CHAPTER XXXIII.

COMMON MILLS—THEIR USES AND OUTPUTS.

I. SECTION MILLS.

Cogging.—The largest and strongest mills in any steel works are the cogging mills, which are intended to reduce heavy ingots to sections which can be dealt with satisfactorily by the smaller finishing mills.

When the ingot has been reduced to dimensions of 6 inches square or more, it is called a "bloom;" if flat, a "slab;" and if to a rough block of almost any shape to be worked up in a smith's shop into small forgings, it is termed a "use." If between 6 inches and $1\frac{1}{4}$ inches square, and cut into lengths ready to be reheated and rolled out in small mills, the resulting bars are known as "billets."

Before the introduction of cogging mills the largest mills in existence were those employed for rolling iron rails, having rolls 24 to 26 inches in diameter. Even when these mills were strong enough, they lacked size for dealing properly with ingots more than 10 or 12 inches square, while most works possessed no mills with rolls more than 18 to 20 inches in diameter, limiting the size of the ingot to 7 or 9 inches square at most. As an ingot at least 10 inches on the side was needed to form a rail 10 yards long, and weighing 65 lbs. per yard (which was the standard rail at the time), some method of reducing the ingot sufficiently before putting it into the mills had to be provided; this preliminary reduction was called "cogging."

Cogging by Hammer.—When the manufacture of Bessemer steel began, steam hammers were just beginning to replace the old-fashioned helves for shingling the puddled balls in the iron works, and steam hammers were naturally employed for reducing the ingots of the new metal to a size suitable for rolling down in the mills.

So long as the ingots were of small size steam hammers answered the purpose perfectly, as the weight of the hammer was generally sufficient to ensure that the effect of the blow would penetrate to the centre of the mass, but to deal with the heavy ingots in use to-day the hammers would have to be of very great size, or the centre of the mass would not be properly worked. If good work is to be ensured, the falling weight should, even for working moderate-sized ingots, be 10 or 15 times the weight of the ingot, and this proportion should be increased as the ingot gets heavier, a proportion seldom obtainable in practice.

In a single-acting hammer the weight is lifted by the force of the steam admitted below the piston, which falls freely when the steam is released; but in a double-acting hammer the force of the steam is also employed to drive the hammer head downwards; practically all steam hammers, with the exception of a few very large ones, are now double-acting. No account is taken of the additional impetus, however considerable, which the steam may impart; an "eight-ton hammer," the size most frequently employed for cogging, means one in which the total weight of the falling parts amounts to 8 tons. Fig. 463 shows the type of hammer which was most frequently employed in this country for cogging ingots. The lower part of the framing

is formed of steel plates and angles rivetted together, while the upper portion is made of cast iron, and passes down between the plates forming the horizontal girder to act as guides for the tup, which is made of either cast

