the first and last pair being driven by power, and the centre pair, which have means of adjustment both vertically and horizontally, running loose. This machine will turn out the angles almost perfectly straight.

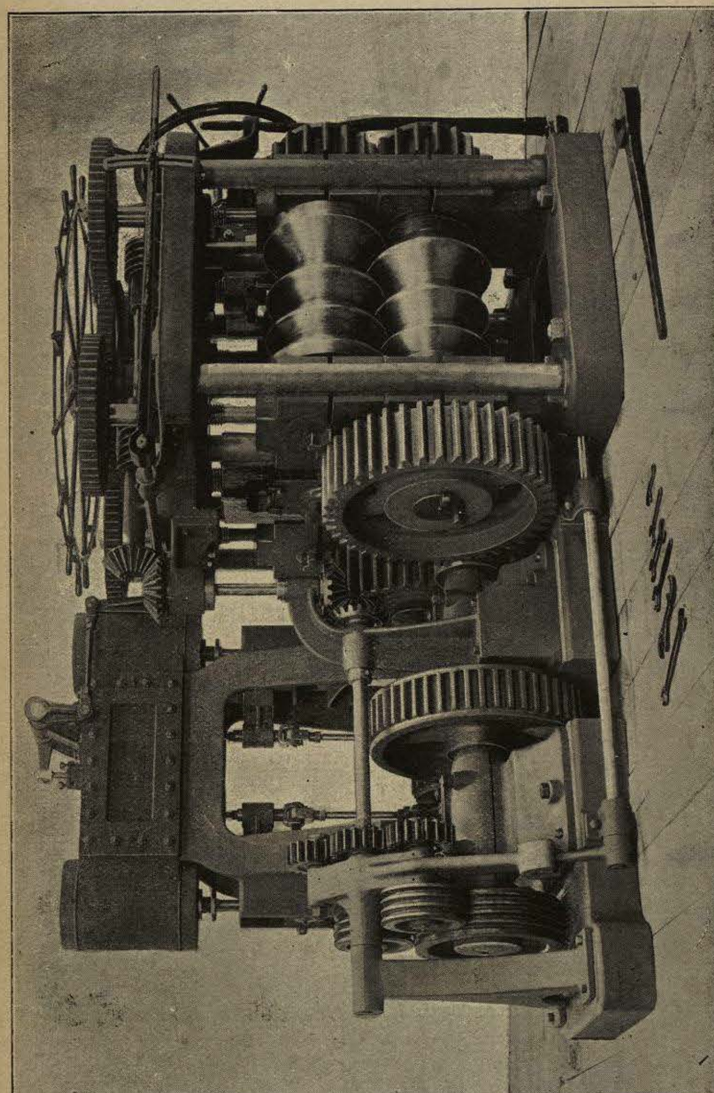


Fig. 477.—Angle Straightening Machine.

Bar Mills are often called "merchant mills," because they are employed for making rounds, squares, and small sections of tees and angles, such as a merchant usually is expected to keep in stock. They have rolls from 22 to 14 inches in diameter, and it is now becoming the common practice in this country to furnish these mills with reversing engines coupled direct to the rolls, and to provide a line of live rollers to take the finished bars to the saws (fig. 473), and a few rollers running free either on or in the ground for the service of the other passes. The Lilleshall mill is a good example of a medium-sized bar mill. When fitted with reversing engines having cylinders of 30 to 20 inches in diameter, by 3½ to 2½ feet stroke, the larger mills will

turn out as much as 120 tons in a 10-hour shift, under favourable conditions, 80 or 90 tons being common practice, while a 16-inch mill may be expected

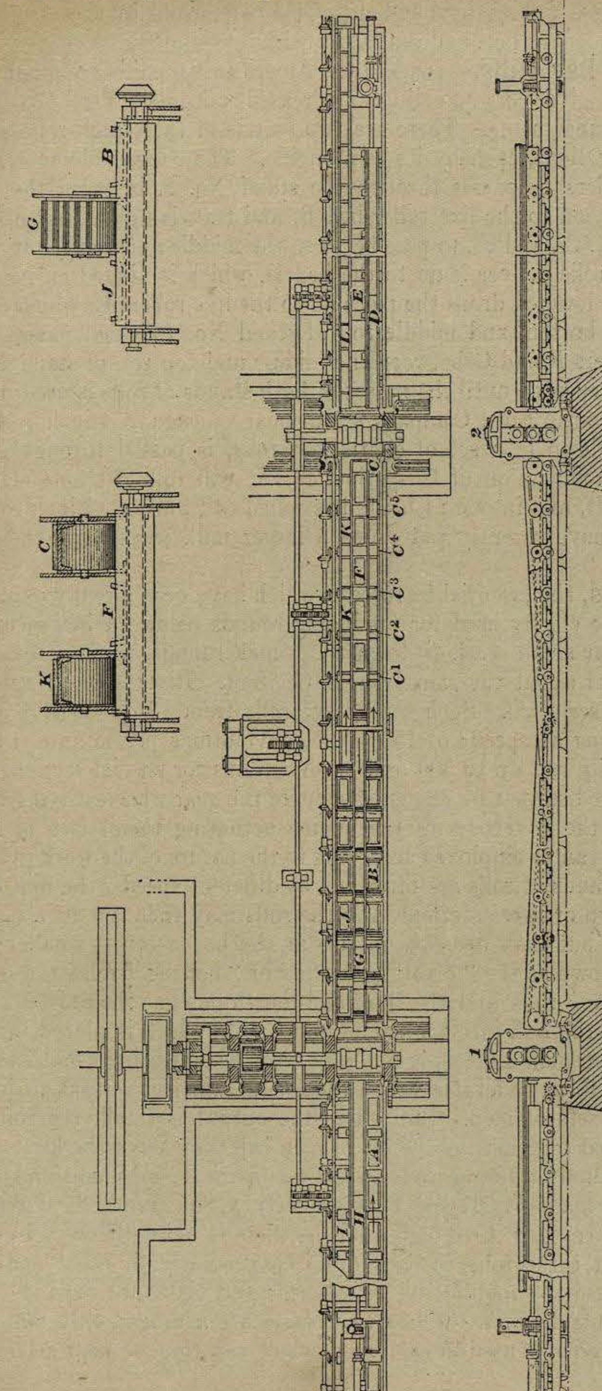


Fig. 478.—Special American Bar Mill.

to deal with 50 to 60 tons. An 18-inch pull-over mill, driven by a single engine, with cylinder 24 inches diameter by 4 feet stroke, and fitted with nothing but hand levers, has turned out 35 to 40 tons of tin plate bar regularly each shift. Difficult or light sections, or frequent changes of rolls, may reduce these figures by one-half. The bars made in these mills are usually sawn to length hot, and sent away without bundling.

