No. 642,009. Patented Jan. 23, 1900.

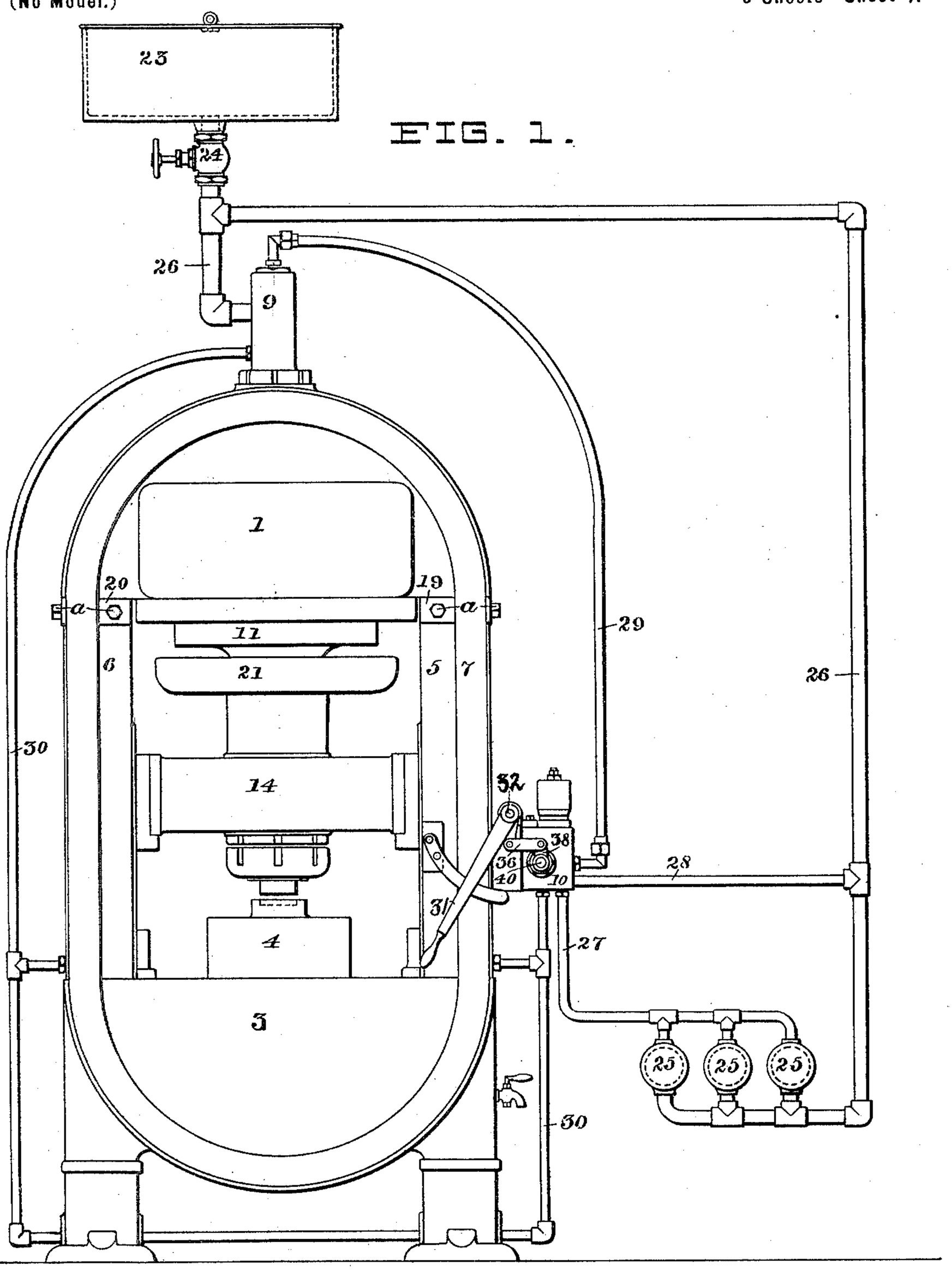
W. & C. SELLERS & W. LEWIS.

HYDRAULIC PRESS.

(Application filed July 11, 1895.)

(No Model.) 9 Sheets—Sheet 1.

FIG. 1.



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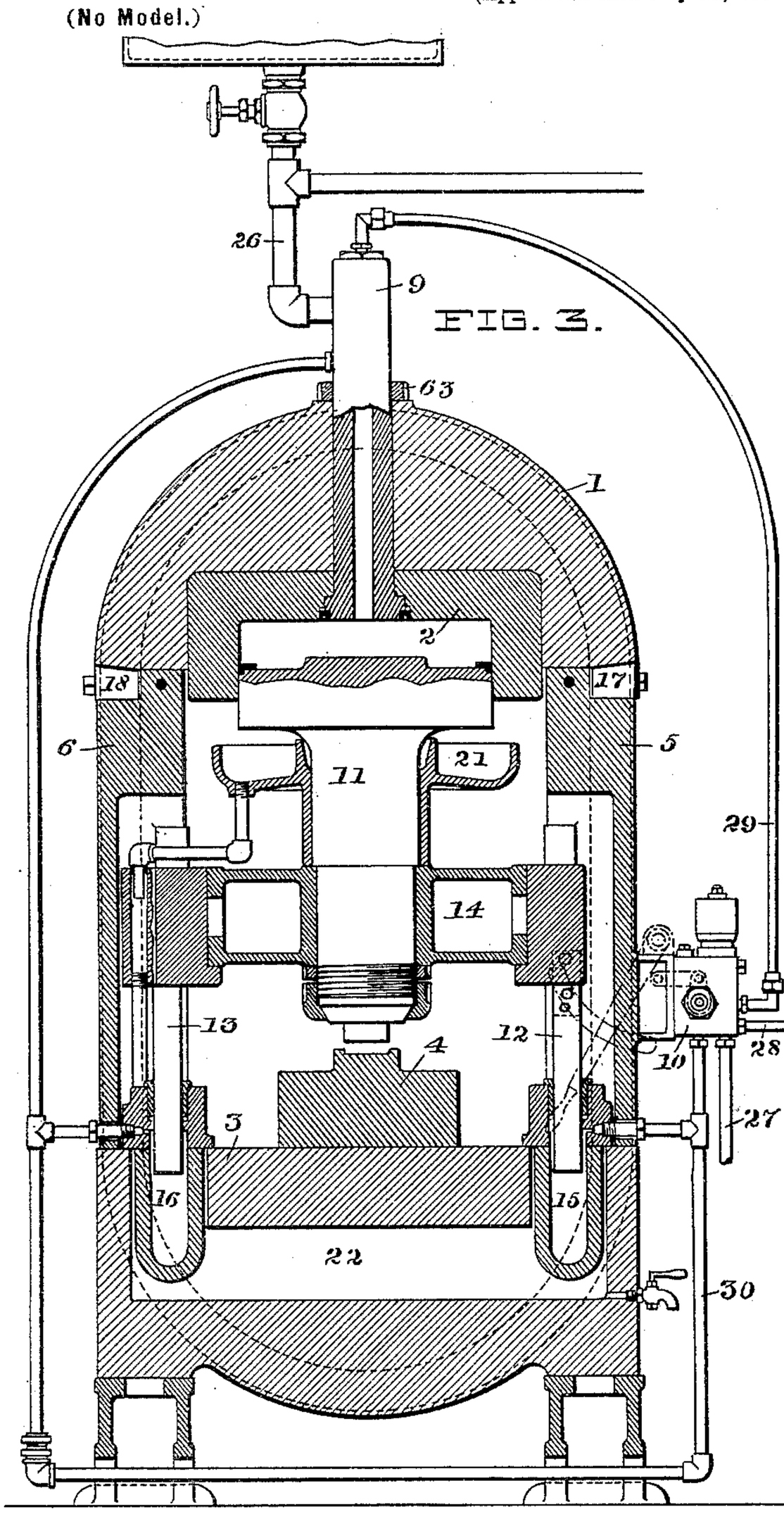

FIG. 3.

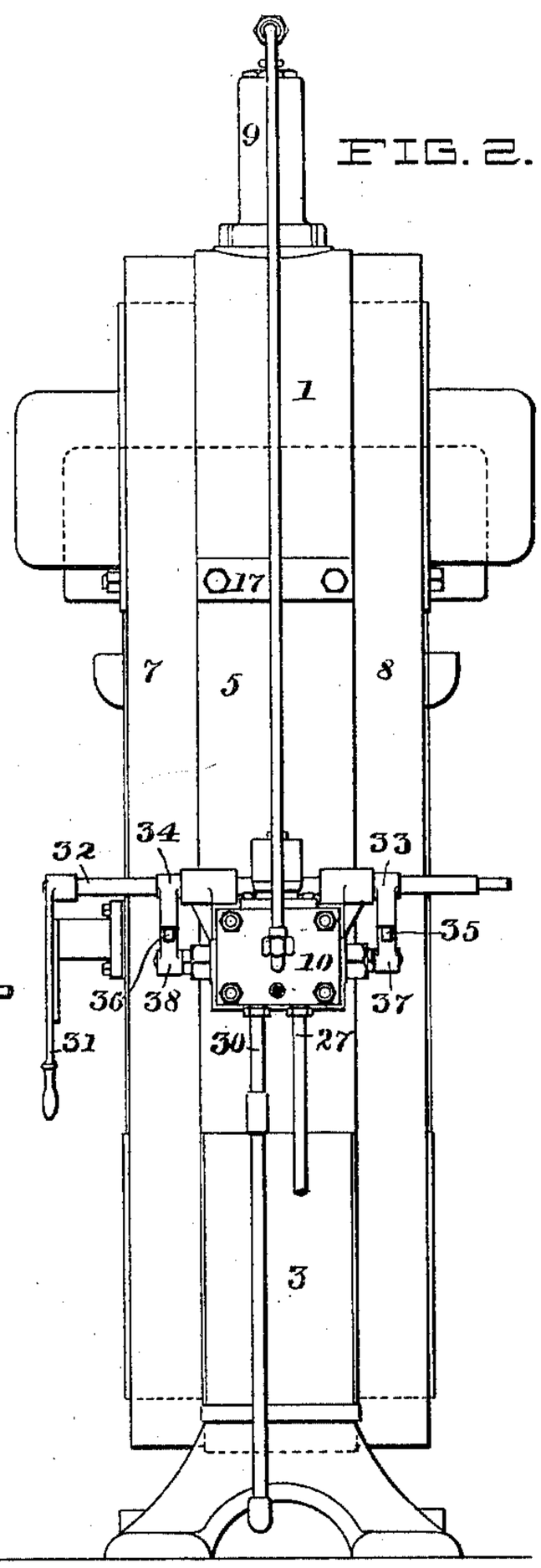

FIG. 2.

