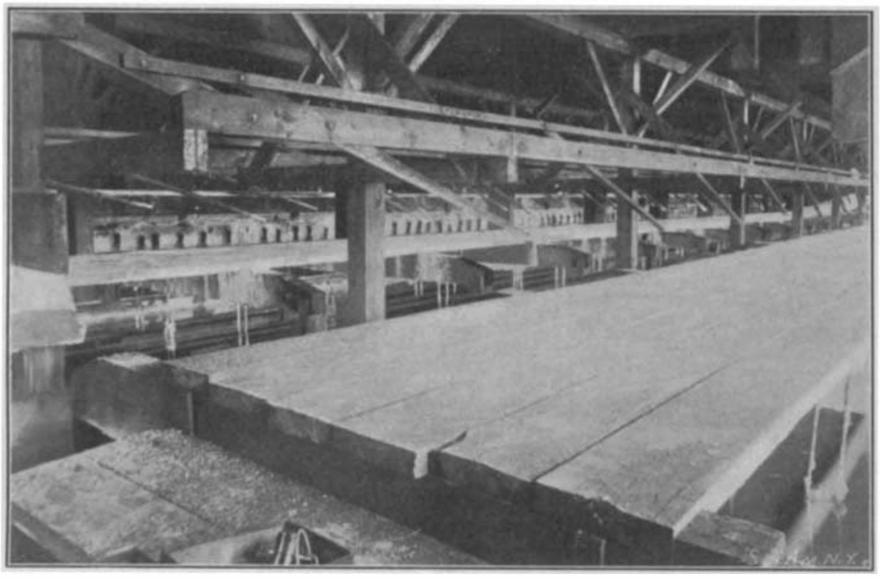
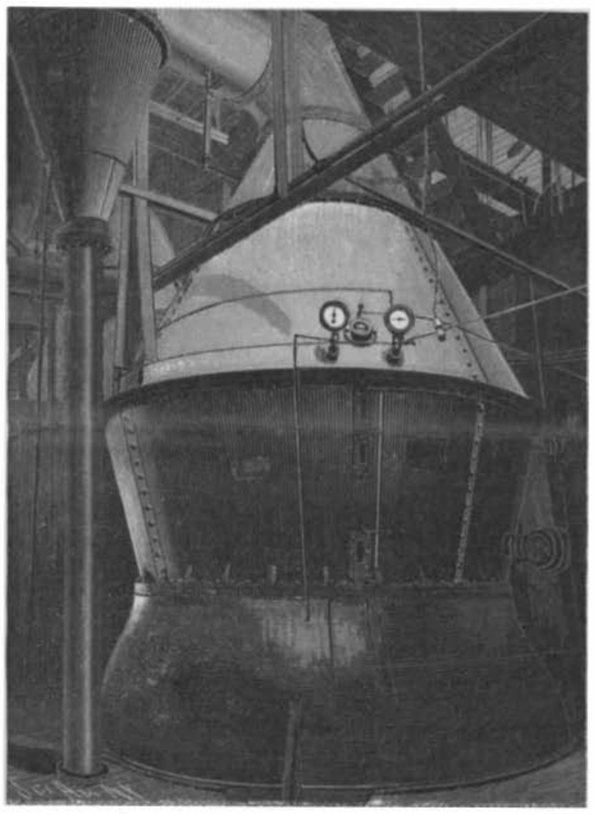
THE MANUFACTURE OF SALT.

Conspicuous among the natural resources of the State of Michigan are the forests which cover a considerable extent of its surface and the large deposits of salt which underlie a great portion of its area. In the vicinity of Manistee, where the "salt blocks" which form the subject of the present article are located, this deposit consists of a stratum of rock salt, which is from 25 to 30 feet in thickness, and lies some 2,000 feet below the surface. Salt blocks are usually built in connection with sawmill plants, with a view to making use of the refuse as fuel; and for this reason the city of Manistee has of late years become such a large producer of salt that about half of all this commodity manufactured in the State is made at that point.

