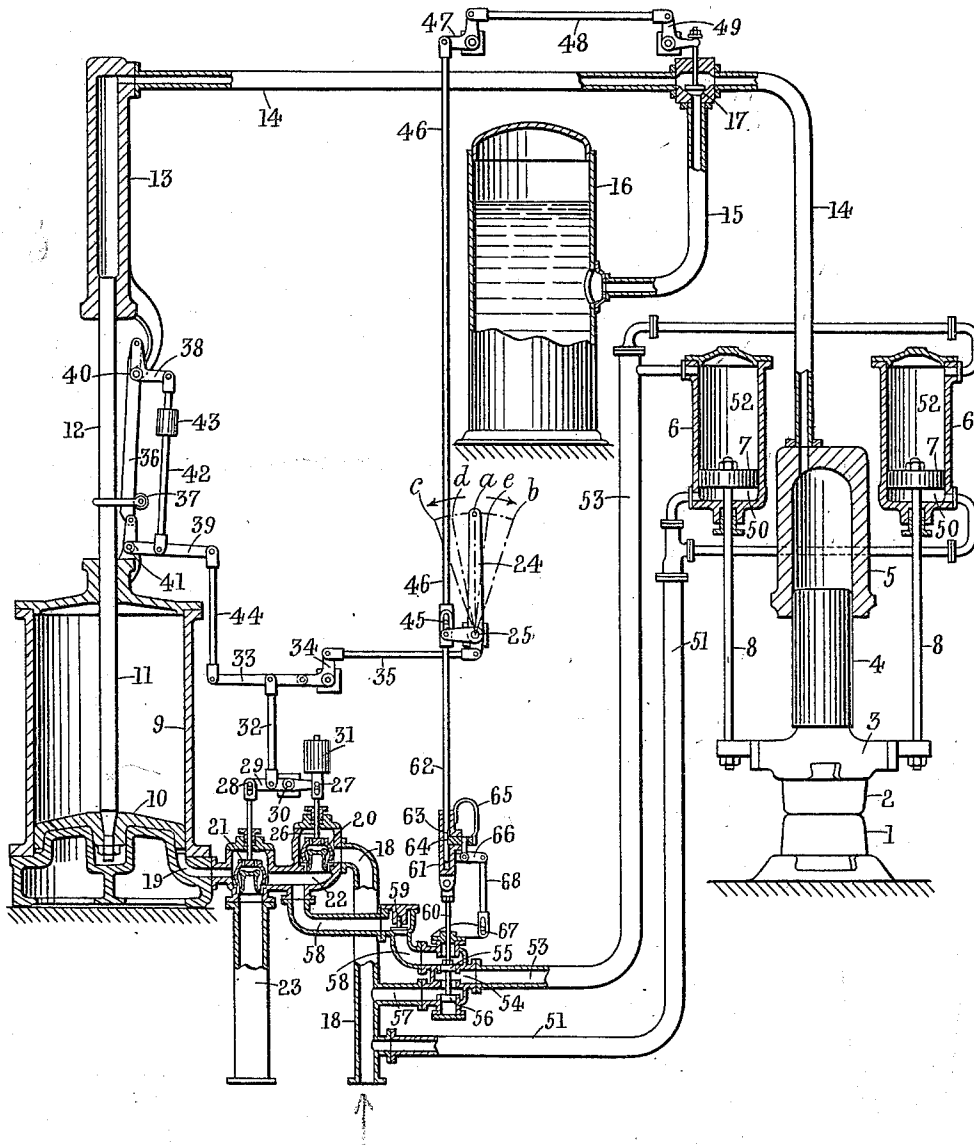


T. E. HOLMES.
STEAM HYDRAULIC INTENSIFIER.
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WITNESSES

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STEAM HYDRAULIC INTENSIFIER.

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To all whom it may concern:

Be it known that I, THOMAS EDMUND HOLMES, a subject of the King of Great Britain, and resident of 8 Oakdale road, Nether Edge, Sheffield, England, engineer, have invented certain new and useful Improvements in Steam Hydraulic Intensifiers, of which the following is a specification.

10 This invention relates to steam hydraulic intensifiers used in connection with hydraulic presses (such as those employed in forging or like operations), wherein both the lifting or return stroke of the presshead
15 and also, when the press is being worked with long strokes, the first or idle part of the downward or operative stroke of the presshead (*i. e.* the part of said stroke prior to the tool encountering the work), are performed under or assisted by the pressure of
20 steam or equivalent elastic fluid (hereinafter referred to as steam); and the invention has for object to enable the greatest practicable economy to be effected in the use of the steam employed for effecting or assisting the
25 descent of the presshead during the idle part of its stroke.

