GERMAN MARINE BOILER CONSTRUCTION.*

By FRANK C. PERKINS.

ONE of the leading marine-boiler manufacturing establishments in Germany is that of the Düsseldorf-Ratinger Rohrenkesselfabrik, formerly Dürr & Co. The accompanying illustrations show the present arrangement of the plant at Ratingen, as well as at Düsseldorf-on-the-Rhine, Germany. In the foreground of one picture may be noted an electrically-operated wharf crane at the Düsseldorf works in the act of placing a marine boiler in position on board a steamer lying alongside the quay. A battery of boilers of 45,176 square feet heating surface and with a capacity of 15,600 horse power is in operation upon the large cruiser "Prinz Heinrich," of the Germany navy, one of which is seen in the accompanying illustration. Fourteen boilers of the Dürr marine type on board the cruiser "Friedrich Karl" of the German navy have a total capacity of 18,000 horse power, and a heating surface of 49,514 square feet. The five boilers noted in one of our pictures are now in operation upon a steamship of the German Line, "Sachsen," the entire battery consisting of eight boilers of 6,370 horse power capacity and 22,712 square feet heating surface.

The Dürr marine boilers are water-tube boilers, and their construction differs considerably from that of land boilers, as more consideration is given to the principal requirements of shipbuilding, regarding space and weight. The water tubes are inclined and closed at their back ends, while their open front ends are joined to a vertical water chamber. One or two steam drums as steam collectors are placed upon the water chamber. A superheater, constructed of circulating tubes, is connected with the steam collector or with the upper part of the water chamber. The furnace is placed below the tubes, which are generally inclosed with a casing of sheet iron.

The principle of the separation of steam and water circulation is carried out in the Dürr marine boiler. The water chamber possesses a vertical partition wall in which feeding or inner circulating tubes are fitted. By this arrangement a circulation of the boiler water is obtained. The water, heated and evaporated in the water tubes and following the ascendant direction of the tubes, enters the back part of the water chamber and rises to the steam drum, where the steam is collected. From the steam drum the water falls down to the front part of the water chamber, and, mixed with fresh feed water, it is forced to travel through the inner tubes to the water tubes, replacing the heated or evaporated water. By this circulation the current of steam, traveling upward, is kept separate from the feed water, traveling downward. As all these passages of water and steam are of large area, a quick and uniform circulation of the boiler water is insured, even if the boilers are forced to the extreme. On the other hand, the construction of only one water chamber allows the water tubes to expand, freely and independently, so that leakages on account of expansion are absolutely avoided, allowing the boiler to be worked with artificial draft without difficulty.

The water chamber or header being welded throughout without any seams and rivets, is stayed by means of stay bolts between the tube doors and tube-hole doors. Above, it is widened in such a manner that the front and back plates are not parallel, but wedge-like, placed one to the other in such a manner as to enlarge the area of the passages for the rising water in proportion to the water used. The front plate of the water chamber is vertically arranged, the partition plate parallel to this, while the back plate is inclined slightly backward. By this arrangement the steam, after having left the water tubes, is allowed to ascend freely, and has less resistance on the vertical partition plate than in a water chamber of an inclined arrangement.

The water tubes are fitted at their front end with welded and conically-turned bands. They are forced by these bands into the tube holes of the back plate of the water chamber, which holes are bored to the same taper gage. The water tubes are pressed and tightened into the tube holes by means of a spindle press or small hydraulic pressure pump, without using any packing. In order to get the required inclination of the tubes at the vertical water chamber, the axis of the cone is placed at a slight angle to the axis of the tube, while the tube holes are bored perpendicularly to the back plate of the water chamber. By this arrangement space is saved, which is a valuable feature. Immediately behind the tube wall the tubes of the two outside vertical rows at each side of the tube bundle are bent to the right and left, and they form and act as a complete water wall, lying one upon the other. By this arrangement the radiation of the heat by the casing is greatly diminished. At the rear ends the water tubes are somewhat reduced, and have an internal strengthening for the tube door. They are placed in a forged iron lattice wall, lying there freely, so that they can expand according to the heat.

