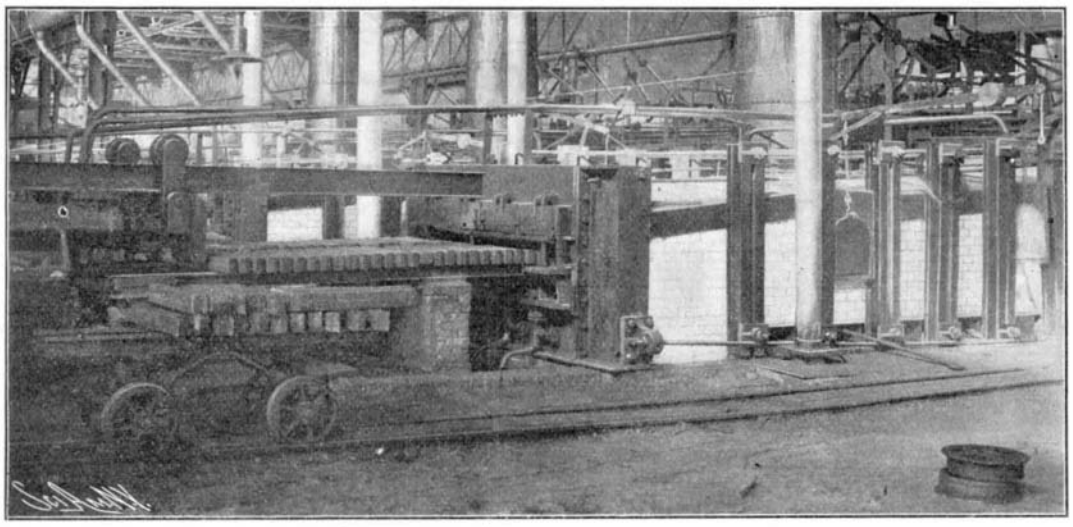
STEEL WIRE AND NAIL MAKING.

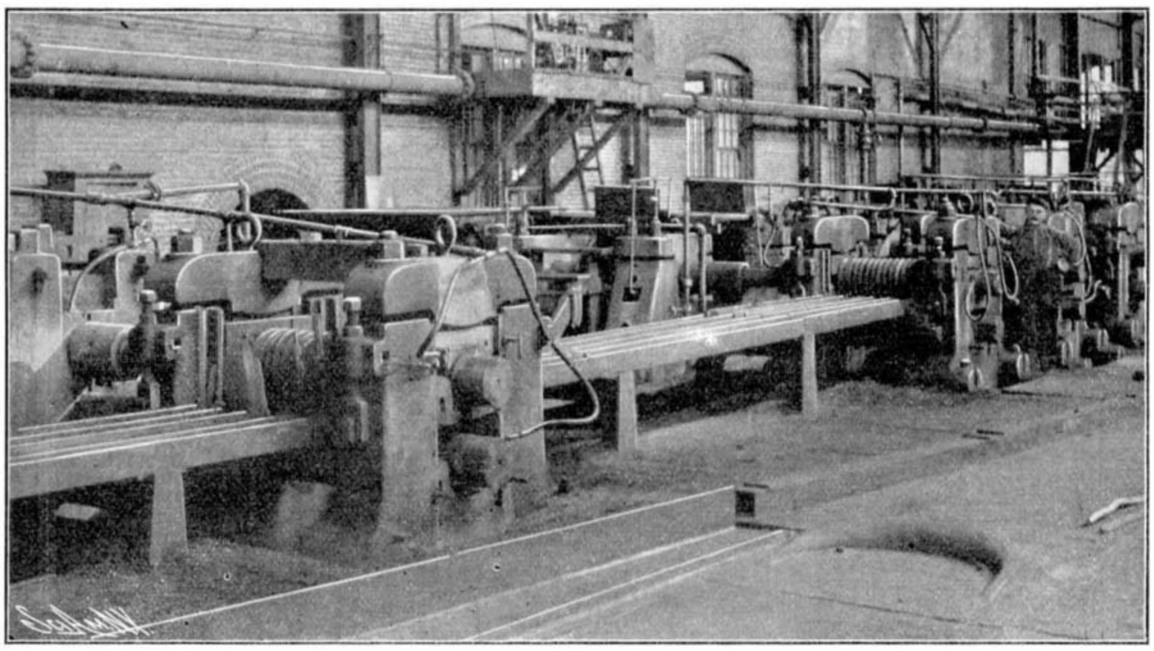
The magnitude and importance of the wire and nail industry in the United States may be measured by the fact that in the year 1902 the mills turned out a total of 1,574,293 tons of wire rods, of which nearly half a million tons were made into wire nails. Time was when both wire and nails were manufactured entirely from wrought iron, and to secure the toughness and high tensile strength required, great care had to be used in the preparation of the iron, the cost of the product being proportionately high. It was only a question of time before steel, because of its less cost and its high strength, became the standard material in this as in other branches of the iron and steel industry; and to-day practically the whole of the wire and wire nails used are made from either Bessemer or open-hearth steel, the latter being specified where wire of the special grades with higher physical properties is required.



