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J. M. TOWLER ET AL

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HYDRAULIC SYSTEM FOR UNLOADING LARGE CAPACITY PUMPS

Filed April 1, 1949

4 Sheets-Sheet 1

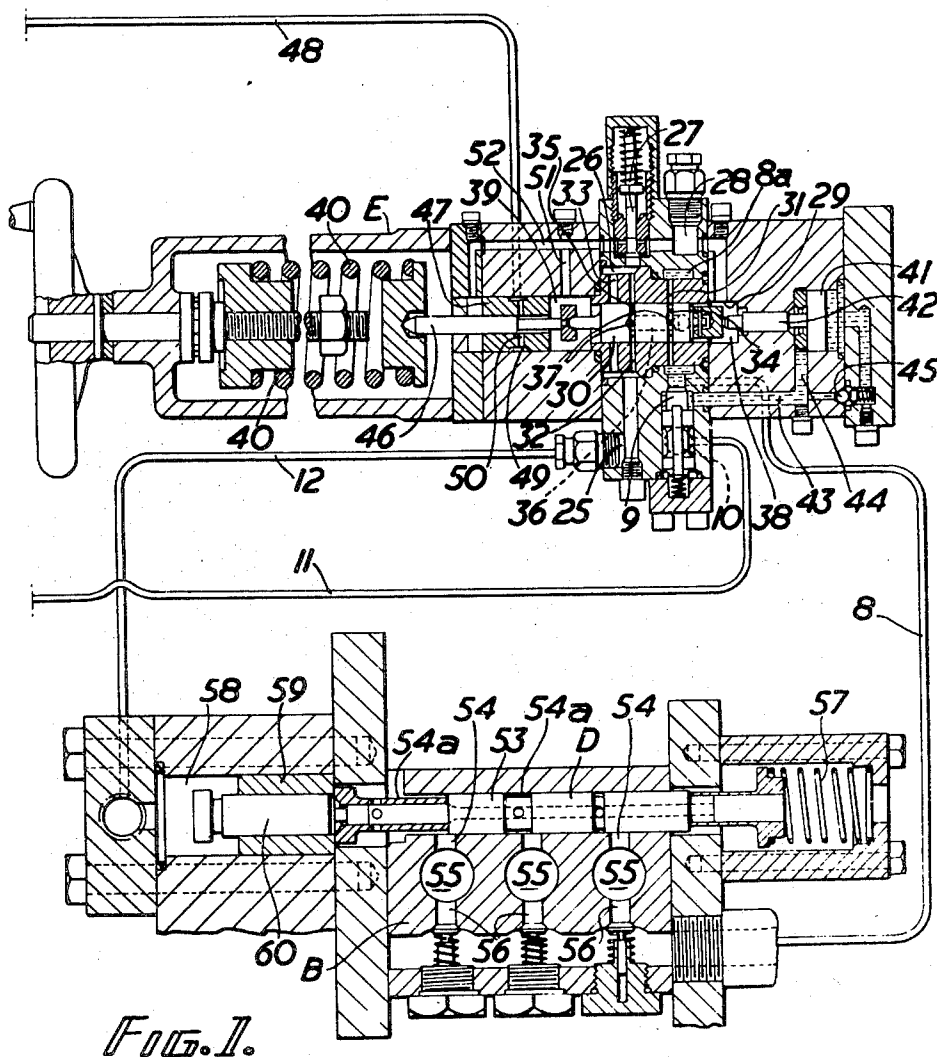


FIG. 1.

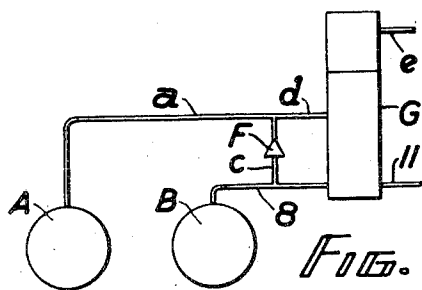


FIG. 5.

Inventors:
JOHN MAURICE TOWLER
FRANK HATHORN TOWLER
By Carlson, Rogers, Hoffman & Wolfe
Attorneys.

July 5, 1949.