The inner of the circulating tubes, folded from thin iron sheets, are fitted in the partition plate of the water chamber with a funnel, in order to avoid any contraction when water is entering. They are joined by means of washers and are easily removed.

The tube doors and tube-hole doors for the back ends of tubes and the holes of the front plate of water chamber are inner closures. They are made from forged iron in such a way that they meet the conical tube holes without any packing material, such as copper or rubber. As the closures are to be put inside, they are pressed into their position by the water and steam pressure. For screwing, they are provided with a screw plug, forged upon them. A cap covering the tube hole is put outside over this plug, and then the door screwed on by means of a nut. In order that the doors join more closely to the tube holes, they are hollow and not solid. At their cone end they have a small rim, equal to the conical band of tubes, preventing a drawing through of the closure. In the event of requiring a more frequent change of water, and to make it possible to empty the tubes quickly, the tube doors are constructed in the form of a nut cap. The cap nuts are joined without any packing, by edges turned to the ring, with which the tubes are lying in the lattice wall.

The steam drum is either laid crossways, and connected at its full length with the water chamber, or is fitted lengthways to the water chamber in the direction of the water tubes. The first arrangement with cross-lying steam drum is generally used in ships of the navy, where the conditions require a saving of space and weight. The second arrangement, with the steam drum lengthways, is especially employed on river steamers, on which jet condensers are used, and offers the advantage of forming a kind of mud collector in the back part of the steam drum.

The superheater is placed inside the boiler itself, and cannot be put out of use. Therefore the tubes of the superheater are always cooled by the steam passing through. With boilers having cross-lying steam drum, the superheater tubes are put into the steam drum's wall, and in boilers with steam drum lying lengthways, they are placed in the back plate of the water chamber. In both cases the superheater tubes are laid horizontally lengthwise of the boiler, and fitted into the boiler plate with the same cone as the water tubes. A chamber with partition plate and inner tubes allows the circulation of steam in the same manner as that of the boiler water through the water tubes and their inner tubes.

The steam is taken from the steam drum by a perforated pipe, placed lengthwise of the steam drum. With highly forced boilers, a system of rebounding angles is fixed before this pipe in order to separate particles of water, if any are carried over.

The furnace is specially designed according to the fuel used, and to the degree of forcing necessary. The grate surface and size of furnace bars are chosen accordingly. The grate generally takes all the space lying below the tubes. The area of combustion is surrounded by brickwork from the grate to the tubes.

In cases where the combustion must be as smokeless as possible, a funnel is provided in the lower part of the tubes, by leaving a greater space between the second and third rows of tubes. Those rows of tubes, lying below the funnel, may then receive a little more inclination than the upper rows, in order to widen the funnel. The highest row of the lower part of the tube bundle is covered by fire-bricks in front for two-thirds of its length, and the lowest row of the upper tube bundle on the rear, two-thirds of its length. By this arrangement, the fire is drawn over the grate to the back.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

ANALYSES AND TESTS OF PAPER.*

THE chemistry of paper, or rather the chemical study of paper from a practical standpoint, is quite a new science, but a few years old. In 1891 the German government, convinced of the utility of such a study, founded the royal bureau for the analysis of Berlin papers—an example which was soon followed by the Paris Chamber of Commerce.

Paper, like all manufacturers' products, is sold at prices varying according to its quality, and consequently its composition. A paper serving for one use is not adapted to another. Each employment requires special qualities.

Thus, printing papers ought to have the property of ready adaptation to the forms, that is the characters, engravings, etc., they must readily receive and keep their color; they must have but little hardness, and be permeable to a certain extent. The degree of hardness will depend essentially on the nature of the pulp employed, and the permeability on the degree or absence of sizing, or on the nature and quality of the loading.

A filtering paper must possess, along with the filtering property, a separating power sufficient to preserve the necessary degree of solidity even after being soaked. Those which are to be used for chemical analysis must be as pure as possible. These properties depend, in great measure, on the nature of the fibers and the percentage in ash.