Continuous Heating Furnace in Which the Billets are Heated for Rolling in Roughing Mill.

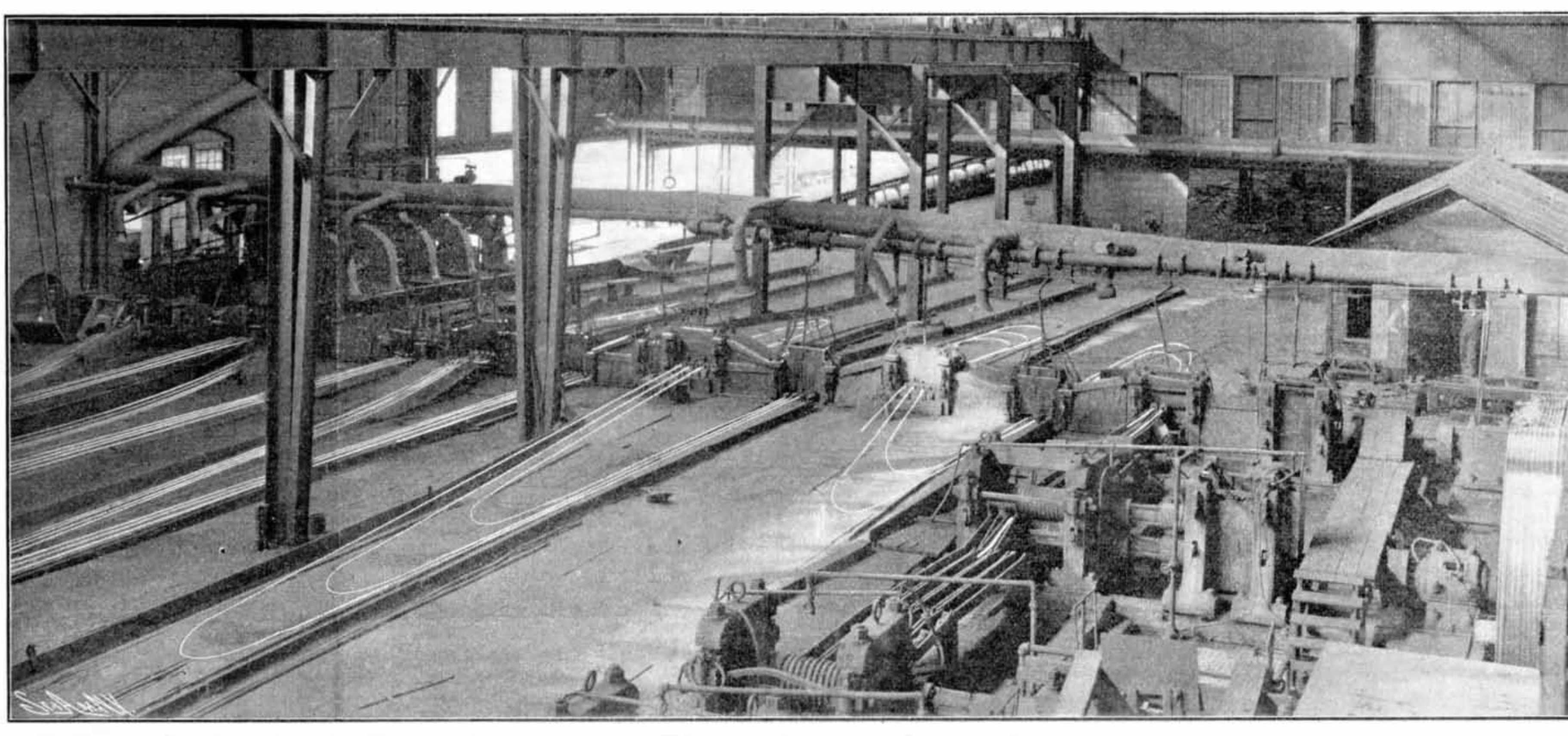
Physical Properties of Steel Wire.—As showing the great increase in strength of steel over iron wire, it may be mentioned that while good black iron wire will show an ultimate tensile strength of about 25 tons to the square inch, and bright hard-drawn wire a strength of 35 tons to the square inch, Bessemer steel wire will stand a strain of 40 tons and open-hearth steel wire 60 tons to the inch. Of the "special" grades of wire a high-carbon open-hearth steel will stand about 80 tons, crucible cast-steel wire about 100 tons, and the best cast steel, or as it is sometimes called, "plow" steel wire, 120 tons to the square inch; while certain qualities of cast-steel wire, made under specifications calling for a particular composition, and requiring very elaborate working, have been produced, showing an ultimate breaking strength of from 150 to 170 tons to the square inch. The process of wire drawing, as will be explained later in this article, serves to greatly improve the physical qualities, and the smaller the size to which the wire is drawn down, the greater is the ultimate breaking strength. The wonderful qualities of piano wire are proverbial, the average strength of English piano wire as given by the manufacturers ranging from 225 pounds for No. 12 music wire gage, which is 0.029 inch in diameter, to 650 pounds breaking strength for No. 22, which is 0.052 inch in diameter. Reduced to the square-inch unit, the ultimate tensile strength per square inch would range from 300,000 pounds to 340,000 pounds. The composition of this remarkable wire is as follows: Carbon, 0.570; silicon, 0.090; sulphur, 0.011; phosphorus, 0.018; manganese, 0.425. An analysis of another wire of unusual strength known as "plow," showed 0.828 per cent of carbon, 0.587 per cent of manganese, 0.143 per cent of silicon, 0.009 per cent of sulphur, 0.030 per cent of copper, and no phosphorus. The tests of this wire ran from 200,000 pounds per square inch for wire 0.191 inch in diameter to 350,000 pounds for wire 0.093 inch in diameter. Of course, with such high tensile strength the elongation or stretch was very small, ranging from 0.75 to 1.1 per cent only.

