A TREATISE ON THE DRY ROT IN TIMBER.

BY THE LATE

MR. THOMAS WADE.

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TO HIS

ROYAL HIGHNESS

THE DUKE OF CLARENCE.

SIR,

I would offer this dedication to your Royal Highness, as a becoming tribute both to your public services, and your private feelings. The former are eminently recorded in the progressive improvement of their invaluable object, and the latter are too generally confessed, to require my testimony in proof of their amiable nature.

The acknowledgment of your Royal Highness's assistance, and attentions to the lamented author of this Treatise, is offered as a pledge of my gratitude, rather than as an argument of your Royal Highness's virtue.

The subject of the Memoir, as it influences the perfection of the Navy, appeals to your Royal Highness's most active anxiety for the benefit of your serious consideration; and I at once, console and congratulate myself, that the scientific manner in which it is treated, will be thoroughly appreciated, in being directed to your Royal Highness's intelligence and acquirements.

I have the honor to be,

Your Royal Highness's

Most obedient, and humble servant,

ELIZABETH WADE.

ADVERTISEMENT.

The Editor, upon whom the melancholy office of publishing this Treatise has devolved, requests in its favour the indulgence of the Reader. Had the Author lived to revise his work, and to prepare it for the Press, it would doubtless have been more worthy of the acceptance of the Public.

TO THE

Honourable Commissioners of the Navy.

UPWARDS of three years ago, you were pleased to grant me permission to visit the Dock-yards at Deptford and Woolwich, for the purpose of obtaining information to assist me in forwarding a plan to prevent the dry rot of timber in shipping, and for a saving in the article of paint.

This subject has continued to occupy much of my time and attention, and having had the honor to receive various communications, permitting my experiments to prevent the rot, to be tried on board several of His Majesty's ships, I think it proper to explain the nature of my pretensions, in return for the confidence you are pleased to repose in me, as well as in justice to myself; because it is impossible to conduct experiments on a large scale, so as to keep the principle of them secret; and as the time has arrived, when I am sure to have the credit of my discoveries, I have not a wish for concealment.

The subject is certainly of the first importance, materially affecting the public good, and this reflection has induced me to publish the results of experiments, and researches, which have been directed to this matter, because, as the subject becomes more generally understood, we may entertain a better hope of eliciting much useful information from others.

To that end, the following memoir will be found to take a popular view of the question, as free as possible from technical terms, and obscure phraseology.

The world is indebted to Becher, the Swedish chemist, for a most learned and elaborate dissertation on the subject of putrefaction. The liberty of adding, by way of notes, short extracts from the work of that illustrious philosopher, will, no doubt be excused, because as he has treated the subject in the most luminous manner, and has been peculiarly happy in his elucidation of the theory of it, the axioms established by him will serve to explain the phenomena of putrefaction in general.

The discovery of the decomposition of air and of water, may be considered among the most splendid trophies of that stupendous and magnificent monument, which was erected to science, by the joint labours of the philosophers and men of genius of the eighteenth century. Had the immortal Newton been reserved for our time, those causes which the state of knowledge of the age in which he lived enabled him but to guess, (yet it is now proved to guess successfully,) would have appeared in the clearest light, and truth would have burst upon us with irresistible splendour. I have forborne to draw a gloomy picture of the extent of the ravages of the rot; I trust the public opinion overrates the evil.

Should I appear to have been too particular in apparently trifling points, or to have introduced matter but remotely connected with the rot, the great importance of the subject must plead my excuse.

In course, I am much indebted to the labours and discoveries of the philosophers alluded to above, and I am most careful to acknowledge such obligations.

From talents usefully exerted, emanate the most splendid social, and patriotic virtues; it being the opinion of the most eloquent writer of our time, " that the means by which Providence raises a nation to greatness, are the virtues infused into great men; and that to withhold from those virtues, either of the living or the dead, the tribute of esteem and veneration, is to deny to ourselves the means of happiness and honour.

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SECTION I.

Of the Growth and Decay of Timber.

THE term Dry-rot seems very improperly applied to denote the decay in timber, which it is generally employed to designate; and the impropriety of the expression, probably, has not a little contributed to involve the subject in obscurity. Not unfrequently we may observe a common error to originate in a misnomer. A very short advance in the investigation of this matter will shew, that moisture is a condition necessary to the putrefactive process; and that water is the most efficient agent in effecting the decomposition of organized bodies.

Much light will be thrown on this subject, and a great deal of useful information acquired, by considering the nature and phenomena of the growth of timber.

In the Spring there is formed, immediately between the bark and the wood, a ring of lymph-ducts, through which, during the year's growth, nourishment is conveyed to the extremities of the tree. At the approach of Winter, these fine parenchymatous vessels become more rigid, and during the extremely cold weather they are completely indurated, and form a solid ring of wood, (still consisting of capillary tubes) which constistutes the increase of the tree for that year. When the tree is cut transversely, these concentric rings are very apparent. The number of them indicates the age of the tree, as their extent does the annual growth. Philosophers are agreed, that fluids rise in these fine vessels of wood by capillary attraction, a phenomenon long observed, but which has not been satisfactorily explained. It is well known, however, that if several tubes of various diameters are so placed that their lower ends are immersed in water, the fluid will rise in them very perceptibly higher than its external surface, in proportion to their several diameters, and much the highest in the finest, or capillary tubes.

It is worthy of observation, that this effect takes place even in vacuo.

This peculiar property of fluids has been particularly noticed, because we shall soon find it a very instrumental and active agent, in the decay of timber.

Of the Decay of Timber.

Having premised thus much, it now seems necessary to notice the appearance of timber, under the influence of what is commonly called the Dry Rot, and to describe the changes it undergoes. At first it swells; after some time it changes its colour; then emits gases, which have a mouldy, or musty smell. In the more advanced stages of it, the mass dries, and cracks in transverse directions. Lastly, it becomes pulverulent, and forms vegetable earth; and generally in some of these stages of decay, the different species of fungus are found to vegetate on the mass. In fact, it differs little from common vegetable putrefaction.

Nature is never more prolific, than when apparently at the point of dissolution. As soon as a vegetable is deprived of life, the matter constituting it begins to undergo changes, in order to enter into new combinations. It is reduced to simple principles, by the aid of warmth, and the presence of air and water. The volatile principles escape in the form of gas, and there remains a dark-coloured mass, which is mere vegetable mould, consisting of earth, carbon, oil, a little iron, &c. The putrid fermentation is nearly akin to combustion, being but a mere gradual process of the same kind, and considerable heat is sometimes evolved during its progress. By means of it, the volatile elastic fluids, as well as the carbonaceous matter, &c. are now in a fit state to become the pabulum, or food of other plants.

The decomposition of vegetable and animal substances, is determined by the same causes, and takes place on the same conditions. The only difference is, that as the combinations of the constituent, or elementary particles of the latter, are more complicated than those of the former, the elastic products disengaged, are also more numerous, and less simple.

The decomposition of organized bodies may be considered as the converse of their* growth.

It must cease to afford us any astonishment, that the remains of plants so rapidly decay, when we reflect on the circumstance, that the various vessels of plants, assimilate their peculiar contents by processes exceedingly slow, by which they are gradually, and almost imperceptibly, elaborated. An alteration of temperature, or the mere rupture of these vessels, is sufficient to lead to a decomposition of their contents.

The researches of chemists of our own time

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* Nam sicut in generatione partes coagulantur, et in corpus formantur, ita in putrefactione partes resolvantur, et quasi informes fiunt.

BECHER.

have shewn, that vegetables are chiefly composed of carbon, hidrogen, and oxigen, (in other words, of the substance called charcoal, and of the elements or constituent parts of water) yet that the intermediate compounds, or distinct substances obtained from vegetables, at least amount to upwards of thirty, each of which is possessed of its peculiar character; and as such, is entitled to be distinguished as a compound principle. Thus we are not only to consider the compounds that may arise, by calculating in arithmetical progression, but also to bear in mind, that a different dose or proportion of any one of these simple substances, may entirely alter the nature of, and give a new character to the compound. The following is a most remarkable instance of this fact: twenty-seven parts oxigen, seventy-two nitrogen, form our common atmosphere, whilst seventy oxigen, twenty-nine nitrogen, form nitric acid, or common aquafortis, products more completely different (previous to our knowledge of their composition,) could scarcely have been suspected or imagined.

SECTION II.

Of Fungus.