Blotting paper must not be sized, while writing papers must have plenty of size.

Paper for cheap books must be as thick as possible; only moderate solidity is needful.

Thus an analysis of a paper is requisite to ascertain whether it is suitable for a given employment. This analysis is rather a thorough study of its different properties with reference to resistance, thickness, sizing, or any other condition connected with a special employment.

I. INVESTIGATION OF THE FIBERS COMPOSING A PAPER.

A. MICROSCOPIC EXAMINATION.—A thorough knowledge of the structure of the fibers is an indispensable condition in recognizing without error the fibers composing a paper. So far, no plan has succeeded in giving a different color to each kind of fiber and thus enabling the eye to mark the distinction.

However, a separation can nearly be made by an iodized solution into three classes, which the eye can distinguish, on account of a different coloration of two of them and an absence of coloration in the third. For this examination, a Nachet microscope magnifying three hundred times is suitable; this power is quite sufficient. The paper is not passed immediately, as it is, under the microscope, for the fibers are loaded with size, kaolin, and other matters which conceal the form.

An average sample of the paper, reduced to small fragments, in water, is boiled with a small quantity of a 2 per cent solution of soda. After boiling for a quarter of an hour, it is washed by decantation, to the complete elimination of the soda. Then the paper mass, with a slight addition of water, is reduced in an agate mortar to a pulp as homogeneous as possible, until all lumps have disappeared. A small quantity is deposited on a well-cleaned slab with a drop of iodine solution. This solution is composed of water, 20 grammes; iodine, 1.15 grammes; potassium iodide, 2 grammes; glycerine, 1 cubic centimeter. The preparation is covered with a plate of glass, and, on examination, the following classification can be made: 1. Fiber colored yellowish red: (a) wood pulp prepared mechanically; (b) jute. 2. Uncolored fibers: cellulose of (a) straw; (b) wood; (c) esparto. 3. Fibers colored brown: (a) cotton; (b) linen; (c) hemp.

We recommend the agate mortar, in order to avoid errors of analysis due to the previous presence of remains of rags which have been used to clean the mortar, and which are invisible in a porcelain mortar. It is essential to render the paper pulp quite homogeneous, for there is scarcely anything but the microscopic examination at command for the quantitative determination of the different component fibers. It is suitable, therefore, to have a preparation representing exactly the average composition of the paper.

1. *Fibers Colored Yellow.*

a. *Wood Prepared Mechanically.*—This pulp is recognized by the special configuration of the torn extremities of the fibers, and from the fact that the latter, which are rarely separated, are usually more or less agglomerated in small parcels. We have also a more rapid and sure chemical method of determination, which we will examine further on.

b. *Jute.*—The characteristic property of the fibers of the liber of this plant is the varying thickness of the walls of the cells in different places, often from one extreme to another, in the field of the microscope. It also often happens that in the image the fibers are seen collected in a single bundle.

2. *Uncolored Fibers.*

a. *Wood Cellulose.*—The fibers of chemically prepared wood are flat, of ribbon form, presenting unbroken extremities. If cellulose is of resinous wood, there will be noticed on the septum constituting the cell, a succession of open places of circular form, presenting the lace appearance commonly called *passe partout.*

The fibers of folious wood do not offer characteristics so distinct and so easily recognizable as those of resinous wood. The bands are much larger and have a small number of pores on the contour, clear-cut and of almond form. The characteristic cells of folious wood are filled with pores presenting the appearance of a sieve.

b. *Alfa Cellulose.*—In general the structure of this cellulose is more delicate and of smaller dimensions than that of straw. The fibers are short, cylindrical, of uniform diameter, with a narrow central canal and rounded extremities, truncated or bifurcated. Besides fibro-vascular bundles of these fibers, there are in alfa, as also in straw, a certain number of cuticular cells, with extremely characteristic dentated contour.

c. *Straw Cellulose.*—In its microscopic characteristics, this pulp much resembles alfa, but its elements are of larger dimensions. There are also found in straw numerous flat and oval cells, quite important in distinguishing straw from alfa, which is completely devoid of these cells.

