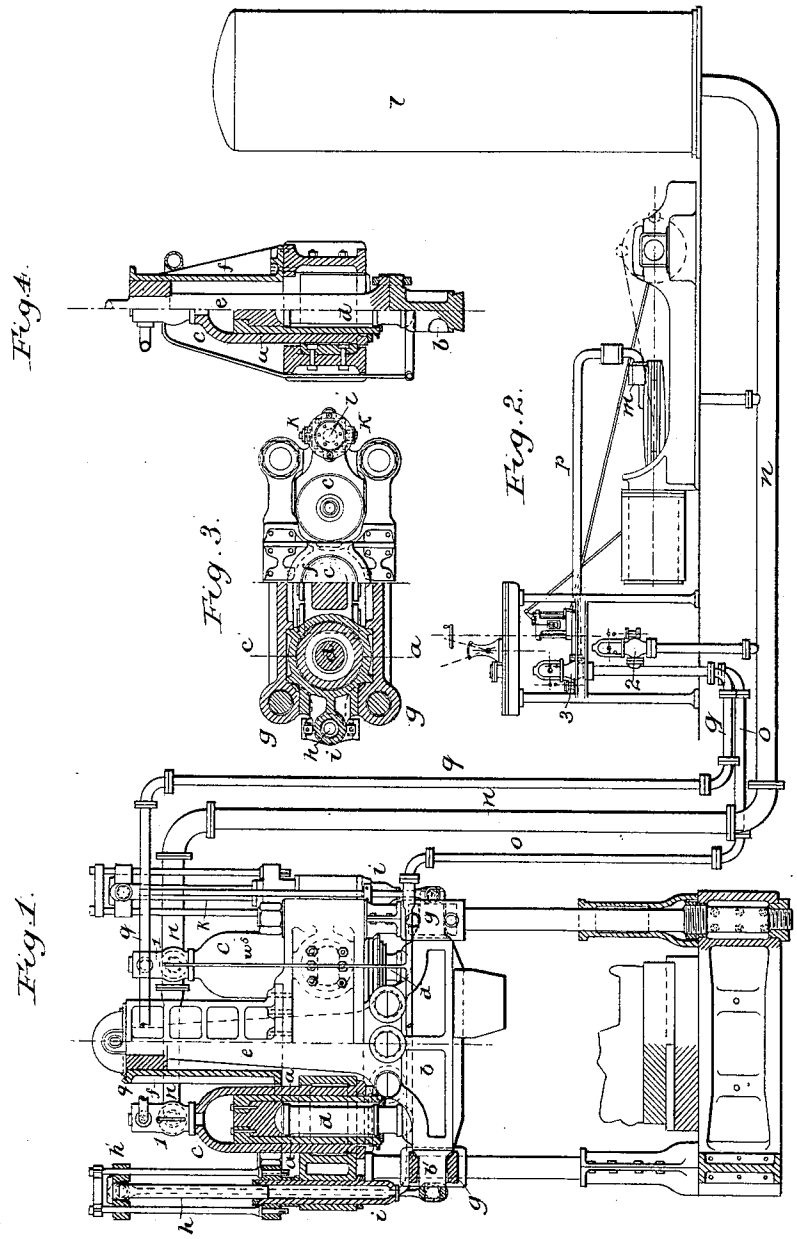
(No Model.) 2 Sheets—Sheet 1.

C. DAVY.

HYDRAULIC FORGING MACHINE.

No. 332,594. Patented Dec. 15, 1885.



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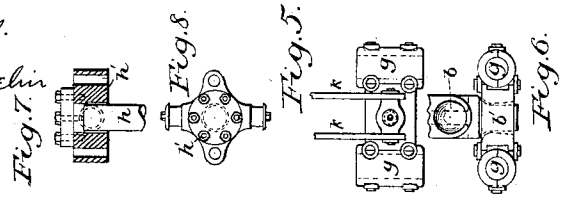

(No Model.) 2 Sheets—Sheet 2.

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Fig. 12.

