REPORT

ON

MACHINE TOOLS AND WOOD-WORKING MACHINERY,

BY

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TABLE OF CONTENTS.

REPORT ON MACHINE-TOOLS AND WOOD-WORKING MACHINERY.

LIST OF ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

NEW YORK, *December* 8, 1881.

Prof. W. P. TROWBRIDGE.

SIR: I have the honor to transmit herewith the report upon Shop-tools, which I have prepared for the Tenth Census of the United States.

This report has been divided into two parts. The first part treats of tools for working metals, or machine-tools, properly so called. The second part treats of wood-working machinery. It was necessary to define the limits of classification in both divisions, in order that the expansion in the sub-classes should not carry the discussion into too broad a field. For this reason it was decided to begin with the materials as they are bought in the market. The tools for the fabrication of the metals into merchant forms are therefore excluded, and the forest sawing-machines for lumber. At the other end of the series, the line has been drawn at the tools which are distinctly special, or which are designed for one particular duty and can not be applied for any other. Between these boundaries, however, lies a very large class of machines which may be made of very wide application, according to the skill of their operators. These are the tools used in building other tools or constructions, and which, therefore, are more fundamental than they. They are, in short, the tools used in the constructive arts rather than in manufactures. Even with this limitation at both ends the field of study is still a wide one, and it is one in which American industry has been particularly active. The standard of mechanical excellence which is imposed by our best engineers demands a high standard in the tools for the construction of such work. The necessity for exact dimensions in machine-work has stimulated designers to arrange their material so that inaccuracy or spring shall be eliminated in the lines of tool travel. Fuller appreciation of the meaning of "bearing-surface" and its importance in tool-building makes the newer tools more durable as well as more exact. There are also other details of design and construction, which will be made evident from the illustrations in the sequel, which are confirmatory of the progress in this direction. It is hoped that the degree of advancement marked by the types discussed will serve as a stimulus to further effort and as a plane of reference to gauge the upward course in this particular during the next decade.

In the preparation of this report I obtained information at first-hand. Visits were paid to the leading centers of tool industry, and the details were ascertained from personal inspection. I would take this occasion to express my obligation to those gentlemen who have so kindly seconded my efforts in gathering accurate details. The uniform courtesy which it was my good fortune to enjoy in cities lying between Boston and Saint Louis has made the discharge of my duties particularly agreeable, especially when it is remembered that the collection of mechanical statistics of this sort is an entirely novel thing. In a very few cases only has information been gathered by correspondence and from catalogues. Catalogues are usually out of date before they are in circulation, and where they have been used care was taken to make sure of their accuracy.

The places visited are included in the list below. Many of them are the centers where many builders are to be found together, and are therefore of deserved importance:

In Connecticut: Danbury, Essex, Hartford, Middletown, New Haven, Norwich, Wolcottville.

In Delaware: Wilmington.

In Massachusetts: Boston, Chicopee, East Brookfield, Fitchburg, Greenfield, Hyde Park, Leeds, Lowell, New Bedford, Northampton, Springfield, Taunton, Westfield, Winchendon, Worcester.

In Illinois: Chicago, Dunleith.

In Maine: Gardiner.

In Michigan: Battle Creek, Detroit, Grand Rapids.

In Missouri: Saint Louis.

In New Hampshire: Concord, Lebanon, Manchester, Nashua.

In New Jersey: Newark, Smithville.

In New York: Buffalo, New York, Rochester, Syracuse, Yonkers.

In Ohio: Alliance, Cincinnati, Cleveland, Dayton, Defiance, Hamilton, Salem.

In Pennsylvania: Erie, Montgomery, Montrose, Philadelphia, Williamsport.

In Rhode Island: Pawtucket, Providence.

In Vermont: Windsor.

With regard to the illustrations, they are, in a majority of cases, from photographs taken directly from the tool. In many cases they are reproduced from cuts which were themselves from photographs. In a few instances the older types are shown, that comparisons may be instituted with the newer designs. There are but few illustrations of unique tools. Nearly all may be considered to exhibit types either of classes or of particular modifications under those classes. It is thought that their number adds particular interest and value to the report.

It is, of course, unavoidable that this report should not contain what is the very latest type of practice at the date of its publication. Invention and industry are so active that improvements are in the market on tools discussed in the first pages before the last pages are penned. It could only be attempted to bring the facts down to the close of the year 1880, and to leave them there. Nor should it be forgotten in these days of specialization of knowledge, how easy it is for any one fact or group of facts to escape the notice of an individual geographically distant from the center whence they proceed or where they are well known. Allowance must be claimed for shortcomings in this regard also. With these words of explanation, I place the report in your hands.

Yours, respectfully,

F. R. HUTTON,
Special Agent, Tenth Census.

PART I.

MACHINE-TOOLS.

PART II.

WOOD-WORKING MACHINERY.

INTRODUCTORY.

It is proposed in this report to review those shop-tools which have become essentials in engineering establishments, such as machine-shops, car-shops, and the like. The purely metallurgical machinery will therefore be excluded, as also the log-sawing machinery and those special machines which are adapted for but one service and the manufacture of one article.

Shop-tools are to supplement and to replace hand-labor. They have two functions. The first and most general is the conversion of metal and of wood into the special forms required for industrial uses. The second function is the performance upon the shaped pieces of the various operations necessary for finishing and fitting. The differences in structure of wood and of the metals are very great, both mechanically and economically, and give rise to very different forms of tools. It will be necessary to take up the two classes separately. The machines for working in metals are known as machinists' tools, or machine-tools. Machines for converting lumber are called wood-working machinery.

The machines for shaping and fitting metals may act by—

A.—Compressing.
B.—Shearing.
C.—Paring.
D.—Milling.
E.—Abrading, or grinding.

The wood-working tools act by—

F.—Scission, or cutting off the fibers.
G.—Paring, or shaving the surface.
H.—Combinations of these two.
I.—By abrading or grinding.

This classification takes account of the precedence of conversion of the material to the fitting operations. This arrangement will be followed in the succeeding discussions.

Part I.—MACHINE-TOOLS.

A.—TOOLS ACTING BY COMPRESSION.

§ 1.

To the class of tools acting by compression belong—

Squeezers for puddled balls.
Roll-trains.
Hammers.
Riveters.
Die-forging presses.
Bending-rolls, straightening- and bending-presses, and assembling-presses.

The squeezers and roll-trains belong to the metallurgical stage of the manufacture of the metal, previous to its delivery to the engineering establishment in merchant form. By the plan of the review, these do not come up for discussion. The first great class will therefore be the division of Hammers.

HAMMERS.

The mechanical hammers act upon the softened metal to change its shape to that desired. They may be driven from the shafting of the shop through belting, or else directly by the steam of the boiler. The first class may be called "power hammers" and may be subdivided into—

Cam-hammers—trip, tilt.
Crank-hammers.
Friction- or drop-hammers.

§ 2.

CAM-HAMMERS.

This type of hammer in its various forms is historically the earliest. Its construction was no doubt suggested by that of the ordinary hand-hammer. In one of its forms (Figs. 1 *a* and 1 *b*) a long helve of wood with a steel head is pivoted at a point behind the center of its length, and the projecting tail is depressed by wipers upon a cam at the back of all. The rise of the head is stopped by a transverse stringer of wood just after the tail of the helve is released from the wiper, and the elasticity of the helve increases the intensity of the blow. Otherwise it could be no greater than that due to the weight of the head. A greater number of blows can also be made per minute, since gravity is assisted in the arrest of the rise and by the downward impulse upon the delivery of the blow.

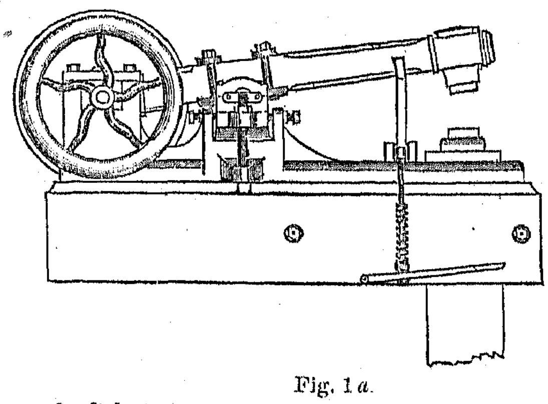


Fig. 1 *a*.

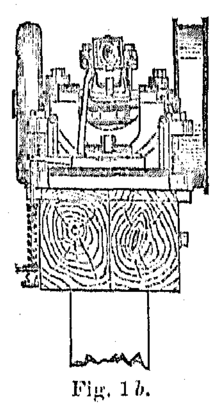


Fig. 1 *b*.

A second form of this type has the cam-shaft between the head and the center of motion (Figs. 2 *a* and 2 *b*). The wipers bear upon a lifter, and the tail of the hammer strikes upon a wooden spring at the rear, causing the rebound. This arrangement has the advantage over the other of lowering the supports of the cam-shaft, and of lengthening the helve segment from anvil to husk without increasing the floor space required. This latter form is, therefore, predominant in the newer types. The hammer is driven by a belt running loose upon a flanged pulley on the wiper-shaft, and engaged by a tightener-pulley pressed against the belt by a foot-treadle which surrounds the anvil. There is also a fly-wheel on the cam-shaft to equalize the variable strain upon it by serving as a reservoir of living force. By varying the tension of the driving-belt, the operator can vary the speed, and hence the intensity of the blows. When the belt slips somewhat the wooden spring is less compressed. There are usually several wipers in the cam-wheel, so that several blows are struck in each revolution. The acting surfaces are of steel let into a holder of cast iron and secured by keys, or else dovetailed. The lip on the tail or at the belly of the helve is also of steel, clamped in place by bolts. These bolts pass through ears in a cap, which overhangs the edges of the helve, so that the bolts do not pass through the wood, but outside of it. The trunnions may be secured to the helve in the same way. The head of the hammer has often been similarly secured, but the shocks and vibrations at this point have been found to crystallize bolts made of the most fibrous iron. Newer practice makes the head and trunnion forging in a ring-form. The helve passes through them and they are secured by wedges. This form absorbs its own vibrations, as they are nowhere suddenly arrested. The lower part of the head is fitted with a dovetail groove, in which the flat face or the various swages may be keyed. The anvil-block, with the face or swage similarly keyed, rests upon a post, either driven into the ground or resting upon the timber foundation of the machine. The pivots for the trunnions are made adjustable longitudinally by set-screws and jam-nuts, so as to bring the dies into any desired lateral relation. The foundation is made of a crib-work of timbers bolted together, but yielding sufficiently to take up the shocks imparted to them. The flexible and elastic belt prevents the shocks upon the cams from being carried entirely to the line shafting. Sufficient strain is thus transmitted, however, to necessitate heavier designs than are adapted for steady transmissions.

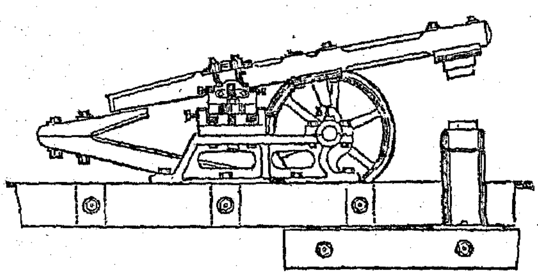


Fig. 2 *a*.

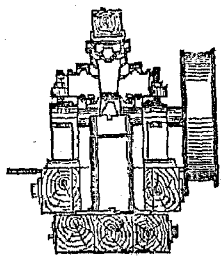


Fig. 2 *b*.

For small work in gun-shops a form of "pony" trip-hammer has been successfully used. The helve and husk and bed-plate are of iron, and the cam-wheel, 10 inches in diameter, makes from 150 to 200 revolutions per minute. There are six cams on the wheel, inserted and held in place by pins. The rapidity of their blows adapts them for small work which is liable to cool rapidly.

It will be at once seen that certain difficulties surround the use of the trip-hammer or any of the pivoted hammers of the cam-disengagement class. The first one is that the face of the hammer will only be parallel to the anvil in one position of the helve. As the helve rotates about a center, a true or parallel blow will be struck only upon a piece of a certain thickness. This is no disadvantage in drawing down, or in taper work, or in work which can be treated across the face of the anvil. But this peculiarity diminishes the adaptability of the hammer for differing classes of work, and it grows worse as the helve is shorter. It can be avoided by raising and lowering the center of motion, but this adjustment can only be limited in amount, on account of the relation between the wipers and the bearing-plate.

Secondly, the limited arc of its motion restricts the applicability of the trip-hammer for deep work or for upsetting. It cannot be made to strike a heavy blow on a large piece, because the weight can fall through but a short distance. But the larger the piece the farther must the effect of the blow penetrate to perfect the welds in the interior, and hence the heavier should the blow be.

Thirdly, the shocks and vibrations of the frame-work and transmissive machinery are a drawback, especially where a large number are driven from one line.

Fourthly, the limits of variation in the intensity of the blows are narrow. A certain minimum cannot be exceeded, which is represented by the weight of the head multiplied by its fall. The maximum intensity is due to this weight together with the impulse due to the rebound. A much wider range is desirable between the first shaping blows and those which should be used to finish the shaped surfaces. But there are certain marked advantages possessed by the trip-hammer. It is cheap in first cost and in foundations. It is adapted for drawing down. Light blows can be delivered with great rapidity. But its special application is found in swage-work between formers. It will hold its own swages on face and anvil, and they can easily be of different diameters and serve as stop-gauges for each other. Hence these hammers will be extensively used for this class of work, and invention and improvement have been in the line of avoiding some of the drawbacks other than those due to the fixed center.

A type of these improvements will be illustrated by Fig. 3. Here, as before, the power is communicated from the line shafting by a belt which may be tightened by a pulley controlled by the treadle which surrounds the anvil. The driving-shaft is, however, no longer a cam-shaft, but carries an eccentric. From the strap of this eccentric a link passes up to an "oscillator," whose center of motion is the fulcrum of the helve. The eccentric is made in two parts. On the shaft is the forged iron eccentric proper, which has a flange upon one side of it. Upon this eccentric fits a composition eccentric-ring, being secured to the first by tee-bolts, which fit in a slot in the flange. The steel eccentric-strap fits upon the composition ring. It will be seen that by this arrangement the total eccentricity or throw of the oscillator may be varied at will from the sum of the eccentricities of the

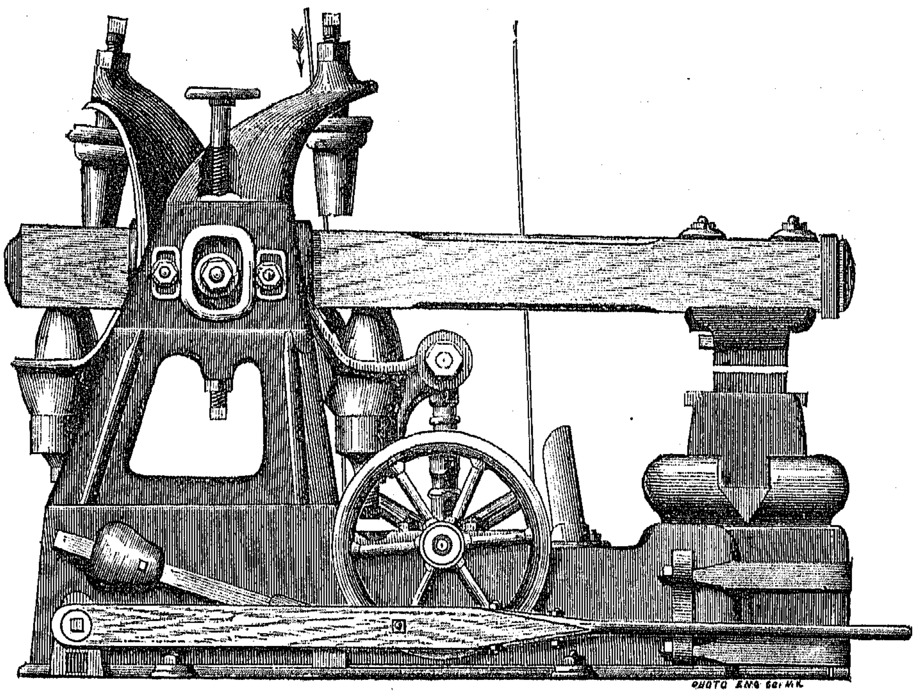


Fig. 3.

two parts to their difference. Hence an adjustable throw is obtained. The link from the eccentric-strap is fitted with a right-and-left sleeve and jam-nuts, so that the height of the hammer may be varied. Between the strap and the oscillator is a double-hinge joint, the pins being at right angles to each other in parallel planes. This prevents any untruth in the dies from making the eccentric-strap heat, because obliged to work out of line. The oscillator transmits its motion to the helve by means of two rubber cushions which are compressed against its under side, and thus alternately lift and force the head. There are two adjustable stationary cushions, secured to the husk above the helve, which arrest the rise and help to start the rise, respectively, without shock to the shaft. The helve is pivoted upon steel pins with jam-nuts, taking into taper steel bushings forced into the trunnion-castings. The pins can be separately raised and lowered by screws in the housings, and by a lateral adjustment the face of the hammer can be brought to coincide with either side of the anvil. The face is bolted to the helve by Norway iron bolts, with leather washers under the nuts to absorb the vibrations. The trunnion-castings are similarly secured. A weighted brake upon the balance-wheel arrests the motion of the shaft when the treadle is released, and the form of the oscillator is such that the hammer will not stop with the dies together. The anvil-block is separate from the bed-plate, being clamped to the front for steadiness only.

It follows from the manner of moving the helve by contact on both sides of its center, and from the use of the rubber cushions, that this hammer can be driven faster than the old style of cam-hammers, of the same size and weight. The cushioned hammers may make blows as rapidly as two hundred per minute, and with an intensity sufficient to heat a small rod to redness. This is admirably suited to keep up a low heat in small steel forging. The separate adjustments of the trunnion-pivots enables any relation of parallelism to exist between the anvil and the face without lining up the dies. The shaft is borne upon the frame and cannot get out of line, the adjustment for different thickness of die being effected by the right-and-left sleeve.

A somewhat similar design, making a specialty of the adjustment for dies of different thickness, is shown by Fig. 4. The trunnions are borne upon large gibbed slides which can be raised and lowered together by the bevel-gear and hand-wheel. As before, the helve is not positively connected to the driving-shaft, but lies between rubber cushions in the oscillating **V**-frame. This frame oscillates around the center of motion of the helve. It is driven by an adjustable eccentric from a shaft which carries the usual fly-wheel and flanged pulley. The loose belt is tightened by the foot-treadle, and the release of the latter applies a brake to arrest the motion. The link is adjustable in length to vary the angle between the anvil and the hammer-face. The shaft is bracketed out from the gibbed slides so as to rise and fall with the trunnions, the slack of the driving-belt being taken up by the tightener.

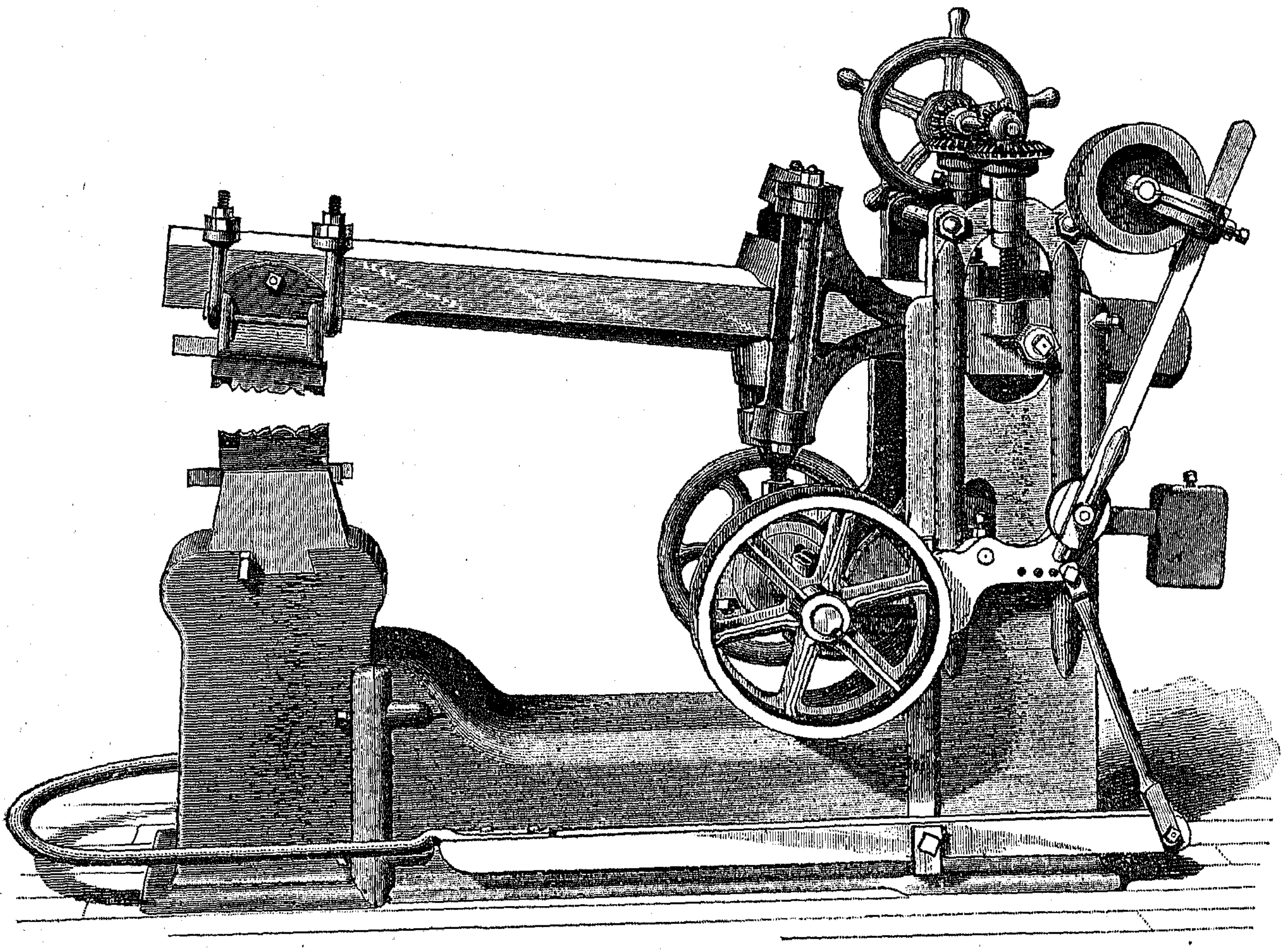


Fig. 4.

It will be seen that in this hammer the adjustment for dies and work of different thicknesses is very easy and rapid, but that considerable shock must be borne by the eccentric-shaft. The use of rubber cushions enables the blows to be delivered quite rapidly.

§ 3.

CRANK-HAMMERS.

The object sought in the design of these hammers is the delivery of a dead-stroke, while the faces of hammer and anvil shall remain parallel for all thicknesses of work. The crank is used to produce the reciprocating motion of the head, either directly or indirectly, and the oscillating helve disappears. It is of course impossible to connect the head directly to the crank-pin. The blow could not then be a dead one, penetrating into the inner particles of the work, but would be an elastic one, affecting the surface only and in part. Moreover, different thicknesses could not be operated on without inconvenient readjustments. It will therefore be found that between the crank-pin and the head there will be interposed springs of some sort. Their effect will be to cause some free motion and to increase the range of the tool and also the force of its blows. The crank is well adapted for this class of motion, inasmuch as it begins the motion of the head by a gradual lift, increasing until half stroke is reached, when the lifting effort slowly diminishes, permitting the inertia of the rising head to slacken the strain on the springs as the crank reverses. On the down-stroke the accelerating crank compresses the spring upon the moving head, giving this extra force to its fall.

One of the hammers of this type is shown by Fig. 5. It is driven by a belt, which may be engaged with the crank-shaft either by a clutch or by a tightener upon the belt running loose. The crank-pin is often made to bolt into a slot in the balanced wrist-plate, so that the stroke of the head may be varied. The head slides between guides on the front, so that it shall always strike a fair blow on the anvil beneath. The connecting-rod, made adjustable in length, carries at its end a clamp for a steel locomotive-spring, whose ends are drawn together by a multiple band of flat leather. The head is hung from the middle of the leather link. It will be seen how the living force of the head will compress the springs on the up-stroke, that compression being given out in the blow. The amount of this compression is controllable by the will of the operator, since it depends entirely upon the speed of the shaft. The more rapid the rise of the head the greater is the efficiency of the spring. The speed, being controlled by the frictional contact of clutch or tightened belt, is varied by greater or less pressure upon the foot-treadle. The anvil is made a part of the frame, which is left open at the back to permit drawing down across the anvil. Very often the faces of the anvil and head are made T-shaped, so as to act equally well whether work is presented from front or side. Here, again, the interposition of the elastic media permits a large number of blows to be made per minute. The 100-pound hammer, suitable for general forging and die-work, may make from 200 to 250 blows per minute.

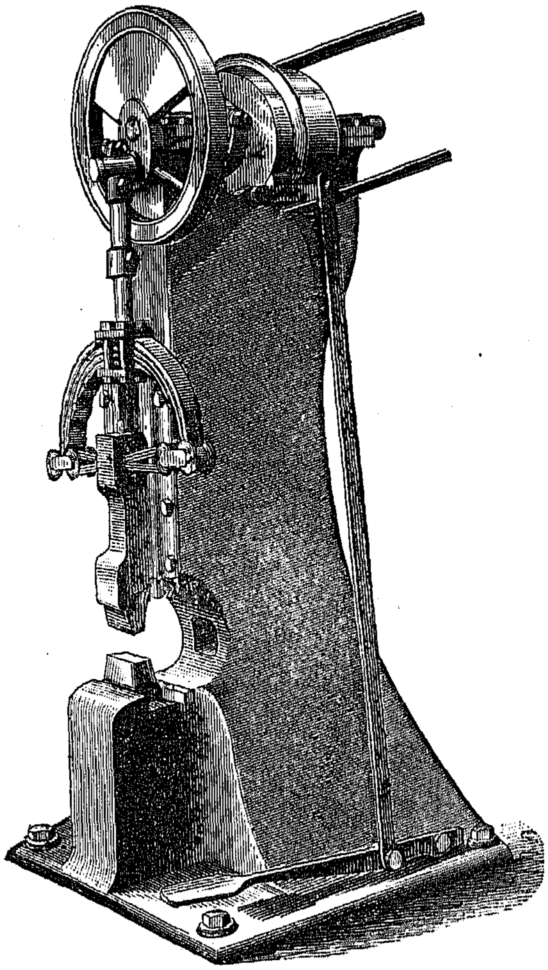


Fig. 5.

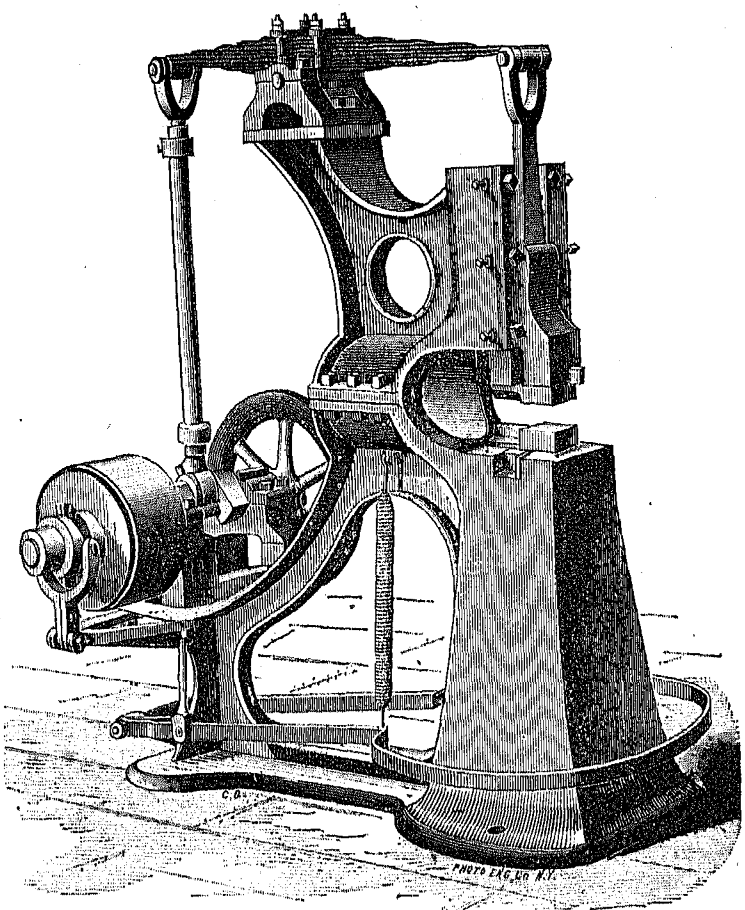


Fig. 6.

A design involving similar principles is illustrated by Fig. 6. Here the crank-shaft, with its friction-clutch, is put lower and nearer the holding-down bolts, and an adjustable connecting-rod causes a spring working-beam to lift and lower the head. The slides are gibbed, and the frame at the rear is made open. It has the same adaptability to machine forging where the depth of the work is being continually varied, and strikes a more or less dead blow.

It were a very natural step to replace the elasticity of a steel spring by the elasticity of a cushion of air and apply it to produce dead blows with a crank-hammer. Such an arrangement is illustrated by Fig. 7. The upper part of the hammer-head is made into a cylinder, truly bored, in which fits a piston, connected by a rod and pitman to the crank-pin. When the pin rises the piston rarefies the air below it, and compresses the air above it. The piston in its rise has uncovered several small ports in the bore of the cylinder, through which air enters below it. The compression of the air has been sufficient between the piston and the top of the cylinder to lift the whole cylinder and head, and the living force of the motion upward will continue after the pin has begun to come down. Hence by compression of the air below the piston will result an increased velocity of fall and greater force of blow than are due to the weight alone. The connection also not being positive, the blow will be a dead one. The crank-shaft, as usual, is driven by a loose belt, engaged by a tightener controllable by the foot. Nearly all have also a brake to arrest the motion quickly. In another design this arrangement is reversed, and the connecting-rod moves the cylinder, while the piston is connected to the head of the hammer.