With cellulose imperfectly prepared, the fibers, which ought to appear colorless in the iodine solution, present a light brownish yellow coloration. The cause is that, in consequence of defective or careless manufacture, the cellulose is not pure, the cells being impregnated with lignine.

3. *Fibers Colored Brown.*

a. *Cotton.*—This appears in the form of black ribbons, frequently twisted together, the extremities being usually formed of lamels, and the fibers often covered with numerous striæ.

b. *Linen.*—Linen is formed of cylindrical fibers, whose extremities frequently terminate in numerous fibrils; their thickness is about half that of cotton fibers.

c. *Hemp.*—The anatomical structure of this fiber singularly resembles that of linen, and one of the most delicate points in the microscopical examination is to distinguish these two kinds of fibers. In many cases it is impossible.

Contrary to what has been said, it often happens in the preparation of paper that very thin lamellæ are detached from the fiber. These are not then in a suitable state for receiving the iodine solution, and of course they are colorless. The analyst may suppose these membranes to be cellulose, if he limits his observation to the absence of color, but if he is guided by the distinctive characteristics of cellulose, he must, in the total absence of these indications, conclude that there is none.

The examination of a paper under the microscope may give an idea of the manner in which the refining has been conducted. The observer should consider whether the fibers appear in a fragmentary state, or whether they are composed of entire cells (of the liber), of which he perceives the pointed extremities.

On account of the great length of their fibers, cotton and linen present, when they are refined, fragments, showing at what point the fracture was produced. According to the appearance of the fracture, it is possible to ascertain whether the refining operation was suitably performed. If the plates of the cylinder were too sharp, or if they were let down too rapidly on the plate, the fractures will appear as distinct cuts, while, if the operation has been suitably conducted, the fracture will appear to have been produced by tearing. The importance of this fact, with reference to the ultimate resistance of the paper, is considerable.

Alfa, straw, and wood (of which the fibers do not exceed one or two millimeters) ought, in the majority of cases, to be in the state of complete cortical fibers, with their two extremities pointed. The refining, when it is conveniently conducted, ought to be limited to the separation of these fibers.

B. CHEMICAL INVESTIGATION.—There is a fiber which can be recognized immediately by chemical process. This constitutes the pulp of wood prepared mechanically. It is known that the lignified tissues of the family of the angiosperms are incrusted with the substance called lignine; the principal component of lignine is a gum called xylane, which, under the action of hydrochloric acid, fixes water and is converted into sugar, a pentose having the name zylose. This, like the pentoses in general, has the property of coloring red a solution of phloroglucine in alcohol. It will be sufficient, therefore, after having treated the paper with hydrochloric acid, for converting the xylane into xylose, to deposit a few drops in a solution of phloroglucine in alcohol. Practically, these

* From the French of M. Engène Pettigont, Engineer-Chemist, in the Revue de Chimie Industrielle.