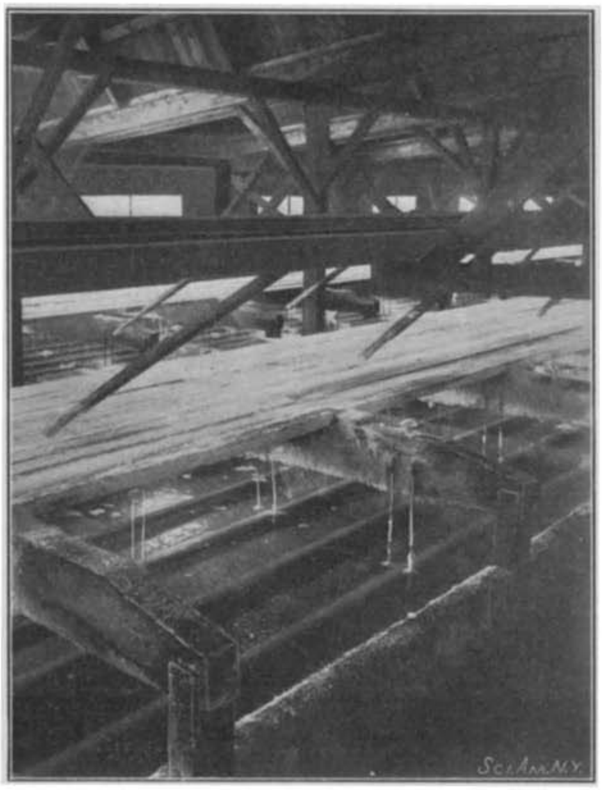


RUNWAY UPON WHICH THE SALT IS SHOVELED FROM THE GRAINER.

As soon as the site of a well has been selected, a cellar is excavated and planked up and a derrick, usually about 80 feet high, is erected and the work of driving commences. The first operation is to sink a section of 10-inch pipe, by means of a sand pump, to a depth of about 400 feet, from which point the well is continued by inserting an 8-inch pipe within the 10-inch pipe and driving it down to the rock formation, the 8-inch pipe extending from the rock up through the 10-inch pipe to the surface of the ground. From the rock formation down, the rock is drilled without any pipe casing, except through such portions as are liable to cave. Salt well No. 5 of the Buckley & Douglas Company's plant at Manistee, which is described in the present article, is fairly typical of the wells in this vicinity. The 10-inch pipe reaches to a depth of 400 feet, the 8-inch pipe to a depth of 616 feet, where the rock formation is encountered. The bed of rock salt, which is 30 feet in thickness, reaches to a depth of 1,985 feet, making a total depth of 2,015 feet. The yield pumped from this well amounts to from 2,000 to 2,400 barrels of brine in twenty-four hours. The same engine, shaft and walking beam used in putting down the wells of this company were formerly utilized to do the pumping, which was accomplished by sucker rods extending down the casing to the pump cylinder in the well pipe. Of late years the air-lift system has been adopted with such good results that 100 per cent more brine is now forced from a well by air than could be raised by the old method. The accompanying diagrams and photographs represent the salt block of the Buckley & Douglas Lumber Company, Manistee, Mich., whose plant is taken as thoroughly representative of the modern state of the art. As the brine is pumped from the well, it is delivered to the storage cisterns, from which it falls by gravity to the settlers, and from the settlers to the grainers. In the settlers it is heated to a temperature of about 170° F. Upon being allowed to cool, the gypsum, which, if it were not removed, would form a coating on the steam pipes in the grainers, is precipitated, and as soon as precipitation is completed the brine is drawn to a long box running across the head ends of the grainers, and from the box it is fed to the grainers as required. The latter are long, shallow tanks, near the bottom of which, and extending throughout their full length, is a series of steam pipes. The brine being admitted to the grainers, the steam is turned on, the liquor soon acquires a high temperature, and rapid evaporation takes place. To assist the precipitation of the grains of salt, the surface of the brine is agitated at frequent intervals by means of a series of paddles which are operated by a lever at the end of the grainer. The salt accumulates at the bottom, until in the course of twenty-four hours there will be a layer from 6 to 8 inches deep. The salt is lifted from the grainer by means of long-handled, perforated shovels, and is deposited on the runway. As soon as it is thoroughly drained, it is shoveled into carts, run out over the storage bin, and dumped.



