[Concluded from SUPPLEMENT No. 1427, page 22862.]

THE KRUPP WORKS AT ESSEN.—II.*

By DAY ALLEN WILLEY.

BOTH Friedrich and his son, Alfred Krupp, believed that a successful industry should own not only the facilities for production, but the sources of raw material forming the base, and this is why the coal and ore mines in connection with the blast furnaces form such a notable adjunct of the enterprises under consideration. One of the principal coal mines is located practically on the site of the Essen works, the other two being situated near Bochum. In all they comprise seven working pits, of which three are at Essen. The former have a maximum depth of 1,700 feet, and at present no less than ten veins of coal are being worked on two levels, the veins varying from 2½ to 6 feet in thickness. Most of the coal is secured by hand mining, but the works are equipped with both overground and underground draining machinery, a hydraulic air compressor for operating ventilators, while a separating and washing floor is installed, which has a capacity of 100 tons hourly. The workings near Bochum contain thirty veins with a total thickness of 112 feet. They are much more extensive than the pits at Essen, and furnish most of the total output of the Krupp mines, which represent nearly 1,500,000 tons yearly. They are also provided with overground and underground draining machinery, as well as hydraulic air compressors, which have a capacity of 10,000 cubic feet hourly, in addition to four ventilators and four separation plants, treating 200 tons an hour. In connection with the mines are sets of coke ovens having a total daily output of 700 tons. These are of the vertical type served from above, but are not provided with apparatus for securing by-products, such as is installed in most of the modern ovens of the United States. The various groups of iron-ore deposits produce annually about 520,000 tons. They include, as stated, 667 different allotments, producing hematite and red ore as well as manganese. The Krupp interest in the Spanish mines is held under the title of the Orconera Iron Ore Company, and a line of steamships owned by the Krupps is devoted to its transportation to Germany.

The blast furnace capacity is not as large as might be imagined when contrasted with the capacity of the

side walls of granite, and are closed by pontoons. Four are inclosed with glass roofs and sides, but are sufficiently lofty to allow the use of overhead traveling cranes operated by electric motors, so that the material can be transferred in this manner without delay. One of the most extensive is so arranged that a flotilla of four or five torpedo boats of the ordinary size can be constructed at once if desired.

The mechanical equipment is on a par with the Essen works in design and capacity. The various departments, such as the forging, fitting, and bending shops, the plate yards, mold loft, joiner and paint shops, are provided with a complete outfit of steam and electrically-driven machinery. Other notable divisions are a plant for model making, also for the manufacture of cylindrical and water-tube boilers, a copper-forging plant, and a plant for testing marine boilers and engines. The equipment includes about 1,000 machine tools in addition to 10 steam hammers and 72 hydraulic and electric cranes. The electric power is distributed by a series of 260 dynamos and motors. It is at the Germania yard that the celebrated 150-ton crane has been installed for placing ordnance, engines, and other-heavy weights on battleships and merchantmen.

Reference has already been made to the importance of this plant in the construction of war vessels. Among the notable craft completed are four battleships for the German navy, including the "Wörth," of 10,000 tons, the "Zähringen," of 11,800 tons, and another ship recently placed in commission of 13,000 tons. A number of the principal naval vessels, such as the battleship "Baden," have been rebuilt. Recent additions to the fleet of German cruisers, such as the "Prinzess Wilhelm," "Nympe," and "Amazone," were constructed in these slips. One of the most notable pieces of work was the "Askold," for which the company secured the contract from the Russian government in competition with several other German firms as well as Italian and Russian yards. This cruiser, which is of 6,000 tons, was not only built for speed, but to carry unusually powerful batteries. She presents a peculiar appearance from the fact that she carries five funnels. After being completed she attained a speed of no less than 24 knots an hour with her triple screws, one knot more than the required rate, developing 19,999 horse power. Among the additions to Germany's merchantmen built at the Ger-

posite vessels, and in the under-water fittings of iron and steel ships.

3. The decay of the brazing-metal in copper steam-pipes.

4. The deterioration, as distinguished from oxidation, of cast iron used for parts of marine engines, and also for other appliances which were in frequent or continuous contact with sea-water.

5. The decay of some propellers made of the patent bronzes when fitted to copper-bottomed vessels.

In the case of condenser-tubes it was apparent that some of the metal became eaten away into holes, while in the other cases mentioned the metal appeared to retain its original form. The former action is "corrosion," and the latter "decay."

Chemical analysis of the decayed portions showed that a change had occurred in the composition of the metal, but did not explain why its strength and properties were so completely modified. It showed that in copper-zinc alloys the process had been mainly one of dezincification, or loss of zinc, while in cast iron, part of the iron, and possibly also of the manganese, had disappeared, the whole of the graphitic carbon remaining.

Although the decay of copper-zinc alloys had been known for many years, the first published research into its cause appears to have been made by Prof. Arnold, who in 1898, investigated the case of the failure of a marine boiler steam-pipe. He pointed out that the brazing-metal of the pipe, when microscopically examined, was seen to possess a duplex structure, similar to that of Muntz metal, both constituents being definite chemical compounds of copper and zinc, but one richer in copper than the other; and he attributed the decay to local galvanic action set up between these constituents, whereby in the first stage, the one less rich in copper becomes dezincified, and subsequently that richer in copper also lost its zinc, the whole then becoming a spongy mass of copper.

Microscopic study showed that the Muntz metal tube-plates, rods, etc., had been subject to similar decay to that pointed out by Prof. Arnold, and also that in the decay of cast iron the complexity of structure doubtless led to the same result, the decay in this case advancing along the lines of the graphite plates and leaving the phosphide eutectic portions till the last.