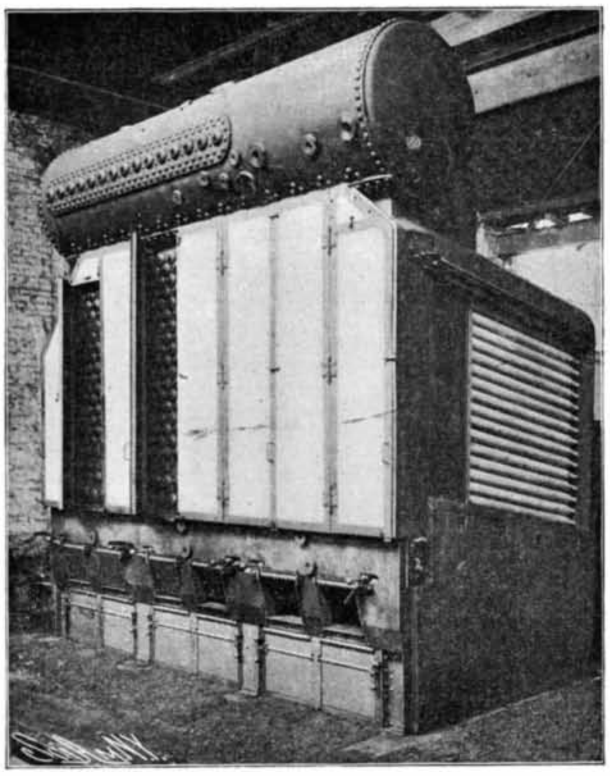
SCIENTIFIC AMERICAN SUPPLEMENT. No 1454

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1903, by Munn & Co.

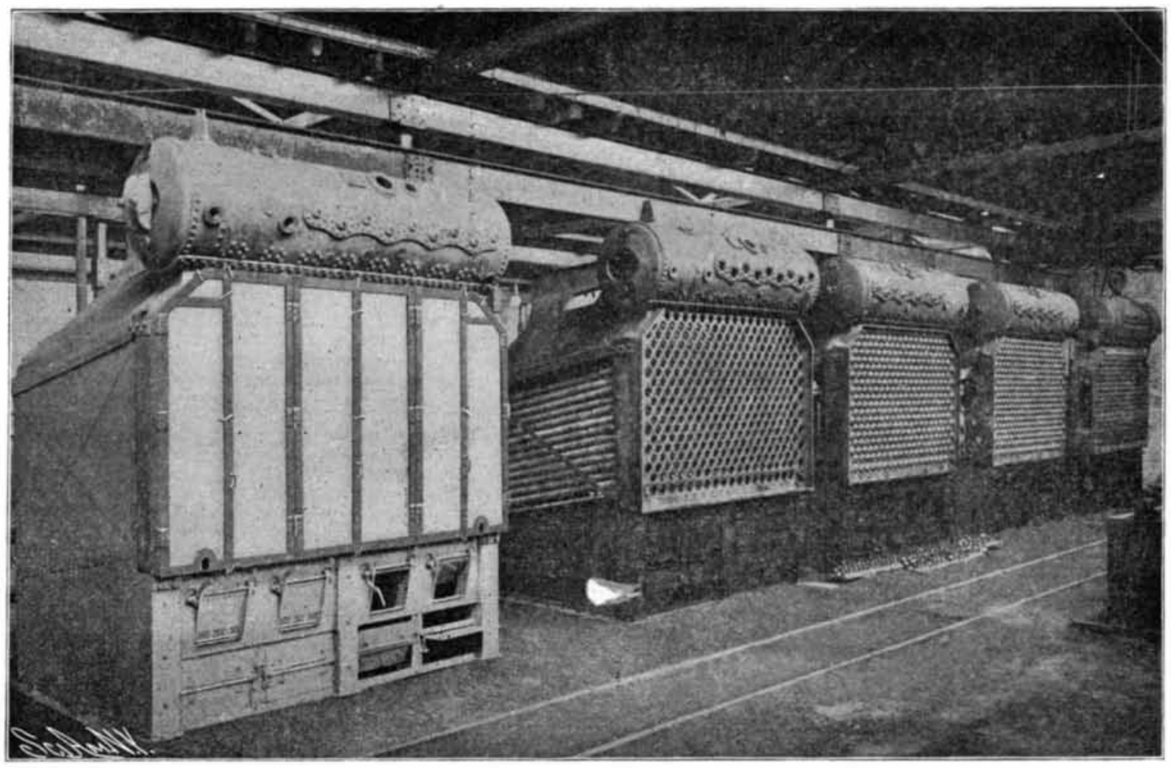
Scientific American, established 1845.
Scientific American Supplement, Vol. LVI. No. 1454.

NEW YORK, NOVEMBER 14, 1903.