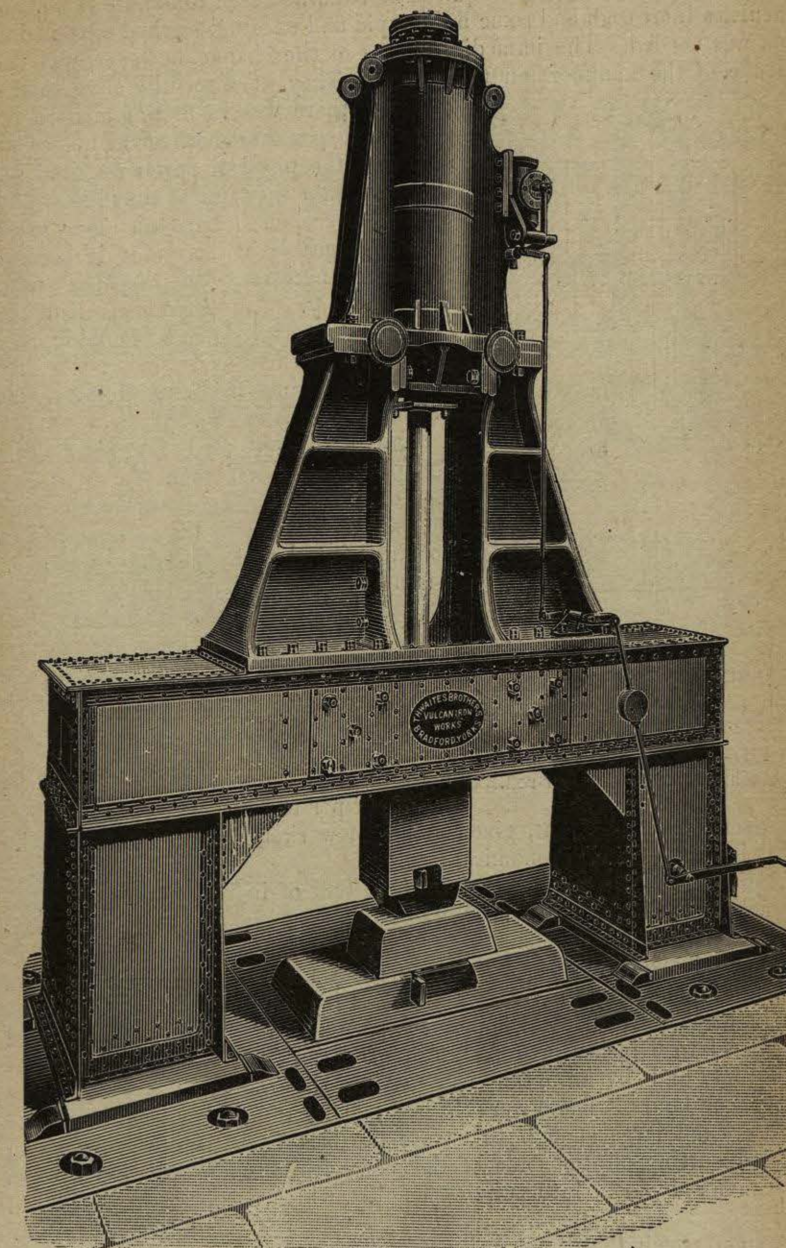

Fig. 463.—Cogging Hammer.

iron or cast steel, and is secured to the head of the piston-rod by means of a ball and socket joint (fig. 464), to allow of the slight play between the two which is found necessary to prevent the breaking of the piston-rod.

The cylinder for an 8-ton hammer is 32 inches in diameter, and the hammer-head has a fall of 6 feet 6 inches.

The practice of hammering the ingots was continued for a long time, but as they became heavier, and required more skilled men to handle them, the difficulties increased, and some more rapid and effectual method of reducing them was needed. The immediate cause of the change, however, was the attitude of the hammermen themselves. They were so fully alive to the difficulty there was in finding men to replace them, possessed both of the necessary skill and the physical power required for the work, that they did as they liked, and worked only when so disposed. They grew so unmanageable at last that it became absolutely necessary to dispense with them entirely. The Americans had led the way by putting down a blooming mill at Cambria as early as 1871, but the first mill of the kind in Great Britain was started at Blochairn in 1884.

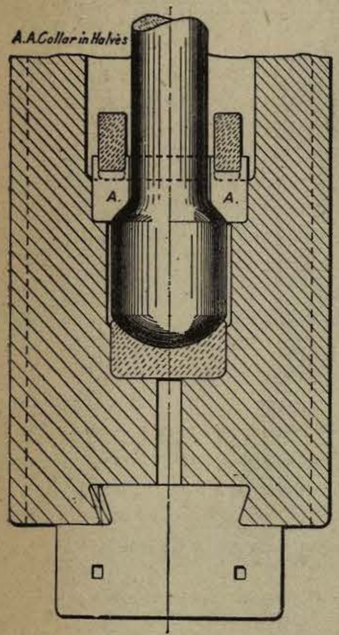

Fig. 464.—Ball and Socket Joints for attaching Tup to Hammer-rod.

The Hammer and Cogging Mill Compared.—It was soon found, as had been expected, that there was considerable economy obtainable by the new method of working, for though the first cost of a cogging mill is so much greater than that of a steam hammer, that it does not pay to adopt it unless at least 150 to 200 tons of ingots are cast each day in the melting shop, yet its output is very much more in proportion to its cost; while the number of men employed, the consumption of steam, and the wear and tear of the machinery per ton of material treated are all so very much less that, given sufficient work to keep it occupied, the mill is by far the more economical tool.

A 6-ton hammer has reduced 60 to 80 tons of ingots, weighing about a ton each, to a size suitable for rolling down in a 22-inch mill every twenty-four hours, and a 12-ton hammer dealing with ingots about twice the weight has reduced about 100 to 120 tons in the same time for rolling off in a 28-inch mill; but by providing ample heating furnaces, and working the men in three shifts of eight hours each per day, 13- to 15-cwt. ingots could be reduced to 6 inches or 7 inches square by a 4-ton hammer at the rate of 90 tons, and by an 8-ton hammer at the rate of 135 tons, every twenty-four hours. These were the sizes of hammers commonly used, and they were not large enough to ensure the best results. The hammering included cutting off the ends of the bar with a knife, and cutting up the hammered bloom into suitable lengths, which a mill, of course, could not do.

A small cogging mill will easily reduce 300 tons of 15- or 20-cwt. ingots in twenty-four hours with about the same number of men, and using little more steam than the hammers, while a larger mill will deal with 600 tons of ingots in the same time with comparatively simple handling appliances, and the same mill, if fitted with good live roller gear and turnover appliances, can do about double this with less men than are required for a small hammer. Some of the most recent mills will turn out 60 tons per hour, whereas the 6-ton hammers required twenty-four hours to do the same work, starting with smaller ingots.

There is much less difficulty in training men to work at the mill than at the hammer, at which they must all work together with considerable method and regularity. The labour cost at a cogging mill when worked up to anything like its full capacity is remarkably small.

For a long time fierce discussions raged as to whether the hammer or the cogging mill produced the better work. The advocates of the hammer declared that the rolls were apt to tear the surface of the bloom and start flaws; where very small mills were used, so that there was too great a difference in the peripheral speed of different parts of the roll, there was some force in the objection. In any mill, if the ingots are too hot, or the material red short, a certain amount of humouring is advisable when the ingot is first inserted, but the increase in the diameter of the rolls has removed most of the objection on this score.

