32.—THE BOWER-BARFF RUSTLESS IRON.

By J. H. KIDDER, M. D.

[From letters to Prof. S. F. Baird.]

I return herewith the specimens of iron pipe treated by the "Bower-Barff rustless iron" process, with memorandum of the results of examination and the following note upon the process itself:

Dr. Percy first pointed out the fact that Russian sheet-iron is much less affected by rust than English, because it has been accidentally coated with magnetic oxide (Fe_3O_4).

Professor Barff, prior to the year 1876, first produced a coating of magnetic oxide upon iron *for the purpose* of preventing rust. He exposed the heated metal to superheated steam, which at high temperatures is decomposed, giving up its oxygen to the iron, while hydrogen escapes.

Mr. George Bower improved upon Barff's method (about the year 1880) by passing the products of imperfect combustion (carbonic oxide, &c.) through highly heated chambers containing air in slight excess of the quantity required to convert carbonic oxide into carbonic acid. The resulting carbonic acid, heated by combustion, enters a chamber containing the articles to be coated, raising them to a high temperature. The iron takes oxygen from carbonic acid and becomes magnetic oxide at its surface, covered by a film of sesquioxide, while carbonic oxide escapes. This process, called the "oxidizing process," is continued for half an hour, when the air inlet is closed and only carbonic oxide admitted to the iron. Carbonic oxide (CO) takes oxygen from the film of sesquioxide covering the magnetic oxide, reducing all of the coating to magnetic oxide. This is called the "deoxidizing process," and lasts twenty minutes. The two may be repeated according to the thickness of oxide desired.

There is no reasonable doubt that magnetic oxide of iron is unaffected by exposure to air or fresh or salt water, or that, if thoroughly and completely applied, a coating of this oxide will protect iron surfaces from rust. The specimens experimented upon appear not to have been thoroughly coated, especially in the screw-threads, and there is some reason for suspecting galvanic action upon the specimen A (in salt water). I believe that the authorities at the Portsmouth dock-yard have already decided that such action will occur when coated and uncoated specimens are exposed together to sea-water.

For further experiment in this direction I recommend that some strips of iron be furnished which have been completely covered with the magnetic oxide, exposing no unoxidized surfaces. The strips may conveniently be 3 inches wide by 4 inches long, but should not be sheared (as in the specimens received last week) so as to expose unoxidized surfaces.

MEMORANDUM.

Two specimens of iron treated by Bower-Barff process; received December 5, 1884.

A. Short tube, with male screw-thread on each end, immersed December 6 in sea-water, in an open jar. The sea-water was from the surface of the sea, 40 miles off Cape Hatteras, and of specific gravity 1,026.1. The pipe showed no rust at the time of immersion. Removed from the water, which has been kept at about 70° F., January 13. The specimen is much rusted, particularly in the screw-threads. One side remains clean, and the corrosion is most decided on the side opposite—possibly because of galvanic action. The water is quite muddy from sesquioxide of iron, and presents a scanty iridescent pellicle containing Bacteria (mostly *B. termo*). No infusoria.

B. A bent coupling, with female screw in each end. Immersed December 6 in tap-water, jar tightly stopped; exposed, together with A, to sunlight and average temperature of 70° F. Removed from water January 13. Specimen has also rusted, but the rust is in this case confined to screw-threads and a file-mark on convex surface. No sign of life in the water.

SMITHSONIAN INSTITUTION,
Washington, D. C., January 13, 1885.

SECOND REPORT.

Since the date of a former report upon the Bower-Barff iron process (January 13, 1885) several new specimens have beeen received, consisting of (A) strips of iron three-fourths inch wide by one-fourth inch thick, and (B) cylindrical rods one-half inch in diameter, all coated with magnetic oxide by the Bower-Barff process. The ends of the specimens, which had been sheared in cutting them into short lengths, showed a little sesquioxide of iron, although supposed to have been treated after cutting.

There being a question as to the occurrence of galvanic action between this magnetic oxide and iron or other metals in presence of sea-water, several battery cells have been made and tested in the course of the last ten days. Each cell was made up of two of the protected strips or rods for one element, a similar surface (about 16 square inches) of unprotected iron for the other, and a sample of very clear sea-water, of specific gravity 1,027, taken in the Gulf Stream about 40 miles northeast of Cape Hatteras. In the earlier experiments the sheared ends immersed were covered with red sealing-wax, and copper wire was used for electrodes. In cells after the first two the sheared ends were covered with bees-wax and platinum wire substituted for copper. In each experiment the circuit was allowed to remain closed for from two to five days.

