Nov. 11, 1958 L. ZIMMERMAN 2,859,591

HYDRAULIC SYNCHRONIZER

Filed July 20, 1955 4 Sheets-Sheet 1

FIG. 1

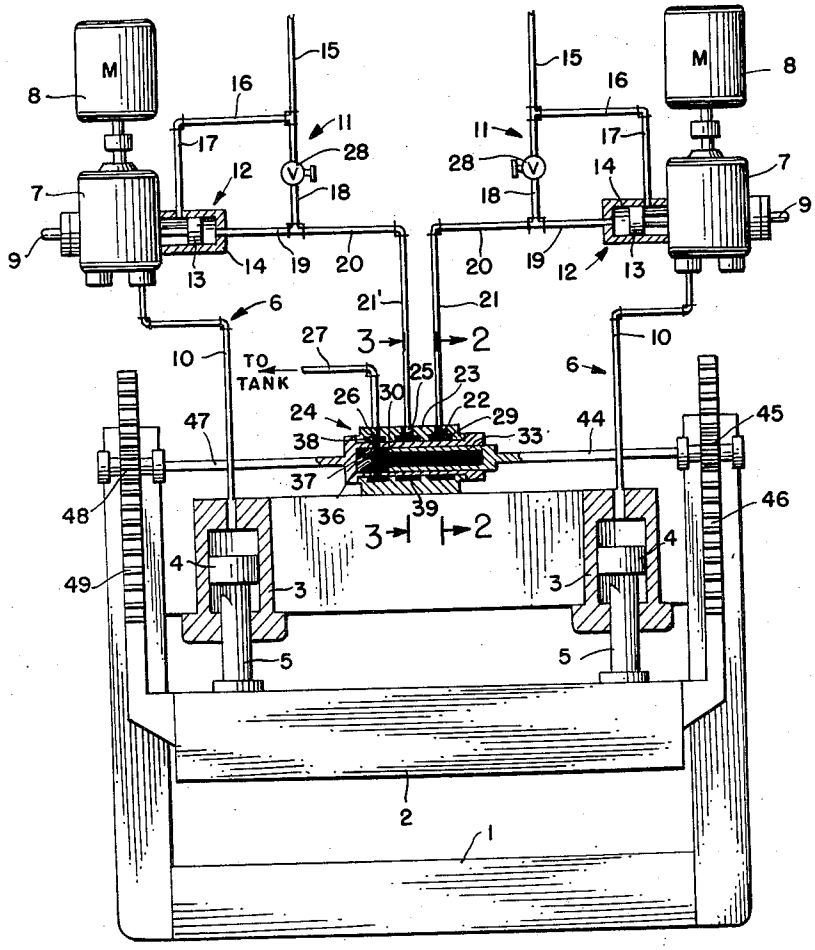


FIG. 2

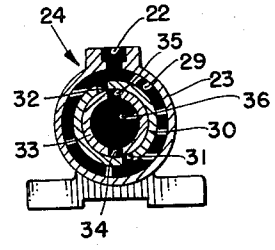
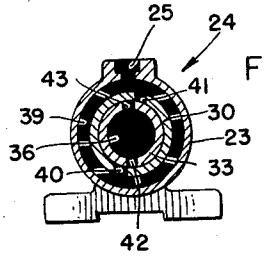


FIG. 3



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Nov. 11, 1958 L. ZIMMERMAN 2,859,591