Billet Yard.—In describing the manufacture of steel wire and wire nails as carried on at the Donora Works of the American Steel and Wire Company, we shall commence our description at that point of the process where the steel has been manufactured into billets, ready for the rod mill. These great works buy nothing in the open market and carry out the whole process of wire manufacture from the smelting of the ore to the final drawing of the wire; but as we have so completely described, in previous articles in this issue, both blast furnace practice and the conversion of the cast iron into steel either in the Bessemer converter or the Siemens-Martin open-hearth furnace, it would be superfluous to go over the ground again. We shall, therefore, commence at the billet stockyard, where the steel is stored conveniently to the heating furnaces of the rod mill. The bulk of the wire and wire nails of commerce are manufactured from Bessemer billets. Open-hearth billets are worked up into rods for the manufacture of chain, for special grades of wire, and for various finished products in which high tensile strength is called for. At the upper end of the rod mill are four billet continuous-heating furnaces, with a fifth in reserve. When the mill is in full operation, four furnaces are continually at work. The billets, which are 4 x 4 inches in section and 36 inches in length, are fed transversely into the furnace, side by side, as shown in the accompanying engraving. They are pushed through the furnace door by a hydraulic charging machine, and by the time they have been heated to the proper temperature for rolling, they are pushed one after the other out through the rear door of the furnace, and fall upon a conveyor, by which they are carried down into the rod mill. It should be mentioned that two of these furnaces are fed by producer gas and two by natural gas, which is drawn from a well on the company's premises, the former gas being supplied by five Laughlin producers.



The 8-pass Roughing Mill in Which the Billets are Rolled Down From a 4 x 4-inch to a ¾-inch Square Section.

