LECTURE

ON THE

Preservation of Wood

AS

Adapted to Shipbuilding,

GIVEN BEFORE THE

U. S. Naval Institute,

BY

CHARLES E. MUNROE,

PROFESSOR OF CHEMISTRY U. S. N. A.

1877.

PRESS OF
THE CLAREMONT MANUFAC[illegible]ING COMPANY,
CLAREMO[illegible] N. H.

THE RECORD

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. III. 1877. No. 5.

U. S. NAVAL ACADEMY, ANNAPOLIS,

June 14th, 1877.

Commander W. T. Sampson, U. S. N., in the Chair.

PRESERVATION OF WOOD.

By Prof. Chas. E. Munroe, U. S. N. A.

Mr. Chairman, Gentlemen,

Wherever life exists we find a constant struggle for its maintenance. In every animal and vegetable substance, so soon as the vital force ceases to act, we see that there is at once a tendency toward the resolution of the atoms of the highly organized structure into simpler compounds. All nature seems to lend its aid to effect this change. The chemical affinities of the constituent substances encourage it, the lower forms of life assist it, and the combined influence of air, moisture and heat complete the change. Everywhere these forces are active and decay and destruction threatens.

All of the products of life which we employ either for food or clothing or for constructing our habitations, our ships, or our tools are exposed to this danger; and one of the most important industrial problems, which man has had to meet, has been the protection of these substances from decay.

It is my intention to-night to confine myself to an examination of the methods proposed for the preservation of one of these substances, wood, and especially as it is employed in ship-building. Though it may seem unnecessary to you that I should give any statistics to show the great value of employing some means for attaining this result, yet it will I believe impress the importance of it more strongly upon our minds if we give a moment to their consideration.

The first fact which attracts our attention is the rapid destruction of our forests which is diminishing the supply and increasing the cost of lumber. While, for instance, a single acre of pine land yields on an average only six thousand feet of timber, billions of feet are annually sold in the United States. In 1855 lumber sold for about $18 per M.; in 1860, for $24; and in 1865 for $45, (Hunt's Merchant's Mag. Feb. '66, p. 106). Excellent authority states that in New England the cost of oak, ash and hickory has doubled during the past twenty years, being now $50 per M., to $25 then, and if the demand were as great as ten years ago it would be difficult to supply it. Certainly prudence demands a less rapid expenditure.

But when we come to estimate the loss, which results from decay, the necessity for preservation becomes still more apparent. It was calculated in 1866, that the loss by the decay of sleepers on American Railroads, amounted annually to $1056 pr. mile, and that if they were preserved by cupric sulphate at a light expense there would be an annual saving of over $4,000,000, (Lewis) and if we included bridges and all the wooden parts of railways subject to decay, it is stated that $20,000,000 would be saved annually, by impregnating them with coal tar (Robbins p. 67). Processes have been devised by which the durability of many kinds of wood can be doubled; hence if we consider how much timber is employed in the United States alone, in buildings, bridges, fences, ships, carriages and machines, we can readily see that a great saving would be effected, that our wealth would be increased, and that a large part of the labor, which is now employed in making good the losses from decay, could be used in production.

It is more to our purpose, however, and it was my desire, to collect some statistics concerning the decay of ships; but such as I have obtained are quite meagre and unsatisfactory.

In 1833 Mr. Edye, (Calculations relating to the Equipment of Ships by John Edye, London), stated that the quantity of wood required annually to keep the five hundred and seventy four ships of the British Navy seaworthy was one hundred and twenty five thousand loads, while only one million loads was required to build them—twelve and one half per cent. Mr. Wm. Chapman, (Preservation of Timber from premature decay, &c., by Wm. Chapman), gives several instances of the rapid decay of ships of the Royal Navy about the commencement of the present century. He mentions three ships of seventy four guns decayed in five years, three of seventy four guns decayed in four years, and one of one hundred guns decayed in six years. Pering, (Brief Enquiry into the causes of the Premature Decay), says that ships of war are useless in five or six years. And he estimates the average duration to be eight years, and that the cost of the hull alone of one of these ships was nearly £ 100,000.