CONDENSER AND UPPER HALF OF VACUUM PAN.

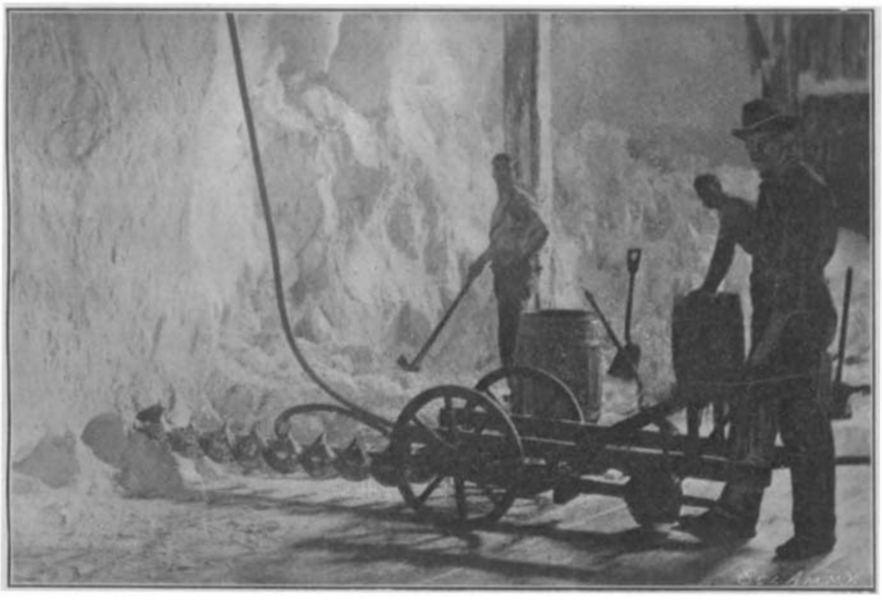


TOP VIEW OF A GRAINER, SHOWING THE BRINE, RUNWAY, AND AGITATING PADDLES.

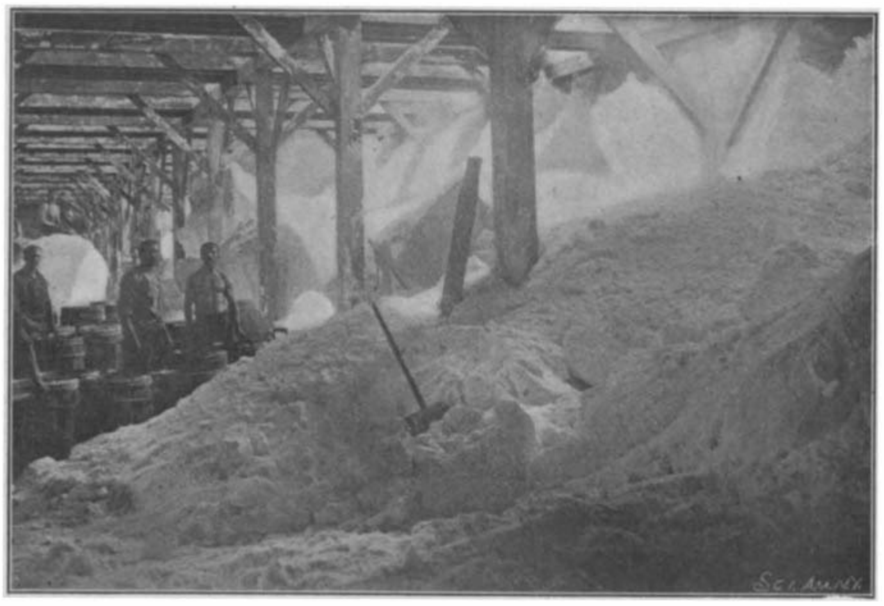
The plant under consideration consists of five wells, three cisterns each 18 feet wide by 100 feet long and 8 feet deep, and six settlers 12 feet wide, 175 feet long, and 8 feet deep, capable of holding about 24,000 barrels. When these cisterns and settlers are all full, they hold enough brine to manufacture over 10,000 barrels of salt.