Another type of crank-forging machinery is shown by Fig. 8. The head is guided between the two uprights, which oblige it to fall so as to strike a fair and dead blow. There is no reinforcement of the weight of the head. The head is lifted by a flat leather belt, which is attached to a pin upon the crank overhead and is a little too long.

The belt is attached to the rotating pin by being clamped to a composition sleeve, S, which takes the wear. As will be seen from Fig. 9, the crank is revolved by the gearing from the belt-wheels, through the ratchet-wheel A and dog *d*. When the drop is up, the crank stands a little forward of its upper dead-center, and is prevented from falling by an arm which strikes against the ratchet-arm R. When this arm is pulled away by pressure upon the treadle below, the drop falls, the dog sliding past the ratchet-teeth, since it moves faster than the latter, and is prevented from clicking by a guard. When the blow is delivered and the ratchet-arm stands up, the dog falls into the ratchet-wheel, and the gear takes hold to lift the drop. The dog stays in gear till the rotation of the arm is stopped as before, or until the weight of the drop pulls the dog out if the treadle is kept down. The lifter-gear is carefully cushioned with rubber disks to absorb shocks, as also are the detents and stops.

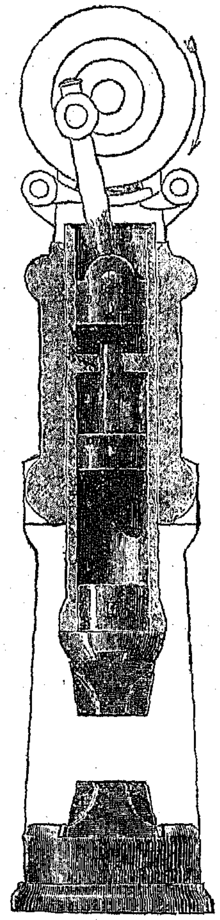


Fig. 7.

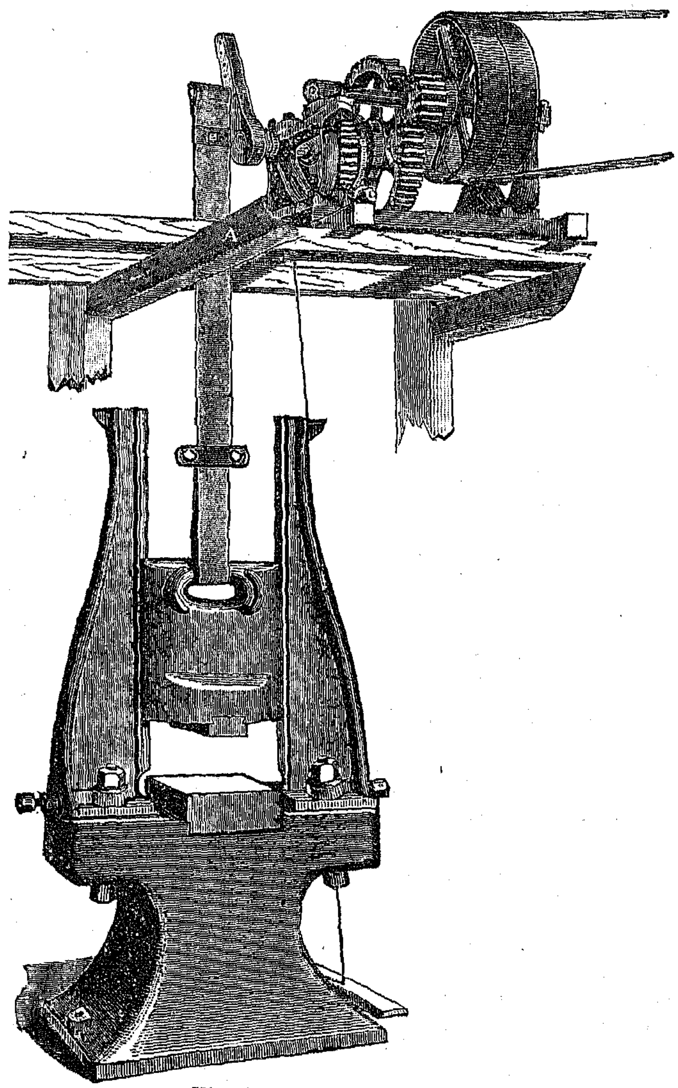


Fig. 8.

This device is admirably adapted for die-forging, and is better for that than for the miscellaneous work of a general forge. It can deliver only from sixty to eighty blows per minute, although they can be heavy and sufficient. It has the advantage of avoiding the necessity of attaching the lifting-gear to the guides, and any settling of the anvil is less annoying or disastrous than in some of the other designs. The flexible yet maintained connection between the drop and the lifting-gear gives an inelastic blow and yet prevents a false blow being given, due to the rebound after the fall of the weight. The length of the lifter-crank is made alterable for different heights of fall, and the uprights are held from spreading by inclining inward the faces of the wings and putting in the holding-down bolts normal to these faces. Lateral adjustment is secured by the set-screws and jam-nuts.

This arrangement has been especially applied for die-forging, when the machine will be called a "drop-press". The process of "drop-forging" depends upon the principle of the flow of metals under strain. A pair of dies is used, each containing one-half of the desired volume. One is secured to the anvil-casting and the other to the face of the drop, so that they shall match when together. The upper die is usually keyed into a dovetail groove in the face of the drop, and the lower one is made to match it by the adjustment of four or six poppet-head screws by which the die is held. The dies are of refined steel, the form to be produced being milled out on a jigging-machine before the steel is hardened and annealed. When in use, red hot-metal in merchant form is put in the lower die so as not quite to fill it. The upper die is released, to fall and force the metal to fill out the interstices of the dies, both upper and lower, of which of course the reproduction is complete. Wrought iron or ingot steel or cast steel can be treated in this way, and quite complicated forms can be very cheaply, because rapidly, produced. The small carriage hardware, gun, pistol, and sewing-machine forgings, and small tools, such as wrenches and the like, are now made in this way, with an enormous increase in the productiveness of a given establishment and a given gang of men. But one blow is usually necessary to complete the forging, and more are unwise, inasmuch as a "fin" of the superfluous metal is forced into the space between the dies, which thin fin cools rapidly. Any extra blows are borne by this fin and will only deteriorate the dies. This fin being removed by putting the shaped piece between "trimming-dies" in a punching-press, any openings will be punched out, and the finished piece will be sheared off from the bar of which it is a part. Slight treatment with emery-wheels or by heavy pressure in a cold-press will be all that is required to produce a finished article. It will be seen that the crank-lifter is very well adapted for this class of work.

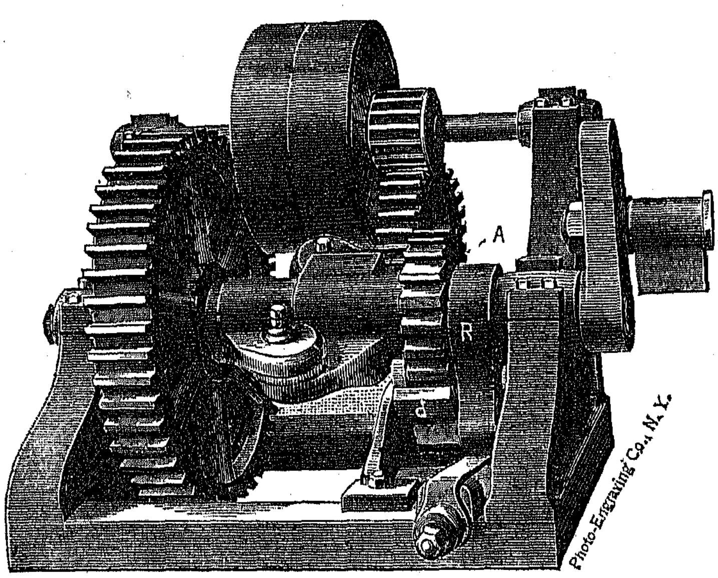


Fig. 9.

§ 4.

FRICTION- OR DROP-HAMMERS.

These hammers have received their special development to meet the requirements of drop-forging. They are adapted to give a small number of blows per minute, by a weight falling through a considerable distance.

The early germ of these hammers is, no doubt, in the old "monkey" hammers. A piece of flat belt-leather passes from the head of the drop over a revolving shaft and down to a weighted handle. The weight of the handle is not sufficient to make the belt seize the shaft, but when the handle is pulled by the forger the normal pressure is sufficient to cause the power to lift the drop. When the handle is released the blow is given. The drop is guided so as to give a true blow.

Hammers somewhat similar are still in use, and successfully. An overhead roller winds up the flat belt when a clutch is engaged. The weight falls when the clutch is released. To prevent shock, the leather is much too long, and a small counterpoise weight on a cord from the roller secures that the belt shall always be rightly wound upon the roller.

If the belt of the early form be replaced by a flat board which can be gripped between two overhead rollers revolving in opposite ways, and which can be released at will, the foundation for the modern friction- or roll-drop hammer is laid. The differences in the different forms will be more in detail than in principle.

In the hammer of Figs. 10 *a* and 10 *b* the two rolls are of cast iron finished smooth and driven in opposite ways by the belt-wheels, which carry one an open and the other a crossed belt. One roll revolves in fixed bearings. The other roll turns in a bearing at each end, which is a cylindrical bushing in the journal-box, the roll-bearing being out of the center of the bushing. It will be seen that if the bushings be revolved through a small angle, the axis of the roll will be displaced laterally, so that the board between the rolls can be released or seized with any desired pressure. The bearings of the fixed roll are made adjustable to compensate for different thicknesses of board and for wear, and to keep the board always vertical. The movable roll is released from the board by the rise of a rod, D, which is connected with loose joints to the foot-treadle, so that the weight of the rod acts to keep the rolls together. Upon the rod D is a chock, which, when struck by the drop in its rise, will lift the rod and release the board, while at the same instant the bent lever-latch on the other side of the head drops in place to keep it from falling. The head therefore remains in place until the treadle is depressed; when the latch is withdrawn the rolls are kept apart, and the head falls. The latch is adjustable on the guides to vary the fall by steps of 6 inches, and the treadle and latch are kept up by a spiral spring or by a weight. The lifter-rod D is made to connect to the treadle by contact-joints so that the rising of the chock need not jar the treadle. A turn-buckle is put in this linkage so as to adjust the relation between the treadle and the rod D without interfering with the latch on the other side, and to permit a rapid series of blows with uniform force without full motion of the treadle.

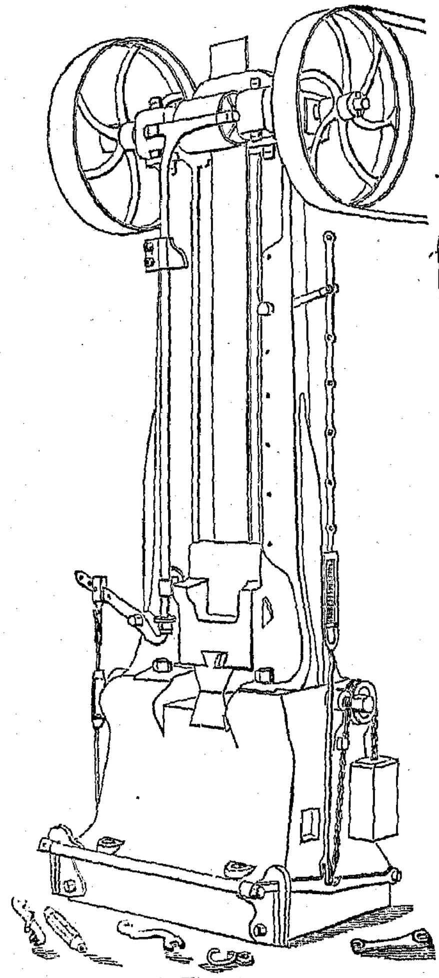


Fig. 10 a.

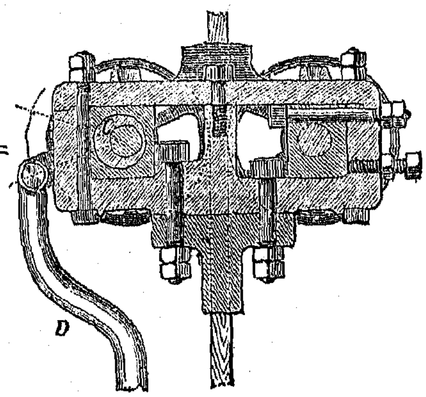


Fig. 10 b.

The next type of hammer has the two rolls geared at each end, one only being driven by one or two belt-pulleys (Fig. 11). The teeth are of involute profile so as to work equally well at different center distances. The movable roll is hung in bearings on a swinging yoke, which is pulled over by a crank-lever acting upon a cam, the lifting-rod being moved from the treadle as before. There is the similar latch-gear on the right-hand side, automatic and adjustable. An automatic trip-gear may be added if a series of uniform blows should ever be called for.

The hammer of Fig. 12 has the two rolls geared together and brought together by eccentric mounting, as before. The contact is maintained by the weight of the lifting-rod D (Fig. 13), reinforced by a spiral spring. As the hammer rises it strikes a dog on the rod, opening the rolls and releasing the board. Since the lifting-rod is not attached to the treadle, as in the former designs, the release of the dog as the hammer falls would close the rolls and stop the fall. To prevent this a switch springs in under the end of the rod, holding it up and keeping the rolls apart. The head has a curved plane on it, which forces out the switch from under the rod when the blow has been delivered, lowering the rod and causing the rolls to lift again. This switch is pivoted upon an eccentric mounting to take account of varying thickness of die or work. The dog-rod can also be worked by hand-lever at side of frame or by a small treadle. The foot-treadle operates a lever overhead attached to a pair of toggle-levers which grip the board on its descent except when held away by the depression of the treadle. If the treadle be held down a number of uniform blows will be struck, which especially adapts this arrangement for certain classes of work. For miscellaneous work and blows of varying intensity the adjustment of the other types gives the operator more freedom in the use of his hands. The toggle-joints are upon eccentric bearings, which let the board slip through them on the up-stroke (Fig. 13), but which hold it when its motion reverses. All such friction contact bearings are made adjustable to compensate for wear and variations in thickness.

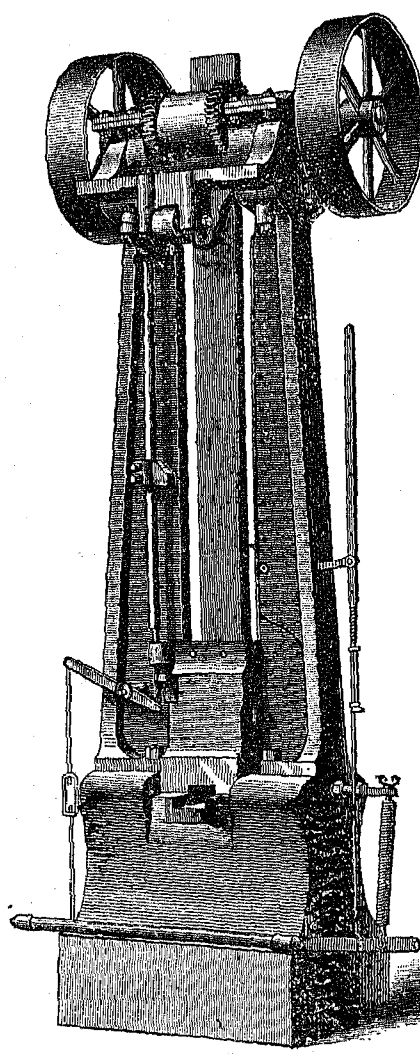


Fig. 11.

All the hammers of this friction-roll type are open to the objection that the rolls when brought together demand that the drop shall start from rest and acquire at once the full speed of its lift. There must therefore be a slip somewhere while the inertia of the head is being overcome. If this slip occurs in the driving-belts they will wear or burn. If it occurs between the board and the rolls the former will become worn into a hollow at the point of first seizure and the rolls will fail to grip at that point. But the board of white oak or hickory is as apt to deteriorate from other causes, and the general adoption of this class of hammer for drop-forging is proof of the satisfaction it has given in that class of work. They do work which could only be done otherwise by heavy steam-hammers, which would involve

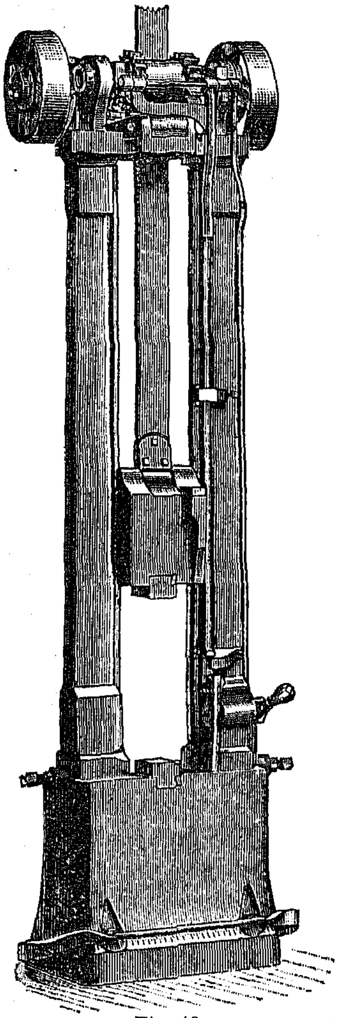


Fig. 12.

great outlay and expensive accessories and give but a limited production. A battery of these hammers can be set up in one establishment and its capacity can become almost unlimited. Ordinary labor can handle them, and but one man is required. In one of the shops for fire-arm manufacture a special type of drop-hammer is in use. A square central pillar has pawls on its four faces and is made to reciprocate vertically. Four guided drops are lifted by each rise and are held from falling by pawls. The release of the pawl of any head, at the will of the operator, permits the head to fall. The heads weigh 500 to 800 pounds, and may fall 30 feet.

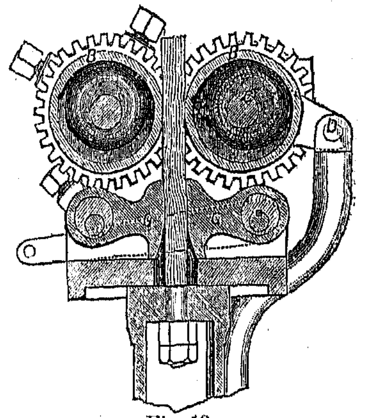


Fig. 13.

§ 5.

STEAM-HAMMERS.

In this class of hammers the power of the steam from the boiler is applied directly instead of indirectly through the engine and shafting of the shop. They form, therefore, a class distinct from the power-hammers previously discussed.

The hammers of the pivoted type directly driven by steam present themselves first. In these the large wooden helve is pivoted upon trunnions, and just in front of the husk is put a steam-cylinder of large diameter and short stroke, below the floor level (Fig. 14). This cylinder is usually single acting, lifting the helve, and letting it fall by its own weight. The rise is arrested by a wooden spring buffer beam at the tail of the helve. The valve admitting steam to the cylinder is a plain slide-valve, worked from the cross-head, or is in the form shown in the cut, a rotary sliding valve. In the form shown in the cut, the rotating valve is balanced by being hung by a brass ring and bolt from a plate of flexible copper or steel in the bonnet of calculated area sufficient to keep the valve from bearing too hard upon the seat with the given working pressure. In the older forms, worked by an arm from the cross-head which struck tappets upon the valve-stem, the difficulty was due to the shocks against the tappets. The valve-stem had a stout thread cut on it, and these two tappets could be separated or brought together for work of different thickness and for different heights of fall. But as the slide-valve was unbalanced, it took considerable power to move it, and the cross-head arms and the valve-stems were continually breaking and becoming battered. Other arrangements for admitting steam were by the use of a cock-valve, which was revolved upon its axis by the cross-head arm which struck tappets having inclined faces, and displaced them around their axis. And again the cross-head arm acted upon two inclined planes in slots in a plate, the planes being adjustable in position at the will of the operator. In the form shown, while the adjustable tappet hand-nuts are retained, yet the valve moves so easily that the gear is not worn out. The valve-seat is near the bottom of the cylinder, permitting the use of a short steam-passage, with long narrow port, and giving a decisive sharp blow. The position of the port for exhausting also enables the condensed water to drain out easily and quickly, and lets the hammer fall easily upon the work. The speed at which the hammer may be driven adapts it for several classes of forging, and it can be applied for billeting and faggoting. In one case where so applied the helve is a box girder of ingot-steel plate. It has the advantages for swage- and die-work possessed by every helve hammer, but also has their limitations.

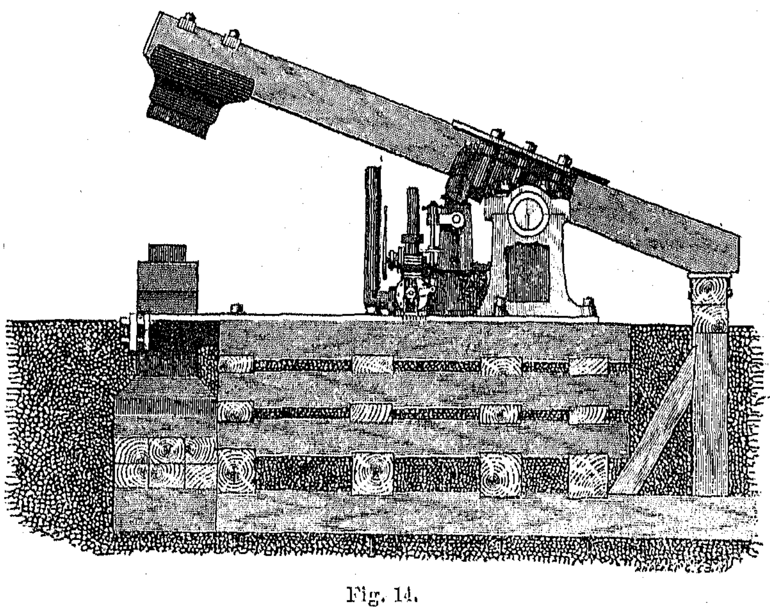


Fig. 14.

To a similar type belongs the steam-striker in limited use in forges. A steam-cylinder of short stroke has its rod connected to the short arm of a rock-shaft. At right angles to this arm is a second arm much longer, on whose end is the hammer-head. A small motion of the short arm, caused by admitting steam into the cylinder, brings the head down with high velocity upon the work between itself and the anvil. The rock-shaft bearings are so adjustable, relative to the cylinder, as to enable the plane of the sledge-stroke to be carried round through 180°.

The direct-acting steam-hammer consists essentially of a vertical steam-cylinder, in which plays the piston actuated by the steam. Upon the end of the piston-rod is the hammer-head, which strikes the work as it rests on the anvil below. The head may either be lifted by the steam and allowed to fall by its own weight, or extra force may be given to the blow by admitting steam above the piston-head. The cylinder will be carried and the head will be guided by the frame, and the admission and exhaust of the steam will be controlled by suitable valve-gearing.

This type of hammer has very marked advantages. Such are the simplicity of its mechanism, the elastic connection between the head and the driving power, and between the head and the frame; the absolute controllability of the blows, in frequency, in power, and in height; the saving of expense of power when the hammer is not in use, and the avoidance of useless wear of belts; and lastly, the economy which results from putting the hammers where they are wanted, without regard to the conditions imposed by transmissive machinery. There may be a small loss from condensation in the steam-pipe, but careful lagging will reduce this to a minimum. Then, further, the direct-acting steam-hammers are adaptable to all classes of work. Plain forging, die-forging, drop-work, upsetting, etc., can all be done upon the one tool without necessitating any change, except in the dies. The work can be presented in any direction, the space around the anvil being open on nine-tenths of the circumference. A number of swages can not be held at once, as in helve-hammers, lest the blows be delivered out of the axial line of the rod.

Steam-hammers are made with single or double frame, according to their weight. The lighter hammers have but one upright (Fig. 22), consisting of a curved post of round or rectangular cored section, supporting the cylinder at the top. The anvil is carried upon a separate post, which passes down through the sole-plate of the upright. The anvil and tup or head are usually put oblique to the plane of symmetry through the upright, so as to enable the smith to present his work fairly either across or along them for drawing down and finishing. The larger hammers have two uprights, giving rise to what has been called the A-frame. Two uprights are bolted to the foundation, one on each side of the anvil, of such a shape as to guide the head by their upper parts in some designs, while the cylinder is cast upon an entablature to which the uprights are bolted. In other designs the piston-rod guides the head and the uprights are of different shape, to give greater room around the anvil and between the frames. Where the shape is such as to give little room between the uprights around the anvil, the latter is either set obliquely or else the legs are spread sidewise, so as to separate each into two and to leave a passage through each. The object of these two arrangements is to enable the forger to hold chisels and fullers at right angles to the work, and to enable him to see it without deceptive foreshortening.

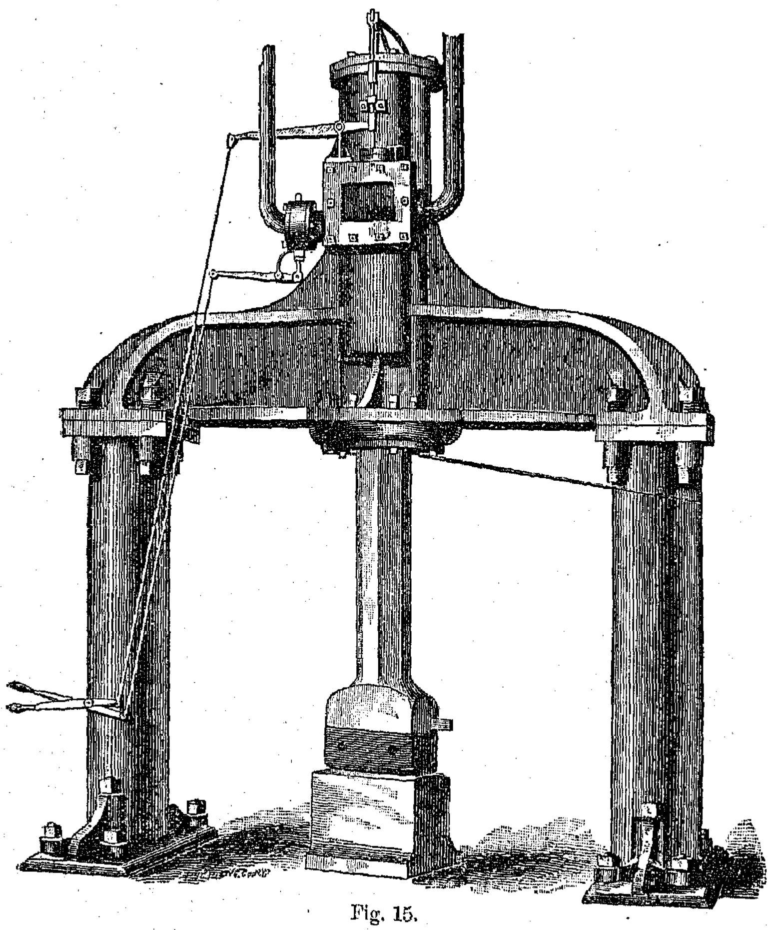


Fig. 15.

To give free room around the anvil the "high-frame" hammer has been made (Fig. 15). The frame consists of two vertical pillars surmounted by an entablature, upon which is secured the cylinder. In this the anvil is set oblique to the plane through the pillars.

The uprights of double-frame hammers are usually bolted and keyed between lugs upon a sole-plate which envelops the anvil-pier (Fig. 16). This sole-plate is bolted by long holding-down bolts to foundation piers of masonry or brick, one at each end, having considerable lateral spread at the bottom to distribute the pressure over a large surface. On marshy ground it will probably be necessary to drive down piles first and cover them with a timber crib-work, around which concrete is rammed. For the lighter hammers the piers may be of cob-work timbers, filled in with concrete. In either case the piers are surmounted with a thickness of timber, perhaps of 3-inch plank, and on this the sole-plate is bolted and trued. The anvil-pier is similarly built, with lateral spread to distribute the blows, but the three or four courses below the anvil-plate will be of heavy timbers bolted together. Between lugs on this plate will be keyed the anvil-block, which again will receive the die in a dovetail groove in its top. In the lighter hammers the anvil may be all in one piece, and rest upon a flat pier of timber passing down through the foundation of the frames. In the single-frame hammers the arrangement will differ only in depth of foundation and in the permissible use of timber (Fig. 17). It is a very usual and excellent plan to use jam-nuts on the foundation-bolts, that they may not become loosened by the vibrations.

A primary difference in different designs of hammers arises from the methods of guiding the head. In the first designs the steam only lifted the piston and head. Hence a small rod was used, and the weight of metal for the blow was put in the head or ram. Therefore it was necessary that it should move between guides in the uprights, to avoid flexing the light rod. In the later designs of the Morison and high-frame hammer the weight for the drop was put into the rod, so that the increased section made it possible to guide the lower end from the cylinder above. This left, of course, a much higher opening around the anvil, but made it necessary to have some arrangement to prevent the rod and die from turning. In the high-frame hammer the rod is made polygonal, and plays through a polygonal stuffing-box (Fig. 18). In the Morison hammer the bar is prevented from turning by the grooves on opposite sides of its upper prolongation which work the valve.