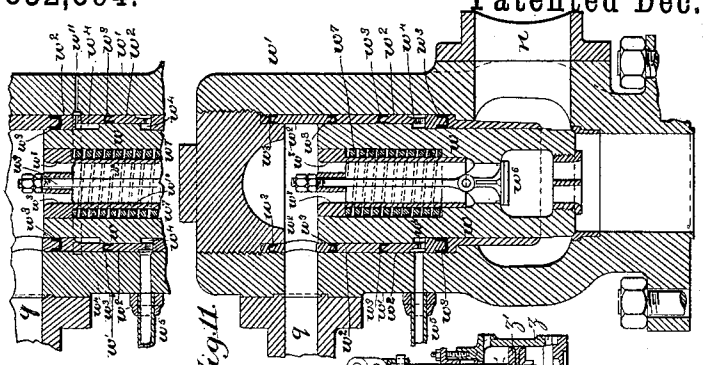


Fig. 11.

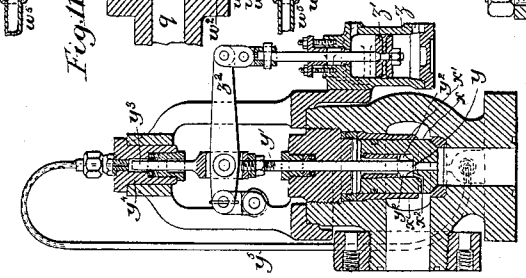


Fig. 13.

Fig. 10.

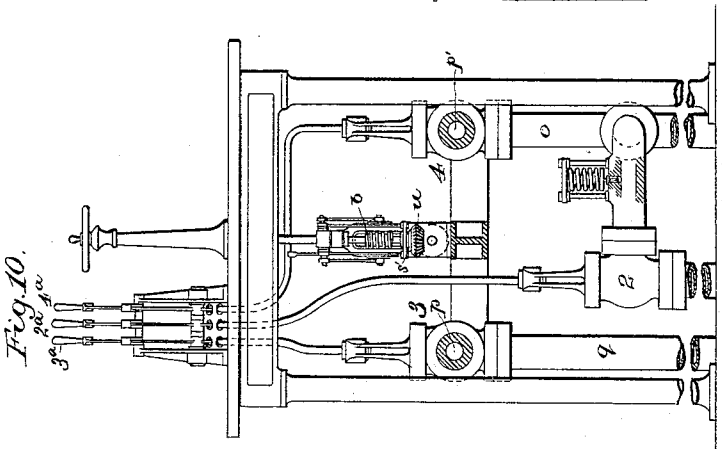
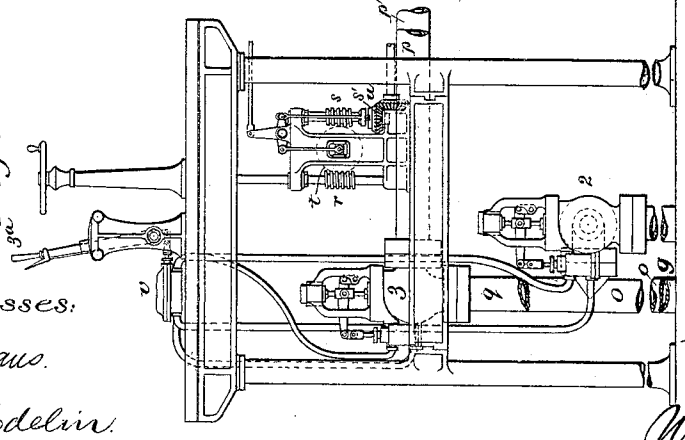


Fig. 9.



Witnesses:
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Inventor
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UNITED STATES PATENT OFFICE.

CHARLES DAVY, OF SHEFFIELD, COUNTY OF YORK, ENGLAND.

HYDRAULIC FORGING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 332,594, dated December 15, 1885.

Application filed May 29, 1885. Serial No. 167,105. (No model.) Patented in England September 29, 1884, No. 12,920; in France April 27, 1885, No. 168,526; in Belgium April 28, 1885, No. 68,686; in Germany May 3, 1885, and in Italy June 30, 1885, XIX, 18,360, and XXXVI, 277.

To all whom it may concern:

Be it known that I, CHARLES DAVY, of 24 Lawson Road, Sheffield, in the county of York, England, engineer, have invented a new and useful Improvement in Hydraulic Forging Machinery, of which the following is a full, clear, and exact description.

This invention relates to improvements in hydraulic forging machinery, specially applicable to forging large masses of steel or iron.

The invention has for its object to avoid undue friction on the working parts (rams, guides, &c.) of the press, in consequence of the expansion by heat of the parts in proximity to the ingot, or in consequence of the nature or position of the work, and also to more effectually guide the moving cross-head of the press, and to provide an improved method of and valves for working the main and lifting rams of the press by high and low pressure water in such manner as to economize the high-pressure water and obtain a quick motion of the moving cross-head toward and away from its work.

