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CHAPTER XL.

FORGING STEEL BY THE PRESS.

Necessity for the Press.—The greater the size of an ingot the looser is its texture likely to be in the centre, and therefore the more does it need working, while the more difficult does it become to effect this by work put on the outside. As was explained in the last chapter, the effect produced by the blow of a steam hammer is too transient to permit of the surface particles transmitting the pressure to the centre, where it is most needed. The cogging mill, although it draws out and works the surface of an ingot to a greater extent than it does the interior, has a more penetrating effect than a hammer, and suffices for ingots of moderate thickness, but for the enormous ingots required for armour plates, something more far-reaching in its effects than even rolling is desirable. To adequately deal with an ingot 3 or 4 feet thick a press is an actual necessity. By maintaining a steady pressure as long as required, and in the best possible direction, the press kneads the metal like dough, and makes it certain that every particle of the ingot, however thick, is thoroughly worked.

The Board of military and naval officers appointed by the U.S. Government to report as to the construction and equipment of gun factories in America, gave the following graphic description of the action of the forging press:—

"The effect produced by it requires to be seen in order to be thoroughly appreciated, and is altogether different from that produced by the hammer. The heated ingot resists the blow of the hammer, but the insinuating, persevering effort of the press cannot be denied. The longer time (several seconds) during which the effort lasts is a great element in its successful effect. As pressure succeeds pressure, the stability of the particles is thoroughly disturbed and a veritable flow of metal induced, which arranges itself in such shape as the pressure indicates; the particles are forced into closer contact, and the whole mass writhes under the constraint which it is impotent to resist." *

History of its Introduction.—Bessemer seems to have early experienced difficulties in properly working the centres of his ingots with such hammers as were then available, and, as early as 1856,† took out a patent for a press to accomplish this work, while his later patent of 1863‡ describes a hydraulic press having all the qualities essential for a tool working on this principle. Fig. 527, copied from the drawing accompanying his patent specification, shows an ordinary Bramah press, whose moving table was replaced by the lower forging tool, which moved, and the upper by the fixed forging tool, the height of which was adjustable by means of a screw on the top. He constructed and worked a press of this kind at his St. Pancras Works.

* *Proceedings of the United States Naval Institute*, vol. x., No. 4, p. 640, 1884.
† Patent No. 1292, 1856. ‡ Patent No. 1439, 1863.

The hydraulic press of to-day is of essentially the same construction, save that, to avoid lifting the whole forging bodily at each squeeze, the cylinder is at the top of the press, and forces the moving tool down on to a stationary ingot.

The ingots made in the early days of the Bessemer process were of such very moderate thickness, that a steam hammer of ordinary size could deal with them, and being more rapid for light work, the hammer re-asserted its superiority. As the Siemens process developed and ingots increased in thickness, conditions altered in favour of the press, which, for dealing with large masses, is more rapid as well as more efficient than the hammer. The immediate cause, however, of the revival of Bessemer's plan was the inability of Sir Joseph Whitworth to employ a large hammer at his works in Manchester, because of the nuisance caused to owners of the adjoining property by the vibration. To meet this difficulty he decided, about 1861, to try the effect of compressing the steel, while in a fluid state, into a mould of suitable form by means of a powerful hydraulic press. The shaping of steel by this means had to be abandoned, but it suggested to Mr. Gledhill, Sir Joseph Whitworth's manager, the possibility of shaping the heated ingot in a press instead of under a hammer.

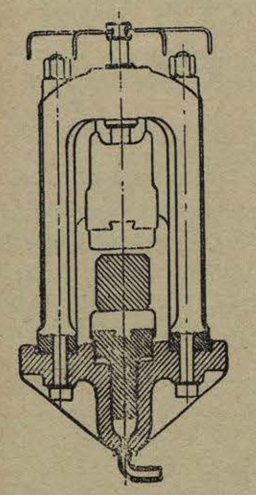


Fig. 527.—Bessemer's Hydraulic Forging Press.

Appearance of Hammered, Rolled, and Pressed Material.—The difference between a blow and a squeeze in shaping material is perfectly visible, if ingots which have been submitted to one or other method of treatment are examined. When an ingot is hammered, the surface, which absorbs the impact of the blow almost immediately, is extended more than the interior, so that the end of the hammered bar is cup-shaped, as shown at A, fig. 528, and if the hammer is very light and falls with a very high velocity, nearly the whole force may be absorbed by the upper surface, which may be extended so that the section of the bar resembles that shown at B. When an ingot,

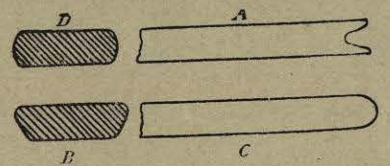


Fig. 528.—Shape of Hammered, Rolled, and Pressed Material.

on the other hand, is subjected to a steady squeeze, the outside, on account of exposure to the air and contact with the cold tools, loses its heat more rapidly than the centre, and flows less easily than the hotter central portions, which are therefore squeezed out, so that the end of a squeezed bar assumes the shape shown at C. If there is a cavity in an ingot, the press tends to close it, but the hammer, by striking the surface, tends to enlarge it.

When an ingot is rolled, the centre is not detruded in the same way as when a press is employed, because the surfaces of the rolls are moving rapidly in the direction in which the bar lengthens, and the rolls therefore drag

forward the outer layers in contact with them, the travel of the piece through the mill meeting with resistance, because it is larger on the entering than on the leaving side of the mill. If, however, a piece is rolled between plain rolls, and not in grooves which prevent it spreading laterally, it will be found that the centre has been spread out so that a cross section of the bar will have the form D, and even the end of an ingot, if short and rolled slowly, may occasionally show a similar rounded appearance, particularly if the centre is hotter than the outside, as is the case when ingots are treated in soaking pits.