HYDRAULIC SYNCHRONIZER

Filed July 20, 1955 4 Sheets-Sheet 2

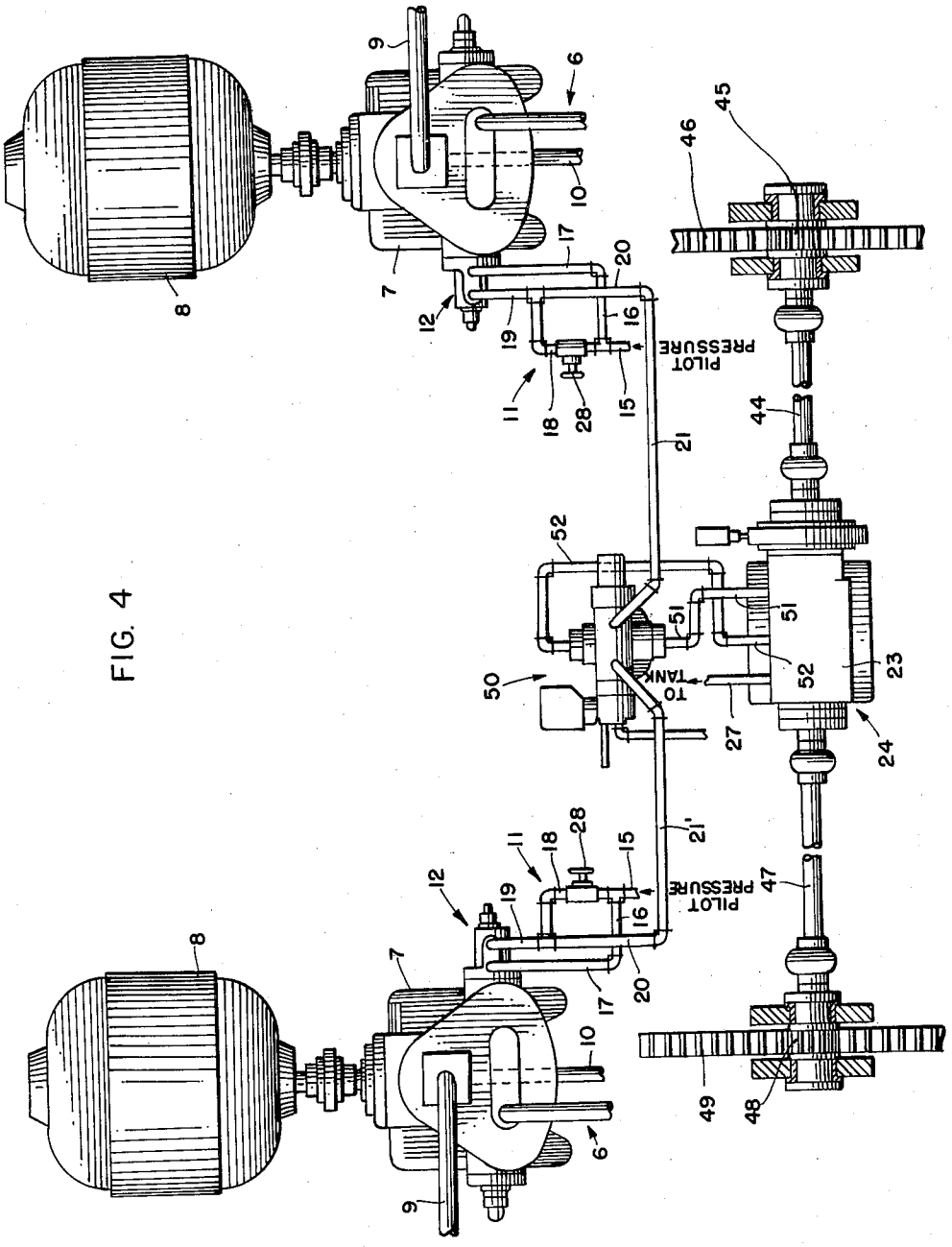


FIG. 4

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Nov. 11, 1958 L. ZIMMERMAN 2,859,591

HYDRAULIC SYNCHRONIZER

Filed July 20, 1955 4 Sheets-Sheet 3

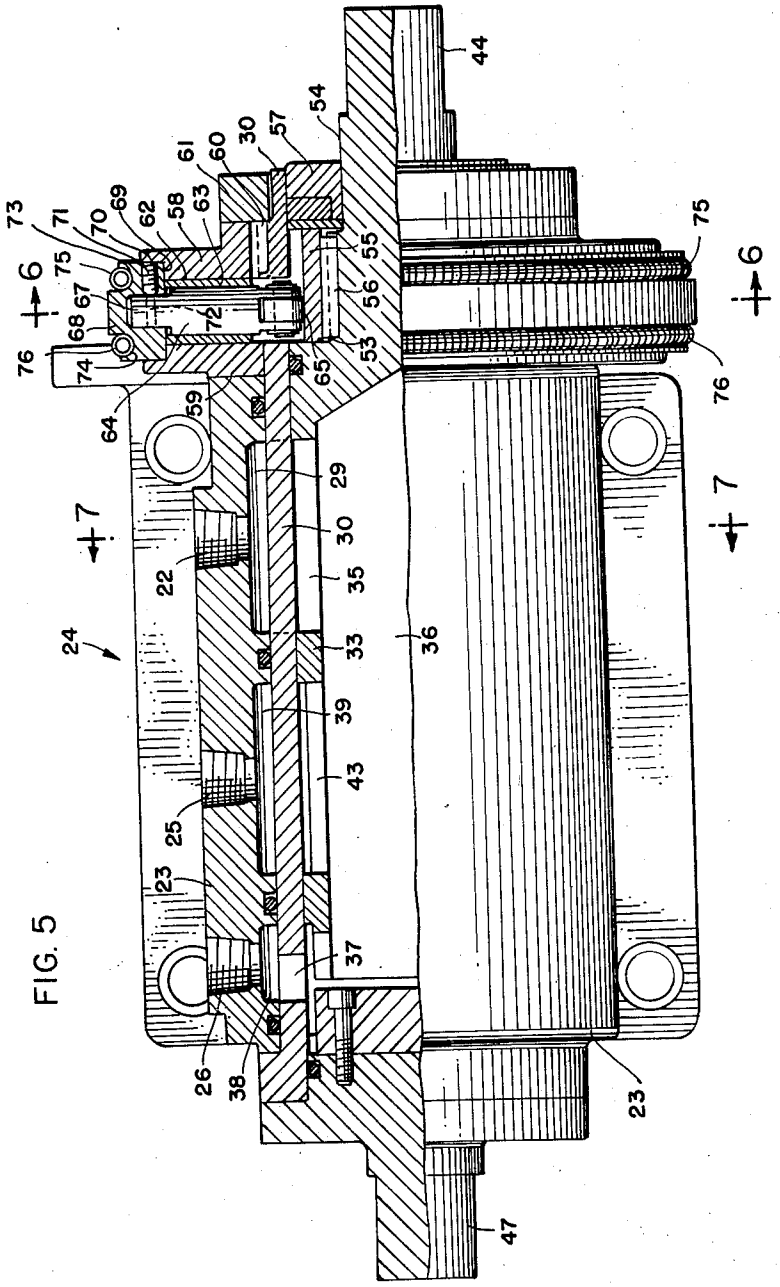


FIG. 5

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Nov. 11, 1958 L. ZIMMERMAN 2,859,591