There are few natural productions, whose origin has given rise to more controversy, than that of the various species of fungus. Some authors have asserted this vegetable to be the cause of the rot, others the effect of it; some, that the matter of rotten wood was absolutely changed into this plant, whilst other writers have insisted on their being a link in the chain between animals and vegetables. Such, and so many discordant opinions arose, no doubt, because the writers had not been able to detect the means of propagation. As the age became more enlightened, it was at length concluded, the fungi's were plants possessing the principle of reproduction; and it may be added, that their seeds, like those of many plants, the eggs of insects, and spawn of some fishes, reptiles, &c. are profusely scattered abroad by the hand of nature; an immense quantity of which, (beyond all comparison, the most abundant part) proves abortive; but the plant, or insect, will be produced on the requisite conditions, and under favourable circumstances.

Thus the proper nidus for the reception of the seeds of the various species of fungus, seems to be wood in a state of progressive decomposition, or the remains of wood, &c. entirely decomposed, being mould containing much vegetable, or animal matter. It may be objected, that various parasitic plants are found on growing trees, but the parts of the trees, to which they are attached, are always, more or less, in a state of decay.

There is evidently some effect produced by these plants, and decaying timber, which is reciprocal. The latter furnishes food for the former, and the decomposition of the wood is accelerated by the growth of fungus, because the gaseous and soluble products are taken up by the plants, as quickly as these principles are disengaged. The reason which inclined the earlier naturalists abovementioned, to class the fungus as a production participating of the nature, and exhibiting characteristics of the animal kingdom, was, because it produced ammonia by distillation, which, in their age, was imagined to be a product exclusively afforded by animal matter. Ammonia is at present admitted to be a constituent of, or to be produced from a few other plants. The fungi's differ then from most other plants, by containing nitrogen, which, uniting with hidrogen in distillation, affords ammonia. Chaptal discovered that carbonic acid gas was very abundant in the fungus, and other subterraneous plants, or to speak more properly, in such plants as grow in the dark.

Now as both nitrogen, and carbonic acid gas, are set free, or disengaged, in considerable quantities from organized matter in a progress of decomposition, it is scarcely necessary to point out, how readily decaying timber in a ship must afford nutriment to the fungus, or to what an immense extent the fungus must accelerate the entire and complete decay of such timber.

The following passage is quoted from an elegant writer of the present day. "Water may "be disposed in a more favourable manner to the "developement of vegetables, by charging it "with the remains of animal and vegetable decom- "position. If, for example, the water be loaded "with principles disengaged by fermentation or "putrefaction, the plant then receives juices al- "ready assimilated to its nature, and these prepared "aliments must hasten its growth. Independent "of those juices already formed, the nitrogen gas, "which constitutes one of the nutritive principles "of plants, and is abundantly afforded by the "alteration of vegetables and animals, must "facilitate their developement. A plant supported "by the remains of vegetables and animals, is in the "same situation as an animal fed on milk only; its

" organs have less difficulty in elaborating this drink,
" than that which has not yet been animalized."

It seems proper in this place, to take notice of the habitudes of vegetables, as to the different quantity of water which they require. Nature in this, as in most other classes of her works, presents us with a great and almost endless variety. Some plants absolutely float in the water, from which they draw their nourishment at every pore, and as in this case, roots would be useless, accordingly no trace of roots can be discovered.

The generality of plants, as they have need of a considerable quantity of water, have roots which extend to a great distance, some more vertically, others more horizontally, and they possess the faculty of absorbing moisture by means of their leaves, branches, &c. Of plants whose transpiration is very limited, it may be observed, that nature presents them in situations, from which we must conclude they have need of very little water. Thus mosses, &c. are constantly found fixed on rocks, frequently on a species of rock not at all porous, and therefore by means of which, water cannot be absorbed from a distance. We find moss growing on small detached fragments of stone, on stones which form walls, and even where the moss is not continuous, on stones which are placed on the tops, and in the sides of walls, where mortar or cement has not been employed. The different species of fungus grow on timber, &c. where there is very little moisture; but this small portion of moisture is absolutely necessary; for if we remove a stone or piece of timber, on which fungus or mosses vegetate, into a dry situation, these plants soon languish and die.

In another part of this memoir we shall consider by what means timber may be rendered entirely unfit, as a nidus, or receptacle, to develope the seeds of fungus.

SECTION III.

Of the Causes of the Rot in Timber.

We must observe, the conditions on which * putrefaction takes place, are, that the substance be exposed to a moderate degree of heat, and that air and water be present. To favor this process as much as possible, the air and water should not be renewed, as they undergo a decomposition, which takes place very slowly:—besides, a current of air would carry off the moisture.

Moisture, however, is the chief cause of the rot in timber. In order to understand the operation of this agent, so powerful in effecting the decomposition of timber, it is necessary to bear in mind the structure of timber.

A thin piece, cut transversely, when viewed through a microscope, appears like a honeycomb, so that a log of timber may be considered as an assemblage of pipes or tubes.

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* Fermentatio ergo definitur, quod sit corporis densioris rarefactio, particularumque aerearum interpositio: ex quo concluditur debere in aëre fieri, nec nimium frigido, ne rarefactio impediatur, nec nimium calido, ne partes raribiles expellantur

BECHER.

From this arrangement of the parts, it will easily be conceived, that when one end of a piece of timber is placed in a damp or wet situation, the moisture will be conveyed to the other end by capillary attraction.

By attending to these circumstances, viz. the situation in which timber has been a long time exposed, and the state in which it was when so placed, we may, generally, accurately foretell in what state it will be found.

Thus, if a piece of timber, completely exsiccated, (or well-seasoned, as it is commonly called) be painted and placed in a dry situation, it will last for ages; but if a piece of timber, having the sap, &c. in it, be painted, it will rapidly decay, because the juices contained, are sufficient for effecting its decomposition, and the covering of paint prevents their escape.

Bond timber in ancient buildings, is generally sound when it is completely enclosed in dry masonry; on the contrary, when it is placed near the corner of a wall, and one end is exposed to the weather, it is always decayed.

Timber covered with water, does not rot, neither will timber placed in a dry air; but a log, half in the water, and half out, as a pile, rots at the water's edge.

The rot seldom or never is perceived in the lower part of a ship, that is, beneath the water line mark; it is generally the worst between wind and water, and the decay extends upwards.

Salt water preserves timber from putrefaction, evidently from the salt it contains; the water which evaporates is fresh, and is disposed to bring on putrefaction; in course, water reduced to the state of vapour, cannot raise any of the salts contained in sea-water. It must be observed at the same time, however, that we have timber of some particular sorts, which is nearly indestructible.

Of this kind may be reckoned Lignum Vitæ, ebony, box, &c. In the two former, perhaps, traces of decay have never been discovered, except in the sappy parts. Box is very rarely found in a state of decay; in the few instances noticed, the logs have been a long time on very moist ground, at the bottom of a pile. Pliny says, the common opinion is, that box, ebony, cypress, and cedar, are indestructible.

The image of Diana at Ephesus, supposed to be of ebony, was never changed, though the temple was ruined and rebuilt seven times.

He adds, that in his own time, the image of Jupiter in the capitol, made of cypress wood, was still fresh and beautiful, though set up in the year after the foundation of Rome 551, nearly 300 years. Lib. 160, cap. 40.

The great durability of these woods, arises no doubt, from their texture. They are very heavy, close-grained, and in fact, are exceptions to the rules already laid down. Water cannot be absorbed by them, they not being sufficiently porous: at the same time, they do not give out any soluble matter to water; at least not without long boiling, or digesting at a very high temperature. Therefore, for two reasons, the great agent that determines the changes in wood in general, here has not any influence.

We have wood of another class, which is very durable, such as Cedar, Mahogany, Teak, some sorts of Pine, &c. These woods are of an open grain, and very porous, but as they contain a quantity of oleaginous, or resinous matter, which occupies all their cavities, moisture cannot insinuate itself. When water is in contact with some of these woods, it cannot wet them, being repelled from their surface; as is also the case, when it is placed to the feathers of certain fowls, which are not wetted for the same reason. Pliny, in his natural history, (lib. 16, cap. 40) says, there was a temple of Apollo at Utica, the timbers of which were Numidian Cedar, said to have stood 1188 years.

It is desirable to endeavour, by art, to make the common and perishable woods, to resemble those which are very lasting, or indeed nearly indestructible.

Some persons would have us to believe, there is an essential difference between what is erroneously termed the dry-rot, and what they are pleased to denominate the common, or wet rot. The reason of making such distinction seems to be, that in the latter case, the powerful agency of rain, sun, frost, &c. alterations, heat, and moisture, is clearly ascertained; whilst in the former instances, no such agency being perceptible, the organization of timber is supposed to be dissolved, and destroyed, by some internal, insulated effort.

But it is perfectly clear, that there cannot be any instance of rot occurring without moisture; and it cannot be of any consequence, whether such moisture be supplied from rain, whether it be absorbed by the end of a piece of timber placed in bilge water, in a wet wall, or damp ground, &c. But, say they, the dry rot always begins in the interior of the work, and sometimes in the very heart of a log of timber.