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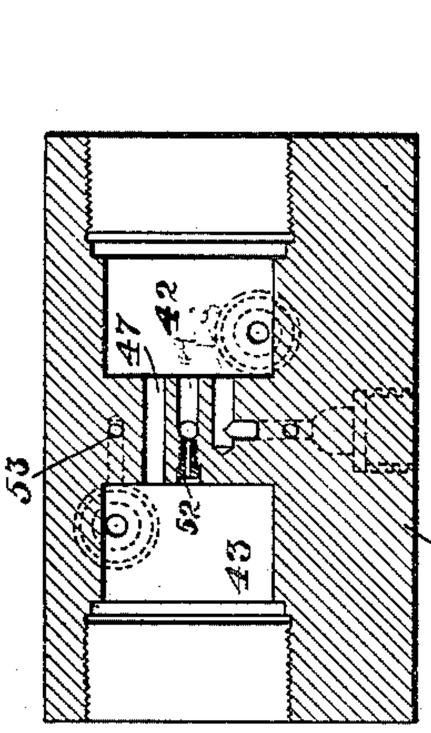

FIG. 7.

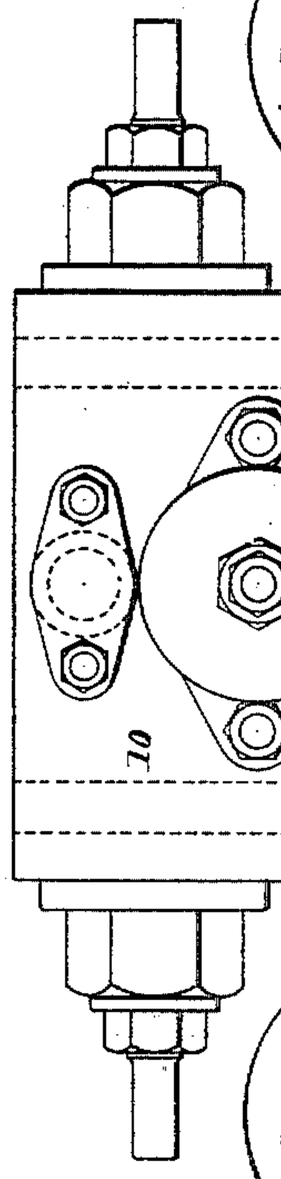

FIG. 4.

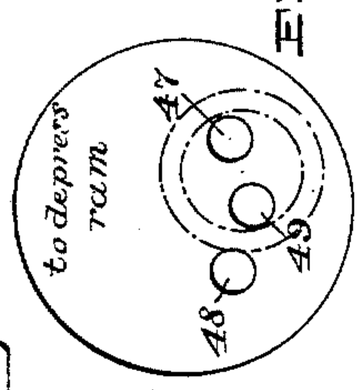

FIG. 10 a.

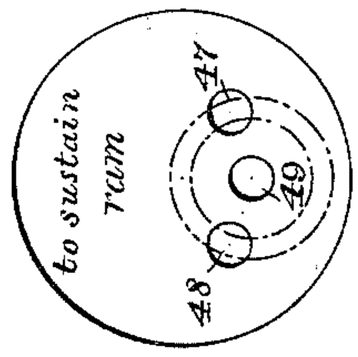

FIG. 10.

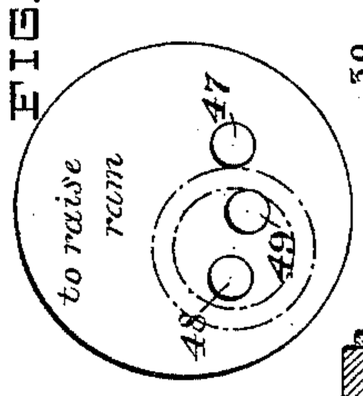

FIG. 10 b.

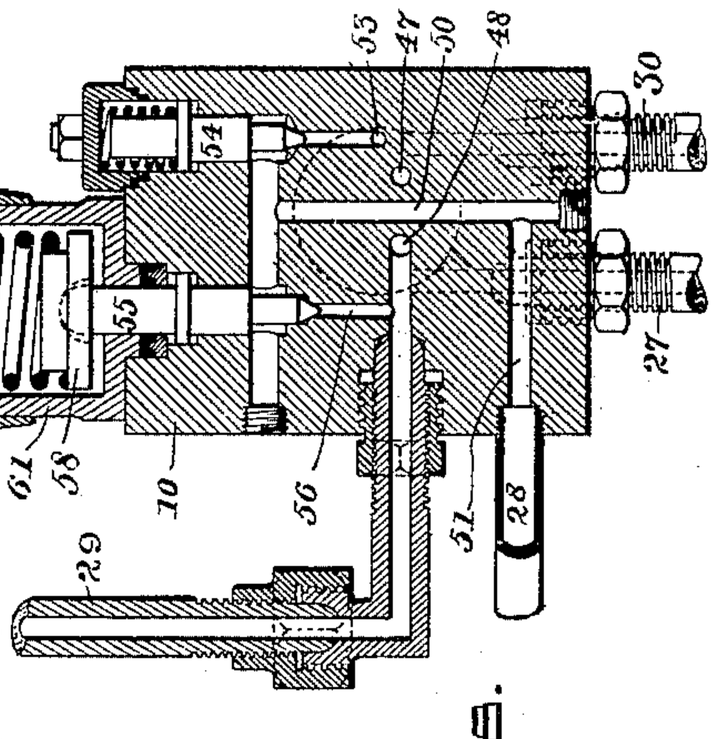

FIG. 6.

FIG. 8.

FIG. 11.

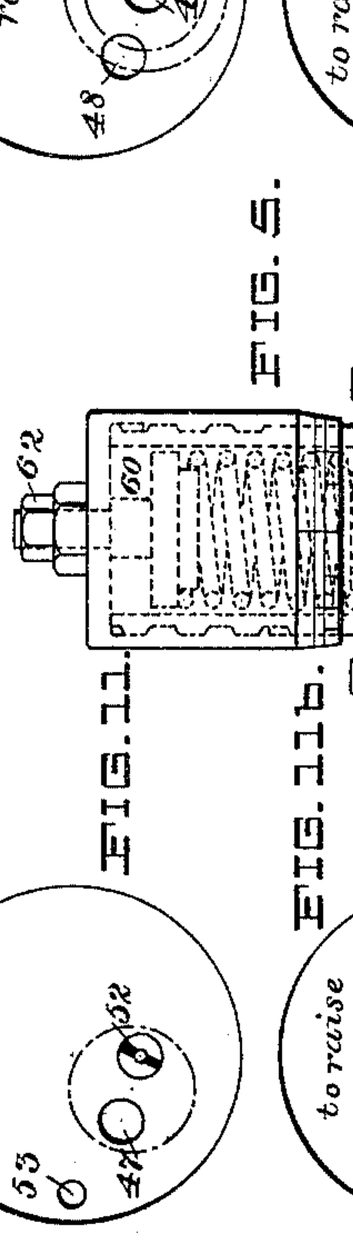

FIG. 11 b.

FIG. 5.

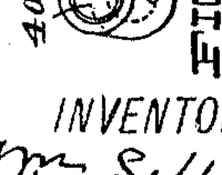

FIG. 9.

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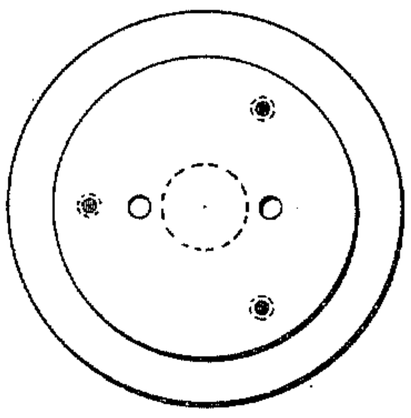

FIG. 13.

FIG. 12.

FIG. 14.

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FIG. 16.