HYDRAULIC SYNCHRONIZER

Filed July 20, 1955 4 Sheets-Sheet 4

FIG. 7

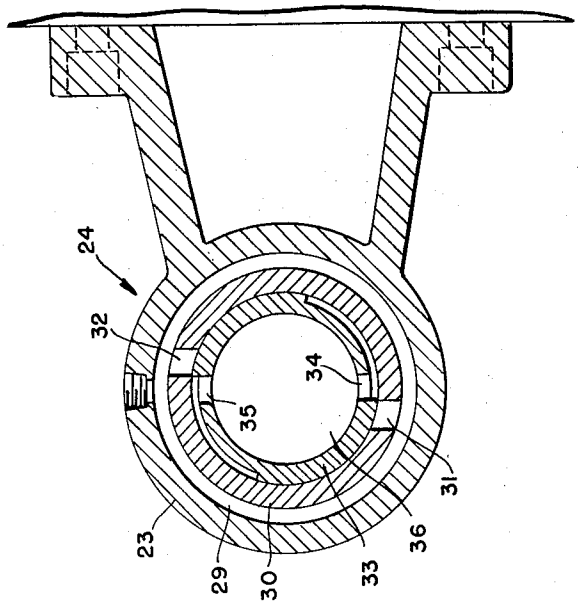
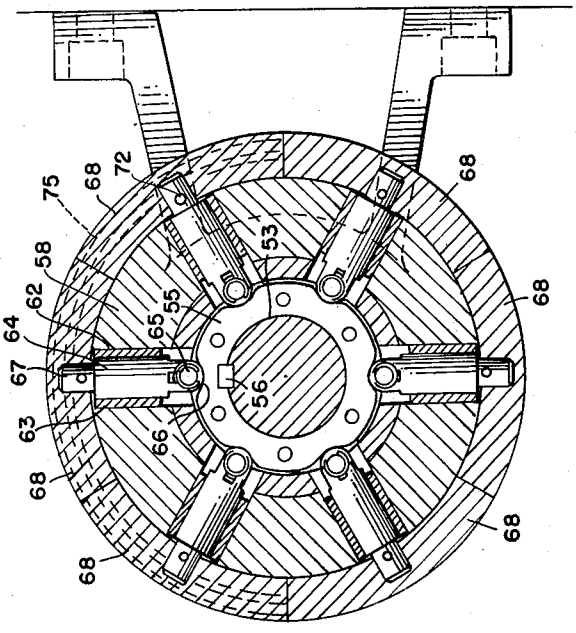


FIG. 6



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2,859,591

HYDRAULIC SYNCHRONIZER

Louis Zimmerman, Palos Heights, Ill., assignor to U. S. Industries, Inc., Chicago, Ill., a corporation of Delaware

Application July 20, 1955, Serial No. 523,291

10 Claims. (Cl. 60—97)

This invention relates in general to a hydraulic synchronizer adapted for use on hydraulic metal working presses and more specifically the invention relates to a device for maintaining the slide of the press level throughout the entire stroke thereof.

In hydraulic presses slides are provided which reciprocate toward and away from the press bed on which there is a die and a work piece to be stamped. The press is provided with a main hydraulic system which provides closing cylinders at each end of the press with hydraulic fluid under pressure for moving the slide toward the bed. Pull-back cylinders are also provided to which hydraulic fluid under pressure is fed for the purpose of moving the slide away from the bed after the drawing operation has been performed.

In hydraulic presses particularly, and especially the larger ones, there is always a tendency for one end or the other of the slide to move faster or slower than the other end especially during the working stroke. Furthermore, if this is permitted to occur, there is a possibility that one part of the slide may press against a work piece when another part does not. There will, therefore, be a tendency for that part of the slide which is out of contact with the work piece to continue to move, whereupon the slide becomes out of alignment and exerts undue pressures against the sides of the press frame. The present invention is designed to overcome these difficulties and to synchronize the movements of the ends of the slide so that they will be maintained at constant relative levels throughout the entire stroke of the slide.

It is, therefore, the principal object of the present invention to provide, in a hydraulic metal working press, suitable mechanism for synchronizing the reciprocating movement of a slide therein and maintaining both ends of the slide at constant relative levels throughout the entire stroke thereof.

Another object of the invention is to provide, in a hydraulic metal working press, a novel form of synchronizing valve operable in response to movement of one end of the slide at a greater rate of speed than the other end thereof to cause said one end to reduce its speed, thereby maintaining both ends of the slide at constant relative levels throughout its entire stroke.

A further object is to provide a hydraulic synchronizer for a hydraulic metal working press wherein a novel form of valve is located in a pilot hydraulic circuit, and wherein mechanical means actuate the valve to maintain the slide level during the reciprocating movements thereof.

Still another object is to provide a hydraulic synchronizer for a hydraulic metal working press having a main hydraulic circuit for reciprocating the slide, and a pilot hydraulic circuit, wherein a novel form of valve is located in the pilot circuit and is actuated by mechanical means operated by the slide when one end of the slide moves faster than the other end thereof, whereby the hydraulic pressure in the main circuit is reduced to retard the movement of said one end.