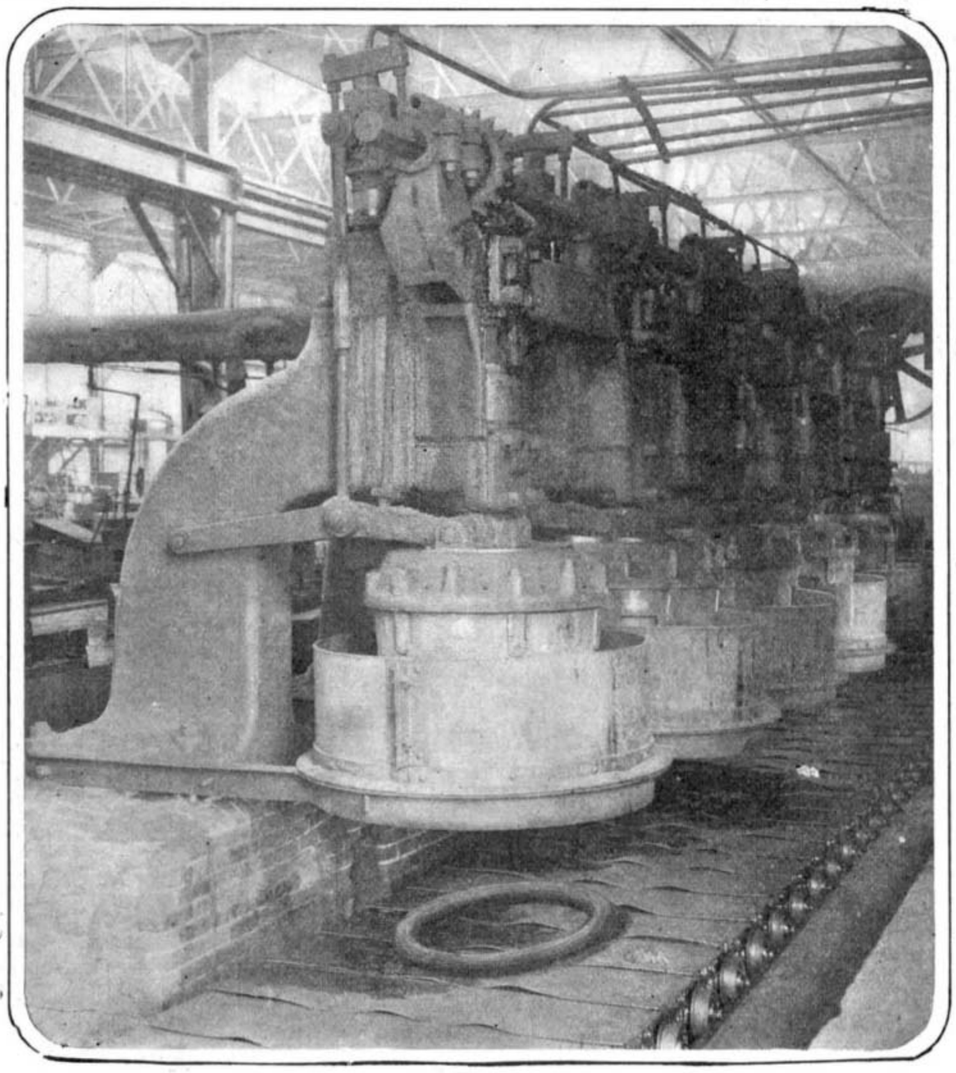
Roughing Mill.—The roughing mill consists of eight pairs of rolls, in which the billet is reduced from a 4-inch x 4-inch section to a ¾-inch square section, and it is in this mill that the steel receives the first installment of that thorough mechanical working which



To the right are seen the three last pairs of rolls of the roughing mill, with two rods passing through them. Extending to the left across the building are the ten sets of finishing rolls with several wire rods following a serpentine course through them. Wire rods are rolled in this mill at the rate of 776 miles in a single shift of 11 hours.