American Bar Mills.—Some of the American bar mills are much more elaborate, and give correspondingly increased outputs. Fig. 478 shows one of such arrangements. There are two stands of three-high rolls driven in opposite directions, each by its own engine. The cogged bloom arriving on the live rollers A, passes through the stand No. 1, between the lower and middle roll, on to the live roller bed B, and travels up the inclined live rollers C_1, C_2, C_3, C_4, and C_5, to pass between the middle and top roll in stand No. 2. These rolls deliver it on to the bed D, which is hinged on its outer edge, and when lowered drops the piece on to the live rollers E, which return it between the bottom and middle roll of stand No. 2, which passes it on by the live rollers F and G between the middle and top roll of stand No. 1. The process is repeated until the passes in both stands of rolls is used up.

In the Wisconsin Steel Company's Mill near Chicago, a 4-inch × 4-inch billet roughed down in a set of continuous rolls, is passed through a mill worked on a modification of this principle; it will roll 150 tons of small sections per shift, and in one 24 hours has rolled 642 tons of 1$\frac{3}{8}$-inch rounds. The company have recently put down a larger mill, worked on the same principle.

Guide Mills, the essential features of which have been already explained (see p. 593), are chiefly used for producing rounds below 1$\frac{1}{2}$ inches in diameter, or similar small sections down to $\frac{5}{16}$-inch rounds, squares, ovals, or other sections of about the same weight per foot. Rivet steel is rolled in mills of this description. Such mills have rolls from 13 down to 8 inches diameter, running at speeds of 150 to 250 revolutions per minute, though some occasionally run up to 300 or 400 revolutions for special sections, and most are arranged so that by changing some of the gear wheels driving them, or by altering the governors of the engine actuating them, two or three different speeds can be employed according to the nature of the work in hand. The different stands of rolls are often run at different speeds, the mill being split up into two or three sections, and the rolls may then not be all of the same diameter, but may decrease in size as the bar becomes smaller; the first pair are known as the "breaking down" or "bolting" rolls, the second as the "stranding" rolls, and the third and fourth pairs as the finishing rolls.

Splitting up the mill into a breaking-down mill, which is placed in front of, and feeds, the smaller finishing mill (the arrangement being usually known as a tandem mill) is preferable where there is a sufficient output to justify employing two sets of men. But where the output is small, the rolls are better all coupled together, as one set of men can then serve the lot.

The bolting and stranding rolls, as shown in the 12-inch mill illustrated in fig. 479, and made by Messrs. Thomas Perry & Son, Limited, of Bilston, are commonly arranged three-high; but as there is more difficulty in accurately adjusting three rolls to each other, particularly in the "end on" direction, because the middle roll gets hotter and therefore expands more than the two outside ones, the last two passes are arranged only two-high, and only one groove is used in each pair, which can thus be kept accurately in adjustment.

Three-high mills, with 12-inch rolls, running about 150 revolutions per minute, can turn out 25 to 30 tons per shift, and have done as much as 35 tons (according to Mr. W. Wylie, the Scotch mills of this size turn out 30 to