With this object in view, the invention consists in the provision of valve-controlled connections whereby this steam may, on the
30 completion of its primary function above mentioned, be admitted to and allowed to act expansively in the steam cylinder of the intensifier, so as to correspondingly reduce
35 the quantity of live steam required in this cylinder.

According to the present invention, the supply of steam employed for producing or assisting the first or idle part of the operative
40 stroke of the presshead is governed by means of a manually controlled valve adapted on the one hand, to admit the steam to the cylinder (or cylinders) wherein it performs the primary function of producing or assisting
45 such idle movement of the presshead, and on the other hand, to cut off the supply of steam to said cylinder and permit the steam therein to pass by way of a non-return valve into the intensifier cylinder so
50 as thereafter to act expansively in both cylinders; any live steam directly admitted to the intensifier cylinder being confined thereto by the non-return valve, while the steam already entrapped within the first-men-
55 tioned cylinder (or cylinders) is permitted

to expand therein so long as the downward or operative stroke of the presshead continues.

In the preferred arrangement, free communication is constantly maintained between the main steam supply pipe and the lower end of the lifting cylinders, and in addition, steam is admitted to and exhausted from the upper end of the lifting cylinders by means of a piston valve of the duplex type adapted to put said end of these cylinders into connection alternatively with the main steam supply pipe and (by way of a non-return valve) with the steam port of the intensifier cylinder; while, in order to render the action automatic, this piston valve is detachably coupled to the
60 handing lever whereby the action of the intensifier and press as a whole is governed, through the medium of automatically acting trip mechanism. 65 70 75

The accompanying drawing illustrates the present invention in an elementary or schematic form as applied to a steam hydraulic intensifier press embodying various known features. 80

In this arrangement, 1 represents the anvil, 2 the forging tool carried by the presshead 3, 4 the hydraulic ram to which the presshead is attached, and 5 the hydraulic cylinder wherein the ram 4 works vertically. 85

6, 6 are the so-called lifting cylinders, wherein the pistons 7, 7 are fitted to work, these pistons being attached by rods 8, 8 to the presshead 3. 90

9 is the steam cylinder of the intensifier, and 10 its vertically-working piston, the piston-rod 11 being upwardly prolonged to form the ram 12 which works vertically in the hydraulic cylinder 13 of the intensifier. 95
14 is the hydraulic main pressure pipe connecting the upper ends of the two hydraulic cylinders 13 and 5, and 15 is a branch leading from this pipe to the air-vessel 16. 100

Communication between the main pipe 14 and the branch 15 is controlled by means of a valve 17, which is normally held closed by superior pressure existing in the pipe 14 but is free to open under the pressure stored in the air-vessel 16 when, a partial vacuum being created in the main pipe 14, it is necessary to admit water from the air-vessel to supply the deficiency. Manually-controlled means (hereinafter more fully described) 105 110

are provided for opening the valve 17 when, the pipe 14 being full of water and both the rams 4 and 12 being lowered, it is necessary to permit the displacement of water from the pipe 14 to the air-vessel in order that the ram 4 may be free to ascend when the presshead 3 is to be lifted by the pistons 7.

18 is the main steam supply pipe, whose communication with the combined inlet and exhaust port 19 of the cylinder 9 is controlled by means of a balanced drop valve 20, while 21 is a similar valve for controlling communication between the passage 22 (which leads from the valve 20 to the port 19) and the exhaust pipe 23. The steam inlet valve 20 and steam exhaust valve 21 are controlled on the one hand manually by means of a handing lever 24 fulcrumed at a fixed point 25 and serving to govern all the operations of the press, and on the other hand automatically by means of hunting gear commanded by the piston 10 of the intensifier. For this purpose the stems of the valves 20 and 21 have each a pin-and-slot connection (indicated at 27 and 28 respectively) with a lever 29 fulcrumed at a fixed point 30; the steam inlet valve 20 being loaded as indicated at 31 so as to hold this valve closed in opposition to the steam pressure acting on its under surface against the unbalanced area of its stem 26. The lever 29 is coupled by a link 32 to a floating lever 33 which is connected on the one hand to the handing lever 24 through the medium of a bell-crank lever 34 (fulcrumed at a fixed point) and a link 35, and on the other hand to the operative member of the hunting gear just mentioned. This member consists of a bar 36 which extends alongside of, but in a direction inclined with reference to, the ram 12, so as to be engaged by a roller 37 carried by said ram; the upper and lower ends of the bar being pivotally attached respectively to bell-crank levers 38, 39 fulcrumed at fixed points 40, 41 and coupled together by a rod 42 carrying a counterweight 43 which constantly tends to restore the bar 36 to the normal position from which the upward movement of the roller 37 displaces it.