The advocates of the mill, on the other hand, contended that the action of the hammer was very superficial, and that while the outside of the ingot might be properly treated, the interior of the mass might be little affected, impact being so transitory that the work done was confined to the surface, and there spent before it could be transmitted to the centre. If the falling weights were small and the velocity great, the action would be almost entirely local, while the more deliberate squeezing action of the rolls made it certain that the pressure was transmitted to the very centre of the mass, a contention which obviously gained force as the ingots became larger.

It is now agreed with practical unanimity that, on moderate sized ingots, as good work may be done by the one method as by the other, while, for heavy ingots, the mill gives better results, and that any superiority in hammered blooms of moderate size is really due to the fact that they are carefully examined, and any surface defects cut out before finishing, while the rolled blooms are run through the mill at too great a speed to permit of the exercise of the same careful inspection. For this reason blooms ordered as "uses" to be worked up abroad are often specified to be hammered, and, as they command a rather higher price, the best ingots are selected for this purpose.

The rolls, exerting a steady continuous squeeze, employ power much more economically than the steam hammer, the action of which is brief and intermittent, while much of its power is wasted in causing vibrations of the surrounding premises. This alone would make it impracticable to employ a hammer of power sufficient to deal with the heavy ingots now made; but the great saving in the cost of labour, and the greater facility with which men can be trained to operate a mill, and its large output, have been the chief factors in determining the almost universal adoption of the cogging mill, even in works where hammers had been already installed. The hammers are now relegated to the making of forgings, or the hammering and punching of tire ingots, which cannot be treated in the tire mill until a hole has been drifted through them, and the ingot roughed out to a form bearing some resemblance to the finished tire.

Size of Cogging Mills.—As the size of the ingots has increased, so necessarily have the rolls of the cogging mills intended to deal with them also increased in diameter. It is seldom that ingots less than 12 to 14 inches square, and weighing less than 15 cwts. each, are cast in present practice, and to deal with such ingots 28- or 30-inch cogging mills are the smallest which can be recommended. Most cogging mills now constructed have rolls about 42 to 45 inches diameter, and are intended to deal with ingots of from 20 to 22 inches square, weighing 2 to 4 tons each, while there are mills having rolls as much as 48 inches in diameter, but it is doubtful if mills of such excessive dimensions give any adequate return for the great increase in their first cost.

A 28-inch mill will cog down 500 tons of ingots in twenty-four hours, but what the capacity of a 42-inch mill is has probably never been really tested, as the melting shops cannot supply ingots enough to keep them fully occupied. Such large mills have cogged down 1,000, 1,500, and even 2,000 tons of ingots in twenty-four hours, and many could do more were sufficient heating furnaces provided to work them up to their full capacity.

As considerable power is required, while the lengths to be dealt with are small, the speed of revolution of the rolls is not important, hence cogging mills are geared to the engines by heavy toothed wheels, which, by enabling the engines to make from $2\frac{1}{4}$ to 3 revolutions for 1 revolution of the rolls, add considerably to their power; ratios as low as $1\frac{3}{4}$ to 1 are occasionally employed, while at the Homestead Works a 38-inch mill is coupled direct to the engine. The engines driving the rolls have cylinders generally from 36 to 50 inches in diameter by 5 to 6 feet stroke, cylinders as large as 60 inches in diameter being rarely employed.

Fig. 465, Plate xl., shows a large cogging mill recently constructed by the Duisburger Maschinenbau Actien-gesellschaft for the Société Métallurgique de l'Oural Volga in Russia, the drawings being taken from the *Iron and Coal Trades Review*.

The rolls are 46 inches in diameter by 10 feet long in the barrel, with necks $19\frac{1}{2}$ inches in diameter by 22 inches long, and the upper roll is provided with a hydraulic balance, the screwing gear being also worked by a hydraulic cylinder driving a rack actuating pinions on the screws. The housing pinions are 48 inches diameter. The mill is driven by a pair of reversing engines having cylinders 40 inches diameter by 52 inches stroke, intended to make 150 to 160 revolutions per minute. The gearing between the engines and mill is in the proportion of 3 to 1, so that the mill makes about 50 revolutions per minute.

Of the live rollers at back and front, three next to the main rolls are of different diameters, in different parts, to correspond with the depth of the passes in the mill rolls.

The ingot turning gear, fitted under the roller-bed in front of the mill, is driven by hydraulic power, and consists of a bogie, which when moved laterally, can transfer the ingot from one pass to another in the rolls, while the second cylinder gives the vertical movement to the three tappets by means of which the ingot is turned over. The bevel pinion which works this turnover gear slides on the shaft, which is provided with four feathers, and is thus able to actuate the other pinion when the bogie is in any position. In addition to the five rollers at front and back of the mill there are a few shorter ones opposite the last passes, where the ingot has a much greater length than it possessed when the rolling began. The ingot is led from the tilter down a few rollers placed on an incline, on to the horizontal roller-bed, and power-driven rollers on the other side take the cogged billet to the hydraulic shears, which, with a pressure of 200 atmospheres, can cut blooms up to 12 inches square. All the live rollers can be driven in either direction by an electric motor of 45 H.P., toothed gearing being employed to reduce the speed of the motor down to that needed for the rollers, and a second motor of the same size drives the rollers behind the mill, while for the rollers carrying the bloom to the shears there is a special motor of 30 H.P.

