this particular instance leads me to lay the facts before you, for it shows how even the element of time which might have been a saving clause in favor of the chemist, is taken from him, and demands of us a most outspoken protest against a growing evil, which may frustrate the ends of justice in some cases, in others cause unjust suspicion to rest upon innocent parties.

PECULIAR PERFORATION OF ZINC RODS.

By Charles E. Munroe.

Through the courtesy of Asst. Eng. B. C. Bryan, U. S. N., of the U. S. Torpedo Boat "Cushing," I received a short time since some fragments of zinc rods which after exposure to the action of hot water in the wing-cylinders of the Cushing's boilers had become perforated throughout their entire length with a central canal.

These boilers are of the Thornycroft pattern and each consists substantially of a horizontal cylinder or "separator," placed in the upper part of the furnace, and two horizontal cylinders placed below in the wings of the furnace, each of these "wing-cylinders" being connected with the separator by a large number of steel "generating" tubes of small diameter which are bent in such shapes and so placed as to form a continuous arch over the grate, and yet spring from the tops of the wing-cylinders and enter the top of the separator. The wing-cylinders are also connected with the separator by means of pipes, known as the "down-comers," which are of larger diameters and have a more direct lead than the generating tubes.

The effect of this arrangement is, that when the boiler is filled with water to its normal level of about half-way up the separator and the fires are started, steam is rapidly generated in the generating tubes from which it rises with the water to the separator, where, by means of baffle plates, separation is effected, the steam passing to the engines and the water descending by the down-

comers to the wing-cylinders, from which it again rises to the generating tubes; the circulation being thus maintained and its velocity being governed by the area and condition of the fire and the extent of the feed.

As, owing to the disastrous effect of scale in these multitubular boilers, soft water only can be used in them, it is essential to condense the exhausted steam, but as the condenser is made of tinned brass tubes with a copper shell the electro-chemical action between the metals tends to pit and corrode the steel boiler; hence to prevent this, and also the pitting, which, as I have elsewhere shown,* may be caused by the action between masses of steel in different physical or chemical conditions, zinc, which is electro-positive to the steel, is put in the boiler in such a way as to be in close metallic contact with it. This practice has long been in vogue for the protection of boilers, but more recently it has come into use for the preservation of the vessels themselves, Mr. Thornycroft, in his "Instructions of March 15, 1889," for the care and preservation of the steel hulls of his torpedo boats, recommending that, in order to protect them from pitting, pieces of zinc be placed on the inside of the vessel at intervals of from 5 to 6 feet apart from stem to stern and as low down as possible, so that they may be immersed in any bilge water present, and so fastened as to be in close metallic contact with the frames of the vessel, the arrangement being made under the supervision of the Naval Chemist.

Usually zinc for boilers is employed in the form of plates which are suspended in the boiler, and this is the form in which it is used in the separator of the Cushing's boiler, but it is introduced into the wing cylinders, which are 14 inches internal diameter by 8 feet in length, in the form of cylindrical rods, $1\frac{3}{4}$ inches in diameter by 5 feet in length, which are squared off for about one inch in length at each end, so as to fit into notches in a steel frame from which they are suspended by their ends in the centre of the wing cylinder. These rods have evidently been cast vertically, and when an unused one is fractured the exposed

* *Proc. U. S. Naval Institute* **8**, *502*; 1882.

surface of the interior shows a mass of feather-like fretted crystals radiating in pyramidal groups from the centre, but forming a compact mass, except for an occasional, but non-continuous, small cavity at the centre. The exterior of the rod is of a dull blue color, and appears to have been "chilled" in casting.

The rods, from which the pieces exhibited before you were taken, had been exposed in the boiler for about two months, but the steam was on during this time for but 608 hours, the pressure varying from 50° to 250° pounds, which is equivalent to temperatures of from 137° to 205° C.* When taken from the boiler, these rods were found to have increased considerably in diameter; to have become oval in form; to be perforated throughout their entire length, with a hole at the centre of somewhat irregular shape, and varying in diameter from $\frac{1}{16}$ to $\frac{1}{4}$ inch; to be more or less corroded at intervals on the surface; to be bent down between the points of suspension; and to be so rotten as to easily break under their own weight.

The extent of the increase in diameter is shown from the following measurements of five sections from used rods, the diameter of the unused rod being $1\frac{3}{64}$ inches.

	DIAMETERS.	
	Greatest.	Least.
1st section	$1\frac{42}{64}$	$1\frac{39}{64}$ inches.
2d "	$1\frac{62}{64}$	$1\frac{38}{64}$ "
3d "	$1\frac{60}{64}$	$1\frac{39}{64}$ "
4th "	$1\frac{51}{64}$	$1\frac{37}{64}$ "
5th "	$1\frac{42}{64}$	$1\frac{44}{64}$ "

When split longitudinally these sections were found to be filled with radial fissures, and the bundles of feather shaped crystals were coated superficially with oxide.

From consideration of the circumstances I am of the opinion that the formation of the tubular canals in the rods is due to the fact that, as cast, the radiating crystalline mass is held in place by the outer envelope of metal which is produced by the contact of the exterior portion of the molten mass with the cooler walls

*J. Perry, *Treatise on Steam*, p. 42, 1874.

of the mould, and that when, through the erosion or corrosion of this envelope by the rapidly circulating heated water, the tension is removed, the crystals are free to move over one another ; and that when cooled from the high temperature to which they have attained the bundles of crystals contract along the transverse axis of the rod, away from the centre, and since there is no longer a contracting, continuous exterior envelope to bring them back to their original positions the canals result. The oval form which the rods assume is due to the action of the force of gravitation at the time when the force of attraction of cohesion among the particles of the mass is least. And the action is aided by the fact that the higher limit of temperature which obtains in the boiler is approximately that at which cast zinc becomes quite easily disintegrated.

The appearance of these rods is shown in the cut where A represents a transverse section of an unused rod, and the remainder represent transverse and longitudinal sections of used rods.

I am informed by Lt. Cameron McR. Winslow, U. S. N., commanding the "Cushing," to whose courtesy I am much indebted, that 250 pounds of zinc are used for a single charge in one boiler, and that when the boilers are first run this charge is so completely destroyed in seven days' steaming, that sometimes only small fragments and sometimes no portion whatever of the zinc is found remaining in the boiler at the end of this time. I have had no opportunity of learning what becomes of this mass, as the "Cushing" was put out of commission when my attention was called to the matter.