No doubt it does, because, when a ship is closed up, the timbers are never dry throughout their whole substance, and many of them being cracked through their whole length, the fissures are soaked with water, yet very frequently very dry on the outward surface; many of the planks with which the ship is closed up, are brought immediately from the boiler, and how can all this moisture be dissipated?

The great internal heat of the ship, assists such moisture to decompose the fibre of the timber so rapidly, that it really would be no easy thing to devise means more prompt or efficacious.

In the instance of dry rot in a house, it happens where the floors, partitions, &c. are supplied with moisture from wet walls, or earth. The aqueous vapour is seen condensed at the back of such timbers; it is then absorbed into the body of them, and the decay goes on rapidly, assisted by the heat of the air in such apartments: if the seed of fungus be present, the plant is developed in all the superfluity of vigour exhibited in an hot-house, where the same means are resorted to, viz. an atmosphere scientifically and artificially heated, and highly charged with aqueous vapour.

Of Antiseptic Processes generally in use.

The conditions on which putrefaction takes place, being, the pressure of moisture, access of air, and a gentle warmth, the antiseptic processes must consist, on the contrary, in counteracting one, or more of these powerful agents.

Nothing is more easy than to preserve bodies from putrefaction, by lowering the temperature of the surrounding air; but this process necessarily is confined to operations on small quantities of matter, when a great degree of cold is artificially induced.

In nature this prevention operates on a large scale, as in* extremely cold weather organized bodies are not susceptible of any change. It is necessary to observe, that the air in the hold of a ship is at a high temperature, and that the exhalations emitted are prejudicial to the human body.

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* Intensum quoque frigus a putredine preservat, unde corpora Stockholmiæ tota hyeme in patibulo suspensa sine putredine animadvertimus.

BECHER.

SECTION IV.

Of excluding the Air.

TIMBER immersed in water does not putrefy, because there is not access of air, and the extrication of gas is hindered.

Animal bodies do not easily* putrefy in running water, for the same reason.

From a survey of London Bridge, taken in 1730, to be seen at Guildhall; it appears, the foundation on which the stone piers are laid, consists of huge piles of timber, driven as closely as art could effect, on the top of which are laid planks ten inches thick, strongly bolted; on these are laid the basis of the stone piers, nine feet above the bed of the river, and only a few inches under low water mark, three feet below the starlings. To prevent the water damaging the work, the lowest layers of stone are laid in pitch instead of mortar. The art of constructing cassons being then unknown, the

* Nimia quoque humiditas a putrefactione impedit, prout nimius Calor; nam corpora in aquâ potiùs gradatim consumi, quam putrescere, si nova semper affluens sit, experientia docet.

BECHER.

foundation of the stone work could not be carried on much under low water mark; though it has been built longer than 600 years, the superincumbent structure has not given way

Sound wedges are found in all ancient bridges, and other buildings, where very large stones are employed.

Their use seems to have been to keep the stone in a proper position, when adjusted, till the grouting, &c. framed in, had become set and hard.

Sound timber, resembling bond timber, is frequently met with in ancient buildings, particularly in the city wall in London.

In taking up the foundation of a weir on the river Air, near to Ferry Bridge, some poplar trees were found in a sound state; even the bark was not decayed. The trees had been in that situation nearly thirty years.

Numerous are the instances in which timber has been preserved sound from remote ages, where access of air is denied. There are some other processes of subordinate consequence, which may be referred to this head, such as covering bodies with paint, resins, pitch, varnish, &c.

SECTION. V.

Of Exsiccation.

THE most common mode of preventing the decomposition of vegetables, is by depriving the substance of moisture.

All timber may be dried.

The stalks, leaves, &c. of most plants may be dried. Hay, straw, flax and hemp, are easily dried. When wet they readily rot, in a damp close place.

Charring the surface of timber may be referred to this head; but the part really charred more readily attracts moisture.

The making Provisions.

Bodies found buried and preserved in sand, many of the soluble parts of animals, and vegetables, when inspissated, may be dried and preserved for a long time.*

* Ita aer frigidus et siccus, imprimis calidus et siccus, a putrefactione quoque preservat, quod in Hispania videmus et locis aliis calidis, sicco-calido aere preditis ubi corpora non putrescunt, et resolvantur; nam cadavera in oriente in arena, imo apud nos arte in furnis siccari, et sic ad finem mundi usque a putredine præservari certum est.

BECHER.

We have instances of the former in inspissated jelly or glue; of the latter, in gums, Spanish juice, and all vegetable extracts.

Many parts of animals very prone to run into the putrefactive process, may be preserved by mere exsiccation, such as the skin, intestines, bladder, &c.

SECTION VI.

Of Seasoning Timber.

FROM the preceding preliminary observations, it is proper to turn our attention to the usual mode of seasoning timber.

It would be a very considerable improvement, if the timber was so disposed, that a current of air might pass more freely through.

The lowest timbers instead of being supported by old, useless, or frequently, rotten logs of timber, should be laid on pig, or ballast iron, or on stone, or any other substance, not at all porous, and therefore incapable of absorbing moisture from the earth.

Stocks of timber should be protected at top from the effects of the sun and rain, and particularly the outward ends of the logs should be kept quite dry.

In the present mode of seasoning timber, traces of the rot are perceptible in the piles, chiefly in the sappy parts of the timber. The introducing a piece of timber in this state into the frame of a ship, must have a most mischievous tendency. Bodies do not undergo any change, unless the union of their component or elementary parts is disturbed by the addition of some new principle. Even then the changes go on very slowly, and almost imperceptibly; but by adding as a sort of ferment a body already much altered, it quickly induces the same state in a large mass of the kind.

We see familiar instances of this effect in the addition of yeast to wort, which accelerates the vinous fermentation in a remarkable manner. The bringing an ignited coal in contact with a large mass of coal, or other combustible matter, quickly excites combustion in the whole: and we may observe the same effect in animals, in the instance of the plague, all epidemical diseases, the small pox, &c.

It appears that in 1684, Dr. Plot paid some attention to the state of the timbers in the Royal Sovereign, when she was stripped of her plank, after having been built 47 years. She was built of timber that had been stripped of its bark in the spring, and which had been felled the second succeeding autumn. He observes, "all the ancient timber, then remaining in her, was so hard, it was no easy matter to drive a nail into it." This description by no means answers the character of old ship timber at present.

The Royal William, built in 1719, has lasted nearly a century. No doubt, the original timbers might have been in a very great degree replaced by others, in the various repairs which these ships had undergone ; yet there seems reason to believe, that the timber employed in them, must have been prepared or seasoned in some mode very different from the seasoning, as it is called, at the present day, in order to account for their enduring so long without change or decay.

It is understood that an examination of the timbers of the Royal William has lately taken place, in order to ascertain, whether they had undergone any preparation ; and the result was, the Gentlemen so employed reported, the timbers did not seem to have undergone any preparation at all. It may seem arrogant in an individual, who is not acquainted with the means employed in this investigation, not to coincide in such opinion, but with all proper deference for the Gentlemen, I am still a sceptic on this point.

Mere intuition could not enable any one to ascertain, whether some chemical impregnation had been resorted to ; but had that fact been ascertained, and established as far as possible, by repeated experiments ; still it would not follow, that the timber had not undergone some preparation to prevent the rot. It is well known, that our ancestors heated plank in a bath of sand, to make it assume its proper shape, instead of steaming or boiling it, as we do at present ; and if this method was also in use to dry the sap out of the timber, it will go very far to explain the cause of the extreme hardness in the timbers of the Royal Sovereign, noticed by Dr. Plot.

The roofs of some of our old buildings are perfectly sound, after having endured for many ages. That of Westminster Hall, constructed of Chesnut, has stood upwards of 300 years. It has lasted so long, merely because there is a free circulation of air, it is laid on dry masonry, and care has been taken to prevent any access of wet, by keeping the slates, lead, &c. in excellent repair.

Great importance has been attached to the mode, and time, of felling timber.

The public boards are said to be in possession of the results of many experiments on this subject. The timber has been felled in every season of the year, and experiments have been made, with a view to ascertain the utility of stripping the trees of their bark, for considerable periods, in some instances for several years, previous to the felling. It is much to be wished the results of the experiments were made public.*

By attending to what happens in the seasoning, and decay of vegetable matter, which is more easily preserved, and at the same time more prone

* Pliny informs us a tree should be cut to the heart round about, in order that the juices may escape, and that it should stand till all the juices have actually run out, before it is felled. Hist. Nat. lib. 16. cap. 39.

to decay, than timber; we shall be able to form a tolerably accurate judgment of what takes place, though much more slowly, in the seasoning and decay of timber.