When we come to our own service we find that here also the loss by decay is enormous. Our live oak ships are exceptional, their average life being, probably, a half century, but I find from an examination of the data given by Emmons (p 23 and 86, et seq.,) that the average cost per ton per year for repairs, was $ 6.00 amounting in the case of a vessel like the Ohio to $ 16,569.57. Up to 1850 the Ohio cost for repairs $ 471,673. * If now we estimate the loss upon the basis of actual sea service we find that the average cost per ton (O. T.,) per year of service was $ 16.19. The cost of repairs to the Ohio per year of service was over $ 89,000, and the United States, Potomac, Brandywine &c., average about $ 35,000 while the Constitution, which was an exceptionally good ship, cost over $ 15,000 per year of service.†

To gather any information about our present Navy is more difficult, and we must wait for some one to record for it what Emmons has so thoroughly done for the Navy previous to 1850. Such as we do find however shows that of late the loss from decay is greater than before. We find vessels built of white oak costing from a quarter of a million to over a million dollars thoroughly useless in eight to ten years. Indeed this is a large estimate, for it is stated by some authorities that the average age of a white oak ship is six years. The difficulties met with in getting any certain knowledge on the subject are best shown by the following extract from a letter from the late chief of the Bureau of Construction and Repairs, Chief Naval Constructor I. Hanscom. He says, "I believe you will only be able to obtain approximate data as to the relative durability of Live and White Oak, White and Yellow Pine timber, as it varies so much, caused by the difference in quality and degree of preservation, either by stowage or by the use of chemicals, that the condition of the timber at the time of using it can hardly be known. Still the contrast in the durability of the timber used in the construction of the "Franklin" and that of the "Delaware"—the former in good condition at the present time (twenty three years), and the latter generally rotten in eight years, each costing nearly the same,

* While the cost of building her was only $ 547,889.

† See Appendix.

(cost of Del. $1,178,000) is so great that a general idea may be obtained by which to judge of the durability of timber used before and after thorough seasoning. I judge that the loss to the Government in using unseasoned timber during six years from 1861 was at least $20,000,000."

Incomplete as these statistics are they give us a partial idea of the magnitude of the loss, which we sustain by decay, and they fully warrant our devising means for arresting it.

One of the chief difficulties which presents itself, when we resort to chemical processes to effect the preservation of wood, lies in its very complicated structure. Being the product of vital processes and also the individual in which these processes are taking place, a tree necessarily contains very many different chemical substances arranged in a complicated manner. It is to the character of the constituent substances and the manner of their arrangement that wood owes the properties which render it so well suited to the purposes to which it is applied.

A brief description of the structure of a tree and the way in which it is formed will more clearly explain these difficulties. If we examine a section of the stem of a tree we observe that it consists; 1st, of the pith or its remains, at the centre; 2nd, of the wood surrounding the pith; and, 3rd, of the bark.

In Fig. 1 is represented a section both vertical and horizontal of a branch of a tree, two years old, as it appears in December. The portion included in the lines marked A is of the first year's growth; those marked B indicate the wood of the second year; while those marked C inclose the three layers of bark; D represents the pith of loose cellular tissue; E represents the pith rays or silver grain of hard cellular tissue connecting the pith with the green or middle layer of bark, which consists wholly of cellular tissue; F marks the outer or corky layer of the bark, which is composed of dry, dead cells, which are formed of consecutive layers from the outer portion of the living green layer; G is the green layer of cellular tissue; H shows the liber or inner bark, made up of cellular tissue penetrated by long bast cells, arranged parallel with the axis of growth; I represents the place of the cambium or growing layer of organizable material which descends from the leaves between the liber and the sap wood during the period of growth; K is a woody fibre, which gives strength to the stem and through which the crude sap rises; L indicates the vessels or ducts, with various markings, such as dots, rings and spirals, which are formed most abundant-

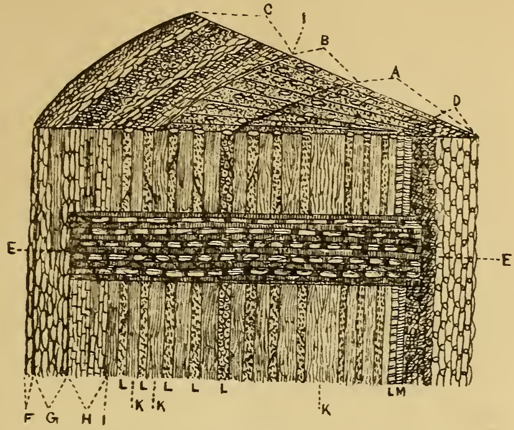


Fig. 1.