WIRE-ROD FINISHING MILL

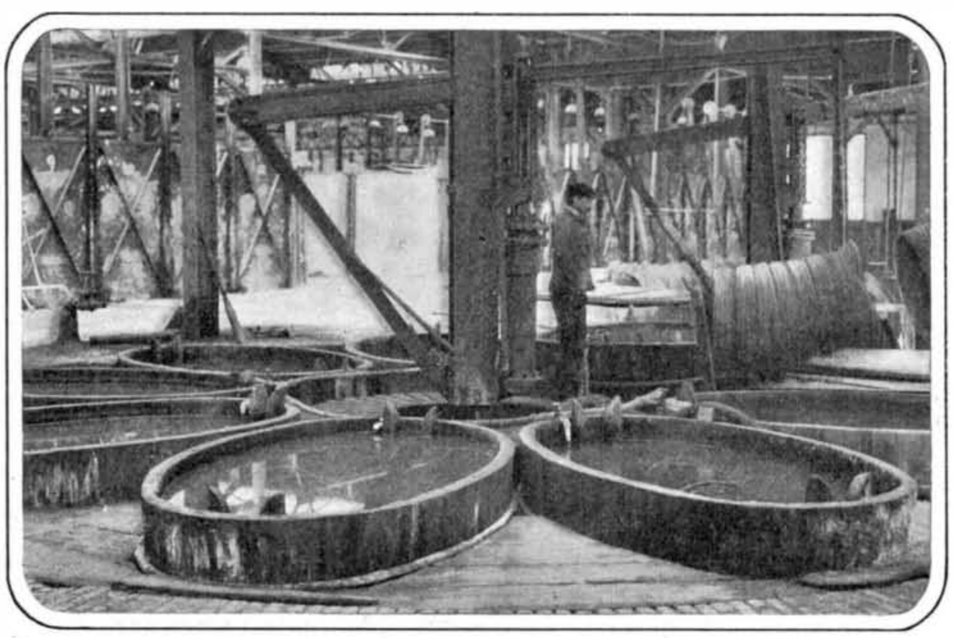
contributes so greatly to its ultimate tensile strength. The arrangement of the mill is shown very clearly in our engraving. Each pair of rolls is placed at an increasing distance from the one that precedes it, in order to allow for the increase in length due to the decrease of section of the billet. It has been found, moreover, that by changing the shapes of the grooves in the successive pairs of rolls, making them alternately square and oval, oval and round, etc., there is not only an economy of power secured, but a more thorough working or manipulation of the metal is obtained, and its qualities are proportionately improved. In the eighth set of rolls, or "pass," as it is technically known, the grooves are three-quarters of an inch square. From these, the last pair of roughing rolls, the rods diverge, some of them being carried to the left, to what is known as No. 1 finishing mill, and others to the right, where they are run through No. 2 finishing mill. The accompanying illustration at the bottom of the page, taken from the upper end of the roughing mill, shows the No. 1 finishing mill, in which the wire rods are given ten more passes and brought down to the required dimensions. The finishing mill lies at right angles to the roughing mill; and instead of the rods passing through pair after pair of rolls in a continuous straight line, they pass through the successive rolls in alternating directions, describing half-circles between each pair, as shown in the illustration. In order to guide the rods into the proper rolls, workmen stand between each pair, and as the rod issues from the rolls it is seized with a pair of tongs, bent around through a half-circle and fed to the next "pass." Consequently, when a rod mill is in full blast, it presents one of the most curious and attractive sights that can be seen in any rolling mill. Owing to the rapid decrease in section and increase in length, as the rod passes through the successive rolls, it is necessary that the speed of the successive rolls be increased; and by the time the rod issues from the tenth roll of the finishing mill, it is traveling at a speed of 1.350 feet per minute, or about 15 miles an hour. Owing, moreover, to the increasing length of the rods as they are rolled down, it happens that although only about two rods at a time are passing through the first of the ten rolls, there will be three or four rods at the fifth or sixth roll, and as many as five or six rods at a time speeding through the tenth or last roll. As the whole of the rolling down from the 4-inch x 4-inch billet to the finished rod, which will be say 13-64 of an inch in diameter, is done at one heat, it can be understood that the scene, when the whole mill is running at full speed, and the white or red-hot steel is winding its serpentine way through the mill, is extremely picturesque, and when seen for the first time, decidedly bewildering. In order to protect the men who stand between the pairs of rolls and direct the course of the rods, a series of curved semi-circular guards or shields are fastened upon the iron floor of the mill, as shown in our engraving, where the course followed by the rods is indicated by a series of white lines. The amount of working to which the steel is subjected in the mills, and the great horse power that is required to perform this duty, may be judged from the fact that the billet, which at the first pass through the mills was 4 inches x 4 inches in section, and only 3 feet long, as it issues from the last pair of rolls is a scant quarter of an inch in diameter and measures no less than 1,189 feet, or not far from a quarter of a mile in length. As the rods leave the last pair of rolls, the ends are caught up and attached to the drums of a set of six Garrett reels, on which they are wound up into a convenient coil for further handling. As soon as the coil is completed, it is dropped from the reel onto the floor of a conveyer, by which it is carried to the wire mill.



As they are completed the coils are dropped on to conveyer and carried to wire mill.

Drums on Which Wire as it Comes From Rod Mill is Wound Into Coils.

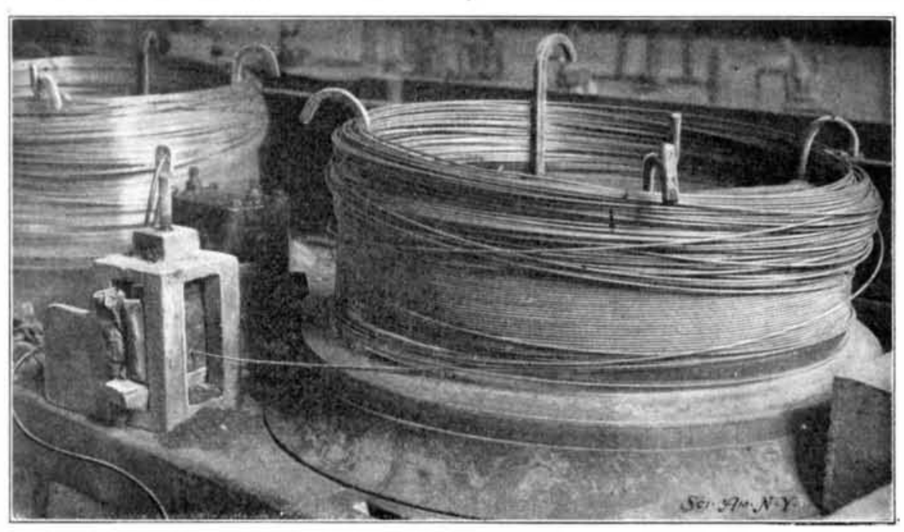
Wire Mill. Cleaning Department.—The first operation in the wire mill is to thoroughly clean the wire, ridding it of scale, oil, dirt, etc. This is done by immersing the coils in wooden vats containing a weak solution of sulphuric acid. The coils are strung on a stout piece of timber, which is lifted by a hydraulic crane and dropped into the vat. There are six of these vats arranged as shown in our illustration. From the vats the coils of wire are lifted and hung upon a circular rack, where they are allowed to slightly oxidize on the surface, the object of the rust being to render it possible to get a good grip upon the wire in the process of drawing it down. The coils are then placed in a bath of lime, which serves to prevent further oxidation, and also to give a slight coating of lime, which will act as a lubricant to the wire in passing through the dies. Next the wire is placed on trucks and taken to the bakeries, where it is dried out thoroughly.