For instance, hay, straw, flax, and hemp, if cut down and thrown in a heap, readily undergo fermentation, and are entirely decomposed in a very short time; but, if cut down and carefully dried, they may be preserved perhaps a century. These vegetables, as well as wood, are much shrivelled by exsiccation: and when at any subsequent time they are infused in water, they are dilated as at first, being in that state as capable of undergoing a decomposition, which is determined by the same causes and agents, and in the same space of time, as at first.

It is submitted, the same phenomena occur in the seasoning and decay of timber; still premising, that a considerably longer period of time elapses, before the effects take place.

From the above observations, it seems desirable, that the caulking with hemp should be discontinued, if a convenient substitute can be found, or to endeavour to render hemp less susceptible of decay.

If seasoning timber be only another name for complete exsiccation (no matter whether the effect be produced in a few days, a few months, or even years,) it cannot be expected that desirable event can be brought about by the present practice.

How can it be expected, that enormous masses of timber, piled horizontally in stacks of immense extent, can ever become dry, in situations where moisture is imbibed from the earth, where they are exposed to all the vicissitudes of the seasons, drenched with rain, scorched by the heat of the sun, and split in various directions by frost?

To the power exerted by these very agents, Mr. Chaptal has attributed the destruction of Granite and the hardest rocks, and the changes which they undergo are well delineated by him.

He observes, "Heat dries their surface, and renders it more accessible, and more penetrable to the water which succeeds; cold divides them, by freezing the water which has penetrated into their texture; insomuch that this concurrence of causes favours the disunion of principles, and consequently the action of water, which clears the surface, carries away the products of decomposition, and makes preparation for a succeeding process of the same nature."

The frame of a ship standing exposed to the weather from 5 to 10 years, is in a situation little preferable to that of the timber piles. Generally, the water reaches some part of her every tide; she is exposed to the rain, to the sun, to frost, &c. In a word, how can we expect the timber to be seasoned, or exsiccated, unless there be something of magic in the name of a ship, when the timbers forming the bow, the poles, &c. are known to be incapable of enduring so long a time, as is supposed to be required to season the Ship. The French, the Swedes, and the Venetians, build ships under cover, and in such case the frame may be said to be well seasoned. When a ship is built exposed to the weather, the lower part forms a grand reservoir for all the rain that falls; and as the timbers in that part are placed as close together as possible, the wet escapes very slowly; those timbers are always soaked with moisture, and to some distance from the keel exhibit a green appearance; this green matter, when viewed through a microscope, is found to be a beautiful and completely formed moss, which vegetates at the expense of the timber. If to season timber be only to dry it, the sooner it is dried the better: and when completely dry, it cannot too soon be employed in ship building, where it should be kept dry. It cannot answer any end to have seven years wear out of a ship on the stocks.

It appears, the ancients did not season the timber employed in ship-building. Pliny informs us, lib. 16, chap. 39, that in the first Punic war, all the fleet commanded by Duellius, was under sail within sixty days after the timber was cut down; also, that the armada sent against King Hiero, viz. 220 ships, were built and afloat in 45 days after the timber grew; and in the second Punic war, the fleet employed by Scipio, was under sail forty days after the fall of the timber.

Of what tonnage these ships were, we have not any account, and it may be objected, that they were very small; but, it will appear in another part of this memoir, that ships were occasionally built in Pliny's time, of a size far superior in tonnage to any in our day.

Some Reasons why the Rot is more frequent than formerly.

It is agreed that oak should not be felled under 60 years, nor above 200 years old; but on account of the great scarcity of timber, it has lately been cut very prematurely; therefore, the trees are not so large, and in order to procure timber of the requisite dimensions, the pieces, technically termed slabs, forming the segment of the circle, are cut off very thin, and the edges of the timber are left somewhat round: formerly those pieces were cut off very thick, and little more than the heart of the tree left. In a word, timber of large scantling has been cut from comparatively small trees; in course, a large proportion of it consisting of sap.*

* Pliny in his Natural History, says, the sap of oak, &c. is apt to rot, therefore, to have good timber, it should be cut away in squaring. Hist. Nat. lib. 16, cap. 37.

A most striking instance of the truth of this remark was observed on inspecting the timbers of the Aid, Transport, built in the year 1811, which was lately stripped of her planks at Deptford, in order to undergo a thorough repair, the slabs had been cut off so thick, that the timbers were quite square, and almost entirely heart; there was scarcely a piece of sap to be seen, and the few traces of decay, which were discernible, were in that part.

Another reason, contributing much to produce this effect, is, that a large proportion of foreign timber has been employed in the construction of ships, which contains much sap, and is very porous. This circumstance is noticed more particularly, because timber of this description seems capable of being made very durable.

Supposing timber to have been well seasoned, (by exsiccation) the present practice of boiling, or steaming, reduces it to the state of green timber, and counteracts all that has been done: formerly, the timber was heated in a bath of sand to make it assume its proper curvature. The expedient of boiling, or steaming timber, began to be used about 60 years ago: it being found that timber was sometimes burnt, or charred, by the former method.

Boiling or steaming pine, or fir, must be very prejudicial; as the water, in which it is boiled, dissolves the resin, which is seen to float plentifully on the surface.

Much stress has been laid upon the destructive action of the gallic acid, or astringent principle contained in oak, which is exerted on the iron bolts and fastenings of ships; and it has been confidently asserted, that teak wood has not any tendency to dissolve or corrode iron. The result of some observation and enquiry on this subject, leads to the conclusion, that both teak and oak have the power of destroying and corroding iron in an equal degree; however, the re-action of the oxidated iron is very detrimental to the oak, whilst the teak does not seem at all affected by it.

When a ship is old, the tree nails, as well as the iron bolts, are almost always found in a state of decay. The moisture easily finds its way through the end, and along the sides of the tree nail, and thus is introduced into the parts of the plank and timbers, where they are perforated to receive the tree-nail: and then passes on in a longitudinal direction, in the interior both of the planks and timbers.

Two improvements in ship-building have been introduced, which, though they are very advantageous and efficacious for the purposes intended, yet, they may perhaps be suspected to contribute in some degree to the premature decay of his Majesty's navy. The first of these, is the practice of caulking the timbers in the lowest parts of the ship to a certain distance from the keel; to which precaution ships are often indebted for their safety: but we must bear in mind, that air, without being renewed, confined a long time in a close place, most remarkably favors the process of putrefaction in organized bodies. On this account, the bread room, and magazine of a ship, being the most confined parts, are generally most rotten.

The other alteration alluded to, is the mode of coppering his Majesty's ships. At the first view it might be thought to have an effect somewhat analogous to the above, by closely confining some portion of air, but on diligent enquiry it appears, the water penetrates between the joinings, or seams of the copper, and that the interstices between the copper and the plank are occupied by a fine mud, which soon insinuates itself.

Copper, however, has a remarkable property of accelerating the decay of iron in contact with it. Great care is used to prevent sheet, or other copper, from coming in contact with iron; yet it frequently happens, notwithstanding all the caution adopted, that these metals do come in contact, and the invariable consequence is, the iron bolt becomes decayed and corroded so as in many instances to be entirely useless, and sometimes the safety of the ship has been endangered.

Among the causes contributing to the premature decay of ships, there is one of more importance than may be generally imagined: that is, the practice of mixing timber of all sorts, and of all ages. There may not be much harm in using green timber, if it stands long enough to be completely dry, or as dry as the rest of the frame, before it is closed or shut in; but what can be expected from a piece of timber, that has been laying ten or twelve years exposed to the weather?

When such a piece of timber presents itself to our notice, it ought to be rejected altogether in a new ship: it should be considered as an old servant that has done its duty, but is now superannuated. At all events, if employed at all, it should be in the repair of an old ship, that has but a little time to run: and even if employed in that way, its services must be questionable, especially if it be made use of when soaked full of water.

Of the means of preventing the Rot.

The bilge water in ships is a powerful agent in accelerating the decay in timber, by its being taken up in the way of capillary attraction, and by these means moisture is conveyed to a great distance. But as it is impossible to prevent the accumulation of bilge water, it seems desirable, to be able to turn the circumstance to some advantage.

On carefully examining the different parts of a ship, under the influence of the Rot, it is obvious, on a very cursory observation, that the lowest parts, which are always wet with the bilge water, are very sound, that the mischief generally begins about the water line, and continues to extend upwards.

There are two reasons why this difference is found. The first may be referred to the theory laid down in Section 3, viz. that timber does not decay which is constantly immersed in water: and the second, to that of Section 9, viz. that organized bodies whose pores are penetrated by saline matter, do not undergo decomposition.