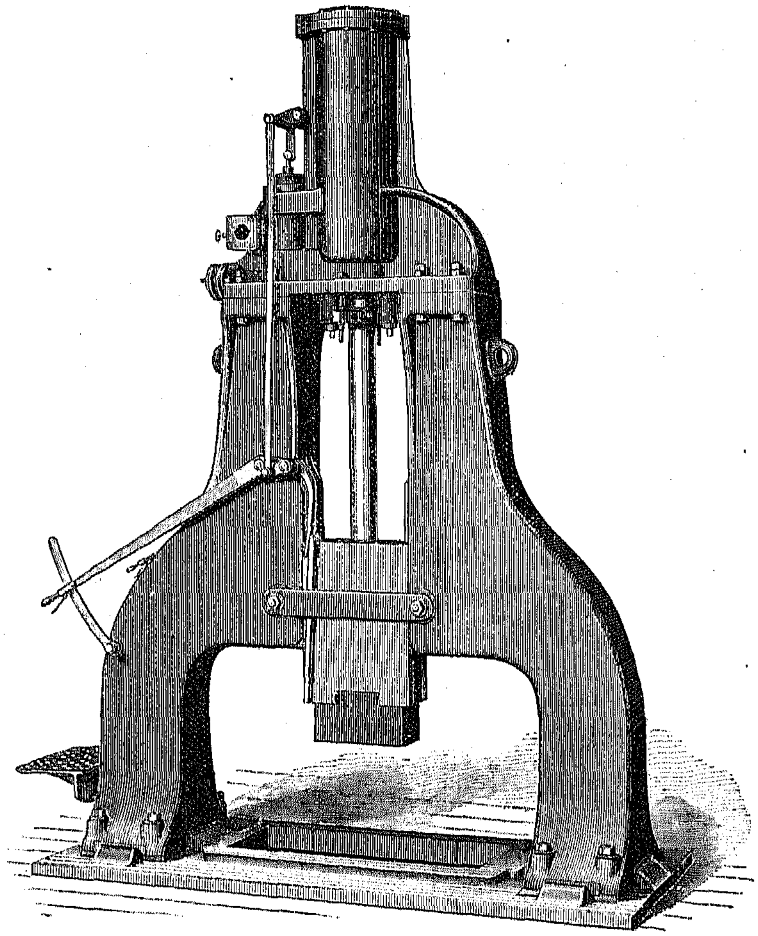
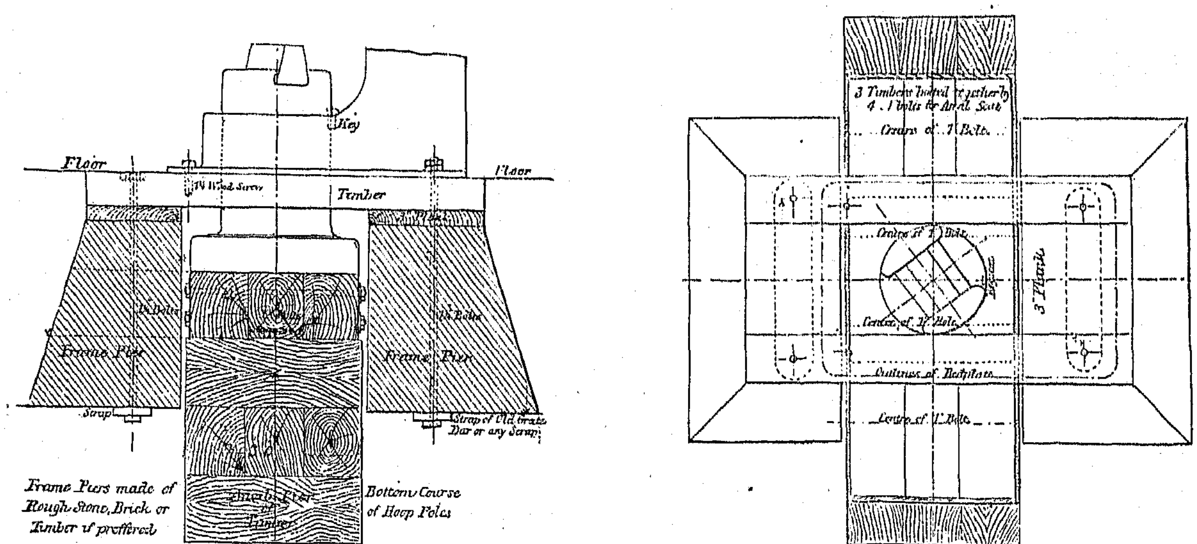


Fig. 16.

The difficulty connected with the guiding by the rod from the cylinder, is that any blows reacting upon the rod outside of its center line tend to force it to one side and cause the stuffing-boxes to leak and wear, even with the increase of bearing surface. The prevalent design of to-day will be seen to favor the other system, even with its drawbacks.

The second difference will be in the actuation of the valve which distributes steam to the cylinder. The valve motion for a steam-hammer presents certain distinctive features. It is desirable that the valve be moved automatically by the hammer, at least in the smaller forms; but the attainment of this end is beset with two difficulties. In the first place, the stroke of the piston needs to be cushioned by steam on the up-stroke, but must



SECTIONAL SIDE VIEW. PLAN.

Fig. 17.

not be so cushioned on the down-stroke. If the blow be cushioned by steam, only part of the force of impact is received by the work. Most of it, in fact, is taken up by the steam-cushion, and the hammer loses at least 50 per cent. of its efficiency. Moreover, dead blows are more potent to change the shape and effect the welds in the interior of the piece than elastic blows. If the reaction of the particles from the blow is not resisted by the weight of the ram upon them, the effect of any blow will be confined to the surfaces only. On the up-stroke, however, there must be a steam-cushion to arrest the piston, else the upper cylinder-head will be knocked out. The valve must have steam lead for the down-stroke, but none for the up-stroke; or, in other words, the valve must open the lower port after the hammer has come to rest. Fig. 18 shows how this steam lead is secured in hand-worked hammers. The rise of the piston strikes a stem which insures the preopening of the upper steam-port, even at the peril of the operator.

The second difficulty about automatic gear arises from the fact that the hammer is to forge pieces of varying thickness. When a piece is to be drawn down, it is much thicker when the first blows are given than it is when it is being finished. Moreover, the hammer may be called on to work a thin flat just after a job of upsetting, so that the valve-gear must act with equal ease for a long or for a short stroke at the lower or upper part of the travel of the ram. This second difficulty is overcome by having the lever to which the valve-stem is attached pivoted to a stud which is not fast to the frame of the hammer. This pivot-stud is upon the end of the short arm of a bent

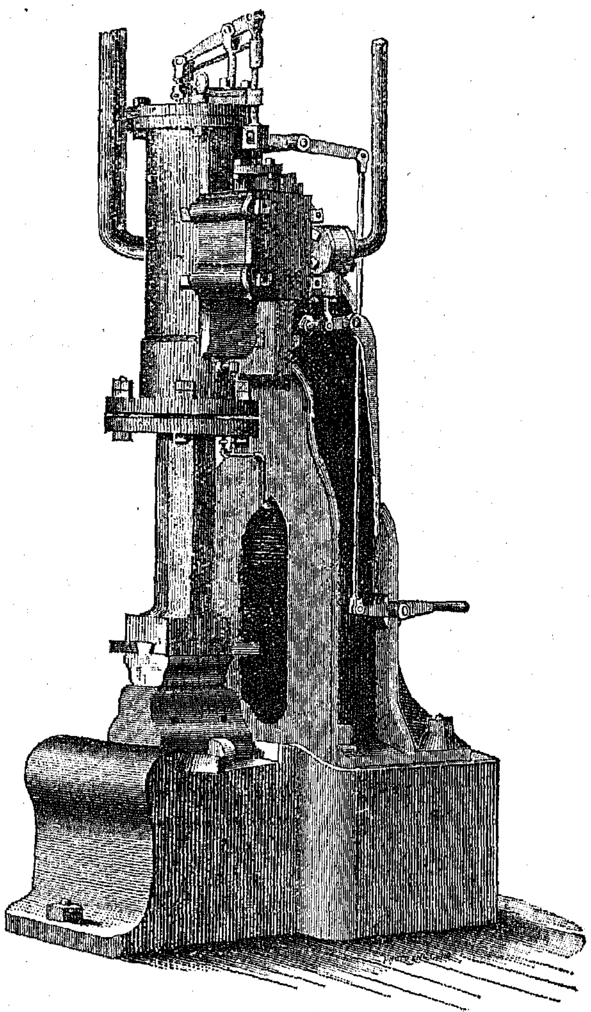


Fig. 18.

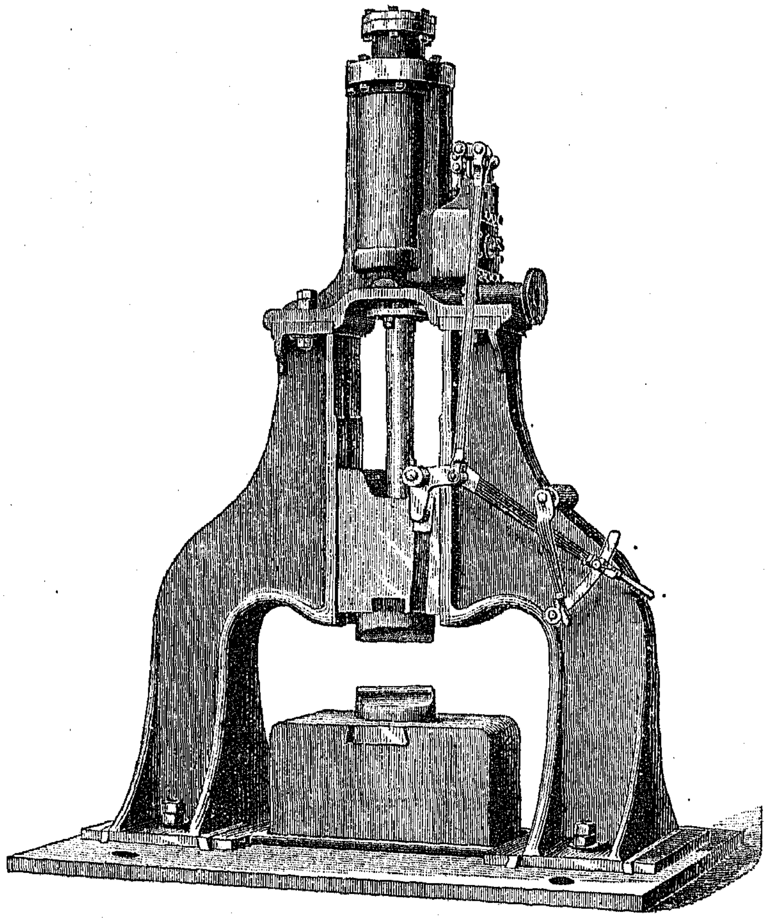


Fig. 19.

lever which turns around a fixed center. This lever is called the working-lever. The long arm ends in a handle, and can be held in any desired position, on a sector near the free end, either by a latch or by a set-screw. The stroke of the ram being so much greater than that of the valve, the arm to the valve-stem will always be shorter than that to the ram, on the floating lever, and therefore a small adjustment of the floating pivot will bring the valve into the proper relation with any part of the length of the stroke.

The overcoming of the first difficulty follows very simply after the second one is provided for. It is accomplished by means of a swinging curved wiper-bar, centered upon the short end of the working-bar in prevailing practice. A short arm at right angles to the plane of the face of the wiper is connected to the valve.

An inclined plane is formed upon one face of the head, and this wiper is held to contact with this plane by the weight of the valve acting upon the short arm of the wiper. When steam drives the hammer down it falls faster than if gravity alone acted on it. Gravity alone acts upon the valve. Hence the descending ram will get away

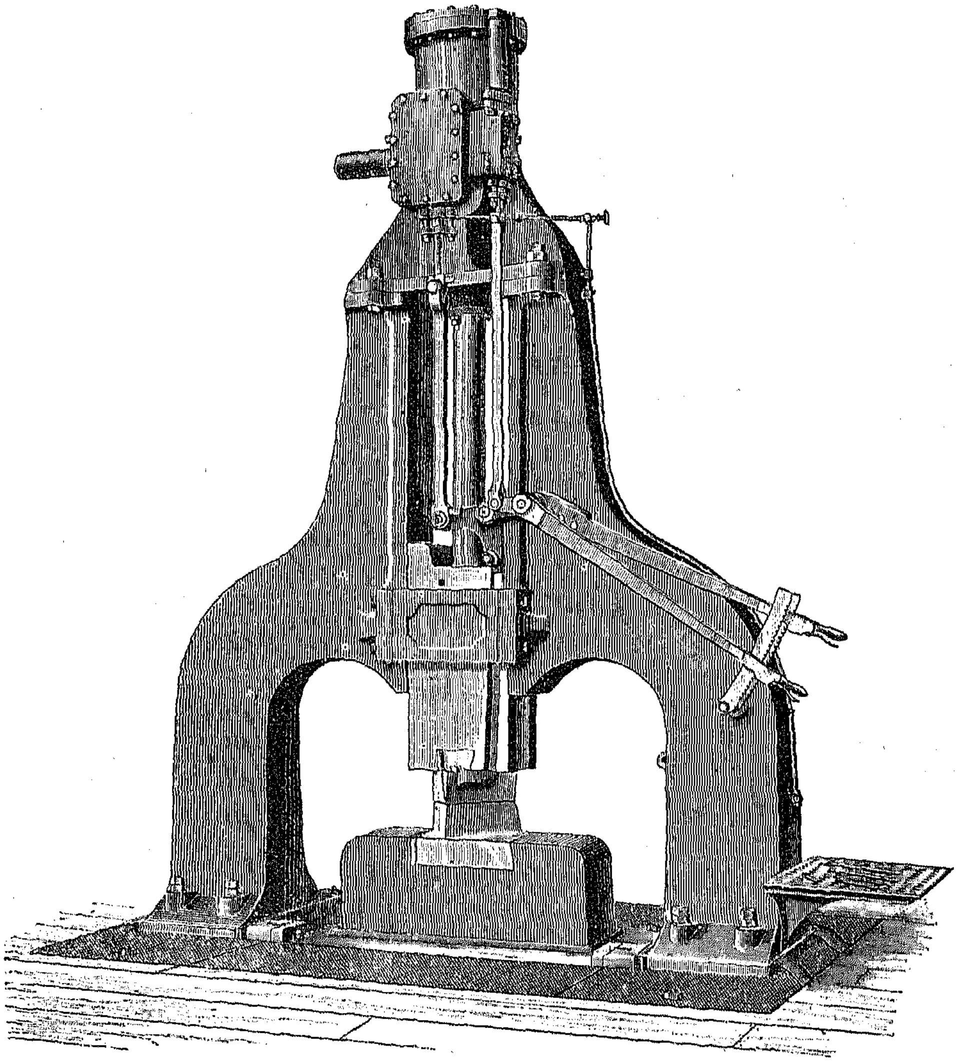


Fig. 20.

from the wiper, which will swing into contact after the hammer has stopped, and properly open the valve. A dead blow will thus be given without steam-cushion. Upon the up-stroke the head and valve move together, and steam lead may be always secured to cushion the rise, or it may be effected by exhaust compression. By handling the working-lever dead blows may be given by the ram as a drop. The working-lever must pull the wiper away, as the two contact surfaces fall at the same rate because acted on by equal forces. Of course, for this gear, the valve must be balanced so as to fall easily under steam. For rapid work the weight may be helped by a spring, or for slow work it may be retarded by artificial friction or by counterpoises.

In the Sellers hammer the connection is positive or maintained between ram and valve, but the coincident motion of the working-lever with the blow retards the admission till after the blow is delivered.

Large hammers are usually worked by hand; but inasmuch as the stroke of these larger valves requires more motion of the working-lever a compound motion is often applied. A groove in the ram moves the long arm of a bell-crank lever, whose short arm is connected to the valve-stem, and whose pivot is on the working-lever as in the previous cases (Figs. 19 and 20). Very many of the largest blooming-hammers are worked directly from the handle, independent of the ram (Fig. 27). In the Miles hammer, shown in section in Fig. 21, the valve is a hollow piston-valve, taking steam from the inner edges and exhausting at the ends and through the middle. The hollow valve permits very short passages, and the position of the exhaust-chamber causes all water of condensation to be carried away from the cylinder even without drip-cocks. The valve-rod needs no stuffing-box with its attendant friction, since it works in exhaust steam only. The piston-rod is tapered into ram and piston, and the piston is packed by steel rings. The head is guided by flat guides with a projecting lip for holding it sidewise, or in some of the smaller sizes the head is planed with V-grooves. An adjustable gib is also used to take up lost motion and wear by inclined planes controlled by a screw. To avoid the danger from "hammering upward", buffer-springs are put below the cylinder, consisting of compound volute car-springs (Fig. 22). These react against the ram and

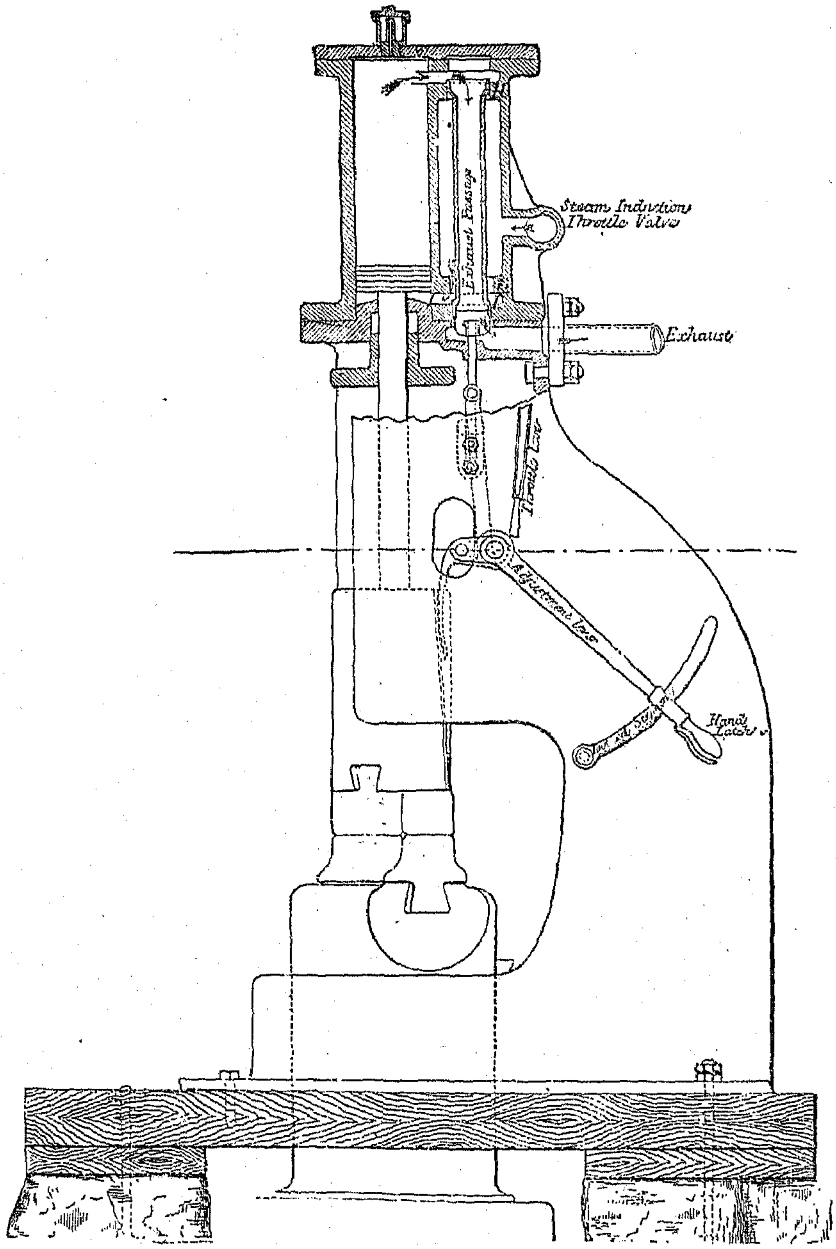


Fig. 21.

prevent injury to the upper cover. The rod is made long enough to permit the piston to protrude through the top of the cylinder when all buffers and the stuffing-box packing are removed. This allows the inspection or renewal of piston-packing without disconnecting the parts.

Fig. 16 shows the larger size, and Fig. 23 shows an especial arrangement for drop-work. The throttle-valve is connected to the dangler by a screw connection, so that the degree of force of any single blow or of any series of automatic blows can be governed by a foot-treadle and the hands of the operator be free for his work.

The throttle-valve for the hammers is the Davis sliding valve of the Corliss type, working in a jacketed casing. The pipes are connected to the hammer by expansion joints, to avoid leaky connections. The openings are arranged so to face as to permit free approach of cranes on both sides.

The Bement hammer (Fig. 24 and Fig. 20) differs in the use of a flat gridiron slide-valve, balanced by means of a shield which slides on a surface opposite to that of the valve-seat. The dangler also is made longer. The piston is cushioned to prevent overstroke by closing over the exhaust passage, which is not at the extreme top of the cylinder. In small hammers the piston and rod are made of one forging. In the larger sizes the rod is slightly tapered and headed over cold. Steel packing-rings are used.

The Morgan and Williams hammer (Fig. 25) uses a square piston-valve. The back and sides of the valve are protected from steam pressure by a hollow trough casting, with ports in the inside of the trough which match the ports in the seat, and are separated in the hollow part by partitions. Steam therefore enters the passages both through the seat-ports and also through those in the shield when opened by the valve. The valve and shield are faced off together upon their lower sides, and the valve is afterward relieved enough to slide under it when the shield is forced to the seat. It is held in place by one or more set-screws in the bonnet of the chest.

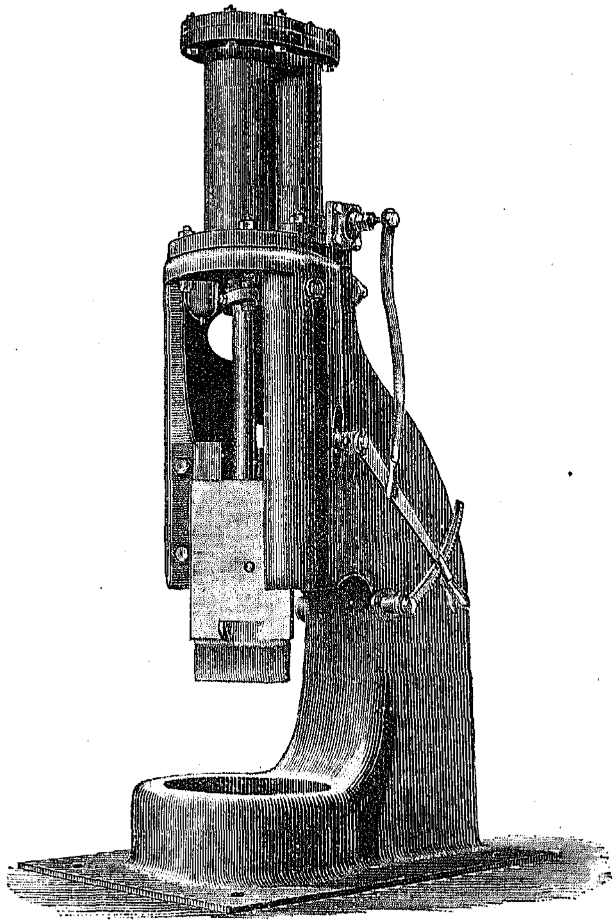


Fig. 22.

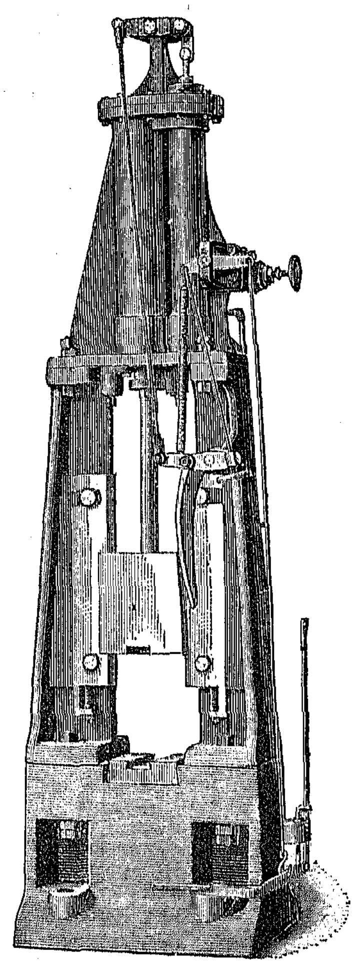


Fig. 23.

For hammers for working steel, which must be handled at high speed, two valves are used, one for steam above the piston and one for steam below, with separate throttle-valve for each chest.

To protect the upper cover of the cylinder, a small cylinder on top contains a volute buffer-spring, whose spindle takes the blow, and should breakage be unavoidable it is the small weaker cylinder which is most sure to go rather than some more expensive part. Ramsbottom's steel piston-rings are used for packing. The rod is fitted as in the Miles hammer with a simple taper fit into the ram. The shocks of impact keep this joint perfect, making it tighter at every blow. The piston is forged on the rod in small hammers. In the larger sizes it is shrunk on and headed over. In place of the dangler or wiper, the valve is moved by a square inclined groove or ridge upon the side of the ram. This controls a bell-crank connected to the valve, the crank being pivoted upon the working-lever. Their drop-hammers have an equalizing pipe on the Cornish system to prevent the necessity of admitting air to the cylinders on the descent. They can be made controllable by the foot of the operator.

In the Sellers hammer (Fig. 26) the ram, rod, and piston are in one forging. The rod is prolonged above the piston to serve to guide the end of the rod by the upper cylinder head as there is no ram guided between slides as in the previous designs. The lower part of the rod is made larger than the upper part above the piston in order that the mass of metal may be greatest near the point of impact. To this large bar is attached the hammer-head proper by means of a circular key and to the head are keyed the dies. For keying the dies a crimped key is preferred, which holds the die with elastic pressure. The key can be bent anew when loosened by use.

The valve-gear is worked by an obvious system of levers, to which motion is imparted from a brass yoke interior to the cap which protects the upper rod. This rod has two opposite diagonal grooves in it, in which fit brass keys attached to the yoke. The up-and-down motion of the rod causes transverse reciprocation of the yoke, which motion is carried out to the valve-levers through the stuffing-box at the back. The pivot for the lever attached to the valve-stem floats from the end of the working-lever. The valve-yoke also serves to keep the hammer-bar from turning round. In addition to this ordinary gear a supplemental valve is introduced, which controls, by hand, the exhaust from the lower port, without interfering with the upper port. This enables quick, but light-cushioned blows to be struck for finishing, the operator being able to gauge their intensity by the completeness of his exhaust-cushion below the piston. The speed of rise is not affected, and the confined steam below expands upon the up-stroke.

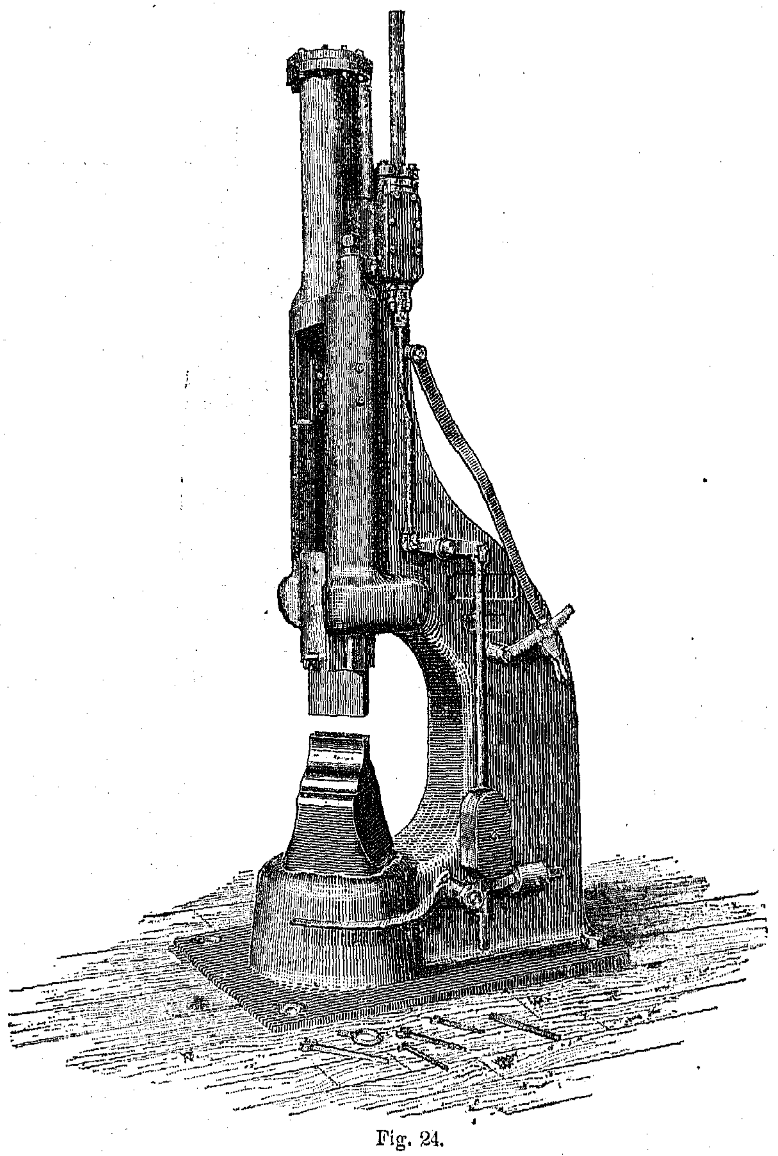


Fig. 24.