Results Obtained by Hammering and Pressing.—If tests are taken from the outer parts of a gun forging which has had the centre trepanned out, little difference is found in the strength or ductility of the material, whether the forging was done under the press or under the hammer, provided the latter was sufficiently heavy for its work; the press showing, if anything, slightly better results. If, however, the test pieces are taken from the cores which have been cut out of the centre of the forgings, the difference in the results is so very marked as to have induced all the best makers of heavy steel forgings to instal presses in place of, or in addition to, their large hammers. The managers of the Bethlehem Works in America were so convinced of the difference, that though they had just constructed, at a cost of £40,000, a hammer with a falling weight of 125 tons, the largest hammer ever constructed, they replaced it within a very few months by a press which cost them £96,000,* and now have four presses at work capable of giving pressures of 2,000, 5,000, 7,000, and 14,000 tons respectively. So much better is the work done by the presses that the hammer is now dismantled.†

The specifications of the German Government require the section of the ingots to be eight times that of the finished forgings, if these are made under a hammer, and only four times if made under a press.

Essentials of a Forging Press.—A forging press consists essentially of a hydraulic cylinder, containing a ram which points downwards, and has attached to its lower end the upper pallet or forging bitt, which is generally carried by a pressing head or tool-holder interposed between the ram and the tool. This tool-holder usually slides upon the turned steel columns which support the cylinder, their lower ends being attached to a strong base casting which carries the lower pallet on its upper side. By admitting water under pressure to the cylinder, the upper pallet is forced down upon the ingot which rests on the lower pallet. Provision is made for lifting the upper tool and the ram by steam or hydraulic power, when the pressure in the main cylinder is released, so that the forging may be turned over or moved into a fresh position to receive another squeeze. Instead of one pressing cylinder, two or more may be employed, and they may be fixed at one definite level, or may be adjustable to different levels to suit the varying thickness of the piece being operated upon, such differences being little more than modifications in constructive details. The really important differences consist in the various methods employed for supplying the water under pressure, and the means adopted for admitting the water to, and releasing it from, the pressing cylinder.

Difficulties with High Pressures.—When the common pressure of 800 lbs. on the square inch is not exceeded, hydraulic machinery is simpler and subject to less wear and tear than ordinary steam plant, nor at double that pressure are any appreciable difficulties experienced; at higher pressures, however, water passes freely through porous spots in cylinder or pump

* *The Engineering Magazine.* H. F. J. Porter.

† *The Engineer*, April 25, 1902, p. 409.

castings, and troubles rapidly increase. To work a press capable of exerting an effort of several thousands of tons, pressures of $2\frac{1}{2}$ to 4 tons on the square inch must be used, or the press cylinder would be of impracticable dimensions.

Great difficulty was found in constructing large cylinders to withstand such high pressures. However thick the walls, cast-iron cylinders cannot be relied on to withstand permanently pressures of more than $1\frac{1}{2}$ tons per square inch, and if strengthened with wrought-iron hoops shrunk on the outside, 2 tons per square inch is about the limit of the capabilities of this material, which is almost invariably porous when of any considerable thickness, because cast iron, like cast steel, becomes looser in texture as its thickness increases. Steel castings were unknown forty years ago, and no ingots existed of sufficient dimensions to enable the cylinder to be cut out of solid steel, as is often done in these days. In some of the early presses constructed for bending armour-plates, the cylinder was made by boring holes in the centre of a series of armour-plates which were piled on each other, with leather joints between the plates, and on the top was a solid plate which formed the end of the cylinder, the whole being held together by strong bolts. In other cases cast-iron cylinders were lined with thin copper, which was impervious to water, and was able to withstand the pressure, when supported by the casting surrounding it, if wrought-iron rings were shrunk on over the cast iron.

The cast or forged steel cylinders now obtainable have solved this difficulty, and the pumps are invariably bored out of solid steel forgings. Much care, however, is needed to maintain the tightness of the joints of pipes and connections, and the packings of the rams and pumps, on the absolute tightness of which the successful working of a press entirely depends.

The valves are the parts which now give most trouble. If a pipe 3 inches in diameter is provided at its upper end with a valve above which is a pressure of water of 4 tons per square inch, and the face of the valve is $\frac{1}{4}$ inch wide, the upper face of the valve $3\frac{1}{2}$ inches diameter will be loaded with a weight of nearly $38\frac{1}{2}$ tons, while the annular seating which has to support this load has an area of little more than $2\frac{1}{2}$ square inches, thus imposing a load, where valve and seat meet, of 15 tons per square inch of surface. Even if the seating be made $\frac{1}{2}$ inch wide, the pressure on the seat will amount to 9 tons per square inch of surface. No wonder that valves slammed down on to their seats by pressures such as this are rapidly destroyed.

Moreover, water subject to a pressure of 4 tons per square inch, flows naturally at a speed of 1,150 feet per second, very little under the speed of the bullet from the Martini-Henry rifle used by the British Army less than twenty years ago; if there is the slightest groove on the face or seating of the valve, the water escaping through it before long cuts out a hole large enough to pass so much water that the pumps cannot make up the leakage. With a pressure of 4 tons per square inch, an opening of $\frac{1}{100}$ square inch in area will allow $2\frac{1}{2}$ cubic feet of water to pass to waste every minute, equivalent to giving about 4 inches travel of the head in a press of average size. The importance of reducing the number of joints and valves to a minimum, when dealing with such high pressures, will be readily appreciated.