Part of the salt manufactured in this plant is made by the vacuum-pan process, for which purpose two pans are in use. The general arrangement of this plant is shown in the accompanying line drawings. The pan itself has a diameter of 11 feet at the steam-belt, *B*, and stands about 50 feet in height. The steam belt consists of two copper heads connected by 1,100 copper tubes 2⅜ inches in diameter and about 4 feet 6 inches in length. There is also a large central tube which is about 3 feet in internal diameter. Below the steam belt the pan tapers to a pipe 12 inches in diameter that leads to the foot of an endless-belt elevator, which carries the salt up to the storage bin, *V*. Above the steam belt the pan enlarges to a diameter of about 15 feet and then contracts to form a 4-foot elbow, which enters the condensing chamber. The water for the condensing chamber enters at the top of the same, falls upon the spray-plate, *D*, and, after having absorbed the steam from the vacuum pan, passes down through the water pipe, the foot of which rests in a sealing tank, *H*. The evaporation is assisted by an air pump, *E*, the suction pipe from which enters the condensing chamber near the water inlet, and reaches to a point just below the spray plate.

In operating the plant the pans are first filled by gravity, after which the gravity supply pipe is closed, and the valve in the pipe connecting with the settlers, *R*, is opened, the brine being drawn into the pans by the vacuum therein as the evaporation proceeds. The water and the air pumps are inserted, steam is admitted to the steam belt, and the process of manufacturing salt begins. The atmospheric pressure being removed from the surface of the brine, the latter boils violently at a temperature which seldom rises above 150° F. The brine rushes upward through the tubes, and under the rapid evaporation the brine becomes so dense that it can no longer hold the salt in solution. Fine crystal grains are formed, as the liquid circulates through the large 3-foot opening in the steam belt, and falling to the bottom of the pan they pass to the foot of the elevator, whence they are taken up and dumped into the drainage bins. After the salt has remained in these bins for a period of sixteen to eighteen hours, it is drawn off into carts, wheeled to the storage bins and dumped. It is customary to use the pans for not longer than twelve consecutive hours, at the end of which period



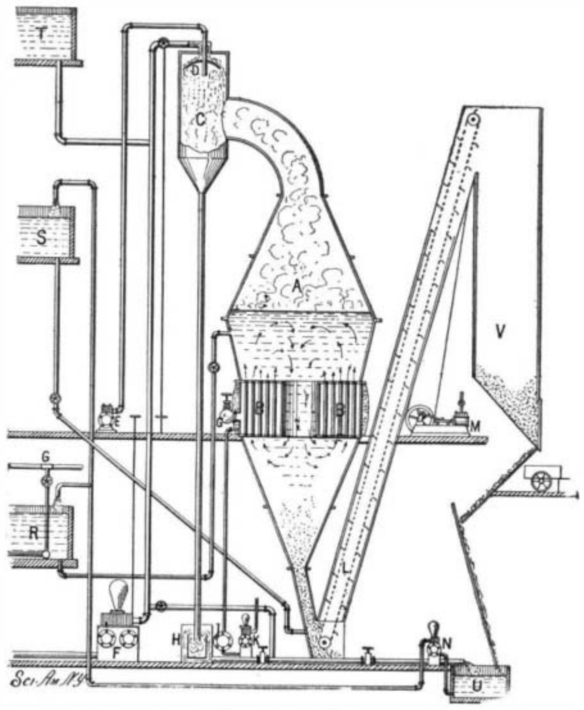
COMPRESSED AIR AUGER FOR LOOSENING COMPACT WALL OF SALT



SALT PACKERS AT WORK IN THE STORAGE ROOMS.