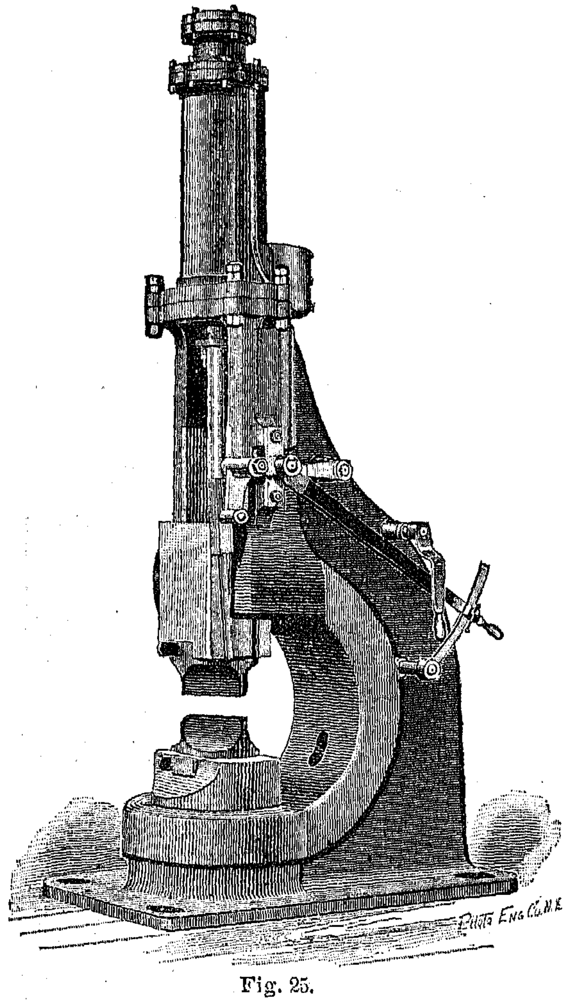


Fig. 25.

The advantage of this system is the free height between the anvil and the end of the hammer-bar. The cylinder also serves, in double-frame hammers (Fig. 27), to brace the uprights at the top. The anvil in these designs is made of five, seven, or eight times the weight of the hammer-bar and accessories. The other designers prefer a relation of one of hammer to ten of anvil.

The simplicity of the construction and mechanism of the steam-hammers of to-day seems to leave but little to be desired. They can be made to deliver elastic or dead blows at the will of the operator, and can be used as drop-hammers. They are therefore fitted for any class of work. They are rapidly displacing all other forms for certain duties, and even in shops driven by water-power they are finding their way. Where power is otherwise running to waste they may be driven by compressed air without losing many of their advantages.

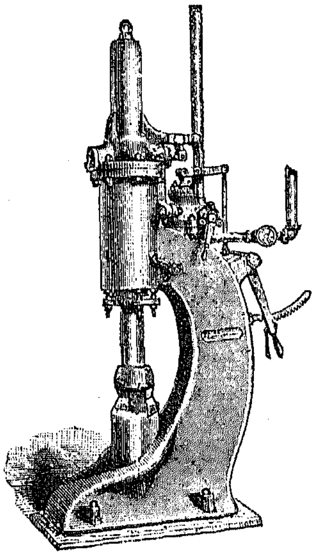


Fig. 26.

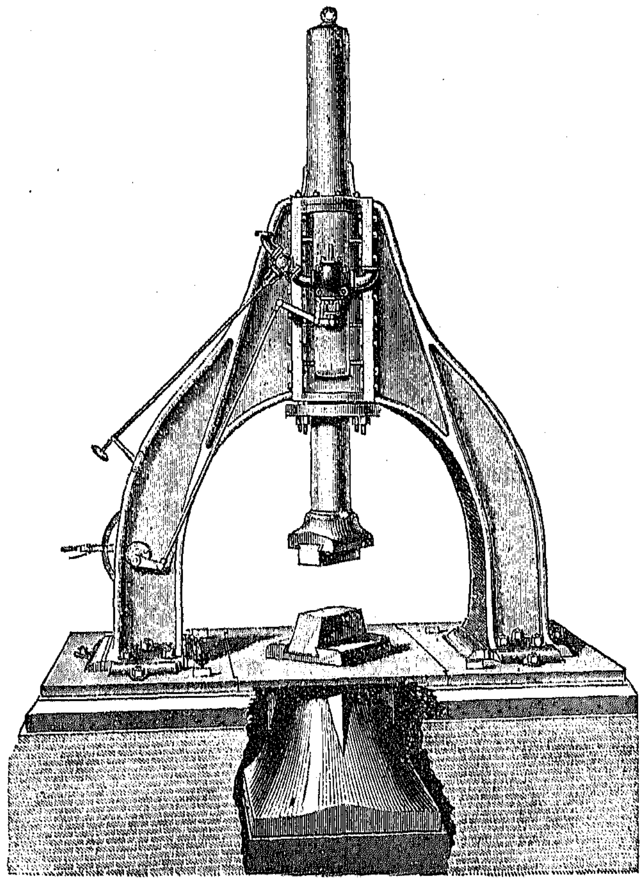


Fig. 27.

§ 6.

RIVETERS.

The next class of tools acting by compression are the riveting-machines. They act to compress and upset the metal of red-hot rivets in the holes of a lap-seam of plate-iron. They also form a head upon each end of the rivet, which bind the joint together by the shrinking of the shank as it cools.

Riveting-machines are of four classes: Power-riveters, steam-riveters, air-riveters, and water-riveters.

The essential parts of a riveting-machine are, first, a stationary stiff post or bolster, which shall serve as an abutment or anvil for the upsetting of the rivet. This bolster carries a stationary die or swage on one side, near the top. The second essential part is a movable guided ram with a die in its end, which shall slide forward and compress the rivet between the moving and fixed dies. This will form the two heads and upset the shank into the holes of the plate so as completely to fill them. The third essential part is the gearing and apparatus for driving and retracting the movable ram. The first two parts must be common to all designs. The variations will be in the driving mechanism. The problem is the gradual exertion of great power through a short stroke.

The power-riveters receive their motion through a belt from the transmissive machinery of the shop. Probably the earliest forms were those in which the ram received its alternate motion from a crank. The rotation of the crank, driven by reducing-gearing from the belt-wheel, forced the die to compress the rivet until the crank came in line with the connecting-rod to the ram. This compression was of great power, since the crank and rod made an elbow-joint as they came into line, although the two links were of unequal length. The special difficulty of this system is that all the reaction of the compression has to be absorbed in rubbing surfaces, on the crank-pin and on the shaft-journals. These, of course, had to be of extra size and all parts had to be of extra weight if excessive wear were to be avoided. To meet this difficulty another form of machine was devised, in which the ram is forced out by a true elbow-joint. When the ram is back, the two links hang down in the form of an obtuse V. The center joint is raised and the links are thus straightened out into line by a cam revolving on a shaft below the links and driven by reducing-gearing, as before, from a belt-wheel. In both forms the gearing to drive the ram is engaged at will by a jaw-clutch. This elbow-joint form has several advantages over the crank-form. The strain is borne by the rigid back of the machine frame on large pin joints. The crank-machine had always to be disengaged when the crank was in one position, with the ram drawn back; the cam-riveter causes the ram to retire by the weight of the links as soon as released by the cam. The cam moreover may be so designed as to maintain pressure upon the rivet until it cools somewhat under the strain. This was inconvenient and difficult, if not impossible, with the crank-form. It is riveting by dead blows, which is impossible with a maintained connection between ram and driving power. Both tools have the advantage of giving a gradual compression to the rivet, which is most favorable for the flowing of the metal which is to fill the holes. They have, however, the disadvantage of being non-adjustable either in length or in force of stroke. For rivets of different lengths in plates of different thicknesses the only adjustment is by changing the swage-dies for others of different length. This is inconvenient and takes time. The effect of excessive compression is either to fray out the edges of the rivet-heads, permitting access of corrosives to plate and shank, or else a film of the rivet opens the lap-joint by squeezing in between the two plates. Finally, the frame of the machine has to be very heavy and deep to accommodate the links and to resist their reaction.

§ 7.

STEAM-RIVETERS.

In the steam-riveters the force of the crank or elbow-joint is replaced by the pressure of steam on a piston-head. The movable ram is secured on the end of the piston-rod from the steam-cylinder, and thus compresses the rivet.

Fig. 28 illustrates the general form of one type. Of this type there are two varieties. One uses a light ram, and depends solely upon the large piston area for the compression of the rivet. The other variety has considerable

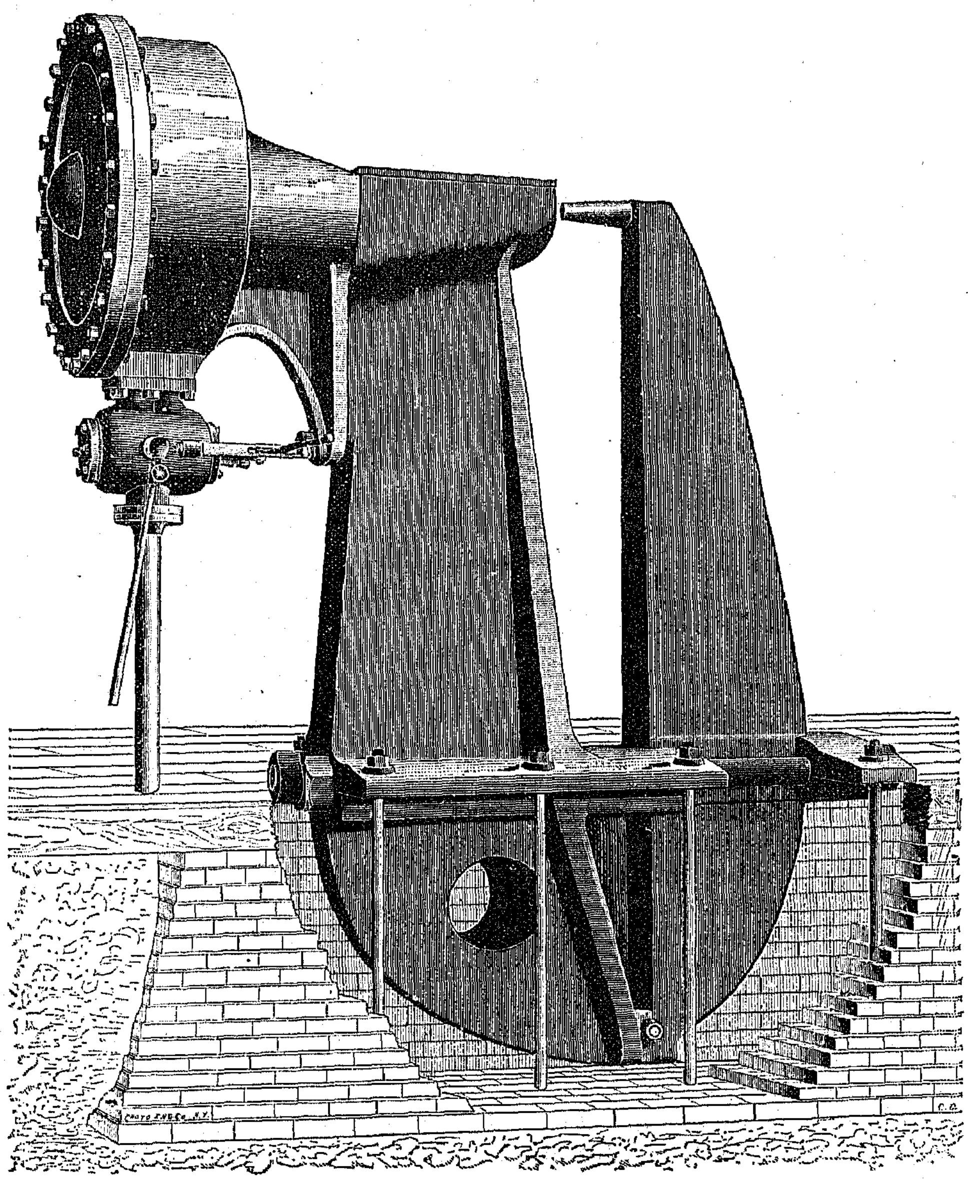


Fig. 28.

weight in the ram and piston, so that when in motion they shall have considerable living force. The compression is effected in part by the living force of this mass and a less diameter of cylinder, and therefore a less volume of steam suffices for the same work as in the other case. This second variety is the approved form of present practice. The piston and ram are made of one large forging, and steam is admitted through a balanced valve behind the piston. After having delivered the blow some of the steam passes through an equalizing-port into the clearance in front of the piston, and by its expansion, when the exhaust-port is opened, retracts the ram. A second form of steam-riveter in use, but not manufactured at this date, has two cylinders connected to the swaging-ram by bell-crank levers in the horizontal riveters, or by links in the vertical machines. These cylinders are of different diameters, the smaller outer one being connected to the heading-die, while the inner and larger one works an annular ram, which holds the plates together while the heading blow is struck. It is much less simple than the prevailing form.

Steam-riveters, as a class, possess many of the same advantages which steam-hammers have over similar tools driven from shafting. The elasticity of the steam cushions the reaction against the cylinder-head. The position of the machine may be independent of the lines of shafting, since the steam-pipe can be carried anywhere. There is no loss of power nor loss by wear of gear during inactivity

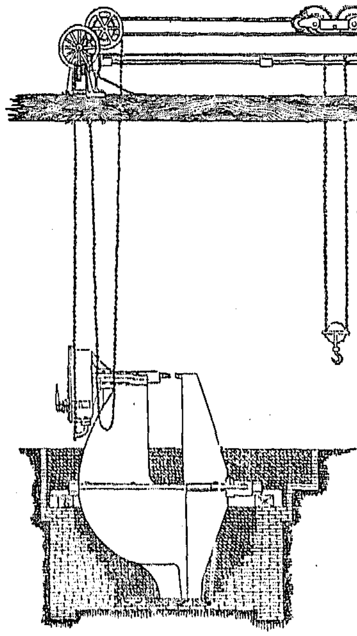


Fig. 29 *a*.

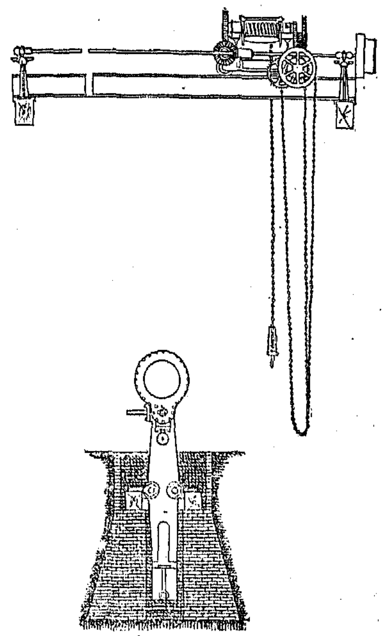


Fig. 29 *b*.

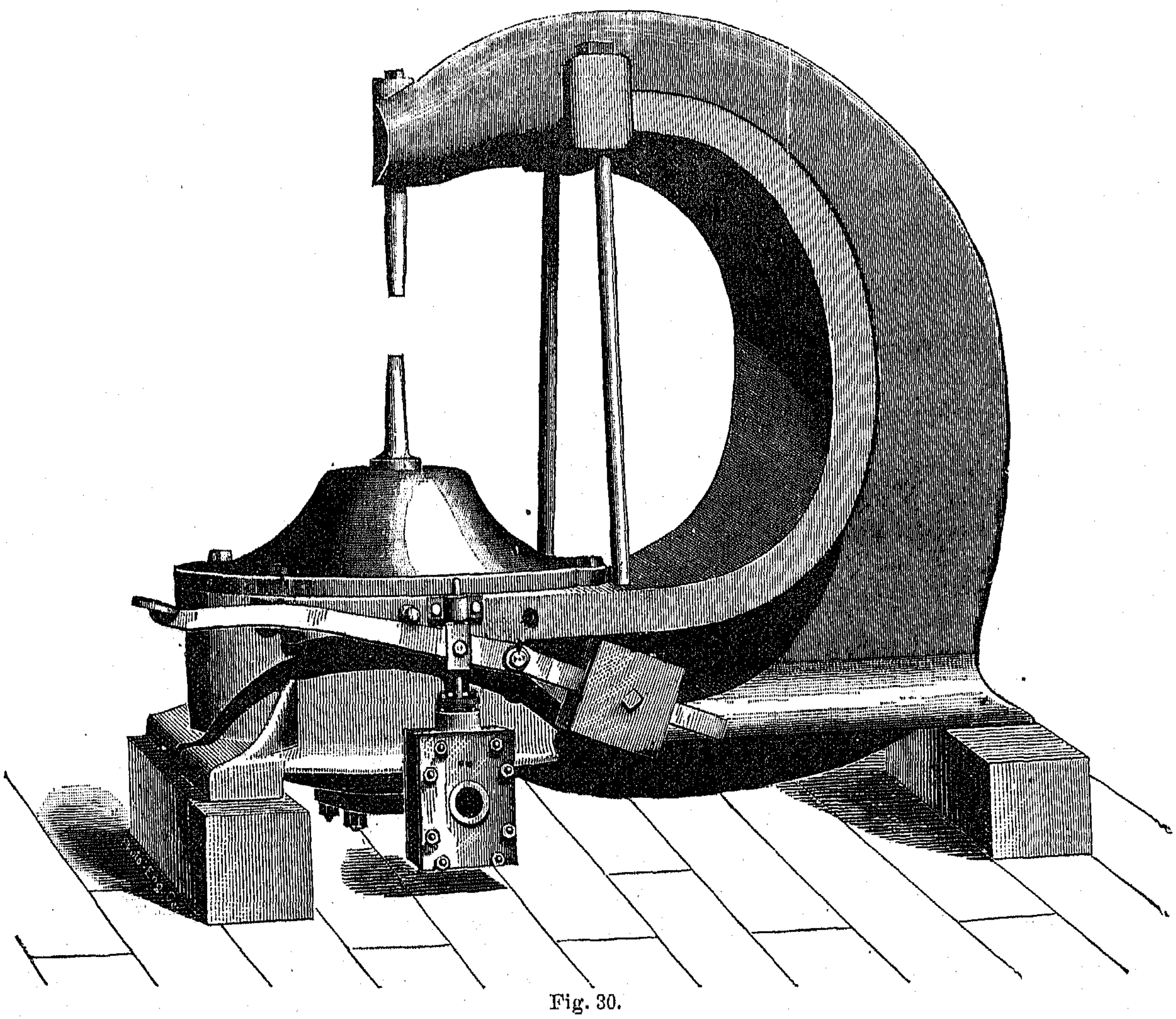


Fig. 30.

of the machine. On the other hand, they deliver a blow upon the rivet before the compression, which causes shocks upon the bolster or stake and wears and strains the machine. There is also a tendency to slide on the foundations, due to the impetus and reaction of the blow, which can only be counteracted by heavy foundations and anchor-bolts. Figs. 29 *a* and 29 *b* show a similar machine with the overhead traveling carriage which accompanies it in the best practice, and Fig. 30 illustrates a horizontally-bedded machine for bridge-work worked by a foot-lever.

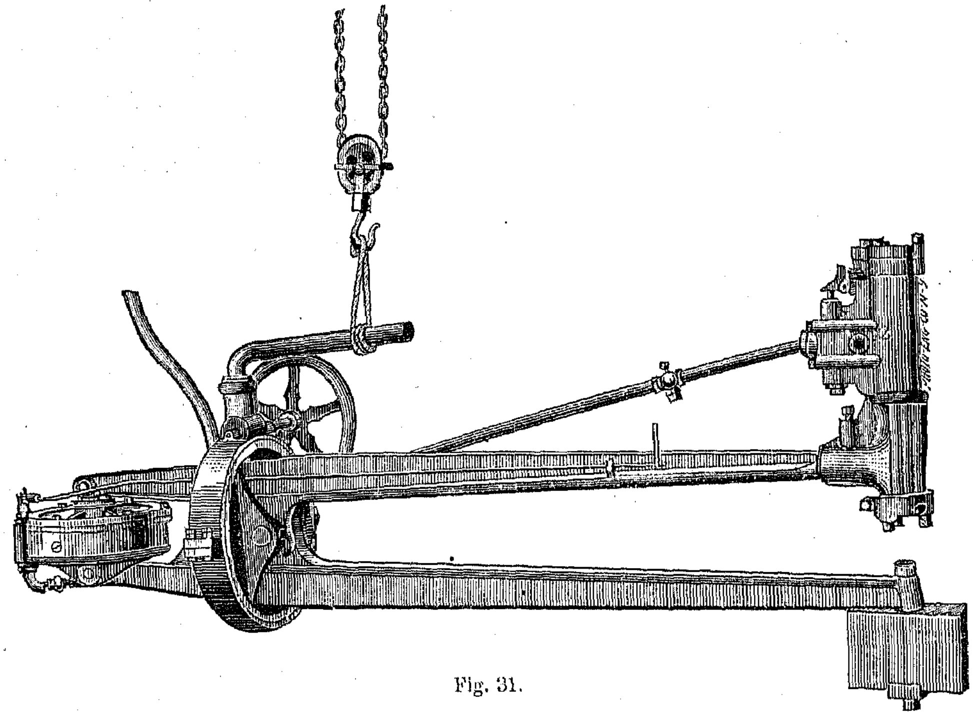


Fig. 31.

§ 8.

AIR-RIVETERS.

The steam-riveter can be worked by compressed air with but little less efficiency. But an especial riveting device to work by air has been introduced which depends upon a different principle. The machine is portable and avoids the expense of foundations. Fig. 31 shows its construction as adapted for boiler-work. The two long arms are pivoted in the suspension ring, which is double, and can be adjusted by the worm and wheel so as to act upon the rivet at any angle. At the farther end is a wide but short cylinder by which the acting ends can be brought together upon the plates before the rivet is inserted. This clamps them together and increases the stiffness of the hold of the stake-arm upon the rivet-head. Upon the free end of the other arm is a small cylinder, with a rivet-swage upon the end of the piston-rod. This small cylinder delivers a number of blows upon the rivet when in place, heading it over upon the clamped plates. About one hundred and fifty or two hundred blows will be delivered per minute, the valve-motion of the cylinder being not unlike that of a rock-drill. The stake-arm has a counterpoise to increase its mass, and the whole machine is swung over its center of gravity. Thirty pounds per square inch is usually sufficient air-pressure.

For work upon girders, where the overreach need not be very large, the form shown in Fig. 32 is used. The machine acts by compression, and not by blows. The air-cylinder opens and closes the links of an elbow-joint upon the outer ends of the nipping-levers.

This form of riveting machinery has the advantages due to its portability, inasmuch as the heavy work does not need to be adjusted to the machine. It also works very rapidly, and steam can replace the air if desired. It is claimed for it that on straight work it will head over two rivets per minute.

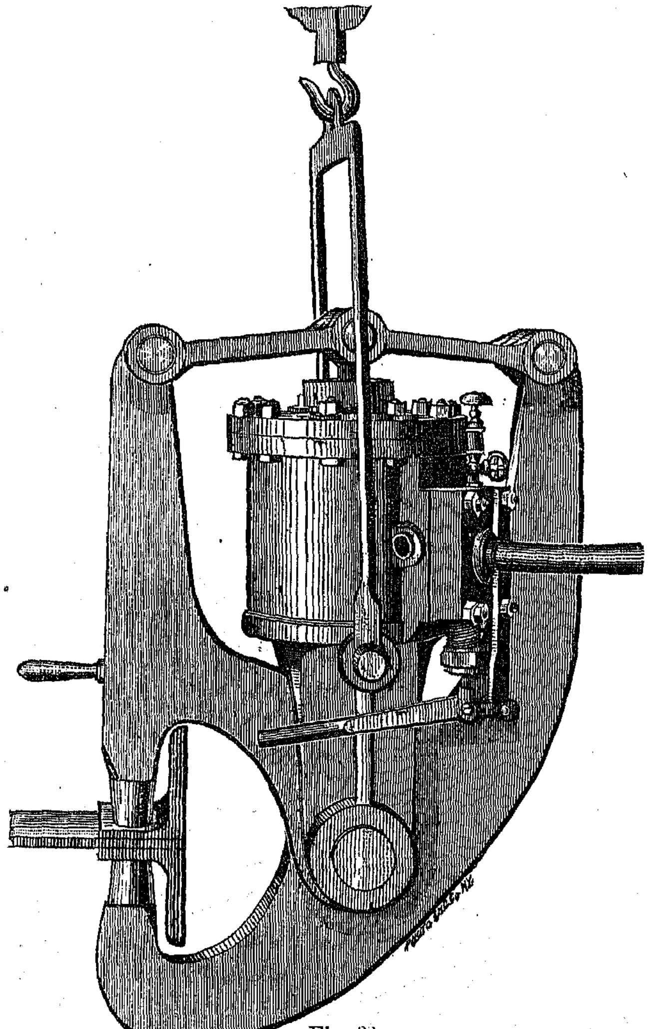


Fig. 32.

§ 9.

WATER OR HYDRAULIC RIVETERS.

The hydraulic riveters differ from the preceding types in the use of an inelastic fluid under great pressures behind the plunger in a smaller cylinder. On account of its density water can be retained at a high pressure per each square inch, and this pressure upon a small area produces a force equal to that due to lighter steam pressure on a large area. The stationary riveter will, therefore, resemble the steam-riveter, but the cylinder will be much smaller (Figs. 33 and 34). Two essential parts of this hydraulic apparatus must be the pump to produce the water-pressure, and the device known as the "accumulator", to keep the pressure uniform. The pump may be driven by steam directly or by a reducing-gear from a belt-wheel. If the pump were to be the sole dependence to work the riveting-ram it would need to be stopped after each rivet, and would need to have a capacity to fill the barrel of the riveter before the rivet should cool. By the use of the accumulator both these drawbacks are avoided.

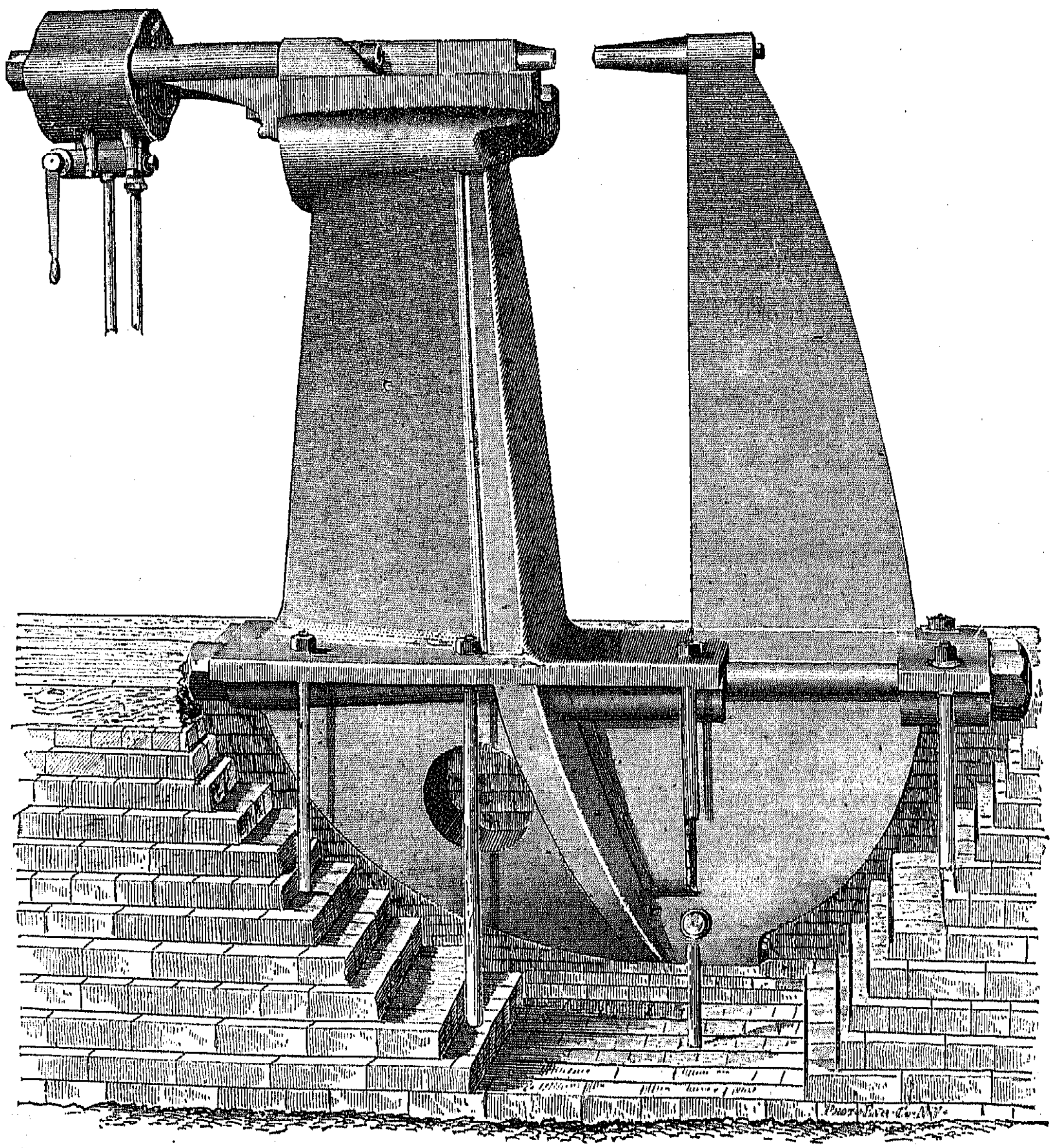


Fig. 33.

The accumulator (Fig. 35) consists of a plunger, which plays through a stuffing-box in the top of a pressure reservoir. Into this reservoir the water is delivered from the pump, and from it is carried to the riveters by pipes, controllable at the machines by valves. It will be seen that when the pumps deliver water into the reservoir, with the outlets closed, the plunger will be floated upward by the accumulating pressure upon its lower end. When an outlet is opened the plunger will sink as the water is withdrawn, but will still maintain the equilibrium between its weight and the pressure of water in the reservoir. By adding weight upon the plunger any desired pressure can be maintained. These weights are hung from the top of the plunger, so that their release or addition can be effected without lifting them into place. When the reservoir is full of water at the desired pressure the accumulator-plunger will be at its highest point. Should the pump continue to force water into the reservoir, the plunger would be forced out. To avoid this, when the plunger has risen to a certain point it opens the valve shown in front by which the forcing-side is connected to the suction-side of the pumps, while the accumulator pressure is shut off. The pump keeps on working under no strain, no more water is added to the accumulator, and yet the pump will resume its normal duty as soon as any water is withdrawn by the machines. Where the pumping is done by a steam-pump, the accumulator-plunger may be connected to a valve in the steam-pipe. When the plunger rises the steam supply is diminished, as it falls lower the speed of the pump is increased because more steam is given to it. The upright of Fig. 35 is a hollow tank into which the water returns after it is exhausted from the riveters. The water is filtered through sponge on its return to remove any scale, etc., which may have been loosened.