As the forging, which is usually more or less rectangular in section until nearing completion, must be constantly turned over between the squeezes, the upper tool has to be repeatedly lifted to allow sufficient clearance for this purpose, and then lowered again until it touches the forging. The lifting is performed by small subsidiary cylinders, which are arranged to have just enough power to lift the pressing head with the ram and tool, and in the lowering operation only sufficient power is required to overcome the pull of these counterpoise cylinders, so that little pressure is needed until the ram has descended so far that the upper pallet touches the ingot. The space in the pressing cylinder which would be left vacant by the descent of the ram must, however, be filled with water before pressure can be put on the forging; and as water at a pressure of several tons on the square inch escapes with great rapidity through the smallest leak, while pumping it into the accumulator has consumed a great deal of power, it is advisable to use it as sparingly as possible. Most presses are, therefore, provided with a secondary supply of water at such a pressure as will overcome the action of the lifting cylinders, and fill the pressing cylinder with water, before the high-pressure water is admitted to give the actual squeeze, whereby a considerable saving in power is effected, each time the head is raised after a squeeze, to allow the forging to be moved into position for a fresh effort.

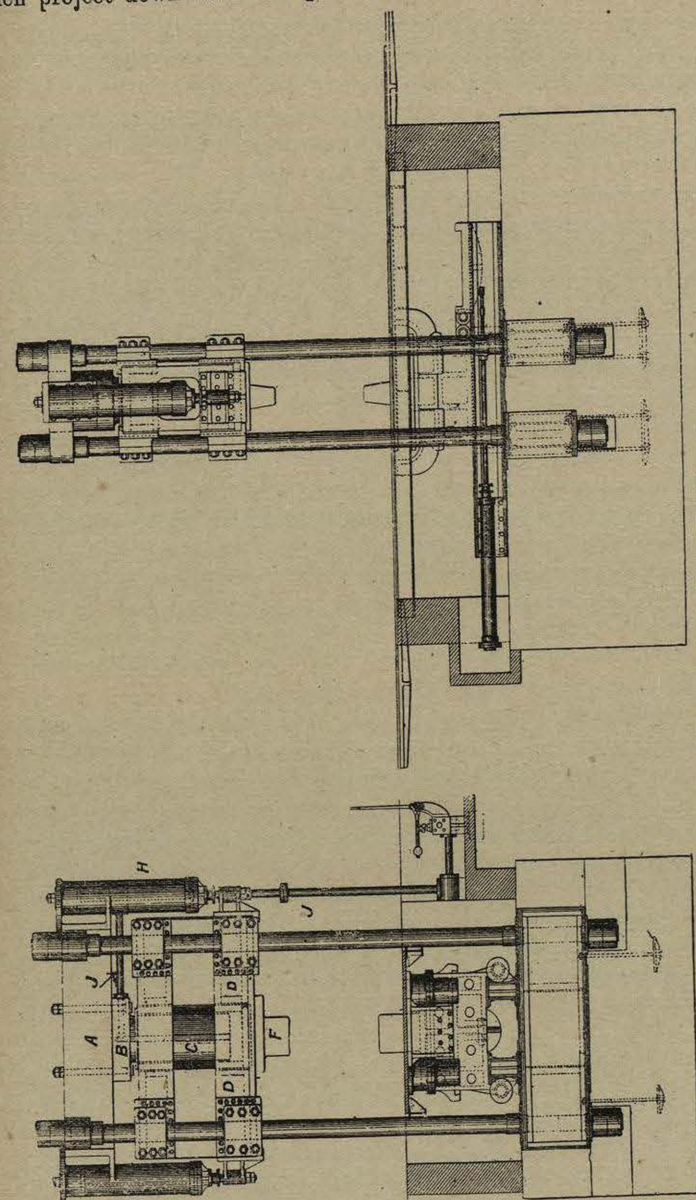
Varieties of Presses.—Presses may be divided into two distinct classes, viz.—(1) Continuous acting presses, in which the pressing tool descends regularly and continuously, under the influence of pressure maintained continuously, throughout the whole of the possible stroke of the head. The action of such presses may be compared to the squeeze which a vice exerts when the screw is turned until the jaws meet. Theoretically such presses are capable of reducing the largest ingot to the smallest section at a single squeeze, as a vice would flatten a ball of putty, but such conditions are not attainable in actual practice. (2) Intermittent action presses, in which the head has an intermittent or step-by-step action, comparable to lifting a load by a crowbar and putting a thicker piece under the bar, after each lift, to form a fulcrum for the next effort.

Continuous-Acting Presses are divisible into two classes, viz.—(1) Those worked from an accumulator. (2) Those worked direct from the pumps without the intervention of any accumulator.

Tannett-Walker Presses.—The late Benjamin Walker was an early and persistent advocate of hydraulic forging; his firm, Messrs. Tannett, Walker & Co., Ltd., of Leeds, had constructed eighteen hydraulic presses before the year 1865, and probably this firm have constructed more of these tools than any other engineers. To secure the maximum economy of steam in their presses, they employ compound or expansive engines fitted with flywheels, to deliver the water into an accumulator loaded with a dead weight, in the same manner as the hydraulic cranes and capstans are supplied with water in the public docks.

When a flywheel is used, an accumulator is necessary to serve as a reservoir, because engines fitted with flywheels cannot be stopped and started just as the water is needed. But as such engines can run and deliver water into the accumulator while the press is pausing, which stored water can be drawn off rapidly when required, the press is rapid in action, though the engines and pumps driving it may be small. The lifting and lowering of the top tool, when not actually pressing the work, is performed by a secondary water service at a pressure of 700 lbs. per square inch, this pressure also serving the cranes and subsidiary appliances.

In some of the presses by these makers the cylinder is turned upside down, the ram, through the centre of which the water is introduced, being fixed to a crosspiece secured to the upper ends of the columns, and the cylinder moves with the upper tool. This arrangement provides long guiding surfaces independently of the ram, which is thus less liable to be scored, while the packing of the ram is kept cool, and is readily accessible. Fig. 529 shows a press of this description. A is the upper entablature to which is secured the ram, B, on which slides the hydraulic cylinder, C, secured with its mouth upwards in the moving head, D, which carries the upper pallet, F. On each end of the entablature, A, are secured the lifting cylinders, G, H, from which project downwards two piston-rods, each secured to one end of the



2,000-TON HYDRAULIC FORGING PRESS.