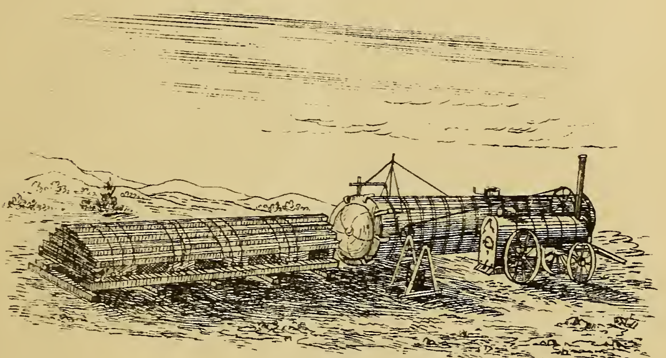
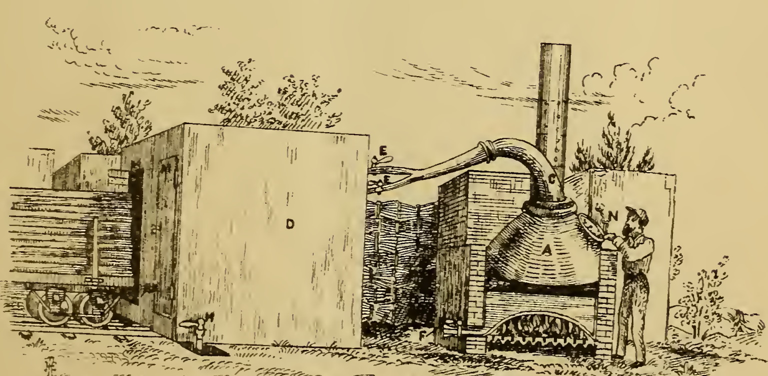


Fig. 2.



HELIOTYPE.

Fig. 3.

ly in the spring and usually contain no fluid. They convey gases and aqueous vapors, and it may be that a large proportion of all the water ascending from the roots to the leaves passes through them as vapor; M is the layer of spiral vessels or ducts, which always inclose the pith and in the young shoot extend into the leaves and unite them to the pith during its life, which ceases with the first season.

Though the assertion has given rise to much discussion it seems now to be well determined that a circulatory system exists in vegetables. For convenience it is divided into the vascular circulation and the horizontal or cellular circulation. In the first the sap from the roots passes up through the woody fibre and the elaborated sap or cambium passes down between the liber and the sap wood. In the second the fluids pass between the pith and the bark. The food for the growth of the tree is secured by the roots and the leaves. The roots absorb water and the nitrogenous and mineral substances which the tree requires. The leaves store up carbon from the decomposition of carbonic acid in the numerous stomatae with which they are provided. From these various substances the several constituents of the tree are formed and by the circulatory system they are conveyed to the part of the individual where they are to perform their functions. Thus we see that while the tree lives, in a healthy state, by means of its roots and leaves, it holds communion with the earth, water, and air, and that the fluids, juices and deposits depend for their movement upon the presence and action of these parts. When this communication is interrupted by drought or exhaustion of the soil, by the stripping of the bark or the felling of the tree, growth ceases. The circulation still continues however, but waste a of tissue begins, decomposition sets in, and the tree becomes the prey of fungoid growth. If however, after felling, we lop off the top of the tree, the vascular circulation ceases, and, if we remove the bark, cellular circulation stops. If now the tree is exposed to dry air at a moderate temperature, all vital processes are arrested and the wood is for the while preserved. Especially is this so if the sap wood is cut away and the pith is laid open.

From this sketch we realize how very complex the physical structure of the tree is. 'A narration of but a portion of the constituent substances will show that its chemical structure is still more diversified. In all plants we find woody fibre or cellulose, and this is covered with incrusting substances formed from the decay of the cells. The following substances are also found in quantities varying with the season and the locality, the species and the age of the plant. They are the constituents of the sap such as albumenoidal substances, starch, grape sugar, cane sugar, gum, tannic acid, coloring matters, pectose, resins, and volatile oils and the ordinary mineral constituents of plants, &c.