Fig. 466, Plate xli., shows a 36-inch three-high American cogging mill as made by Messrs. Mackintosh, Hemphill & Co., of Pittsburg, for several

versing Cogging Mill. [To face p. 746.

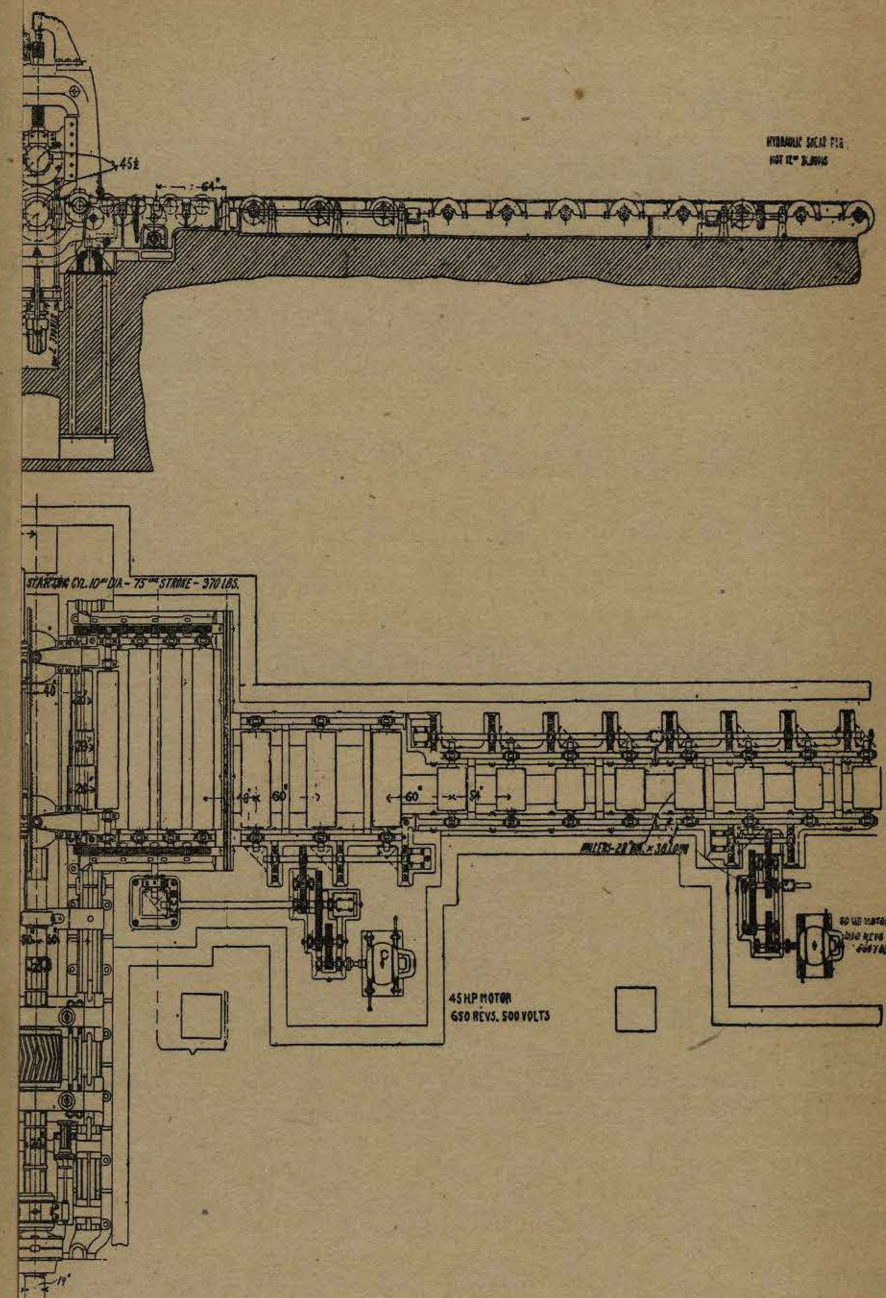

Fig. 465.

PLATE XL.—Reversing Cogging Mill.