Fig. 529.—2,000-ton Hydraulic Forging Press, by Tannett, Walker & Co., Ltd.

moving head, D. A pressure of water of 700 lbs. on the square inch is constantly maintained below the pistons in the lifting cylinders, so that the moving head is held up to the top of its stroke, unless water at a pressure of 2 or 3 tons on the square inch is admitted by the pipe through the centre of the ram, B, when the resistance of the lifting cylinders, which really act as counterpoises to balance the weight of the moving head and its attach-

ments, is overcome, and the head is forced downwards. Immediately the pressure in the cylinder, C, is released, the head is raised again by the pressure in the lifting cylinders, so that all that is necessary to work the press is to admit water through the valve when the head is required to descend, and to release this water when it is desired that the head shall rise.

In other cases, in order to avoid the side thrust which would be liable to come on a ram pointing downwards if it projected far from the cylinder, the upper part of the press containing the pressing cylinder is made movable on the upright columns (fig. 530), so as to be capable of adjustment at such a height above the base as may best suit the thickness of the piece on the anvil, the adjustment being effected as follows :—The four columns on which the head slides are secured at the top in a heavy cross casting, and to this

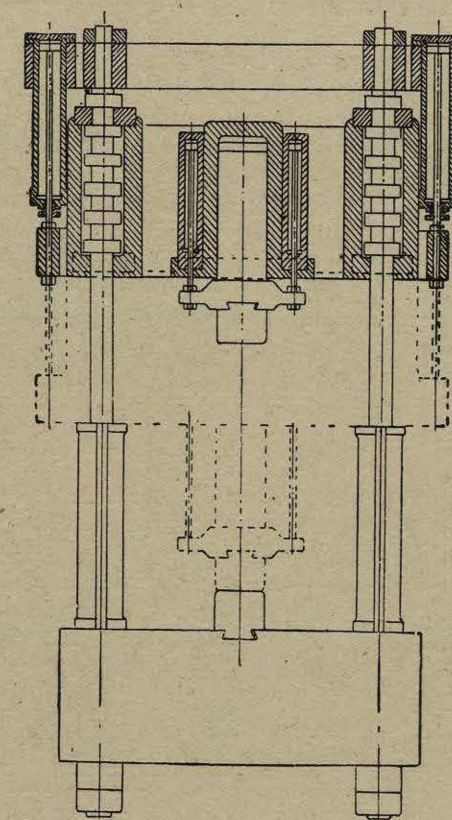


Fig. 530.—Tannett-Walker Forging Press, with pressing cylinder capable of adjustment to varying levels.

casting are attached hydraulic cylinders, by means of which the movable casting containing the pressing cylinder may be raised or lowered. The columns at their upper ends are not circular throughout, but have cross-pieces forged solid with them projecting on opposite sides at regular intervals, as shown in fig. 530. The head can slide freely on these columns, but on the top of the movable head, at each corner, are placed circular nuts (fig. 531), having rectangular holes slotted through them, through which the cross-pieces on the columns can pass. By turning these nuts through a quarter of a circle round the circular portions of the columns between the projections, the head is locked firmly in position. The action is similar to dropping a T-headed bolt into a T-shaped slot, and giving it a quarter turn, when the bolt cannot be pulled out again. The rotation of the nuts is performed by small hydraulic cylinders.

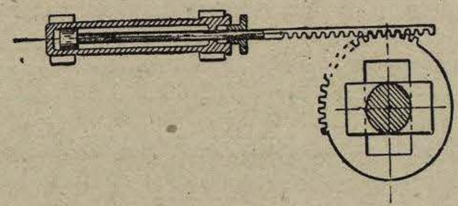


Fig. 531.—Locking arrangement of Tannett-Walker Adjustable Press.

A press at Seraing is worked with three accumulators, loaded with a weight of 125 tons, and according as one, two, or three cylinders are supplied by the pumps, the pressure obtained is 200, 300, or 400 atmospheres, that pressure only being used which is found to be sufficient to accomplish the work in hand.

The Bochum Press.—This press (fig. 532), which was introduced at the Bochum Works, in Westphalia, is another example of a continuous press worked by accumulators. The pressure of water employed is 600 atmospheres, or nearly 4 tons per square inch, and is maintained by accumulators loaded with compressed air instead of with dead weights, the object being to avoid the shock caused by the momentum of the falling weight when the escape valve is closed suddenly. The squeeze is put on by this high pressure, but the lifting and lowering of the head, and the working of the cranes is done by water, at a pressure of 700 lbs. per square inch. Two pairs of pumping engines are provided, one pair to supply each pressure, the low pressure delivering into ordinary weighted accumulators, and the high into the air-loaded ones. To maintain the air pressure in the accumulators air compressors are installed. The ram of this press is not of one uniform diameter, but the upper part works in a continuation of the cylinder which is of smaller diameter than the lower portion, the respective areas being as 1 : 3. By admitting the pressure of the water either to the smaller ram only, or to the annular space only, or to both spaces at once, it is possible to obtain, with the same water pressure, three different powers in the proportion of 1 : 2 : 3, giving a pressure on the forging of 1,300, 2,700, and 4,000 tons respectively. The additional leathers add to the risk of leakage, but it is said that all three can be replaced in about two hours.