It may be objected, that the part of a ship above described, does not come in contact with bilge water; but, in answer to that, it must be remembered that every upright timber, the lower end of which is in a situation to absorb salt water, will by capillary attraction convey it to the higher end.

Should the joint be extremely close, it will be carried still further; but on account of the openness of the joining, the communication is generally much impeded, or perhaps entirely cut off.

The upper parts of a ship, where the Rot is most conspicuous, are plentifully supplied with moisture of another description.

A considerable quantity of water in a state of vapour continually exhales from the lowest part of a ship, and is readily condensed again into a fluid state in the upper.

The salts contained in sea-water, not being at all disposed to assume the state of vapour, remain in solution; whilst the water possessing sufficient volatility for that purpose, is raised up in vapour quite fresh. Thus the lowest parts of a ship are saturated with water, very much loaded with saline matter, which resists putrefaction altogether but the upper parts are slightly moistened by water in a fresh state, a circumstance highly favorable to the putrefactive process.

From a careful consideration of these facts it is obvious, that in order to prevent the decay of timber in contact with air and moisture, we must either fill up the pores which absorb moisture, or render the ligneous fibres insoluble.

This may be accomplished by employing some processes whose effects bear considerable analogy to tanning; by means of which operation, a skin soluble in water, forming jelly or glue quickly susceptible of putrefaction, is made into leather, a substance not at all soluble in water, (at least not without long boiling, or digesting at a high temperature) and which endures for a long period, indeed sometimes for several centuries.

Some useful hints may be collected by observing the state of oak, and other trees, found in bogs, and peat mosses, where they have been preserved for ages, and are so hard they can scarcely be cut, though either immersed in water, or very moist. The period when these tracts of country have been disforested is beyond the notice of our records.

This bog-wood seems to be altered by iron, which renders the astringent, and other principles of the wood insoluble. It is found of a bluish black, of the colour of ink, produced by the union of iron with astringent substances.

The water, which drains from peat-mosses, seems to be a dilute infusion of astringent substances, as the peasants in some parts of Ireland make a bad sort of leather, by steeping hides in the ditches made to drain their peat-bogs.

Firs, or pines, dug out of bogs, have undergone less change than other trees, and are as inflammable as ever. The resinous particles interspersed through the timber have manifestly preserved it from change or decay.—This mode of preserving timber should be an object of imitation.

Experiments it appears have been instituted in His Majesty's Dock-yard at Woolwich, with a view to ascertain the possibility of impregnating timber with oleaginous matter, in a state of vapour, and the report is, that the trials failed, owing to the explosion of the apparatus. It is easy to perceive that the mode adopted could not have answered, admitting that the accident had not happened; but there certainly are simple modes of impregnating timber with oleaginous, and (which is much better) with resinous substances.

We sometimes see fishing nets, sails of ships, of windmills, &c. which are rendered of a brown colour by being boiled or steeped in a solution or infusion of bark, or some other astringent substance. The above articles so prepared, are said to last a long time. The vegetable fibre is doubtless rendered insoluble, and the practice bears a considerable analogy to tanning; indeed, the operation is occasionally conducted in tan-pits.

It has been observed, ships employed in the Southern Whale fishery become penetrated with oil, and when once in that state they are scarcely susceptible of decay.

In order to form a judgment of this last fact, it is necessary to make more particular enquiries, and to institute some experiments, before the effect can be duly appreciated; however, it is evident, the adding an animal substance, of itself so prone to run into putrefaction, is not so proper as the addition of drying vegetable oils, which have not that tendency. It must also be remarked, if timber be saturated either with animal or vegetable oil, it will be more likely to be attacked by rats, insects, worms, &c.

The French smear the timbers of their ships, with a composition said to be a preparation of iron, which they think prevents the rot. There does not seem any probability, that great advantage can arise from any outward mechanical application to timber.

In ancient buildings, it was the custom to place pieces of timber in the kitchen chimnies, from which chains were suspended supporting culinary apparatus, and whereon to hang salted meats, &c. These pieces of wood are so impregnated with oleaginous matter, from the smoke, aided by heat, that it is very difficult to know what kind of wood they are. Some of the specimens are of a dark brown colour, others nearly black, all are as hard as ebony, and probably as indestructible as that wood. Pliny alludes to some process having considerable analogy to this, in his 23rd book, cap. 1. He says "as smoke eateth away and consumeth the moisture and mouldiness in timber, which is the cause of rottenness, so it also preserves wines."

SECTION VII.

Comparison of Teak, Oak, and other kinds of Timber.

It has been shewn, that when a vegetable is deprived of life, the matter constituting it begins to undergo changes, in order to enter into new combinations, being first reduced to simple principles by the aid of warmth, and the presence of air and water. Timber is durable, on the contrary, in proportion as the influence of these powerful agents is counteracted, or prevented.

The usual mode of seasoning timber by exsiccation, can be but of little use. Timber thus prepared is found indeed to shrink, and lose much of its weight, but in very old oak timber, procured from ancient buildings, immersed in water, or exposed in a damp situation, readily acquires the weight, and swells to the dimensions of green timber, from which in its properties it does not materially differ.

Out of a great many experiments undertaken with a view to discover certain differences in various kinds of timber, which might conduce to their decay, or durability, many are omitted by reason of their not leading to any useful result, but the following observations are worthy of notice.

		lb.	oz.
No. 1.	A cubic foot of oak newly felled weighs ..	77	10
2.	Ditto, dried seven days in the air	71	7
	Shrunk		
3.	Ditto, dried in an oven..	57	6
	Shrunk $\frac{1}{8}$		
2.	Ditto, soaked 12 hours, gained..	6	6
	Expanded $\frac{1}{8}$		
3.	Ditto, do. 24 do..	1	11
	Expanded		
	Dry oak 200 years old soaked 24 hours, gained	6	7

and there did not seem to be any difference between the degree of expansion of the old oak, when compared with new dry oak. When the old oak was reduced to shavings by the plane, and these were boiled several hours in water, no perceptible difference was discovered between the decoction and that of new oak when treated with reagents; at least, not more than the difference which may be noticed in the decoctions of various specimens of new oak. It follows then, if oak which has been 300 years in a dry building, absorbs moisture as rapidly as new dry oak, and in consequence is extended to the same dimensions, that the seasoning is best which renders the exsiccation most complete, and in the least time.

Much difference of opinion has arisen concerning the comparative weight of oak and teak, though as the latter is always the same, or very nearly so, the result of the comparison must depend on the quantity of moisture contained in any given specimen of oak. Various durable woods which do not absorb moisture, or expand when immersed in water, are no doubt to be met with in many parts of the Globe. Some specimens, having the name of Stink wood, I suppose from their peculiar smell, have lately been imported from the Cape of Good Hope. The ancients seem to have been acquainted with them, for Pliny tells us in his Natural History, book 16, chap. 41, "that those who went with Alexander the Great into the east, report that in the Isle of Tylos, within the Red Sea, certain trees were employed to construct ships, which would last 200 years;" and in chapter 40, he says "the more odoriferous wood is, the more durable."

The encomiums bestowed on teak, and on teak-built ships, have been great, and without doubt most deservedly so; yet praises may be lavished beyond all propriety on deserving objects, till the extravagance of such panegyric excites wrong impressions in the minds both of the encomiast and his hearers. Thus it has fared with the subject now under consideration. The admirers of teak have not been able to discover the difference between the causes of the durability of teak timber, and the conditions necessary to constitute the strength of a teak, or any other ship. Nothing, however, is more easy than to shew, that a very feeble ship may be constructed of most durable materials, whilst of perishable timber it is possible to construct a ship of uncommon strength, as far as the capability of resisting violence is to be considered.

In the Minutes of Evidence taken before the Select Committee of the House of Commons, on East-India shipping, there is an account of two ships, (the Chichester and Dover) being blown ashore, during a violent storm at Madras, in April, 1811; the former of these was French built, and the latter built of teak at Bombay in 1791. The French-built ship was driven to pieces by the gale. The Teak-ship lay for several months on the surf at Madras, which is supposed to be the most violent surf in the world, perfectly entire. Carpenters were employed at a great expense in getting her to pieces, and at last they were obliged to blow her up with gunpowder.

Now, notwithstanding any difference that may exist between the degrees of durability of the timber, it is evident the capability of resisting this violence must be sought for in another cause. Had the teak-built ship been built on the principle of the oak-built frigate, she must have suffered the same fate, she would have fallen to pieces under the same treatment; and had it been possible that an oak, or even a fir-built ship, could have been constructed as teak ships usually are, the same recourse to gunpowder would have been necessary.

The extraordinary capability of a teak ship to resist violence, must be imputed to the mode of construction, and we must attribute the long duration of these ships, to the uncommon durability of the timber.

