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Preservation of Wood in Damp and Wet Situations. By H. W. Lewis, University of Michigan.

GRADUATING THESIS.

No introductory apology for the theme of this paper is judged necessary. A few plain statements will show that the subject is one of vast though unheeded importance.

The annual drain which is exhausting our forests is startling when we remember the vast areas of our country utterly destitute of timber—when we learn, for instance, that "upon the 55,000 square miles of Illinois, there grows not a single pine large enough from which to fashion a board.* Statistics show that, in 1865, above 5,000,000,000 feet of lumber, 2,000,000,000 of shingles, and 900,000,000 pieces of lath were sold in Chicago alone.† Michigan and Wisconsin almost entirely supply that market. 6000 feet of pine lumber per acre is an average yield.‡ No formal calculation is necessary to show us that, with the present demand, a single generation will exhaust the supply those States can afford.

* Hunt's *Merchant's Mag.*, Feb., 1866, page 105.

† Lumber, 5,089,033,033 feet; shingles, 3,560,093,212; lath pieces, 938,297,743. —Hunt's *Merchant's Mag.*

‡ "An average estimate of the product of lumber of all the pine lands in the State is 6000 feet to the acre. Some sections will overrun, some fall short, of this amount." * * * "Seven years will exhaust all the pine lumber within five miles of any of the navigable rivers."—*The Pine Lands and Lumber Trade of Michigan*, page 4.

But the consumption increases in a rapid ratio. It has already raised the prices. Clear lumber sold for $18 per thousand in 1855, for $24 per thousand in 1860, and for $45 per thousand in 1865.* And following close on Chicago, in this trade, are Albany and Pittsburgh.†

Improvidence will soon, we fear, make us as dependent on foreign supplies of timber as is England, who has already granted numerous patents for processes promoting the durability of the lumber every enlightened nation must have.

Shall we employ those processes whose utility experience has demonstrated? Self-interest returns but one answer. But in American railway management, self-interest seems to be disregarded. While the average life of English railway sleepers is fifteen years, that of American sleepers is only seven years.‡ Allowing 2112 sleepers per mile, at fifty cents each,§ $1056 per mile of American railroad *decays* every seven years. Thoroughly impregnate those sleepers with sulphate of copper, at a cost of five cents each, and they would last twice as long. Thus would be effected a saving of $880 per mile‖ in the seven years, on sleepers alone. In the United States are 33,908·6 miles of railroad.¶ The whole saving on these lines would be $29,839,568, or upwards of $4,262,795 per annum.

Again, English engineers deride American wooden railway bridges. Eight years is their average duration.** Creosote them and they are good for double or treble that time.†† For ordinary railroad purposes they cost $40 per linear foot.‡‡ The use of Bethell's process would effect a great saving on such a line as the Grand Trunk Railway, whose wooden bridges measure 9355 feet upon the Montreal and Portland division alone.§§ Further illustrations of the importance of preserving timber from decay seems unnecessary. Let us proceed to the discussion of this desirable object.

In situations so free from moisture that we may practically call them dry, the durability of timber is almost unlimited. The roof of Westminster Hall is more than 450 years old. In Stirling Castle are carvings in oak, well preserved, over 300 years of age. Scotch fir

* Hunt's *Merchant's Mag.*, Feb., 1866, pages 106 and 107. † Ibid., p. 105.

‡ *New American Cyclopædia*, vol. xiii., page 734.

§ *Scientific American*, February 17, 1866. Also Col. Berrien's (Chief C. E. of M. C. R. R.) estimate of their cost for the past two years on the "Michigan Central Railroad."

‖ Five cents, at seven per cent. compound interest, amounts, in seven years, to eight cents. 50 cents — 8 cents = 42 cents saved *on each sleeper* at the end of seven years. $0·42 × 2112 = $887·04 saved per mile in seven years.

¶ De Bow's *Review*, February, 1866, page 207.

** *Civil Engineer's Journal*, vol. xxiv., page 282.

†† "A properly constructed railway bridge of suitable materials may be fully relied on for twenty years."—*Journal Franklin Institute*, vol. xxxvi., page 1.

‡‡ *Civil Engineer's Journal*, vol. xxiv., page 282.

§§ *Journal Franklin Institute*

has been found in good condition after a known use of 300 years,* and the trusses of the roof of the Basilica of St. Paul, Rome, were sound and good, after 1000 years of service.† After these well attested examples of preservation, the further consideration of wood in this state seems unnecessary.