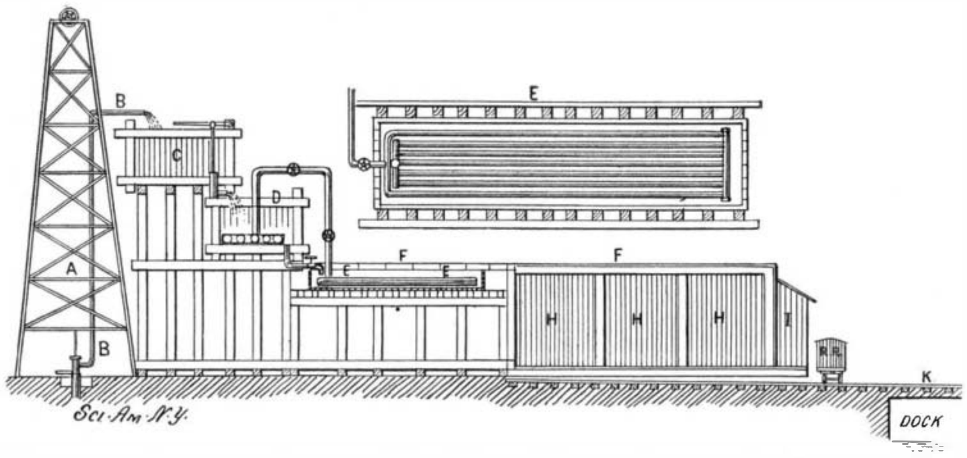
they are emptied, boiled out with fresh water, and cleaned. One of the pans is run during the day and the other during the night, each pan making in a twelve hour run from 600 to 700 barrels of salt, the combined production being from 1,200 to 1,400 barrels a day.

In the manufacture of salt it is a recognized necessity that a large quantity must be kept in storage, and for this purpose the salt is dumped into vast storerooms which measure from 200 to 300 feet in length, and the same in width; the amount in store frequently aggregated 400,000 barrels. As these rooms are from 16 to 20 feet deep the salt becomes tightly packed, and has to be worked loose by packers with picks, shovels, grubhoes, etc., who proceed to quarry, break up and pack the salt into barrels. With the coarser grades of salt made in the grainers this is not a difficult matter, but the finer grained, vacuum-pan salt becomes compact and very hard, and the packer soon finds himself confronted by a wall of salt 20 feet in height and as white, if not as hard, as marble. To undermine and bring down this mass of salt is a dangerous operation, and involves long delays; and to overcome these difficulties, the companies have used a compressed-air driven spiral auger, which is 10 inches in diameter and provided with a double spoon point. The auger is mounted on a truck and the back end of the shaft is attached to a 3 horse power Boyer rotary air drill machine. A row of holes is driven into the salt wall at a height of 10 inches from the floor for a distance of 6 feet into the mass, the holes being drilled as closely together as possible. After an interval of one to three hours, a fall of salt takes place, a mass equal to 400 or 500 barrels of salt being brought down in each section. The saving of labor by the use of the compressed-air drill is shown by the fact that sufficient salt can be undermined and caved in this manner in one-half day to keep the packers at work for two or three days following.



A, vacuum pan; *B*, steam belt; *C*, condenser; *D*, spray plate; *E*, air pump; *F*, cold water pump; *G*, steam pipe; *H*, sealing tank; *K*, hot water pump; *L*, elevator; *N*, brine pump; *R*, brine settler; *S*, brine tank; *T*, water tank; *U*, brine vat; *V*, drainage bin.

VACUUM PAN PLANT.



A, well derrick; *B*, brine pipe; *C*, cistern; *D*, settler; *E*, grainer; *F*, runway; *H*, store bins; *I*, packing shed; *K*, salt car tracks; *E*, grainer.

A SALT BLOCK GRAINER.

MANUFACTURE OF GUNS AND ARMOR AT THE BETHLEHEM STEEL WORKS.