From the composition and structure of the healthy material our discussion naturally turns to the consideration of the manner in which the decay (Eremacausis) takes place and of the conditions most favorable to its progress. When wood in a moist state is ex posed to air it undergoes decomposition; a species of fermentation is occasioned by the nitrogenized constituents, in consequence of which oxygen is absorbed, carbonic dioxide and water are exhaled, and the wood crumbles down into a blackish brown vegetable mold called humus, ulmine or geine. This decay occurs most rapidly in young, spongy wood, which admits the air most freely and at the same time contains a proportionately larger quantity of the albuminous substance, than the harder and older portions. The decomposition of these albuminous constituents favors the growth of lichens and fungi and encourages the ravages of insects, to which the albuminous portions in particular afford nutriment. Pure woody fibre by itself, is only very slightly affected by the destructive influences of weather as we see in cotton, linen, paper and other materials, formed from nearly pure cellulose. The decay arises wholly from the presence of the substances in the wood that are foreign to the woody fibre, but are present in the juices of the wood while growing, and consist chiefly of albuminous matter, which, when decaying, causes the destruction of the other constituents of the wood also. Since resinous woods resist the action of damp and moisture for a long time, they are quite lasting ; next in respect to durability follow such kinds of wood as are very hard and compact and contain some substance, which like tannic acid, resists decay.

The conditions which obtain then are these ; a limited supply of air, a moist atmosphere, and a moderate temperature. Change either of these conditions and decomposition ceases. You will recall that these conditions air, moisture and heat are the very same as were shown by our eminent associate, Dr. Gihon, to exercise so baneful an effect upon the health of those who live in ships. Remove the moist atmosphere and while the health of the inhabitants is benefited the destruction which assists in polluting the air is delayed.

Mr. Finchau, formerly Principal Builder to Her Majesty's dockyard, at Chatham, tried an experiment to show that the presence of all these conditions was essential to decay. He bored a hole in a perfectly sound timber in an old oak ship. The admission of air to the central part of the wood, moisture and heat being already present, caused the hole to-be filled up in the course of twenty-four hours with mold which speedily became so compact as to admit of being withdrawn like a stick.

Other cases may be cited of the remarkable freedom of wood from decay when any of these conditions are changed. For instance, when there was free circulation of air and an absence of moisture as in the roof of Westminister Hall we find well preserved wood over four hundred and fifty years old (1866). The carvings in oak at Stirling Castle are also over three hundred years old (1866), and Scotch fir was found in good condition after three hundred years, and the trusses of the roof of the Basilica of St. Paul, Rome, sound and good after one thousand years. Instances of longevity where there was an absence of air, and the wood was submerged in water, are found such as the piles from the foundation of the old Savoy Palace perfectly sound after six hundred and fifty years, the piles from Old London Bridge perfectly sound after eight-hundred years, &c.

Preservation.

In accordance with these observations, Wagner, (Chem. Tech. p. 474, Am. ed.), divides the methods adopted for the preservation of wood as follows: 1. the elimination, as much as possible, of the water from the wood previously to its being employed; 2. the elimination of the constituents of the sap; 3. by keeping up a good circulation of air near the wood so as to prevent its suffocation as it is termed; 4. by chemical alteration of the constituents of the sap; 5. by the gradual mineralization of the wood and thus the elimination of the organic matter; and to these may be added 6, by the use of antiseptic agents.

The first of these is the most universally employed method, i. e. by seasoning. As formerly carried on, the wood, carefully protected from sun and rain, was stored away for years. An active circulation of air was permitted and by the slow action of this air all the moisture was extracted from the wood. As the presence of moisture is essential to the fermentation of the albuminous and saccharine constituents of the sap this fermentation is thereby prevented. But beside the loss of interest on the capital invested and the time required for this result to be attained this method has other objections. If the timber is in the log it is liable to become rent, and if the pith is not bored out it is liable to decay at the heart before the moisture can be evaporated from it. If cut into lumber great care must be taken to prevent warping and cracking. Consequently various processes have been proposed for hastening the drying, while yet it is so controlled that cracking and warping are avoided. Several of the processes of seasoning depend too upon the removal of the sap. We have water seasoning, seasoning by steaming and boiling, seasoning by smoke drying and stove drying, seasoning by scorching and charring, seasoning by extraction of sap, &c. Water seasoning, which is effected by submerging the wood for some time in water, renders it brittle. Seasoning by steaming and boiling also diminishes the strength and elasticity of the wood, for at temperatures somewhat below the boiling point, that is at 140° F., the albumen is coagulated and this seals up some of the water or sap in the wood and thereby weakens the cohesion of the particles. The process of smoke drying answers quite well but the same result is more easily attained by the Bethell or Robbins process to be described farther on. Stove drying renders the wood quite hygroscopic and leaves the pores open. Scorching and charring are only applicable to wood already thoroughly seasoned. If green wood is treated in this way the outside only is protected; the sap is sealed up in the interior and ferments and then decomposes. It may be well to mention here that the same unfortunate result is brought about if the green wood is covered with a coat of paint. The protection is wholly superficial and is very deceptive. It is far better to leave the wood uncovered for then if there is a free circulation of dry air, the wood will gradually season as the sap is evaporated. Owing to the belief that paint or varnish will protect wood under any circumstances it is no unusual occurrence to find the painted wood work of old buildings completely rotted away while the adjacent naked parts are quite sound. But the preservative action induced by charring seasoned wood is undoubted, for by the destructive distillation of the superficial layer various antiseptic agents are formed which find their way into the interior of the wood and the charcoal left upon the surface acts to destroy all fungoid germs which seek an entrance. This process has been long employed for preserving piles &c., and has been used in the Portuguese and French Navies. M. de Lapparent makes use of a gas blowpipe, the flame from which is allowed to play upon every part of the timber in succession. By this means the degree of torrefaction can be regulated at will. Instances of the efficiency of this process are cited as follows. Charred wood has been dug up which must have lain in the ground fifteen hundred years, and was then perfectly sound. At Herculaneum, after two thousand years, the charred wood was found to be whole and undiminished. The methods proposed for seasoning by the extraction of the sap alone have been abandoned as impracticable.

