

IRON THAT WILL NOT RUST.

In 1856 Sir Henry Bessemer invented a process of steel making which revolutionized the iron and steel business. By this method it was possible to turn out an immense tonnage at a low cost and with a low percentage of carbon and manganese. To be able to produce in large quantities and at a low cost a metal which had even greater tensile strength and ductility than good iron, at once enabled steel to take the place in commerce hitherto held by iron.

While steel had a greater tensile strength and greater rigidity than iron, it had certain limitations which have grown increasingly apparent. These limitations appear in the use of steel where it is subject to severe corrosive agents; as, for example, in the atmosphere of cities impregnated by the fumes of gas or coal smoke, at the seashore with its salt air, in the ground with its dampness, or in localities where it becomes the intermittent conductor of electrical currents. Steel has come to be considered, under these conditions, and notwithstanding its extreme hardness of texture, a comparatively short-lived metal.

Iron nails, taken from demolished houses that were built in the eighteenth century, are handed about as curios; for to-day, in many a shingled roof, the shingles outlast the steel nails. The Department of Agriculture voiced the sentiments of the farmer when it urged upon wire makers the necessity of improving the character of the wire fence, so that the farmer

slag distributed throughout iron was believed to act as a rust preventive.

The same authority says: "If we accept the electro-chemical explanation of the corrosion of iron, there can be no doubt that conditions which inhibit electrolytic effects also inhibit corrosion, and *vice versa*. The purer the iron in respect to certain metals which differ electro-chemically from iron, and the more carefully the lack of homogeneity and bad segregation are guarded against, the less likely are the electrolytic effects to become serious. These points constitute the essential problems which confront the manufacturer who desires metal that will have a high resistance to corrosion."

A few years ago the American Rolling Mill Company, of Middletown, Ohio, began to investigate the possibility of producing from their open-hearth furnaces, from which they were making high-grade steel by the usual method, a steel very low in carbon and manganese. The success achieved in this direction suggested that it might be possible to reduce the scrap and pig iron to a molten mass in an open-hearth furnace and cast it into ingot iron, without introducing the impurities that are known to be active agents in corrosion.

In making steel by the open-hearth process, the furnace is charged with many tons of selected scrap and pig iron, and the charge is raised to a sufficient temperature to burn out the carbon and the greater part

"The above material," says the report, "is very exceptional for its purity, and is the most non-corrosive material that I have examined."

Four specimens of ingot iron subjected to tests to determine its tensile strain showed the following results: Breaking strain per square inch, from 49,857 pounds to 51,905 pounds; limit of elasticity per square inch, from 35,395 pounds to 41,377 pounds; elongation per cent of length, from 40 per cent to 48 per cent.

We present a set of comparative illustrations, showing the results of corrosion tests on various articles of commerce, one of each pair being made of the new ingot iron, and the other of steel or other material. In every case, both specimens were immersed in a bath of 25 per cent sulphuric acid. The ingot iron and charcoal eyebolts were treated in the bath for six hours, at the end of which time the ingot-iron eyebolt showed a loss of 15.5 per cent, and the charcoal-iron eyebolt a loss of 77.3 per cent. In a five-hour test of two railroad spikes, the ingot-iron specimen lost 11.2 per cent, and the steel spike 79.1 per cent. Even more remarkable was the comparison of ingot-iron and barbed-wire fencing material, the steel wire losing 92.3 per cent at the end of one and a half hours, and the ingot-iron wire losing only 6.1 per cent. In a forty-five minutes' test of two nails, the steel nail lost 68.9 per cent, and the ingot-iron nail 4.13 per cent. The two specimens of corrugated roofing material were placed in the bath for fifty minutes, at the end of which time the steel



Ingot iron.
Loss, 15.5%.

Charcoal.
Loss, 77.3%.

Ingot iron. Steel.
Loss, 4.13%. Loss, 68.9%.

Ingot iron. Steel.
Loss, 6.1%. Loss, 92.3%.

Ingot iron. Steel.
Loss, 2.4%. Loss, 78.2%.

Ingot iron. Steel.
Loss, 11.2%. Loss, 71.9%.