The bell-crank lever 39 is coupled by a link 44 to the floating lever 33, the arrangement of the parts constituting the hunting gear being such that, assuming the ram 4 and presshead 3 to be raised, then, when the handing lever 24 is shifted from the mid or normal position (which it is shown as occupying in the drawing and which may be designated as *a*) in the direction for causing pressure to be exerted upon the ram 4 (*i. e.* the direction toward the right hand limit of its movement, designated *b* in the drawing), the valve 20 will be opened to admit steam beneath the intensifier piston 10, which will rise and cause hydraulic

pressure to be transmitted from the cylinder 13 to the cylinder 5 until, as the piston 10 approaches that point in its travel which corresponds to the point at which the handing lever 24 is held, the valve 20 will be automatically closed and the piston 10 will be arrested on reaching the point in question.

The handing lever has a pin-and-slot engagement as at 45 with a rod 46 coupled (through suitable connections as at 47, 48) to a lever 49 adapted to open the valve 17 positively, without interfering with the freedom with which said valve is adapted to open automatically under the influence of superior pressure in the air-vessel 16. The arrangement in this respect is such that when the handing lever 24 is shifted from its mid or normal position *a* to a point *d* between the latter and the farthest limit *c* of its movement in the direction for causing the ram 4 and presshead 3 to be raised (*i. e.* the direction toward the left hand in the drawing), not only will the exhaust valve 21 be opened to allow any steam present in the cylinder 9 to escape therefrom as the piston 10 descends, but the valve 17 will be lifted from its seat so that, as the ram 4 is raised (in the manner hereinafter explained) and consequently forces water from the cylinder 5 into the pipe 14, any surplus water in said pipe (beyond the quantity required to fill the cylinder 13 as the ram 12 descends) will be permitted to pass into the air-vessel 16.

In the case of large apparatus and high hydraulic pressures it will be obvious that the rod 46, instead of being mechanically connected to the valve 17 as indicated in the drawing, may operate said valve through the medium of a power relay.

For the purpose of the present invention the lower ends 50 of both lifting cylinders 6 are in permanent connection with the main steam supply pipe 18 by way of a pipe 51, with the result that, as a cushion of live steam will be maintained beneath the pistons 7 so long as steam is supplied to the system as a whole, the presshead 3 and ram 4 will have a constant tendency to rise to the highest limit of their stroke. According to the present invention the upper end 52 of each lifting cylinder is capable of being either on the one hand supplied with live steam from the pipe 18 or on the other hand exhausted into the intensifier cylinder 9 beneath the piston 10, these operations being effected under the control of the handing lever 24 and in coördination with the other operations of the press. With this object in view, the upper ends 52 of both lifting cylinders 6 are connected in common, through a single pipe 53, with the middle chamber 54 of a duplex piston valve 55, 56. The lower member 56 of this valve controls the connection between the cham-

ber 54 and a branch 57 leading from the main steam supply pipe 18, while the upper member 55 of the valve controls the connection between the chamber 54 and a branch 58 leading, by way of a non-return valve 59, to the passage 22, which is in permanent connection with the port 19 of the steam cylinder 9 of the intensifier. The piston valve 55, 56 is capable of occupying either of two positions, namely, the normal or lowered position wherein it closes the communication between the pipes 18 and 53 and establishes connection between the pipes 53 and 58, and the raised position (shown on the drawing) wherein it establishes connection between the pipes 18 and 53 and closes the communication between the pipes 53 and 58; the means by which these changes of position are produced being as follows: The piston valve 55, 56, which works vertically, tends to assume the lowered position by gravity (assisted if necessary by spring pressure), and is detachably coupled to the handing lever 24 through the medium of trip mechanism whereof (in the example illustrated) the lower member, permanently connected to the valve-stem 60, consists of an upright socket 61 while the upper member, permanently connected to the lever 24, consists of a plunger 62 slidable lengthwise in said socket and forming a downward prolongation of the rod 46 previously referred to. The plunger 62, at a point within the length of the socket 61, presents a lateral notch or recess 63 with which a latch 64 carried by the socket tends to engage; this latch, which is slidable through a lateral opening in the socket 61, being pressed by a spring 65 in the direction to engage the notch. The arrangement is such that when, the valve 55, 56 being in its lowered position, the handing lever 24 is moved to the point *c*, the plunger 62 will descend so far into the socket 61 as to permit of the latch 64 entering the notch 63, so that when the lever 24 is afterward returned toward the point *a*, the socket 61 will participate in the upward movement of the plunger 62 and the valve 55, 56 will be raised to its highest position (shown on the drawing) when the lever 24 reaches its mid position *a*.