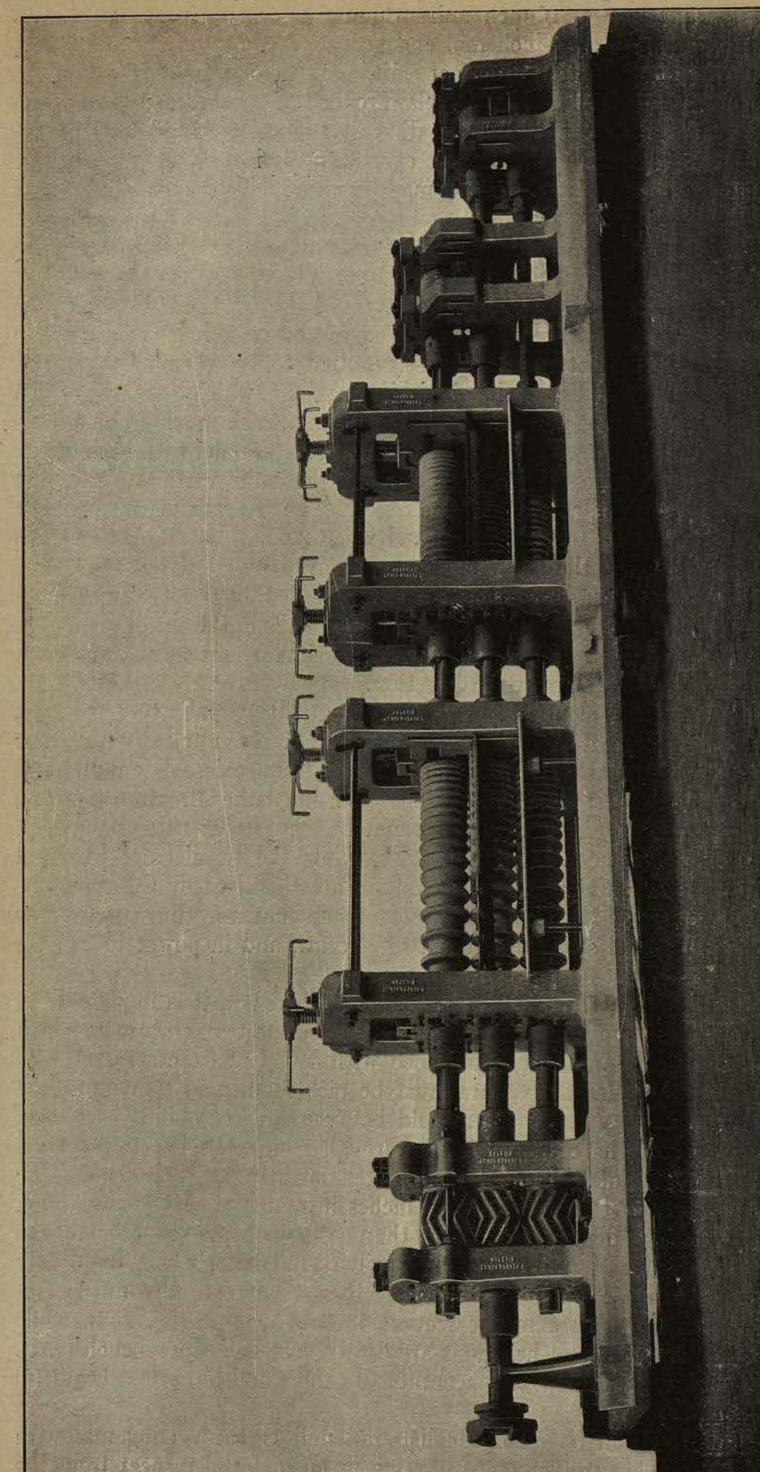


Fig. 479.—12-inch Three high Guide Mill

40 tons*), while 9- and 10-inch mills, running proportionately faster, can do 18 to 20 tons, and an 8-inch mill engaged on $\frac{3}{16}$ to $\frac{5}{8}$ rounds, and $\frac{1}{4}$ to $\frac{5}{8}$ square, may average 12 to 15 tons per shift. All these figures depend on the time lost in changing rolls, which for plain rounds or squares can be effected in less than half an hour, but where difficult and complicated sections are made some hours may be lost before everything is in correct adjustment, and running satisfactorily. The bars made in guide mills are usually sheared to length when cold, and the smaller sizes tied up in bundles for despatch.

Kirkstall Bars.—A method of producing round bars much straighter and more truly cylindrical than they could possibly be made in the ordinary mill, was introduced by Mr. Ambrose Butter, of the Kirkstall Forge, about thirty years ago. The bar was first rolled in the ordinary way to a size slightly larger in diameter than it was required to be when finished, and was removed while still hot to the planishing machine, which consisted of two flat discs, about 3 feet in diameter facing each other, each mounted on a horizontal shaft, so that the axes of the two shafts were parallel with each other, and in the same horizontal plane, but not in the same vertical plane, one shaft being 9 inches in advance of the other. The bar was placed between the two discs, parallel to their faces, and when its axis cut the axis of the two horizontal shafts, the bar was simply revolved by revolving the discs; but by raising it $\frac{1}{4}$ inch above the centre, it travelled longitudinally through between the discs in the direction of its own axis while in the act of revolving, and by depressing it $\frac{1}{4}$ inch below the centre, a similar motion of translation was imparted to it in the opposite direction.

The bar to be rolled was allowed to cool until it attained to a red heat just visible in day light, and the discs were kept freely supplied with water which was sprayed on them. The bar was freed from scale, made round and straight, and had imparted to it a dark blue polish due to the formation of Oxide.

The bars vary in diameter, and are not as accurate as turned shafting, but are sufficiently good for rough work, while the tensile and torsional strength of the material and the elastic limit are all raised by the comparatively cold working. Mr. David Kirkcaldy found that iron thus treated was increased in torsional strength about 20 per cent., and in power to resist a transverse load about 33 per cent.

Cold-rolled Shafting.—When a bar is finished hot, it is impossible to say what will be its precise diameter cold, because the temperature at which it is being finished cannot be determined with sufficient exactness. Where extreme accuracy is necessary, bars must be pickled in acid to remove the scale, and finished by rolling them cold between rolls of chilled cast iron, having grooves of the ordinary form, through which the bar is passed a great number of times, being turned round slightly at each pass. One works make bars in this way up to 5 inches in diameter and 50 feet long, which they declare do not vary more than $\frac{1}{1000}$ inch above or below the nominal size, a great improvement on the Kirkstall bars, which frequently varied more than $\frac{20}{1000}$ inch in 3 inches. Round bars are also finished in reeling machines described in the section on tube-making (fig. 552), while small rounds, squares, and hexagons are drawn cold in a draw-bench (*q.v.*), fig. 551, which makes them very accurate to gauge, and imparts a beautiful polished surface.

English Rail Mills.—The English rail mill is a reversing mill with rolls about 26 inches in diameter, differing in no material respect from the ordinary bar or section mill of the same size. Before 1870, when rails were

* *Iron and Coal Trades Review*, 6th September, 1901, p. 598.

rolled in pull-over mills, few mills did more than 50 tons per shift; the maximum obtained was 100 tons. The reversing mills put down during the next few years turned out 150 to 175 tons per shift; by 1880 the output had risen to 350 tons; and ten years later again, with engines coupled direct to the rolls, 350 tons were obtained. Bolckow Vaughan's mill has turned out, on an exceptionally good run, over 600 tons a shift, and, according to Mr. Windsor Richards, has made over 4,000 tons in a week. To obtain this output, however, three separate mills—a cogging mill, a roughing mill, and a finishing mill—are employed, each mill provided with its own pair of reversing engines, which have a large reserve of power to ensure the utmost rapidity of action.