The timbers of a teak ship are placed close to each other, so that each timber has a full and perfect bearing on those timbers in contact with it, continued through its whole length, without any interval or intermission, and if possible these timbers may be brought into closer contact, by wedges, screws, &c. so as to be almost water tight. The planks which are bolted transversely to those timbers, are not only in close contact, bearing on each other in every part, but they are rabbitted at the edges and ends, through all which rabittings nails are driven and afterwards clenched. In course there is not any caulking. Such a ship presents, in every direction, a solid mass of timber, no part of which is disposed to quit its relative situation, or is in danger of being displaced by any violence; and so compact a machine may be likened to a boat or canoe, hollowed out of one solid compact log of timber.

Pliny, lib. 16, cap. 40, speaking of large trees, says, " there was a piece of timber brought to Rome, by order of Tiberius Cæsar, which was larch, 120 feet in length, and two feet in thickness, from end to end." In Pliny's own time there was a piece of timber brought by M. Agrippa 100 feet in length, and 1½ foot in thickness; but he mentions a fir tree of height far beyond all others, which was the mast of the large ship employed by the Emperor C. Caligula, to bring the Vatican obelisk from Egypt to Rome. The compass of this mast was four fathoms (24 feet). He says, the ship was the largest ever seen, requiring 120,000 modii of lentils for ballast only, about 3000 tons. This obelisk, of red granite, is 150 feet long.

It was removed from the ruins of the Vatican Circus, to the Piazza in the front of St. Peter's, by Pope Sixtus V. in 1586, who erected it, with the labour of 800 men, and 100 horses, on the spot where it now stands. In the reign of the Emperor Claudius, this ship was sunk at the mouth of the Tiber, to form the foundation of a fortress which he erected there.

The pirates on the coast of Germany make their boats of one entire tree, hollowed ; some of them hold thirty men.

How different is the structure of an European-built ship. Here the timbers are some inches apart, (from 2 to 4,) with the exception of those near the keel. The planks secured transversely to those timbers, have a space or interval between them to receive the caulking, of about half an inch, more or less; they are chiefly fastened with tree-nails, or wooden pins about an inch and half in diameter, or little more; a considerable part of these are injured, or broken by forcing in a quantity of oakum, by means of caulking-irons, to make the ship water tight. So great is the force used on this occasion, that the plank is evidently driven from its position or situation, and the edges occasionally project so much, that it becomes necessary to smooth them, previous to putting on the copper.

In course, when a ship is built with timbers which are set at a distance from each other, and the planks are not in close contact, she must be more or less ricketty. In taking the ground, all the violence will be exerted on the fastenings, which being unable to resist the shock, break, and the ship necessarily falls to pieces. The teak ship being close timbered and planked, having every part compact, and bearing on another, without any space for play or friction, her fastenings are not put to any very severe trial. A ship can only go to pieces either by the greater part of her bolts and fastenings failing, or by the breaking of a very large proportion of her planks and timbers. This last case is impossible, at least it must suppose a greater degree of violence than a ship is ever likely to encounter.

I am not aware of any reading on the subject, but it is very probable, that in the infancy of naval Architecture, attempts would be made to construct ships with close timbers, and close planks. The result must be, that if such timber were employed in a moist state, the shrinking occasioned by drying would cause them to open, and the end proposed would be defeated. If the timbers were used in as dry a state as possible, when they became moist, by the great expansive power of the water, the dilatation of the timbers would break the ships in pieces, as we see a cask burst, that has been too tightly hooped. Should planks, and fastenings, be able to resist the great expansive power of the water, the timbers would necessarily be pinched into a much smaller compass that they would otherwise occupy. This effect would be more likely to take place if some softer wood were mixed with oak, but it is most likely the power of expansion would prove irresistible, as the quantity of timber contained in the length of a large ship would have a tendency to extend in length several feet, and the expansion of the plank in a longitudinal direction, would amount to a mere nothing, at least it would be imperceptible.

SECTION VIII

Of impregnating Timber with resinous and, oleaginous Matter.

Having, I trust, shewn the essential difference between oak and teak, and it being obvious, in that difference may be found the cause, why the latter is but little disposed to resist change or decay, whilst the former is nearly indestructible, the idea naturally occurs, that we should by all means in our power, endeavour to make the one resemble the other.

And as some erroneous opinions have gone abroad respecting teak, it seems necessary in this place to make the nature of that timber better understood. The best teak is procured at Malabar, whence it is carried to various parts of India, for the purpose of ship-building. The practice of the ship-builders at Bombay, is to employ the best materials they can procure, and after the most diligent inquiry, it does not appear there is any instance of the rot having been observed in a Bombay teak ship.

In Bengal, the builders are in the habit of mixing their timber very mucb, in consequence, some traces of rot have been discovered. A ship of 1,200 tons was lately built at Calcutta, of Saul, Sisso, and Teak. Another species of timber is employed in India, scarcely inferior to Teak, called Poon. Of this, as well as teak, masts are made, which never split, but they are much heavier than those of pine or fir.

The great power of teak to resist putrefaction, arises from the whole substance of the timber being most intimately mixed, and thoroughly penetrated, and impregnated with oleaginous and resinous matter, which prevents the absorption of moisture; for which reason, teak cannot shrink, or contract, neither, by the same rule, can it be swelled or dilated. Therefore, the rarefaction of the substance, and the consequent interposition of air, water, &c. by which the parts are expanded, and as it were set at a distance from each other, are prevented, consequently the great agents that determine the changes of wood in general, here have not any influence. Resinous substances were found by Sir J. Pringle, in his experiments, to be very efficacious in resisting putrefaction. The antiseptic power of camphor, is stated by him, to be 300 times greater than that of common salt.*

There are various modes by which oak may

* Pliny tells us "the more odoriferous a piece of timber is, the more durable." Lib. 16, cap. 40.

be impregnated with resinous, or oleaginous matter. The Americans hollow out a kind of cup on the top of their masts, into which turpentine is occasionally poured, which very soon disappears, finding its way down the interior of the timber. As the heat of the sun causes the turpentine to descend from the upper part of the mast, such an addition must have two good effects, viz. to make the timber less brittle, and to prevent its splitting.

On this principle, some experiments have been tried in the Dock-yards, where the oak has been placed vertically, and oil applied as above; but surely linseed oil, or some vegetable oil, should be employed, as fish oil is so apt of itself to undergo the putrid fermentation. If the timber be very dry, the oil will penetrate more quickly than could be imagined, and the effect may be promoted, by raising the temperature of the air in the apartment where the experiment is conducted.

After trying numerous experiments, the results of which need not here be mentioned, because they did not seem to lead to any useful purpose or conclusion, the following method of impregnating timber with resinous or oleaginous matter, appeared on all accounts the most eligible.

The cheaper oils, or colophony, (usually known by the name of common resin) may be dissolved in a lixivium of caustic alkali, into which solution, either hot or cold, if timber be immersed in a tolerably dry state, it will quickly be saturated with the oil, &c.

If it be afterwards plunged into water slightly acidulated with sulphuric, or any cheap acid, or alum in solution, the alkali is immediately separated by its superior attraction or affinity for the acid, and the pores and cavities of the wood are found to be all penetrated and impregnated by the resinous matter.

It will be perceived, that the solution here recommended has very considerable analogy to soap; but it will be highly improper to employ a solution of soap, for the following reasons.

The hard soaps made in England contain animal fat, or tallow. The soft soap contains resin and fish oil, both this last article, and the fat of animals, are very prone to run into the putrefactive process. All the labour, expense, fuel, and trouble necessary to concentrate the solution of soap into a solid state, may be saved, as well as the Excise duty paid by the soap maker.

The vegetable oils, for the reasons above mentioned, should be preferred, in case oil be used, but common resin is undoubtedly the cheapest, and in all respects the most proper material to be employed in this service. The quantity of resinous matter taken up by oak is so small, that the expense is scarcely worth speaking of. The labour and trouble of making experiments on a large scale are much diminished, or rather may be said to be entirely done away, since that truly ingenious and beneficial plan has been adopted, of boiling and bending straight pieces of timber for the futtocks, &c. of His Majesty's ships; particularly when it is considered, the scarcity of compass timber had become very alarming, and occasionally it could not be procured with long waiting. The eminently antiseptic powers of oil have been long known. Pliny writes lib. 15, cap. 7. "Oil is thought to be singularly effica-"cious in preserving ivory from putrefaction. "The image of Saturn at Rome is full of olive oil within."

All the leather known by the names of buff, buckskin, chamois, &c. is prepared by means of olive oil, without any admixture of bark or astringent substances, alum, &c.

It must be admitted at the same time, that timber impregnated with oil will not be disagreeable to rats, worms, cockroaches, &c. The contrary is the case when resins are employed, on account of their peculiar smell and taste.