Vats of Dilute Sulphuric Acid in Which Wire is Cleaned Preparatory to Wire-Drawing.

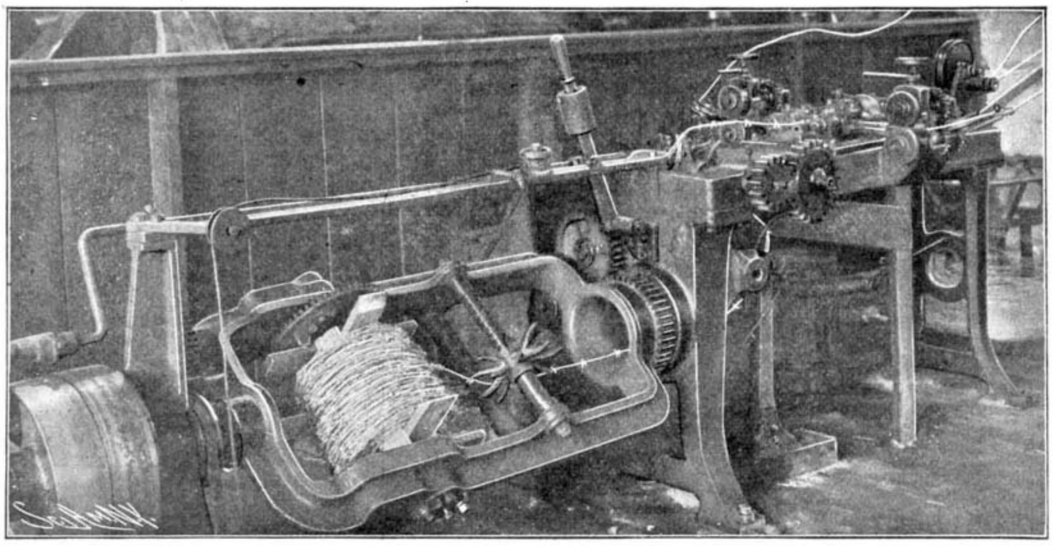
Wire Drawing.—Up to this point the product is known by the technical name of "rods," and it is only after it has been drawn down in the dies that it is known commercially as "wire." Wire drawing is of quite ancient origin, for about the year 1300 A. D. wire was made by pulling it through draw plates. There are descriptions extant of wire-drawing machinery which were published in the sixteenth century, and after that date it gradually took the place of the older method of hammering out the wire by hand, which dates back to some eight hundred years before the Christian era. Wire drawing has the advantage of permitting the production of a much smaller wire than could be produced under the rolls, while the very process of drawing down the wire greatly enhances its physical qualities, increasing the tensile strength to a truly remarkable degree. The wire-drawing machine consists of a stout bench, on which is mounted a strong cast-iron drum, on which the wire is wound as it is drawn through the plate. The draw plates, or die plates, as they are called, are stout blocks of cast steel which are perforated with conical holes, carefully gaged to the exact desired size of the wire. The holes have a slight taper, the wire, of course, entering at the larger end of the hole. The coil of wire is placed on a spool located on the floor of the shop near the bench, and the end of the wire having been swaged down, it is passed through the die plate and attached to the drum, which then

Annealing Room, Where Wire is Subjected to Steady Temperature for Several Hours to Remove Strains.



Wire is Drawn Down Through a Hole in Hardened Steel Plate and Reduced to the Finished Size.

WIRE DRAWING.