The section of the rail is checked every hour or half-hour, to see that there is no material wear or error in adjustment of the rolls, which usually require redressing every two or three turns or "shifts," few rolls running longer than this. If the wear is trifling the redressing can be accomplished

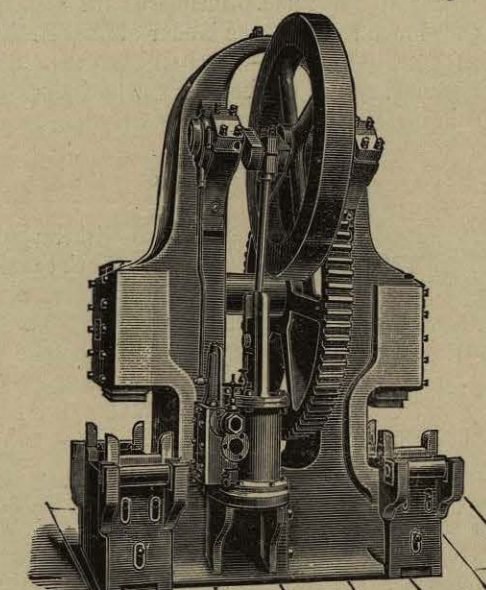


Fig. 480.—Double-rail Straightening Machine.

with the rolls in place, but usually the roll is changed and another one substituted for it, which may be accomplished in half an hour to an hour, if there is a good power-driven crane over the mill.

The rails are cut into lengths while hot by means of saws, and are skidded on to the hotbed to cool, during which process they become considerably shorter, the precise amount of shrinkage varying with the heat at which they are finished. As this heat cannot be controlled exactly nor can allowance be made for it, because the eye is unable to judge the temperature correctly in varying conditions of daylight (and as it is absolutely requisite for convenience in laying that all rails shall be of precisely the same length); they are pared to length when cold by passing them between two rotating discs, one acting on each end of the rail. These discs are provided with numerous cutting tools set in their faces.

The four holes for the fish-bolts are then drilled simultaneously, and as the drill-spindles are fixed at definite distances apart the holes are spaced precisely alike in every rail, without the necessity for any templating or marking off.

Rails are straightened in machines made for the purpose, one of which, manufactured by Messrs. Francis Berry & Sons, of Sowerby Bridge, is shown in fig. 480. This machine can straighten two rails at once, one on either side of it. Each half has a pair of blocks in the bottom bed and rollers on which to run the rail, and above them a block moved up and down by an eccentric pin on the end of the main shaft. One workman sits down opposite the machine, and others push the rail over the rollers. Whenever the man in charge perceives a crook in the rail, which he detects readily by running his eye along it, he signals to his helpers, who turn the rail with its convex side upwards, and the man at the press lays on the rail between the points of support on the bed a piece of iron of such thickness that, when the block descends, it bends back the rail to the extent required to straighten it.

In some of the most modern plants the rails are run while still hot through straightening rolls acting on the same principle as the angle-straightening machine (fig. 477), thus much reducing the labour of final straightening.

Inspecting and Testing Rails.—When finished the rails are laid out side by side for the convenience of the inspector, who walks over them and examines one side; he passes to a second lot while the first lot are being turned over for him to see the other side. He gauges a few here and there to see that they are correct to section, and checks over the length and position of the holes for the fish-plates.

A steel rail must possess sufficient hardness to withstand abrasion and toughness enough to resist fracture under the sudden shock caused by running a heavy train over it at high speed. To secure hardness the Carbon has been raised during the past fifteen or twenty years from 0·3 or 0·35 to 0·4 or 0·5; that in rails used for street tramways on which speeds are low occasionally running as high as 0·65, and for special purposes as high even as 0·95. To compensate for the increased brittleness of the material, the weight of the rails on main lines has been raised from 56 or 80 lbs. to 84 or 100 lbs. per yard.

Most rails now rolled range from 50 lbs. on small lines to 100 lbs. on main lines, and the test applied to such rails to ensure sufficient hardness consists in laying a short piece of rail on two bearings 3 or 3½ feet apart, and loading the centre with a weight of 10 to 20 tons, according to the weight of the section, under which the rail must show no appreciable permanent set, while there should be no undue deflection under a load of double this amount. To guard against brittleness, a weight of 1 ton is dropped on the rail resting on the same bearings as before, from a height of 10 to 20 feet according to section, and this blow must cause no sign of fracture. Instead of only one blow some engineers specify for several, commencing with a fall of only 5 feet, and increasing the height until the maximum is attained, while others stipulate the extent to which the rails must deflect under every blow.

American Rail Mills.—The modern American rail mill is arranged three-high, and, like the English plant, consists of three or even four separate mills, each driven by its own engine. The output of these mills is very high, 1,000 tons per shift being commonly obtained from the most modern plants. The speed of rolling is not exceptionally high, 25-inch to 27-inch rolls making 85 to 90 revolutions per minute, but the heavy outputs are due chiefly to the fact that the three-high system admits of two pieces being rolled in a stand of rolls simultaneously, and to the fact that in such mills the grooves open upwards and downwards alternately, so that the rail does

not need to be turned upside down between each pass as in the reversing mill. Where turning on the side is necessary at the blooming or roughing rolls, this is performed by receiving the bar in a grooved trough which turns over as the tables rise and fall, while in the passage from one stand to another the form of the live rollers on which the rail travels turn it over. The tables also move sideways in rising, and so carry the bar horizontally from one groove to another. All these arrangements save the time consumed in the English mills in turning over and skidding the bar horizontally, and greatly add to the rapidity of production. A very good account of the American system of rail-rolling will be found in Mr. Wellman's paper on "Four American Rolling Mills."*

This rapidity of working has its drawbacks, inasmuch as it is found that the rails finished at these high heats do not wear so well as those made years ago, when the slower speed compelled the finishing to be done at a lower temperature, and the American purchasers of rails are insisting that instead of passing the rail through the last pass at a heat which was found to average 1,790° F., they shall be held back until they have fallen to a temperature which ranges between about 1,575° and 1,600° F. This can be done without affecting the speed to any appreciable extent, and it gives a much finer grain to the steel, which can be readily detected if the fracture of the two rails is compared. It is found, that when finished at this lower temperature, the saws require to be set about an inch nearer together to leave the rail of the same length when cold.

The ordinary American rail mill is a three-high mill fitted with lifting tables, and the cogged bloom is passed to and fro through one stand, and then transferred to another of similar construction. Each stand is usually driven by its own engine. The final pass is made through a two-high stand, either coupled to the end of the last three-high stand, in the same way as the finishing rolls of the bar mill (fig. 479), or else driven by a separate fourth engine. To avoid frequent changes of worn rolls, this last pair contain several passes all alike, so that when one is worn out another can be used. This pair are sometimes chilled rolls.