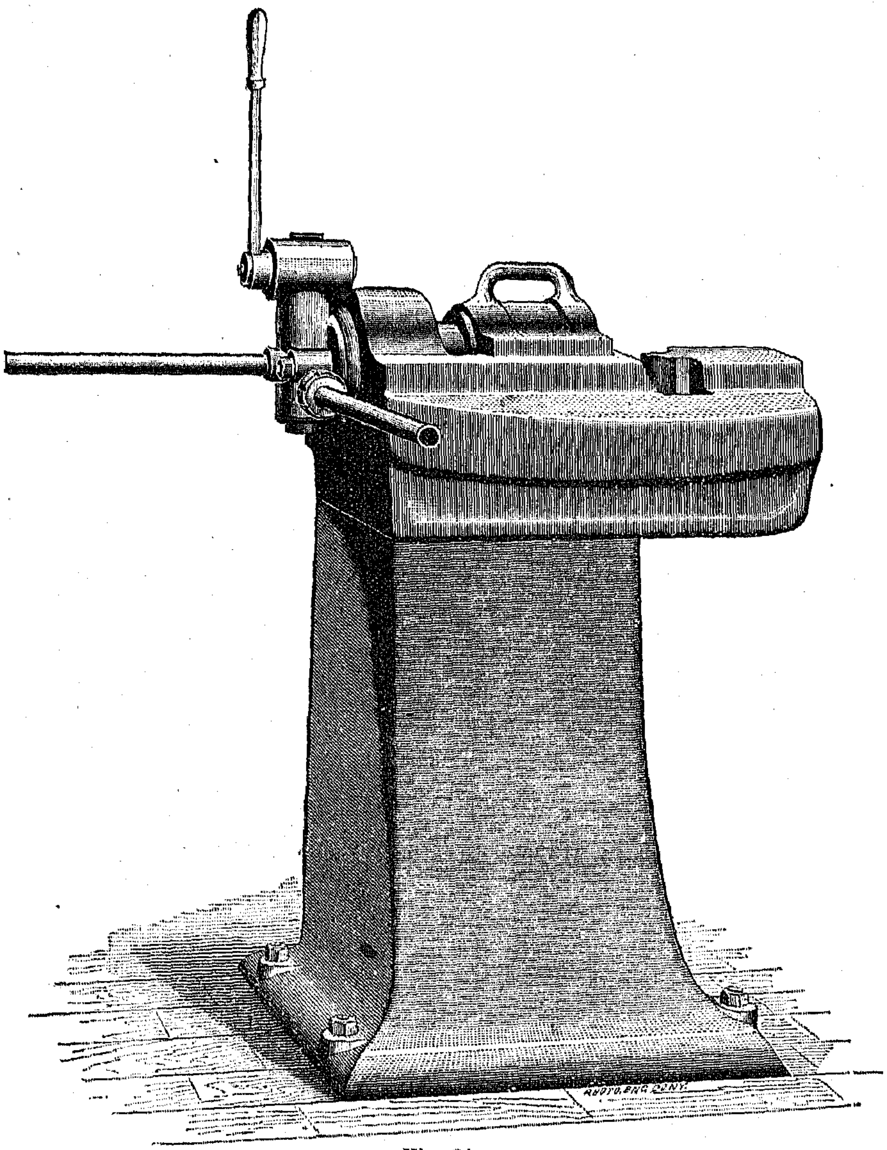


Fig. 34.

For bridge-work, the portable machines shown in Figs. 36 *a*, *b*, and *c* are approved. The machine is hung on the arc from an overhead carriage or from a traveler. It can be presented at any angle to the work, and a worm and wheel gives adjustment in the plane at right angles to the arc. The jaws are levers of the third order, pivoted on a ball-joint at the long ends and held from separating by a spiral spring. Water from the accumulator is admitted to the plunger through a valve and draws the dies together. A reverse motion of the valve-lever shuts off the pressure and opens the exhaust-valve. When the exhaust-valve is open, a small piston attached to the bottom of the barrel serves to draw back the plunger and open the dies. It is claimed for this machine that with it a skillful operator can drive from ten to sixteen rivets per minute in straight work upon girders.

The great advantage of the hydraulic riveter is due to the fact that it compresses the rivets without a blow. The great density of the driving fluid permits its gradual flow through the controlling-valve, and as it has no expansive force of its own, the advance of the ram upon the rivet is a gradual one. The pressure upon the heads of the rivets can never be any greater than that due to the previously determined load on the accumulator. Therefore, the plates can not be forced apart in the joint nor distressed by any excessive pressure in the upsetting. They have hitherto been open to the drawbacks due to the high pressures at which they were worked. An average pressure was from 1,000 to 1,800 pounds per square inch, but this pressure is very severe upon the packing of the rams. Leather cup-packing seems to give the best results, but it is cut sharply through at the bends. Practice is therefore tending to reduce the pressures and enlarge the plunger areas. Pressures of 350 pounds to the square inch are much less difficult to manage, and the advantages of riveting by an inelastic pressure are retained. For girder-work in yards, or under open sheds in winter, there may be dangers from freezing of the water, against which special precautions must be taken.

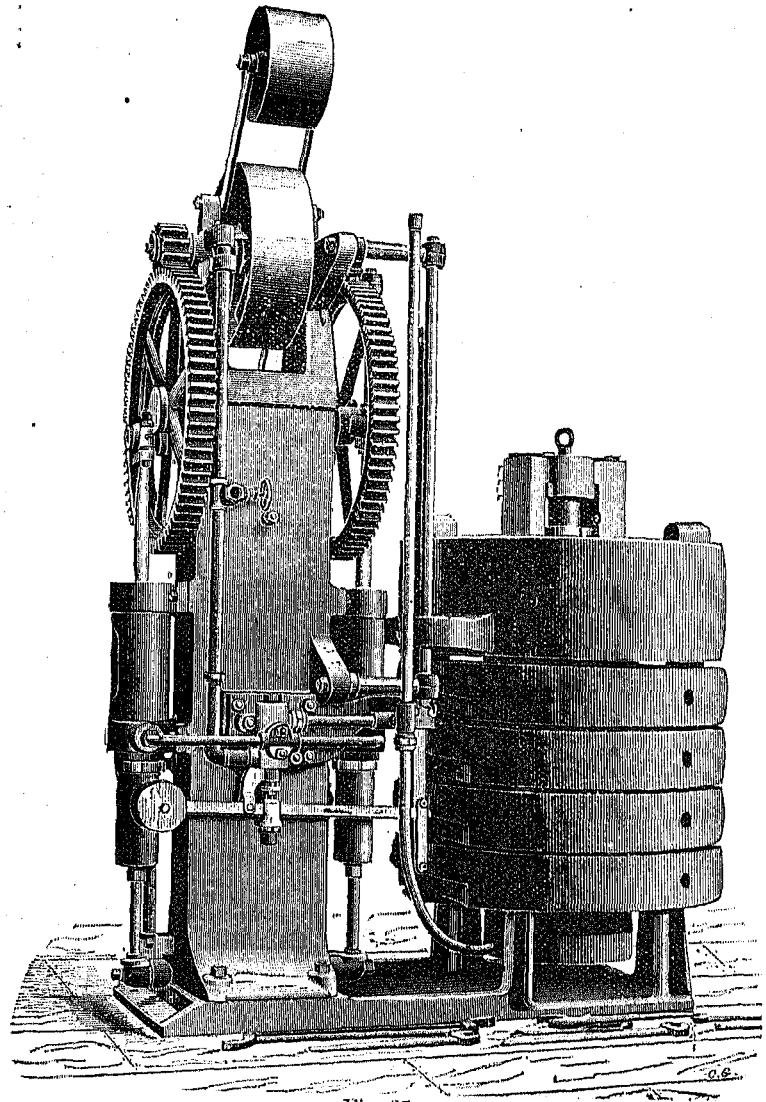


Fig. 35.

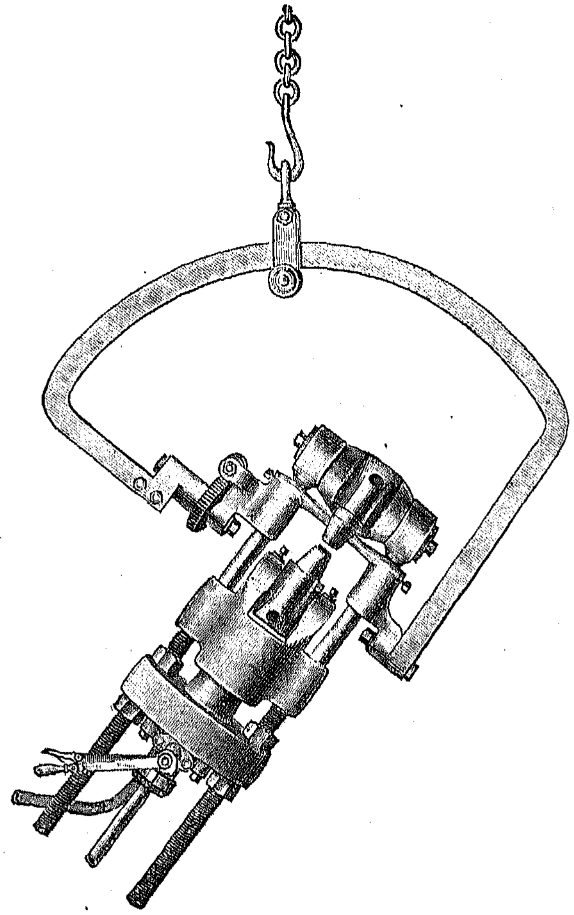


Fig. 36 *b*.

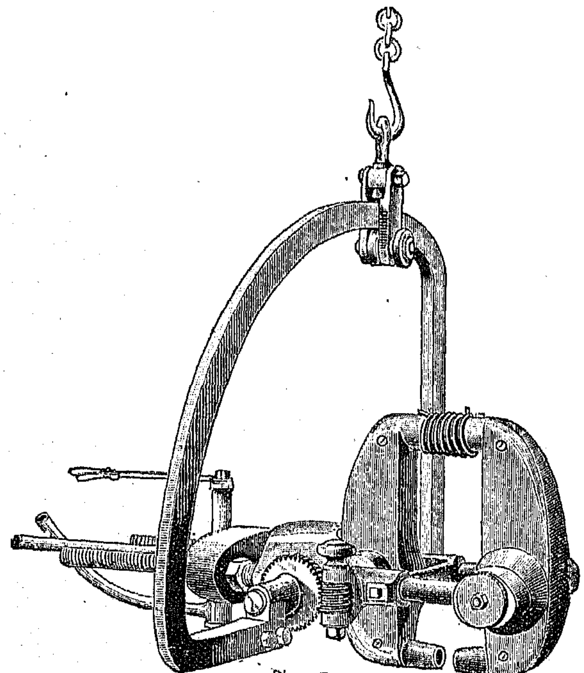


Fig. 36 *a*.

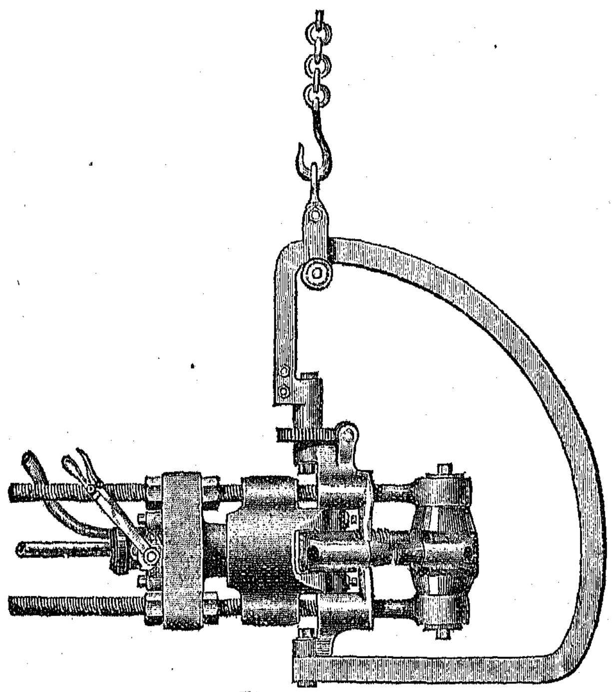


Fig. 36 *c*.

§ 10.

DIE-FORGING MACHINERY.

The principle of these machines is but an extension of that on which hydraulic riveting is based. The material to be shaped is exposed at a welding heat to great pressures between dies which are actuated by hydraulic plungers. Every part of the die is completely filled by this pressure, and an exact reproduction is obtained. The effect of this gradual pressure upon the forging is much more favorable than the effect of hammer blows. Blows upon the

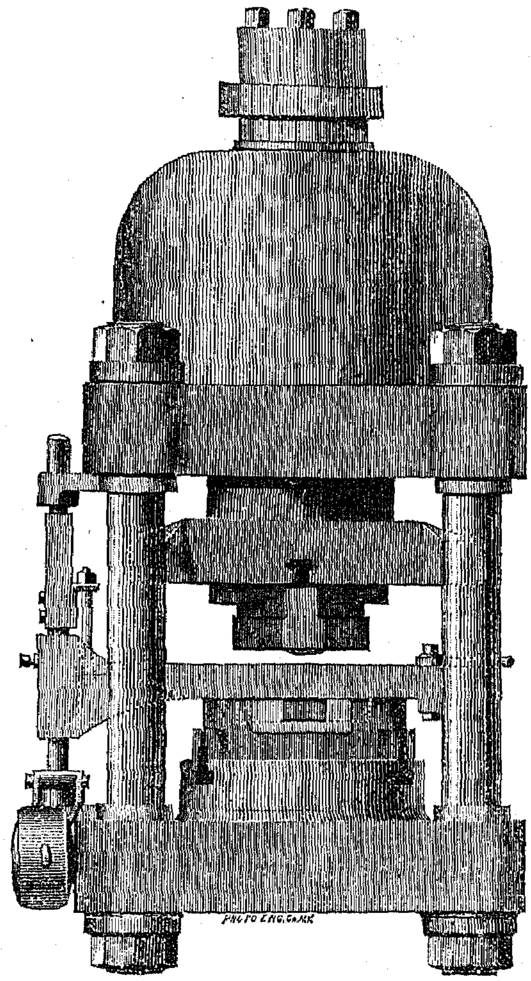


Fig 37.

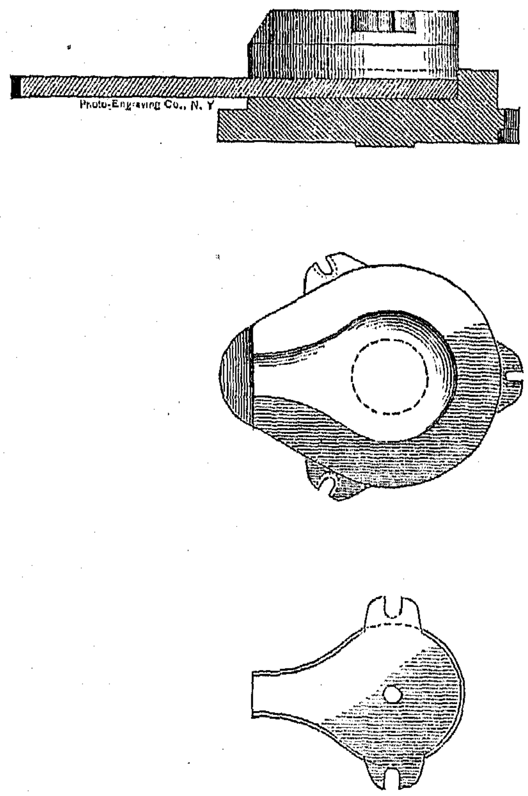


Fig 38.

forging delivered through a fuller or swage often act upon the surface only, and leave the interior parts less affected. This is shown by the drawing out of the top and the bottom of a forging farther than the center. In rolling this phenomenon gives rise to "pipes". The gradual pressure forces out the material in the middle first, thus showing the compression to have been pervasive.

This process of die-forging has been applied with especial success to the manufacture of eye-bars or chord-links for bridges. The enlarged head or eye is formed from the metal of the bar without the weakening effect of a common weld, and with much greater economy.

Two sets of presses are employed. The first upsets the end of the bar into approximately the finished profile, while the neck of the bar below the heat is closely gripped between serrated jaws. The heat is restored to the end to relieve the strain at the neck, and it is put in a flatting-press with male and female die and brought to the exact shape and thickness (Fig. 37). A nipple on the male die makes a central depression upon the eye where the pin-hole comes (Fig. 38), which depression guides the punch which forms the hole. The punch is usually hydraulic—shaped and acting like a vertical riveter. The only loss of metal is by scale and the small fin at the dies. The punched blanks can be welded under pressure and utilized as nuts. One difficulty met with is the danger of thinning the bar at the joint of eye and straight length.

Two accumulators are used to furnish the hydraulic pressure for the presses. One is weighted to produce 400 pounds or so to the square inch of plunger, and water is taken from this to fill the plunger-barrel and to exert what pressure it will. Then, if necessary, the first valve is closed and communication is made with the second accumulator, which is weighted to 2,500 pounds to the square inch. Less water at the heavier pressure is thereby

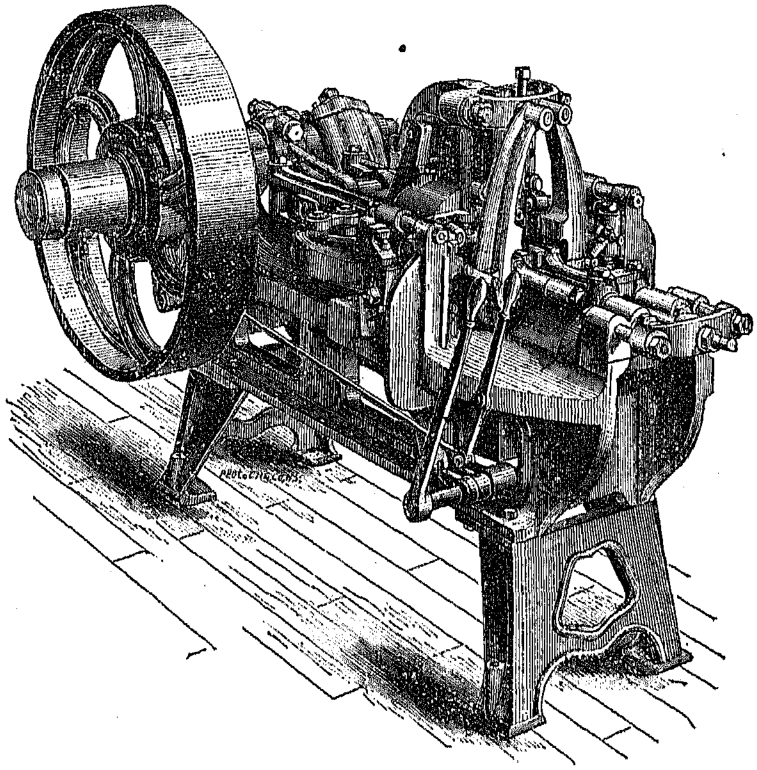


Fig. 39.

used, resulting in a saving of the power necessary, but many works are using only one accumulator to avoid the greater first cost.

This principle of forging between dies by hydraulic pressure can be carried very much further and applied to many shapes. The saving of time and the superiority of product are to be set over against the first cost of the plant.

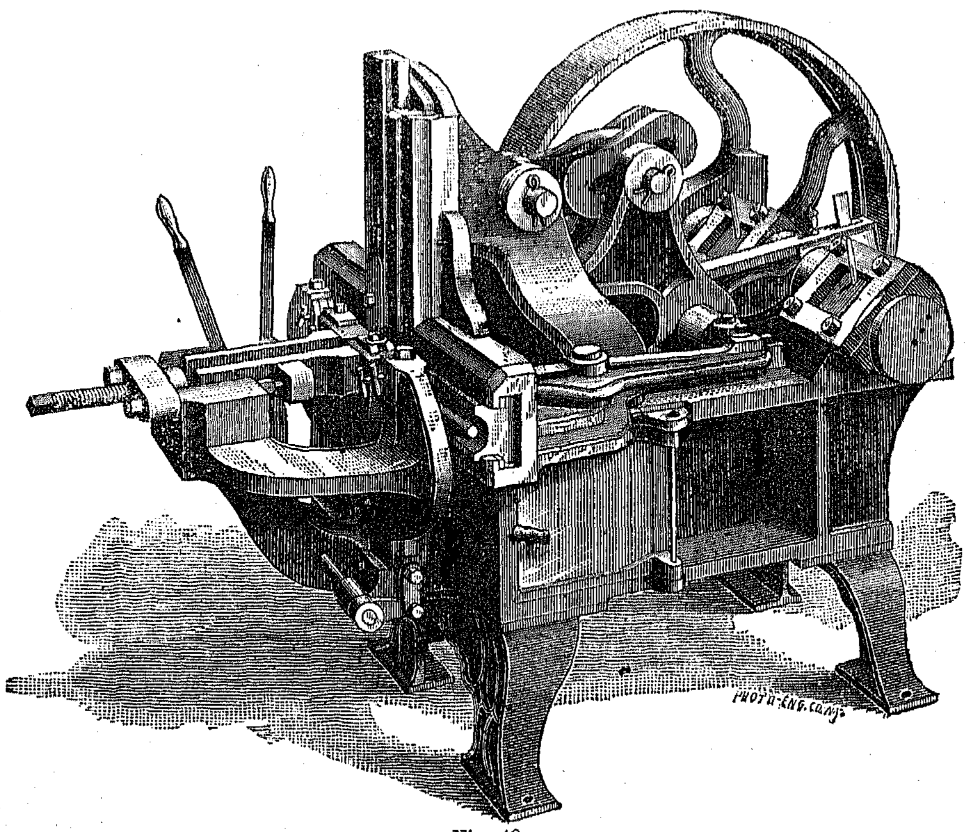


Fig. 40.

Another method upsets the end of the bar by pressure of a ram driven by steam pressure. The bar is held between plungers, from which hydraulic pressure is relieved through a small valve as the upset is made. This yielding grip is thought to distress the bar less than a rigid clamp. Upon the upset end a piece is welded to make up the thickness when the eye is formed between dies on head and anvil of a steam-hammer.

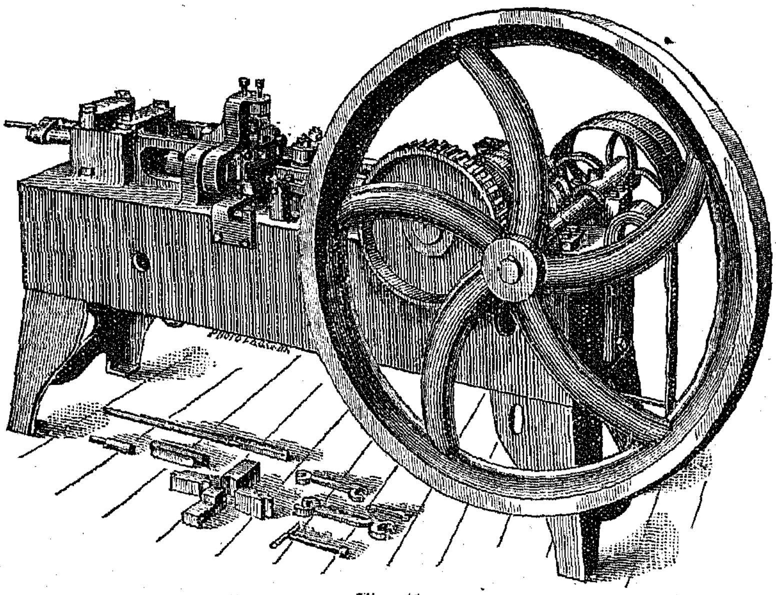


Fig. 41.

Under die-forging machinery must also be included the machines for making bolts and nuts. Many large shops which use a great number of bolts of different forms prefer to head over their own stock in the blacksmith shop, and for such work these tools are adapted. Fig. 39 shows the Burdict improved bolt-forger; Fig. 40 is the Abbe machine, an outgrowth of the former, and Fig. 41 shows the Burdict machine for making hot-pressed nuts from the bar.

In the bolt-header (Fig. 39) the iron is held between clamp-dies which are moved by the hand-lever at the extreme right. The grip is by means of an elbow-joint, and is for steadiness only. The blank is kept from end motion by a screw-stop at the end of the vise. Hence there will be no change of section of the rod under the heated head. Blows are delivered upon the end of the blank by the upset-die, which is connected to a short crank on the fly-wheel shaft, and the forming-dies in pairs act laterally upon the upset metal. The formers act twice for every one blow of the upset. The forging-levers act only when engaged by a clutch operated by the second hand-lever, thus avoiding unnecessary wear. The slides of the formers are gibbed to take up wear, and the pin-joints are bushed. The links from the long slide of the upset make an elbow-joint combination with the side levers, and the top and bottom swages are moved by a pin working in a curved slot. Four revolutions of the shaft will form a head, and from 3,000 to 8,000 bolts is the capacity of the machine in ten hours.

Fig. 42 illustrates another type. The nut-machine (Fig. 41) makes the nut at one operation without fin or burr, saving the expense of trimming the blanks.

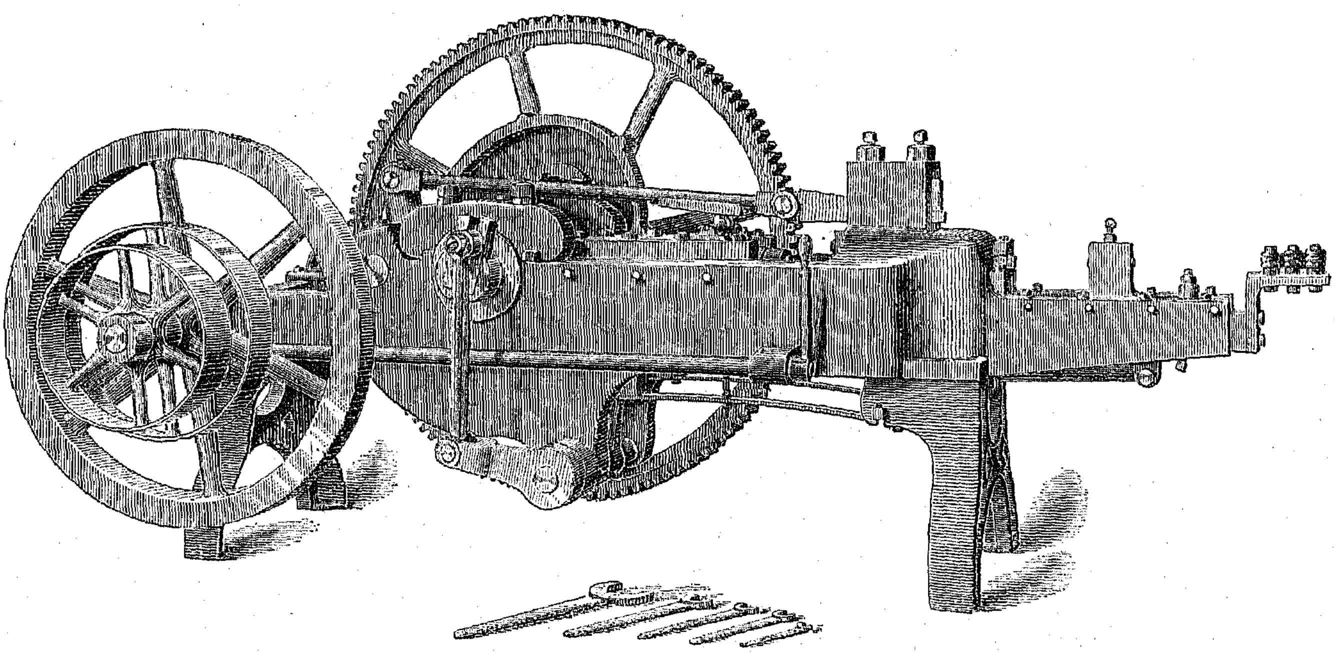


Fig. 42.

There is a variety of other machines which might come under this class, such as the rivet, spike, nail, and horse-shoe machinery, but as these are machines manufacturing directly and only for the market, in accordance with the original plan they will be passed over.

§11.

BENDING-ROLLS—STRAIGHTENING- AND BENDING-PRESSES—ASSEMBLING-PRESSES.

BENDING-ROLLS.

For curving plate iron or steel for boiler purposes, or for other cases where cold shaping may be required, the combination of three rolls is used. This appears in two forms. The two lower driven rolls may be fixed, and lie in the same horizontal plane, while the third roll lies above the other two and over the hollow between them. This top roll is adjustable vertically to give the required degree of curvature. The other form has the upper and one lower roll fixed and driven, while the third roll is adjustable obliquely toward the other two (Fig. 43). The adjustable roll is not driven in either case. The first form has the advantage of causing no calendering action. The curving takes place round the adjustable roll, which is not driven, and the two driven rolls both act upon the outside surface. The disadvantage is that it is not

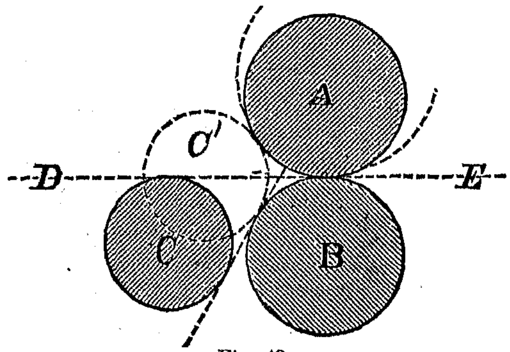


Fig. 43.