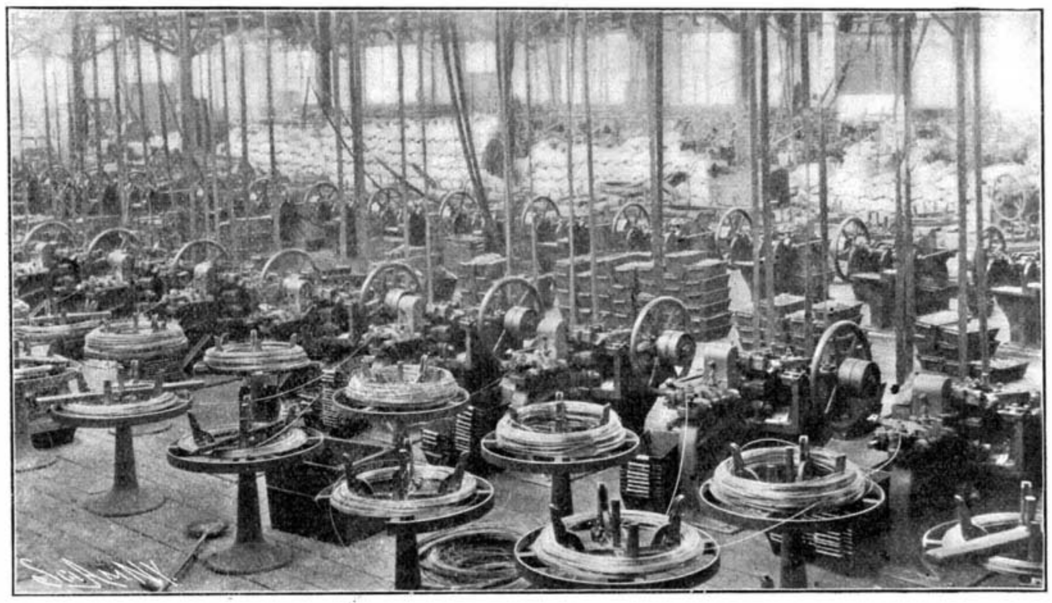


In this department 150 tons of barbed wire are made in a day.

A BARBED-WIRE MACHINE

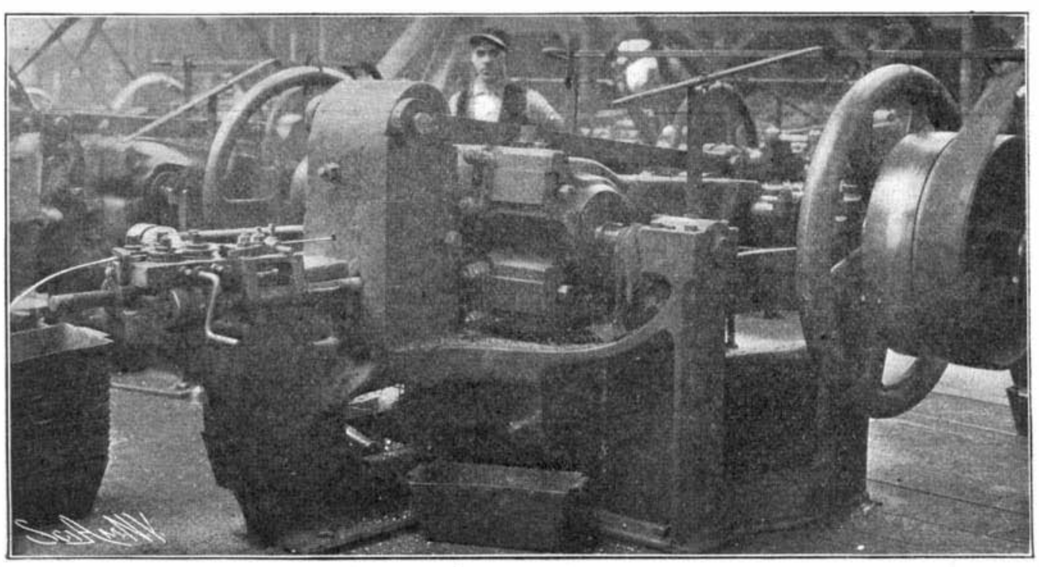
proceeds to wind up the wire until the whole coil has been drawn down. One of our engravings shows a near view of the process of wire drawing. As the wire drawing is done cold, it can be well understood that with several score of these machines running at the same time, it requires very powerful motive power to drive the mill. After it has been drawn down, it is necessary to remove the strains in the wire, and it is accordingly taken to the annealing room, where it is loaded into the large annealing pots shown in our engraving. After the pot is filled, it is carefully sealed with sand to exclude the air, and the wire is exposed to a steady heat for a period of from eight to nine hours. Of the total product, part is now ready for the open market without any further treatment, a small portion of it is sent to the galvanizing room to be galvanized, and a large proportion of it goes to the nail mill to be made up into wire nails or barbed wire.