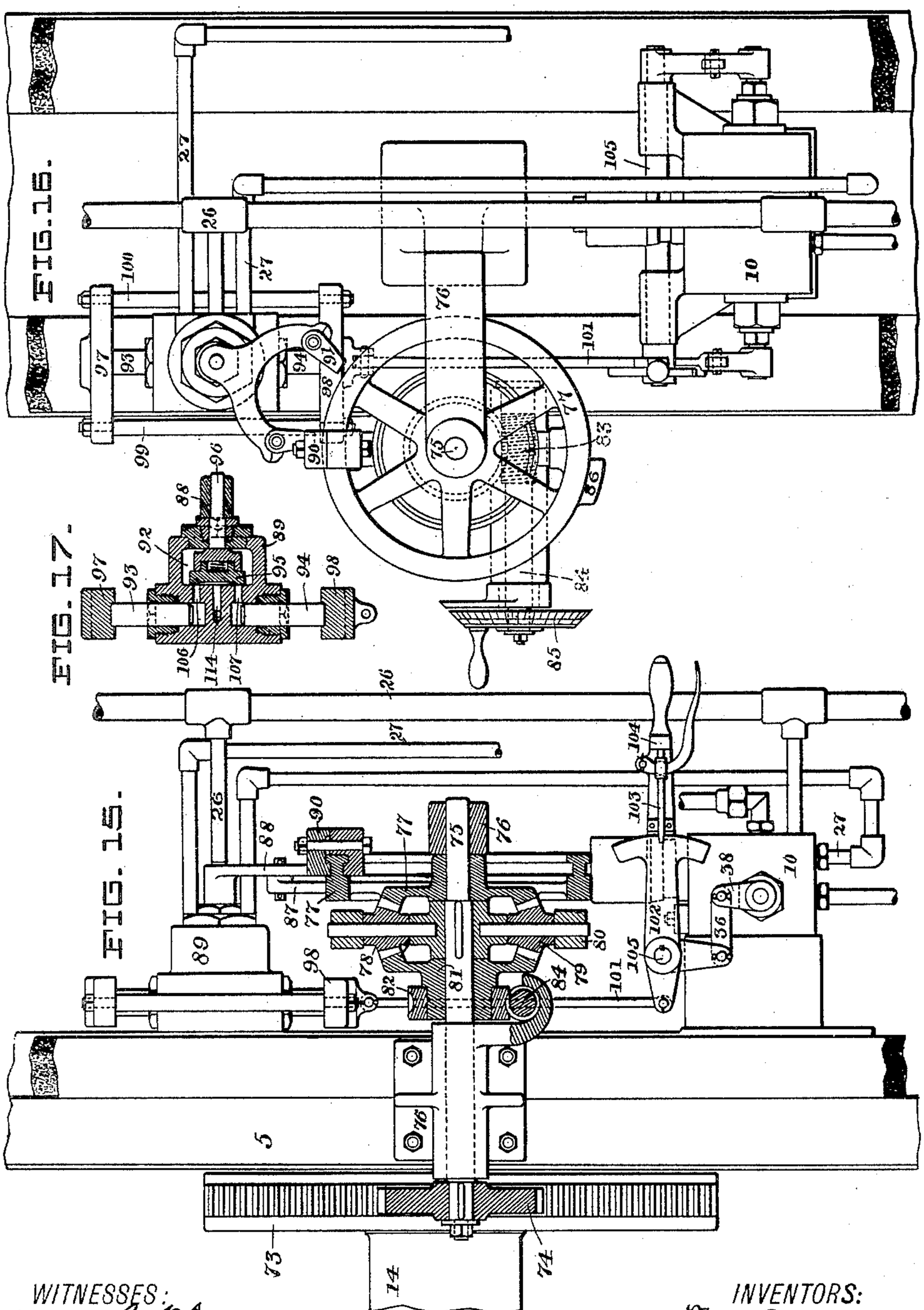

FIG. 17.

FIG. 15.

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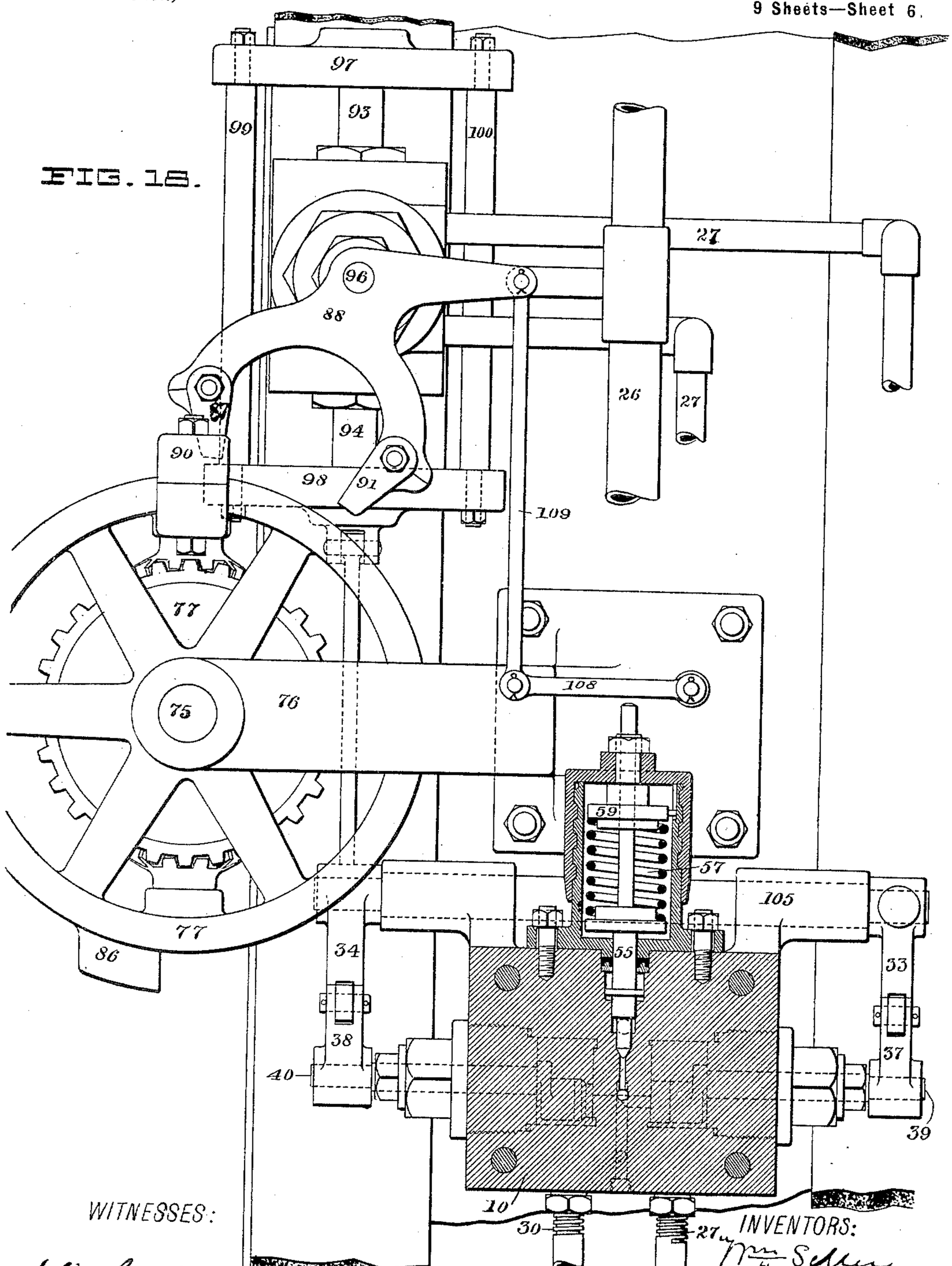
(No Model.) 9 Sheets—Sheet 6.

FIG. 18.



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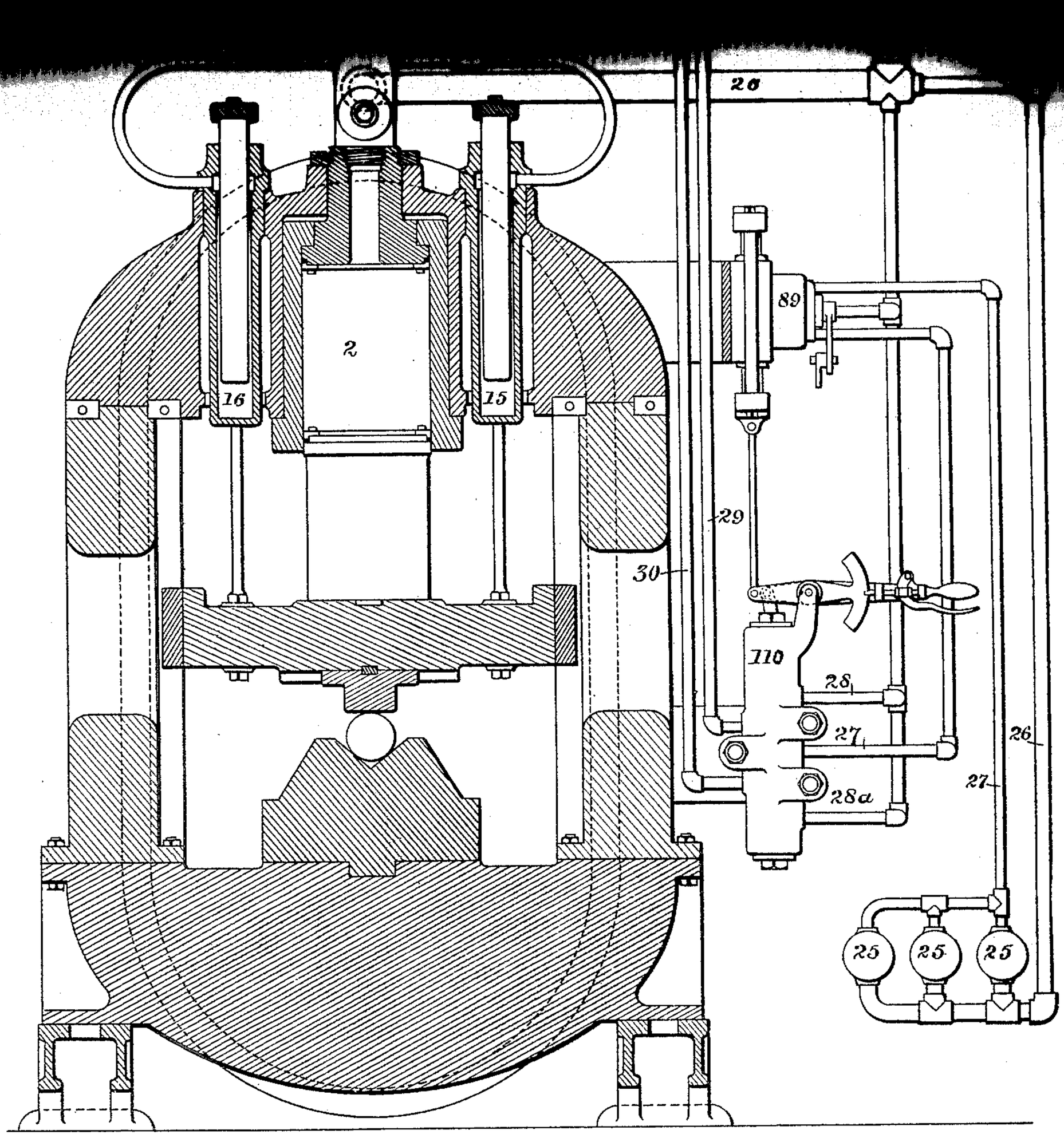

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HYDRAULIC PRESS.