J. M. TOWLER ET AL

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HYDRAULIC SYSTEM FOR UNLOADING LARGE CAPACITY PUMPS

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4 Sheets-Sheet 2

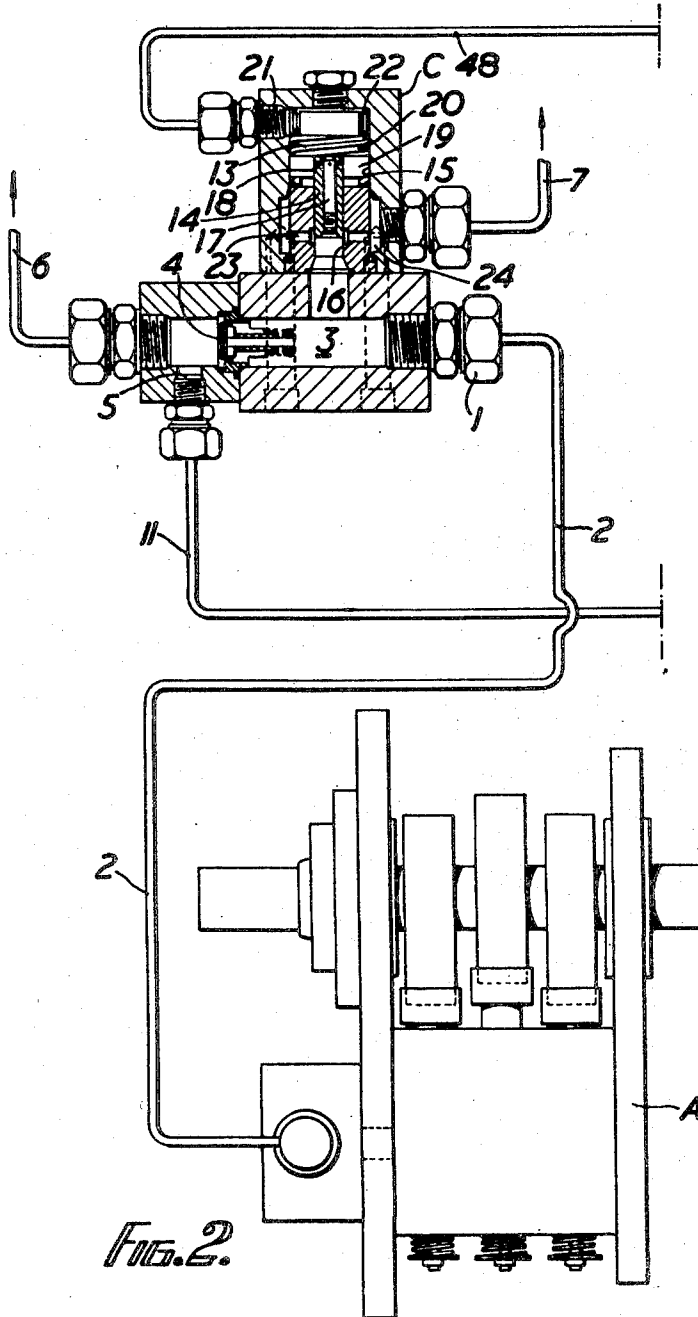


FIG. 2.

Inventors:
JOHN MAURICE TOWLER
FRANK HATHORN TOWLER

By Carlson, Pitzer, Huttman & Wolfe
Attorneys.

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J. M. TOWLER ET AL

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HYDRAULIC SYSTEM FOR UNLOADING LARGE CAPACITY PUMPS

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4 Sheets-Sheet 3

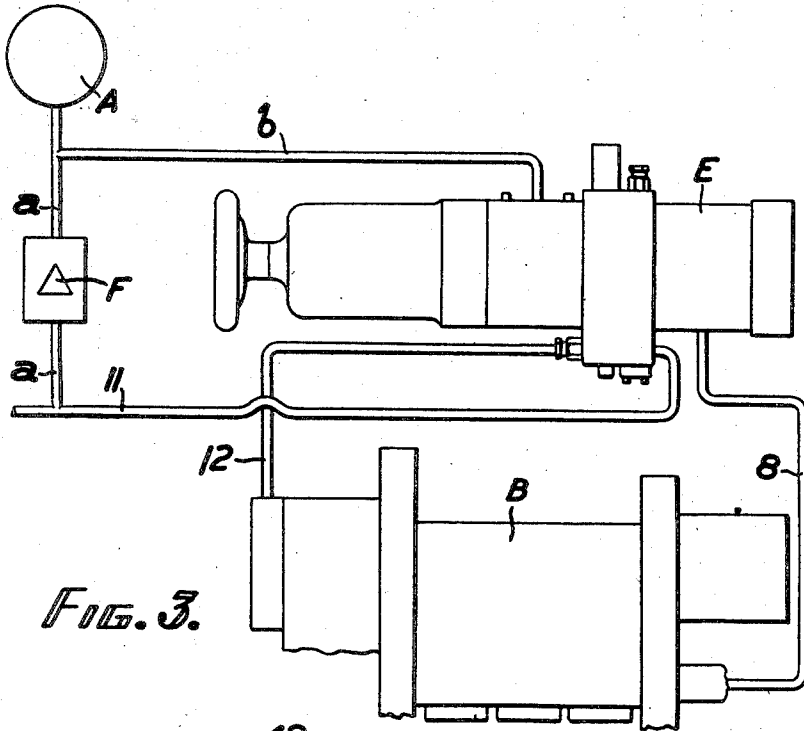


FIG. 3.