PROCESSES DEPENDING ON THE CHEMICAL ALTERATION OF THE SAP.

The first of these processes that went into general use was Kyan's process, patented in England in 1832, and soon after in this country. This process, called Kyanizing, consisted in immersing the wood in a dilute solution of mercuric chloride (corrosive sublimate) until it was thoroughly saturated, or if time was an object, injecting the solution by pressure in a closed vessel from which the air was first partially exhausted. In England a solution of one kilo. of the salt to eighty to one hundred liters of water is employed for railway sleepers. They are laid in an open tank. In Baden they remain in the solution, when they are to be impregnated to a depth of 82 m. m., for four days, 85 to 150 m. m., for seven days, 150 to 180 m. m., for ten days, 180 to 240 m. m., for fourteen days, 240 to 300 m. m., for eighteen days, the solution consisting of one kilo. of salt to two hundred liters of water. When taken out the wood is washed and dried.

The use of the mercuric chloride depends upon the fact that it converts the albumen into an insoluble compound, while the salt itself becomes reduced to the mercurous chloride. This process was extensively adopted in England, and to some extent in this country. The objections urged are that the salt employed is costly, that when open tanks are used the process is tedious, and when closed vessels are employed the method is very costly, that the mechanics who shape the wood are liable to be poisoned by the salt, and that the bolts which hold it are liable to corrosion. But the process when faithfully executed seems to effectually arrest the rapid decay of timber in exposed situations.

Zinc chloride has an effect upon wood somewhat similar to that of mercuric chloride while it is a much cheaper salt. In 1838, Sir Wm. Burnett was granted a patent for preserving wood by this material and the process was known as Burnettizing. A solution of one kilo. of zinc chloride to ninety liters of water is employed. The wood is placed on a car and run into a large, air-tight, cylinder of iron and the solution is forced in under pressure. Although this method is not a sure preventive of decay the advantages which result from using it are more than sufficient to justify its application to most kinds of timber in common use, and in situations favorable to rapid decay. It has also a distinct effect in rendering wood less liable to warp and crack when placed in dry situations. It is open to the same objection as the mercuric chloride that the salt will act upon the iron or copper fastenings. This process has been quite thoroughly tried in this country by Mr. J. B. Francis of Lowell, Mass., and its preservative power in many cases was quite well shown. Pieces of various woods treated by Burnett's process were partially buried in the ground side by side with unburnettized similar pieces of the same woods. They were kept there for over five years, and at the end of that time while the unprepared specimens were thoroughly decayed most of the burnettized ones were in good condition. Especially was this the case with birch, beech and poplar.

In the same year in which Burnett secured his patent another patent was granted in England to Bethell for the use of the heavy oil of tar for impregnating wood. This material is obtained as one of the by-products in the manufacture of coal gas. Although its composition varies considerably it always contains carbolic and cresylic acids, which are among our best known antiseptic agents together with various resinous, empyreumatic, and asphalt forming substances. The perservative influence of these substances is well known.