In order that the invention may be more readily understood, I have illustrated it in the accompanying drawings, forming part of this specification, wherein—

Figure 1 is a front elevation, partly in section, of the press. Fig. 2 is a corresponding elevation of the engine's valve-gear and air-vessel, showing the pipe-connections to the various rams of the press. Fig. 3 is a plan, partly in section, of the press-head and rams. Fig. 4 is a vertical section, partly through the central guide, of the moving cross-head. Figs. 5 and 6 are respectively an end elevation and plan of the guide-blocks of the moving cross-head. Figs. 7 and 8 show details, on a larger scale, of the connections of the lifting-rams and their cross-heads. Figs. 9 and 10 are front and side elevations, on a larger scale, of the valve-gear shown in Fig. 2. Fig. 11 is a central vertical section, on a larger scale, of one of the compound automatic valves shown applied to the pressing-rams in Fig. 1. Fig. 12 shows a slight modification of Fig. 11. Fig. 13 is a central vertical section, on a larger scale, of one of the hydraulic valves shown in Figs. 9 and 10.

To carry out my invention, I construct a press having a pair of inverted rams, *a a*, hereinafter called the "pressing-rams," which act upon a movable cross-head or tool-holder, *b*, and force it in the direction of the work for applying the necessary pressure to an ingot or other piece of steel or iron to be forged. The pressing-rams *a* work in ram-cases *c*, fixed in the press-head and supported in the usual manner on four columns attached to a foundation or bed plate. The rams *a* are hollow cylinders or trunks closed at their upper ends, and they transmit the pressure to the cross-head *b* through thrust-rods *d*, having simple (or preferably universal—*i. e.*, ball-and-socket) joints at their upper and lower ends, in order to permit of any horizontal deviation or rocking motion of the cross-head (due to the above-mentioned causes) without throwing undue lateral strains on the rams *a* or their cases *c*. The movable cross-head *b* is provided in the center of its length with a rigid arm or tail-piece, *e*, projecting upward and terminating in a head or block that works loosely in a cylindrical guide, *f*, rigidly supported on the press-head midway between the two ram-cases *c*. The rigid arm or tail-piece *e* may be cast upon or forged solid with the cross-head, or secured thereto by bolts, or by hoops shrunk on projecting half-bosses on the tail-piece and cross-head. The ends of the moving cross-head *b* terminate in gudgeons *b'*, and fit, (with sufficient clearance to allow of the expansion of the cross-head by heat,) in the manner of a ball and socket, in guide-blocks *g*, which guide-blocks *g* encircle and work upon the supporting-columns, or are otherwise guided, the gudgeons being midway between a pair of columns, (when four are used,) as shown in Fig. 7.

For the purpose of lifting the moving cross-head *b* after a downward stroke, I employ one or more rams, *h*, (preferably two,) hereinafter called the "lifting-rams." These rams *h* are contained in cases *i*, and they are of considerably smaller area than the pressing-rams, but preferably of the same length of stroke, and they are connected to the end gudgeons, *b'*, of the moving cross-head *b* by pairs of rods *k* and small cross-heads, which are connected to the rams *h* and gudgeons *b'* of cross-head *b* in such way as to form simple (or preferably universal) joints, as shown.

To facilitate the changing of the packing,

the lifting-rams *h* have flanges forged or cast upon their upper ends for the purpose of securing them to the cross-heads *h'*, and at the same time to permit of their easy removal, and the cross-heads *h'* have holes in them sufficiently large to allow of the lifting-rams passing through, and are also provided with bolt-holes corresponding with holes in the flanges of the rams, so that when the bolts are removed the rams may be withdrawn from their cases through the cross-heads.

If only one lifting-ram is used, it may be fixed centrally over the tail-piece *e* and be connected thereto or to the cross-head *b* by suitable rods and joints.

It is an essential object of my invention to relieve the rams, particularly the pressing-rams, and the columns (or other guides of the moving cross-head) from undue side strains and consequent friction arising from the nature of the work, or from the expansion of the moving cross-head by heat, and I accomplish my object by the system of guides and ball-and-socket thrust-rod bearings already described.

The press may be arranged to work horizontally, instead of vertically, as will be readily understood.