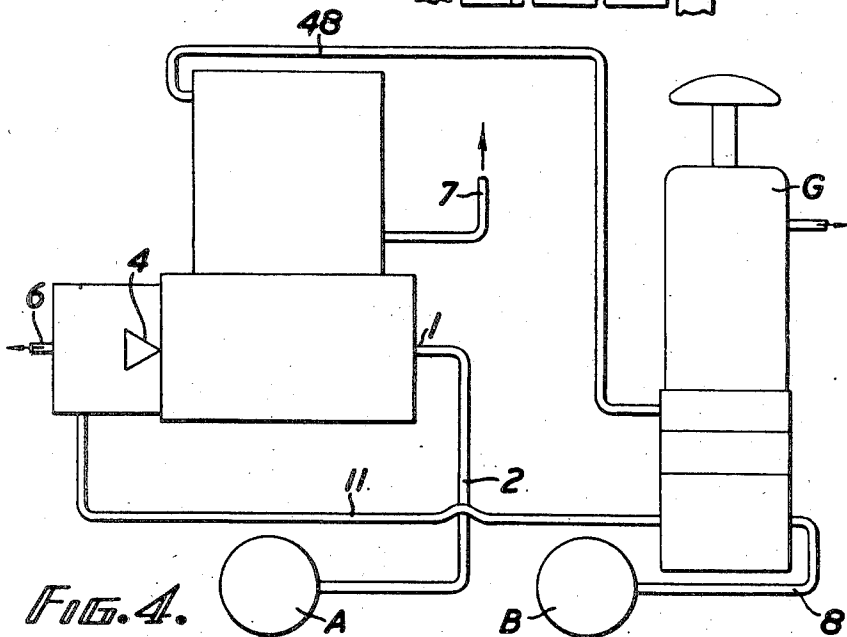


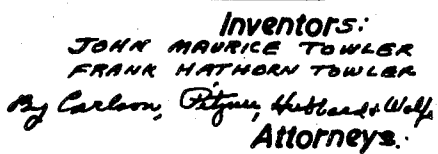
FIG. 4.

Inventors:
JOHN MAURICE TOWLER
FRANK HATHORN TOWLER
By Carlson, Titner, Hutton & Wolf
Attorneys.

J. M. TOWLER ET AL

HYDRAULIC SYSTEM FOR UNLOADING LARGE CAPACITY PUMPS

4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

2,475,413

HYDRAULIC SYSTEM FOR UNLOADING
LARGE CAPACITY PUMPSJohn Maurice Towler, Skipton, and Frank
Hathorn Towler, Otley, EnglandApplication April 1, 1949, Serial No. 84,916
In Great Britain May 25, 1945Section 1, Public Law 690, August 8, 1946
Patent expires May 25, 1965

8 Claims. (Cl. 103—39)

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The present application is a continuation-in-part of our allowed application Serial No. 680,498, filed June 29, 1946, and entitled "Hydraulic system for unloading large capacity pumps," in which application there is disclosed and claimed the specific form or species of the invention illustrated in Figs. 1 and 2 of the present application.

This invention relates to an hydraulic system for controlling the supply of pressure liquid to an hydraulic press. In some classes of press work it is necessary to move the press ram rapidly whilst under full pressure and where the ram is of large diameter this involves the supply of a large volume of liquid, and, in consequence, the use of a large capacity pump. At the end of the working stroke make-up liquid only is required to maintain the pressure in the hydraulic main so means must be provided to reduce the supply of pumped liquid. One way of doing this is to cause the excess liquid supplied by the large pump to escape past a relief valve. This is however an objectionable method as it results in the heating up of the oil and considerable noise.

Another method which we employ in connection with our smaller capacity pumps is to unload the pump rams by means of an unloading valve which operates automatically under the influence of the pressure in the pump main. This method is however quite unsuitable in the case of the large capacity pump as it means that the same is caused to cut in and out repeatedly, giving rise to violent shocks and noise.

The object of the present invention is to provide a new or improved system by means of which the required pressure liquid is supplied by two pumps, a large capacity pump and a small capacity pump and in which the large capacity pump may be fully unloaded and loaded without undue shock or noise and by means whereby the maximum pressure in the system generated by the two pumps is controlled by a single adjustment.

Broadly the present invention consists of an hydraulic system for controlling the supply of pressure liquid to an hydraulic press comprising a large capacity pump for supplying the main liquid for operating the press ram, a small capacity pump for maintaining substantially constant the pressure in the delivery main and an automatically operating control means having two valve portions one of said portions being adapted to control the delivery of the large capacity pump so that said delivery is diverted wholly to exhaust at a predetermined pressure in the delivery main and the other valve portion being adapted to control the delivery of the small capacity pump

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whereby said small capacity pump is caused to maintain pressure on the press ram after the large capacity pump has been cut out, said valve portions both being subject to a common load so that the maximum pressure in the system generated by the two pumps is controlled by a single adjustment.