II. FLUID COMPRESSION AND FORGING.

Our first article of the present series on the manufacture of guns and armor was devoted to the Open Hearth process, which, it will be remembered, is used exclusively in the manufacture of steel at the Bethlehem Works. We have seen that steel which is to be worked up into armor plate is cast in huge ingots, the largest of which will weigh as much as 135 tons apiece; while the steel which is to be forged into guns (technically known as "gun steel") is subjected to what is known as the Whitworth fluid compression treatment, which is designed to secure in the ingot that density and freedom from internal cavities, flaws, and impurities which is indispensable to the production of the highest class of forgings. The same results are obtained in the armor plate ingot (though in a lesser degree) by casting them with a considerable excess of metal known as the "sinking head," which serves to compress the cooling ingot and collect the impurities at the surface.

Fluid compression, then, is designed to remove certain defects which are common to all steel ingots not so treated. Chief among these are "blow holes," "piping" and "segregation." When the metal is being poured into the mould, air is apt to be drawn in with it, producing cavities in the metal, a defect which is also liable to be caused at certain stages of the cooling of the ingot by the generation of gas within the body of the metal. The most efficient way of getting rid of this trouble is to subject the molten metal in the mould to heavy compression during the process of cooling. One of our illustrations shows the massive 7,000-ton press in which all the gun steel is treated immediately upon being drawn off from the furnace. The mould is built up of massive cylindrical segments to the desired height upon a movable platen, which is located at the bottom of the casting-pit. After being filled with fluid steel the mould is run under the hydraulic press and the steel is subjected to an increasing pressure. As a result, the formation of blow holes is completely prevented.

"Piping" is the formation of a hollow cavity through the center of the ingot. It is due to the fact that the metal solidifies first at the surface of the mould and, as it cools, shrinks away from the center and from the top, leaving a long, axial cavity through the ingot. In the big armor-plate castings, the extra metal in the sinking head is added to allow it to flow down and compensate for this shrinkage; while in the fluid compression process the hydraulic pressure forces the fluid metal of the upper part of the mould down through the center, thus securing the same result, but with a greatly improved density, due to the enormous pressure applied.

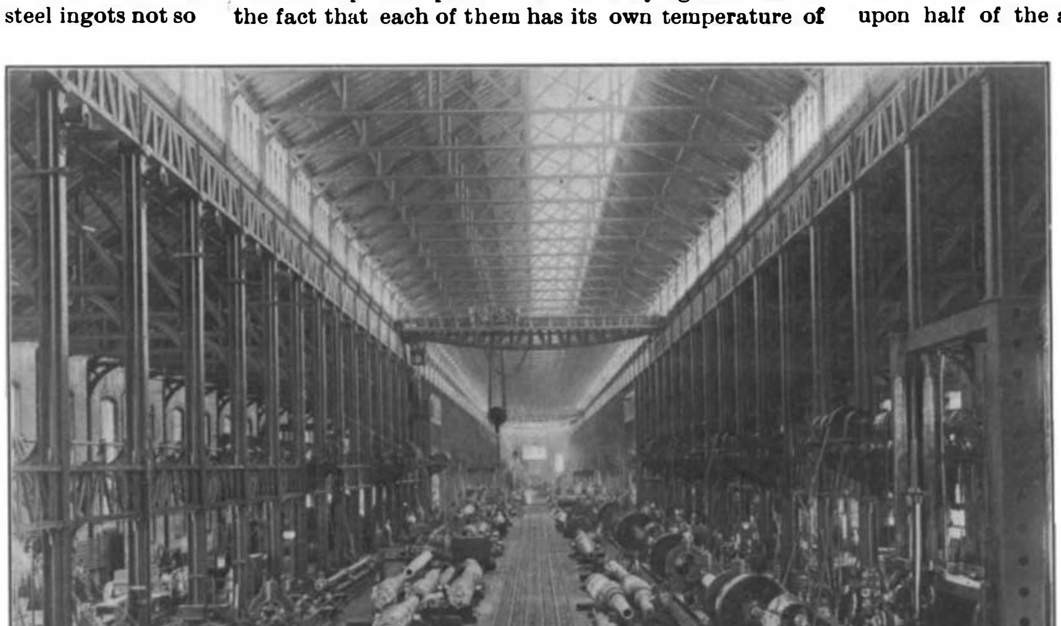
"Segregation" is a mechanical and chemical separation of the component parts of the solidifying steel due to the fact that each of them has its own temperature of cooling. Unfortunately, as the mass cools, each of the ingredients (sulphur, phosphorus, silicon, manganese, etc.) tends to flow toward the central and upper portions of the ingot, thus forming a central core of less purity than the body. Fluid compression greatly mitigates this tendency, and causes the segregation to take place toward the center and toward the upper extra length of ingot. Blow holes being absolutely prevented, the result is an ingot that is perfectly solid throughout its whole mass, while the segregation is removed by cutting away the head and boring out the central core before forging.