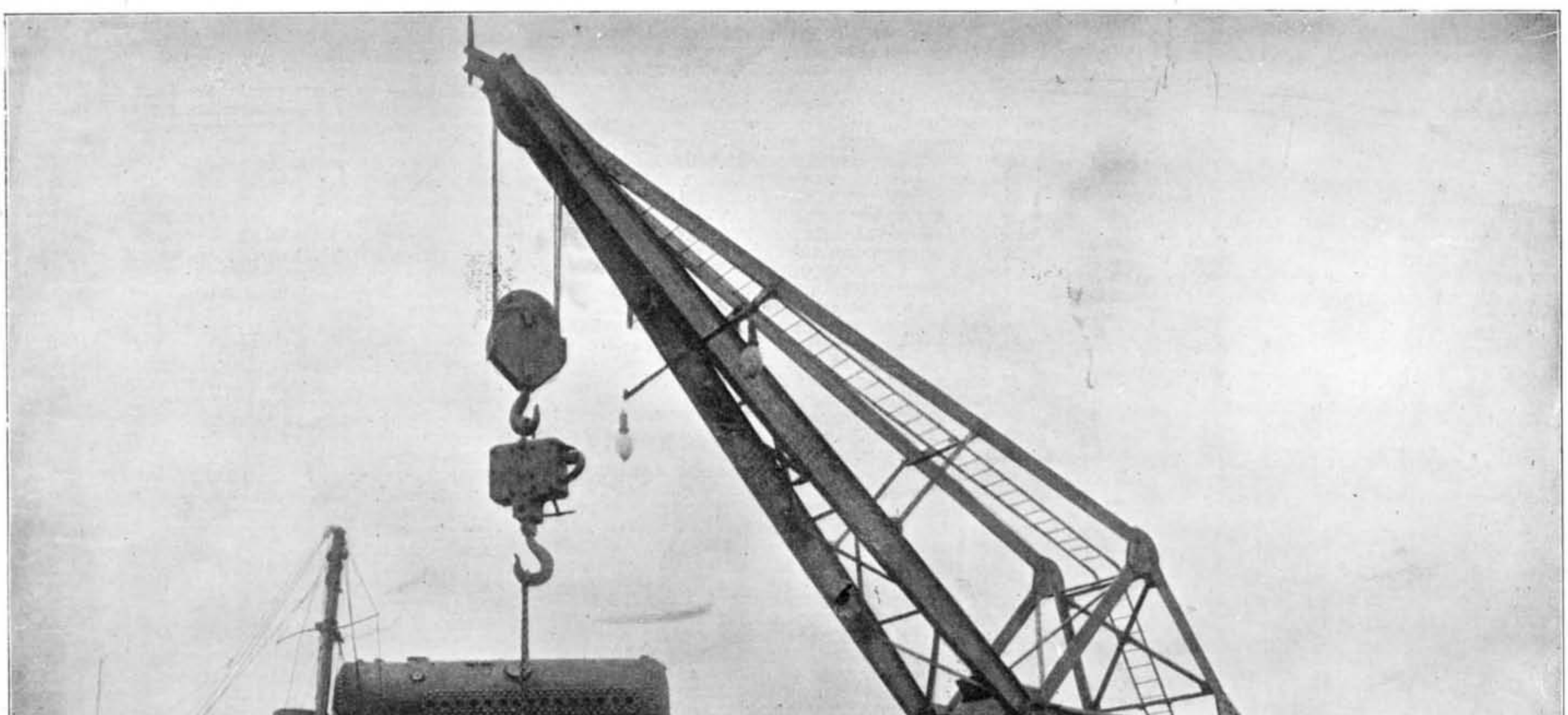
Scientific American Supplement $5 a year.
Scientific American and Supplement, $7 a year.



A DÜRR MARINE BOILER.



FIVE DÜRR BOILERS, FORMING PART OF BATTERY OF EIGHT HAVING TOTAL CAPACITY OF 6,370 H. P.



ELECTRICALLY-OPERATED WHARF CRANE LOWERING A MARINE BOILER INTO POSITION.

GERMAN MARINE BOILER CONSTRUCTION.