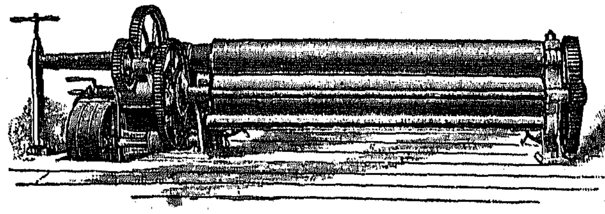


Fig. 44.

easy to start the plate into the rolls, and that they will not curve it exactly near the edges of the plate. In the second form the two driven rolls pinch the plate, so that it must enter, and the third roll bends close to the edge.

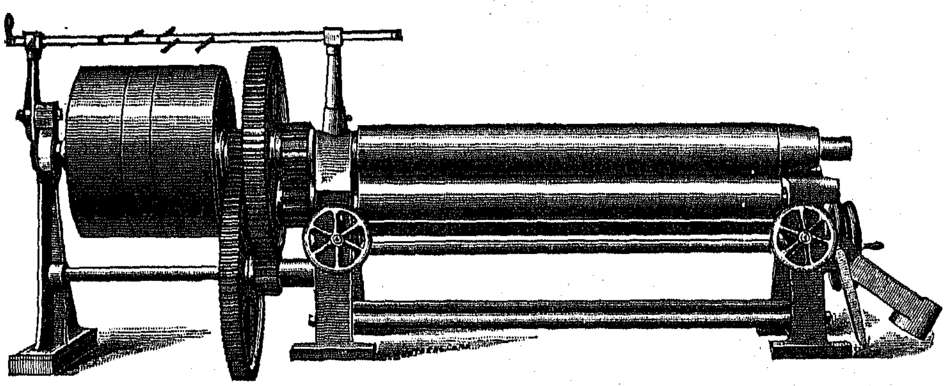


Fig. 45.

But the upper roll is acting upon a surface of less length than the lower after the piece is curved, yet they are driven at the same speed. To obviate the frictional loss from this inequality the lower roll, in the best practice,

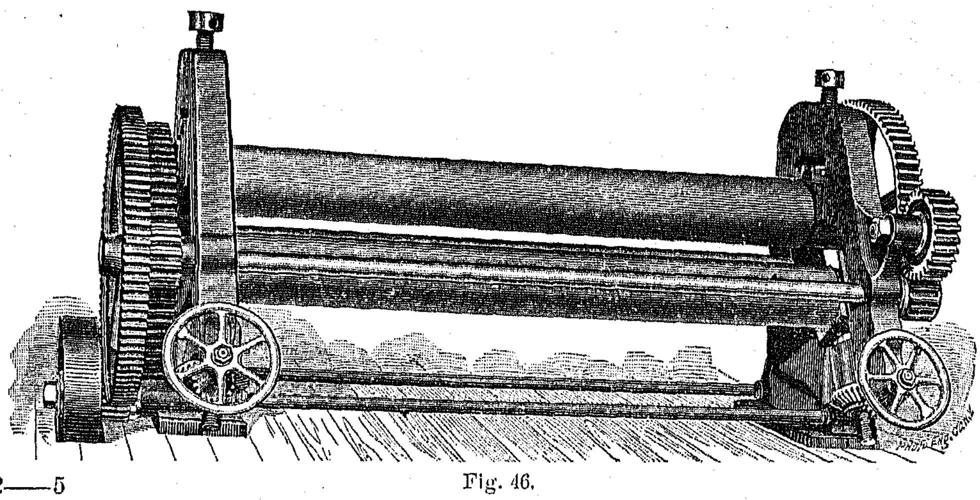


Fig. 46.

is driven by an epicyclic gear, so that the excess of length may be compensated for and pass into the gear (Fig. 44). This avoids also the calendering of the plate. The compensating gear consists in a set of four bevel-wheels forming a rectangle, the two smaller ones being upon a diameter of the wheel which drives both rolls, and of the other two, one is connected to the gear on the upper roll and the other to the gear of the lower. Any inequality of resistance in the rolls is equalized by the rolling of the small bevel-wheels upon the larger. The rolls are geared at both ends by large gears and small pinions, so that they shall drive truly. They are driven by open and crossed belt, with one fast and two loose pulleys. The shifters may either be plain forks, or else some of the special designs may be used, by which one belt is shifted off before the other is shifted on. The housing of the upper roll is made removable, in order that flues or any other work rolled into a full cylinder can be taken off. In the form shown in Fig. 45 the roll need not be lifted that the flue may clear. The design of Fig. 44 makes the lifting necessary. The screws for lifting the two ends of the curving-roll are usually geared together, that true cylindrical curvature may be given. When the plates are to be bent into-wind, as in ship-work, they may either be presented diagonally or the two ends of the curving roll may be raised unequally (Fig. 47). In the pyramidal form the rolls must be brought together with the work between them. Not infrequently, therefore, the adjusting-screws are headed by worm-wheels and driven by power. With the other form hand-gear only is necessary, and is preferable from its greater exactness (Fig. 46).

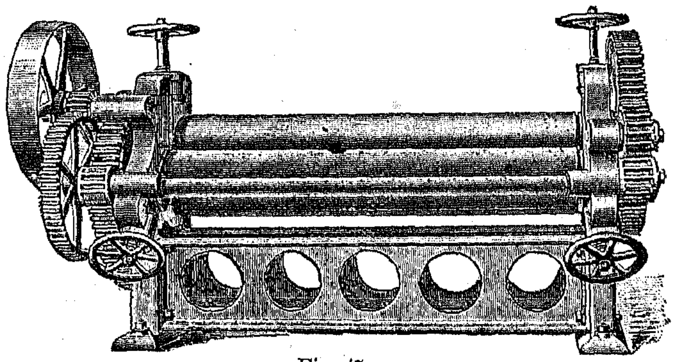


Fig. 47.

Where the rolls are revolved by hand-spikes, and one lower and the upper roll may be driven, the pyramidal form is approved, because of its simplicity. For power-driven rolls, the other arrangement is preferred.

§ 12.

STRAIGHTENING- AND BENDING-PRESSES.

After work has left a roll-train and has become cool, it is very often found to be out of true. Unequal contraction, if the work was finished hot, may produce this result, the shape may have compelled calendering, or the removal of a skin which kept the work straight in the rough may also cause it. In either case straightening machinery is made necessary.

To straighten a curved beam or rail a heavy pressure is to be exerted upon the work through a short distance, while it is held upon two supports. The machine may be either horizontal or vertical, and usually acts upon the principle of the crank, the crank and connecting-rod forming an elbow-joint combination. The essential parts will therefore be the two abutments for the support of the work, and a crank-shaft which can be adjusted with respect to the abutments for different thicknesses of work and different amounts of curvature.

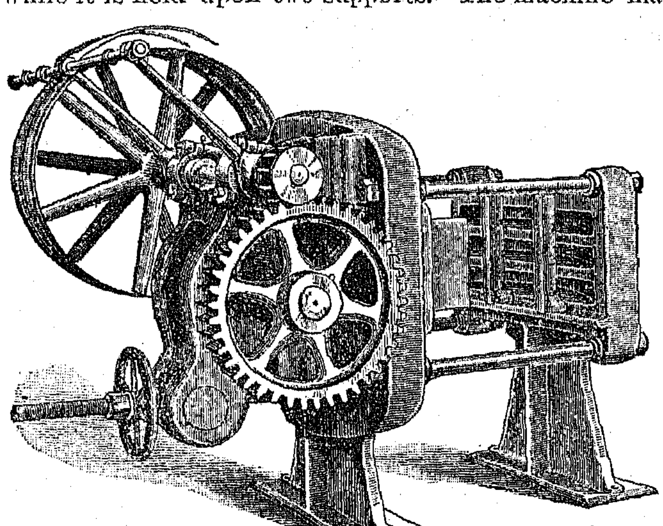


Fig. 48.

Fig. 48 shows a horizontal machine of this class. The abutments are tied to the plunger frame by the four bolts, and the bearings of the crank-shaft are borne upon the heavy frame swinging around the center of the pinion-shaft. By tightening the hand-wheel nut the end of the bending-plunger comes nearer to the abutment. The gear-wheel travels around the pinion, always remaining in gear with it. A vertical machine for similar purposes is also made, whose mechanism resembles closely that of the vertical punches. The horizontal machine is especially adapted for working upon bridge or other girder work, as the parts lie horizontally upon trestles, at an easy height for sighting. By raising the height of the abutment supports of these machines, they can be used for curving straight work for any uses for which such pieces may be required.

Fig. 49 illustrates a hydraulic machine for curving railroad-iron. The abutment may be changed for different degrees of curvature, and the bending speed may be varied by the lever without stopping the pump.

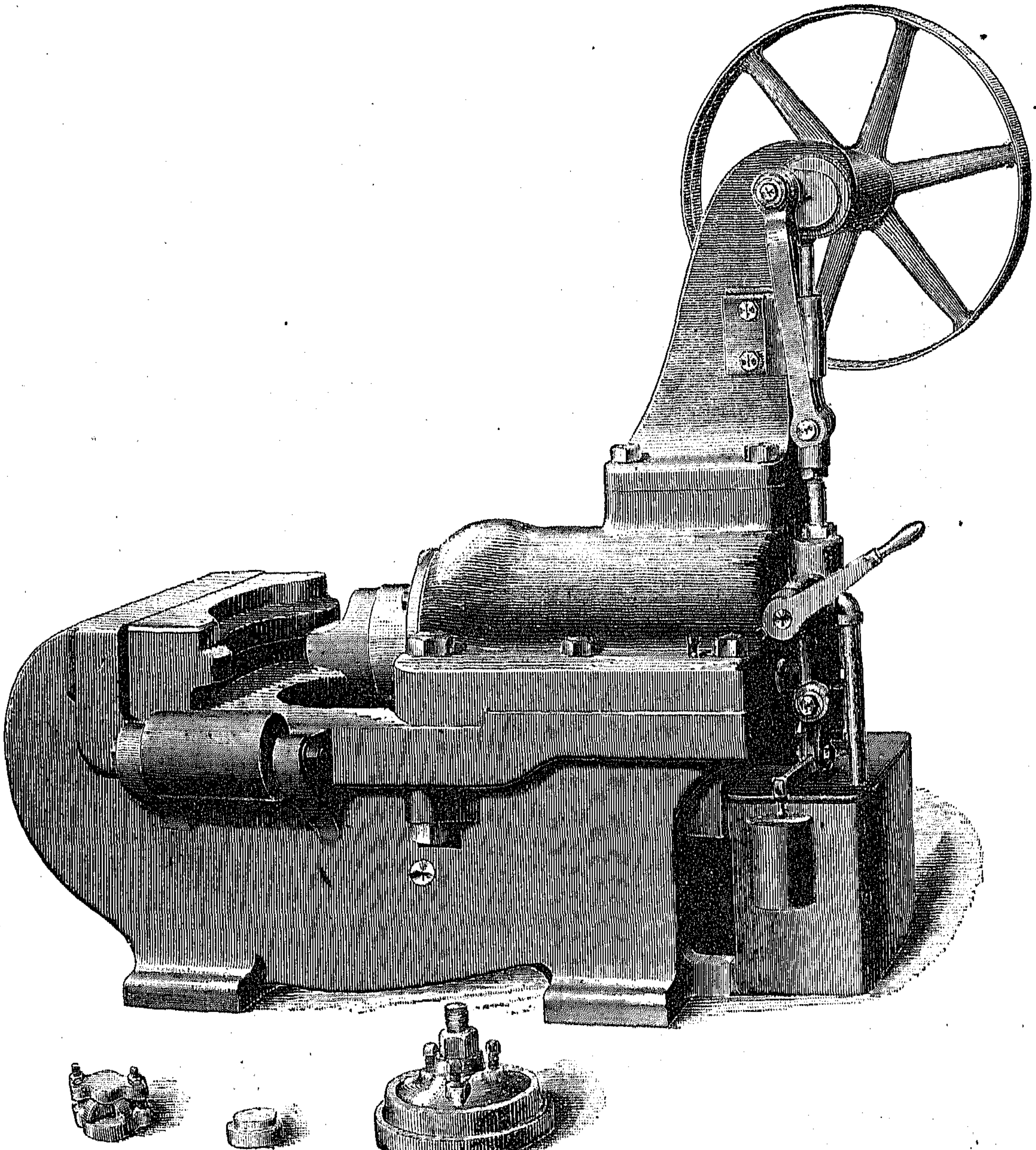


Fig. 49.

§ 13.

ASSEMBLING-PRESSES.

Under this head come those machines which are used in putting together the parts of engineering work. They are most generally applied for putting crank-pins into cranks, and for forcing the wheels of cars and locomotives upon their axles. The principle of the hydraulic press is most generally applied, inasmuch as that has the advantages of slow velocities and very great power, and the exact pressure can be known by a pressure-gauge. The machine must consist of an abutment to resist the pressure of the ram, the supports for the work, the cylinder and frame for the ram, and the pump and its gear.

Figs. 50, 51, 52, and 53 show the general forms. The pumps are usually double, to insure regular motion of the ram. Designs (Figs. 52 and 53) have the pumps of different diameters. When the larger one is working the ram moves rapidly. When the limit of its capacity is reached it can be shut off by a hand-wheel, and the smaller pump will complete the pressure to the limit of the machine. At 100 strokes per minute no irregularity of motion is felt. The fluid used is oil taken from a reservoir in the base of the frame. When the work has been forced home, the pressure can be let off into the reservoir by turning the large hand-wheel and the ram is retracted

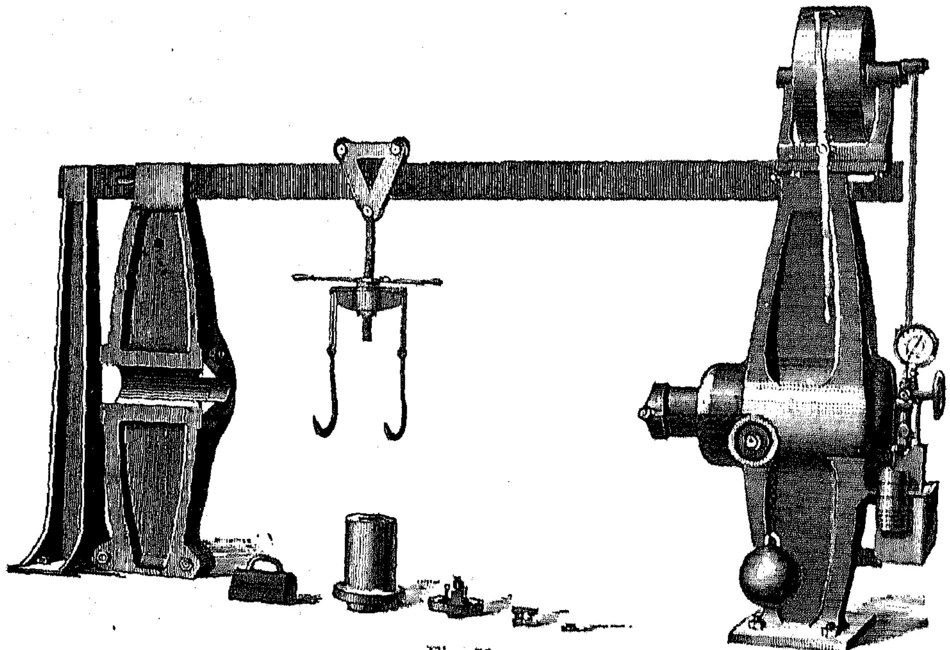


Fig. 50.

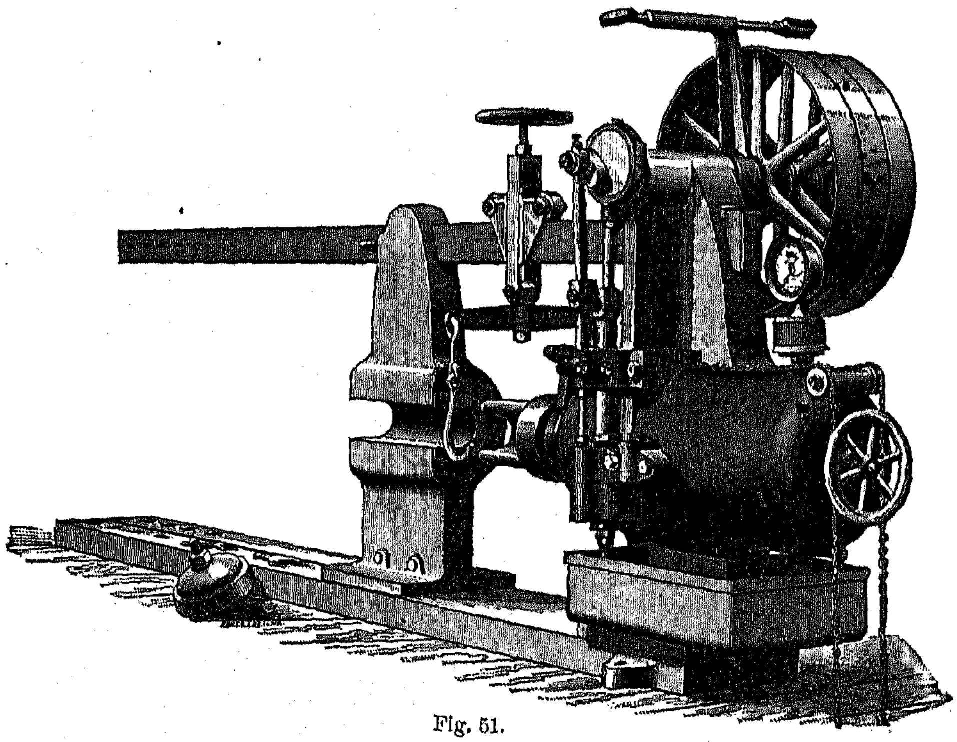


Fig. 51.

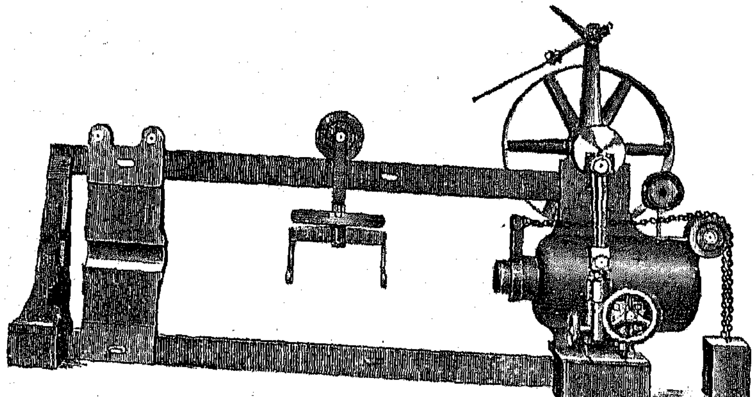


Fig. 52.

by the counterpoise. The ram-cylinder is provided with a safety-valve (often put beyond the control of the operator) and a pressure-gauge. To prevent the sweating which cast iron will manifest under high pressures, one builder lines the cylinder with seamless copper expanded against the lining. Cup-leather packing is used for the gland, made upon formers which accompany the machine.

The abutment is tied to the ram-cylinder casting by the sole-plate below and the reach-rod above. The abutment is fitted with rollers either above or below to make easy the adjustments for different lengths, and is held in place by keys at top and bottom. It can thus be used to take apart work as well as to force it on. From a buggy on the reach hangs an equalizing beam, adjustable for different diameters by the screw-and hand-wheel. It will support any work in the line of the axis of the machine and over its center of gravity.

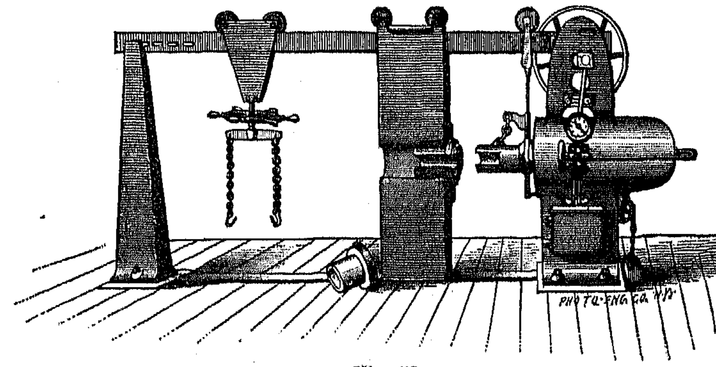


Fig. 53.

These assembling-presses have become almost a necessity. In car-axle work, where the "wheel-fit" on the axle is made cylindrical and seven-thousandths of an inch larger than the hole in the wheel, practice has shown that the wheels will never come off when forced in place by a pressure of 30 tons. To get this by the old hand-screw press would be very laborious and would take entirely too much time, while it would be hard to ascertain exactly what pressure was being applied. The hydraulic press avoids all these difficulties, and is therefore in very general use.

§ 14.

B.—TOOLS ACTING BY SHEARING.

This class includes those tools which act upon the metal by cutting through or cutting off the fibers or elongated crystals of which it is composed. This may be done by perforating the metal as when a plate is punched, or by separating it into two parts at a vertical plane as when a bar is sheared.

The tools in this class will therefore be the punches and the shears. They can be discussed together, since their action and construction are identical. There must always be found the abutment upon which the metal must rest, and an edge or plane through which the shearing force will pass. In the shearing-machines these two are straight; in the punches they are circular.

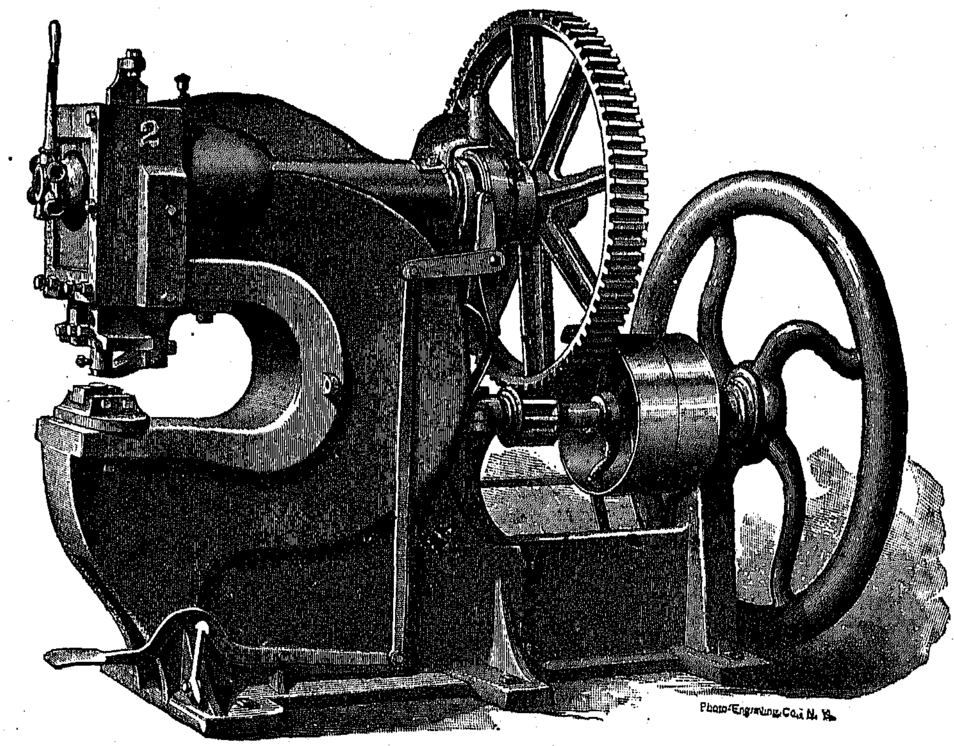


Fig. 54.

Shearing-machines may be reciprocating or rotary. Punches can be reciprocating only, from their nature. They are usually driven by belting from the line shafting of the shop. Increasingly, however, practice is tending toward the use of a separate engine for each large tool of this class. The cylinder is bolted to the framing, and it

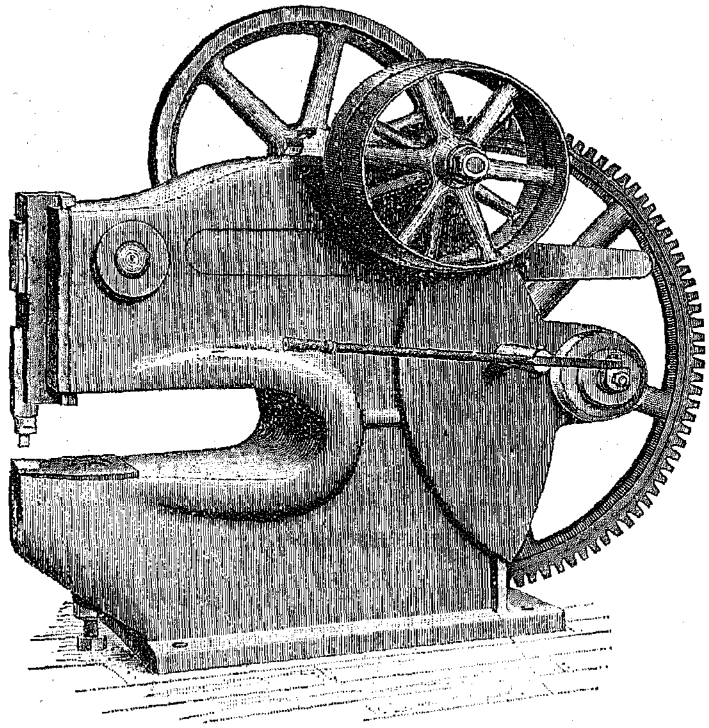


Fig. 55.

uses the former belt-shaft for its fly-wheel shaft. This system has the advantage of rendering the tool independent Any stoppage of the machinery does not arrest its work, and it can be put wherever most convenient, without regard to the conditions imposed by shafting, etc.

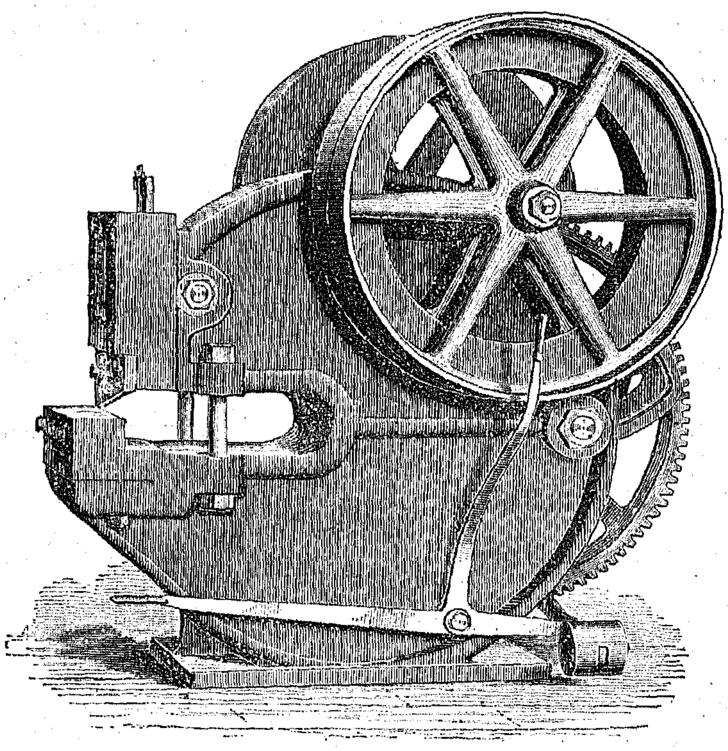


Fig. 56.

The reciprocating machines, punches, and shears can be grouped under two classes. The first includes those in which the slide carrying the shearing-plane is moved by a crank or eccentric. The second class includes those in which motion is given through a lever to the shearing-plane.

