other products, radium A, radium B, and radium C, is also accompanied by the decomposition of water, the problem becomes a very complicated one.

The curve obtained by plotting the rate of increase of the gases formed against time shows a much more rapid increase than the rate of decay of the emanation would warrant. The period of half-value of the

emanation is 3.8 days, that of the increase of gases is 2.53 days. The curves, however, resemble each other in character. The lives of radium A, radium B, and radium C, are very short, their combined half-period of decay being less than an hour; but as they are being continuously produced, owing to the decay of the emanation, a constant maximum is quickly

produced, which falls off as the emanation decays. Attempts to allow for this disturbing influence have been made, but without success, and it appears probable that the partition of the emanation between gas and water, and the recombination of the hydrogen and oxygen in the gaseous system, render any such attempts futile in the present state of our knowledge.

DESTRUCTIVE MARINE WOOD BORERS.

VARIOUS METHODS OF PROTECTING TIMBER STRUCTURES.

BY CHARLES. M. RIPLEY, M.E.

On both the Pacific and the Atlantic coasts, reports from railroad and other engineers indicate that the action of the teredo during the past summer has caused great destruction through docks, trestles, bridges and other structures over salt water. The farthest point north which the teredo has yet attained according to reports has been Nova Scotia on the Atlantic coast and Alaska on the Pacific coast. Civil engineers are devoting serious thought to the matter, and particularly in the vicinity of New York this subject has demanded attention of late.

At an early stage of growth the teredo is free swimming, traveling about in the water and attacking any woodwork which may have been left exposed, entering it by a hole not larger than a pin head. After they have started their boring the teredos grow not only in length but also in diameter, and sometimes have been known to have reached diameters as great as three-fourths of an inch. The teredo is whitish in color, and has two small flexible tubes or siphons continuously extending into the water from the small entrance hole in the wood. It is very important that these vital organs be constantly submerged in comparatively pure salt water, as it is through these organs and from the water that the teredo gets his nourishment. Thus it is that any substance which will permanently cut off the surface of the wood from contact with pure salt water, will not only kill the teredos that are already in a pile but will prevent the entrance of other teredos.

It is extremely difficult to inspect a pile and discover the presence of the teredo until a vast amount of damage has been done, for the reason that although the interior may be perfectly honeycombed, the exterior presents an almost perfect appearance. The writer took occasion to weigh a 3-foot section of a 12-inch pile which had been withdrawn from a bridge in a bay within a radius of 50 miles of New York city, and was astonished to find that the weight of the section mentioned was but 11 per cent of its original weight as yellow pine, which was calculated on a basis of 0.9 specific gravity. This fact was more astonishing since there were no openings upon the exterior of the pile save the tiny holes at which the teredo originally entered.

Railway engineers have planned and worked for years to prevent the action of teredo, limnoria, and other marine wood borers which destroy the piles of

The copper sheathing method is a good protection. However, copper is liable to corrode in salt water, not only at the joints, but around the nail heads. The expense, both for material and for labor, in applying copper is to be considered, as is also the fact that the exact depth to which a pile is to be driven is not

or earth from the base, a line of attack is offered to the teredos.

An improvement on the sewer pipe is the new lock-joint pipe. This consists of sections of a concrete pipe, cast in halves so that it may be bolted round a pile when the latter is in position. The pipe is

THE VARIOUS METHODS OF PROTECTING WOOD PILES FROM SALT WATER WOOD-BORING MOLLUSKS.

It will be noticed that the scour of the water, which often lays piles bare below their "armor belts," is one of the principal difficulties confronting the engineer.

always known in advance, and hence the copper sheathing is likely to be made to extend either too close to the bottom of the pile, where it is useless in the mud, or too high toward the top of the pile, where it is unnecessary above the high water line. Later engineers have attempted to protect piles by means of tarred burlap wound spirally around the pile. Materials floating down stream tended to tear the burlap; also barnacles and oysters clinging to the material after the tar was more or less covered with weeds and slime tended to pull away the protection and leave the pile exposed near the top.

The lowering of the old mud line often occurs where the stream is narrowed by the introduction of piling or other obstructions. The tar burlap necessarily has difficulty penetrating the old mud line as the pile is driven, and hence as the mud line later recedes, the pile is left exposed at the bottom, a point which cannot be inspected without a diver.

Concrete has been used as a coating around piles, molds being placed by divers and the concrete poured in; one difficulty incidental to this method has been that as the mixture was poured down through the water in the mold it tended to weaken. Cases have been found where piles protected by this method were really exposed at the bottom, since nothing but gravel descended through the water to that depth and the teredo could enter the interstices between the grouting.

A later attempt is split vitrified pipes placed around the pile, held in place by wires, and then filled with concrete.

Another method is ordinary sewer pipe strung over the top of the pile and filled with sand. This method overcomes the difficulty mentioned in connection with a concrete covering or filling, as the sand filling allows the sewer pipe to descend as the mud line recedes, but in a new structure this method must be installed before the deck is placed. In old structures caps of the piles must be removed before the pipes can be placed. This obviously interferes with the speed of construction of new work and also interferes with traffic when applied to old structures. A serious objection is that repairs to one section or one pile necessitate the removal of the cap from that entire bent.

Many of the various sheathings used may develop a weakness in course of time; and if one vulnerable spot shows, the teredo may enter in and work destruction through the pile. All the methods mentioned—with the exception of the sewer pipe—are liable to undermining. The coverings are attached to the pile, and if the scour of the water removes the wood

larger than the pile, and the space between is filled up with fine sand. Thus it is claimed that the pipe does not adhere to the pile but settles gradually and follows the mud line, always keeping the pile protected throughout the field of attacks of the marine wood borers. It may be interesting in this connection to know that the teredo must have continued access to the water in order to live. It is thus impossible for the teredo to enter a pile above this protection and live so long as this protection stands above the high water mark.

This system can be applied to old structures as easily as to new, without removing the deck, without interfering with traffic and without the necessity of employing a diver and his expensive outfit. Inspection is a simple matter since sand showing at the

ANOTHER EXAMPLE OF TEREDO DESTRUCTION.

The outer surface of the wood (at the bottom) shows no sign of the destruction inside.

WHERE THE TEREDO DOES HIS WORK.

top assures sand in place down to the lowest mud line.

Green spot soap consists of 400 parts each of coconut oil, kidney suet, and 40 per cent lye, 50 parts of ox-gall and 25 parts each of oil of turpentine and ultramarine blue.

A SECTION OF A BALK RIDDLED BY TEREDOS.

docks, wharves, bridges, and trestles in the regions where salt water is to be spanned.

It was once attempted in Holland to preserve the piling of dikes by means of driving thousands of round-headed iron tacks into the pile. Small boys were employed for this purpose and more or less success attended it, but the expense is obviously prohibitory and on existing structures the work can only extend from low water upward unless the services of a diver were employed.