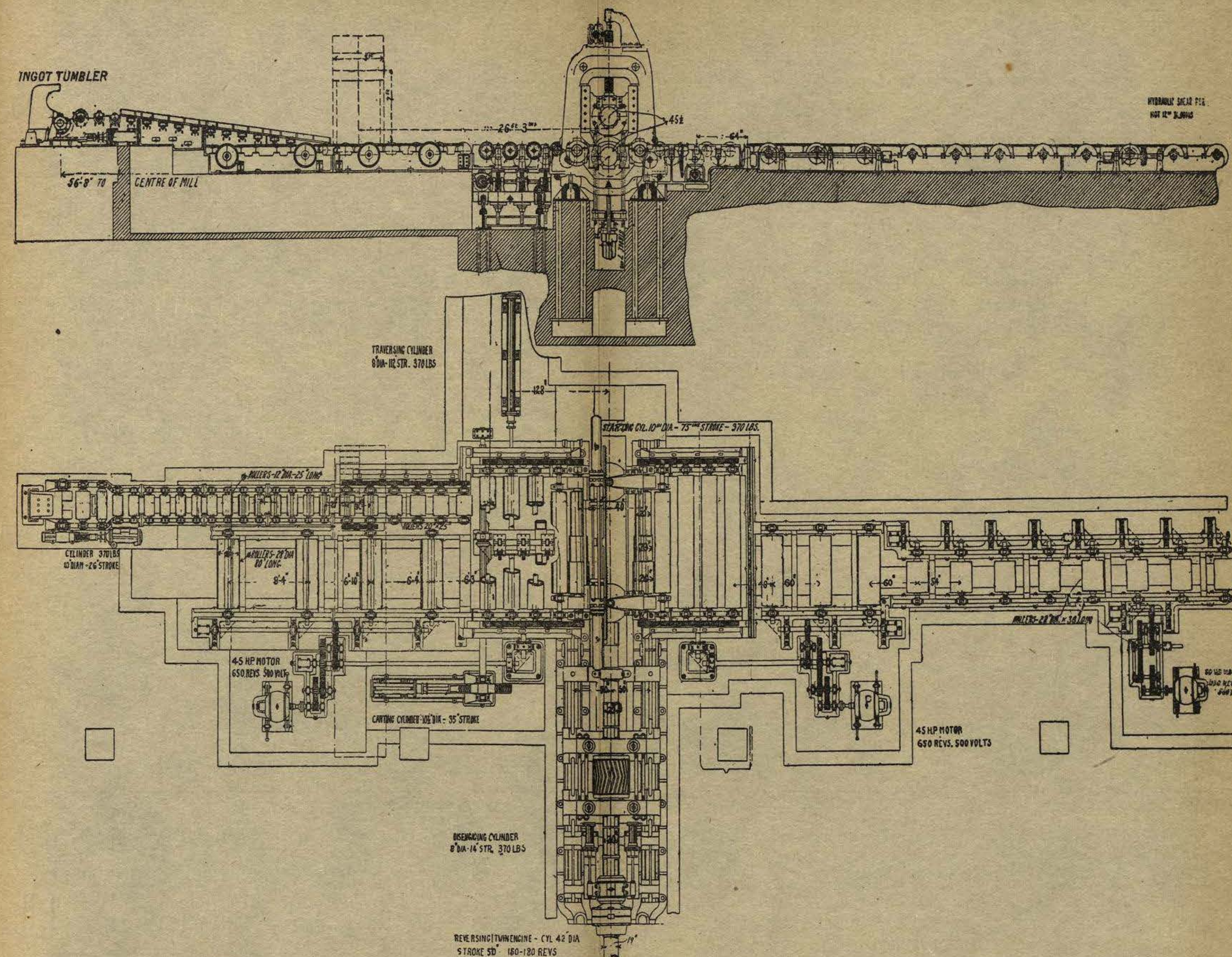

Fig. 465.

e-high Mill, with 36-inch Rolls. [To face p. 746.

Side Elevation.