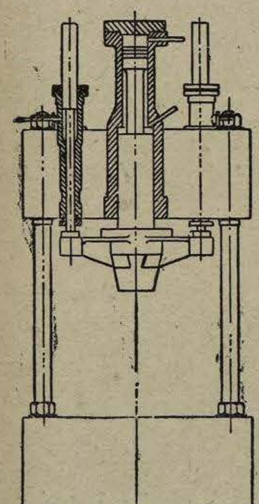


Fig. 532.—The Bochum Forging Press.

The valves are actuated by relays, consisting of small hydraulic cylinders, to which pressure is admitted to lift the valves. All are controlled by the movement of one handle. The first portion of the travel of the handle releases the water from the pressing cylinder, when the pressing head is raised by the pressure in the lifting cylinders; a slight further movement closes all the valves, and the head remains stationary; a further movement

admits the low-pressure water which brings the head down on to the work, and the final portion of the travel admits the high-pressure water, which is only employed when the head is touching the ingot.

As many as 30 strokes per minute can be obtained when the press is employed on light finishing work, and a 4,000-ton press is said to turn out on an average 30 tons of forgings per day.

Whitworth's Press.—This press is a continuous press worked without an accumulator, so far as the actual pressing is concerned, though an accumulator is employed for the lower pressure for moving the head and handling the cranes. To ensure rapidity of working, this lower pressure in the Whitworth press is very high (about 2 tons per square inch), and is obtained from engines pumping into weighted accumulators. The squeeze is obtained by allowing the water to pass direct into the press cylinder instead of into the accumulator, so that the pressure is obtained direct from the engine to the pressing ram. When the water is not required a bye-pass valve is opened, and the water is pumped round and round without meeting any resistance, so that the engines running empty are relieved of the load. Fig. 533 shows a Whitworth press. In some of the Whitworth presses the top head is adjustable, to suit the thickness of forging in hand, and can be moved

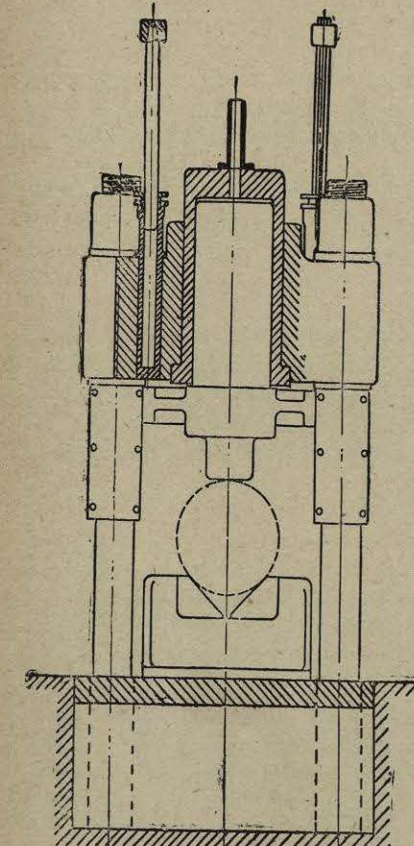


Fig. 533.—Whitworth's Forging Press with Fixed Cylinder.

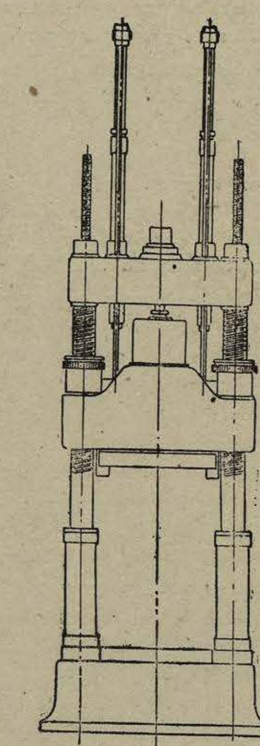


Fig. 534.—Whitworth's Forging Press with Adjustable Cylinder.

up or down on the columns, which are provided with nuts, maintained in contact with the head by means of gearing. Fig. 534 shows a press of this description. Attached to the Whitworth presses is a large dial like a clock face, on which travels a hand actuated from the pressing head, which shows how far the two tools are apart, and informs the workman when the forging is nearing the finished size.

Davy's Press.—This press, made by Messrs. Davy Bros., of Sheffield, is a continuous acting press working without an accumulator. The chief feature of the press (fig. 535) is the form of the pressing head, which is shaped like an inverted letter **T**, the cross arms being provided with slide blocks, *g*, bored to fit the columns, and the stalk, *e*, projecting upwards through the entablature, *a*, and sliding in a bored guide. On either side of the stalk are situated the two pressing cylinders, *c c*, which carry hollow rams, inside which are spherical-ended thrust rods, *d d*, the lower ends of which rest in spherical sockets made to receive them in the pressing head, *b*. The object of the T-shaped head is to provide a guiding surface as high as possible above the guides on the columns, so as to resist the lateral strains which are set up by placing the forging out of the centre of the anvil, and are apt to thrust the ram against the side of the cylinder and cause scoring, which rapidly destroys the leather packings. The rams are not coupled direct to the crosshead, because the latter expands when in proximity to a hot forging, and might thrust the rams against the sides of the cylinders.

In most presses the pressing head is raised by maintaining a constant pressure in the counterpoise cylinders, which exert a continuous lifting effort on the head. When the forging is squeezed, this lifting power is overcome by the greater force developed in the main cylinder driving the water or steam contained in the lifting cylinders back into the accumulator or boiler, according as water or steam is employed in these counterpoise cylinders. A constant pressure is not maintained in the lifting cylinders of the Davy press, but when the head is required to be raised, the flow of water from the pumps is diverted from the pressing cylinder to the lifting cylinders; and when the head requires to be lowered again on to the forging ready for a fresh squeeze, the release of the water from the lifting cylinders leaves the head free to fall by its own weight on to the forging; this it does at a speed of about 2 feet per second, the action of gravity being assisted by the supply of water at a pressure of 60 lbs. per square inch, which is also used to fill the cylinders, *c c*. The engines are then started and the squeeze begins, the pressure rising to 4,500 lbs. per square inch if the resistance of the ingot is sufficient to call forth this power. The secondary water supply, loaded to 60 lbs. pressure per square inch by compressed air in the receiver, *l*, prevents air getting into the pipes and cylinders; the main pumps draw from this service, thus securing a rapid flow into the barrels with no risk of drawing air, enabling the suction valves to be made much smaller than would otherwise be possible.