Delivery of the small capacity pump is preferably controlled automatically by means of an unloading valve which operates to unload one or more of the pump chambers according to the demand on the pump in maintaining substantially constant the pressure in the delivery main but the same may be caused to blow off through a relief valve.

The two valve portions may each form part of a separate control valve but in the preferred arrangement the valve portions are mounted in tandem and so that the valve portion controlling the large capacity pump opens first.

The large capacity pump is unloaded by diverting the whole of its delivery to exhaust, and this is effected under the control of an automatically operating valve means which functions to open the pump delivery to exhaust when a predetermined maximum pressure in the main is exceeded.

Where the capacity of the large capacity pump is sufficiently small unloading may be effected directly by one of the valve portions of the aforesaid control valve but where the capacity of the said pump is too large to be unloaded in this direct manner the unloading is effected by an additional automatically operating valve, hereinafter referred to as an amplifier unloading valve, but the operation of this amplifier unloading valve to unload the large capacity pump is controlled by one of the valve portions of the main control valve.

Where the small capacity pump is of the sustained pressure type its delivery is controlled automatically by means of an unloading valve which operates to unload one or more of the pump chambers according to the demand on the pump and so to maintain substantially constant the pressure in the delivery main. In this example the main control valve will be of the kind adapted to pass liquid to the unloading valve of the small capacity pump for its operation at a lower pressure than exists in the main. Such a control valve is hereinafter referred to as a "master" control valve.

Alternatively however the small capacity pump may be unloaded by one of the valve portions of the control valve, which thus acts as a relief valve and in this arrangement the large capacity

pump may either be unloaded by the other valve portion of the control valve or by a separate amplifier unloading valve.

In order that the invention may readily be carried into effect four different embodiments will now be described by aid of the accompanying drawings in which:

Fig. 1 illustrates in sectional elevation a master control valve and a small capacity pump of the sustained pressure type, and

Fig. 2 a large capacity pump and an amplifier unloading valve the whole constituting an example of the embodiment in which the large capacity pump is unloaded by an amplifier unloading valve and the small capacity pump by the unloading of each pump in turn, the whole being under the control of the master control valve.

Fig. 3 is a diagram illustrating the embodiment in which the amplifier unloading valve is dispensed with the large capacity pump being unloaded directly by one of the valve portions of a master control valve.

Fig. 4 is a diagram illustrating the embodiment in which the large capacity pump is unloaded by an amplifier unloading valve the small capacity pump being unloaded directly by one of the valve portions of a control valve which in this example is not a master control valve as in the first two examples.

Fig. 5 is a diagram illustrating the embodiment in which the large capacity pump and the small capacity pump are both unloaded directly by different valve portions of a control valve as used in the embodiment illustrated in Fig. 4.

Figs. 6 and 7 show in part sectional elevation a fixed pressure combined relief and unloading valve for use in the embodiments of Figs. 4 and 5.

The system illustrated in Figs. 1 and 2 comprises a large capacity pump A, a small capacity pump B, an amplifier unloading valve C for controlling the unloading of the pump A, and unloading valve D associated with the pump B and a master control and unloading valve E for controlling the supply of pressure liquid to the unloading valve D and for controlling the escape of liquid from the amplifier section of the valve C, but like references will be used to indicate like parts in the description of the other examples.

As will be seen from the drawing the delivery of the large capacity pump A is connected to the inlet 1 of the amplifier unloading valve C by means of a pipe 2 and the liquid so delivered passes along a passage 3, past a non-return valve 4, into a space 5 and so out to the hydraulic press, not shown, by way of pipe 6.

Whilst the hydraulic press is capable of using the pressure liquid delivered by the large capacity pump A said liquid will continue to flow through the valve C by the path above set forth but as soon as the press has completed its pressure stroke the resulting rise in the pressure of the liquid within the passage 3 of the valve C causes said valve to operate automatically to open an alternative path for the liquid from the pump terminating in the pipe 7 which leads to exhaust. The liquid pump by the small capacity pump B is delivered through the pipe 8 into an annulus or chamber 8a in the master control valve E from whence it passes by way of non-return valve 9, outlet 10, and pipe connection 11 to the space 5 in valve C, and so to the hydraulic press by way of pipe 6.

The liquid so delivered by the pump B to the master control valve is utilised to effect the operation of said valve to deliver liquid at a lower

pressure for the operation of the unloading valve D by way of pipe 12. The operation of the valve E is also utilised to cause automatic operation of the amplifier section of the valve C in a manner hereafter to be described. It is to be understood however that this amplifier section consisting of a large area piston is only required in those cases where the capacity of pump A is too large to be handled by a simple unloading valve.