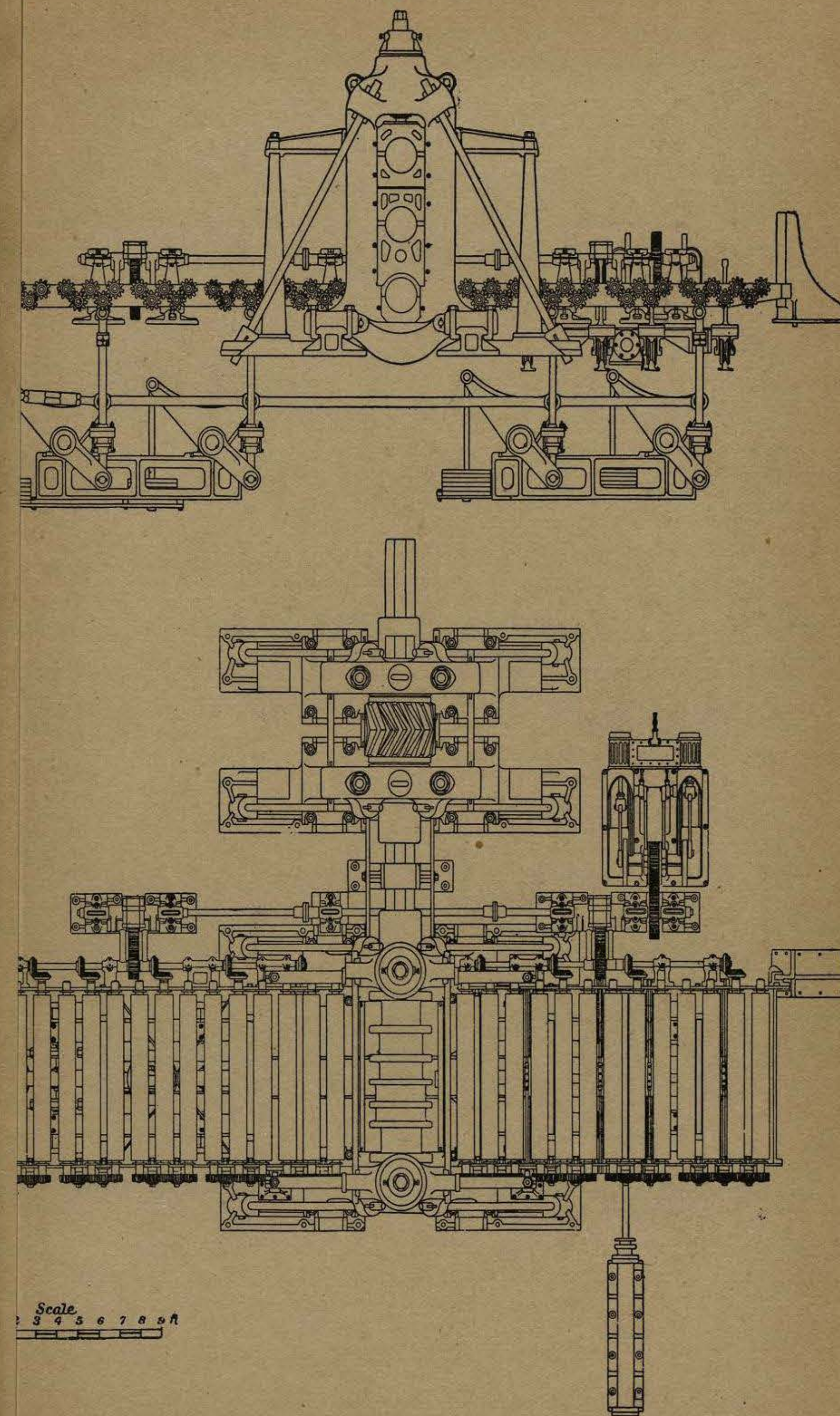

Fig. 466. *Plan.*

PLATE XLI.—American Three-high Mill, with 36-inch Rolls. [To face p. 746.

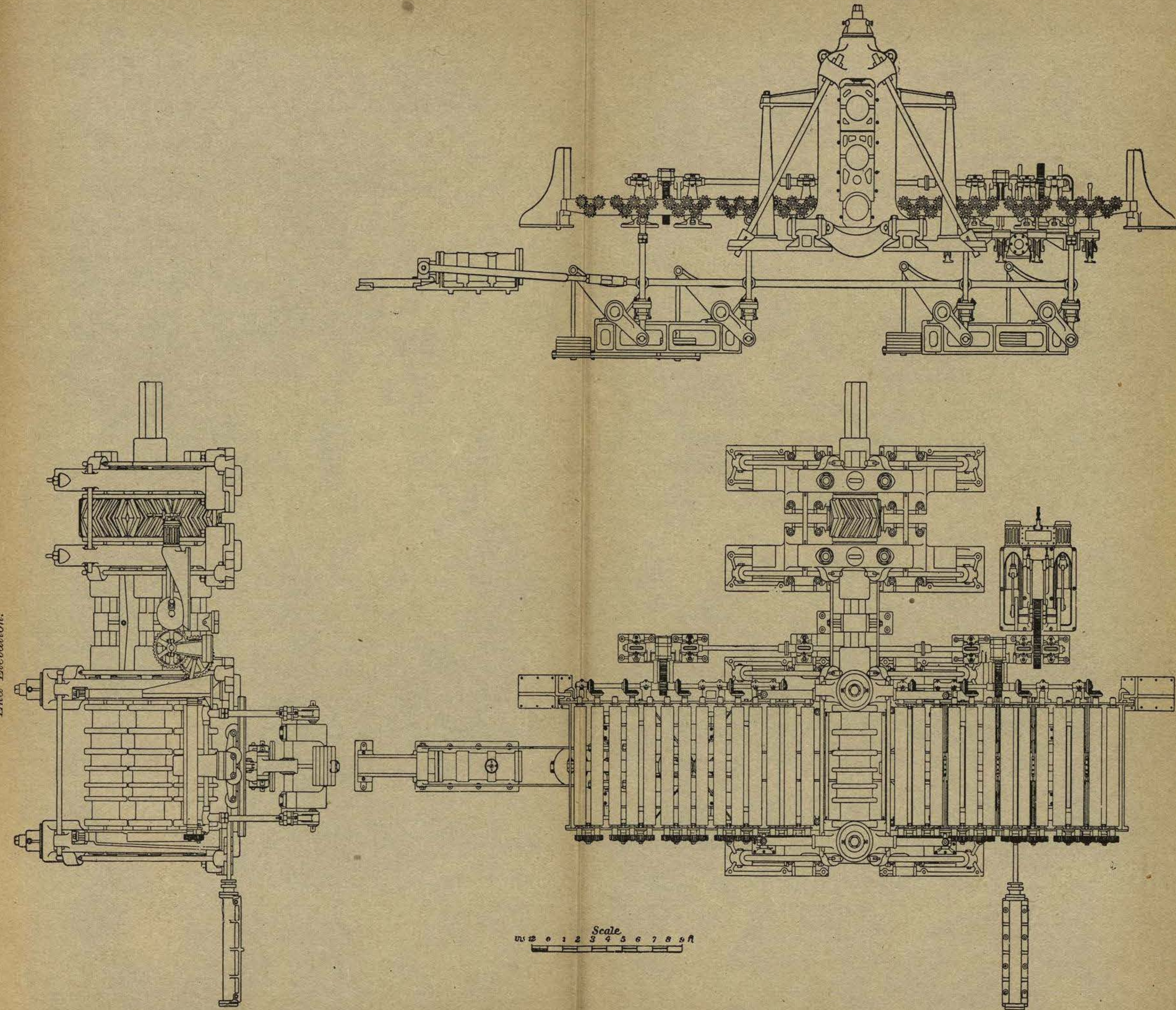

Fig. 466.