Wood constantly wet in fresh water is quite as durable. Piles were dug from the foundations of old Savoy Palace, in a perfectly sound state, after having been down 650 years. The piles of old London Bridge were found sound and perfect 800 years after they were driven.‡

While the acidity of bog-water retards decay, it seems to us that part of the preservative property attributed to the stagnant liquid§ should be ascribed to the salts of metals or alkaline earths held in solution, and deposited among the woody fibres.

In the above situations, the action of natural agents cannot be improved. But in certain other conditions, man must resort to preservative processes to secure permanence of structure. For convenience of discussion we have introduced the following classification:

1. When wood is damp we have to guard against dry rot.

2. When wood is alternately wet and dry we have to guard against wet rot.

3. When wood is constantly wet in sea-water we have to guard against teredo navalis and limnoria terebrans.

1. *Wood in Damp Situations.*—When unseasoned wood is surrounded by dead air, it very rapidly decays, fine fungous growths extending through every part. After the rot has begun, the mere contact of decayed and sound wood seems sufficient to ensure, by a catalytic action, its spread through the latter. This has probably led some observers to their conclusions, that the accompanying parasitic plants, Merulius lachrymans (or L. vastator) and Polyporus hydridus, cause the decay. But the highest authorities now regard these growths as accessory, and beginning only after a suitable habitat has been prepared for them.‖ Thus the fungus acts the part of a scavenger and converts corrupt matter into new forms of life. The presence in the timber of the fungi spores is easily explained. The researches of Pasteur show that atmospheric dust is filled with minute germs of various species of animals and plants, ready to develop as soon as they fall into a congenial locality. He concludes that all fermentation is caused by the germination of such infinitesimal spores.¶ That they elude observation, does not seem strange, when we consider that some

* The *Builder*, vol. ii., page 638. † Ibid., p. 616. ‡ Ibid., p. 616.

§ *Civil Engineer's Journal*, vol. xxi.

‖ "There is no reason to believe that fungi can make use of organic compounds in any other than a state of decomposition."—Carpenter's *Comp. Physiology*, page 165. (See also *Encyclopædia Britanica* on this subject.)

¶ "Powders suspended in the air are the exclusive origin, the first and necessary condition of life in infusions, in putrecible bodies, and in liquids capable of undergoing fermentation."—See translation of Pasteur's experiments in vol. xxxii., page 9 of *American Journal of Science.*

infusoria are only $\frac{1}{24000}$ of an inch in length.* Admitting that they are only ten times the linear dimensions of their germs, the latter will be $\frac{1}{240000}$ of an inch long. But with the best microscopes we cannot perceive objects measuring less than $\frac{1}{80000}$ of an inch. These germs might find their way into the growing plant through both roots and leaves. The whole tree is thus filled with the seeds of decay, awaiting suitable conditions to spring into growing organisms. The prolonged vitality of spores, made necessary by this theory, cannot be a serious objection, when we remember the vigor of the "mummy wheat," and the unknown plants which start from the earth raised from deep excavations. Indeed, time, even when measured by centuries, seems hardly to affect the vitality of vegetable germs.

But what prepares timber for the germination of the fungi spores? Probably fermentation of the juices and semi-solids of the moist wood. For fermentation, five conditions are necessary,† viz: 1. Presence of water. 2. Temperature from 40° to 110° Fahr. 3. Presence of a ferment. 4. Presence of a fermentable body. 5. Exposure to the atmosphere.

Three of these conditions almost always prevail. Very rarely, if ever, can we maintain the temperature of any timber construction below 40° Fahr., or above 110° Fahr. Probably countless numbers of ferment spores are annually absorbed into the fluids of the smallest sapling. Completely excluding any construction above earth and water, from the atmosphere, is practically impossible. The two remaining conditions we can generally prevent.

1. We can remove the water by thorough seasoning, and in damp situations we can practically prevent its return by ventilation or resinous coatings.

Examples of remarkable durability of wood have been cited. With equal care in selecting and preparing the lumber, modern constructions might last as long. But while the wood of those old edifices was drying through years of preparation, the timber of modern constructions is translated from the primitive forest into a painted and varnished city dwelling in less than a single year's time. No wonder that in a very few decades, the whole structure is unsafe,‡ and that an odor of decay makes the mouldering rooms untenable.