A still further object is to provide a hydraulic synchronizer for a hydraulic metal working press wherein rapid increases in speed of movement of one end of the slide therein over the other end are prevented, and when conditions are such that such increases of speed tend to occur, and would occur except for the action of the synchronizer, a novel form of valve will be actuated to overcome such tendency, whereby the slide is maintained level throughout its entire stroke.

Other objects and advantages of the invention will become apparent upon reading the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagrammatic illustration of a press embodying the present invention;

Fig. 2 is a transverse sectional view through the diagrammatic illustration of the synchronizing valve of Fig. 1 taken substantially along the plane of line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 2 taken along the plane of line 3—3 of Fig. 1;

Fig. 4 is a layout of the pilot hydraulic circuit in which the synchronizing valve is located;

Fig. 5 is an elevational view, partly in section, of the synchronizing valve;

Fig. 6 is a vertical transverse sectional view through the valve taken along the plane of line 6—6 of Fig. 5, and

Fig. 7 is a vertical transverse sectional view through the valve taken along the plane of line 7—7 of Fig. 5.

The hydraulic synchronizer of the present invention may be applied to hydraulic presses currently in use and thus has the advantage that the system need not be incorporated as an integral part of the press at the time of its manufacture. The invention and its manner of operation may be generally understood by a reference to Fig. 1 wherein the press bed is indicated by the numeral 1 and the slide is shown at 2.

Since conventional hydraulic presses utilize the closing and pull-back cylinders which are actuated hydraulically for reciprocating the slide, the details of such a hydraulic system are not illustrated herein. In Fig. 1, however, the closing cylinders at each end of the press are designated by the numeral 3 and are shown as embodying a piston 4 therein. A rod 5 connected to the piston 4 has the slide 2 suspended therefrom so that reciprocation of the piston 4 will also reciprocate the slide 2.

In actual practice on a large press there will be two such closing cylinders at each end of the press and two pull-back cylinders which are actuated to move the slide away from the bed. The main hydraulic circuit is shown only diagrammatically in Fig. 1 and is indicated at each end of a press generally by the numeral 6. The hydraulic fluid is forced through the circuit by means of a pump 7 at each end of the press driven by a motor 8. The hydraulic fluid is pumped from a suitable source of supply through an inlet 9 and is forced outwardly under pressure through pipes 10 connected to the cylinder 3. These cylinders are mounted on a stationary part of the press frame so that when fluid is fed into the cylinder it will drive the pistons 4 downwardly carrying with them the slide 2 moving it toward the bed 1.

The synchronizer embodying the present invention utilizes a pilot hydraulic circuit generally shown at 11, one for each end of the press. A control member 12 is associated with each pilot hydraulic circuit 11 and includes a piston 13 and a cylinder 14. Hydraulic fluid under pressure from a suitable source (not shown) is forced through a pipe 15 which communicates with the pipes 16 and 17 to direct fluid under pressure into the cylinder 14 at one side of the piston 13 therein. A pipe 18 also connects with the lead-in pipe 15 and communicates with a conduit 19 in communication with the cylinder 14 at the opposite side of the piston 13 therein. At

one end of the press in one of the pilot hydraulic circuits, a conduit 20 communicates with the conduits 18 and 19 and connects with a pipe 21 which is also connected with an inlet opening 22 in the casing 23 of the synchronizing valve generally indicated at 24.

The other pilot hydraulic circuit also has its conduit 20 connected with the conduits 18 and 19 but in this case the pipe which leads to the synchronizing valve is indicated by the numeral 21' and is connected to an inlet opening 25 in the casing 23 of the valve 24.

An outlet opening 26 also in the casing 23 has connected therewith a pipe 27 which will carry hydraulic fluid back to the tank.

A valve 28 is located in each of the pipe sections 18 for the purpose of regulating the pressure of the pilot hydraulic fluid being delivered to the synchronizing valve 24.

Each of the control devices 12 is connected with its associated pump 7 in the main hydraulic circuit so that it may be said that the control device is common to both the main hydraulic circuit and the pilot hydraulic circuit. Pilot hydraulic pressure is directed against one side of each piston 13 and is the same side connected to the pump 7 which causes hydraulic pressure to be exerted through the main circuit to each of the closing cylinders 3. Pilot hydraulic fluid under pressure passes through each of the valves 28 and through each pipe 18 and is directed through the pipes 19 to the outer end of each piston 13 in opposition to the pilot pressure at the opposite side thereof. The regulated pilot pressure is also exerted through the conduits 21 and 21' to the synchronizing valve 24.

Thus far it may be seen that when the pumps 7 are operating to direct fluid under pressure either to the closing cylinders or to the pull-back cylinders, if anything should occur to cause either of the pistons 13 to move outwardly toward the end of its associated cylinder 14, then the pressure in the associated main hydraulic circuit would be immediately reduced and the end of the slide being driven by that particular hydraulic circuit would immediately have its speed of movement reduced until the condition which caused the piston 13 to move outwardly was corrected to return it to its normal position of equilibrium.