American works. It is provided with the usual lifting-tables and turnover gear; the rolls do not need adjustment during the operation of rolling, because twice as many passes can be got with three rolls in a three-high cogging mill as with two rolls in a reversing mill.

Slabbing Mills perform a duty similar to cogging mills, but instead of rolling the ingot into a long square bloom for making sections, they reduce it into a flat bloom, called a slab, for forming a plate. The slabbing mills are usually provided with one or two more passes at the ends of the rolls, which can either produce approximately square or hexagon billets, or can be used to roll the edges of the slab which is rolled on flat in the middle of the rolls, and on edge near the ends of the barrel. The output of the slabbing mill is rather less than that of the cogging mill, as the work is less conveniently performed. In America universal mills are often used for slabbing purposes (see Chapter xxvii.).

Bloom Shears.—To enable a cogging mill to be worked to the best advantage a heavy shear is required to cut the ingot, when reduced to a

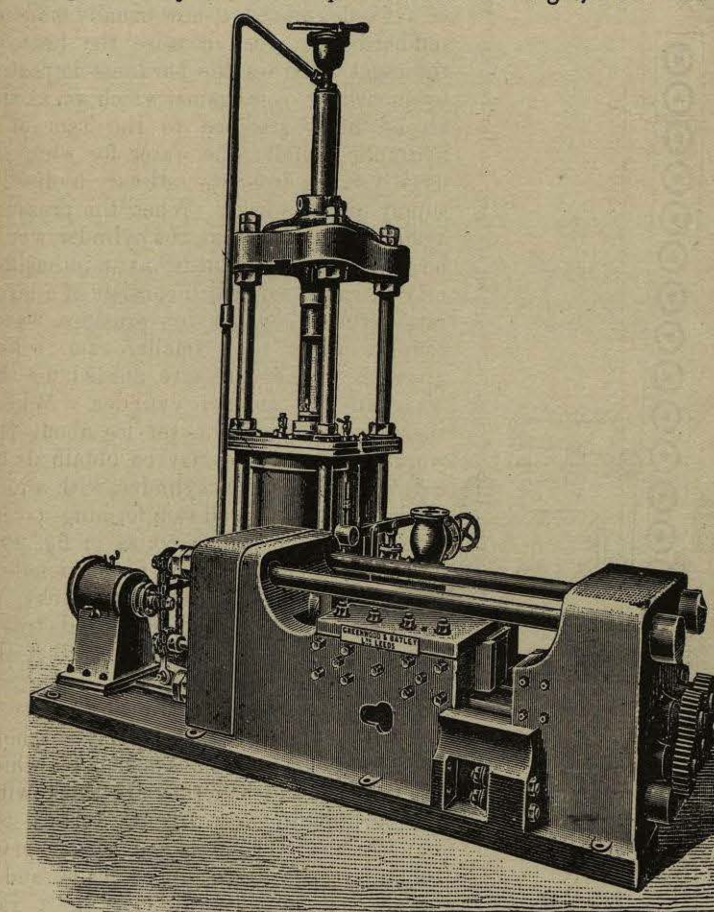

Fig. 467.—Horizontal Bloom-shear worked by Steam Intensifier.

section having a definite weight per foot, into accurately-measured lengths, so that each piece when taken to the other mills shall have the precise weight wanted to make the particular section desired with the least possible waste from crop-ends.

Works which possess bloom shears find three or four sizes of ingots sufficient to enable a piece of any weight required to be cut without waste, and avoid the unsatisfactory plan of filling some of the moulds only to such a height as will give the requisite weight—a point not easily hit off in practice—or of keeping a great variety of sizes of moulds, which is also objectionable. Mr. Hollis stated* that the saving in cost effected at Tudhoe by using only three sizes of moulds, instead of the forty at one time necessary, amounted to £6,000 per annum.

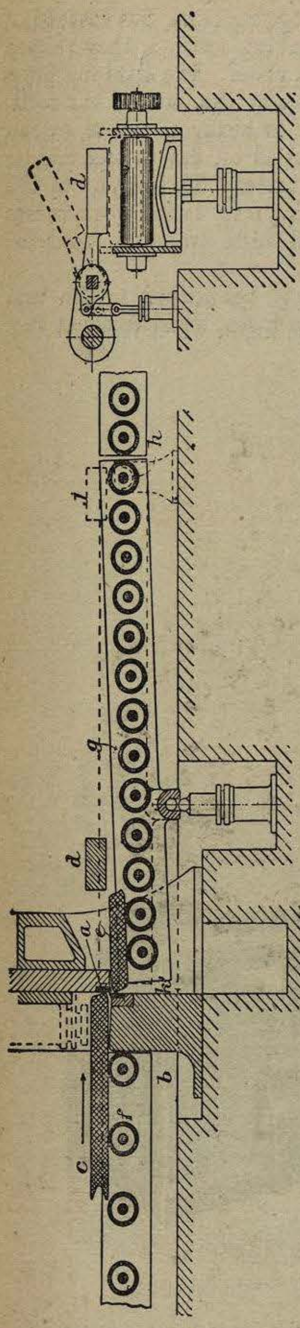

Fig 468.—Section through Bloom Shears, showing Hinged Roller-bed and Measuring Stop.

