SCIENTIFIC AMERICAN

ESTABLISHED 1845

MUNN & CO. - - Editors and Proprietors

Published Weekly at

No. 361 Broadway, New York

TERMS TO SUBSCRIBERS

One copy, one year, for the United States, Canada, or Mexico........$3.00
One copy, one year, to any foreign country, postage prepaid, £0 16s. 5d. 4.00

THE SCIENTIFIC AMERICAN PUBLICATIONS

Scientific American (Established 1845) ....$3.00 a year
Scientific American Supplement (Established 1876)............... 5.00 "
American Homes and Gardens... 3.00 "
Scientific American Export Edition (Established 1878).......... 3.00 "

The combined subscription rates and rates to foreign countries will be furnished upon application.

Remit by postal or express money order, or by bank draft or check.

MUNN & CO., 361 Broadway, New York.

NEW YORK, SATURDAY, JULY 14, 1906.

The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

TUNNELING BY THE FREEZING METHOD UNDER THE EAST RIVER.

In nearly all sub-aqueous tunneling as at present practised, air pressure within the tunnel of sufficient strength to counterbalance at the heading the pressure of silt and water is obligatory. The increase of pressure required above that of the atmosphere is approximately one pound per square inch for every two feet of depth. With a small tunnel of, say, six feet bore, the difference of pressure required between the top and bottom of the tunnel is slight (three pounds), but with a tunnel of a large diameter (twenty-three feet) such as is required for a railway, this difference in pressure becomes four times as great. As the air pressure at the top of a tunnel heading of the latter size is some ten or twelve pounds greater than is needed to properly counterbalance the inward pressure of sand or silt at that point, there is a constant seepage of compressed air through the river bed. This tends to loosen the material of which the bed is composed, and if the thickness of silt is not sufficient, or if its consistency is not good, there may be a blowout, whereby a hole is made in the bed of the river and the tunnel is liable to be flooded. The expedient must then be resorted to of dumping clay upon the bed of the river, in order to strengthen it and fill the hole, as well as to increase the depth of earth above the tunnel roof.

In the two tunnels now being constructed for the Pennsylvania Railroad Company under the East River, there have been a considerable number of blowouts. These occurrences are rather spectacular, as a great column of water is projected twenty-five feet or more into the air. They have been the object of much comment from the newspapers. According to the engineer in charge of the work, however, these blowouts have not been more numerous than was expected. The method of stopping them by dumping clay upon the river bed is an old one, it having been first used some seventeen years ago by the same engineer in the initial work upon the Hudson River tunnel. This engineer is the man who superintended the construction of the Blackwall tunnel under the Thames, in which case there was a distance of five feet intervening between the top of the tunnel and the top of the river bed. A blanket of clay fifteen feet thick was deposited upon the river bed at this place, and the tunnel was driven without any blowouts. Somewhat similar conditions have been met with on the west shore of the East River. The twin tunnels, which are only fourteen feet apart, start from a shaft which was sunk at the edge of the river, and run for about one hundred feet through solid rock. As they emerge from this rock, the face of which forms a gradual incline, they run partly through rock and partly through sand. At this point there was but ten feet of sand above the line of the tunnel, and it was necessary to dump clay upon the river bed in order to obtain a total thickness of twenty feet. After the tunnel had been completed for about one hundred to one hundred and fifty feet, this clay was removed and discharged farther out in the river, thus making it possible to push forward another section of tunnel. This, it will be seen, is a rather laborious method of preparing the way for the tunnel, but despite the fact that this method had to be resorted to for a considerable distance from shore, the tunnels have advanced at an average rate of from five to eight feet a day. The contract time for the completion of the tunnels expires in a little over two years hence. In order to complete them within this time, the contractors have only to progress at the rate of three or four feet a day. Thus it will readily be seen that in all probability they will be able to carry out their contract. Of the four tubes being run under the river, one of each pair has been pushed forward 600 feet from the shaft on the Manhattan shore, while the other two have gone out 110 and 250 feet respectively, the former being just about to emerge from the rock, while the latter is in the section consisting of rock and sand. The reason that one tunnel of each pair is being pushed forward instead of the two is that the contractors did not want to run the risk of a blowout in one tunnel affecting the work in its twin. This would not be liable to happen if one of each pair was pushed forward, since the two pairs of tunnels are 150 feet apart. The total distance under the river is about 4,000 feet. The two tunnels that are farthest along have reached the point of greatest depth—83 feet—below the surface of the river. The tunnels which are being driven to meet these from the Long Island side have been constructed for a distance of 1,500 feet from East Avenue, Long Island City, and they are already out some little distance beneath the surface of the river. At just what point the tunnels being driven from the two shores will meet, it is at present difficult to say. The Blackwell's Island ledge of rock must be penetrated at the center, and the probabilities are that the western tunnels will be driven through this rock, and will meet the eastern tunnels on the other side of it.

