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 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 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 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

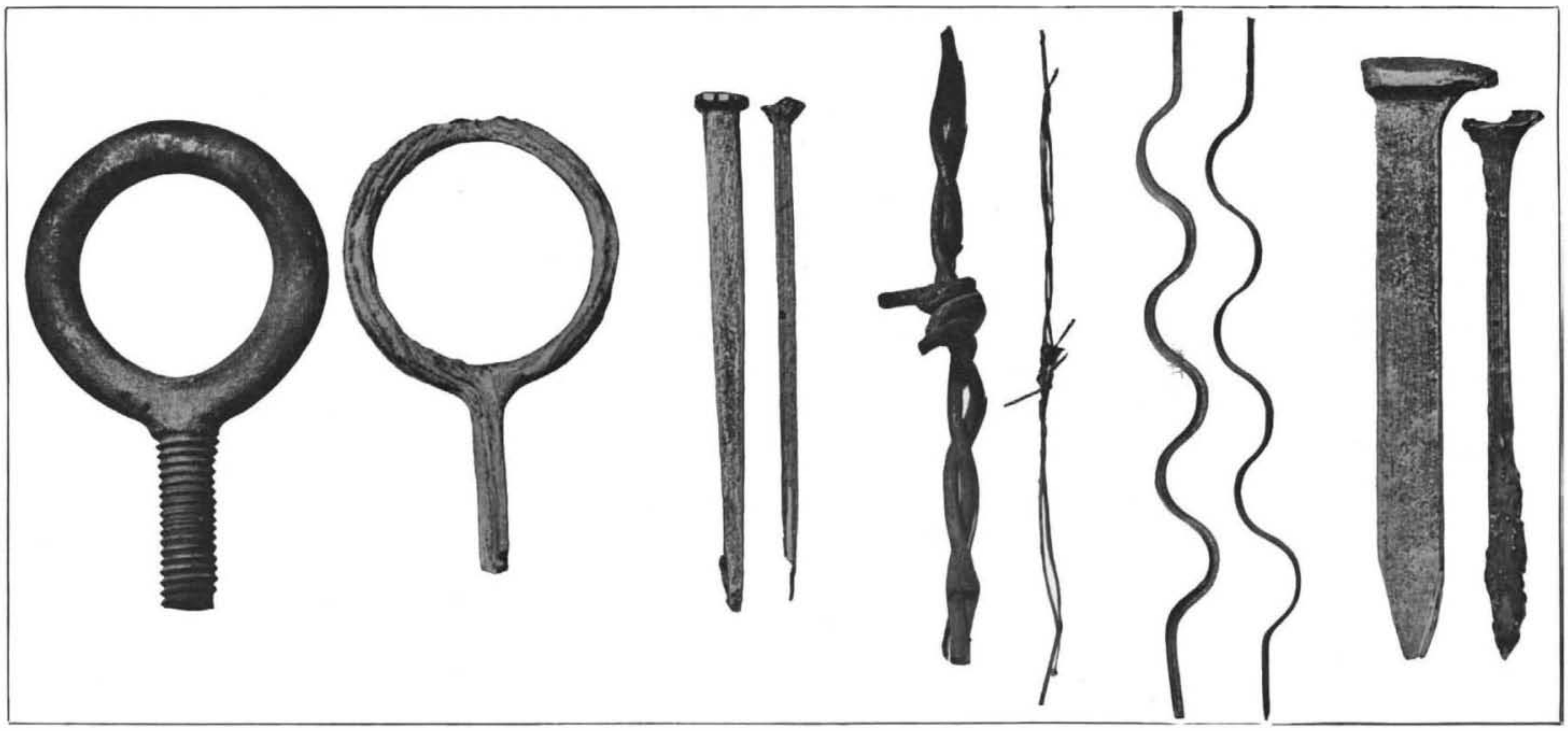
The corrosion test of the above samples, which were immersed in a 5 per cent solution of sulphuric acid for twenty-four days, showed:

Loss, steel	14.41 per cent
Loss, American ingot iron	0.21 per cent

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



Ingot iron. Loss, 15.5%. Charcoal. Loss, 77.3%. Ingot iron. Loss, 4.13%. Steel. Loss, 68.9%. Ingot iron. Loss, 6.1%. Steel. Loss, 92.3%. Ingot iron. Loss, 2.4%. Steel. Loss, 78.2%. Ingot iron. Loss, 11.2%. Steel. Loss, 71.9%.

CORROSION TESTS IN BATH OF 25 PER CENT SULPHURIC ACID.

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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