CORROSION TESTS IN BATH OF 25 PER CENT SULPHURIC ACID.

using it would not have to renew it every five to nine years. The thrifty housewife, pleased with the beauty and strength of her new galvanized water pail, is surprised and indignant at having her maid call her attention, as it seems to her after a very short time, to the holes in the bottom.

It is generally considered a plausible, if not demonstrated theory, that this fugitive nature of steel comes from its chemical structure. The elements introduced into the molten mass of iron in the furnace and in the ladle to convert iron into steel are essentially impurities. Under certain conditions an electrolytic action is set up within the structure of the steel between these impurities, with a resultant disintegration of the metal.

There is a growing conviction that the corrosion of metals is due to this electrolytic action. According to the latest theory, rusting commences on the surface of the metal because of a difference of potential there, a condition which is due to the impurities in the metal, such as carbon, sulphur, phosphorus, and particularly manganese. Dr. A. S. Cushman, in a pamphlet entitled "The Corrosion of Fence Wire," published by the United States Department of Agriculture, arrived at the conclusion that steel corroded more rapidly than iron for several reasons, chief among which were the following:

First. The presence of and the irregular distribution of manganese in steel, there being little if any of that substance present in iron.

Second. The greater destruction of steel by electrolysis as compared with iron, due to the presence of manganese and various metalloids in greater quantities than in iron.

Third. The absence of slag in steel, whereas the

of the other impurities. When these have been reduced to the desired extent, a predetermined amount of carbon and, in particular grades of steel, of other ingredients, is added to the molten metal, until its composition has been brought to the exact point called for by the specifications for the particular grade of steel which is being made. In the experimental work of the company above referred to, the treatment was entirely one of elimination, the effort being to get rid of practically the whole of the impurities, and bring the metal as nearly as possible to the condition of absolutely pure iron. They carried the process of burning out the impurities even further than is done in the manufacture of commercial steel; and there the process stopped, leaving in the bath a remarkably pure iron, which was subsequently cast into ingots, and was available for use in the rolling mills and elsewhere for manufacture into commercial products.

An analysis of this iron in comparison with commercial steel, as made by William M. McPherson, professor of metallurgy, Ohio State University, Columbus, Ohio, showed the following results:

| | Steel. | American Ingot Iron. |
|------------------|----------------|-------------------------|
| Sulphur | 0.048 per cent | 0.021 per cent |
| Phosphorus | 0.094 per cent | 0.005 per cent |
| Carbon | 0.11 per cent | 0.02 per cent |
| Manganese | 0.47 per cent | Trace |
| Silicon | Trace | Trace |

The corrosion test of the above samples, which were immersed in a 5 per cent solution of sulphuric acid for twenty-four days, showed:

| | |
|--------------------------------|----------------|
| Loss, steel | 14.41 per cent |
| Loss, American ingot iron..... | 0.21 per cent |

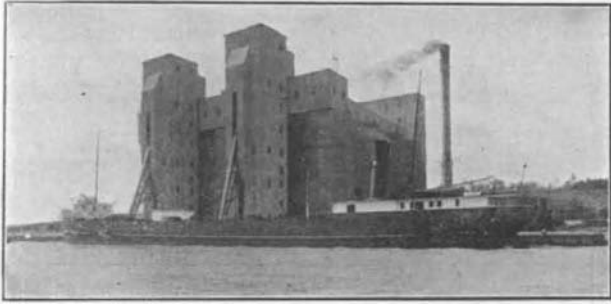
specimen had lost 78.2 per cent, and the ingot iron 2.4 per cent.

CHICAGO'S SIXTY MILES OF FREIGHT SUBWAY.

In our Engineering Number of December 5th of last year we illustrated a system of freight subway which had been proposed for solving the serious problem of freight congestion on the streets of this city. In the present Middle West Number we present illustrations of a complete system of freight tunnels, aggregating sixty miles in length, which has been completed below the business center of Chicago, and is now regularly engaged in conveying merchandise and the city's mail directly to and from the railways, the Post Office, and the various office and commercial buildings of the city. The Chicago freight tunnels stand as a unique achievement among the great municipal undertakings of the world; and the capital city of the Middle West very justly prides itself upon the magnitude and completeness of this constructive work, which ranks in importance with that other great Chicago enterprise, the Drainage Canal.