With a view to using it in future tunneling operations, the Pennsylvania Railroad is experimenting with a new system which was invented by Mr. Charles Sooysmith, and which consists, in the main, in first driving a small pilot tunnel and then, after installing in it a series of circulating pipes, of freezing the moist material around the tunnel a sufficient distance to allow of enlarging the smaller tunnel in the frozen silt. In order thoroughly to test the practicability of this idea, the company drove, from the base of an eighty-foot shaft located at the foot of East Thirty-fifth Street, a seven-and-one-half-foot tunnel, 160 feet long, out beneath the surface of the river. The least depth of material above this small tunnel is about twenty feet. Placed longitudinally along the walls of the tunnel, throughout its entire circumference, are a series of pipes for the circulation of the brine of a refrigerating plant located on the pier. By means of this arrangement a temperature of about 35 deg. Fah. below zero has been constantly maintained in the tunnel for some months, with the object of freezing the sand to a radial distance of thirteen and three-quarters feet. At different points in the tunnel holes have been pierced through the cast-iron shell, and run at varying distances into the sand. Sealed in these holes are thermometers with electric recording devices, which record the temperature constantly at the different depths. The result reached thus far is that the sand has been frozen about the tube a distance of nine feet in all directions, so that about two-thirds of the distance to be frozen has already been reached. The idea is to obtain a frozen cylinder thirty-five feet in diameter, or twelve feet larger in diameter than the completed tunnel. There will thus be a ring of frozen earth six feet thick to sustain the pressure of sand and water above and around the larger tunnel while the plating is being placed. By removing the plates of the small tunnel and quarrying out the frozen material, the enlargement of the tunnel can thus be accomplished without the use of any compressed air and without the danger of blowouts. It is estimated that the enlargement of a tunnel by this method will require from three to six months. The pilot tunnel can be driven in half the time required to construct a full-sized tunnel, and as all delays from blowouts would be avoided, it seems probable that a gain might be made in the time required for construction as well as in the cost of building. Perhaps the greatest advantage would be found in the fact that no air pressure would be required, and, consequently, there would be no delays to the work nor loss of life from this cause. In the present East River tunnels, according to the statement of the engineer in charge, fourteen men have succumbed as the result of working in the high pressure (thirty-four pounds to the square inch above atmosphere), while the work has been greatly delayed by the frequent necessity of changing the pressure when different kinds of material were being passed through.

THE GOVERNMENT AS AN ARMOR-PLATE MANUFACTURER.

Another periodical investigation of the armor-plate industry of this country is about to be undertaken. The House of Representatives has instructed the Secretary of the Navy to ascertain whether or not it is advisable to establish a government mill, thereby placing once more upon record its dissatisfaction with the present methods of obtaining armor plate for our navy.