In some recent American rolling mills, in order to save the time lost in lifting and lowering the table, and in transferring the materials from one stand of rolls to another, this plan is departed from, and arrangements are used which give results comparable with the continuous billet mill (see p. 814), from the finishing pass, in which pours a continuous stream of finished material.

To roll a rail in an ordinary continuous mill, in which the housings are placed close in front of each other, is hardly practicable for the following reasons:—First, the rail would be in so many pairs of rolls simultaneously, that the speeds would need to be very accurately adjusted, necessitating the use of very heavy gears, the friction of which, and of so many roll necks, would be a serious matter. Secondly, the percentage of reduction required in the various succeeding passes differs with the particular section to be produced. Thirdly, the construction of the twisted guides necessary to turn over the piece between the different passes, which presents difficulties even in the case of simple sections like billets, would prove an almost insuperable obstacle when dealing with rail sections.

The difficulty is surmounted by placing the different stands so far apart that the rail is not in more than one pair of rolls in any one instant. If the mill is only intended to re-roll short lengths of defective rails into others

* *Min. Proc. Inst. C.E.*, 5th May, 1896, vol. cxxvi., p. 156.

of lighter section, the stands may be in one straight line, as in the case of the M'Kenna mills,* but if it is to roll new rails from cogged ingots, these must be produced in lengths of 130 to 230 feet to avoid loss by crop ends, and in that case the distance between the stands would be so great, and the engines so numerous, as to render the arrangement scarcely practicable. Accordingly, the rail is passed through two stands in a line, and then returned through other stands coupled end to end with the previous rolls.

Fig. 481 shows a mill of this type having eight stands of three-high housings, A, B, C, D, E, H, I, and K, and three stands of two-high, F, G, and J, coupled to three stands of three-high pinions, all three engines running in the same direction. Though the eight stands have three-high housings, the rolls in them are only worked two-high, because in housings A, B, E, and K the place of the top roll, and in housings C, D, H, and I of the bottom roll of the trio, is occupied by a dummy roll used to drive the roll in the housing next beyond it, just as in the Belgian rod mill (fig. 501), where a top and bottom roll are omitted alternately. The cropped bloom enters between the middle and bottom roll of stand A, then between the same rolls of stand B; on issuing from them it is simultaneously lifted and transferred so as to return in the opposite direction between the middle and top roll of stands C and D; after leaving them it is simultaneously transferred and lowered ready to pass back again between the bottom and middle roll of stands E and F, and on through the two-high stand G; then it is transferred and lifted to pass back once more between the middle and top rolls of stands H and I; then lowered once more to return through the two-high stand J, and between the middle and bottom rolls of stand K, and thence direct to the saws. In this way lifting tables carrying reversible live rollers are avoided altogether.

The rail mill of the Ohio Steel Works, near Youngstown, is arranged in this way, and the output is said to be from 750 to 800 tons per shift of eight hours.

In the South Chicago Mill, there is an ordinary three-high roughing mill, followed by a succession of two-high and three-high stands coupled end to end in two lines, so that the rail passes in somewhat similar fashion forwards to one mill and backwards to another.

In the Republican Iron and Steel Company's rail mill at Youngstown there is a 26-inch roughing mill, which is practically a Brown reciprocating mill (see p. 629), but with three instead of two pairs of rolls, the outside pairs working on the bar simultaneously in the manner of a continuous mill. One of the centre pair of rolls is coupled to the engine, and the similar rolls of the outside pairs driven by gears from the crank-shaft. The 8-inch square cogged bloom makes its first journey through the mill by entering a working pass in the No. 1 pair of rolls, travelling idly through enlarged openings in the No. 2 pair, to enter a working pass in No. 3 pair. It is then transferred laterally to make a return journey, returned through enlarged openings between the No. 3 pair, into an active pass in No. 2, whence it travels through enlarged openings in No. 1, and then makes a third journey similar to the first. After this it passes on to an ordinary 28-inch three-high mill, and finally through a finishing two-high stand driven by the same engine.

The most recent of the American rail mills is the Gary mill of the American Steel Corporation. The ingot passes in succession through two pairs of 42-inch two-high rolls geared to one electric motor, then through two stands

* *Engineer*, February or March, 1906.

of 40-inch two-high geared to a similar motor, all the rolls being in one line. These rolls increase in speed as the ingot lengthens, the first pass (speaking from memory) running only about ten revolutions per minute. The object is to compress the ingot slowly in the first few passes, so as to close up any

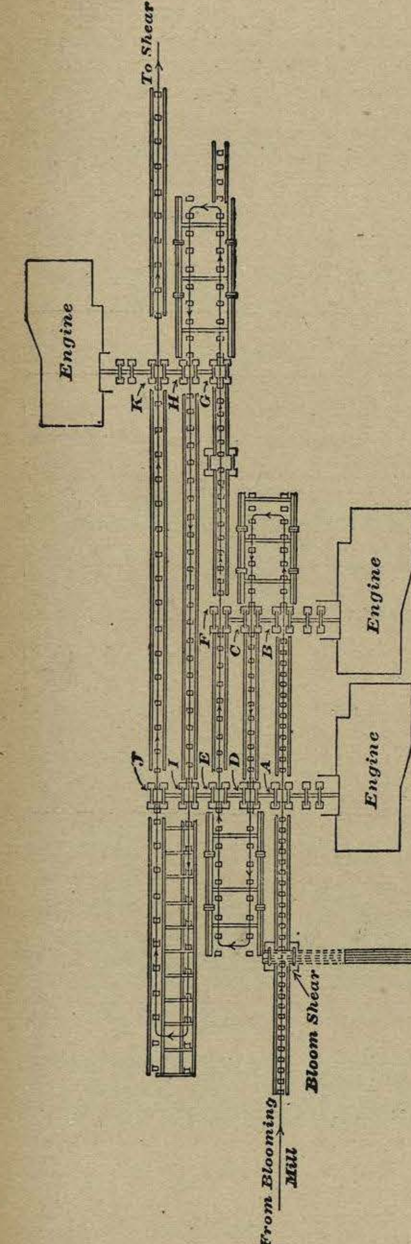


Fig. 481.—American Rail Mill.

