41. It will be understood that the throttle lever 46, once it is adjusted, is not moved unless it is desired to change the setting of the throttle valves so as to change the speed of the impacters.

The correcting valves 35 and 38 are actuated only in the event that a non-synchronous condition of the impacters develops. These valves are actuated differentially by the arrangement now to be described. A mechanical link 49 interconnects the two correcting valves 35 and 38, and at the center plane of the apparatus there is provided a swing arm 50 having its upper end fixedly pivoted in said central plane at 51 and having its lower end pivotally connected to a central yoke of link 49 at 52. The supporting pivot 51 for the swing arm 50 is fixed in said plane on a stationary bracket 53 of the stationary frame. A rocker arm 54 is pivotally connected

at 55 to the swing arm 50 intermediate the ends of the latter. A pair of detecting elements 56 and 57 are mounted on stationary pivots 58 and 59 provided on the stationary frame, and these elements are engageable by cam projections 60 and 61 on the heads of the impacters. The movable detecting elements are connected to the ends of rocker arm 54 by links 62 and 63. Biasing springs 64 and 65 are arranged as shown in association with the links 62 and 63 to urge the detecting elements 56 and 57 into engagement with the heads of the impacters. Thus, it will be seen that element 56 is urged counter-clockwise with respect to its pivot 58, while element 57 is urged clockwise with respect to its pivot 59.

As the impacters move through their work or power stroke the detecting elements 56 and 57 are moved against the action of the biasing springs, and if the movements of the detecting elements are precisely synchronous, the rocker arm 54 is simply moved about its pivot 55 and there is no movement of the swing arm 50. However, if the movements of the detector elements 56 and 57 are not synchronous, there is an unbalance of the forces acting on the rocker arm 54 and, consequently, there is a resultant force on the swing arm 50 through pivot 55 that moves the swing arm 50 in one direction or the other according to the direction of unbalance. The movement of swing arm 50 effects differential operation of the correcting valves 35 and 38 to correct the non-synchronous condition which caused the unbalance. The operation of the correcting arrangement may be better understood from the following description of the operation of the apparatus as a whole.

In operation of the apparatus the control valve 33 moves between the positions shown in Figs. 2 and 3 and, of course, the control valve 36 moves similarly. In Fig. 1 the apparatus is at the end of an operating cycle, with the impacters at the end of their return stroke, and the apparatus is ready to commence the next operating cycle. In the condition of Fig. 1 some of the fluid has been trapped at the ends of the cylinders during return of the impacters, the pistons 15 and 16 having closed the ends of ports 23 and 25. As mentioned above, the purpose of this is to cushion the impacters during return and to prevent them from striking the ends of the cylinders.

To commence the next operating cycle, the control lever 41 is thrown to its power stroke position so as to move the control valves to the position shown in Fig. 3. The operation of impacter 13 and control valve 33 is typical and will be described with reference to Figs. 1 to 3. At this time pressurized fluid is admitted to the pressure end of the cylinder 11 from a suitable source (not shown) through the fluid inlet 66 and through the control valve ports 67 and 68. The cylinder end of port 23 is initially closed by the piston 15, but the pressurized fluid flows from this port through the by-pass port 29 and forces the valve 30 to open so that sufficient fluid is applied to the piston to initiate movement of the impacter. As the end of port 23 is uncovered the main flow of fluid enters the cylinder from this port and drives the impacter at high speed through its power stroke. As may be seen in Fig. 3, during the power stroke of the impacter the fluid previously admitted to the cylinder during the last return stroke is exhausted through port 24, control valve ports 69 and 70, and the exhaust port 71. It will be noted that in the form of the apparatus shown in Figs. 1 to 6, the correcting valves 35 and 38 are in the exhaust passages and they govern the rate of exhaust flow.