The amplifier unloading valve C illustrated in the diagram is of the packing-less piston type and comprises a piston 13 and plunger 14 in one piece which is a close sliding fit in a valve body having two corresponding concentric bores 15 and 16 respectively. For facility of description we will assume that this valve is disposed with its axis vertical, with the piston at the top and the plunger projecting downwards into the smaller bore of the valve body, which bore is open at the bottom and communicates with the liquid pressure in space 3. The plunger is provided with a central bore 17 extending upwards to a point just below the piston where a number of radial holes 18 provide communication between the central bore and the space 19 below the piston. The circumference of the piston is provided with a helical groove 20 which serves as a restricted passage between the lower and upper areas of the piston. The valve bore in which the piston is a close sliding fit is closed at the top and provided with an outlet 21 which is opened and closed by a valve in the master control valve E. A light spring 22 is provided within the piston bore to resist the upward movement of the piston. The lower part of the valve body is provided with a number of radial holes 23 communicating between the plunger bore and an annulus 24 which in turn communicates with the exhaust outlet 7 in the side of the valve body. When the piston is in the bottom position the radial holes 23 are covered by the lower end of the valve plunger and the valve is closed. When the piston is moved upwards these radial holes are uncovered by the valve plunger thereby opening the delivery of pump A to exhaust. It will be understood from the above that the construction of the valve is such that the liquid pressure has at all times free access to the under side of both the plunger and the piston and restricted access to the upper side of the piston through the helical groove in the circumference of the piston. The operation of the valve is therefore as follows: When the liquid pressures reaches a predetermined figure the outlet 21 is opened to exhaust. Pressure liquid then flows up through the valve plunger into the space 19 under the piston and thence through the helical groove around the circumference of the piston into the space above the piston and out through the said outlet and owing to restricted passage through the helical groove the pressure below the piston must become greater than that above the piston, so that as the flow increases through the outlet 21 the pressure difference across the piston increases sufficiently to move the piston upwards in opposition to the resistance of the light spring 22 and as the piston rises the lower end of the valve plunger uncovers the radial holes 23 in the plunger bore and the valve is open to exhaust. Then if the pressure falls sufficiently for the master control valve to close the outlet 21 against the escape of liquid the pressure builds up on top of the piston so as to restore hydraulic balance when the piston is moved downwards by the light spring 22 and the lower end of the valve

plunger again covers the radial holes 23 and the valve is closed to exhaust.

The example of combined master control and unloading valve illustrated in the diagram incorporates in its body the annular chamber 8a, and outlet 10 said outlet receiving liquid from the chamber 8a under the control of the non-return valve 9, and outlet 25 for connection to the unloading valve D of pump B by the pipe 12 said outlet receiving liquid from a further annular chamber 26, a spring pressed relief valve 27 open to the pressure of the liquid in said annular chamber 26 and an exhaust outlet 28.

Within the valve body, so as to be surrounded concentrically by the annular chambers 8a and 26, is a bore 29 for the reception in a close sliding fit of a valve plunger or piston 30. The annular chambers are in communication with the interior of the bore 29 by means of two sets of radial passages, one set 31 connecting the bore with the annular chamber 8a and the other set 32 connecting the bore with the annular chamber 26. A further set of radial passages 33 is provided to connect the chamber 26 with the bore at a point above the set of passages 32 to connect said chamber 26 with the exhaust outlet 28 when the valve plunger is in its normal position.

Cut in the exterior surface of the valve plunger so as to encircle the same are annular grooves 34 and 35. These grooves are spaced longitudinally a distance equivalent to the distance between the centres of the sets of radial passages 31 and 32 with which they are adapted to register when the valve plunger is in the raised or open position shown in the drawing.

The grooves 34 and 35 communicate with a longitudinal passage 36 within the interior of the valve plunger by means of radial holes 37. By this means a passage for liquid is provided between the annular chambers 8a and 26 when the valve plunger is in the displaced position and said chambers are isolated from each other when the valve plunger is in the opposite or normal position, and said plunger is always in hydraulic balance laterally. At opposite ends of the valve plunger are spaces 38 and 39 which are always in free communication with exhaust outlet 28. The plunger is therefore always in hydraulic balance longitudinally.

In the drawing the valve plunger is shown in the displaced position and passing liquid from pump B to the unloading valve D at a pressure which is predetermined by the load on the valve 27 and lower than the pressure within the annulus 8a. The movement of the plunger to this displaced position is effected against a spring 40 by pressure liquid acting upon the lower of full pressure side of a piston 41, the stem of which enters the space 38 and abuts against the lower end of the valve plunger.

The pressure liquid which acts against the underside of the piston 41 is derived from the annular chamber 8a and for this purpose this chamber is connected with both ends of the cylinder in which the piston works by passages 43 and 44. In the passage 43 is positioned a non-return valve 45 which serves to pass liquid freely to the outside of the piston but which closes automatically under the influence of its spring, when the pressure falls, to close the passage and prevent the liquid from escaping from the outer end of the aforesaid cylinder. The liquid thus trapped is permitted to escape at a relatively slow rate by leakage past the piston to the inner end of the cylinder to join the liquid in the chamber 8a for

which purpose the piston 41 is given sufficient clearance in its cylinder to permit the said leakage to take place at the desired rate.