This explanation of local galvanic action, however,

SINGLE SHEET OF METAL ROLLED AT THE ESSEN WORKS.

other works. The principal plant, the Rheinhausen, is comparatively new, being built in 1896. It includes three furnaces of 14,150 cubic feet capacity each, producing from 200 to 225 tons every 24 hours. The furnaces are provided with steam hoists, four Cowper heaters, and produce principally Bessemer and hematite pig iron. An interesting feature in connection with the plant is the service of the ore, a series of Brown hoist conveyors electrically driven, being used for transferring the ore from shipboard to the plant. The blowing engines are of the vertical compound type, furnishing 32,000 cubic feet of air per minute, but the power plant also includes a gas engine fed by furnace gas which operates an electric motor, two 250 horse power steam engines for operating dynamos, and two compound pumping engines. The other furnaces produce the balance of the 1,900 tons daily, which is the average output of this division of the Krupp industries. They include four furnaces at Mühlhofen works, three at Hermanns works, and four at Johannes works, but none are of modern type.

The Germania shipyard, or the Kiel plant as it is sometimes called, after the name of the city near which it is located, is one of the oldest in Europe. Originally a specialty was made of marine engines and boilers. The present works were located at Gaarden, a suburb of Kiel, in 1865, and were leased by the Krupps in 1896, and only purchased last year. Friedrich Krupp realized their value as an adjunct to his other industries, and since they have been under the present control, they have produced marine architecture, not only in battleships, cruisers, and smaller war vessels, but merchant vessels. While the plant at present in use has a frontage on Kiel Harbor of about 1,300 feet and covers 350 acres of ground, an additional area has been purchased, which is more than double its present capacity. As it is, slips are provided for the construction of seven vessels at one time, the slips ranging in length from 377 to 640 feet, with a width of from 85 to 100 feet. Three others which are planned will range from 600 to 836 feet each; but as will be noted from the dimensions, the facilities are such that the largest type of battleship yet planned can be built in the most capacious of these inclosures. They represent the latest idea in construction, the lower portion being of concrete with

mania yard are the Lloyd ships "Bonn" and "Halle," also the famous "Kaiser Wilhelm der Grosse," which has made such a record in trans-Atlantic service.

The enlargement of this yard, carried out as planned by the late Friedrich Alfred Krupp, will make it probably the greatest shipbuilding plant in the world, and give it facilities for turning out more than twice the tonnage which its former capacity represented, as a considerable portion of the present works will be rebuilt. It will cover an area of 600 acres, and employ about 3,000 more men than the old yard, when all of the new shops are in operation. Most of the improvements have been completed.

Two interesting features in connection with the industries described are the proving grounds for ordnance at Meppen, laid out in connection with the Essen works, also the Gruson works. It is here that the tests have been made which have given the Krupp guns such a reputation among military experts, owing to the elaborate and costly trials, which have not only included ordnance, but projectiles and armor plate. Sections of every kind of armor plate manufactured to fill orders are carried to these grounds and attacked by ordnance of varied caliber. Every piece of artillery is also tested at one of the proving grounds before being sent away from the works.

THE DECAY OF METALS.*

By J. T. MILTON, M. INST. C. E., and W. J. LARKE.

THE durability of metals under the conditions in which they were actually used is of great importance, and must always receive as careful consideration from engineers as questions of strength or cheapness. Copper, brass, gun-metal, and other alloys were chosen for use on account of their durability; but even these metals were sometimes found to corrode or decay under seemingly obscure conditions. It was to cases of such decay, and to a discussion on their probable causes that this paper is devoted.

The following examples of the decay referred to are adduced:

1. The pitting of the tubes of marine surface-condensers.
2. The decay of brass or yellow-metal bolts in com-

did not account for the corrosion and decay of condenser-tubes which were made of an alloy not having a duplex structure; nor did it explain why cast iron in some cases did not decay, even although its composition and structure were the same as in other cases where decay took place.

Condenser-tubes were usually made of an alloy consisting of, nominally, 70 per cent copper and 30 per cent zinc. The Admiralty specification was, not less than 70 per cent copper and 1 per cent tin, the remainder being of zinc; while one of the large mail steamship companies, as the result of considerable experience, had the tubes made of 78 per cent copper, 21 per cent zinc, and 1 per cent tin.

These were nominal compositions, for commercial copper and zinc were rarely pure. If the impurities became uniformly diffused through the mass of the alloy it would still be homogeneous, but if they had a tendency to segregate, as it was well known some elements did in steel, there would still be such want of uniformity as might set up local galvanic action and lead to local pitting or corrosion. Segregation was not only possible during the solidification of the alloy in the original casting, but might also occur while the metal was at a high temperature during the operation of annealing, which was several times repeated in the course of the drawing process.

If segregation occurred during solidification only, the drawing process would cause the impure portions to be much elongated in the direction of the tube's length, and the resulting corrosion would be seamy; whereas if it occurred also to a marked degree during annealing, the corrosion would affect more rounded areas. Examination of the insides of condenser-tubes revealed cases of deep corrosion of both kinds; but in addition it was seen that the general surface of the inside of the tubes had become partially dezincified to an extent sufficient to cause it to crack when the tube is flattened.

In order to determine whether the various impurities which are commonly present in copper-zinc alloys do tend to segregate or diffuse during annealing some experiments, detailed in an appendix, were made. These experiments incidentally threw some light upon the changes of structure which Muntz metal, and also the 70 to 30 copper-zinc alloy underwent, due to changes of heat treatment.

Considerable protection is given to copper-zinc alloys,

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