(Application filed July 11, 1895.)

(No Model.) 9 Sheets—Sheet 8.

FIG. 20d.

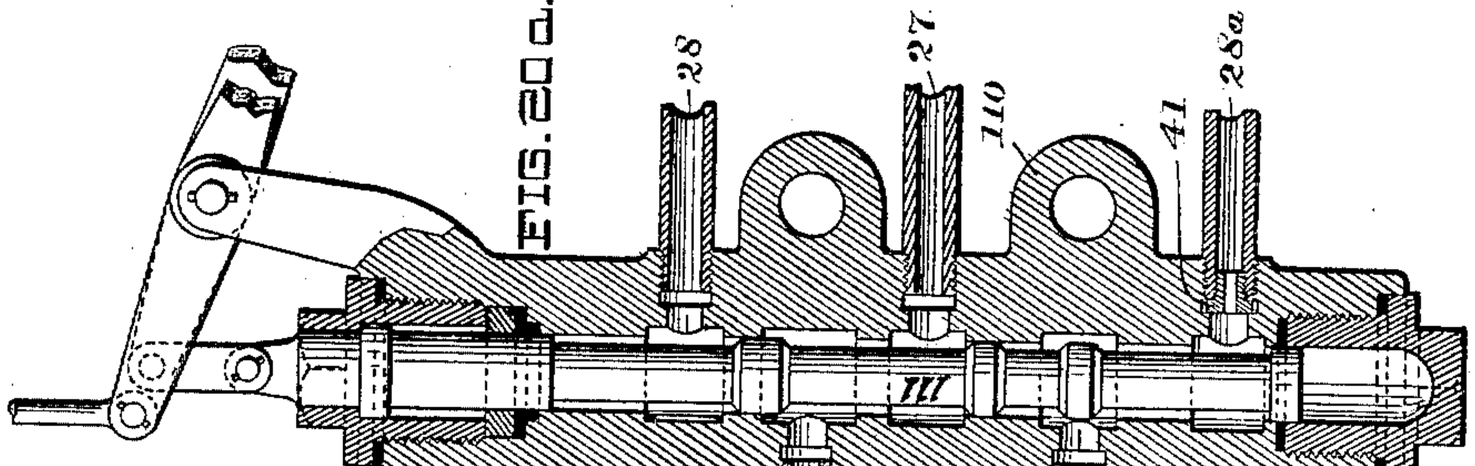
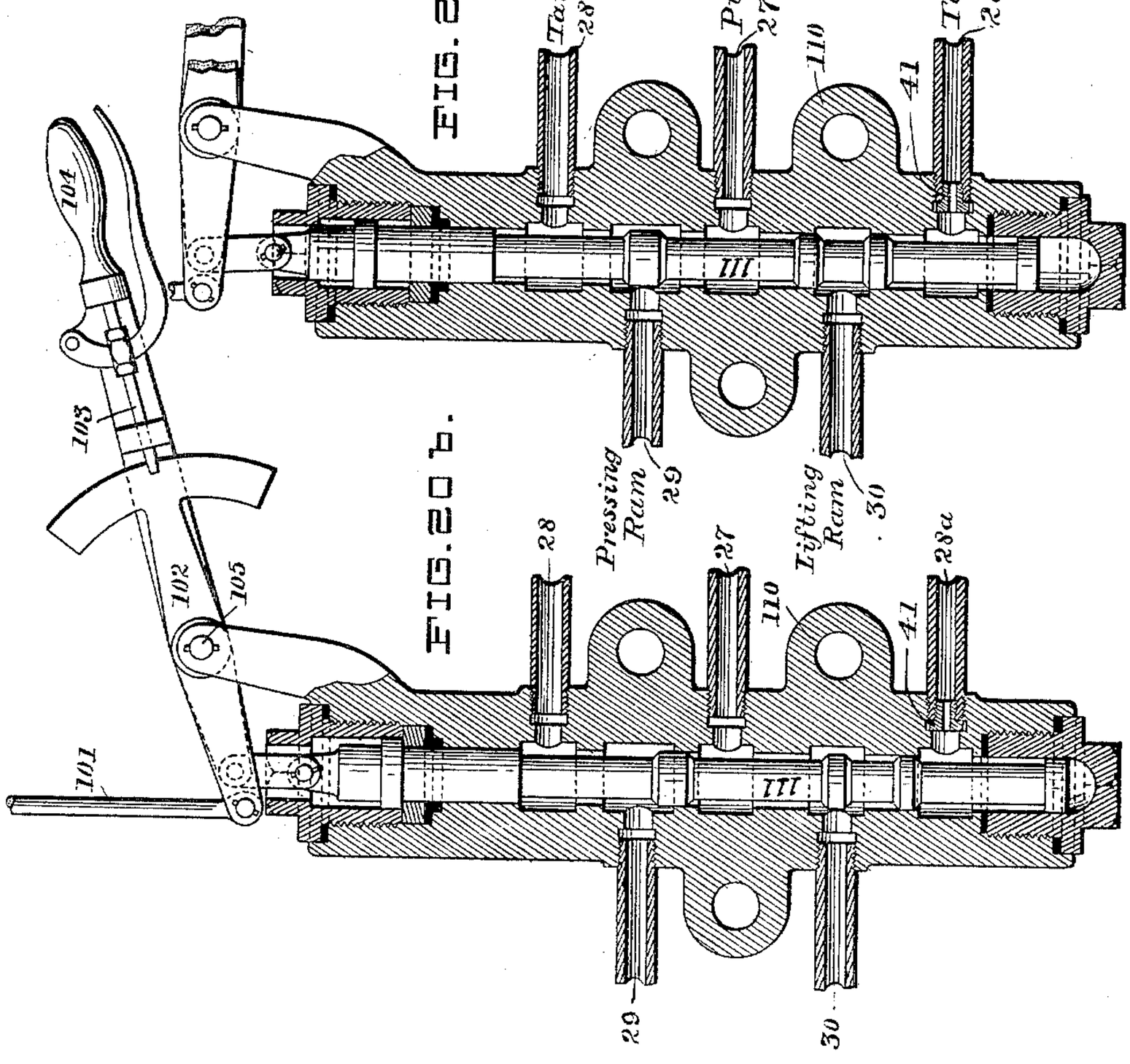


FIG. 20.



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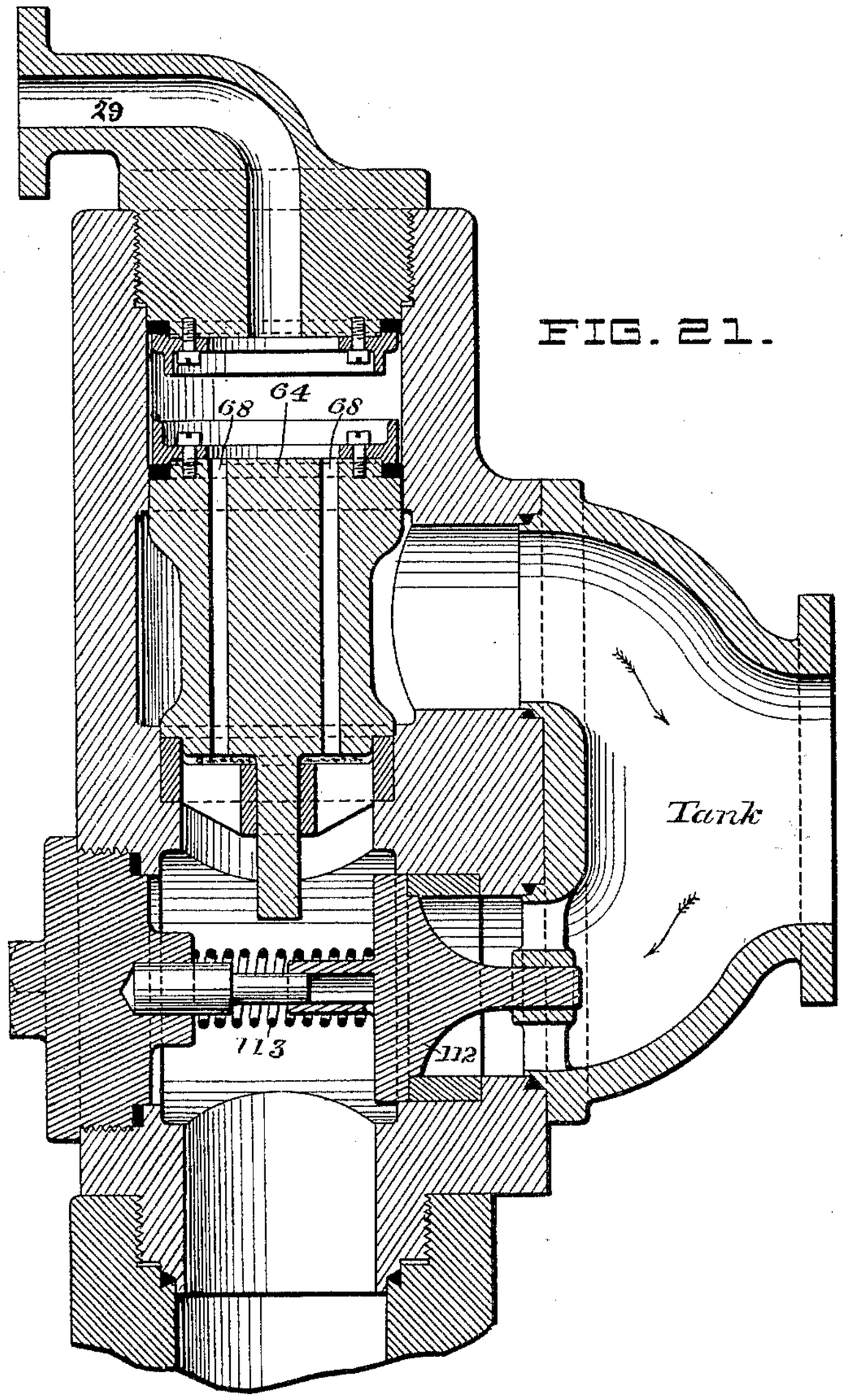

FIG. 21.