The underlying conditions which have led to the construction of the subway are the same as those that have prompted two powerful construction companies to make an offer to build a similar freight subway system beneath New York city, namely, the intolerably congested condition of the street traffic. It is the slow-moving and bulky dray and the various freight and express vehicles that are chiefly responsible for the growing street congestion in the business centers of our great cities. It is claimed that, before the construction of its tunnel system, the conditions in the heart of Chicago were worse than in any other city,

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Southern Pacific, and on the level it would be capable of hauling a train weighing 10,000 tons and carrying about 7,000 tons of freight at a speed of ten miles an hour.

CHICAGO'S SIXTY MILES OF FREIGHT SUBWAY.

(Continued from page 448.)

not even excepting New York. The many trunk railroads which center in Chicago have done their best to shorten the haul to and from the freight terminals and the various business houses, for if one looks at a map of Chicago it will be seen that these terminals are located in the very heart of the city, and that they have reached a point beyond which, because of the high value of land, they cannot possibly go.

The credit for the solution of the problem of freight distribution is due to Albert G. Wheeler, who several years ago applied to the City Council for a franchise on behalf of the Illinois Tunnel and Telephone Company for the construction of a system of tunnels which should be used for the transmission of "sounds, signals, and intelligence by means of electricity or otherwise." The franchise was granted and work was commenced in a very unostentatious manner, the necessary capital being found by private parties. The lines as now completed extend from Armour Avenue and Archer Avenue on the south to Chicago Avenue and Kingsbury Street on the north to Green Street on the west. The greater part of the sixty miles of tunnel is six feet in width and seven and a half feet in height, but there are also trunk tunnels which are twelve feet in height and vary in width from ten to fourteen feet. It was stipulated that the floor of the tunnel should be about forty feet below the street level, and as it is generally seven and a half feet high, it follows that the tunnel roof is about thirty-three feet below street level. By constructing the system at this depth all interference with the water and gas pipes and sewers of the city was avoided, and sufficient room was left for the construction of a complete passenger subway system between the street surface and the tunnel whenever the city should be prepared to take up such a work.

It was stipulated in the franchise that the tunnel must be built below the center line of the streets, and this has been done. In prosecuting the work, shafts were sunk, as a rule, in the basements of various buildings, which were rented for the purpose of the tunnel company; and these basements were used for mixing the concrete and for installing the air-compressing plants which supplied the necessary air at ten pounds pressure for the pneumatic system under which the whole work was prosecuted. From the shafts above mentioned the workmen drifted out to the center of the street, where the work of excavation was carried on in opposite directions. In the earlier years of construction the material was hoisted to street level, loaded into contractors' carts, and hauled to the dumping ground on the lake front; this work being done entirely in the night time, to avoid any interference with the already crowded traffic of the day time. In later years the dump cars have been run to the surface by means of an incline and hauled by electric locomotive to the lake front,

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2. How to Overhaul Your Car.

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5. Anti "Joy Ride" Devices.

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where already an addition has been made to the area of the city's park of about twenty acres. As the average fill is forty feet in depth, it can be understood that, had this enlargement been made by the city itself, it would have cost about \$600,000.

The system is operated entirely by electricity, and the equipment consists at present of 175 motors of the Jeffrey and the General Electric types and 3,502 cars. There is a telephone installed on every block, and the movements of the trains are directed entirely by this means.

Although the wording of the franchise would indicate that the tunnels were to be constructed primarily for the installation of telephone and telegraph lines, it will be understood that the greatest revenue-earning power will be derived from the transportation of freight. It is estimated that about one hundred thousand tons of freight are hauled through the streets of Chicago each day; and if the tunnel company should haul only one-third of this, the total for the year would amount to over ten million tons. Hitherto no great effort has been made to push this branch of the business; but now that the system is about completed, it is expected that full connections will be made with the various business houses, and great increase in traffic will follow. Connection between the various warehouses and the tunnels is made by sinking a shaft and equipping it with electric elevators, which run from the track level below to the particular floors of the warehouse upon which the freight is to be delivered. In the case of a big warehouse, such as Marshall Field & Company, the loaded cars are hoisted to the desired floor, unloaded, loaded with the outgoing freight, returned to the tunnel, and drawn to the particular railroad freight station desired. It will not, of course, be possible to have direct connection between warehouse and tunnel in every case, and hence central depots will be provided at various suitable locations throughout the city, so placed that the average haul by team will not amount to more than one or two blocks. One immediate advantage of the system is that the wholesale houses are now able to carry on business throughout the twenty-four hours of the day. Under present conditions, after the teams have gone home for the night, the goods that are ready for shipment have to wait until the following day; and at busy seasons of the year it is not unusual for a delay of several days to occur. By using the tunnel system, the merchant can make immediate shipments of his freight, whether it consists of one truckload or fifty.