By means of the arrangement just described the pressure liquid is permitted to act against an effective area of the piston 41 equal to the area of the stem 42 and when this pressure is sufficient to overcome the resistance of the spring 40 the valve plunger is forced inwards to the position illustrated in the drawing. By thus permitting the pressure liquid to have free access to the outer side of the piston the valve plunger is rendered fully sensitive to and is immediately actuated by a sudden increase in the pressure of said liquid and by restricting the escape of the liquid from the outer side of the piston the return movement of the valve plunger by the spring is damped to prevent hunting.

As will be seen from reference to the drawing the spring loadings on both the valve plunger and the relief valve 27 are independently adjustable so as thereby to vary the pressure of the liquid passing to the cylinder of the unloading valve D and of that passing to the press cylinder independently.

So that the valve E may also function as an unloading valve for controlling the escape of pressure liquid from the outer side of the piston 13 in the amplifier section of the valve C the plunger 30 of the master control valve E is extended to coact with a plunger 46. This plunger is a fluid-tight fit in a bush 47 and, at its lower end, is of reduced section so that in the open position shown in the diagram said reduced section provides a passage for the escape to exhaust of pressure liquid from the outer side of the piston 13 in valve C by way of pipe 48, annulus 49 and radial holes 50. The exhausting liquid first enters space 39 and then passes out to the exhaust outlet 28 by way of passages 51 and 52.

The unloading valve D comprises an automatically operating plunger 53 which is moved longitudinally and relative to a discharge outlet 54 in the wall of each pump bore 55, said outlets 54 being additional to the usual valve controlled pump discharge outlets 56 and said longitudinal movement being effected against a spring 57 constituting a predetermined load. For thus moving the plunger 53 the pressure liquid from valve E is admitted to a space 58 and it there acts against a piston 59 and a ram 60, the piston being of substantially larger area than the ram on which it is mounted for independent relative movement. With this arrangement the first part of the plunger's stroke is effected by the pressure liquid acting against the combined areas of the piston 59 and the ram 60 and this movement is utilised, in the illustrated example, to unload two of the pump chambers by bringing two reduced portions 54a in the length of the valve plunger into correspondence simultaneously with two of the outlet ports 54. The unloading of the last or third pump chamber in the series is effected by the ram alone and this requires a substantial rise to occur in the pressure liquid before it can take place owing to the much smaller area presented to the pressure liquid by the ram than was presented by the combined areas of the piston and the ram which was available for imparting the first part of the unloading stroke. This enables the last pump bore, or pump where separate pumps are under control, to be cut in and out rapidly to supply make-up liquid to the hydraulic press to counteract normal leakage when the

pump A is cut out, with the other pump chambers or pumps remaining unloaded.

It will be seen that with the arrangement just described both pumps are controlled or unloaded by two valves operating in tandem and subject to one load adjustment whereby the valves do not have to be adjusted independently. If desired the two valves may be combined in one valve body.

In the embodiment illustrated in Fig. 3 the amplifier unloading valve C of the first embodiment is dispensed with but such embodiment comprises a large pump A, a small pump B of the sustained pressure type, a master control valve E and a non-return valve F.

When the master control valve is in its normal position the large pump A delivers its pressure liquid by way of pipe a, non-return valve F, into the main pressure main 11 and so to the press.

The small pump B delivers its pressure liquid by way of pipe 8 into the chamber or annulus 8a of the master control valve (see Fig. 1) past the non-return valve 10 into the pipe 11 and so to the press with the pressure liquid from the large capacity pump.

When the press has completed its stroke the pressure in the main 11 and consequently in the chamber or annulus 8a will rise and as this liquid has free access to the outer side of the piston 41 the valve plunger 30 of the master control valve will be displaced against the spring 40 until the valve spindle attains a position where the valve piston controlling the large capacity pump is in its open position, when an alternative passage for the liquid pumped by the large capacity pump will be opened permitting the same to flow through the pipe b into passage 52 and out to exhaust through the outlet 28 in the master control valve.

Owing to the superior pressure on the underside of the non-return valve F and the continued supply thereto of liquid from the small capacity pump this valve will be held seated so liquid delivered by the small capacity pump will continue to pass by way of pipe 11 to the press until a predetermined pressure is reached when this supply will only be sufficient in quantity to supply make-up to maintain substantially constant pressure in the main 11 owing to the partial unloading of the small capacity pump by operation of the unloading spindle 53 of the small pump which will occur in the manner described in connection with Fig. 1.

The system just described will continue to function in the above manner at each operation of the press.

In the embodiment illustrated in Fig. 4 an amplifier unloading valve is employed but a combined relief and unloading valve G hereafter to be described, is employed in place of the master control valve of the previous embodiments, thus permitting the small capacity pump to be of the non-sustained pressure type as its unloading will be taken care of directly by one of the valve portions of the combined relief and unloading valve after the large capacity pump has been unloaded.