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UNITED STATES PATENT OFFICE.

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HYDRAULIC PRESS.

SPECIFICATION forming part of Letters Patent No. 642,009, dated January 23, 1900.

Application filed July 11, 1895. Serial No. 555,662. (No model.)

To all whom it may concern:

Be it known that we, WILLIAM SELLERS, COLEMAN SELLERS, and WILFRED LEWIS, of the city and county of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in Hydraulic Presses, of which improvements the following is a specification.

The form of press which is the subject of our invention is adapted to a variety of purposes—such as forging, coining, stamping, punching, and shearing, in which great pressure and rapidity of action may be required with movements controlled by hand or automatically. Machinery of this class is comparatively new and has been applied more particularly to hydraulic forging, for which purpose the form of press best known consists of a lower head or base upon which the anvil is supported, an upper head which carries the forging-ram, and cylindrical columns which connect the two heads together and by their tensile strength resist the forging-pressure of the ram. The upper head is adjustable vertically upon these columns and may be set close to the work, so that with the short stroke to which this press is limited the forging-ram may be guided by the cylinder in which it moves, and no other guide is provided. It is apparent that with a ram so guided a long stroke would be inadmissible, and even with a short stroke it will be observed that the guiding length of the ram is least when the greatest lateral support is required. The power to operate the press is derived from pumps at a considerable distance, which, with their fly-wheel connections, are in constant motion, delivering water into a circulating-pipe which leads to and from the press, and in so doing they perform no work other than that required to overcome the friction of their moving parts and of the water in the pipes. Near the press is a deflecting-valve operated by hand, which when open permits an unobstructed flow from and to the pumps, but when closed the current from the pumps is deflected into the cylinder which carries the forging-ram, forcing it down upon the metal to be forged and continuing to press upon it so long as the deflecting-valve is closed and the pumps continue to operate. It will be observed, however, that the work performed by the pumps will be exactly proportioned to the resistance, and as it rarely happens that this resistance can be prolonged the fly-wheel will give out the force stored up in it, so that the steam-pressure need not be greatly augmented to produce the proper forging effect, and a high degree of economy is thus attainable. The upward or return stroke is effected by a constant pressure from an accumulator acting upon draw-back plungers on each side of the forging-ram. The draw-back pressure thus acts like a counterweight to resist the downward stroke of the forging-ram, and it becomes operative to raise this ram as soon as the deflecting-valve is opened to relieve the pumping-pressure. This form of press may be designated as the "single-acting system with continuous flow," the pumping-pressure being exerted to force the ram in one direction only. In this form of press the forging-ram being counterbalanced and forced downward by the pumps alone its descent is necessarily slow, and a later form of press has been designed to remedy this defect. In this later press the pressing-cylinder is above, as before, but the pumps are arranged to force the forging-ram upward as well as downward, so that when the lifting-pressure is released the forging-ram will not only drop by its own weight, but being connected with a pressure-reservoir through large pipes it is assisted in its descent by the water which flows on the top of this ram and fills the cylinder ready for pumping-pressure, which is then applied until the forging-ram has pressed the metal it is operating upon to the desired extent. The pumps are then stopped, the valves reversed, and the pumps again started, discharging fluid into the lifting-cylinders, which being small, as compared with the pressing-cylinders, the ascent may be as rapid as the descent, the water in the pressing-cylinder being forced back into the reservoir ready for the next descent of the forging-ram. In this system the pressing-cylinder is not vertically adjustable, as in the one first described, and the ram is guided to resist lateral strains. The cylinder, how-

ever, is long enough to admit of all the adjustment required, so that the movements of the ram are not only more rapid, but its adjustment to the proper height can be more readily effected than in the first system. In this latter system the pressure-pumps act to drive the forging-ram in both directions, and it may therefore be designated as "double acting," but the flow is not continuous. The pumps must be started and stopped for every stroke, and it is more properly designated, therefore, as a "double-acting system with intermittent flow." To such a system there are very serious objections, for although provision has been made for a quick movement of the forging-ram in both directions and for requiring less pumping capacity the number of manipulations are so much increased that the number of strokes per minute are probably decreased, and as no fly-wheel can be used and the steam cannot be worked expansively it will fall below the first system in economy also.

Another and a later form of press has been designed in which the operating-cylinders are placed in the lower head and motion is communicated to the forging-ram in the upper head by movable uprights sliding through bearings in the lower head. High and low accumulator-pressures are used and provision is made for rapid movement of the forging-ram to and from its work; but the manipulations are excessive, the flow is not continuous, and it belongs to the class last described and is subject to the same disabilities.

One object of our invention is to operate the press by pumps running continuously and to govern the movements of the pressing-ram automatically or by hand at will so as to attain the greatest exactitude in its work with the greatest rapidity in its operation without diminishing the control of the operator.

It is a further object to provide means for adjusting the stroke of the pressing-ram while it is working automatically so as to determine the size of the work to the greatest nicety.

It is a further object to provide means for limiting the stroke of the pressing-ram to the attainment of any desired pressure; and it is a further object to obtain the necessary movement of the pressing-ram in both directions in the shortest possible time without increasing the capacity of the pump beyond that required for the rate of movement in pressing.

To these ends the nature of our invention consists in an automatic valve communicating between the pressing-cylinder and a supply-tank, whereby circulating fluid may be rapidly admitted to and discharged from the pressing-cylinder when the actuating fluid is directed to the pressing-ram or to the lifting-rams.

It further consists in a pilot-valve and an automatic stop-motion by which the operating-valve may be controlled from the pressing-ram to repeat a given stroke with precision.

It further consists in a pilot-valve and an adjustable safety-valve by which the operating-valve may be controlled to repeat a given pressure with precision.

It further consists in a latched hand-lever in connection with the automatic motion by which the press may be thrown at once from automatic to hand control, or vice versa.

To facilitate the description, we have designated the fluid delivered from the pumps as the "actuating fluid" and that delivered to or from the tank as the "circulating fluid."

That our invention may be more thoroughly illustrated and its performance be more clearly explained we now refer to the drawings which form a part of this application, in which—

Figure 1, Sheet 1, is a front elevation of a hydraulic press arranged for striking medals which embodies our present improvements and shows the pumps, valves, tank, and piping employed when arranged to operate by hand only. Fig. 2, Sheet 2, is a side elevation of the press shown in Fig. 1; and Fig. 3 is a vertical section on the center line of Fig. 2, showing the pressing and lifting rams, valves, and piping, the pilot-valve and automatic mechanism being omitted for the sake of clearness, and the press is shown as operated entirely by hand. Fig. 4, Sheet 3, is a plan of the operating-valve. Fig. 5 is an elevation of the same, showing in section one of its circular slide-valves controlling the flow of the actuating fluid. Fig. 6 is a section on the center line of Fig. 5, and Fig. 7 is a section on the center line of Fig. 4. Fig. 8 is a plan of the slide-valve in chamber 42, Fig. 5; and Fig. 9 is a plan of the slide-valve in chamber 43, Fig. 5. Figs. 10 and 11 are enlarged views of the valve-seats for Figs. 8 and 9, respectively, showing in broken lines the position of the valves when set in their middle position to sustain the ram and allow the circulating fluid to pass through. Figs. 10^a and 11^a show the position of the valves when moved to direct the actuating fluid into the pressing-cylinder to depress the ram. Figs. 10^b and 11^b show the position of the valves when moved to direct the actuating fluid into the lifting-cylinders to raise the ram. Fig. 12, Sheet 4, is a sectional elevation of an automatic supply and exhaust valve. Fig. 13 is a plan of the valve, and Fig. 14 a plan of its seat. Fig. 15, Sheet 5, is a front elevation of the pilot-valve, operating-valve, and the mechanism, partly in section, between them to control the operating-valve automatically. Fig. 16 is a side view of the same, and Fig. 17 is a sectional elevation of the pilot-valve. Fig. 18, Sheet 6, is an enlarged view of the mechanism shown in Fig. 5, showing more particularly and in section the operating and safety valve in connection with the pilot-valve to work automatically up to any predetermined limit of pressure. Fig. 19, Sheet 7, is an elevation in section of a forging-press, showing the piping and valves

arranged for automatic or hand control. The lifting-cylinders are above the cross-head instead of below it, as shown in the medal-press, and the operating-valve is designed for water instead of oil. Fig. 20, Sheet 8, is a vertical section through the operating-valve, showing the valve as set to sustain the pressing-ram and to permit an idle circulation of the water pumped. Fig. 20[a] is a similar section showing the valve as set to depress the pressing-ram, the actuating fluid being directed to the pressing-ram while the water in the lifting-cylinders escapes to the tank. Fig. 20[b] is a similar section showing the valve set to raise the pressing-ram, the actuating fluid being directed to the lifting-rams while the water in the pressing-cylinder discharges into the tank. Fig. 21, Sheet 9, is a sectional elevation of an alternate form of the automatic supply and exhaust valve.