The engine is started every time a squeeze is to be taken, and when the compression has been carried as far as desired, the flow of water is switched on to the lifting cylinders; as the relative areas of the pressing and lifting cylinders are as 16 : 1, it will be understood that the lifting of the head is done very rapidly, while its descent, until the moment of contact with the forging, is equally prompt.

The pumping engines employed consist of two horizontal engines, without a flywheel, coupled one at each end of a stout crank-shaft; on this shaft are three parts made sufficiently eccentric to the main bearings to serve as

pins for driving the three single-acting pumps, *m*, which are placed between the engines; the latter, having two cylinders coupled at right angles, and, as previously stated, no flywheel, are in this respect like the reversing engines

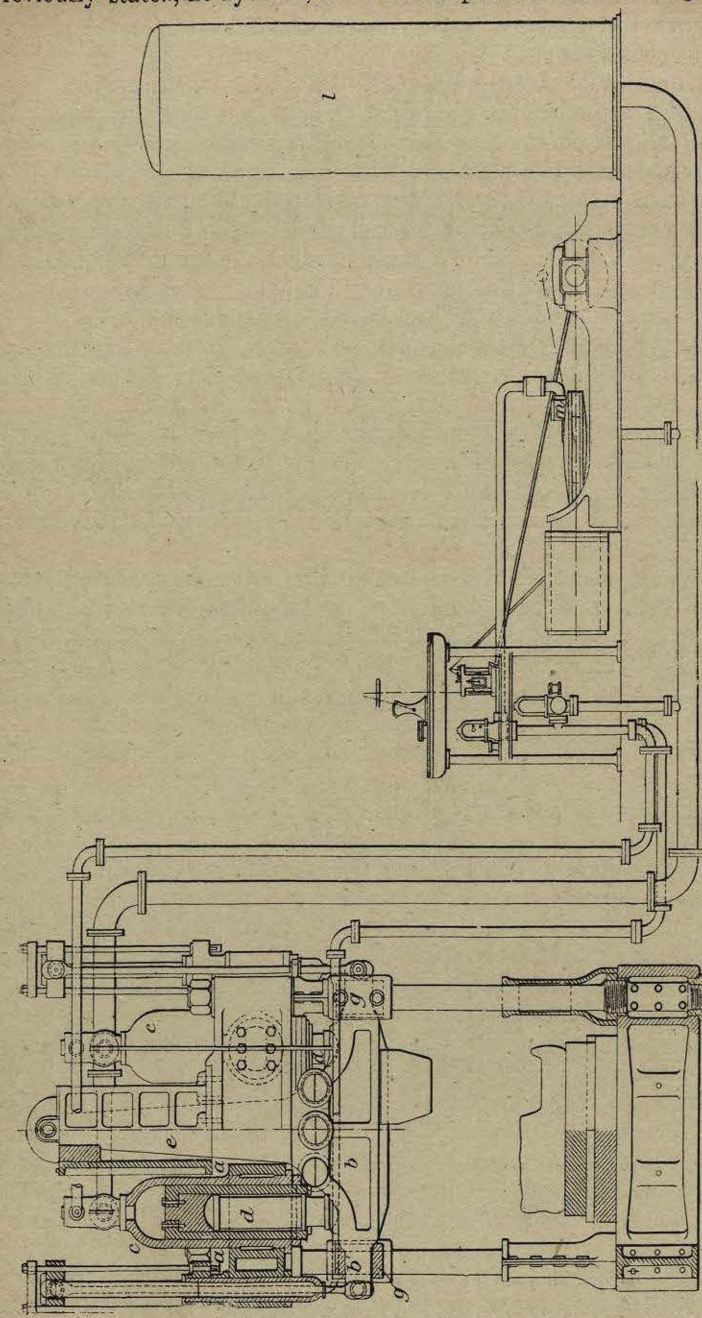


Fig. 535.—Davy's Original Forging Press.

of a rolling mill, which can be started or stopped instantly. One revolution of the engines depresses the head half an inch, or raises it 8 inches, so that the tool can be adjusted both with rapidity and exactitude. Only two levers are required for controlling the three motions, one for starting or stopping the engines and one to adjust the valves, the actual movement of which is effected by relay cylinders.

Messrs. Davy Brothers' recent improvements have removed their presses into the class to be next described.

Intermittent Acting Presses.—Presses having neither an accumulator to contain a store of water on which to draw, nor pumping engines capable of supplying it continuously, must necessarily work intermittently. They are divisible into two classes—(1) those in which the pressure is obtained direct from a steam piston whose rod forms the plunger of a pump, the arrangement being merely an intensifier with steam in the large and water in the small cylinder; and (2) those in which the pressure is obtained from engines having a rotating crank-shaft, incapable of giving the continuous supply employed in presses which have a continuous action.

Davy Brothers' New Presses.—For presses exerting a pressure of 2,000 tons and upwards, the inverted T-shaped cross-head, with twin cylinders one on either side of it, are retained, but for smaller presses only one central cylinder is fitted. Water under an air pressure of 60 lbs. per square inch is stored in a large vessel as before, and whenever the press is not squeezing the forging, the full pressure of this water is maintained in the hydraulic cylinders of the press and intensifier, and in the connecting pipe between them, so as to exclude air.