Bethell placed the wood in an air tight cylinder (See Fig. 2) and first produced a vacuum, by which means the air and moisture were extracted from the wood. Then the liquid was forced in until a pressure of one hundred and fifty pounds to the square inch was obtained, and the pressure was continued until the wood was sufficiently saturated. This process was very successful, specimens which were treated in this way having remained unchanged when buried for over eleven years. Dr. Ure says of this process, "the effect produced is that of perfectly coagulating the albumen in the sap, thus preventing its putrefaction. For wood that will be much exposed to the weather, and alternately wet and dry the mere coagulation of the sap is not sufficient; for although the albumen contained in the sap of the wood is most liable and the first to putrefy, yet the ligneous fibre itself, after it has been deprived of all sap, will, when exposed in a warm, damp situation, rot and crumble into dust. To preserve wood, therefore, that will be much exposed to the weather, it is not only necessary that the sap should be coagulated, but that the fibres should be protected from moisture, which is effectually done by this process.

The atmospheric action on wood thus prepared renders it tougher, and infinitely stronger. A post made of beech, or even of Scotch fir, is rendered more durable, and as strong as one made of the best oak, the bituminous mixture with which all its parts are filled acting as a cement to bind the fibres together in a close, tough mass, and the more porous the wood is, the more durable and tough it becomes, as it imbibes a greater quantity of the bituminous oil, which is proved by its increased weight. The materials which are injected preserve iron and other metals from corrosion; and an iron bolt driven into wood so saturated, remains perfectly sound and free from rust. It also resists the attack of insects; and it has been proved by Mr. Pritchard, at Shoreham Harbor, that the *teredo navalis*, or naval worm, will not touch it."

In this country a patent has been granted to Robbins* for an improvement in Bethell's process. He employs the oil of tar and drives the sap from the wood. Then he forces the tar in, in the form of a vapor, in which condition it is claimed that it penetrates more deeply into the wood and in a shorter time. It is claimed also that the wood is cleaner than when prepared by Bethell's process. One side of the Vandalia was treated in this way and it is proposed to compare its durability with the wood of the other side, both being manifestly under similar conditions.

The objections which have been urged against the use of coal tar compounds are that they impart a disagreeable odor to the wood; that the wood is difficult to work, as it clogs the tools, and that it renders the wood more inflammable.

One of the most interesting methods devised for introducing preservative agents into the pores of wood is that suggested and applied by Boucherie. Deep cuts were made in the trunk of a living tree near the roots, a sort of tank built around them, and the tank filled with the solution. (See Fig. 4.) Sometimes the tree, immediately after felling, was placed upright in the solution. In either case the solution was drawn up by the aspirative force of the tree, and penetrated even to the leaves. According to Hyett (Parnell's Chemistry) a poplar tree, ninety feet high, placed with its lower end in a solution of acetate (pyrolignite) of iron of specific gravity 1.056, absorbed about ten feet cubic in six days. Afterward the method was modified by applying a rubber cup to the larger end of the log as it lay on the ground with the top lopped off. Then the solution was allowed to flow from a hight, in order to exert

* For form of apparatus see Fig. 3.

Description of Fig. 3.

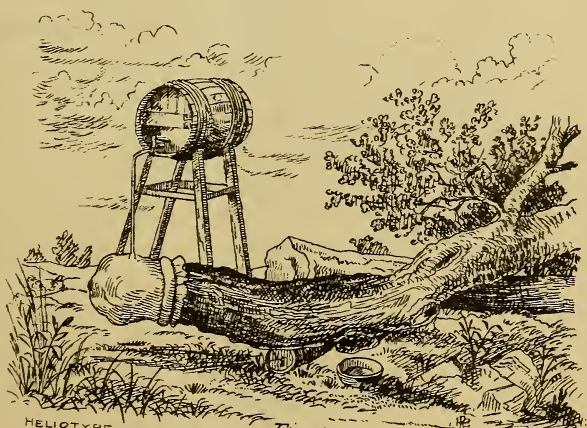
A, represents a retort in which the coal tar, resin or oleaginous substances or compounds are placed and subjected to the action of heat, B is the man-hole for reaching the interior. C the pipe with branches E E which connects the retort with the wood chambers D. F discharge pipe for retort. H discharge pipe for vapors condensed in chambers.

pressure, into the cup. (See Fig. 5.) By this means the sap was forced out and the solution flowed in. When the solution began to issue from the opposite end the operation was completed. Boucherie tried various substances but the one which he decided upon as the best was cupric sulphate. The solution used is one kilo. cupric sulphate to one hundred litres of water.