Referring to Figs. 1, 2, and 3, 1 is the upper or cylinder head, in which the pressing-cylinder 2 is carried. 3 is the lower or anvil head, upon which the anvil 4 is supported. 5 and 6 are columns separating the heads of the press, and 7 and 8 are bands compressing them firmly upon the columns. 9 is the automatic valve, attached to the pressing-cylinder 2 and shown more particularly in Fig. 12. 10 is the operating-valve. (Shown also in Figs. 4, 5, 6, 7, 8, 9, 10, and 11.) 11 is the pressing-ram, and 12 and 13 are the lifting-rams, both guided by the cross-head 14, attached to the pressing-ram 11 and guided in the uprights 5 and 6. 15 and 16 are the lifting-cylinders. 17 and 18 and 19 and 20 are blocks or wedges through which the tension on the bands is resisted by the columns. The cylinder-head 1, anvil-head 3, cylinder 2, columns 5 and 6, and tensile members or bands 7 and 8 are assembled by placing them in position, as shown, with the pressing-ram blocked up on the anvil-head, so that by admitting fluid-pressure to the cylinder 2 the cylinder-head 1 and anvil-head 3 will be forced apart. This fluid-pressure is preferably adjusted at fifty per cent. in excess of that at which the press will be worked, and while so adjusted the blocks or wedges 17, 18, 19, and 20 are inserted and secured by the bolts *a a* to the columns 5 and 6, so that when the fluid-pressure is removed the columns must sustain the tensile strain of the bands 7 and 8, thereby maintaining any desirable strain in the bands 7 and 8 and rendering the whole structure extremely rigid. The blocks 17, 18, 19, and 20 are represented in the drawings as wedges, but for large presses parallel blocks fitted to the openings when the maximum strain is applied will be safer, as less liable to be displaced. 21 is a drip-dish to catch any leakage from the pressing-cylinder, and 22 is a reservoir in the lower head into which all leakage is drained. 23 is a tank at a convenient elevation, containing the working fluid. 24 is a valve by which the supply may be shut off for renewal of packing or general repairs. 25 25 25 are the cylinders of a three-throw pump, which receives its supply from the tank 23 through the pipe 26 and discharges it through the pipe 27 into the operating-valve 10. 28 is a pipe communicating between the valve 10 and pipe 26, through which pipe the actuating fluid passes when the pump is operating while the rams are not operating, and this whatever the position of the rams when their movement is arrested. 29 is a pipe communicating between the operating-valve 10 and the automatic valve 9, through which pipe the actuating fluid passes to force the pressing-ram downward. 30 is a pipe communicating between the operating-valve 10, the lifting-cylinders, and the automatic valve 9, through which pipe the actuating fluid passes to the lifting-cylinders to raise the pressing-ram. 31 is the operating hand-lever, attached to the rock-shaft 32. This shaft carries the arms 33 and 34, which connect by the links 35 and 36 with the arms 37 and 38 on the valve-stems 39 and 40.

The operating-valve (shown in Figs. 4, 5, 6, 7, 8, 9, 10, and 11) consists of the body 10, in which the chambers 42 and 43 are formed to receive the circular slide-valves 44 and 45 on the stems 39 and 40. These stems are coupled, as described, to move together and maintain the valves 44 and 45 in the same relative positions. The actuating fluid is received in the chamber 42 through the pipe 27 and passes in the position shown in Fig. 10 by way of the holes 47 and 48 under the valve 44 and out through the opening 49 to the passage 50, Fig. 6, and thence through the passage 51 to the pipe 28 and back to the pumps or to the tank 23. The hole 47 passes directly through to the chamber 43, Fig. 7, and is covered by the valve 45, Fig. 5. The fluid in this chamber sustains the pressing-ram and may escape through the plug 52 when the valve 45 is moved to uncover it, so that when the plug 52 is covered by the valve 45, as shown in Figs. 10 and 11, the pressing-ram will be sustained and the flow from the pumps will be discharged under the valve 44, as previously described. The size of hole in the plug 52 is proportioned to the speed of descent required in the pressing-ram, and as the plug is removable the speed is thus easily adjusted. To avoid the possibility of entraining air, it is desirable to limit the speed of descent by the ability of the supply tank and pipes to fill the pressing-cylinder without a partial vacuum being formed, and by varying the size of the opening in this plug the highest practicable speed can be experimentally determined. The passage through the plug 52 leads to the passage 50 and thence to the tank. 53, Fig. 6, is a passage from the chamber 43, Fig. 7, to the small safety-valve 54, Fig. 6, its object being to relieve the lifting-cylinders of undue pressure when the outlet through 52 is suddenly closed by the valve 45. 55 is the stem of an adjustable safety-valve seated against the operating-pressure through the passage 56, Fig. 6. This

passage is enlarged above the valve-seat, and the stem 55 fits loosely therein, so that when the valve begins to open a larger area is at once exposed, thus causing it to open wide and remain open under a reduced pressure. To prevent pounding, the valve-stems 54 and 55 are provided with collars, as shown, around which the fluid must leak, producing slow and steady movements. The valve-stem 55 is loaded by the spring 57, resting on the washer 58 and abutting against the abutment-bolt 59 in the adjusting-nut 60, which surrounds the spring-case 61, attached to the valve-body 10. The lower edge of the nut 60 is graduated, and when set for any desired pressure it may be held in position by the lock-nut 62 on the bolt 59, the latter being keyed, as shown, to the spring-case 61. The operating slide-valve is shown and described in a compact and convenient form, particularly suitable for the use of oil as the actuating fluid. No packing is required for the valve-seat, and when properly lubricated slide-valves are preferable to piston-valves, which depend upon packing for their proper performance of duty. In large forging-presses, however, where water is used as the actuating fluid a slide-valve is not desirable on account of the difficulty of lubrication under large surfaces and heavy pressures. For such cases the piston-valve shown in Fig. 20 is preferable. For the sake of clearness the packing for this valve has been omitted, as it is well known and in common use for hydraulic valves of the Finby type and because, as in the slide-valve just described, our improvement does not consist in the packing, but in the means adopted to raise, depress, or sustain the ram in connection with a pump, which must have a constant outlet for its continuous discharge, although this discharge may or may not be at a constant rate. The discharge from the pumps enters the valve-body 110 through the pipe 27 and is not interrupted for an instant as the valve moves into any of the three positions shown. In Fig. 20 the discharge passes into the pipe 28, communicating with the tank. In Fig. 20^a it passes into the pipe 29, communicating with the pressing-ram. In Fig. 20^b it passes into the lifting-cylinder through the pipe 30, and as the outlet to the tank closes the valve to the lifting-ram opens, so that for an instant the fluid begins to enter the lifting-cylinder before it stops flowing to the tank. Thus a continuous discharge from the pumps is provided for in every position of this piston-valve, as well as in the slide-valve previously described. When set, as shown in Fig. 20^a, to discharge against the pressing-ram, the lifting-cylinders exhaust to the tank through the pipe 28^a, in which the open plug 41 is inserted to regulate the speed of descent. In taking this position it is proper to note that the exhaust begins before the flow to the pressing-ram is fully established; otherwise the lifting-cylinders might be ruptured by the action of the pumps on the pressing-ram.

In the operating slide-valve first described we have two valve-chambers, one of which, 43, receives the actuating fluid through the other chamber 42 and controls the exhaust from the lifting-cylinders, while the chamber 42 receives a constant supply of actuating fluid from the pumps and discharges it into one of three passages leading to the tank, the pressing-cylinder, or the valve-chamber 43. The valves 44 and 45, covering the ports in the chambers 42 and 43, are made to slide on their seats together by the oscillation of the valve-stems 39 and 40, coupled to the rock-shaft 46, to which the hand-lever 31 is attached. Thus when port 48 is closed, as shown in Figs. 10^b and 11^b, the actuating fluid must escape from the chamber 42 by the passage 47, and thence to the lifting-cylinders, raising the ram, and, when the port 47 is closed, as shown in Figs. 10^a and 11^a, by the valve 44, the actuating fluid must escape by the port 48 into the pipe 29, and thence to the pressing-cylinder, while at the same time the port 52 is uncovered by the valve 45 to allow the fluid in the lifting-cylinders to escape back into the tank. The same fluid is thus used over and over again and no waste except leakage or evaporation can occur. Other fluids than water may therefore be used to advantage, and this valve, as shown and described, is designed especially for oil. When water is used, lubrication of a slide-valve becomes more difficult and the piston form of valve with leather packing, as shown in Fig. 20, is preferable; but whatever particular form the valve may take it must have the capacity to receive and to direct in any one of three different directions all of the discharge from the pump without for an instant interrupting the continuity of its flow. Referring to Figs. 20, 20^a, and 20^b, 110 is the valve-body, and the pipes connected therewith lead to the different parts of the system, as indicated. 111 is the piston-valve, and, as shown in Fig. 20, the pump, pressing-ram, and tank are all in communication with each other, while the water in the lifting-cylinders is locked up, so that the pressing-ram will stand in any position it may have assumed when the valve was moved to the position shown in Fig. 20. Other parts corresponding to those shown in Figs. 7 and 5 have been designated by the same numerals, and an inspection of the valve in its three positions will show that the same result has been accomplished as described for the operating slide-valve. By means of either form of operating-valve we can therefore direct an actuating-stream of fluid from a pump to the operations of a press, so as to limit the load upon the pump to an unobstructed circulation of the fluid when the press is at rest and when it is at work to the raising of and to the depression of the rams. To economize