So highly specialized is this industry of making armor plate, that it may well be doubted whether the government can very successfully compete with the Carnegie, Bethlehem, and Midvale companies, the only three firms which now maintain properly equipped mills for the rolling of armor. Many years ago, long before the Midvale company was started, the public harbored dark suspicions of a secret understanding between the Carnegie and Bethlehem companies whereby the price of armor plate was maintained at an inordinately high figure. Although the investigation which was then instituted for the purpose of determining the advisability of establishing a government plant failed to expose any such dishonest agreement, it may be questioned whether these gloomy doubts were ever removed. The new investigation which has been ordered would seem to show that they still linger.

A very cursory examination of the armor-plate industry should convince even the most ardent advocate of the Federal making of armor how hopeless a competitor of the private steel mills the government would be. In the first place, a plant must be designed and constructed at an expense that may, perhaps, be utterly disproportionate to the cost of its product for many years. In the second place, not every engineer is capable of designing a great mill, and the competent men are in the permanent employ of the great steel mills on a salary princely in comparison with the small sums the government usually doles out to its employés. It may be that Congress by appropriating the necessary funds for the employment of able engineers may overcome this obstacle. Still, the difficulty remains of obtaining efficient workmen. Whatever may be the willingness of Congress to set aside funds for the designing and building of a plant, it is questionable whether it would be willing to pay the salaries now drawn by the superintendents and higher officials of the larger steel mills. To add to the possible troubles in which the government may be involved, we must mention the difficulties which would be presented by the labor unions. The private steel mills have the great advantage over the government in having at their command a large force of picked technical experts skilled by long years of experience in manufacturing armor plate for the special tests which it must withstand at the hands of the government inspectors. Because the labor unions make no distinction between capable men and incapable and because they will tolerate no attempt on the part of employers to pay a competent man more for his labor, the private mills have rid themselves of men whom they could ill afford to pay the disproportionately high wages demanded and have retained only the very flower, as it were, of their operatives. The government can, therefore, hope to secure for its own mill (if it should ever be constructed) merely the discarded labor of the Bethlehem, Carnegie, and Midvale plants. An edifying picture of the possible results of such a course is to be found in the government printing office.

THE CANADIAN COMMISSION'S REPORT ON THE ELECTRIC SMELTING OF IRON ORES.

The preliminary report of the commission appointed by the Canadian government to inquire into the advisability of establishing a plant for the smelting of iron ore by electricity will not be deemed as illuminating or as exhaustive by those metallurgists who had hoped to find in it more trustworthy information than the desultory papers scattered through the technical press are able to impart. The chief criticism to be leveled at the report is to be found in the fact that the experimental plant, the operation of which constitutes the chief topic of discussion, was not worked for protracted periods under commercial conditions, and that the efficiency and cost data given are based on a few very good performances which may or may not be repeated in active practice. Realizing that the conditions which underlie the electrical reduction of iron in Europe must necessarily be different from those which obtain in Canada, it was determined to build a plant at Sault Ste. Marie for the purpose of ascertaining the cost of electrical reduction in Canada. Basing its estimate on a 10,000-horse-power hydro-electric plant, equipped with furnaces for producing 120 tons of iron during a day of twenty-four hours, the commission found as a result of its experiments that a ton of pig iron could be made for $10.69. Assuming that furnaces and accessories would cost $100,800, a charcoal plant $50,000, a power plant $500,000, and a furnace electrode plant $6,000, making a total of $656,800, and, furthermore, allowing 15 per cent for depreciation, interest, and amortization, the commission figures that the cost would be about $2.43 per ton of iron produced. Unfortunately this estimate is based upon the production of 4.32 tons of pig iron per horse-power year, which was obtained only in one instance. Apparently no estimate is available on continuous operation under commercial conditions for any extensive period.

It may be that a plant designed and operated continuously on a large scale would be able to produce its pig iron at a cost within the figures given by the report. Still we are hardly justified in making that assumption on the basis of the experimental tests conducted at Sault Ste. Marie.

A NEW ALGOL VARIABLE.

A few Harvard plates examined by Mrs. Fleming led to the discovery of an interesting variable, RR Lyrae, 192242, described in Harvard Circular 54. From a similar examination of recent plates, Mrs. Fleming