These shears are constructed on two distinct systems (1) the direct-acting hydraulic plan, and (2) the geared method of working. The hydraulic shears consist of a fixed knife-edge, now usually made of self-hardening steel, because the heat of the ingot destroys the hardness imparted by quenching, over against which works the second blade attached to the ram of a hydraulic cylinder, the water for which is usually taken from the ordinary hydraulic supply of the works. When the pressure available is so low that the cylinder would be of inconvenient dimensions an intensifier may be employed, which consists of a large ram actuated by the low-pressure water coupled direct to a smaller ram, which gives the higher pressure needed for the work in the smaller cylinder. Where there is no hydraulic service about the works the pressure may be obtained by a direct-acting steam cylinder, with a long stroke, driving a small ram forming a continuation of the piston-rod, as in fig. 467. The shear cylinder is of proportionately larger diameter and shorter stroke, so contrived as to give the reduced travel and greater thrust needed to effect the cut.

Where the cogged ingots or billets to be cut are square, the shear may act horizontally, but to cut slabs for plates which are much wider than they are thick without turning them on edge, a vertical cut is necessary. The first slab shears made consisted of a fixed upper blade, and a lower one mounted directly on a ram working upwards in a hydraulic cylinder, but so much trouble was experienced from the hot scale falling into the packing, destroying it, and scoring the ram, that such machines are now contrived to have the bottom blade fixed and the upper is made movable. Seeing the

* *Iron and Steel Inst. Journ.*, 1893, vol. ii., p. 123.

piece cut off is detruded by the shear blade in its descent, it is not possible to use rollers to carry it fixed in a rigid frame, and a length of the roller-bed just beyond the shears is therefore hinged at its further end, and supported by a balance weight or a hydraulic ram, so that it can yield to the cut and rise again as the blade rises. The length of the piece to be cut off is determined by raising the blade and running the slab on the live rollers against a stop on the further side of the machine. This stop can slide along a bar provided with a graduated scale parallel with the roller bed, the bar being hinged so as to enable the stop to be lowered on to the rollers, its exact distance from the shear blades being shown on the scale. In fig. 468, *a* is the upper blade and *b* the lower. The piece to be cut, *c*, enters from the left, and is carried forward until it meets the measuring

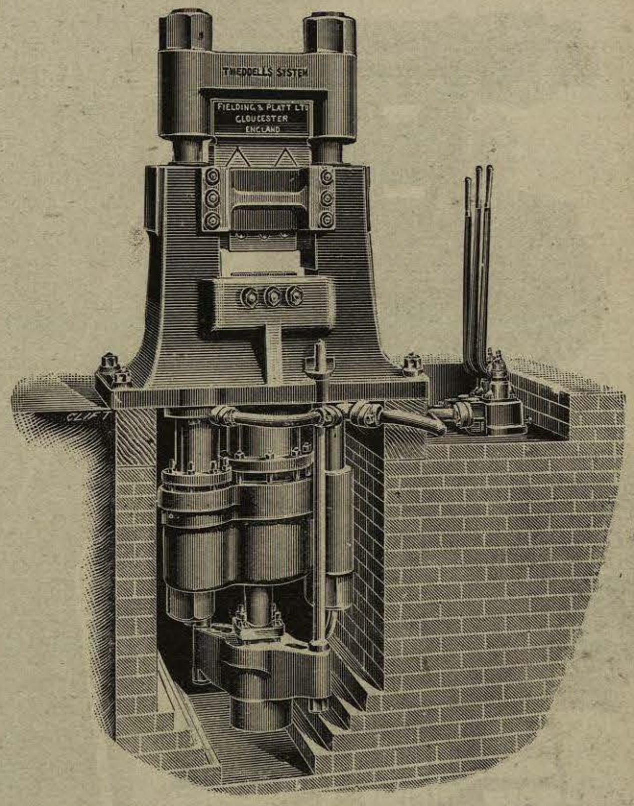

Fig. 469.—Vertical Hydraulic Ingot Shear with Three Powers.

stop, *d*, when the blade descends and cuts off the end, *e*. A cylinder, shown in dotted lines, is sometimes added to hold the bloom firmly while the end is cut off. The rollers, *f*, are fixed in rigid frames, the others are carried in the movable frame, *g*, hinged at *h*. The position of the measuring stop when arranged to cut off the longest pieces is shown at *j*. As soon as the cut has been made the stop is lifted, and the portion sheared off is carried away to the finishing mill by the live rollers.

Before cutting into lengths, the rough defective end of the slab will have been cut off, a space, *k*, being often left between the frame of the shears and the first roller beyond, through which the crop end may fall on to a travelling band, which removes it to some convenient place ready for remelting.