The fluid press, like much of the plant at this establishment, is of truly monumental proportions. It consists of an upper head weighing 120 tons, in which is carried the plunger, a 135-ton base containing the hydraulic cylinder, and four vertical connecting screws, each 50 feet long and 19 inches in diameter. The base is located entirely below the floor of the pit, and in our engraving only the head of the piston is visible. Above the piston is placed the platen upon which the mould is built up. The moulds vary in diameter and height, according to the size of the ingots. A plunger, to match the internal diameter of the mould, is attached to the head, and as the mould is raised the plunger bears down upon the fluid metal, preventing its escape.

As soon as the ingot has cooled it is taken from the mould and placed upon the lathe, and the extra length cut off and returned to the scrap heap. It is then placed in a boring mill and an axial hole bored through it. After this, it is reheated in a large gas-fired furnace, a process which must be carried out slowly, great care being taken to let the heat penetrate the metal uniformly; for sudden heating of the exterior while the interior was yet relatively cold would further increase the heavy strains which are set up in the ingot during the process of cooling. The ingot, it must be remembered, cools from the outside and shrinks away from the interior, and when it is cold the interior is in a condition of strain. If the reheating were done too rapidly, the surface metal would be pulled away still further from the center and the strains increased.

In the manufacture of gun steel, with which we are now dealing, the risks of overstrain during the heating are greatly reduced by what is known as hollow forging. Before reheating, as above stated, the ingot is put in the lathe and bored throughout its whole length, an operation which not only allows the heat to act more evenly on the mass of metal, but also serves to get rid of the impurities due to segregation, which, as we have already seen, gather in the center of the ingot. The boring out of the center permits the heat to act from the center outward as well as from the exterior inward, with the result that the metal expands evenly throughout its whole mass, and the danger of cracking is entirely removed. After the ingot has been raised to a temperature from 1,800 to 2,000 degrees, a steel mandrel is placed through its center, and it is picked up by a powerful overhead crane and taken to the hydraulic forging press. The mandrel serves in some sense as an internal anvil, and the work is concentrated upon half of the amount of metal that it would act upon if the piece were solid throughout. The consequence is that the metal receives more of that "working" which is the very essence of first-class forging.

There has been a radical change in the last few years in the methods of producing heavy forgings. The blow of the steam hammer has given place to the steady pressure of the hydraulic press. The pressure applied in forging a piece of steel should be of such a character as to penetrate to the heart of the metal, causing a flow of the metal to occur throughout its whole mass. Naturally the flowing of the metal requires that the proper amount of pressure shall be maintained for a sufficient period. The sharp, heavy blows of the hammer, it has been found, do not penetrate the mass of forging, nor do they produce the desired flow. In the earlier forgings, particularly those that were made for the shafts of steamships, the interior was found to have been but little affected by the forging and to be practically in the condition which it held in the ingot state. On the other hand, the slow-



Length, 1,375 feet; width, 116¼ feet.

BETHLEHEM STEEL WORKS—THE GUN-FINISHING MACHINE SHOP.