The latch 64 is engaged by the vertical arm of a bell-crank lever 66 fulcrumed to the socket 61, the horizontal arm of this lever being adapted, when the socket itself is raised to the level corresponding to the mid position *a* of the handing lever 24, to encounter a resistance such for example as a fixed pin 67 to which the lever 66 is coupled by a slotted link 68, so that on such upward movement of the socket being continued in consequence of the handing lever being shifted to the point *c* (a short distance from the point *a* toward the limit

b), the latch 64 will be retracted from the notch 63 against the stress of the spring 65, and the valve 55, 56 will thereupon drop back to its normal or lowered position.

The operation of the apparatus as above described is as follows: Assuming the handing lever 24 to be in its mid or normal position *a* as shown, while however the piston valve 55, 56 is resting in its normal or lowered position, it follows that, if live steam be turned on into the main steam pipe 18, this steam will be prevented by the valve 20 from entering the intensifier cylinder 9. Steam will also be prevented by the piston valve 55, 56 from gaining access from the pipe 18 to the pipe 53 and the upper ends 52 of the cylinders 6, but will fill the pipe 51 and, entering the lower ends 50 of the lifting cylinders, will exert upward pressure upon the piston 7. If, at the commencement of operations (*i. e.* on steam being thus admitted to the system) the intensifier piston 10 and ram 12, and also the main ram 4 and lifting piston 7 be all in their lowest positions as shown, it will be obvious that, as the hydraulic cylinders 13 and 5 and the hydraulic main pipe 14 will all be full of water and the relief valve 17 will at the same time be closed, the steam admitted as above stated to the lower ends 50 of the lifting cylinders will be unable to raise the pistons 7 so as to lift the presshead 3 and main ram 4. Consequently, in order to set the press in operation by lifting the presshead so as to permit of the work being introduced between the anvil 1 and tool 2, the handing lever 24 must (as a preliminary measure) be shifted from its mid position *a* to the position *d* whereat it opens the relief valve 17 so that, the surplus water being free to escape from the pipe 14 into the air-vessel 16, the steam pressure beneath the pistons 7 will be permitted to raise the latter and thus lift the presshead 3 to the farthest limit of its stroke. If, now, the presshead and tool being thus fully raised and the work being on the anvil, the press is to be worked with long strokes, the handing lever 24 is first moved to the extreme position *c* in the direction for lifting the presshead, with the result that the piston valve 55, 56 becomes automatically coupled to the handing lever by means of the trip mechanism. By now moving the handing lever 24 back to its mid position *a*, the piston valve will be raised so as to admit steam to the upper ends 52 of the lifting cylinders 6; the steam pressure thus permitted to act upon the upper side of the lifting pistons 7 thereupon reacting with the weight of said pistons and of the presshead 3 to lower the latter (in opposition to the resistance of the permanent cushion of steam beneath the lifting pistons) until the tool 2 encounters the work. A slight fur-

ther movement of the handing lever 24 in the direction for causing the presshead to descend (namely, from the mid position *a* to the position *e*) will allow the trip mechanism to disconnect the piston valve 55, 56 from the handing lever, whereupon this valve will drop back to its normal position, cutting off the steam supply to the upper ends 52 of the lifting cylinders and connecting the latter with the intensifier cylinder 9. The steam already admitted to the upper ends of the lifting cylinders will now expand therein and also in the intensifier cylinder, so that the intensifier piston 10 and ram 12 will be raised and the presshead 3 will be forced down to effect an initial compression or penetration of the work.