The testimonials to the efficacy of cupric sulphate are quite numerous. In some of the German mines it has given better results than zinc chloride. (Dingler's Poly. Jour. 1871, Vol. 202, p. 174.) But on certain German railways where it had been employed to protect the sleepers it was found to attack the iron. It is said in defense of the process that if the wood is thoroughly dried after impregnation, the iron will not be acted upon. However this may be, in ships where copper fastenings are used there would be no action. In 1855, the jury of the French Exposition made an extremely favorable report upon Boucherie's process, asserting not only its value, but its superior cheapness over the plan of creosoting. (Jour. Frank. Inst. 1856, vol. 32, p. 1.) In 1846, about eighty thousand sleepers saturated with cupric sulphate together with some that were unprotected, were laid down on the Northern railway of France. In 1855 that is, nine years afterward, the prepared sleepers were as good as ever, the others having long been decayed and replaced by new ones. For preserving telegraph posts, the cupric sulphate has been similarly effective. The saving to the French lines alone, up to 1855, was estimated at two and a half millions of francs (Compte Rendus 1868, vol. 67 p. 713.) By the report of the commission to the exposition at Vienna we learn that this process is still resorted to for this purpose and that telegraph posts are made to last from fifteen to twenty years. (Vol. II, L. 2, p. 18.) Examples of the preservative value of cupric sulphate could be easily multiplied, but one more will suffice. In 1868, Boucherie Jr. exhibited to the French Academy specimens of wood which had been prepared according to his father's process and exposed since 1847. These specimens were as sound, as elastic, and as strong as when new, and readily yielded the reaction of the copper they still retained. Here was a test of twenty years standing.

The rationale of the action of cupric sulphate has been stated by Koenig. (Am. Jour. Sci. 2 series, Vol. XXXII, p. 274.) The action is first the union of cupric sulphate with the resinous and albuminous constituents and next the dissolving of the albuminous compounds by the excess of the cupric sulphate solution. By long immersion it is said to be pos-

Fig. 4.



HELIOTYPE.

Fig. 5.

sible to remove all of the nitrogenized bodies. Resinous woods retain the most basic salt.

The process is useful only for green wood, and best adapted to light, porous, easily perishable woods.

Beside the substances mentioned a multitude of others have been suggested but they have generally been abandoned. Some have aimed to introduce solutions of different substances so that the interchange of their atoms shall take place in the pores of the wood and an insoluble deposit will be formed there. But the tendency is to some extent to petrify the wood and thus to destroy those characteristics which adapt wood to its uses. You can easily realize how useful a carpenter's tools would be in shaping stone.

I will speak of but one other method and that you are all somewhat familiar with. It is the preservation of wood by salting. This method of treating ship frames is imperatively required by the lake underwriters in new vessels of the first class. The American Lloyds recommend it but do not make it an absolute condition.

"The mode of salting is to fix stops of boards between the timbers of the frames about the height of the load line, and when the ceiling and planking are worked and the plank-sheer ready to go into place the spaces between the timbers are filled with salt. Near the end of the vessel the salt is sometimes put between the frames quite down to the deadwood. A vessel of five hundred tons will take one hundred bbls. of salt applied in the usual manner." (W. W. Bates Ag. Rept. 1866.)

The use of salt depends upon the fact that it incrusts the timbers and prevents the fermentation from taking place at the surface, but if applied to unseasoned wood its action being only superficial it does not arrest the decomposition of the interior. It has been used by Boucherie as a substitute for cupric sulphate but it could not compare with it. The use of it is objected to because being a deliquescent salt it keeps the atmosphere moist. Beside it is corrosive. For instance so long ago as "between 1768 and 1773, the practice prevailed of saturating ships with salt; but this was found to cause a rapid corrosion of the iron fastenings and to fill the vessels between decks with a constant damp vapor." (T. A. Britton, p. 112.)

As we examine the various processes which are in use we observe one fact, that they are all of them adapted only to light, porous, easily penetrated woods. Only the sap wood of oak and denser woods can be reached, but this is the part which is most liable to decay and most in need of a preservative agent.

The conclusion to which I have come then is the following.

The preservative processes enable us to use an inferior quality of wood with great safety. When vessels must be built in great haste and of inferior material, the wood should always be subjected to the action of a preservative agent.

It would no doubt be advantageous to treat the hard varieties of wood after they have been thoroughly seasoned, for although the treatment would be only superficial, in thoroughly seasoned wood, this would be sufficient. Of the materials employed the use of cupric sulphate appears to me to be the best applicable for ship timber as regards cost, inflammability, freedom from odor, corrosive properties, poisonous action, deliquescence, durability and ease of application.