The apparatus in connection with the press consists of an air-vessel, *l*, (or an accumulator,) which is partially filled with water at a pressure sufficient to cause the pressing-ram cases to be filled with water when the rams and cross-heads descend with the rapidity desired, a set of high pressure pumps, *m*, capable of being stopped or started quickly, and a system of valves, Nos. 1 and 1 and Nos. 2 3 4, for the admission and discharge of water to and from the pressing-ram cases and lifting-ram case or cases. The upper ends of the pressing-ram cases *c* are connected to the lower part of the air-vessel *l* by the low-pressure main *n*, on which (as near as possible to the rams) are placed the compound automatic valves 1 and 1 (or a single valve) for automatically opening and closing communication of the pressing-ram cases *c* with the air-vessel. The chambers of valves Nos. 1 and 1 are also connected (above the valve) by a pipe, *q*, with delivery-pipe *p* of the high-pressure pumps, the communication being controlled by valve No. 3. The lower ends of the lifting-ram cases *i* are connected by a pipe, *o*, with the low-pressure main *n*, and with the delivery-pipe *p'* of the high-pressure pumps *m*, the communication of said pipe *o* with the main *n* or with the delivery-pipe *p'* being controlled by the valves Nos. 2 and 4, respectively. The suction-valves of the high-pressure pumps *m* are in communication with the low-pressure main *n* and air-vessel *l*.

I will here describe the construction and operation of the compound automatic valves Nos. 1 1.

Referring to Figs. 11 and 12, this valve consists of a tubular plug, *w*, contained in a suitable casing, *w'*, said plug closing against a seat at the lower part of the casing, and controlling the communication between the pressing-ram case *c* and the low-pressure main *n*. This plug *w* is of two diameters, and is fitted to slide in a corresponding bushing, w^2, provided with suitable cup-leather or other packings, w^3. Between the plug and bushing an annular chamber, w^4, is formed, which is in free communication by a pipe, w^5, with the lifting-ram cases *i* or the pipe *o*, so that on admitting high-pressure water to the lifting-ram cases it is at same time admitted to the annular chamber w^4, whereby the plug *w* is lifted from its seat to allow the water in the pressing-ram cases to return through the low-pressure main *n* to the air-vessel. This annular chamber is of such area that the pressure exerted therein is sufficient to keep the valve *w* open to the low-pressure main *n*, in order to allow the pressing-ram cases *c* to be refilled with water on the descent of the pressing-rams *a*. Within the tubular plug *w* is seated an inner valve, w^6, opening in the opposite direction to the plug or valve *w*, and controlling the communication through the tubular valve *w* of the high-pressure main *g* with the pressing-ram cases *c*. This inner valve, w^6, opens with the pressure, and is loaded by a spring, w^7, sufficiently to cause the plug *w* to be closed (by the high-pressure water from main *q*, acting on the back or upper end of plug *w*) before the inner valve, w^6, will open to allow the high-pressure water to enter the pressing-ram cases *c*. The pressure which tends to close the plug *w* suffices to keep it closed and prevent high-pressure water leaking past it into the low-pressure main *n*. The spring w^7 is contained in a chamber within the plug *w*, and is compressed between the end of said chamber and a flanged head, w^8, attached to the rod w^9 of valve w^6, the spring being confined in the chamber by a lining, w^{10}, to which the head w^9 is attached. The area of the upper or rear side of the plug *w*, although always greater than the orifice of its seat, may be less than that shown in Fig. 11 by surrounding the plug with a second annular chamber, as shown in Fig. 12, which is in free communication by a hole, w^{11}, with the atmosphere, so as to minimize the pressure tending to close the plug *w* onto its seat and allow the pressure exerted in the first-mentioned annular chamber, w^4, to act with greater effect when it contains only low-pressure water—as, for instance, while the press is at rest—whereby the plug *w* will under ordinary circumstances be maintained in its open position.