In this embodiment the pressure liquid is discharged by the large capacity pump to the inlet 1 of the amplifier unloading valve from whence it flows past the non-return valve 4, and pipe 6 to the press. When the pressure in the main rises sufficiently the amplifier unloading valve will function as described in connection with Figs. 1 and 2 to unload the large capacity pump under the control of the leading valve portion of the control valve G, leaving the small capacity pump

loaded, until the resulting further rise in pressure in the main causes its controlling valve portion in the valve G to open and so unload the small capacity pump also.

In the further embodiment illustrated in Fig. 5 the non-return valve F of Fig. 3 is substituted for the amplifier unloading valve of Fig. 4. In the diagram illustrating this embodiment the supply pipe a of the large capacity pump A and the corresponding pipe 8 of the small capacity pump B are connected by a cross pipe C having in its length the non-return valve F which is so arranged as to permit pressure liquid from the large capacity pump to pass into the pipe 8 when the controlling valve portion of the control valve G is closed but preventing the flow of liquid in the opposite direction. During the working stroke of the press pressure liquid from both pumps will pass into the control valve G by way of pipe 8 and out through pipe 11 to the press. When, however, the press ram reaches the end of its stroke the rise in pressure in the main (pipes 8 and 11) will cause the control valve G to function so that its leading valve portion will open and provide an alternative path for the liquid delivered by the large capacity pump which will then enter the body of the valve G by way of pipe d and so out through pipe e to exhaust. A further rise in pressure in the main will cause the other or following valve portion of the control valve G to open and permit the liquid from small capacity pump B to find its way to exhaust, also through pipe e.

The control valve illustrated in Figs. 6 and 7 is an example of one that is suitable for use in the embodiments illustrated in Figs. 4 and 5 and it combines the functions of a relief valve and an unloading valve. As illustrated this valve comprises two valve spindles 61 and 62 arranged in tandem and these spindles are so dimensioned and arranged in relation to the ports which they control that the valve spindle 62 operates to pass liquid before the valve spindle 61 for the reason that the valve spindle 62 controls the passage of liquid from the large capacity pump A and the other valve spindle controls the passage of liquid from the small capacity pump B. By this means when the delivery from the large capacity pump is passing to exhaust the small capacity pump is still delivering pressure liquid to the press or other hydraulic machine which is being operated.

The valve spindle 61 is formed with a reduced portion 63 in its length so as to leave a small portion 64 at its outer end the diameter of which is slightly less than full diameter to permit liquid to leak past its periphery from the annulus formed between the reduced portion 63 and the bore in which the spindle works to the space 65 at the outer end of the spindle for the purpose of damping the return movement of the valve spindle.

The reduced portion 63 is dimensioned to constitute a transfer passage to pass liquid from a series of radial holes 66 to a further series of radial holes 67 longitudinally spaced from the holes 66. These latter holes in turn, at their outer ends, open into a circumferential space 68 which in turn opens into a space 69 which is open to the underside of the valve spindle 62. This latter spindle has a reduced portion 70 extending part way up its length from one end and is dimensioned so as to function as a transfer passage to pass liquid from an annulus 71 to the space 69 when the valve spindle is in the open position.

Liquid entering the space 69 passes by way of passages 72, 73 to an exhaust outlet 74 whilst pressure liquid from the large capacity pump

enters at 75 into the annulus 71 in the case of the large capacity pump and at 76 into the radial holes 66 in the case of the small capacity pump. When the two valve spindles are in the valve closed positions pressure liquid from both pumps will enter at 76 and pass out through outlet 77. When however the press ram reaches the end of its stroke the consequent rise in pressure in the liquid acting against the valve spindle 61 will cause the spindle to move and with it the other spindle 62 against a load imposed by a spring 78 until a position is reached when the reduced portion 70 of the spindle 62 breaks into holes 79 communicating with the annulus 71 thus permitting said reduced portion to pass to exhaust a gradually increasing proportion of the liquid delivered by the large capacity pump. Should the pressure continue to rise due to the continued supply being passed to the press by the small capacity pump, the valve spindles will continue to move until the reduced portion 63 of the spindle 61 breaks into the radial holes 67 when liquid from the small capacity pump will be by-passed into the space 69 and so to exhaust through outlet 74 with the liquid from the large capacity pump.

We claim:

1. An hydraulic system for controlling the supply of pressure liquid to an hydraulic press comprising a large capacity pump for supplying the main liquid for operating the press ram, a small capacity pump for maintaining substantially constant the pressure in the delivery main and an automatically operating master control valve having two valve portions one of said portions being adapted to control the delivery of the large capacity pump so that said delivery is diverted wholly to exhaust at a predetermined pressure in the delivery main and the other valve portion being adapted to control the delivery of the small capacity pump whereby said small capacity pump is caused to maintain pressure on the press ram after the large capacity pump has been cut out, said valve portions both being subject to a common and adjustable load so that the maximum pressure generated by the two pumps is controlled by a single adjustment.