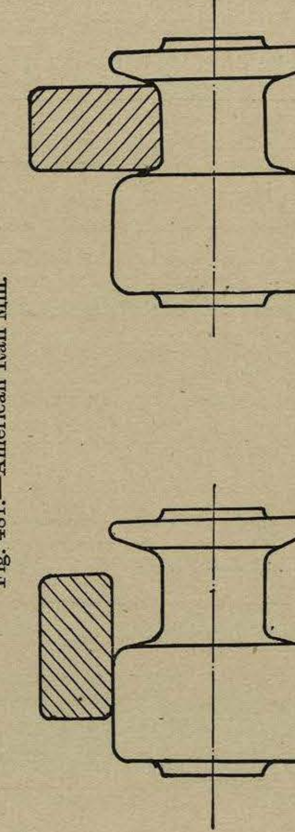


Fig. 482.—Method of Turning Bloom on Edge by means of Live Rollers.

imperfections and avoid tearing the surface. The roughed ingot is given a quarter turn between each stand by passing over live rollers shaped as in fig. 482. When the bloom arrives on those rollers which support it on one side only, it falls over into the groove in the upright position (fig. 482).

The bloom then passes to a 40-inch three-high cogging mill, in which it receives five passes, and then passes backwards and forwards through a succession of 28-inch three-high and two-high mills. There are five hot saws, all cutting simultaneously. A good description of this mill will be found in the *Iron Age*, April 1, 1909.

The tremendous first cost of plant of this kind, and the numerous rolls needed to produce a single section, can only be justified where vast orders are obtainable for sections all precisely alike, or differing very slightly from each other, and could not be contemplated in European works, which are called upon to produce so many different sections.

The following particulars of the size and weights of ingots and the number of passes in American rail mills is taken from a report by Mr. P. H. Dudley, presented to the International Railway Congress, May, 1905:—

DIMENSIONS AND WEIGHTS OF INGOTS AND NUMBER OF PASSES MADE.

	Name of Steel Company.					
	Carnegie.	Cambria.	Lackawanna.	Maryland.	Pennsylvania.	Illinois.
Ingots—						
Size on top, . ins.	15 ×17	16×19	16×16	18×19	16×16	$16\frac{1}{8}\times17\frac{7}{16}$
Size on base, . ins.	$17\frac{1}{2}\times19\frac{1}{2}$	20×23	18×18	20×21	17×17	$17\frac{3}{4}\times19\frac{3}{4}$
Length, . . .	5 to 6 ft.	6′ 2″	6 ft.	5 ft.	5′ 6″	6 ft.
Weight in lbs., .	4,600 to 5,000	6,500 to 7,200	4,800 to 5,200	5,420 to 6,080	4,000	6,400
Number cast per heat,	8	4	6	6 to 8	5 to 6	5 to 6
Passes—						
Blooming train, .	9	15	6	13	9	9
Roughing train, .	5	7	4	6	6	3
Intermediate train, .	5	3	5	4	..	2
Finishing train, .	1	2	1	1	5	4
Total number, .	20	27	16	24	20	18

The practice of cutting off the ends of worn rails and re-rolling them to a somewhat lighter section is becoming well known in America, where Mr. M'Kenna has secured a patent for the process, the details of which are carefully worked out. The patentee claims that these rails, which are finished at a temperature of about 1,400° F., wear longer than new rails.*

Speaking generally, the inspection of finished rails in America is not so minute and critical as that to which the English rail-maker often has to submit. The demand for rails in the States is so great that the American manufacturer can decline to supply any rails, if the tests demanded are such as he does not care to accept; nor will he quote unless the rail required resembles pretty closely one of his own standard sections. English makers cannot afford to be so discriminating.

Tire Mills.—The tires used on the wheels of railway vehicles were at first made by rolling an iron bar to the section of the intended tire, cutting this bar to the requisite length, bending it into a circle and welding the ends together to form a hoop, in precisely the same way as the village blacksmith makes the tires for farm waggons.

* "Renewing Steel Rails," *The Iron and Coal Trades Review*, 20th July, 1900, p. 121.

Before very long, however, Mr. I. G. Bodmer invented a machine for rolling these tires to approximately exact diameter and section, after being bent and welded. This machine, the first for rolling railway tires, was erected and put to work in 1842 at the works of P. R. Jackson & Co., Limited, Salford Rolling Mills, Manchester, these works having been established just previously for the supplying of railway material. This machine continued in use until 1874, when it was dismantled, not being quite strong enough for rolling the steel tires, which in the meantime had generally displaced wrought-iron ones. Photos of this machine can be seen at Messrs. Jackson's works.

When Bessemer steel rails were introduced it was soon found that steel tires must be used on them, and in 1863 Messrs. Jackson designed and made for a leading Sheffield firm, and soon after for Mr. Ramsbottom, of Crewe Railway Works, mills for rolling weldless steel tires up to the largest sizes. The method then introduced is the one now generally adopted.

The ingots required for the manufacture of tires are cast in the form of a frustum of a cone with flat or domed top, or as a short circular piece shaped much like a Stilton cheese, but with a conical top. The moulds are close-topped, and the ingots are run from the bottom, each ingot being of the weight required to form one tire (see pp. 31-33, 177-180, Section I.). Locomotive tires are often made from hexagonal ingots which are cast from the top; the upper third is cut off for remelting, and the remainder, when cold, is cut up into lengths by saws, each length making one tire. The "cheeses" are heated and hammered down under a steam hammer, which upsets them and enlarges the diameter of the blank until it is about 6 inches thick; a hole is then punched under the hammer through the centre of each disc, and the ring so formed is in some cases taken direct to the rolling mill. In others it is removed to a second hammer having a bitt in the anvil, with a nose projecting from one side, much resembling the ordinary bick of the smith's anvil. The upper tool secured to the hammer-head has a face which serves to rough the outer surface of the tire blank to something approximately like the shape of the finished tire, the workmen turning the ring round through a portion of a circle after each blow (fig. 483). Usually two or three hammers are employed in succession, one suited for each step in the process of roughing out, but occasionally all the operations are conducted under one hammer, the different operations being effected on different parts of the bitts. At Crewe, at Messrs. Vickers' works, and at some other places, a press is now employed instead of a hammer for the preliminary flattening and punching, and in some works the blanks, after being punched, are roughed out in a roughing mill provided with a pair of horizontal rolls, the lower roll having a bearing at each end, but the upper roll overhanging its bearings, so that the blank can be slipped on without removing the upper roll.