* "Some infusoria are not more than $\frac{1}{24000}$ of an inch in diameter, and if we suppose the spores to be only $\frac{1}{10}$ of the parent's linear dimensions, there must be an incalculable amount of germs no larger than $\frac{1}{240000}$ of an inch in diameter. Since, according to Sullivant and Wormley, vision, with the most powerful microscopes, is limited to objects of $\frac{1}{80000}$ of an inch, we need not be surprised that we do not always see the floating germs of animals and plants."—Note by the translator of Pasteur's researches, *American Journal of Science*, vol. xxxii., page 9.

† Notes on Prof. A. B. Prescott's *Lectures on Organic Chemistry* in the University.

‡ For an account of the rapid destruction of the floors and joists of the Church of the Holy Trinity, Cork, Ireland, by dry rot, see *Civil Engineer's Journal*, vol. xii., page 303. For an account of the decay of floors, studs, &c., in a dwelling, see the *Builder*, vol. vi., page 34.

"In some of the mines in France the props seldom last more than fifteen months." *Annales des Mines.*

Thorough ventilation is indispensable to the preservation of even well-seasoned *naked* wood in damp localities. The rapid decomposition of sills, sleepers, and lower floors is not surprising where neither wall-gratings nor ventilating flues carry off the moisture rising from the earth, or foul gases evolved in the decay of the surface mould. In the close air of cellers, and beneath buildings, the experiments of Pasteur detected the largest per centage of fungi spores. Remove the earth to the foot of the foundation, and fill in the cavity with dry sand, plaster-rubbish, &c., or lay down a thick stratum of cement to exclude the water, and provide for a complete circulation of air, and lower floors will last nearly as long as upper ones.*

Various expedients have been resorted to, in order to hasten the seasoning process. Mr. P. W. Barlow's patent† provided for exhausting the air from one end of the log, while one or more atmospheres press upon the other end. This artificial aërial circulation through the wood is prolonged at pleasure. However excellent in theory, this process is not practicable. By another method, the smoke and hot gases of a coal fire are conveyed among the lumber, placed in a strong draft. Some writers recommend the removal of the bark one season before felling the tree. All good authorities agree *that the cutting should take place in the winter season.*‡

An impervious covering upon undried timber is very detrimental, for by it all the elements of decay are retained and compelled to do their destroying work. The folly of oiling, painting, or charring the surface of unseasoned wood is therefore evident. Owing to this blunder alone, it is no unusual thing to find the painted wood-work of older buildings completely rotted away, while the contiguous naked parts are perfectly sound.

In concluding this part of the subject we may say, *thoroughly season your lumber, afterwards cover it with varnish, paint, or pitch, or maintain around it a constant and thorough circulation of air.*

2. We can remove the fermentable body, or chemically change its nature.

Woody fibre consists chiefly of cellulose and lignine. The former is very durable, and the latter moulders away but slowly, when exposed to air and moisture. But permeating through these, and increasing from the heart to the alburnum, are nitrogenous substances of the sap and immature wood, mostly vegetable albumen. These are the fermentable bodies we desire to remove or change. A patented process has been proposed to wash out the albumen by water flowing in at one end of the log while a vacuum was produced at the other. Theoretically satisfactory, this method does not seem to have been adopted. Boiling and steaming partly remove the ferment spores, but *may not*

* The *Builder*, vol. xi., page 46. † *Civ. Eng. Jour.*, vol. xix., p. 422.

‡ Experiments detailed in the *Cosmos* show conclusively that winter-cut pine is stronger and more durable than that cut at any other season of the year.—*Ann. Sc. Discovery* for 1861, page 346.

"Oak trees felled in the winter make the best timber."—The *Builder*, 1859, page 138.

destroy the vitality of those remaining. For, according to Milve-Edwards, he has seen tardigrades resist the prolonged action of a temperature of 248° Fahr., and has known them to survive a temperature of 284° Fahr.* That low forms of vegetation are fully as tenacious of life cannot be doubted.

Boiling and steaming also coagulate the albumen at 140° Fahr. Although coagulated albumen is insoluble in water, the water of solution is, by this heating process, sealed up in the wood, and the cohesion of the latter is said to be diminished.