The construction of the synchronizing valve may be more clearly understood by reference to Figs. 2, 3, 5, and 7. With respect to Figs. 2 and 5, it will be noted that the inlet 22 through the casing 23 leads to an annular recess 29 surrounding an outer tubular sleeve 30. This outer sleeve 30 is provided with diametrically opposed openings 31 and 32 extending therethrough. This outer sleeve 30 surrounds an inner tubular sleeve 33 which is also provided with opposed openings 34 and 35 through the wall thereof. It will be noted from viewing Fig. 2 and looking toward the right through the valve 24 as viewed in Fig. 1, that the opening 31 through the outer sleeve 30 is positioned immediately to the right of the opening 34 through the inner sleeve 33. These openings 31 and 34 are normally out of communication with each other. Likewise, the opposite opening 32 through the wall of outer sleeve 30 is positioned to the left of opening 35 through the inner sleeve 33 and these two openings normally are out of communication with each other.

Pilot fluid under pressure delivered through the inlet 22 will fill the annular recess 29 around the outer sleeve 30. Since the openings 31 and 32 are in communication with the annular recess 29, these openings will also be filled with the hydraulic fluid under pressure. If and when a condition occurs which will cause clockwise rotation of the outer sleeve 30 as viewed in Fig. 2 or counterclockwise rotation of the inner sleeve 33, then the openings 31 and 34 will immediately be brought into communication with each other. At this time the openings 32 and 35 will also be brought into communication, whereupon the pilot hydraulic fluid under pressure being delivered through the inlet opening 22 will be relieved or reduced and the fluid will pass through to the interior 36 of the inner sleeve 33. From this interior the fluid will then be delivered through the outlet openings 37 in the wall of the sleeve 30 to an annular recess 38 in the casing 23 to the outlet passage 26 and pipe 27 to be carried back to the tank. The reason that the pressure of the pilot hydraulic fluid will be relieved is because the valve 28 in pipe 18 is set so that sufficient fluid will be unable to pass therethrough to satisfy the pressure requirement. This fluid pressure then is compensated for by the fluid passing through pipes 16 and 17 to the inner side of piston 13 which will cause the piston to move outwardly. This in turn reduces the pressure in the main hydraulic circuit so that less pressure will be exerted upon the particular piston which is driving that end of the slide.

As will presently be seen, the reduction of pressure in the main hydraulic circuit at one end of the slide will slow down the movement of that end of the slide immediately causing relative rotation between the inner and outer sleeves in the opposite direction to again position the openings 31 and 34 and the openings 32 and 35 out of communication with each other. At this moment the required pressure is satisfied by the pilot fluid passing through valve 28 and pipes 18, 20 and 21 causing the piston 13 to resume its normal position and increasing the pressure at that end of the slide exerted by the main hydraulic circuit.

Referring now to Fig. 3 and viewing the section through the synchronizing valve as looking toward the right thereof from the position shown in Fig. 1, it will be noted that the outer sleeve 30 is surrounded by a second annular recess 39 in communication with the inlet passage 24 connected to the pipe 21' associated with the pilot hydraulic circuit at the opposite end of the slide. In this area the outer sleeve 30 is provided with the opposed openings 40 and 41 through the wall thereof. The inner sleeve 33 has the opposed openings 42 and 43 through the wall thereof. The openings 40 and 42 are normally out of communication with each other and the openings 41 and 43 are likewise out of communication under normal conditions. However, when conditions are such as to rotate the outer sleeve 30 in a counter-clockwise direction or the inner sleeve 33 in a clockwise direction, the respective openings 40 and 42 and the openings 41 and 43 will be brought into communication with each other permitting the flow of the hydraulic fluid from pipe 21' through the annular recess 39 and the communicating passages in the walls of the outer and inner sleeves to the interior 36 of the inner sleeve where it is carried away in the same manner previously described through the outlet opening 26 back to the tank.

Since the pilot fluid passing through the valve 28 at this particular end of the slide cannot be supplied fast enough to satisfy the pressure requirements, it will result in outward movement of piston 13 which causes a reduction in the fluid pressure of the main hydraulic circuit associated with this end of the slide, thereby retarding the movement of that end of the slide. Again, as will presently be seen, this condition will cause the respective openings 40 and 42 and the openings 41 and 43 to be positioned out of communication with each other, whereupon the pilot pressure will increase to move the piston 13 inwardly and return the operation of the main hydraulic circuit back to normal.

The arrangement of the elements embodying the invention is such that when the right-hand end of the slide as viewed in Fig. 1 moves downwardly at a greater rate of speed than the opposite end thereof, the inner sleeve 33 will move relative to the outer sleeve 30 in a counterclockwise direction, as viewed in Fig. 2. If, however,

the left-hand end of the slide moves at a greater rate of speed than the right-hand end thereof, the outer sleeve **30** will move relative to the inner sleeve **33** in a counter-clockwise direction as viewed in Fig. 3.