2. An hydraulic system according to claim 1, wherein the delivery of the small capacity pump is controlled by an automatically operating unloading valve which functions to unload all but one pump chamber at a predetermined pressure and to load and unload the last pump chamber in the series to supply make-up liquid for maintaining pressure on the ram after the large capacity pump has been cut out, said unloading valve comprising a valve member in the form of a sliding plunger, a spring opposing the movement of said plunger to unload in sequence the pump chambers of said pump, and a ram operated by pressure liquid from the master control valve and displaced thereby to unload the pump chambers when said pressure liquid is at a predetermined pressure sufficient to overcome the opposing pressure of the spring.

3. An hydraulic system according to claim 1, wherein the delivery of the small capacity pump is controlled by an unloading valve operated by pressure liquid from the master control valve and by a relief valve forming part of the master control valve, said relief valve having a member, a spring for maintaining said valve member shut, said valve member being subject to the pressure of the liquid being passed to the unloading valve whereby as the pressure of said liquid exceeds a

predetermined amount the valve member is forced to the open position against the action of the spring to by-pass to exhaust any surplus pressure liquid.

4. An hydraulic system according to claim 1, wherein the delivery of the large capacity pump is controlled by the master control valve through the intermediary of a non-return valve.

5. An hydraulic system for controlling the supply of pressure liquid to an hydraulic press comprising a large capacity pump for supplying the main liquid for operating the press ram, a small capacity pump for maintaining substantially constant the pressure in the delivery main and an automatically operating control means having two valve portions, one of said valve portions being adapted to control the delivery of the large capacity pump so that said delivery is diverted wholly to exhaust at a predetermined pressure in the delivery main and the other valve portion being adapted to control the delivery of the small capacity pump, whereby said small capacity pump is caused to maintain pressure on the press ram after the large capacity pump has been cut out, said valve portions both being subject to a common load for controlling the maximum pressure generated by the two pumps.

6. An hydraulic system for controlling the supply of pressure liquid to an hydraulic press comprising a large capacity pump for supplying the main liquid for operating the press ram, a small capacity pump for maintaining substantially constant the pressure in the delivery main, a non-return valve interposed in the delivery passage between the large capacity pump and the delivery main, an unloading valve associated with the small capacity pump, said unloading valve comprising a valve member in the form of a ram operated sliding plunger, a spring opposing the movement of said plunger to unload in sequence pump chambers of said pump and an automatically operating master control and unloading valve having two valve portions one of said valve portions serving to control the delivery of the large capacity pump so that said delivery is diverted wholly to exhaust at a predetermined pressure in the delivery main and the other valve portion serving to control the delivery of pressure liquid to the ram of the unloading valve of the small capacity pump to control the delivery of said pump whereby said small capacity pump is caused to maintain pressure on the press ram after the large capacity pump has been cut out said valve portions both being subject to a common load so that the maximum pressure generated by the two pumps is controlled by a single adjustment.

7. An hydraulic system for controlling the supply of pressure liquid to an hydraulic press comprising a large capacity pump for supplying the main liquid for operating the press ram, a small capacity pump for maintaining substantially constant the pressure in the delivery main, an amplifier unloading valve adapted to divert the whole of the delivery from the large capacity pump to exhaust at a predetermined pressure and a combined relief and unloading valve having two valve portions one of said valve portions controlling the operation of the amplifier unloading valve and the other valve portion controlling the unloading of the small capacity pump said valve portions operating in such manner that the large capacity pump is unloaded whilst the small capacity pump is left loaded until a further rise in pressure occurs when a resulting further move-

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ment of the controlling valve portion produces the unloading of the small capacity pump, the valve portions of said combined relief and unloading valve both being subject to a common load so that the maximum pressure generated by the two pumps is controlled by a single adjustment.

8. An hydraulic system for controlling the supply of pressure liquid to an hydraulic press comprising a large capacity pump for supplying the main liquid for operating the press ram, a small capacity pump for maintaining substantially constant the pressure in the delivery main, a pipe connecting the delivery of the large capacity pump to the delivery of the small capacity pump, a non-return valve in said pipe arranged to open to pass liquid from the large capacity pump delivery to the small capacity pump delivery and a combined relief and unloading valve having

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two valve portions, one of said valve portions serving to control the delivery of the large capacity pump so that said delivery is diverted wholly to exhaust at a predetermined pressure in the delivery main and the other valve portion serving to control the delivery of the small capacity pump whereby said small capacity pump is caused to maintain pressure on the press ram after the large capacity pump has been cut out until a further rise in pressure occurs to cause further movement of the controlling valve portion when the small capacity pump is also unloaded, said valve portions both being subject to a common load so that the maximum pressure generated by the two pumps is controlled by a single adjustment.

JOHN MAURICE TOWLER.
FRANK HATHORN TOWLER.

No references cited.