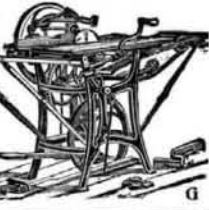
The tunnels will serve many useful purposes outside of that of transportation of merchandise. One of these, and a very important one, is that of the hauling away of material from the excavations for buildings within the city. Hitherto, this has been done by teams upon the surface; but the present method is to run a steel chute from the excavation down to the tunnel on an angle of about forty-five degrees. The workmen wheel the material to the mouth of the chute, and dump it; and it is received and drawn away by cars, which are successively moved below the mouth of the chute in the tunnel. When a train has been made up, an electric locomotive hauls it to the dump on the lake front. By this method as much as 2,100 cubic yards of material has been removed from the basement of a single building in one day. The best that has ever been accomplished by teams in the same time is 420 cubic yards. Another important service rendered is that of bringing coal to the boiler plants of the various houses and the hauling away of ashes and other refuse.

In no direction has the tunnel proved more successful than that of the transportation of mail. A twelve by thirteen-foot subway has been constructed below the United States Post Office building, ex-

(Concluded on page 458.)

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(Concluded on page 459.)

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READ THIS COLUMN CAREFULLY.—You will find inquiries for certain classes of articles numbered in consecutive order. If you manufacture these goods write us at once and we will send you the name and address of the party desiring the information. There is no charge for this service. In every case it is necessary to give the number of the inquiry. Where manufacturers do not respond promptly the inquiry may be repeated.

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Inquiry No. 9038.—Wanted, the address of the Chipman Electric Purifying Co.

Inquiry No. 9042.—Wanted the address of Farney Safety Razor Co.

Inquiry No. 9044.—Wanted to buy outfits necessary for agate polishing.

Inquiry No. 9046.—Wanted, machinery used for the manufacture of all kinds of fruit boxes, baskets and crates.

Inquiry No. 9047.—Wanted, the address of parties who install plants for making oxygen or ozone gas.

Inquiry No. 9048.—Wanted, address of manufacturers of metal table slides for extension tables.

Inquiry No. 9049.—Wanted, to buy rotary brushes suitable for a shoe shining machine.

Inquiry No. 9050.—Wanted, to buy equipment for manufacturing starch and denatured alcohol from potatoes, also manufacturers of equipments for vegetable canneries.

Inquiry No. 9051.—Wanted, to buy machinery for extraction of cotton seed oil on a small scale.

Inquiry No. 9052.—Wanted, to buy machinery, etc., for a beer plant, that manufactures beer by means of glucose.

Inquiry No. 9053.—Wanted, address of firms who install plants to manufacture nitrogen.

Inquiry No. 9054.—Wanted, address of manufacturers of articles made from mica.

(Concluded from page 457.)

tending from Jackson Boulevard to Adams Street. The mail is thrown down chutes from the mailing platform to the platform of the subway, where the pouches are placed in the cars of the company and sent on to their destination. In the receiving of the mail at the Post Office, the pouches are unloaded from the cars onto a thirty-inch belt, which carries them up an incline to a point just below the driveway, where a cross-belt receives them and delivers them onto the mailing platform. For this work the tunnel company employs sixty-six electric motors and one hundred and fifteen cars. During the year 1907, the electric mail trains made 337,060 trips and carried 10,059,567 bags, pouches, and packages of mail, with a record of 99.51 per cent perfect as regards the time of delivery at the various tunnel stations. On the day before Christmas of that year, the tunnels handled over 50,000 bags, pouches, and packages, which were transported in 1,391 cars and in 1,229 trips.

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