The impacting power stroke of the impacters having been completed, the control lever 41 is thrown to the position for return of the impacters, effecting movement of the control valves 33 and 36 to the position of Figs. 1 and 2. The exhaust ports are now closed, and pressurized fluid is admitted through the intake ports to the return ends of the cylinders, thus moving the impacters

through their return stroke. Thus, in the case of impacter 13, as may be seen in Figs. 1 and 2, pressurized fluid flows through inlet 66 and valve ports 67 and 72 to port 24. The return movement of the impacter is relatively slow due to the restricted size of the port 72. During the return stroke of the impacter the fluid which was previously admitted to the cylinder during the last power stroke is exhausted through port 23, control valve port 68, and exhaust opening 73 until the piston 15 closes the port 23, near the end of travel of the impacter. The fluid trapped at the end of the cylinder cushions the impacter and brings it to a stop in the position shown in Fig. 1. The apparatus is now ready to commence the next operating cycle.

Consider again the power stroke of the impacters during which fluid previously admitted to the return end of the cylinders is being exhausted through valves 35, 38. As the impacters move through the power stroke they actuate the sensing elements 56 and 57 as previously described. If the impacters are precisely in step or in synchronism with one another, the movements of the sensing elements 56 and 57 will likewise be in synchronism with one another, and the swing arm 50 will remain in the vertical position shown in Figs. 1 and 3. The operation depicted in Figs. 1 and 3 assumes such synchronous condition, and the correcting valves 35 and 38 are not actuated.

Assume now that a non-synchronous condition arises such as represented in Fig. 6. In this figure the impacters are moving in their power stroke and impacter 13 is ahead of impacter 14 so that element 56 is deflected to a greater extent than element 57. This unbalanced condition causes a force to be applied to the swing arm 50 through pivot 55, causing the swing arm to move about its pivot 51 toward the more advanced impacter. Consequently, the mechanical connection 49 is shifted in the same direction, causing closing movement of valve 35 and opening movement of valve 38. This effects slowing down of the more advanced impacter and speeding up of the less advanced impacter, thus bringing them into synchronism.

Fig. 7 shows a modification of the apparatus in which the correcting valves are disposed in the intake port rather than in the exhaust port, one of the correcting valves being shown at 35a. This modified form of the apparatus operates in exactly the same manner as does the form shown in Figs. 1 to 6, the only difference being that the correcting valves effect the correction by controlling the relative rates of intake fluid flow instead of by controlling the relative rates of exhaust flow. Thus, in the condition depicted in Fig. 6, movement of the mechanical connection 49a (Fig. 7) toward the left would effect closing movement of valve 35a and opening movement of the correcting valve associated with the other cylinder.

Fig. 8 shows a further modification in which two correcting valves are associated with each cylinder, one valve being in the intake port and the other being in the exhaust port. In the illustration correcting valves 35b and 35c are shown in association with the left-hand cylinder. These valves are interconnected by the link 74 so as to be moved simultaneously by the mechanical connection 49b. The operation is the same as in the case of the apparatus shown in Figs. 1 to 6, the only difference being that the correcting action is effected by controlling both intake and exhaust. Thus, in the particular condition represented in Fig. 6, the movement of connection 49b (Fig. 8) toward the left would effect closing movement of valves 35b and 35c and would effect opening movement of the corresponding correcting valves associated with the other cylinder.

While several forms of the invention have been illustrated for the purpose of disclosure, the invention is not limited thereto, but contemplates such other forms or

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modifications as may occur to persons skilled in the art.
We claim:

1. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, means for effecting flow of operating fluid to and from said cylinders to actuate said members, a pair of valves arranged respectively in association with each of said cylinders to vary the flow of operating fluid, means for detecting lack of synchronism of the movements of said members, and means interconnecting said detecting means and said valves normally ineffective to operate said valves but operable by said detecting means upon detection of non-synchronous movements of said members for effecting differential operation of said valves to synchronize the movements of said members.

2. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, a slide valve at each cylinder for effecting flow of operating fluid to and from said cylinders to actuate said members, means for actuating the slide valves in unison, a pair of interconnected rotary valves arranged respectively in association with each of said cylinders to vary differentially the flow of operating fluid, a pair of sensing elements engageable respectively by said members for actuation thereby according to the individual movements of the members, and means operable only by non-synchronous movements of said elements resulting from non-synchronous movements of said members and connected to the interconnected valves for effecting differential operation of said valves to synchronize the movements of said members.

3. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, means for effecting flow of operating fluid to and from said cylinders to actuate said members, a pair of interconnected valves arranged respectively in association with each of said cylinders to vary differentially the flow of fluid, a swing arm having a fixed supporting pivot and connected to the interconnected valves through a movable pivot, a pair of pivotally mounted sensing elements engageable respectively by said members for actuation thereby according to the individual movements of the members, a rocker arm pivotally mounted on said swing arm intermediate said pivots, and a pair of links connecting said elements with the respective ends of said rocker arm, whereby non-synchronous movements of said elements resulting from non-synchronous movements of said members cause movement of said swing arm and consequent differential operation of said valves to synchronize the movements of said members.

4. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, control valve means at each cylinder for controlling flow of operating fluid to and from said cylinders to actuate said members, a receiver operatively connected to the control valve means at each cylinder, a pair of jointly controllable transmitters connected respectively to the receivers for effecting actuation of the control valve means through the receivers, a pair of valves arranged respec-

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tively in association with each of said cylinders to vary the flow of operating fluid, means for detecting lack of synchronism of the movements of said members, and means interconnecting said detecting means and said valves normally ineffective to operate said valves but operable by said detecting means upon detection of non-synchronous movements of said members for effecting differential operation of said valves to synchronize the movements of said members.

5. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, a valve chest at each cylinder, a slide valve in each valve chest for controlling flow of operating fluid to and from said cylinders to actuate said members, manually-operable means for actuating the slide valves in unison, a pair of interconnected rotary valves arranged respectively in the valve chests for said cylinders to vary differentially the flow of operating fluid, a pair of sensing elements engageable respectively by said members for actuation thereby according to the individual movements of the members, and means operable only by non-synchronous movements of said elements resulting from non-synchronous movements of said members and connected to the interconnected valves for effecting differential operation of said valves to synchronize the movements of said members.

6. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, control valve means at each cylinder for controlling flow of operating fluid to and from said cylinders to actuate said members, manually-operable means for actuating said valve means, a pair of interconnected valves arranged respectively in association with each of said cylinders to vary differentially the flow of fluid, a swing arm having a fixed supporting pivot and connected to the interconnected valves through a movable pivot, a pair of pivotally mounted sensing elements engageable respectively by said members for actuation thereby according to the individual movements of the members, a rocker arm pivotally mounted on said swing arm intermediate said pivots, and a pair of links connecting said elements with the respective ends of said rocker arm, whereby non-synchronous movements of said elements resulting from non-synchronous movements of said members cause movement of said swing arm and consequent differential operation of said valves to synchronize the movements of said members.

7. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders having ports extending to their end portions for admission and exhaust of pressurized fluid, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members through work and return strokes, means for effecting flow of operating fluid to and from said cylinders to actuate said members, said means including intake and exhaust conduits, a pair of valves arranged respectively in the exhaust conduits for the cylinders to vary the rate of exhaust fluid flow from the cylinders during the work stroke of said members, means for detecting lack of synchronism of the work stroke movements of said members, and means interconnecting said detecting means and said valves normally ineffective to operate said valves but operable by said detecting means upon detection of non-synchronous movements of said members for effecting differential operation of said valves to synchronize the work stroke movements of said members.

8. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders having ports extending

to their end portions for admission and exhaust of pressurized fluid, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members through work and return strokes, means for effecting flow of operating fluid to and from said cylinders to actuate said members, said means including intake and exhaust conduits, a pair of valves arranged respectively in the intake conduits for the cylinders to vary the rate of intake fluid flow to the cylinders during the work stroke of said members, means for detecting lack of synchronism of the work stroke movements of said members, and means interconnecting said detecting means and said valves normally ineffective to operate said valves but operable by said detecting means upon detection of non-synchronous movements of said members for effecting differential operation of said valves to synchronize the work stroke movements of said members.

9. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders having ports extending to their end portions for admission and exhaust of pressurized fluid, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members through work and return strokes, means for effecting flow of operating fluid to and from said cylinders to actuate said members, said means including intake and exhaust conduits, valves arranged in the intake and exhaust conduits for each of said cylinders, movable means interconnecting the valves of one cylinder with those of the other cylinder to vary differentially the fluid flow for the cylinders, a pair of elements engageable respectively by said members for actuation thereby according to the individual work stroke movements of said members, and means operable only by non-synchronous movements of said elements resulting from non-synchronous movements of said members and connected to the said interconnecting means for effecting differential operation of the valves of the respective cylinders to synchronize the work stroke movements of said members.

10. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, means for effecting flow of operating fluid to and from said cylinders to actuate said members, a pair of valves arranged respectively in association with each of said cylinders to vary the flow of fluid, a swing arm having a fixed supporting pivot and connected to said valves to effect differential variation of the fluid flow at each cylinder upon movement of said arm about its fixed pivot, means for detecting lack of synchronism of the movements of said members, and means operable by said detecting means for actuating said arm, whereby to cause differential operation of said valves to synchronize the movements of said members.

11. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, means for effecting flow of operating fluid to and from said cylinders to actuate said members, a pair of valves arranged respectively in association with each of said cylinders to vary the flow of fluid, a swing arm having a fixed supporting

pivot and connected to said valves to effect differential variation of the fluid flow at each cylinder upon movement of said arm about its fixed pivot, a pair of pivotally mounted sensing elements engageable respectively by said members for actuation thereby according to the individual movements of the members, a rocker arm pivotally mounted on said swing arm, and a pair of links connecting said elements with the respective ends of said rocker arm, whereby non-synchronous movements of said elements resulting from non-synchronous movements of said members causes movement of said swing arm and consequent differential operation of said valves to synchronize the movements of said members.

12. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, a slide valve at each cylinder for effecting flow of operating fluid to and from said cylinders to actuate said members, means for actuating the slide valves in unison, a pair of rotary correcting valves arranged respectively in association with each of said cylinders to vary the flow of fluid, a swing arm having a fixed supporting pivot and connected to said correcting valves to effect differential variation of the fluid flow at each cylinder upon movement of said arm about its fixed pivot, means for detecting lack of synchronism of the movements of said members, and means operable by said detecting means for actuating said arm, whereby to cause differential operation of said correcting valves to synchronize the movements of said members.

13. In an apparatus of the class described, a pair of aligned and spaced fluid cylinders, a pair of movable members extending respectively from the inner ends of said cylinders and having pistons within the cylinders for operation of said members toward and away from each other by pressurized fluid supplied to the cylinders, a slide valve at each cylinder for effecting flow of operating fluid to and from said cylinders to actuate said members, means for actuating the slide valves in unison, a pair of rotary correcting valves arranged respectively in association with each of said cylinders to vary the flow of fluid, a swing arm having a fixed supporting pivot and connected to said correcting valves to effect differential variation of the fluid flow at each cylinder upon movement of said arm about its fixed pivot, a pair of pivotally mounted sensing elements engageable respectively by said members for actuation thereby according to the individual movements of the members, a rocker arm pivotally mounted on said swing arm, and a pair of links connecting said elements with the respective ends of said rocker arm, whereby non-synchronous movements of said elements resulting from non-synchronous movements of said members cause movement of said swing arm and consequent differential operation of said correcting valves to synchronize the movements of said members.

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