APPENDIX.

Table showing the cost of repairs per ton per year of life and per ton per year of sea service up to 1850 *of vessels of the U. S. Navy.*

	Rate Guns.	Tonnage.	Commenced Building.	Launched.	Cost. Building complete	Cost. Repairs to 1850.	Time from launching. yrs.	Time Building. yrs.	Sea service to Jan. 1850. y.m.d.	Repairs pr. ton pr. year of life.	Repairs pr. ton pr. year of sea service.
Franklin,	74	2257	1815	1815	438,149	27,487	35	1	8,9,8	.35	1.38
Columbus, 2	74	2480	1816	1819	426,930	260,468	31	3	8,1,20	3.36	12.97
Ohio, 2	74	2757	1817	1820	547,889	471,673	30	3	5,3,10	5.70	32.65
North Carolina,	74	2633	1818	1820	431,852	369,176	30	2	4,9,16	3.07	29.33
Delaware,	74	2633	1817	1820	543,368	459,199	30	3	6,9,2	3.59	25.31
Independence, 2	54	2257	1814	1814	421,810	538,392	36	1	7,5,26	6.60	31.89
United States,	44	1607	1796	1797	299,336	658,106	53	1	20,5,17	7.73	20.07
Constitution,	44	1607	1796	1797	302,719	495,236	53	1	32,0,24	5.82	9.61
Potomac,	44	1726	1819	1821	350,000	390,244	29	2	10,8.23	7.80	20.93
Brandywine,	44	1726	1821	1825	399,217	644,496	25	4	17,4,9	14.93	21.58
Columbia, 2	44	1726	1825	1836	336,891	136,339	14	11	6,5,12	5.65	12.25
Congress, 4	44	1867	1839	1841	399,088	122,631	9	2	6,1,2	7.39	10.86
Cumberland,	44	1726	1825	1842	357,475	114,802	8	17	4,10,21	8.31	13.58
Savannah,	44	1726	1820	1842	400,739	78,260	8	22	4,7,27	5.67	9.86
Raritan,	44	1726	1820	1843	406,087	81,663	7	23	4,4,6	6.76	10.88
Constellation,	36	1778	1796	1797	314.212	400,982	53	1	22,5,17	5.92	13.97
Macedonian, 2	36	1341	1832	1836	258,872	67,135	14	4	6,2,7	3.58	8.15
Average cost,										$6.02	$16.19

The first nine columns are compiled from Emmons' Statistical History. The last two are added by me.

AUTHORITIES.

Physiology of Circulation—*J. B. Pettigrew.*

Circulation of Sap in Plants—*W. S. Clark.*

Wood—*Watts Dict. Chemistry, Vol. V. p.* 1044.

Treatise on Dry Rot in Timber—*T. A. Britton.*

Ship Timber in U. S.—*W. W. Bates, Ag. Rep't.* 1866, *p.* 472.

Eremacausis—*Watts Dict. Chem. Vol. II., fig.* 497.

Decay of Wood Fibre—*Miller's Organic Chemistry, p.* 139.

Preservation of Wood— " " " "

Preservation of Wood—*Wagner's Chem. Tech. p.* 472.

Preservation of Wood in Damp and Wet Situations—*H. W. Lewis.*

Jour. Frank. Inst.—*Vol. L. II. p.* 217.

Decomposition of Organic Bodies, *Gmelin Vol. VII, p.* 90.

Cellulose, *Gmelin Vol. XV, p.* 123.

Wood, *Gmelin Vol. XV, p.* 149.

Burnettizing—*pph. J. B. Francis, C. E. Lowell, Mass.* 1859.

Preservation of Wood—*Rept. to City of Boston* 1873, *F. W. Clarke.*

Thilmany Process—*N. A. Wood Pres. Co. Cleveland, Ohio.*

The Robbins Process for Rendering Wood Imperishable—*Nat. Pat. Wood Pres. Co* 1867.

Statistical History of the Navy of the U. S. from 1775 to 1853—*by Lt. Geo. F. Emmons U. S. N. Wash.* 1853.

Pelouze et Fremy Traiti de Chimie—*Tome. IV, p.* 776, et Seq.

Conservirng des Holzes—*Zwick Chem. Tech. p.* 906.

First Forms of Vegetation—*Hugh Macmillan.*