The galvanometer showed a decided current in all of the experiments, the pole attached to the protected plate being positive. Magnetic oxide is therefore electro-negative to unprotected iron, as was to have been inferred from the known electric relations of the protoxide and sesquioxide of which it has been supposed to be made up. The current is scarcely, if at all, stronger when two cells are connected in series than in each of them examined singly. The unprotected iron (electro-positive) element wastes away, remaining clean excepting for a thin, greenish, semi-gelatinous film (hydrated ferrous carbonate), while the cell fluid becomes turbid within twelve hours from the accumulation of sesquioxide of iron. In three out of four cells small masses of sesquioxide adhered to the surface of the protected (electro-negative) element, and were found to mark spots of disintegration and removal of magnetic oxide. In one cell the protected surface remains unaffected after seventy-two hours of closed circuit, the fluid being densely turbid by the accumulation of sesquioxide.

When diluted hydrochloric acid (about 4 per cent. strength) is used as an exciting fluid, the action is much more vigorous and both plates are attacked, the unprotected more actively than the protected. When copper is substituted in a sea-water cell for unprotected iron, the direction of the current is reversed, copper being electro-negative to magnetic oxide, and the magnetic oxide is rapidly decomposed, with the production of sesquioxide. Iron is found (after fourteen hours) deposited upon the copper surface and in solution in the filtered cell fluid. No copper is to be found upon the iron surface or in solution.

It appears from these experiments that there *is* galvanic action between unprotected wrought-iron and the magnetic oxide of iron in presence of sea-water, at the expense of the unprotected iron. The action differs only in degree from the ordinary rusting of iron, which has been well described as a galvanic process from the moment that a particle of sesquioxide has been formed. The beginning of rust is generally determined by the presence of carbonic acid, which produces hydrated ferrous carbonate, and is in turn displaced by oxygen in solution in the water. From the moment of the appearance of sesquioxide of iron, a compound which is electro-negative to iron, galvanic action begins, and determines a further supply of oxygen by electrolysis of the water. So in the cells here referred to hydrated ferrous carbonate is found upon the positive surface, and sesquioxide of iron free in the liquid or adhering to the negative surface. Internal currents result from the interaction between iron, its carbonate, and its oxides, and diminish the resultant current strength as measured by the galvanometer.

The experiments still indicate that the covering of magnetic oxide is not thick enough or not complete, since most of the specimens have broken down more or less in sea-water. If thoroughly coated there seems to be no reason to fear damage to protected iron near unprotected iron in sea-water, the tendency of galvanic action in that case being altogether against the unprotected iron, which is electro-positive to magnetic oxide.

It appears, however, that the neighborhood of copper or its compounds in sea-water would probably be destructive to a surface of magnetic oxide, as was the case in the experiment noted. Whatever galvanic action occurs in such a couple must necessarily be at the expense of the magnetic oxide. The presence of zinc, tin, or lead would probably be protective to the iron.

In conclusion I may say that this examination indicates that the magnetic oxide is an effective protection against the ordinary processes of iron rust; that the kind of galvanic action which occurs between iron and its magnetic oxide in presence of sea-water is altogether at the expense of the former; that the neighborhood of copper, nickel, silver, or other metal electro-negative to the magnetic oxide of iron in presence of sea-water will lead to the speedy destruction of the magnetic oxide; and, finally, that the specimens thus far examined appear to have been exposed to the protective process for too short a time to insure full security under the conditions presented by the requirements of the Fish Commission.

SMITHSONIAN INSTITUTION,
Washington, D. C., February 23, 1885.

33.—REPORT OF OPERATIONS AT THE HATCHING ESTABLISHMENT FOR MARINE FISHES, ARENDAL, 1884.*

By G. M. DANNEVIG.

To the Management of the Arendal and Omegn branch of the Society for the Promotion of the Norwegian fisheries:

I have the honor to submit to the board of managers the following report of the operations of the hatching establishment during the year 1884:

COD.—On account of the easily foreseen difficulties in procuring the necessary number of parent fish, the purchase of these was commenced at the beginning of the year and continued without interruption until about the middle of the month of April. The fish obtained were, however, very small, and yielded in consequence little spawn, which will, to some extent, explain the comparatively small result which the establishment has to show for the present year. It will be evident also, from the detailed report given below, that there were other causes which operated strongly in the same direction. Besides, we should not leave out of consideration the fact that, as director of the establishment, I had to confront an entirely new experiment, and that, in addition to theoretical knowledge, there is required also a practical acquaintance

**Beretning over Virksomheden ved Udklækningsanstalten for Saltvandsfisk.* Arendal, 1884. Translated from the Norwegian by TARLETON H. BEAN.