The disadvantages of the crank-system are that the strain of the cut must be borne upon the crank-pin, which must necessarily overhang, and the power of such machines is limited to the pressure practicable upon rubbing surfaces of the area of the pins. These rubbing surfaces being therefore, of necessity, large, the work of friction

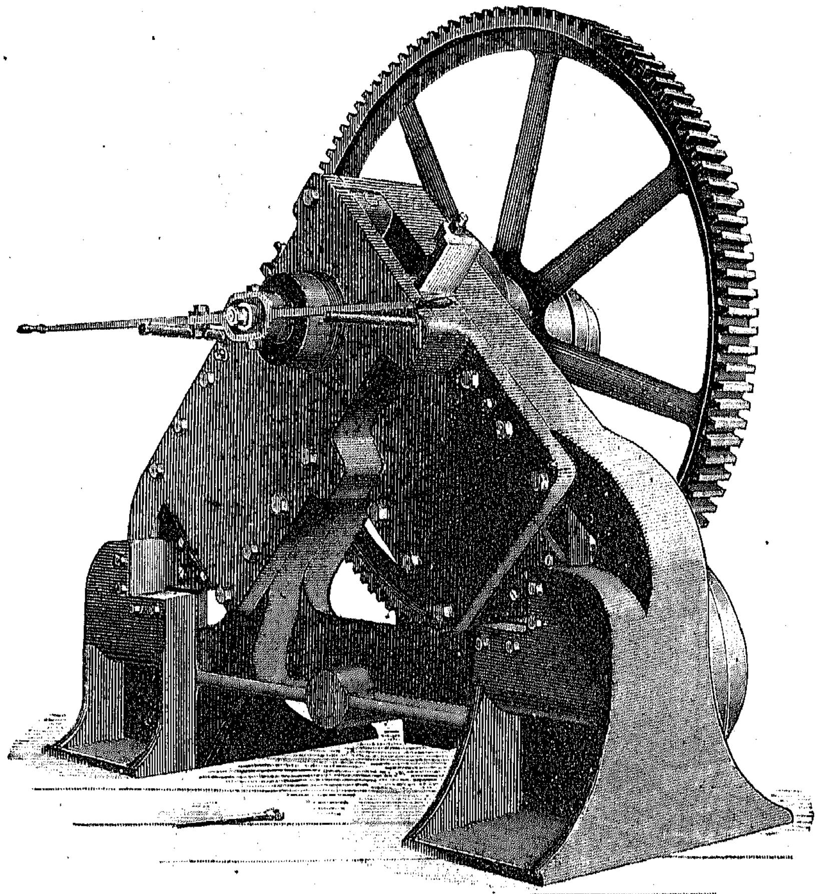


Fig. 57.

upon the circumference of the pin is also large, absorbing some of the power of the machine. The crank-system has the advantages of compactness, of distributed pressure upon the crank-shaft bearings, and of ready adjustability

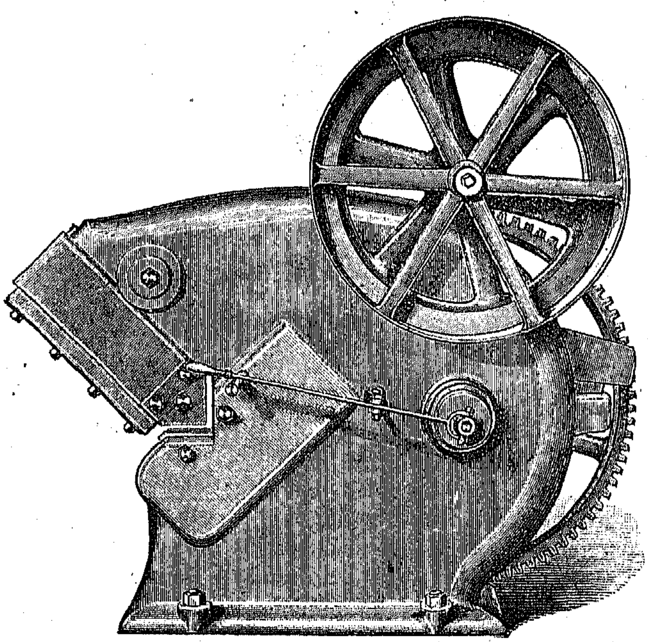


Fig. 58.

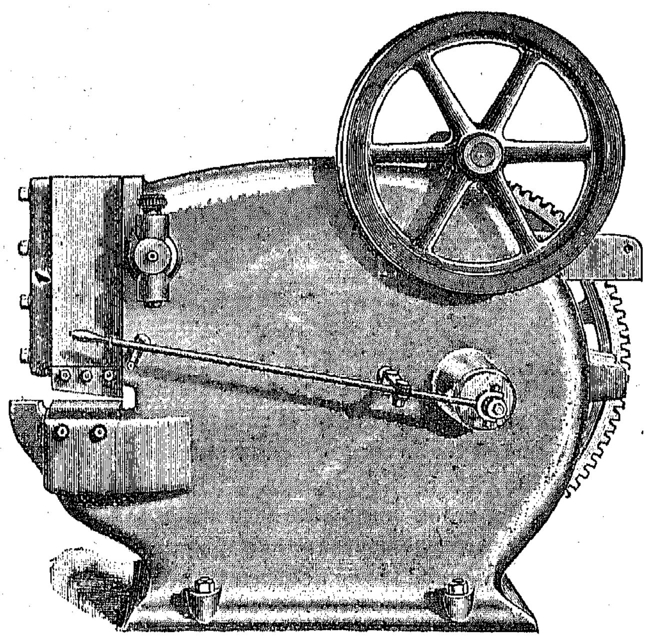


Fig. 59.

from in front. The power of the crank as it straightens into the line of the cut is very great. The disadvantages of the lever-system are that the necessity for metal at the fulcrum diminishes the capacity of the machine, and the cam should have a double bearing to prevent the slide from being caught down, since, when released, the lever will fall with a heavy blow. Moreover, the stroke and release are of the nature of a shock, which causes the metal of the lever and of the frame to become fatigued.

The advantages of the lever-system are the diminished sliding of the rubbing surfaces at slide and at fulcrum, where pressure is great, while the cam at the long end of the lever works under lighter pressures, so that the work of friction is lessened. Moreover, the cam may be shaped to give a quick-return motion, and to permit the shearing-plane to remain stationary at the top of its stroke during a large part of a revolution. This makes the handling of work more easy, and may prevent the necessity of stopping the machine after a stroke.

In view of the close equivalence of the reasons in favor of the two systems, the prevailing practice favors both about equally. Most engineers prefer what they have been accustomed to.

Fig. 54 shows a very good illustration of the crank-punch or shear. A fast-and-loose belt-wheel shaft, carrying a fly-wheel, drives a pinion which turns a large gear loose on the crank-shaft. This gear can be clutched to the

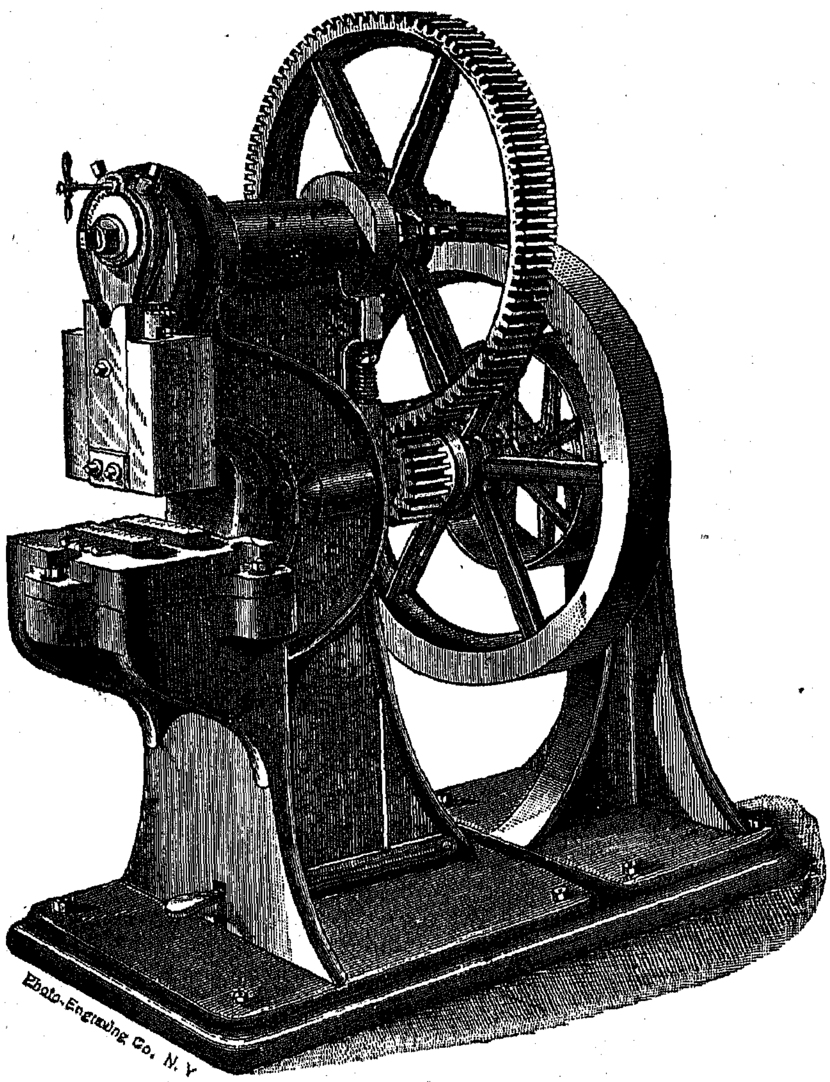


Fig. 60.

crank-shaft by the foot-treadle or by hand-lever. The fly-wheel equalizes the work of the single-acting plunger. The crank-shaft in this design is prolonged through the cap in front of the plunger, in order that the shaft may be turned by hand for accurate location of the punch before the power is applied. The punch is carried in a taper socket in the base of the plunger. Shear-plates bolt against a shoulder upon the wide, flat side. The inoperative components of crank-motion are very often taken up in a slide-block working in a rectangular opening made in the plunger, with arrangements to take up wear. Other plans use a short connecting-rod with wide bearings.

Below the punch is the abutment or die for the support of work. This is made of a diameter larger than that of the punch by two-tenths of the thickness of metal operated upon. This causes the punched hole to be tapering, but makes the extrusion of the blank more easy, and probably for that reason distresses the plate less. The cutting-edge only acts to sever the fibers for a very short distance. Below that it is the compressed metal of the work which acts to shear, and as this naturally widens as it goes down, the blank forced through is conical in shape.

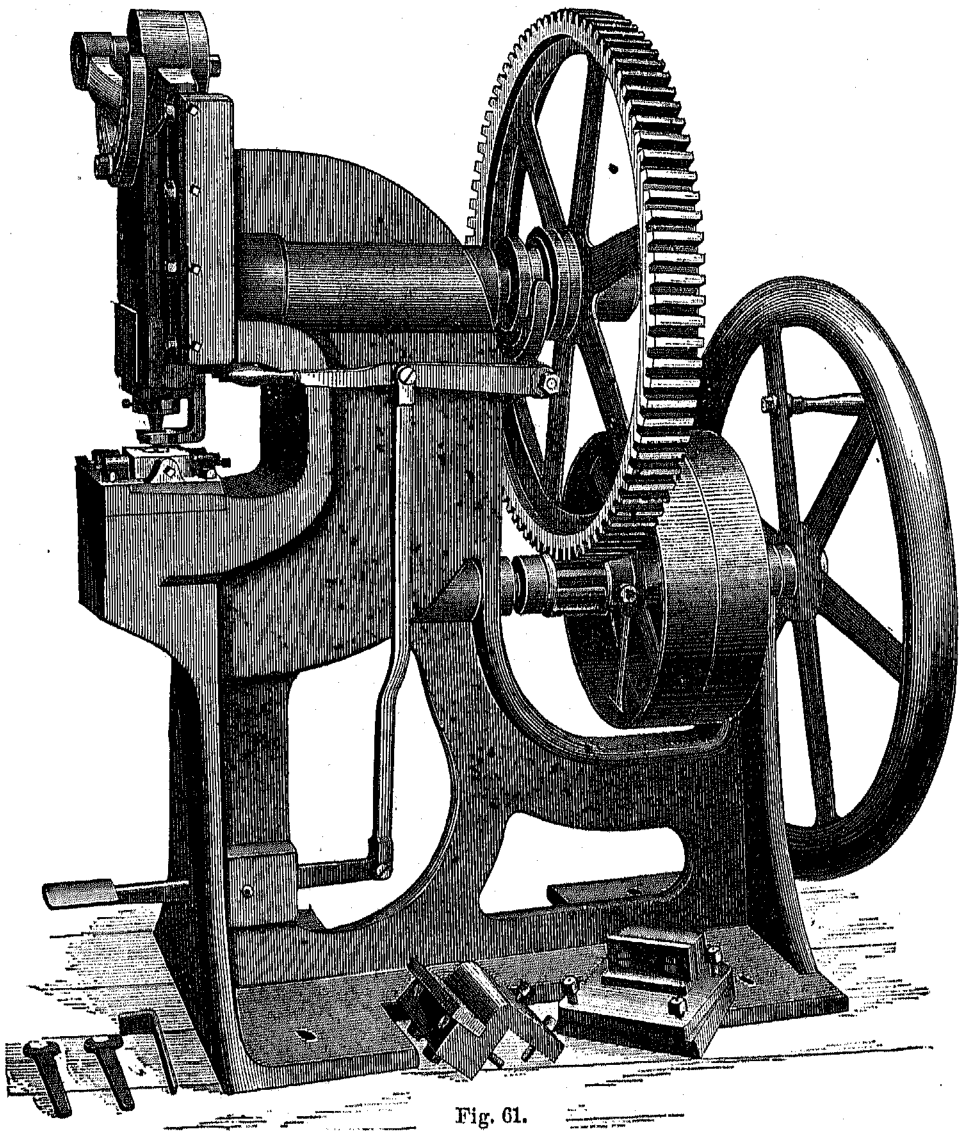


Fig. 61.

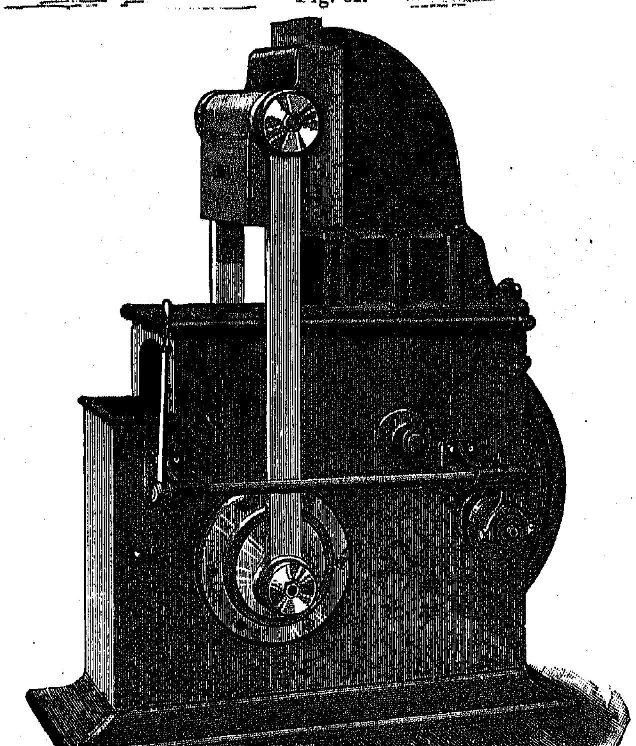


Fig. 62.

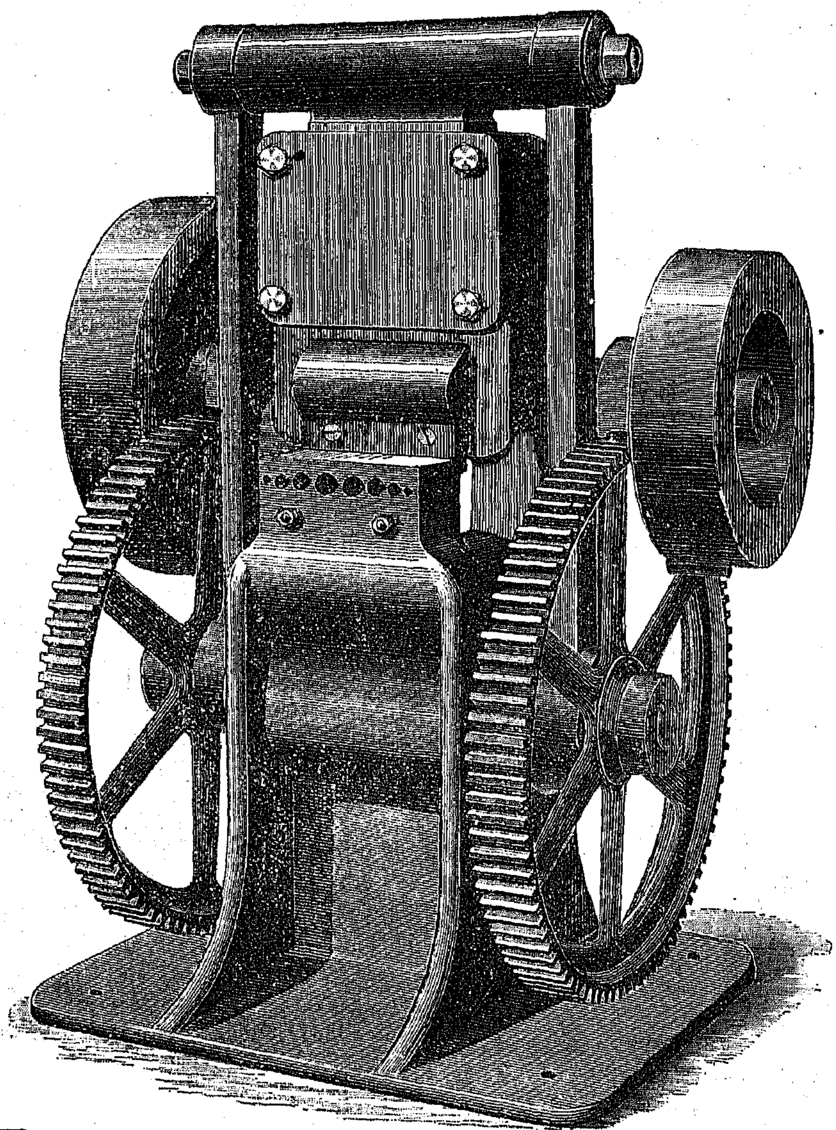


Fig. 63.

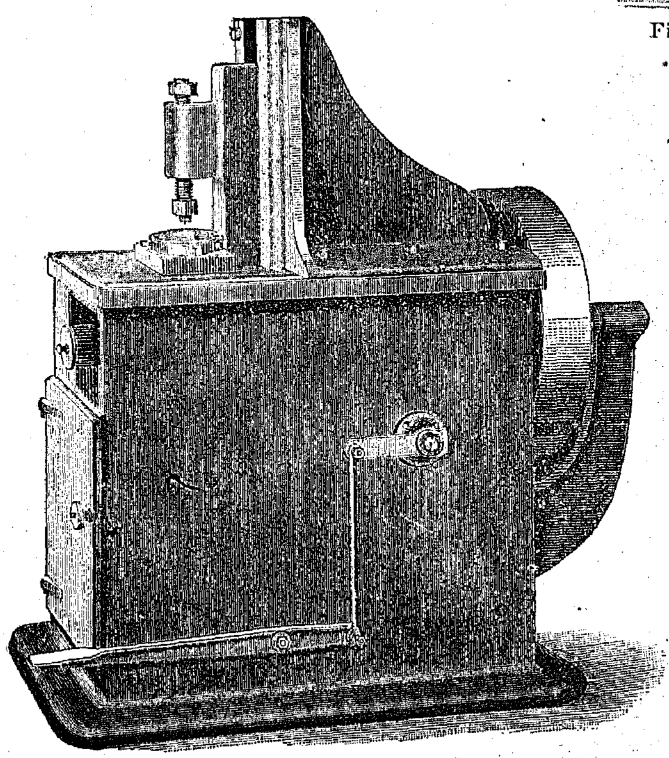


Fig. 64.

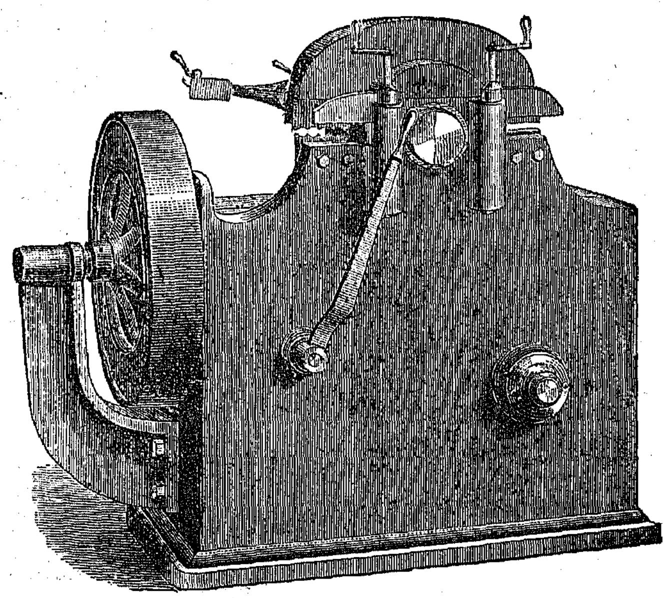


Fig. 65.

Should this conical frustum meet an abutment with a hole in it no larger than its smaller base, extra power would be required to shear this cone into a cylinder so as to fall through the hole. The abutments for shears are of a shape suited to their work. For round bars the blades should be shaped to segments of circles to take them in, else the sheared ends will be bruised and flattened when the cutting force comes upon a fraction only of the projected area of the bar. Strippers or "take-offs" are frequently applied to prevent the rise of the plate with the punch. They are adjustable vertically for different thicknesses of work. Figs. 55 and 56 illustrate the modern form of lever-punch and shear. The punch is put at the very front of the machine, which is made narrow so as not to obstruct the view. The die-seat is cut away like the horn of an anvil to enable flanged work to be handled. The holes can be punched to within one inch of the corner. In the shears the tools are fitted upon interchangeable loose blocks so that they may be converted from one use to the other, or may be adapted for any required shape. For plate the

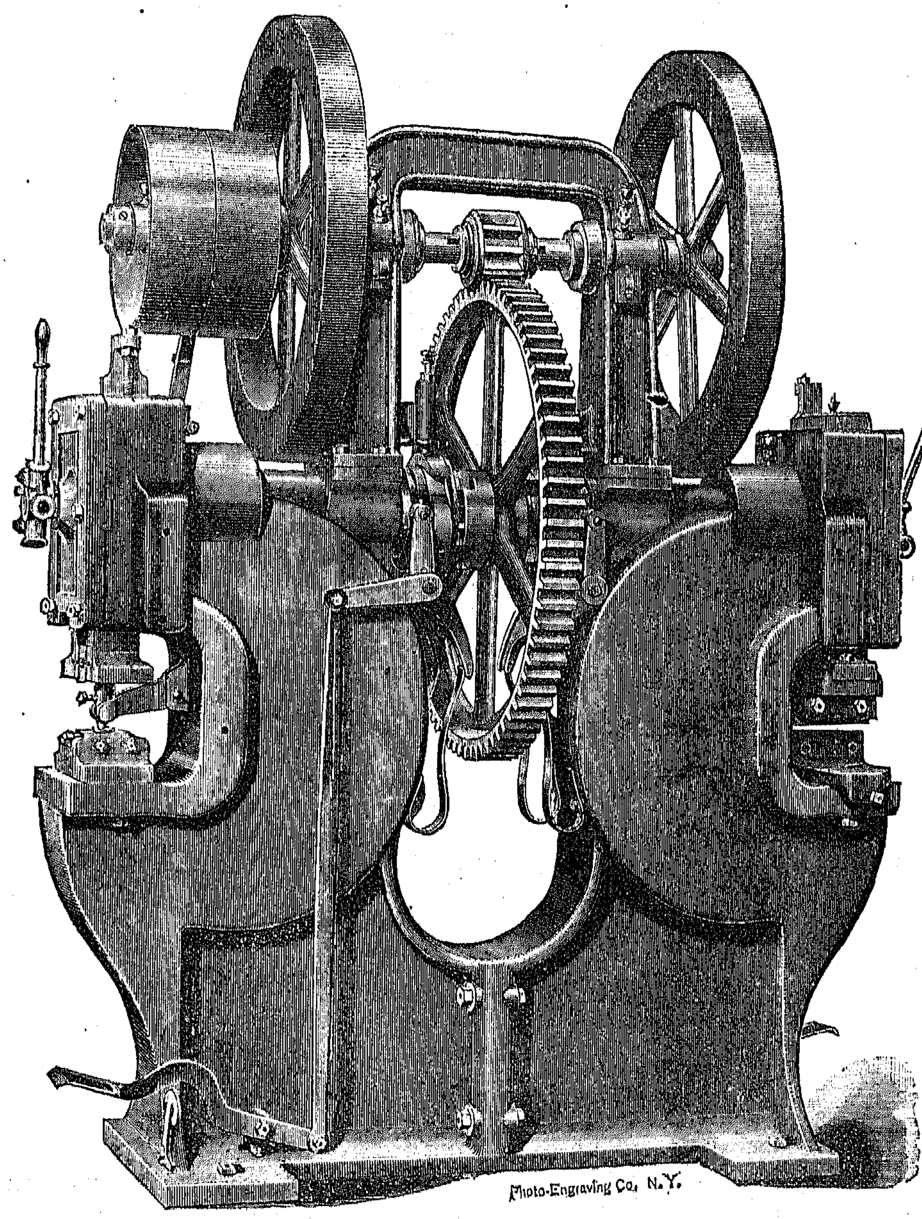


Fig. 66.

shear-blades are usually at right angles to the long axis of the frame; for bars they are parallel to it. When the plungers are guided internally the front and sides of it are left free, and proper tools can be secured to either front or sides, according to their service. By this system also the dies and blocks can be adjusted as they wear or are ground, and punches for cutting at desired intervals may be applied by adapting special blocks to hold them.

Shears for angle-iron are shown by Figs. 57 and 58, and one for bar iron by Fig. 59. The latter is arranged with its fulcrum upon an eccentric-ring, adjustable through the milled head, by which the position of the plunger at its highest point is made variable. A similar limitation may be effected by cushioning the fall of the long end of the lever. This rests upon a block of hard wood, and a thicker block permits less height of rise.

A type of light crank-punch, with connecting-rod and adjustable rise, is shown by Fig. 60. The crank-pin is carried in an eccentric-ring, to whose face the connecting-rod is fitted. By turning this ring in the connecting-rod the effective length from crank-pin to punch-face may be varied by the eccentricity of the ring. A large size of a different design of a similar machine is shown by Fig 61.

For heavy punching of shapes from small work the type of double-connection crank-press (Figs. 62 and 63) has been introduced. The gearing is inside the hollow base and is engaged by a friction-clutch. Such a machine is capable of overcoming a resistance of 200 tons. The two connecting-rods distribute the reaction and the wear.

In the broaching-press of Fig. 64 the plunger is worked by connecting-rod from a crank upon a worm-wheel shaft. The worm turns in a pan of oil.

In the shear for flats and rounds (Fig. 65) the principle of the lever is introduced. The cutter-head is of T-shape, the center of motion being between the jaws. To the lower end of the T in the housing is attached a rod from an eccentric which is part of a worm-wheel. This wheel is driven by a worm upon the driving-shaft. This

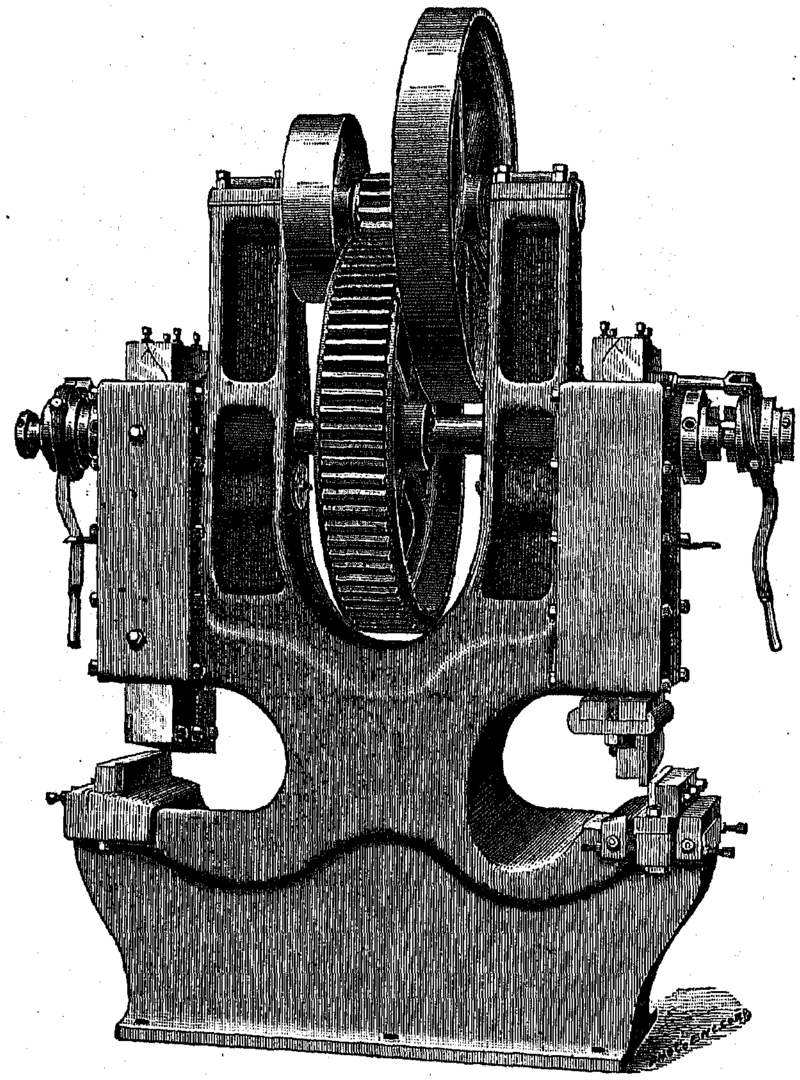


Fig. 67.

combination of screw, crank, and lever gives a compact machine of great power. By it round iron may be sheared of 3 inches diameter and flats of 1½ inches in thickness. The old styles of "alligator" shear, where the cutting-edge is on the lever itself, is not often made for large work. Its cut is weakest at the end of its stroke when the greatest length of edge is in action.