To accomplish this result the outer end of the inner sleeve **33** is connected with a shaft **44** on which is mounted a pinion **45** in mesh with a rack **46** mounted on the right-hand end of the slide **2**. The outer sleeve **30** has secured thereto a similar shaft **47** on which is mounted a pinion **48** in mesh with a rack **49** secured to the opposite end of the slide. Thus, as the slide moves downwardly carrying with it the racks **46** and **49**, a rotation of the pinions **45** and **48** will occur causing a like rotation of shafts **44** and **47** and the inner and outer sleeves **33** and **30**, respectively, connected therewith. Thus, during the downward movement of the slide, both the inner and outer sleeves will rotate together in the same direction and presumably at the same rate of speed which will prevent any communication between the openings through the walls of these sleeves. If, however, the right-hand end of the slide begins to move at a greater rate of speed than the left-hand end thereof as viewed in Fig. 1, then pinion **45** will rotate faster than pinion **48** and inner sleeve **33** will likewise rotate faster than outer sleeve **30**. Since both sleeves are rotating in a counter-clockwise direction as viewed in Fig. 2, it will be immediately apparent that as soon as the inner sleeve **33** rotates faster than the outer sleeve **30**, communication will be established between the openings **31** and **34** and the openings **32** and **35**. When this occurs, the pilot pressure of the fluid being delivered to the valve through pipe **21** will be reduced, thereupon reducing the pressure of the hydraulic fluid in the main circuit associated with the right-hand end of the slide, thereby immediately causing the speed of movement of that end of the slide to be retarded in the manner above explained. As soon as this retarding movement takes place, the pinion **45** will rotate at a slower rate to bring it into conformity with the speed of rotation of the pinion **48**.

If the left-hand end of the slide is caused to move at a greater rate of speed than the opposite end thereof, then the outer sleeve **30** will rotate at a greater rate of speed than the inner sleeve **33**, whereupon communication will be established between the openings **40** and **42** and the openings **41** and **43** causing a drop in pressure in the line **21'** as above explained, and a corresponding drop in pressure of the main hydraulic circuit associated with the left-hand end of the slide, thereby retarding its reciprocating movement and bringing the speed of rotation of the pinion **48** into conformity with the rotation of pinion **45**.

Fig. 4 illustrates the actual layout of the pilot hydraulic circuit shown diagrammatically in Fig. 1. The same reference numerals refer to the same parts in both figures. In the actual layout, however, the pipes **21** and **21'** are not connected directly to the synchronizing valve **24** but are connected indirectly thereto through a solenoid operated 4-way valve generally indicated at **50**. The diagrammatic showing of Fig. 1 is satisfactory for the purpose of illustrating the principle of operation of the invention. However, it is obvious that on the return or upper stroke of the slide **2** the outer and inner sleeves **30** and **33** will rotate in a direction opposite to that which occurred during the downward movement of the slide. Thus, the synchronizing valve would not operate during upward movement of the slide without reversing the connections to the valve of the pipes **21** and **21'**. In other words, the valve would operate to maintain the slide level only when the inner and outer sleeves thereof rotate in a counter-clockwise direction as viewed in Figs. 2 and 3. When the slide moves upwardly, these sleeves will rotate in a clockwise direction so that in order for the valve to function properly the pilot hydraulic circuit at the left of Fig. 1 must be brought into operation when the inner sleeve **33** rotates too fast because of the increased speed of movement at the right end of the slide, as viewed in Fig. 1. Conversely, the pilot hydraulic circuit at the right of Fig. 1 must function when the outer sleeve **30** rotates faster than the inner sleeve due to the increased speed of movement of the left end of the slide, as viewed in Fig. 1.

Summarizing briefly, during the down stroke of the slide, the fluid from pipe **21** should be delivered to the inlet opening **22** in the valve and the fluid from pipe **21'** should be delivered to the inlet opening **25** in the valve. On the up stroke of the slide, the fluid from pipe **21** should be delivered to inlet opening **25** and the fluid from pipe **21'** must be delivered to the inlet opening **22**.

The solenoid operated 4-way valve **50** shown in Fig. 4 accomplishes the foregoing result. This valve is commercially available and is well known in the art and its operation need not be described in detail. It is sufficient for present purposes to indicate in Fig. 4 that the pipe **21** leads to the valve **50** and for the down stroke of the slide the fluid is directed through the valve and outwardly through the pipe **51** to the inlet opening **22** of the valve **24**. Pipe **21'** from the other pilot hydraulic circuit leads also to the valve **50** and during the down stroke of the slide the fluid therefrom will pass through the valve and through the conduit **52** to the inlet opening **25** in the valve **24**.

When the slide reaches its lowermost position it is customary and well known construction to have the slide operate a limit switch which operates suitable valves in the main hydraulic circuit to direct the fluid from the closing cylinders to the pull-back cylinders, whereupon the slide is then moved upwardly away from the bed. At this same moment the limit switch will also actuate the solenoid of valve **50** so that during the upward movement of the slide fluid in pipe **21'** will be delivered through the valve **50** and outwardly through the conduit **51** to the inlet **22**. Likewise, the pilot fluid from pipe **21** is changed so that it will flow through the valve **50** and outwardly through conduit **52** to the inlet **25**. When the slide reaches its uppermost position another limit switch will be actuated to reverse the flow of the pilot hydraulic fluid and to again change the main hydraulic fluid back to the closing cylinders.

During the up stroke of the slide the synchronizing valve will operate in the same manner as on the down stroke of the slide to synchronize the movement of the ends of the slide to maintain them substantially equal in their speed of movement. When one end of the slide moves faster than the other, then the inner and outer sleeves will be rotated relative to each other, thereby reducing the pressure against the outer end of one of the pistons **13** allowing the piston to move outwardly and causing a drop in pressure in the main hydraulic circuit to retard the movement of that particular end of the slide.