The adjustment of the height of the press-head, A, fig. 536, is effected as follows:—To raise it, a check valve at B between the connecting pipe, C, and the air vessel, D, is raised, and steam pressure is at the same time admitted below the pistons of the lifting cylinders, E, E, when the upward movement of the press-head forces the water back into the air vessel, further compressing slightly the volume of air on the surface of the water. To lower the head, A, this steam is released, and the cross-head descends by gravity at such speed as is found convenient—usually about 1 foot per second.

The squeeze is given by hydraulic pressure exerted by a steam intensifier, consisting of a steam cylinder, F, the piston-rod of which, G, projects upwards forming the plunger of a hydraulic cylinder, H, inverted above it, between which and the press cylinder is a connecting pipe, C. If the steam cylinder of the intensifier is 40 times the area of the piston-rod forming the plunger, when steam of 150 lbs. per square inch is admitted below this piston, it produces an intensified pressure of about $2\frac{1}{3}$ tons per square inch in the hydraulic cylinder, H, at the top of the intensifier, which is conveyed to the cylinder, J, of the press by the connecting pipe, C.

Simultaneously with the admission of steam below the piston of the intensifier, steam is admitted also below the pistons in the lifting cylinders, E, E, attached to the head of the press, the object being that in case the resistance to the downward motion of the cross-head should cease suddenly, as may happen by the slipping of the forging, or when cutting or punching it, the press-head shall not drop, but continue moving in perfect synchronism with the piston of the intensifier.

In short, the function of the steam admitted below the pistons of the lifting cylinders is to get rid of "back-lash," and cause the piston of the intensifier and the head of the press to move temporarily, as if they were positively connected to each other.

The movement of the piston of the intensifier is itself controlled by Holmes' and Davy's patent single-hand lever gear, so that the piston moves in perfect synchronism with the hand of the workman who controls it; and

in this way the slightest movement of the workman's hand is responded to by a simultaneous and equivalent movement of the head of the press.

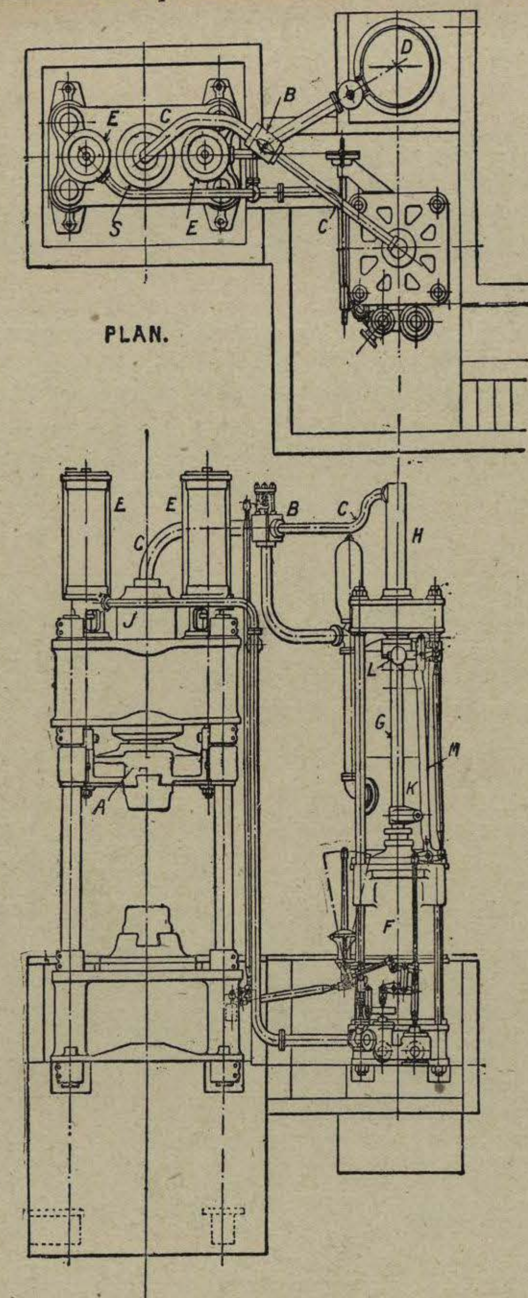


Fig. 536.—Davy Brothers' New Quick-acting Press.

The simultaneous motion of hand and press is obtained as follows:—Coupled to the piston-rod of the intensifier is a cross-head carrying a small roller, K; a balance weight, L, keeps pressed against this a bar, M, having its edge slightly inclined to the direction of travel of this roller, so that as the roller continues to rise it continues to press the bar to one side. This bar is coupled to one end of a floating lever; the steam and exhaust valves are coupled to the middle, and the handing lever to the other end of the floating lever, so that the act of the workman moving one end of the floating lever lifts the steam valve, admitting steam into the intensifier, and forcing up the plunger, to which is fastened the cross-head carrying the roller; the latter being in contact with the inclined bar forces it to one side, closing the steam valve and opening the exhaust valve. The result is that the further the workman moves the handing lever the further does the intensifier piston rise before the small roller pushes the bar aside, and so shuts off the steam. When the man's hand stops, the piston stops; if the man's hand moves slowly, so does the piston, the movement of the head of the press exactly copying the movement of the workman's hand. To prevent accidents there is a set-off at the end of the bar, which shuts off the steam entirely at the end of the stroke, and prevents the man knocking out the cylinder head.

The whole of the movements are controlled by one hand lever, which can be moved into positions which we will call 1, 2, 3, 4, 5, and 6. Positions 1 to 4 adjust the height of the head before the squeezing begins, while 4 to 6 regulate the squeezing stroke after the position of the head is adjusted.