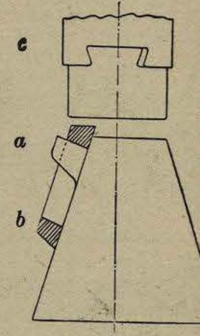


Fig. 483.—Hammering Tire Blank.—*a*, Bitt on anvil; *b*, tire blank; *c*, head of hammer.

Fig. 484 shows a tire mill of recent date by Messrs. P. R. Jackson & Company, Limited, Manchester. It consists of a pair of vertical rolls with two or four grooves to give, at one operation, the form of the tire required; the roll to the left in the illustration is removable, and can be lifted by means of an hydraulic cylinder and chain provided for the purpose on the front of the machine. The roll to the right is the large or main roll, and is driven by gearing from the engine. A horizontal roll is carried in a frame which is movable to and fro along the plate or table, for the various diameters of tires; this small roll serves to steady the tire during the operation of rolling, and to keep it down on the carrying rolls in the table. There are also two small steadying rolls running free on vertical spindles on each side

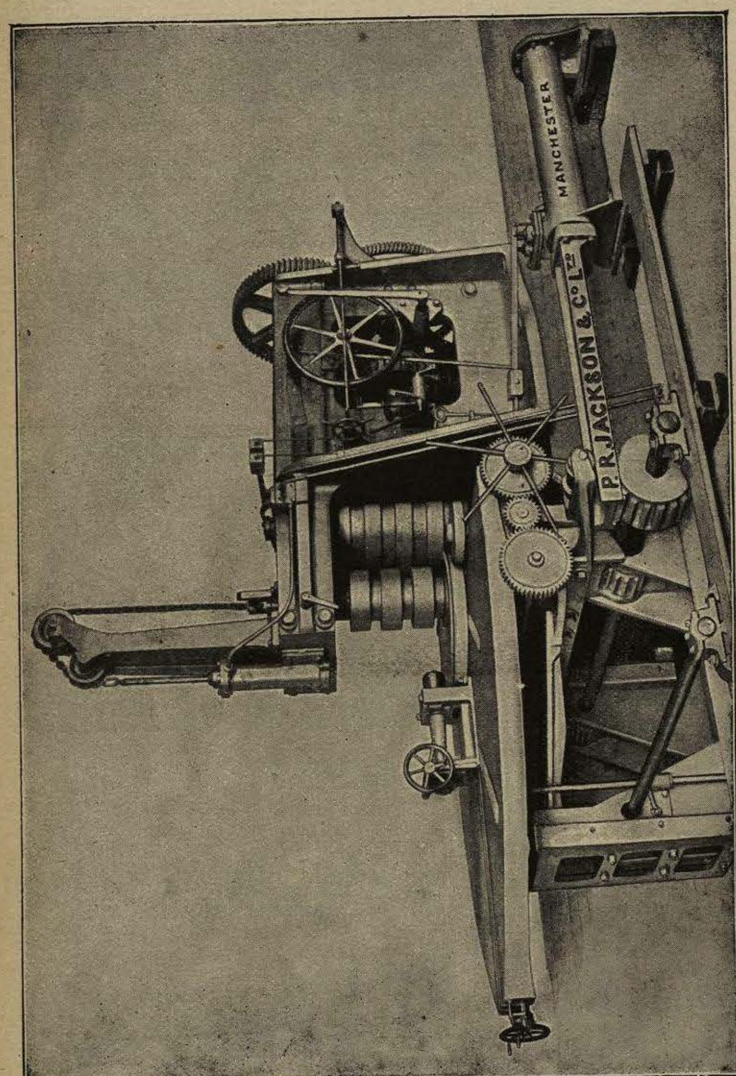


Fig. 484.—Tire-Rolling Mill.

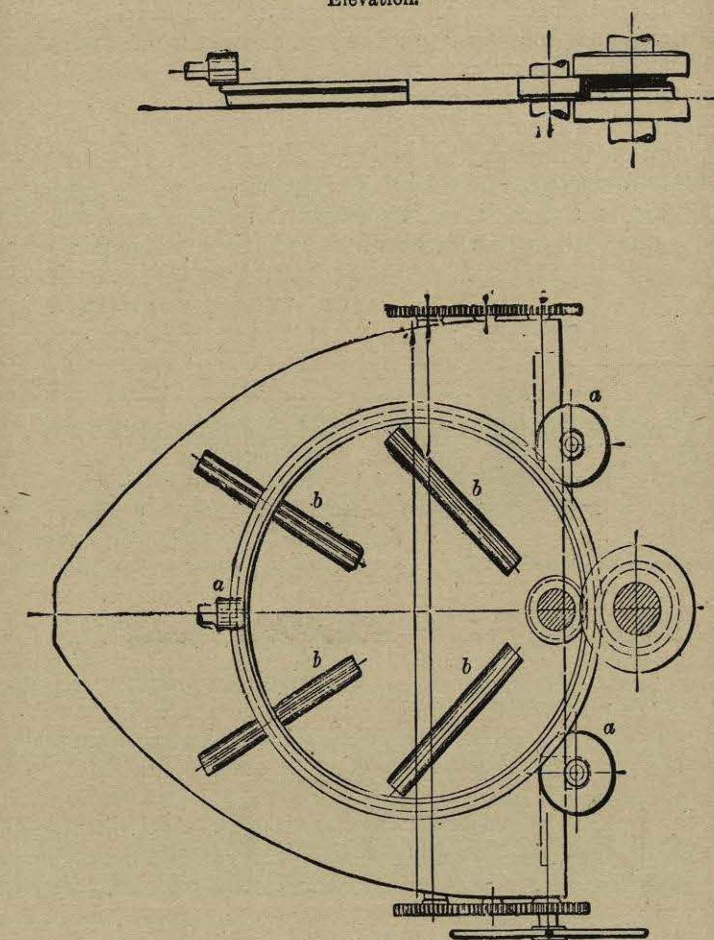
of the main rolls, and kept to the tire by screws, which serve to steady the tire during the operation. The sketch (fig. 485), shows the arrangement. The table is adjustable vertically to meet the different grooves or passes on the rolls.