Another feature of the invention is the provision of mechanism which has a damping effect on the rate at which one end of the slide will increase its speed over the other end thereof. That is to say, in the absence of such a device one end of the slide might have a tendency to either rapidly increase its speed or move a relatively great degree over the other end of the slide, which would thereupon have a tendency to move the pistons **13** back and forth constantly. This self-centering or equalizing feature is illustrated in greater detail in Figs. 5 and 6 of the drawings.

In Fig. 5 particularly it will be noted that the inner sleeve **33** extends outwardly beyond the casing **23** of the valve **24** and is provided with the stepped annular shoulders **53** and **54**. A ring **55** is placed over the shoulder **53** and is secured to the inner sleeve **33** by suitable means, such as a key **56**. The ring **55** is then held in place by a suitable retaining means including a ring **57** adapted to fit over the shoulder **54**.

The outer sleeve **30** also extends outwardly beyond the

end of the casing 23 of the valve 24 and at its outer end is spaced from the shoulders 53 and 54 on the inner sleeve 33. An outer ring 58 then fits over the outer sleeve 30 and abuts against the end 59 of the casing 23. This outer ring 58 is also rotatably secured to the outer sleeve 30 by means such as the key 60. This outer ring is then held in place by suitable means including a retaining ring 61.

The outer ring 58 is provided with a plurality of spaced radially extending openings 62 each of which receives a bushing 63. An arm 64 is located within each bushing 63 and is mounted therein for longitudinal reciprocation. The inner end of each arm 64 has rotatably mounted thereon a roller 65 which is positioned normally at the bottom of a recess 66 in the ring 55. This arrangement may be more clearly understood by viewing Fig. 6.

The outer end of each arm 64 is provided with an extension 67 of lesser diameter, each of which is received in a suitable recess in a ring segment 68. There is provided one such ring segment 68 for each arm 64.

The segments 68 are placed circumferentially around the ring 58 and each is adapted to seat in a recess on the periphery of the ring 58 provided by the shoulders 69 and 70. A set screw 71 extends laterally inwardly through each segment 68 and has the inner tapered end thereof received in a hole 72 through the extension 67, thereby to prevent the roller arm 64 from rotating about its longitudinal axis.

Each segment 68 is provided with grooves 73 and 74 around the outer periphery thereof so that when all of the segments are in place end to end around the ring 58, these grooves 73 and 74 will be continuous and annular. Extension springs 75 and 76 are located in the annular grooves 73 and 74, respectively, for the purpose of holding the roller arms 64 normally inwardly and tending to maintain the roller 65 of each such arm in the innermost point of the associated depressions 66.

Thus, the ring 55 in which the depressions 66 are located is keyed to the inner sleeve 33 and rotates therewith. The arms 64 are positioned in the ring 58 which in turn is keyed to the outer sleeve 30. When the inner sleeve 33 rotates relative to the outer sleeve 30, it must move against the force of the springs 75 and 76 holding the arms 64 inwardly, and will tend to force the rollers 65 to climb upwardly along the slope of the depressions 66. Likewise, relative movement of the outer sleeve 30 will urge the arms 64 outwardly against the force of the springs 75 and 76.

This equalizing device has a tendency to keep the inner and outer sleeves rotating at a constant rate. If, however, either end of the slide begins to move more rapidly than the other end and at a rate sufficient to move one of the sleeves relative to the other against the force of the springs 75 and 76, then the valve will be actuated as previously described to retard the speed of that particular end of the slide, thus synchronizing the end movements thereof and tending to maintain them constant and to retain the slide level throughout its entire stroke.

It has been determined in actual practice that when the slide starts downwardly from its upper position, there is a tendency for the slide to rock but with the use of this equalizing mechanism in the valve itself, the tendency to rock becomes less as the slide moves downwardly so that by the time the draw takes place, there will be little or no movement of the pistons 13 except for that which may be caused by unequal pressures exerted by each end of the slide after it contacts the work piece.

Changes may be made in the form, construction and arrangement of parts from those disclosed herein without in any way departing from the spirit of the invention or sacrificing any of the attendant advantages thereof, provided, however, that such changes fall within the scope of the claims appended hereto.

The invention is hereby claimed as follows:

1. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuit, a like plurality of main hydraulic circuits for reciprocating the slide, means to actuate said valve means when one end of the slide moves at a greater rate of speed than the other end thereof, and control means, common to each of said main and pilot circuits operable when said valve means is actuated to control the pressure in the main circuit to which it is connected and retard the speed of movement of said one end of the slide.

2. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuits, a like plurality of main hydraulic circuits for reciprocating the slide, mechanical means connecting the ends of the slide with said valve means and operable to actuate said valve means when one end of the slide moves at a greater rate of speed than the other end thereof, and control means common to each of said main and pilot hydraulic circuits operable when said valve means is actuated to control the pressure in the main hydraulic circuit to which it is connected and retard the speed of movement of said one end of the slide.

3. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuits including outer and inner tubular sleeves having passages through the walls thereof, said passages being normally out of communication with each other but adapted to communicate with each other upon a relative rotation between said sleeves, a like plurality of main hydraulic circuits for reciprocating the slide, means to actuate said valve means by rotating one of said sleeves with respect to the other said sleeve when one end of the slide moves at a greater rate of speed than the other end thereof, and control means common to each of said main and pilot hydraulic circuits, said valve means being operable when actuated to relieve the pressure on one side of one of said control means, whereby the pressure on the opposite side thereof will act on said control means to reduce the pressure in the main circuit at said one end of the slide and retard the speed of movement thereof.

4. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuits, a like plurality of main hydraulic circuits for reciprocating the slide, a rack at each end of the slide and reciprocable therewith, a pinion in mesh with each of said racks, a shaft for each of said pinions connected directly with said valve means and operable to actuate said valve means when one end of the slide moves at a greater rate of speed than the other end thereof, and control means common to each of said main and pilot hydraulic circuits operable when said valve means is actuated to control the pressure in the main hydraulic circuit to which it is connected and retard the speed of movement of said one end of the slide.

5. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuits including outer and inner tubular sleeves having passages through the walls thereof, said passages being normally out of communication with each other but adapted to communicate with each other upon a relative rotation between said sleeves, a like plurality of main hydraulic circuits for reciprocating the slide, a rack at each end of the slide and reciprocable therewith, a pinion in mesh with each of said racks, a shaft for each of said pinions, one shaft being connected with said outer sleeve and the other shaft being connected to said inner sleeve, whereby when one end of the slide moves at a greater rate of

speed than the other end thereof one of said sleeves will rotate with respect to the other sleeve to actuate said valve means, and control means common to each of said main and pilot hydraulic circuits, said valve means being operable when actuated to relieve the pressure on one side of one of said control means, whereby the pressure on the opposite side thereof will act on said control means to reduce the pressure in the main circuit at said one end of the slide and retard the speed of movement thereof.

6. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuits, a like plurality of main hydraulic circuits for reciprocating the slide, a rack at each end of the slide and reciprocable therewith, a pinion in mesh with each of said racks, a shaft for each of said pinions connected directly with said valve means and operable to actuate said valve means when one end of the slide moves at a greater rate of speed than the other end thereof, and control means including a piston and cylinder assembly common to each of said main and pilot hydraulic circuits operable when said valve means is actuated to control the pressure in the main hydraulic circuit to which it is connected and retard the speed of movement of said one end of the slide.

7. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing value means common to said circuits including outer and inner tubular sleeves having passages through the walls thereof, said passages being normally out of communication with each other but adapted to communicate with each other upon a relative rotation between said sleeves, a like plurality of main hydraulic circuits for reciprocating the slide, means to actuate said valve means by rotating one of said sleeves with respect to the other said sleeve when one end of the slide moves at a greater rate of speed than the other end thereof, and control means including a piston and cylinder assembly common to each of said main and pilot hydraulic circuits, said valve means being operable when actuated to relieve the pressure on one side of one of said control means, whereby the pressure on the opposite side thereof will act on said control means to reduce the pressure in the main circuit at said one end of the slide and retard the speed of movement thereof.

8. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuit including outer and inner tubular sleeves having passages through the walls thereof, said passages being normally out of communication with each other but adapted to communicate with each other upon a relative rotation between said sleeves, a like plurality of main hydraulic circuits for reciprocating the slide, a rack at each end

of the slide and reciprocable therewith, a pinion in mesh with each of said racks, a shaft for each of said pinions, one shaft being connected with said outer sleeve and the other shaft being connected to said inner sleeve, whereby when one end of the slide moves at a greater rate of speed than the other end thereof one of said sleeves will rotate with respect to the other sleeve to actuate said valve means, and control means including a piston and cylinder assembly common to each of said main and pilot hydraulic circuits, said valve means being operable when actuated to relieve the pressure on one side of one of said control means, whereby the pressure on the opposite side hereof will act on said control means to reduce the pressure in the main circuit at said one end of the slide and retard the speed of movement thereof.

9. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuits, a like plurality of main hydraulic circuits for reciprocating the slide, means to actuate said valve means when one end of the slide moves at a greater rate of speed than the other end thereof, equalizing means operably connected with said valve actuating means to prevent any rapid increase in the speed of movement of one end of the slide over the other end thereof, and control means common to each of said main and pilot circuits operable when said valve means is actuated to control the pressure in the main hydraulic circuit to which it is connected and retard the speed of movement of said one end of the slide.

10. A hydraulic synchronizer adapted for use with a hydraulic metal working press having a reciprocating slide, comprising a plurality of pilot hydraulic circuits, synchronizing valve means common to said circuits, a like plurality of main hydraulic circuits for reciprocating the slide, mechanical means connecting the ends of the slide with said valve means and operable to actuate said valve means when one end of the slide moves at a greater rate of speed than the other end thereof, equalizing means connected between said mechanical means and said valve means to prevent any rapid increase in the speed of movement of one end of the slide over the other end thereof, and control means common to each of said main and pilot circuits operable when said valve means is actuated to control the pressure in the main hydraulic circuit to which it is connected and retard the speed of movement of said one end of the slide.

References Cited in the file of this patent

UNITED STATES PATENTS

1,900,050	Ernst	Mar. 7, 1933
2,312,213	Ferris	Feb. 23, 1943
2,380,973	Kopp	Aug. 7, 1945