I will now describe the construction and operation of the valves Nos. 2, 3, and 4 for controlling the admission and exhaust of water to and from the pressing and lifting ram cases. These valves are alike, and one of them is represented in Fig. 13. This valve is of the "floating" or "pilot" type—that is to say, it is composed of an outer tubular valve or plug, *x*, and an inner or pilot valve, *y*, seated with-

in the outer valve and opening in the same direction. The valve or plug x slides within a suitably-packed guide cylinder or bushing, x', closed at the upper part, in which the plug x works as a piston in a cylinder, the plug x being so fitted therein as to allow a slight leakage of water to pass to the top side of the plug, (or a by-pass, x^2, being provided for the same purpose,) in order to admit sufficient pressure to the upper side of the plug x to keep it closed down on its seat, this pressure being released when the pilot-valve is opened, the plug x being then in equilibrium, and therefore easily lifted. The pilot-valve y is attached to or formed on the end of the spindle y', which is provided with wings y^2, having a limited play in the plug x, in order to cause the latter to be raised from its seat after the pilot-valve y has been opened by the motion of said spindle y'. The special feature of improvement in the construction of these valves consists in providing a balancing-ram, y^3, working in a cylinder, y^4, at the opposite end of the spindle to that at which the pilot-valve y is situated, the said balancing-ram being of about the same area as the pilot valve y, and its cylinder being in communication by a pipe, y^5, with the space at the under side of the valve, the plug x and valve y being thus both in a condition of equilibrium. The motion is imparted to the spindle y' for opening valves x y in the order above mentioned, and for closing them in the opposite order, by an auxiliary piston, z', acting on a lever, z^2, connected to spindle y', the said piston working in a cylinder, z, and being acted on by fluid-pressure derived from the air-vessel l, (or it may be from an independent source or by steam-power.) The supply and exhaust pipes to and from the various cylinders z of the valves Nos. 2, 3, and 4 in Figs. 2, 9, and 10 are controlled by three small slide-valves working in a common chamber, v, (or it may be separate chambers,) and respectively actuated by three hand-levers, 2^a 3^a 4^a, corresponding, respectively, to the valves Nos. 2 3 4.

I will now describe the method of working the press and the proper sequence for opening and closing the valves. Assuming the air-vessel to be charged, the cross-head b to be at the bottom of its stroke, and the valves Nos. 2, 3, and 4 closed, the valve No. 4 is first opened. The pumps being then started, high-pressure water is forced through pipe o into the lifting-ram cases i and into the annular chamber of each valve No. 1, whereby the valves Nos. 1 1 are opened. The superior pressure exerted on the lifting-rams raises the cross-head b and forces the water from the pressing-ram cases through the low-pressure main n into the air-vessel, where the power expended in overcoming the action of the low-pressure water on the pressing-rams is stored up. As the delivery of the pumps is large relatively to the capacity of the lifting-ram cases, the ascent of the cross-head is very rapid. When the cross-head is raised to the desired height, the pumps are stopped and the valve No. 4 is closed. The cross-head is lowered, when required, by opening the valve No. 2, the valves Nos. 1 1 being held open by the pressure in pipe o acting in their annular chambers, whereupon the cross-head and pressing-rams descend to the required point by their own gravity, (in the case of a vertical press such as that illustrated,) aided by the differential pressure due to the difference of area of the pressing and lifting rams, (or wholly by such differential pressure in the case of a horizontal press,) the water in the lifting-ram cases i being returned to the air-vessel through the low-pressure main n while the pressing-ram cases are filled with low-pressure water. The valves 1 1 and pipe n being of large diameter, the descent of the cross-head may be very rapid. Valve No. 2 being left open, the working-pressure is applied at the required moment by opening valve No. 3 and starting the pumps, whereupon the valves Nos. 1 1 automatically close the communication between the air-vessel and the pressing-ram cases c and open the communication with the pipe q, whereby high pressure is applied in the pressing-ram cases c and the forging is subjected to the necessary pressure. The pumps being stopped, the valves 2 and 3 are closed and the cycle of operations repeated. By this arrangement it is only necessary to pump sufficient water into the air vessel to compensate for leakage.

Instead of returning the water to the air-vessel, as above described, the high-pressure pumps may draw their water from an open tank, and the water from the ram-cases may be allowed to run to waste. In this case it will be necessary to provide separate pumps of sufficient capacity for maintaining the pressure in the air-vessel.