Pliny, lib. 40, cap. 39, says, "the oil of Cedar will protect any timber anointed with it, from worm, or rottenness."

SECTION IX.

Of impregnating Timber with Salts.

From a connected series of experiments, made with sufficient precision, by Duhamel and others, it has been proved, that water holding in solution much saline matter, is positively poisonous to plants, and that by plunging vegetables into water so impregnated, they immediately languish and die. Mr. Thouvenel has shewn, that none of the salts in these solutions pass into the vegetable.

To this general observation the marine plants form an exception, the muriate of soda being decomposed in them, and they are found to contain a considerable quantity of soda. Plants of this description are burnt, and the ashes being lixiviated, yield the barilla or kelp of commerce, being an impure soda; and when the vegetables which thus yield soda, are transplanted to situations at a distance from the sea, they at first yield less soda, and at last nothing but potash, the common saline produce of all vegetables.

Previous to entering on the subject of impregnating timber with salts, it will be proper to observe on the nature of different salts, which, on account of their cheapness, and other qualities, naturally present themselves to our notice.

These may be divided into sorts, viz. acids, alkalies, neutral salts, compounded of an acid and an alkali, earthy salts, compounded of an acid and an earth, and metallic salts, compounded of an acid and a metal. These may again be subdivided, from their habitudes, into the following: soluble, insoluble, efflorescent, or those which in the common temperature of the atmosphere part with their water of crystallization, and fall to powder; and deliquescent, or those which have the power of attracting moisture from the atmosphere, and of running into a fluid state.

The deliquescent salts are entirely out of the question; because, though many of them have the power to preserve organized bodies a long time from decay, yet from their habit of attracting moisture, a ship, the timbers of which were impregnated with such materials, would always be in a damp state; and all the copper, iron, and other metals within their influence, would be quickly corroded.

With regard to the permanent and efflorescent salts, it seems highly probable they will all be equally efficacious in preventing putrefaction, in such bodies as are impregnated with them; therefore our choice of them ought to be regulated, and determined, by their cheapness, &c.

As to the neutral salts, which are insoluble, or nearly so, there does not seem any reason why we should reject the use of them. The salts of which they are compounded, are in general very soluble; thus the insoluble salt may be formed in the body of the timber, by impregnating it with one of the component salts, in the first instance, and afterwards by plunging the logs into water, containing some of the other component saline matter. Selenite for instance, is insoluble or nearly so, it is very cheap, and not liable to any alteration in the ordinary temperature of the atmosphere.

The salts compounded of Barytes should be rejected, because, though they are plentiful, cheap, and have some qualities eminently fitting them to be employed for this purpose, yet they are without any exception very poisonous.

SOLUBLE.

P Nitrate of Potash.
D Muriate of Soda.
P Sulphate of Alumine.
E Do. of Soda.

METALLIC.

P Sulphate of Copper.
P Do. of Zinc.
E Do. of Iron.

ALKALINE.

E. Carbonate of Soda.
D. Do. of Potash.

INSOLUBLE SALTS, OR NEARLY SO.

P. Sulphate of Lime.
P. Do. of Barytes.
Carbonate of do.
P. Do. of Lime.

When wood is impregnated with saline matter, the taste is so nauseous, that it may bid defiance to the attacks of rats, the worm, cockroaches, &c. The reason why some sorts of timber are not attacked by vermin, has not escaped the sagacity of Pliny. He says "some woods are so bitter, and others so hard, that worms cannot eat into them." Lib. 16, cap. 41.

Timber, completely saturated with saline matter, seems nearly indestructible, and absolutely incombustible.

Timber impregnated with saline matter, is not any longer susceptible of fermentation; in course, the impure airs or gases which are necessary to form the nutriment of fungus, are not evolved, and the timber in this state, is not a fit nidus, or receptacle, for the seeds of the different tribes of these plants.

SECTION X.

Of Ventilation, and of the extraneous Matters found in the Atmosphere.

Before we enter on the subject of ventilation, it is absolutely necessary to direct our attention to ascertain the nature of what is understood by the atmosphere; also to notice the extraneous matters found in it, whether accidental impurities, or otherwise, because a complete knowledge of these things will leave little of obscure in the subject, and will lead us to satisfactory conclusions, as to the most feasible, and convenient mode of correcting such impurities.

The earlier philosophers imagined the atmosphere to be a simple homogeneous element. Modern discoveries however convince us that it is a most heterogeneous mass, compounded of all the different products disengaged from the various bodies which have the power of decomposing it; as well as holding in solution aqueous vapour, and exhalations from such substances as are disposed to assume the volatile state.

Water being also a compound body, possessing one of its principles in common with air, it is not easy to conceive a more complicated mixture than the atmosphere, when it is considered that one, or both of the former, are constantly decomposed in the following operations, viz. in the eruptions of volcanoes, in thunder storms, the combustion of all inflammable bodies, the putrefaction of animal and vegetable substances, by the breathing of animals, by the transpiration of vegetables, by fermentation, rusting or calcining of metals, reducing metals from the ore, burning lime, alkalies, &c.

On a large scale in the grand operations of nature, it has been so ordered by a beneficent Providence, that some of these operations counteract the bad effects produced by the others, that some of them have a tendency to render the atmosphere impure, whilst others restore that degree of purity of which it had been deprived, and so keep up the equilibrium of its salubrity. In operations where the energies of man are concerned, it is often far otherwise, and it is necescary by art to restore the purity of air, which is found to be contaminated in crowded neighbourhoods, in ships, in hospitals, mines, vaults, prisons, &c.

Pure atmospheric air is composed of two permanently elastic gases, viz. oxigen gas 27 parts, nitrogen gas 72 parts. It is fluid, and very elastic; and though changing its dimensions with the temperature, no experiments lead to the inference that it can be congealed, or reduced to the solid state by cold. It is said to be invisible, but when an object is viewed through a great mass of air, at an immense distance, or when viewed above us, it reflects some colour, and that generally blue, or one inclining to blue. It is probably without smell, or taste, at least custom has rendered these imperceptible; lately it has been clearly ascertained to have a specific gravity; some of the ancient philosophers had observed facts which led to that conclusion; for instance, they were aware that a bladder filled with air was heavier than when empty, but the deplorable state of chemical knowledge could conduct them no further.

This property of air is of wonderful importance in the economy of nature. Were it not for the pressure of air on its surface, water would no longer be found on our globe; even the sea would soon cease to exist. A very simple experiment proves this assertion, viz. water placed in the vacuum of an air pump, immediately assumes the state of vapour or steam.

The analysis and recomposition of water, does great honour to the philosophers of the 18th century. The labours of those gentlemen have proved incontestably that water is compounded of two elastic gases, viz. oxigen gas 85 parts, hydrogen gas 15 parts. Pure water is about 850 times as heavy as atmospheric air, a cubic foot weighing about 70lb. It does not produce any sensation on our organs, of taste or smell. It is capable of dissolving air, gases, stones, &c. and it is the most efficient and active agent in effecting the decomposition of organized bodies. The evaporation of water is owing to its being soluble in air, the quantity so dissolved being determined by the temperature. Air, containing water in solution, is as dry, colourless, and transparent as before. The instruments contrived to point out the moisture of the air really deceive us, they do not afford any indication of the quantity of water contained in the atmosphere, they can only give us information concerning the quantity of water in the act of uniting with, or of parting from the air, at the instant of observation. When water is decomposed by combustible bodies, the oxigen is absorbed, and the hydrogen is set free. Sometimes the hydrogen is pure, at other times it is mixed with various bodies, or holds them in solution and in either state may cause dreadful explosions, detonations, &c. When water is decomposed by vegetation, on the contrary, hydrogen is absorbed, and oxigen is set free.

Thus the transpiration of vegetables, restores the salubrity of the atmosphere, of which it has been deprived by the respiration of animals. Much hydrogen is accordingly contained in oils, wood, alcohol, pitcoal, &c. In whatever mode water has been decomposed, its constituent parts have always been found the same; and if 85 parts oxigen, and 15 parts hydrogen, be united by combustion, 100 parts of pure water are constantly obtained. In the violent torrents of rain which fall sometimes in thunder storms, and at other times, the water is newly and immediately formed, thunder being now understood to be occasioned by a most rapid and instantaneous combustion of oxigen and hydrogen gases, which have been ignited by the electric spark; in course, the product is water.

The number of gases with which we are acquainted is about thirty; but as there are only some of them very likely to be found mixed with atmospheric air, it will be sufficient to notice the nature of these, and to observe on the modes in which they are produced.

Nitrogen Gas, or Azote.