Nail Mill.—In the nail mill there are no less than 150 separate machines, while there is now under construction an additional mill which will contain 150 more machines. As each of these is capable of turning out from 150 to 500 finished nails per minute, it can be well understood that the nail mill is a very busy section of the establishment. A modern nail machine of the kind with which these shops are filled is one of the best examples of the enormous increase in capacity which has resulted from the introduction of labor-saving machinery. In front of each machine is a reel, upon which the coil of wire is placed. One end of the wire is led into the machine, and as the power is thrown on, one sees the wire disappear through a small hole in the massive vertical casting (see engraving); while to the accompaniment of a rapid succession of blows that sounds for all the world like a Gatling gun in action, a stream of the finished wire nails begins to pour out of the side of the machine into small iron boxes placed to receive them. The wire first passes between two pairs of horizontal, grooved wheels, which are pressed firmly together to give the required tension to the wire as it is drawn into the machine after each finished nail has been formed and cut off. The nail is pointed by the action of a pair of pliers with V-shaped cutting edges, and the head is formed up by the action of a very powerful cam-operated member, which strikes a hammer-like blow. As each nail is finished, the wire is gripped, and enough of it drawn forward to form another nail. The 3-D fine nails are turned out at the rate of 500 per minute, and the large 60-D nails at the rate of 150 per minute. In this mill 4,000 tons of nails are made in a single month, and when the new addition is completed, the capacity will be increased to 8,000 tons. The boxes of finished nails are covered up and taken to big, revolving iron cylinders, known as rumblers, where they are rolled over and over, the nails being thrown against each other and against the sides of the cylinders and receiving that high polish which characterizes the finished product. The time during which they are treated in the rumblers varies according to the size and quality of the wire. A certain amount of sawdust is also used during this process, in order to clean the nails thoroughly of grease and dirt. The nails are then loaded into 100-pound kegs, stenciled with the size and weight of the nails and the makers' name, and taken to the warehouse, shown in the engraving, in which are stored about 140,000 100-pound kegs, weighing in the aggregate some 7,000 tons.



Eight thousand tons of nails are made in this shop per month.

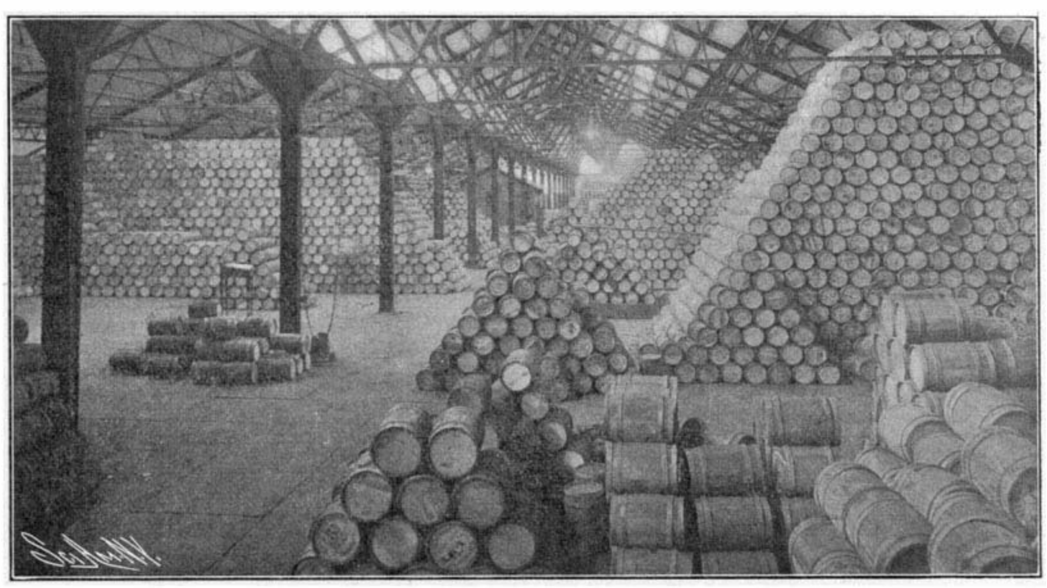
WIRE-NAIL-MAKING DEPARTMENT.



This machine is making 150 60-D nails per minute; three-penny nails are made at the rate of 500 per minute.

A WIRE-NAIL-MAKING MACHINE.

Barbed Wire.—Another interesting department is the barbed wire shop, in which hundreds of the ingenious machines, shown in our engraving, are in busy operation. Back of this machine, which is engaged in making what is known as 2-point Glidden barb wire, are placed four coils of wire, carried on reels. The wire from two spools serves to form the strands, and the wire from the other two spools is used for the "barb." The two strand wires, which are heavier than the others, are led between a pair of friction wheels, and drawn to proper tension. They are then met by the two other strands, which are led in transversely, one on either side. At stated intervals of a few inches, according to the spacing of the barbs, a pair of revolving fingers catch the two barb wires and give them a twist around one of the strand wires, and at the conclusion of the twist two pairs of shears cut the ends of the barb diagonally, giving them the desired sharp points. The two wires next pass downwardly around an idler, and then horizontally into a combined winding and twisting frame. The frame itself revolves on a horizontal axis parallel with the machine, and serves by its revolution to twist the two strands. On a shaft arranged transversely within this frame is carried the barbed-wire spool, on which the finished product is wound ready for the market. When it is once started, the operation is continuous and extremely rapid, 150 tons of finished product being turned out in this department daily.



The nails are put up in 100-pound kegs; this warehouse has a capacity of 7,000 tons.

WIRE-NAIL STOREHOUSE.