I prefer to drive the high pressure pumps m by a pair of steam or other engines, the regulating-valve of which may be opened and closed by mechanism so arranged that the engines will make any desired number of revolutions or parts of a revolution, and then stop automatically. For this purpose I control the regulating-valve by means of what is designated a "hunting-gear," the preferred arrangement consisting of two similar screws, r s, Figs. 9 and 10, placed with their axes parallel and journaled in bearings at a convenient distance apart. One of the screws is provided with a hand-wheel, or its equivalent, and may be caused to rotate on its axis by an attendant, the other screw being rotated in a contrary direction by spur or other gear taking motion from any revolving part of the engines. A worm-wheel, t, mounted between the screws gears with both of them at once, and its axle is carried by slide-blocks fitted in guides. When one of the screws is rotated, the wheel is caused to turn, the other screw acting for the time being as a rack, a reciprocating motion being thereby imparted to the

wheel-axle for the purpose of operating the regulating-valve of the engine, with which the said axle is connected by any suitable means. The one screw, *r*, is turned by hand when it is desired to start the engines, the other screw, *s*, being driven in the opposite direction by spur or other gear, *u*, receiving motion from the engine-shaft, and thus counteracting the effect of turning the hand-screw and tending to return the wheel to its normal position, which corresponds to the closed position of the valve. By this means the valve is eventually closed in a longer or shorter time after the hand-screw is stopped, according to the distance the wheel was displaced from its normal position. The screw *s* is driven through the medium of a friction-clutch, *s'*, in order to guard against the possibility of the pumping-engines continuing in motion after the steam is shut off, owing to the presence of steam in the steam-chest. Should the pumping-engines "overrun" the hand-wheel, the friction-clutch will be lifted out of gear by the T-shaped lever connected with the worm-wheel axle, thus avoiding breakage.

The method of working above described is not limited to the particular press hereinbefore described, but is applicable to other hydraulic forging-presses in which one or more pressing-rams and one or more return or lifting rams acting in the opposite direction to the pressing-rams are used.

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 forging-press, the combination, with the moving cross-head or tool-holder, of a rigid arm or tail-piece extending through the press-head and working in a vertical guide above or beyond the press-head, substantially as shown and described, for the purpose specified.

2. In a hydraulic forging-press, the construction of each pressing-ram in the form of a hollow trunk or cylinder closed at the inner end, and the combination therewith, and with the moving cross-head, of a thrust-rod working on a joint at each end, substantially in the manner and for the purpose specified.

3. The combination and arrangement, substantially as shown and described, of the moving cross-head or tool-holder, its central rigid arm or tail-piece and guide-cylinder therefor, the pair of pressing-ram cases and rams, constructed in the form of hollow trunks, thrust-rods working on universal joints between the rams and cross-head, and the universal joints between the ends of the cross-head and their guide-blocks, all for the purpose of permitting a slight horizontal deviation or rocking motion of the cross-head without throwing undue side strains on the rams and guides of the press.

4. In a hydraulic forging-press, the combination of the cross-head having a rigid tail-piece moving in a guide or cylinder, a pair of hollow pressing-rams acting through universal-jointed thrust-rods, guide-blocks for the cross-heads, with universal joints between the cross-head gudgeons and the guide-blocks, and a pair of lifting-rams connected by pairs of rods and universal joints to the gudgeons of the cross-head, substantially as set forth.

5. The compound automatic valve herein described, consisting of a tubular plug-valve controlling the communication of the pressing-ram cases with the low-pressure main, and surrounded by an annular chamber wherein high-pressure water acts to open the tubular valve, an inner spring-loaded valve opening in the opposite direction to the tubular plug-valve and controlling the communication of the high-pressure main with the pressing-ram cases, the parts being constructed, combined, and arranged to operate automatically, substantially in the manner and for the purpose specified.

6. The combination, with the floating or pilot valve composed of a balanced tubular plug-valve and an inner or pilot valve combined to operate in the manner described, of a balancing ram and cylinder in communication with the space in front of the valve, said ram and cylinder being of such an area and so applied as to counterbalance the pressure on the face of the pilot-valve, substantially as specified.

7. The combination, with a hydraulic forging-press having pressing and lifting or return rams acting in opposite directions, and of different areas, of an air-vessel, a set of high-pressure pumps, pipe connections and valves so arranged and operated that the cross-head will be brought into working position in the manner described, the working-pressure applied by the differential power of high-pressure water acting on the pressing ram or rams opposed by low-pressure water on the lifting ram or rams, and the cross-head raised out of work by the differential power of high-pressure water acting on the lifting ram or rams, and opposed by low-pressure water acting on the pressing ram or rams, whereby power is economized, a quick motion of the cross-head toward and away from its work is obtained, and the same water used over and over again, substantially as specified.

The foregoing specification of my improvements in hydraulic forging machinery signed by me this 15th day of April, 1885.

CHARLES DAVY.

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