Albumen is also coagulated by sulphate of copper, pyrolignite of iron, chloride of mercury, chloride of zinc, &c. Some of the compounds thus formed are albuminates of the metallic oxides. Probably this is the reason why some of those salts are such excellent preservatives. But the researches of Kœnig† show that, when blue vitriol is employed, a certain portion of basic sulphate of copper remains combined in the pores of the wood so that water will not wash it out. The most resinous woods retain the most of the basic salt. Impregnated woods also contained, he found, less nitrogen than natural. It is even possible, he states, to remove all the azotized compounds by long immersion in the sulphate solution. The albuminous substances first precipitated by the solution, are redissolved by excess, as in case of concentrated sulphuric and muriatic acids.‡ The operation of such solutions should, therefore, be one of lixiviation. Knœig hopes, similarly, to explain the action of the chlorides. A recent experiment on animal albumen by Professor Prescott, shows that its precipitate by the chloride of mercury, *is* also soluble in excess of the chloride solution. From this we may conclude that the antiseptic qualities of the chlorides depend, at least partly, on their dissolving out the albumen.

But could all the nitrogenous substances be removed, thereby preventing fermentation, the cellulose and lignine of unprotected wood would slowly decompose. Hence the salt used should act on those substances also. According to good authority, sulphate of copper has this action. M. Weltz maintains that, after a time, the sulphuric acid leaves the base, and acting upon the timber, carbonizes it. He has seen the props in a mine, opened 1800 years ago, charred by the free acid thus eliminated and in a perfect state of preservation, while their surfaces were covered with metallic copper in regulus.§

The use of corrosive sublimate was patented by Mr. Kyan in 1832; that of chloride of zinc by Burnett in 1838. M. Boucherie has used

* "Although, in ordinary cases, the death of animals takes place when the temperature is sufficiently high to coagulate the hydrated albumen in their tissues, we know that this is not always so in case of those previously dried. I have seen tardigrades resist the very prolonged action of a stove whose temperature stood at 120° C., and in the researches of Mr. Doyère, the heat was carried to 140° C., (284° F.,) without death ensuing from the heat."—Mr. Edwards on "Spontaneous Generation."—*Am. Jour. Science*, vol. xxvii., page 405.

† *Am. Jour. Science*, 2d series, vol. xxxii., page 274.

‡ *Brande and Taylor's Chemistry*, p. 634.

§ *Annual Sc. Discov.*, 1865, p. 51.

solutions of blue vitriol and pyrolignite of iron. Easy impregnation of the wood is the great merit of his method.

Each process has in turn excited the most extravagant hopes, and neither has justified a tithe of the expectations formed. While "Kyanizing," "Burnettizing," or the use of any salt whatever, has not prevented the ravages of teredo navalis or limnoria terebrans, each of the processes named improves the durability of wood exposed to dampness. Each is, therefore, worthy of explanation here.

Kyan's specified solution* was one pound of chloride of mercury to four gallons of water. Long immersion in the liquid in open vats, or great pressure upon both solution and wood, in large wrought iron tanks, is necessary for the complete injection of the liquid. The durability of well kyanized timber has been proved, but the expensiveness of the operation will long forbid its extensive adoption.

For "Burnettizing,"† a solution of chloride of zinc—one pound of salt to ten gallons of water—is forced into the wood under a pressure of 150 lbs. per square inch.

Boucherie employs a solution‡ of sulphate of copper one pound to water twelve and a half gallons, or pyrolignite of iron one gallon to water six gallons. He encloses one end of the green stick in a close fitting collar, to which is attached an impervious bag communicating through a flexible tube with an elevated reservoir containing the salt liquid. Hydrostatic pressure soon expels the sap at the opposite end of the log. When the solution makes its appearance also, the process is completed.

He finds the fluid will pass *along* the grain—a distance of 12 feet—under a lower pressure than is required to force it *across* the grain—three-fourths of an inch. The operation is performed upon green timber with the greatest facility.§

* *Civil Engineer's Journal*, vol. v., page 202. † Ibid., vol. xiv., p. 471.

‡ *Civil Engineer's Journal*, vol. xx., p. 405.

§ As a modification of this method he also cut a channel in the wood throughout the circumference of the tree, fitted a reservoir thereunto, and poured in the liquid. The vital forces speedily disseminated the solution throughout the tree.

(To be continued.)

Cantor Lectures.—On Submarine Telegraphy. By Fleeming Jenkin, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 690.

(Continued from page 163.)

LECTURE II.

Shallow and Deep Sea Cables.—The lecturer first alluded to the omission from the first lecture of any mention of the new insulators—balata, Parkesine, collodion, Mr. Mackintosh's material, and others. This omission was an oversight, due possibly to the fact that, as he