time, however, rapid movements of the pressing-ram to and from its work are desirable, and to this end the automatic supply and exhaust valve (shown more particularly in Figs. 12, 13, and 14) has been introduced. The function of this valve is to open and to close communication between the pressing-ram and the tank. It does not affect the operation of the pump in any way, and it forms no part of the pump and valve system. 9 is the valve-case, extending into the pressing-cylinder 2 and secured by the nut 63 to the upper head 1, Fig. 3. 64 is the automatic supply and exhaust valve, fitted in the upper part of the valve-case and guided at its lower end by the stem 65 in the valve-seat spider 66. 67 is a plug closing the outer end of the valve-case, through which the actuating fluid is admitted from the pump through the conduit 29. 68 68 are passages in the valve 64, through which this fluid passes to the pressing-cylinder. The passages 68 68 through the valve 64 simply afford an uninterrupted passage at all times that a passage is required for the actuating fluid. For this purpose it is not requisite that the passage shall be through the valve 64. Any conduit that will deliver this fluid from the operating-valve, above as well as below the valve 64 when it is seated would answer the purpose, and to illustrate this we have shown by dotted lines on Fig. 12 such a connection as a substitute for the passages 68 68 through the valve 64. The conduit which connects the pump with the pressing-cylinder may enter the cylinder direct, or it may enter the valve-case 9 below the valve 64. In either case the passages 68 68 serve to carry the pressure in the pressing-cylinder through the valve 64 to its enlarged upper end, and thereby hold it down upon its seat. 69 is a piston fitted in the valve-stem chamber 70 to act against the stem 65 and raise the valve 64 when pressure is admitted through the pipe 30, which communicates with the lifting-cylinders 15 and 16. This piston 69 is packed at the top, as shown, to prevent the pressure-water from the lifting-cylinders escaping around the piston without raising it and the valve 64. The lower end of the piston 69 forms a valve which when seated prevents the pressure of water under the valve 64, when it is seated on the spider 66, from escaping around the stem 65 into the pipe 30. This pressure continues to sustain the valve 64 in the position shown so long as the lifting-cylinders support the weight of the pressing-ram, so that a large volume of fluid may pass under the valve 64 to and from the tank without obstruction; but when the downward movement of the ram is arrested by striking the anvil or a piece of work resting upon it the lifting-cylinders are thereby relieved of pressure and the valve 64 descends to its seat upon the spider 66, shutting off communication through the pipe 26 with the tank, while the actuating fluid from the pumps passes through the holes 68 68 and performs the work of pressing or shaping the material under the dies. The upper end of the valve 64 is slightly larger in diameter than its seat, to make it close tightly on the valve-seat 66. When pressure is again admitted to the lifting-cylinders for the return stroke of the ram, this pressure operates through the pipe 30 to raise the valve 64; but its rise is limited by the ring 71 abutting against the ring 72, which are formed to inclose a small quantity of fluid and act as a dash-pot. The seat of valve 64 is similarly protected against pounding, and rapid movements of this valve are thus permissible without injury. The actuating fluid flows through the valve 64 and the circulating fluid flows under this valve while the pressing-ram is descending to its work. After the pressing-ram has reached its work, which, as above described, closes the valve 64, no time is lost in continuing the descent of the pressing-ram by the actuating fluid which is flowing through the valve 64, until by a movement of the operating-valve the actuating fluid is directed under the lifting-rams, the cylinders of which being much smaller in diameter than the pressing-cylinder, the pressing-ram is returned quickly, so that rapid movements in both directions are obtainable, while the power and time are economized in the operation of the press.

In the alternate form of automatic valve shown in Fig. 21 the connection between the valve 64 and the lifting-cylinders 15 and 16 is dispensed with, and instead of the single valve 64, operated by the pressure in the lifting-cylinder, we have the two check-valves, as shown, opening in opposite directions, one of which admits tank-water to the pressing-cylinder and the other allows the cylinder to discharge rapidly back to the tank. As shown in Fig. 21, the actuating fluid may pass through the valve 64 by the holes 68 68, or it may pass through an outside conduit, as indicated in Fig. 12 by dotted lines. The holes 68 68 are made, preferably, of small area to restrict the flow through them from the pressing-cylinder and allow the valve to open freely; but large holes provided with check-valves or a loose disk to cover all the holes and opening outward, as shown by dotted lines in Fig. 21, may be used if the conditions are such as to make the resistance of these holes worth considering. The passage 29 communicates with the tank when the rise of the pressing-ram lifts the valve 64, and the two valves 64 and 112 act exactly like the valves of a pump, drawing in through one and discharging through the other. Whether the pressing-ram is provided with the two valves above described or with the one valve previously described, it acts as a pump at every stroke, drawing the fluid after it as it descends, whether the source of supply is above or below it, and discharging the fluid as it is raised by the lifting-rams; but when

the valve 64 is raised by the pressure under the lifting-rams the flow of fluid to and from this pump is unobstructed, while with the two valves last described this flow is obstructed by the tension of the spring, which closes the induction-valve in one case and the weight of the eduction-valve in the other.

For the system illustrated in Fig. 1 the manipulation of the operating-valve requires close attention, and for certain purposes, where the stroke of the pressing-ram must be made and repeated with precision, a system of automatic control is desirable. For this purpose the operating-valve must not only be moved its full stroke for each reversal of the pressing-ram, but this movement must be effected by some force that will continue in operation after the pressing-ram has come to rest. Otherwise the ram will be liable to stop at the end of its stroke.

Referring to the system of automatic control illustrated in Figs. 15, 16, and 17 and further detailed in Fig. 18, 73 is a rack attached to the cross-head 14 and engaging the spur-wheel 74 on the shaft 75, carried in the stand 76, bolted to the upright 5. 77 is a bevel-wheel with an outer clamping-rim centered loosely on the shaft 75 and engaging with the pinions 78 and 79, carried in the frame 80, which is keyed to the shaft 75. 81 is a bevel-wheel centered loosely on the same shaft and engaging also with the pinions 78 and 79. 82 is a worm-wheel securely attached to 81 and engaging with the worm 83 on the shaft 84, to which the indexed hand-wheel 85 is attached. The outer rim of 77 has formed upon it the lug 86 to engage with the toe 87 on the rocker-arm 88, attached to the stem of the pilot-valve 89. The stop 90 is adjustable on the rim of 77, and when clamped in any given position engages with the toe 91 on the rocker-arm 88. The pilot-valve 89, Fig. 17, consists of the chamber 92, through which the actuating fluid is made to pass, and the plungers 93 and 94, to either of which pressure is admitted by the movement of the circular slide-valve 95 on the valve-stem 96, to which the rocker-arm 88 is attached. The plungers 93 and 94 are yoked together by the cross-heads 97 and 98 and the bolts 99 and 100. The cross-head 98 is connected by the link 101 with the operating-valve lever 102, which is expanded at one end to form a segment and notched to receive the latch 103 on the hand-lever 104. Both levers 102 and 104 are pivoted on the same stud 105, and the hand-lever 104 is bent to form a bell-crank for attaching the link 36 to communicate motion to the arm 38. The pilot-valve 89 is interposed between the circulating-pumps 25, Fig. 1, and the operating-valve 10, and the valve-chamber 92 may be regarded as an enlargement in the pipe 27, through which the actuating fluid is made to pass. 106 and 107 are openings to the plungers 93 and 94, which are shown as covered by the valve-seat 95. 114 is an opening under the valve-seat 95, which permits the fluid in either chamber of 93 or 94 to escape into the pipe 26, communicating with the tank when the actuating fluid is admitted to the other chamber. It will now be seen that as the cross-head 14 moves down the wheel 77 will rotate and the stop 90 will act against the toe 91 on the rocker-arm 88, shifting the valve-seat 95 to admit pressure on the plunger 94 and exhaust from the plunger 93. The yoke 98 and link 101 will thus be forced down as far as it can go, and the operating-valve 10 will be set to admit the flow to the lifting-cylinders. As the cross-head moves up the wheel 77 will be rotated in the same direction as 74 at twice its rate of speed until the lug 86 acts against the toe 87 on the rocker-arm 88, moving the valve-seat 95 to admit pressure under the plunger 93, reversing the operating-valve and the movement of the pressing-ram. The pressure in the valve-chamber 92 must exceed the pressure in the pipe 26 by the amount required to overcome the fluid friction in the pipes, and when work is being done in either direction this excess of pressure may be very great; but when the excess is small the resistance of the operating-valve is also small, and when large the work to be done is proportionately great. It is not impossible to operate the valve 10 directly from the stops on the rim of 77; but it is desirable that when the operating-valve is set for movement in either direction the ports shall be fully opened, and this purpose is accomplished by the intervention of the pilot-valve, which must always take an extreme position and carry with it the operating-valve. It is evident that the length of stroke on the cross-head 14 can be accurately determined by the position of the stop 90, and it will be seen that the location of this stroke is determined by the worm-wheel 82 and its indexed hand-wheel 85, while the length of the stroke is determined by the distance between the movable stop 90 and the fixed stop 86 on the frame 80. The bevel-wheel 81, to which the worm-wheel 82 is attached, acts as an abutment for the pinions 78 and 79, and as the abutment moves the relation between the wheel 77 and the cross-head 14 varies. Thus while the cross-head is running automatically on a given length of stroke the distance between dies at the end of the downstroke can be accurately measured and controlled, and by means of the mechanism just described the operator is enabled to combine the rapidity of automatic action with the utmost nicety of adjustment. For this purpose the epicyclic train is particularly well adapted, for by its use the means for adjustment is always convenient, while the rate of movement of the stops may be greatly varied from that of the cross-head. As shown and described, the diameter of the circle in which the outer ends of the stops travel is nearly double the diameter of the

pinion which gears with the rack on the cross-head, so that from this cause alone the stops will travel nearly twice as fast as the cross-head; but as this epicyclic train is shown and described, the stops will make two revolutions for one of the pinion, so that, as shown, the stops will travel nearly four times faster than the cross-head. If, however, the frame 80 should be centered loosely upon the shaft 75 and this frame should be arranged to carry the stops now carried by the wheel 77 and 77 should be keyed to the shaft 75, the frame 80 would only revolve at one-half the rate of the wheel 77 and the stops would then travel at nearly the same speed as the cross-head. By means also of the latched lever 104 the automatic control may be at once cut loose and the press may then be operated entirely by hand. When so operated, the movement of the pilot-valve has no effect, because it is cut loose from the operating-valve. The toes 87 and 91 are each hinged on an end of the rocker-arm 88, so that either can swing toward the other without moving the rocker-arm. If either stop 86 or 90 is between the toes 87 and 91 and is pushed against either toe, it will carry the rocker-arm with it until the stop will pass under the toe it is moving. If then the wheel 77, with its stops 86 and 90, continues to move in the same direction, the next stop will come in contact with the back of the other toe, raise it, and pass under it without moving the rocker-arm, and as the other toe is already raised, so that the stops will pass under it, the rocker-arm will not be moved until the direction of rotation of the wheel 77 is reversed.