Double machines are very much used. They have the capacity each of separate machines and take less room and power than two. Figs. 66, 67, 68, 69, and 70 show types of these. Fig. 66 shows an independent stop-motion for throwing out the clutches when the plungers are up. The forked bent lever, moving the clutch, is acted upon by the bent spring to disengage the clutch whenever the latter is released. When the treadle is depressed by the foot the clutch is engaged and this spring is compressed. When the clutch is closed the cased spiral spring above the clutch forces down a vertical roller to bear against a ridge on the clutch and keep the two halves together. This ridge is broken opposite the part of the clutch corresponding to the top of the stroke, and as soon as that

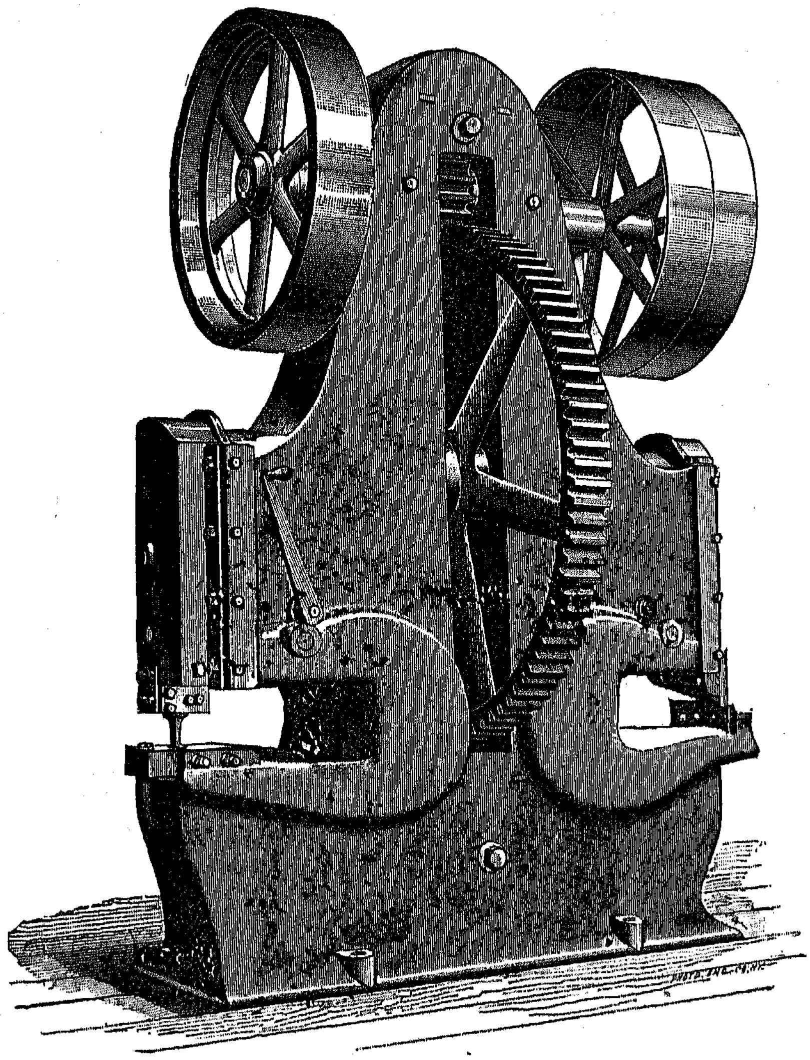


Fig. 68.

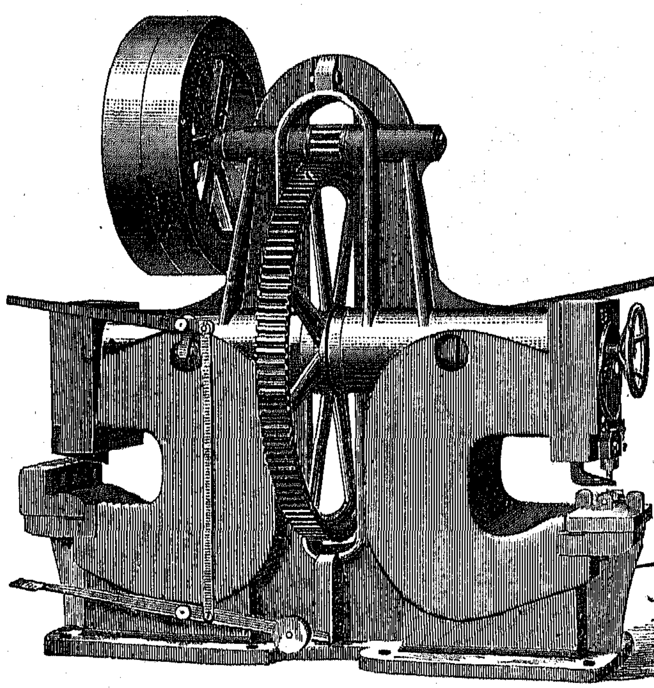


Fig. 69.

part is reached in the revolution, the treadle-spring throws out the jaws, since the vertical roller no longer holds. In Fig. 69 the fly-wheel weight is put in the belt-wheel, effecting a saving of cost of manufacture of the tool.

The same cut shows the hand-gear for bringing the punch down upon the work. These double machines are made so that either side can be worked without the other, or both at once. Often the shear side works continuously, as less time is usually required to adjust the shearing line than the circle for the punch. For reasons of compactness, these double tools are crank-machines.

For taking very long and exact cuts upon girder or ship-plate, the work should be held in place. It must also be possible to arrest a cut at a given point with accuracy. To accomplish these results the machine of Fig. 71 has been designed. The shear-blade is secured to a slide, guided vertically by the sides of the frame. Motion is given

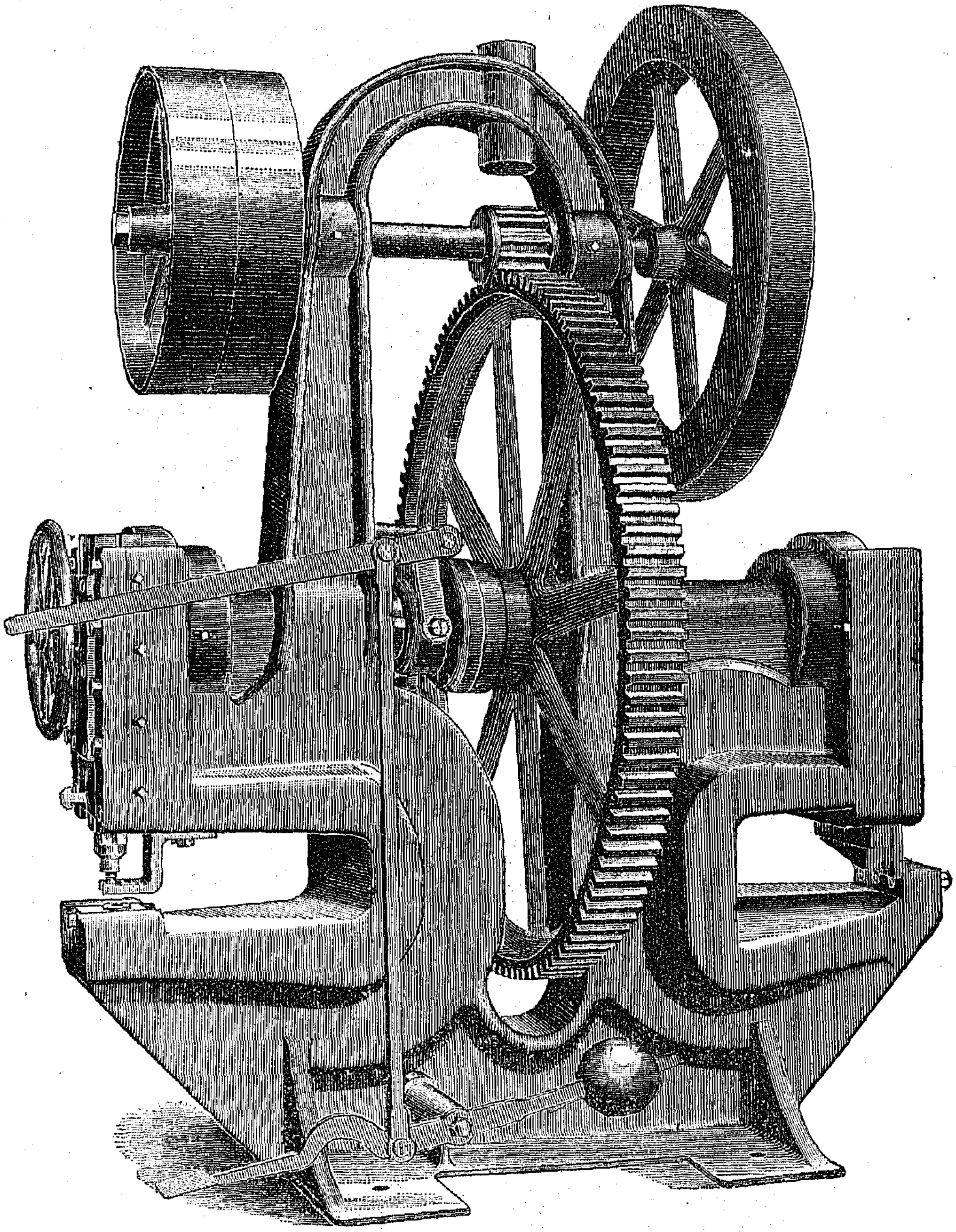


Fig. 70.

to this slide through a long solid pitman making contact-joints with the slide and the bent lever which drives it. The contact is maintained on the up-stroke by the tension-links which pass through the pitman. The driving-lever is hinged at the top of the frame, and the long end carries a toothed sector which is driven by a worm of four threads. This worm receives its motion through the pair of bevel-wheels from a belt-wheel combination of one fast and two loose pulleys with open and crossed belts. The belts can be shifted by hand, or automatically by the slide itself. The shifters can be moved by adjustable chocks. By making the overhead pulleys of different

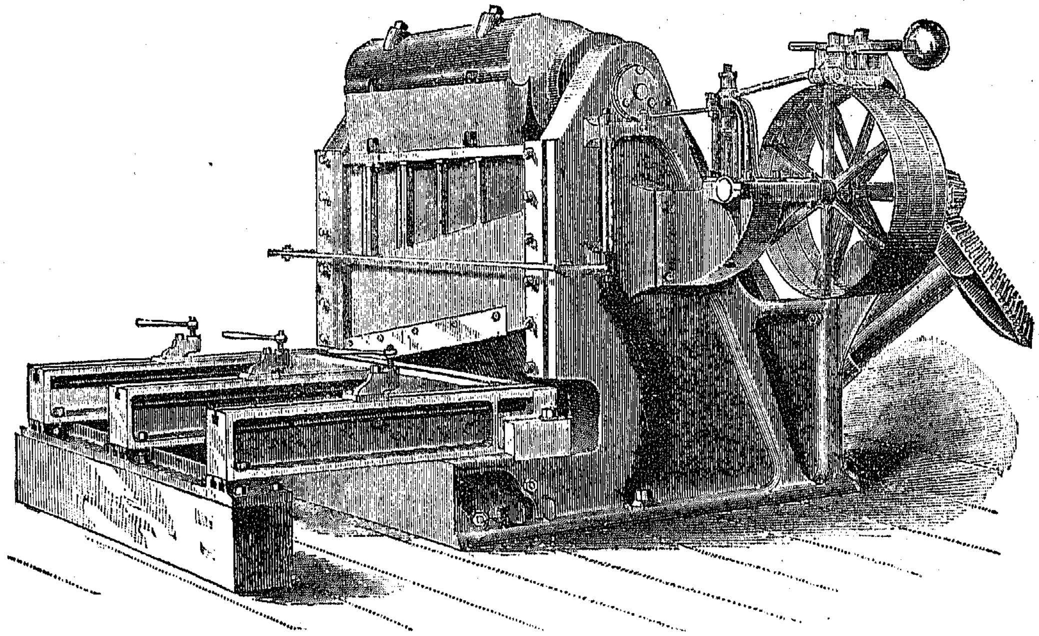


Fig. 71.

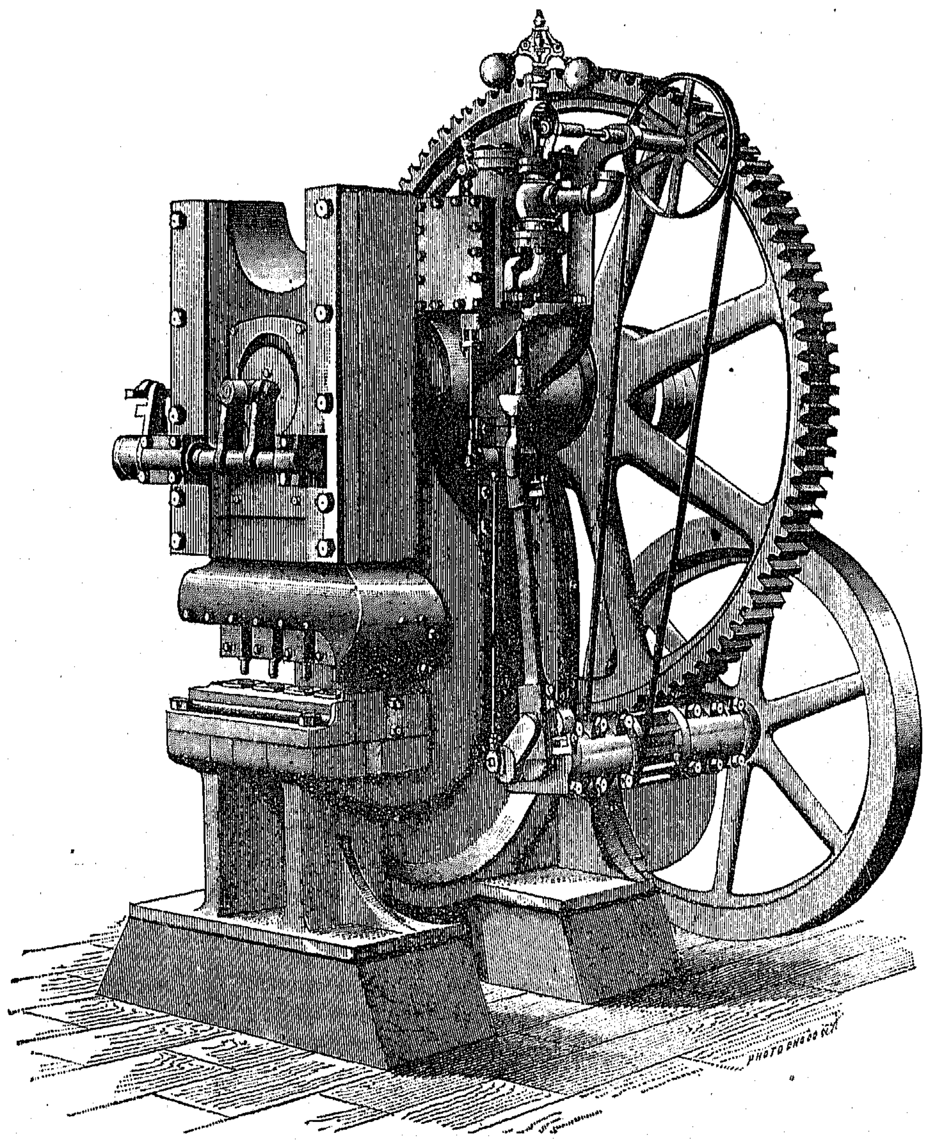


Fig. 72.

diameters, the up-stroke can be made to be more rapid than the cutting-stroke. The slide stays up until the plate is set and clamped for the next cut. The shearing-blade is here entirely under the control of the operator in every part of its stroke. Curved blades and a curved abutment may be applied with great ease for ship-work.

The wide front of the slide makes it very easy to secure special tool-blocks for multiple punching, or for punching in variable series, as in top and bottom chord webs in riveted girder-work. A combination holder may punch several spaced holes and shear the oblique end of a diagonal brace at one stroke. This can also be done on most punches with free plungers.

A crank-press of similar capacity is driven by three wrought-iron eccentrics, working upon cast-iron slide-blocks in yokes. The yokes take up wear at the pillar-bolts at the ends. The clamping-gear for the plate is automatic, being effected by a cam acting against an elbow-joint. The clutch is disengaged by a roller and side cam as in the design of Fig. 66.

Figs. 72 and 73 show two arrangements of the tools which are driven directly by steam in a cylinder which is part of themselves.

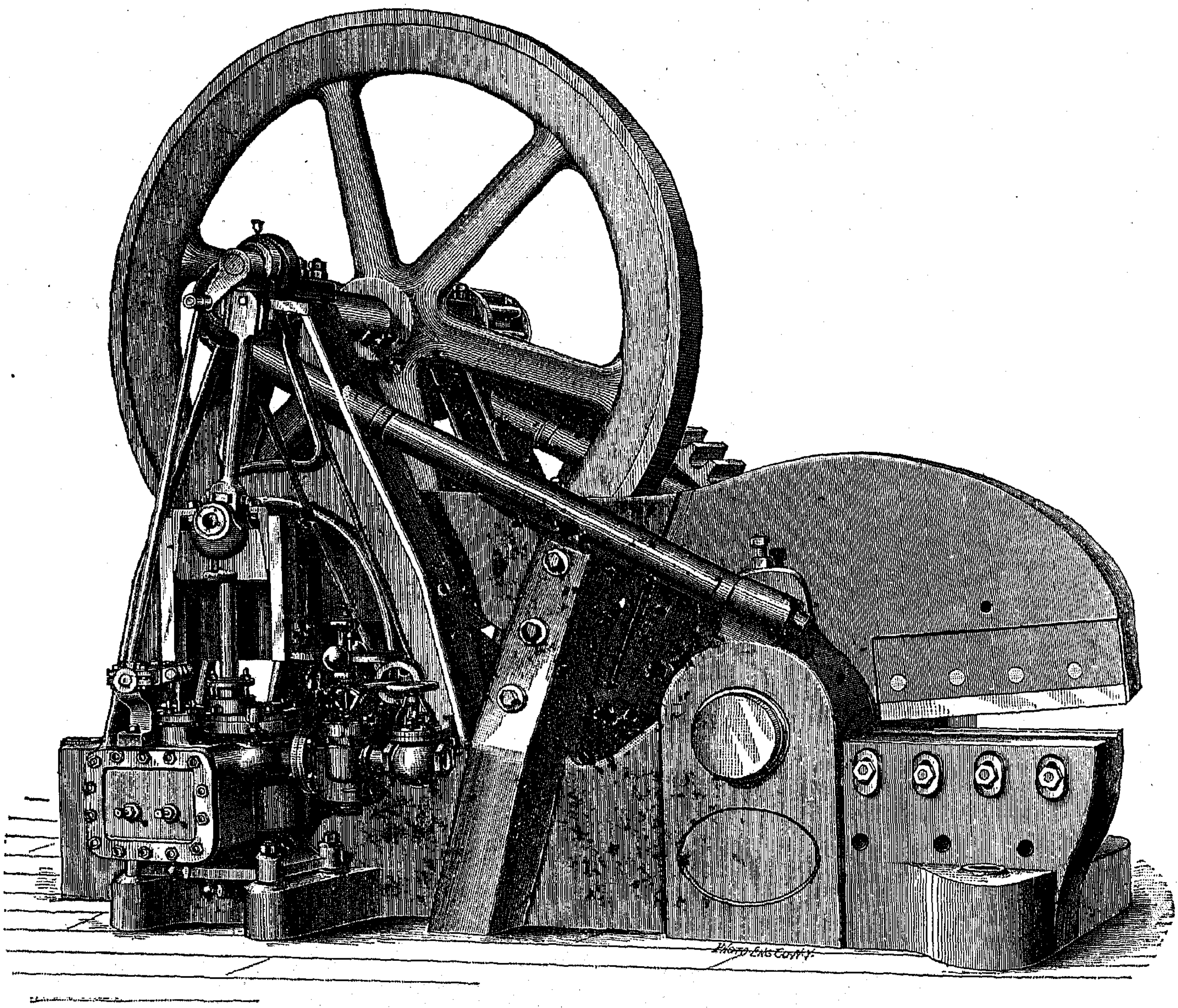


Fig. 73.

Allusion should also be made to the punches and shears which are worked directly by fluid pressure upon a piston or plunger which carries the shearing-plane at its outer end. They are not extensively in use at present, but would find their application in works which were provided with excess of hydraulic power, or in which shaft transmissions would be inconvenient.

Great economy of time in punching results from the use of spacing-tables or similar gauging devices by which the holes can be made equidistant. Without these the holes must be laid out with templet, and the plates may not be presented to the punch directly at the mark. In either case marking and adjusting to the mark take longer than the actual perforation. These tables are carriages running transversely to the machine and arranged with a rack and different pinions, or a screw and change wheels or some other device for producing exact reproduction of standard units (Fig. 74). With such devices and multiple punches two men can cut one thousand holes per hour.

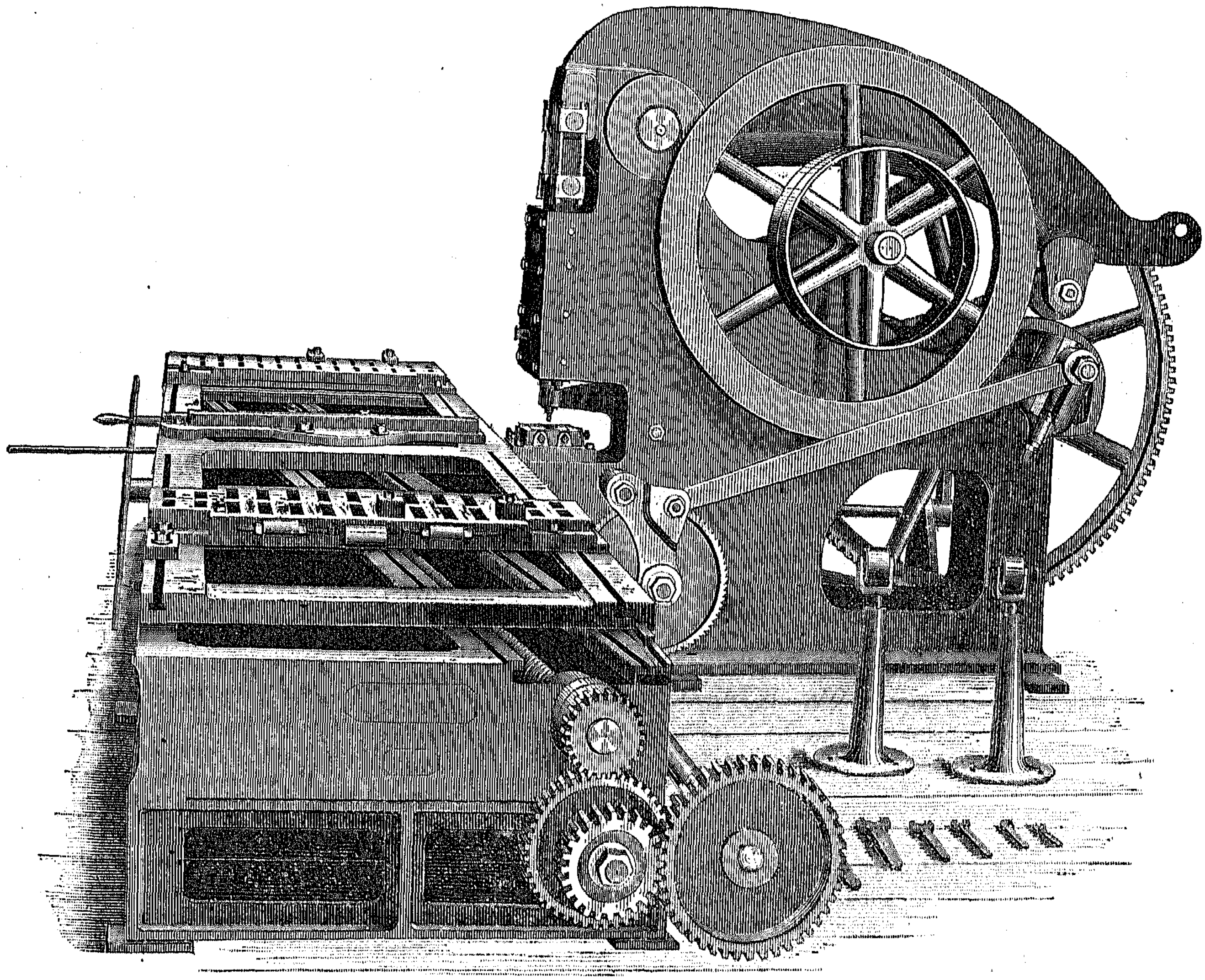


Fig. 74.

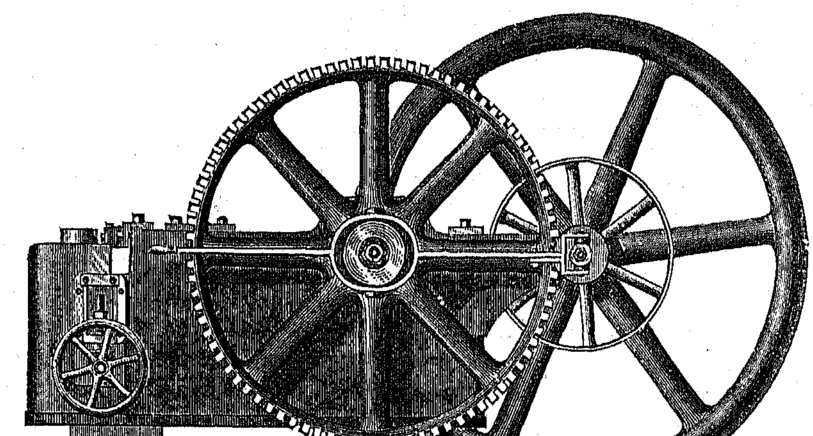


Fig. 75.

These devices can make the proper allowance for the different circumferences of outer and inner sheets in cylindrical boilers. Horizontal punches for flanged boiler-heads or fire-boxes or for angle- or tee-iron are also in use. They are called for because of the special limitations imposed by some shapes. Fig. 75 illustrates one type of such tools.

In limited use is also a type of shear for boiler-plate, the plane of whose stroke is oblique to the horizon. The idea of this is to shear the edge of the plate upon a bevel and remove the necessity of edge-planers to make ready the sheet for caulking.

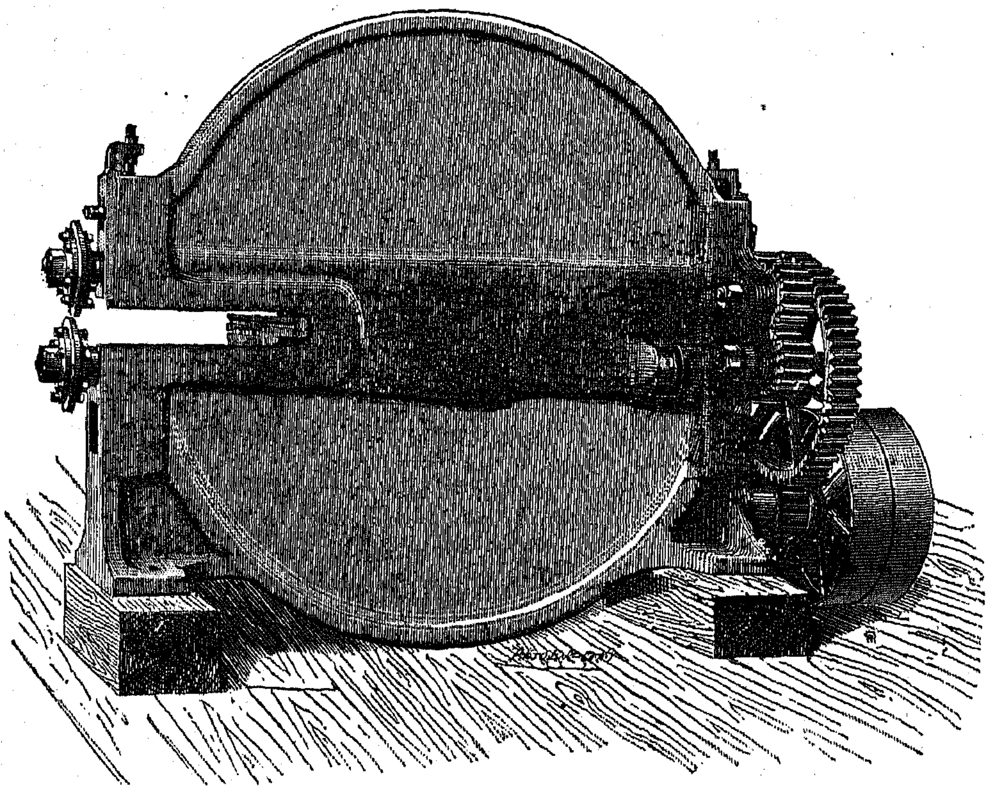


Fig. 76.

In the class of rotary shears but few large examples are seen. Two disks of steel slightly beveled and over-lapping are driven by power, and the plate to be sheared is fed against their point of contact. The disks can be brought together as they wear, both being driven by expansion gear linked to the spindles of the cutters, and can be set axially for different spaces at the cutting-point. They meet their chief application for light iron or other sheet-metal work, since they will cut a curved line. The disadvantage for heavier plate is that the knives grow jagged and chatter and mar the work. They are not very extensively in use at this date.

Fig. 76 gives an illustration of one design for large work, up to ⅝ of an inch thick.

Punches and shearing-presses are extensively used in drop-forging work for trimming or broaching the work after leaving the dies. They are also used to produce a cold-press finish upon pieces which would otherwise have to be milled. The double-connection presses are used for this class of work. In the sheet-metal presses, and in those used for the manufacture of drawn goods, shearing is also done, but these tools are beyond the province of this discussion. These tools belong either to the crank class or to a special class of roller-cam presses.

§ 15.

C.—TOOLS ACTING BY PARING.

To this class belongs the majority of the tools of the finishing- or fitting-shop. It includes all those in which the desired figure is produced at the working point by the scraping or cutting action of a wedge-pointed tool. Since they act upon the cold metal and remove relatively small amounts of material in the cut, these tools are much better adapted for working to exact dimensions than those acting by compression or shearing. They can also produce an ornamental finish upon the material which they shape. These features adapt them for the needs of the shop from which the completed work is to be delivered.

Paring-tools belong to two classes. The first includes those in which the relative motion of tool and work is circular or spiral. These can only produce surfaces of revolution, and include lathes, drills, and boring-machines. The second class includes those in which the relative motion of tool and work is rectilinear. These will produce plain surfaces by planers, shapers, and slotters, and also curved surfaces made up of straight line elements by the two latter tools.

The greater part of revolving machinery is made up of surfaces of revolution. The cylinder of these is by far the most important. The lathe will therefore be discussed first.