If it be desired to continue the squeeze, live steam may be admitted to the intensifier cylinder 9 (so as to cause the presshead to be forced down by hydraulic pressure yet further or more powerfully) by a further movement of the handing lever beyond the position *e* in the direction of *b*. The increased steam pressure thus produced in the intensifier cylinder will be confined thereto by the action of the non-return valve 59; the continued expansion of the steam entrapped within the upper ends 52 of the lifting cylinders co-acting, however, with the hydraulic pressure resulting from the operation of the live steam in the intensifier cylinder 9. On the completion of the working stroke of the presshead, the handing lever 24 is returned toward the mid position *a*, with the result that the supply of live steam to the intensifier cylinder 9 is cut off by the closure of the valve 20, the exhaust valve 21 of this cylinder is opened, and the hydraulic pressure due to the action of the intensifier ceases. When the steam pressure in the intensifier cylinder 9 falls below that in the upper ends 52 of the lifting cylinders, any pressure yet remaining in the steam previously entrapped within the latter will force its way past the non-return valve 59 and escape to the exhaust by way of the exhaust valve 21 of the intensifier cylinder. As the steam piston 10 of the intensifier returns to its normal position, the presshead 3 will rise in consequence of the constant steam pressure existing beneath the lifting pistons 7, so that all the parts will be restored to their initial position in readiness for a repetition of the cycle of operations described.

If it be desired to work the press with short and rapid strokes, the operation is substantially identical with that hitherto known. That is to say, assuming the presshead 3 to be initially raised as already described and the work to be in place between the anvil 1 and tool 2, the handing lever 24 is at once moved from the mid position *a* in the direction of the extreme position *b* for

causing the presshead to descend, without any preliminary movement in the opposite direction as above described. The result of this is that, the piston valve 55, 56 being left in its normal or lowered position, no steam is admitted to the upper ends 52 of the lifting cylinders, and the presshead 3 is forced down against the permanent cushion of live steam (in the lower ends 50 of the lifting cylinders) solely by the hydraulic pressure resulting from the action of live steam in the intensifier cylinder 9; the handing lever 24 being moved to and fro at the pressure side of its mid position (*i. e.* between the positions *a* and *b*) at a rate and to an extent corresponding to the rate and amplitude of the strokes which the tool 2 is required to perform.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a second steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for admitting steam to the second steam cylinder for causing the main hydraulic ram to perform the idle part of its operative stroke, and means for allowing steam to pass from the second steam cylinder to the intensifier steam cylinder at will.

2. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a second steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for admitting steam to the second steam cylinder for causing the main hydraulic ram to perform the idle part of its operative stroke, means for allowing steam to pass from the second steam cylinder to the intensifier steam cylinder at will, and means for admitting steam to the second steam cylinder for causing the main hydraulic ram to perform its reverse stroke.

3. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and

so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a second steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for admitting steam to the second steam cylinder for causing the main hydraulic ram to perform the idle part of its operative stroke, means for allowing steam to pass from the second steam cylinder to the intensifier steam cylinder at will, and means for maintaining in the second steam cylinder a constant supply of live steam for causing the main hydraulic ram to perform its reverse stroke.

4. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a second steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for admitting steam to the second steam cylinder for causing the main hydraulic ram to perform the idle part of its operative stroke, means for allowing steam to pass from the second steam cylinder to the intensifier steam cylinder at will, and a non-return valve for preventing steam passing in the reverse direction between said cylinders.

5. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a second steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be removable in unison therewith, a valve capable of occupying two alternative positions, in one of which steam is admitted to the second steam cylinder for causing the main hydraulic ram to perform the idle part of its operative stroke, and in the other of which positions steam is cut off from said second steam cylinder and permitted to pass therefrom to the intensifier steam cylinder, and means for operating said valve under manual control.

6. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein

and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a second steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, a valve capable of occupying two alternative positions, in one of which steam is admitted to the second steam cylinder for causing the main hydraulic ram to perform the idle part of its operative stroke, and in the other of which positions steam is cut off from said second steam cylinder and permitted to pass therefrom to the intensifier steam cylinder, valves for controlling the supply of live steam to the intensifier steam cylinder and the exhaust of steam from the same, a hand-lever for operating said valves, and trip-mechanism for connecting and automatically disconnecting the previously mentioned valve to and from said hand-lever.

7. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a double-acting steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for maintaining a constant supply of live steam to one end of the double-acting cylinder for causing the main hydraulic ram to perform its return stroke, a steam-passage leading to the opposite end of said double-acting cylinder, a connection from said passage to the source of steam supply, a second connection from the same passage to the intensifier steam cylinder, a non-return valve on the last-mentioned connection for preventing the passage of steam from the intensifier steam cylinder to the double-acting steam cylinder, a valve for establishing communication between said passage and the respective connections alternatively, and means for operating said valve under manual control.

8. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a double-acting steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in

unison therewith, means for maintaining a constant supply of live steam to one end of the double-acting cylinder for causing the main hydraulic ram to perform its return stroke, a steam-passage leading to the opposite end of said double-acting cylinder, a connection from said passage to the source of steam supply, a second connection from the same passage to the intensifier steam cylinder, a non-return valve on the last-mentioned connection for preventing the passage of steam from the intensifier steam cylinder to the double-acting steam cylinder, a valve for establishing communication between said passage and the respective connections alternatively, valves for controlling the supply of live steam to the intensifier steam cylinder and the exhaust of steam from the same, a hand-lever for operating said valves, and trip-mechanism for coupling and automatically uncoupling the previously mentioned valve to and from said hand-lever.

9. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a double-acting steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for maintaining a constant supply of live steam to one end of the double-acting cylinder for causing the main hydraulic ram to perform its return stroke, a steam-passage leading to the opposite end of said double-acting cylinder, a connection from said passage to the source of steam supply, a second connection from the same passage to the intensifier steam cylinder, a non-return valve on the last-mentioned connection for preventing the passage of steam from the intensifier steam cylinder to the double-acting steam cylinder, a valve for establishing communication between said passage and the respective connections alternatively, valves for controlling the supply of live steam to the intensifier steam cylinder and the exhaust of steam from the same, a hand-lever for operating said valves, hunting gear connected to said hand-lever and valves and to the intensifier steam piston for controlling said valves in accordance with the adjustment of the hand-lever, and trip-mechanism for coupling and automatically uncoupling the previously mentioned valve to and from said hand-lever.

10. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic

cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a double-acting steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for maintaining a constant supply of live steam to one end of the double-acting cylinder for causing the main hydraulic ram to perform its return stroke, a steam-passage leading to the opposite end of said double acting cylinder, a connection from said passage to the source of steam supply, a second connection from the same passage to the intensifier steam cylinder, a non-return valve on the last-mentioned connection for preventing the passage of steam from the intensifier steam cylinder to the double-acting steam cylinder, a valve for establishing communication between said passage and the respective connections alternatively, valves for controlling the supply of live steam to the intensifier steam cylinder and the exhaust of steam from the same, a hand-lever for operating said valves, hunting gear connected to said hand-lever and valves and to the intensifier steam piston for controlling said valves in accordance with the adjustment of the hand-lever, trip-mechanism for coupling and automatically uncoupling the previously mentioned valve to and from said hand lever, an air vessel, a connection therefrom to the water passage between the two hydraulic cylinders, a valve on said connection for admitting water automatically to said passage from the air vessel when the pressure in the latter is superior to that in the former, and means for enabling the last-mentioned valve to be opened manually in opposition to the pressure in said passage.

11. In a hydraulic press, the combination of an intensifier steam cylinder, a piston fitted to work therein, an intensifier hydraulic cylinder, a ram fitted to work therein and so connected to the intensifier steam piston as to be movable in unison therewith, a main hydraulic cylinder, a ram fitted to work therein, a passage for water under pressure between the two hydraulic cylinders, a double-acting steam cylinder, a piston fitted to work therein and so connected to the main hydraulic ram as to be movable in unison therewith, means for maintaining a constant supply of live steam to one end of the double-acting cylinder for causing the main hydraulic ram to perform its return stroke, a steam-passage leading to the opposite end of said double-acting cylinder, a connection from said passage to the source of steam supply, a second connection from the same passage to the intensifier steam

cylinder, a non-return valve on the last-mentioned connection for preventing the passage of steam from the intensifier steam cylinder to the double-acting steam cylinder, a valve for establishing communication between said passage and the respective connection alternatively, valves for controlling the supply of live steam to the intensifier steam cylinder and the exhaust of steam from the same, a hand-lever for operating said valves, hunting gear connected to said hand-lever and valves and to the intensifier steam piston for controlling said valves in accordance with the adjustment of the hand-lever, trip-mechanism for coupling and automatically uncoupling the

previously mentioned valve to and from said hand-lever, an air-vessel, a connection thereto from the water-passage between the two hydraulic cylinders, a valve on said connection for admitting water automatically to said passage from the air-vessel when the pressure in the latter is superior to that in the former, and a connection between the hand-lever and the last-mentioned valve for enabling said valve to be opened in opposition to the pressure in said passage.

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Witnesses:

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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."