For the purpose of hydraulic forging the mechanism shown in Figs. 15, 16, and 17 is sufficient for all requirements; but for stamping and coining, where a definite pressure is desired rather than a definite movement, the press may be run automatically by the attachment shown in Fig. 18. Here the stem of the safety-valve 55 is extended and carried up through the bolt 59 to act against the lever 108, which is connected by the link 109 with a projection on the rocker-arm 88. The lug 86, acting against the toe 87, limits the upward movement of the cross-head, and when a given pressure is attained on the down-stroke the safety-valve blows off, impinging against the lever 108 and reversing the movement automatically.

In Fig. 19 the arrangement of parts has been determined especially with reference to hydraulic forging, the lifting-cylinders 15 and 16 being placed above and away from the heat of forging, while a cylinder of long stroke 2 is used for adapting the press quickly to work of variable dimensions. Here the operating-valve 110, Fig. 20, is shown coupled to the pilot-valve 89, Fig. 17, and the pipes are connected as previously described for automatic action.

The automatic mechanism shown in Figs. 15 and 16 has been omitted for the sake of clearness, but it is applied as shown in Figs. 15 and 16, and derives its motion from the rack 73, which in this case is attached to one of the suspension-rods which connect the lifting-rams with the cross-head.

It is evident that the safety-valves shown in Fig. 6 and the special feature of the safety-valve shown in Fig. 18 are applicable alike to either form of operating-valve, and that although not shown in connection with the piston-valve they are intended to be used therewith whenever required.

The operation of a press embodying our improvements may now be described by reference to Figs. 1 and 19. When operated by hand, as shown in Fig. 1 and further detailed in Figs. 4, 5, 6, 7, and 12, the actuating fluid flows from the pumps 25 25 25 through the pipe 27 to the operating-valve 10, and when the operating-lever stands, as shown, in its middle position the flow continues through the pipe 28 and back to the pumps. At the same time the fluid in the lifting-cylinders is locked up and the ram remains at rest in whatever position it may be. Now when the hand-lever is pushed down the fluid in the lifting-cylinders will exhaust through the pipe 28, letting the ram descend, while the circulating fluid flows into the pressing-cylinder through the automatic valve 9, which is held open by the pressure required to force the fluid in the lifting-cylinders through the contracted outlet in the operating-valve. At the same time the actuating fluid is passing through the pipe 29 through the automatic valve into the pressing-cylinder, and as soon as the ram meets resistance, checking its movement, the pressure which supports the automatic valve is withdrawn and it closes, while the ram continues to advance by the actuating-fluid alone. Having finished the stroke at the pressure desired for striking a medal or for coining, the adjustable safety-valve blows off, which raises the hand-lever, and the operating-valve is thereby set to direct the actuating fluid into the lifting-cylinders and open communication between the pipes 29 and 28. The pressure thrown into the lifting-cylinders at once opens the automatic valve and allows the fluid in the pressing-cylinders to discharge without obstruction into the tank. Having finished the return stroke, the hand-lever may be brought again to its middle position and the pumped fluid returns to its original circulation through the pipes 27 and 28. If through carelessness the return stroke is continued until the pressing-ram stops against its end of the cylinder, the small safety-valve 54, Fig. 6, opens and no damage occurs.

Referring now to Fig. 19, in connection with Figs. 12, 15, 16, 17, 18, and 20, the automatic operation of the forging-press can be readily understood. The pumps 25 25 25 receive, as before, a supply of fluid through the pipe 26 and discharge it through the pipe 27, which now passes to the pilot-valve and thence to

the operating-valve instead of directly to the operating-valve, as before. With the operating-valve set in its middle position, as shown, circulation takes place through the pipes 28 and 26 back to the pumps, while the pressing-ram is at rest, sustained either by the work or by the lifting-rams. The pressing-ram is now at the end of its downstroke and may be supposed to be at work forging, the pilot-valve has been shifted by the automatic mechanism, and the plunger 94, Fig. 17, is now moving the operating-valve into the position shown in Fig. 20[b]. When this position is reached, the actuating fluid passes into the lifting-cylinders, the valve 64 will be raised by the pressure from the lifting-cylinders, and the pressing-cylinder will then discharge into the tank without obstruction as the pressing-ram is raised. Having moved a certain distance, determined by the adjustment of the stops 86 and 90, Fig. 16, the stop 86, acting against the toe 87 of the rocker-arm 88, moves the pilot-valve and admits pressure against the plunger 93, which immediately sets the operating-valve in the position shown by Fig. 20[a]. The lifting-cylinders will now exhaust to the tank and the pressing-ram will descend until the forging-die strikes the work. Its cylinder will be filled through the pipe 26 from the tank and by the actuating fluid which passes into the tank-supply through the passages in the valve 64. When the forging-die strikes the work, the pressure on the lifting-cylinder is relieved and the valve 64 will close immediately, when the ram will advance to its work by the action of the pumps alone. In this way the press will continue to run automatically, and while thus running on a given length of stroke the position of that stroke can be varied as desired by means of the indexed hand-wheel 83, so as to accurately determine the size of the work. Whenever it is desired to stop, the automatic mechanism is disconnected by the latch 103 on the hand-lever 104 and the press comes entirely under hand control.

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent, is—

1. In a hydraulic press, a lifting-ram, a pressing-ram, a pump and a tank, in combination with a valve which deflects the liquid flow from the pump, to the lifting-ram, to the pressing-ram, to the tank, locks the liquid under the lifting-ram, and maintains at all times an open passage for the flow from the pump, and means which provide an open passage from the tank and from the pump to the descending pressing-ram, and automatically closes the passage from the tank to the pressing-ram when the descent of the ram is retarded by an obstruction which will sustain its weight.

2. In a hydraulic press, a lifting-ram, a pressing-ram, a pump and a tank with mechanism to deflect the liquid flow from the pump to the lifting-ram, to the pressing-ram, to the tank, to provide at all times an open passage for the flow from the pump, in combination with a reciprocating hydraulic plunger which operates the mechanism, and the pilot-valve which determines the direction of the flow from the pump to the hydraulic plunger.

3. In a hydraulic press, a lifting-ram, a pressing-ram, a tank and a pump, a valve-case provided with a port, which receives the flow from the pump, and ports which discharge it to the lifting-ram, the pressing-ram and the tank, respectively, in combination with a valve which moves within the valve-case, and deflects the flow from the pump, to the lifting-ram, to the pressing-ram, and directly to the tank, without passing to the pressing-ram or to the lifting-ram, *seriatim*, in combination with a reciprocating hydraulic plunger which operates the valve, and the pilot-valve which determines the direction of the flow from the pump to the hydraulic plunger.

4. In a hydraulic press, a pressing-ram, a pump and a tank, a valve which controls the admission from the tank to the pressing-ram and an open passage connecting opposite ends of said valve, in combination with a conduit between the pump and the pressing-ram.

5. In a hydraulic press, a pressing-ram, a lifting-ram, a tank and a pump, in combination with a valve the seat end of which is smaller than the other end and which controls the admission from the tank to the pressing-ram, an open passage connecting opposite ends of said valve, a conduit between the pump and the pressing-ram, and a conduit between the valve and the lifting-ram whereby the valve will be raised and sustained by fluid-pressure under the lifting-ram, seated by gravity and locked upon its seat by fluid-pressure upon the pressing-ram.

6. A hydraulic operating-valve, consisting of two valve-chambers with a valve in each, the valves so connected that they must move together over their respective ports, in combination with a conduit which connects a port over which the valve in one chamber moves, with a corresponding port in the other chamber.

7. In a hydraulic press, a pressing-ram, a lifting-ram, a tank and a pump, an operating-valve movable by a reciprocating hydraulic plunger, and a pilot-valve which determines the direction of the flow from the pump to the hydraulic plunger, in combination with an epicyclic train, one member of which is driven from a reciprocating part of the press, another member is adjustable about a shaft in the axis of the train, and a third member is provided with stops which actuate the pilot-valve.

8. In a hydraulic press, a pressing-ram, a lifting-ram, and an operating-valve, an adjustable safety-valve, and a pilot-valve, in combination with mechanism operated by a

ram of the press which moves the pilot-valve in one direction, and a system of levers actuated by the adjustable safety-valve which moves the pilot-valve in the opposite direction.

9. A hydraulic operating-valve, provided with a latchable lever for moving the valve by hand, in combination with a lever vibratable about the fulcrum of the latchable lever, and connected to a reciprocating hydraulic plunger operated by a pilot-valve which determines the position of the operating-valve, with means for latching together or unlatching the two levers at will.

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