Whatever can decompose atmospheric air, leaves this gas; it has a peculiar smell, which may be observed after the firing of gunpowder. Sometimes it may be smelled in fogs, the aqueous vapour having attracted oxigen from the atmosphere. It is very deleterious, and is much heavier than air.

Oxigen gas: eminently fitted to support combustion, and the respiration of animals. It has neither smell nor taste. Heavier than atmospheric air.

Hydrogen gas: capable of taking fire, therefore originally called inflammable air. If iron, and some other metals, be moistened, the water is decomposed, and this gas is produced. It is incapable of supporting life, but may be breathed several inspirations, or about a minute. It is the lightest of all ponderable substances, and is therefore chiefly used for balloons.

Hydro-carburet, or Carburetted Hydrogen: this gas is found in various states of combinations, the hydrogen being united with carbon in different proportions, according to the mode in which it is produced.

It is very inflammable, is often found issuing from coal pits, &c. when it takes fire by contact of a lighted candle, and sometimes it produces fatal explosions, and is called fire damp. The air bubbles arising from stagnant water, which may be procured in large quantities by stirring the mud at the bottom, is this gas. It is used in lamps for lighting streets, &c. and is known by the name of Gas Light. When it is saturated with carbon it is called olesiant Gas, from its property of forming an oil, when mixed with oxigenated muriatic gas; it is lighter than air.

Phosphoretted Hydrogen: This gas is very pernicious to animals. If they inspire it, they die immediately. It is produced by the putrid decomposition of animal matters in bogs or marshes, and produces the appearance known by the name of ignis fatuus, or Jack with a lantern.

When produced by art, the most vivid flashes of fire are seen to dart from the surface of the containing vessels, and the objects around are illumined with a greenish or bluish light, more elegant than can easily be imagined. This gas has the property of spontaneous ascension.

An explosion also takes place when it comes in contact with nitrogen, oxigen, or oxigenated muriatic gas. It is lighter than air.

Carbonic acid gas: is very heavy, extinguishes flame, kills animals, may be decomposed very easily. It is found abundantly in Brewers' vats, in vaults, wells, mines, &c. is also called choke damp. It is produced by combustion, fermentation, breathing of animals, putrefaction, &c. It is elastic and much heavier than air.

Ammoniacal gas: kills animals, extinguishes flame, is not easily decomposed. It is disengaged from all animal matters by putrefaction, and from some vegetables, *particularly fungi*, and from feces, urine, perspiration, &c. It islighter than air.

Specific gravity of these gases.

Weight of 100 cubic inches in grains.

		grains.
Air	Nitrogen	30. 1
	Oxigen	34.

Water	Do.	34
	Hydrogen.	2. 613
	Hydro-carburet.	to 14 20.—
	Phosphoretted Hydrogen	to 10 17.—
	Carbonic acid Gas	46. 5
	Ammoniacal.	.18. 15
	Atmospheric air.	31.—

With the exception of oxigen gas, and atmospheric air, all air, or gases, may be pronounced extremely deleterious, and pernicious to animal life ; surely then, it is of the first importance to discover means of getting rid of them in ships, crowded apartments, &c.

Various methods have been devised to effect this purpose, some of which may boast of considerable ingenuity ; however, it is plain they may all be referred to two principles ; the expelling them altogether by mechanical means, or by some addition to decompose, neutralize, and render them harmless.

But of all the methods I have been able to conceive, that which seems to answer the purpose best, depends upon the specific gravity of these gases compared with that of Atmospheric air. In mines, wells, brewers' vats, vaults, &c. we constantly hear accidents happen by reason of the gases which occupy the lower part of them, and sometimes fill all the cavities till they run over, and escape at the top. Indeed, the heavier gases may be poured from one vessel to another, like water or any fluid. The lighter may be also retained in an inverted vessel, for instance, under a glass turned bottom upwards. No one has ever been able to explore the famous grotto del Cane at Naples, because it is always filled with noxious air (chiefly carbonic acid gas) which kills all animals attempting to enter it. It is highly probable, gases lighter than air, are produced at the same time, but they escape upwards by their volatility. If an oblong aperture, like a well, be enclosed at top, all the gases lighter than air must occupy the highest part, and all those heavier than air will subside to the lowest part. The middle space will be occupied by atmospheric air. Now if an orifice be made at top, and bottom, the heavier and lighter gases will escape in different directions, and the whole space will be filled with atmospheric air. Thus, if the windows of an apartment reach to the top of it, and the door to the bottom, nothing need be done to ventilate it, but to admit external air. Should the windows be at a distance from the top, a pipe at the ceiling should communicate with the external air, and if the apartment be entered by many steps, the same communication should be made at the floor.

No 1.

Navy Office, 7th October, 1813.

MR. THOMAS WADE,

IN return to your letter of the 23d ult. requesting permission to visit the Dock-yards at Deptford and Woolwich, for the purpose of obtaining information to assist you in forwarding a plan for the preventing the dry rot in shipping and timber, and the saving of the article of paint, we refer you to Commissioner Cunningham, who will admit you to both yards if he sees no objection.

We are,
Your affectionate friends,
F. J. HARTWELL,
W. RULE,
E. BOUVERIE.

Providence-Place,
Upper Kennington Lane.

No. 2.

Navy Office, 25th Feb. 1814.

SIR,

WITH reference to your letter of the 17th instant, I am commanded by the Commissioners of the Navy to request you will attend the Committee of Surveyors at this office, on Monday morning next, at half past ten o'clock,

I am, Sir,
Your humble Servant,
R. C. NELSON.

Mr. Wade,
Kennington Lane.

No. 3.

Navy Office, 6th March, 1814.

MR. THOMAS WADE,

WE have received your letter of the 24th ult. explaining the manner in which you mean to prepare the timbers of His Majesty's ships Eurydice and Tribune, to prevent the dry rot; and acquaint you that we thank you for the communication.

We further acquaint you that the officers of Deptford Yard have informed us, that the beams for the magazine of the Eurydice are ready for your experiments for the prevention of the dry rot.

We are,
Your affectionate friends,

F. J. HARTWELL,
(Signed) H. PEAKE,
R. SEPPINGS.

Kennington Lane.

No. 4

Navy Office, 16*th March,* 1814.

Mr. Thomas Wade,

With reference to the conversation lately had with you on the subject of the plan to which your letter of the 17th ult. relates, for the prevention of dry rot, we acquaint you that we have determined that an experiment shall be made thereof, on board His Majesty's Ship Tribune, and that you will receive information from the officers of Woolwich Yard when her beams are ready to undergo the intended process.

We are,

Your affectionate friends,

F. J. HARTWELL,
(Signed) R. SEPPINGS,
H. LEGGE.

Kennington Lane.

No. 5.

Navy Office, 22*d March,* 1814.

Mr. Thomas Wade,

We acquaint you that we have determined to try your experiment for the prevention of the dry rot, on board His Majesty's Ship Eurydice at Deptford, as well as the Tribune at Woolwich; and have given directions to the officers of the Dock-yard on the subject.

We are,

Your affectionate friends,

F. J. HARTWELL,

R. SEPPINGS,

H. LEGGE.

Kennington Lane.

No. 6.

Navy Office, 4th May, 1814.

Mr. Thomas Wade,

Having determined on a trial of bending some of the long fourth futtocks for His Majesty's Ship Hawke, by the method you allude to in your letter of the 18th ulto. We acquaint you, that in consequence of what we have represented, we consent to your preparing some of those timbers according to your plan for preventing dry rot; and we desire that you will make preparation for the execution of this service, having given the necessary directions to the Officers of Woolwich Yard on the occasion.

We are,

Your affectionate friends,

F. J. HARTWELL,
R. SEPPINGS,
H. LEGGE.

Kennington Lane.

No. 7.

Navy Office, 13*th May*, 1814.

MR. THOMAS WADE,

THE Officers of Deptford Yard having informed us that the materials for the magazine of the Eurydice are all prepared and waiting for your experiment to prevent the dry rot, we desire you will attend at the said yard without delay, that the Officers may proceed in completing the magazine.

We are,

Your affectionate friends,

F. J. HARTWELL,
H. LEGGE,
P. FRASER.

Kennington Lane.

No. 8.

Navy Office, 23*d March*, 1815.

Mrs. Elizabeth Wade,

We have received your letter of the 13th instant, wherein you inform us of the death of your husband, Mr. Thomas Wade, and assure us of your ability to conduct the experiments in which he was engaged, in the preparing of Timber to prevent the dry rot, and acquaint you, that we have directed the Officers of Woolwich yard to allow you to conduct the experiment upon the timbers in the Hawke, on which your husband was employed.

We are,
Your affectionate friends,
W. SHIELD,
H. PEAKE,
H. LEGGE.

Kennington Lane.

G. Sidney, Printer,
Northumberland Street, Strand.