Suppose the press to be at rest, with the press head in its lowest position, the upper tool resting on the lower, the intensifier piston at the bottom of the cylinder, and the hand lever vertical in position No. 4. It is required to raise the head sufficiently to admit a forging on the anvil. The workman pulls the hand-lever towards him into position 2, thus lifting the check-valve to permit the water in the press cylinder to be forced back into the air vessel by steam admitted at the same time below the pistons of the lifting cylinders, and the head rises; when sufficiently high he pushes the lever back into position 3, when the check-valve closes, and the head remains suspended while the forging is adjusted. When adjusted the man pushes the handle on into position 4, thereby releasing the steam from below the lifting pistons, and allowing the press-head to fall; and the pressure of air in the receiver forces the water through the check valve and fills the press cylinder, so that when the press-head rests on the forging the system, between the intensifier ram and the press cylinder, will be full of water.

Immediately the hand lever is moved into any position between 5 and 6, the intensifier and press-head will move together, just like the opposite ends of a powerful lever, the intensifier passing through feet, while the press-head moves through inches. Whatever be the total load on the ram of the intensifier, it is multiplied on the ram of the press in direct proportion to their respective travel, which, of course, is inversely proportional to their respective areas. All the workman has to do to squeeze down the head is to keep on pushing the lever from him until it reaches position 6, when the available stroke is used up. To raise it he pulls the lever back again to position 5, the press-head dancing up and down just as he moves his hand backwards and forwards, usually from 60 strokes per minute with large, up to 150 per minute with small, presses. This rapidity of action, greater even than that of a steam hammer, makes the press most convenient for finishing forgings by rapid and light planishing strokes, and removes the last objection which could be urged against forging presses.

Suppose the workman, having made one squeeze, wishes to move the forging along to take a fresh squeeze of the same depth on the next bite,

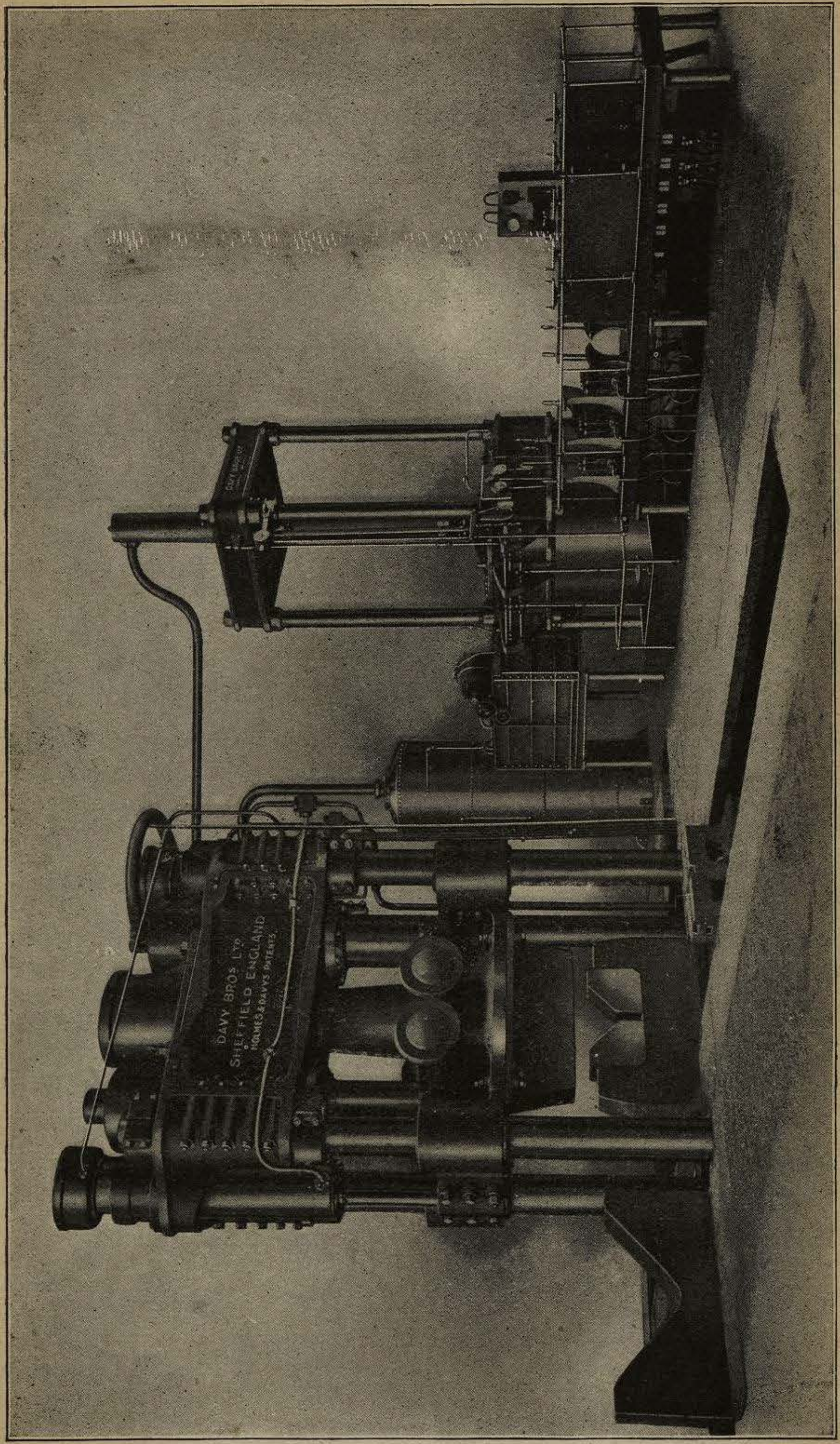


Fig. 537.—Davy's 4,000-ton High-speed Forging Press, with Steam Hydraulic Intensifier and Hydraulic Manipulating and Tool-changing Gear.