The process of working is as follows:—The one vertical roll having been lifted, and the horizontal roll and the small steadying rolls having been drawn back, a hammered tire blank, raised to a bright yellow heat, is laid

on the table, the movable vertical roll is dropped through the hole in the centre of the blank, and the mill is started. The operation of rolling the tire between the two vertical rolls is exactly the same as would take place in an ordinary rolling mill, if the two ends of the bar being rolled were joined together above the top roll, and the whole mill were then laid on its side.

The rolls are fed together so as to reduce the thickness and increase the circumference of the tire, by means of screws worked, through gearing, by a

Elevation.



Plan.

Fig. 485.—Table of Tire-rolling Mill, with tire in position.—*a, a, a*, Steadying rolls; *b, b, b, b*, carrying rolls.

small pair of engines fixed to the main frame, at the opposite side to that from which the illustration is taken, the large hand wheel shown on the side of the main frame regulating the amount of compression when finishing, and pointers on a graduated scale serving to record the thickness to which the tire has been reduced, and the diameter of the tire. The tire is roughed more or less to size and shape on the bottom pass in the rolls, the rolls are then separated and the table raised by means of the hydraulic cylinder on the extreme right of the illustration, which actuates a rack driving a pinion keyed on the horizontal shaft below the table. The shaft, by means of other pinions gearing into three racks, raises the table, so as to bring the tire opposite the second pass in the rolls, in which it is further rolled to shape, or finished, and then if required to the third pass. The horizontal roll and the steadying rolls are brought into action during this part of the rolling, as shown in fig. 485. Water is thrown over the tire during the finishing operation to remove the scale, and its diameter is tested by means of a gauge before removing it from the mill. The adjustment and gauging is so sensitive that tires can be rolled exact to diameter, or exact within the narrowest practical limits, and in many cases the tires have been fitted on wheels without requiring to be either bored or turned. It takes about one and a quarter minutes to roll a tire, and a mill will turn out about 150 tires in a day of ten hours, with four men, and will need about 450 H.P. to drive it.

In Munton's American Tire Mill the ingot is cast with a central hole formed by a core, and is slit up into four tires in the slitting mill, shown in fig. 486; the tires are then finished in pairs in the finishing mill.

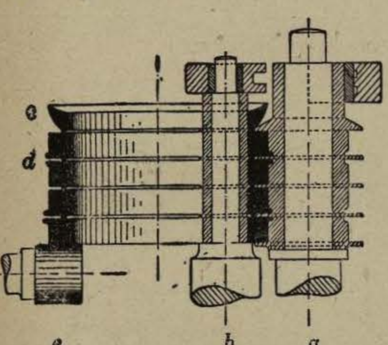


Fig. 486.—Munton's Tire Mill.—*a*, Fixed roll; *b*, adjustable roll; *c*, carrying roll; *d*, hollow ingot rolled out, and slit into four rough tires; *e*, waste top of ingot.

Particulars of the chemical tests, &c., will be found set forth in the Appendix to this work, under the heading of Tire Specifications.

The tires are tested by selecting about 2 per cent. from the bulk, and allowing them to fall from a height on to a metal plate, or by dropping on them a falling weight, or, most recently, by compressing the sides together with a hydraulic press into approximately the form of a figure 8, the amount of deflection from a true circle, before showing signs of fracture, being a measure of their toughness.

Some makers anneal their tires before despatch, thus relieving the internal strain due to rolling and irregular cooling.

That this strain is considerable was proved by Mr. A. A. Stevenson, of The Standard Steel Company, Burnham, Pa., who gave the results of tests taken from railway tires immediately the tires were cold, and after they had been allowed to stand for a few days, the test pieces being cut in duplicate, and tests being as far as possible made in each case on the same part of the tire.

In some rare cases where tires are required for very severe service they are oil-hardened, but this is by no means frequent.

Occasionally small hoops for guns and crushing mills are rolled in tire mills in the same way as the railway tires.

Messrs. John Brown & Co., Limited, of Sheffield, have recently put down a large mill working in the same way as a tire mill, except that the rolls are placed horizontally instead of vertically, which is driven from the engine working their armour plate mill, said to be capable of exerting 12,000 H.P. In this mill they are rolling out trepanned ingots of 24 tons weight into steam turbine drums up to 12 feet diameter by 8 feet long.* They have

* *The Engineer*, November 12th, 1909, p. 497.

also supplied weldless locomotive boiler shells and steam drums for tube boilers up to 5 feet diameter by 11 feet 6 inches long made in the same mill.*

TABLE CXVI.—Change in the Strength of Tires Shortly After Rolling.

Elastic Limit.	Ultimate Strength.	Elongation per cent.	Reduction per cent.	Remarks.
53,490	107,460	15·00	19·20	Pulled within three days after tire was made.
56,037	108,700	16·30	24·30	Ten days later.
50,940	99,590	14·00	22·20	Pulled within three days after tire was made.
53,000	103,464	18·00	27·40	Ten days later.
56,037	111,050	10·00	12·37	Pulled within three days after tire was made.
61,130	111,410	15·00	21·50	Ten days later.
70,370	121,250	11·00	14·01	Pulled five days after tire was made.
71,980	121,970	14·00	17·89	Seven days later.
65,080	121,470	11·50	13·55	Pulled seven days after tire was made.
64,400	121,160	13·00	16·30	Fourteen days later.

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* *The Engineer*, October 29th, 1910, p. 476.