PRESERVATION OF FISH NETS

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INTRODUCTION.

The art of net preservation grew up long ago, as it might be expected inevitably to do, where it was necessary to make fishing gear of nonliving plant fibers that are exposed to the destructive effects of water, air, and sunlight. The word "art" of net preservation as distinguished from "science" of net preservation is used advisedly; one needs to see only the multiplicity of recipes for curing or preserving nets to be convinced that the processes belong to the same class as cookery or home treatment of diseases, where each locality and often each family has its own recipes or formulas, which are tenaciously adhered to and believed in. The many recipes found in the literature represent the fisherman's efforts to make his expense and labor count for more by prolonging the life of the net and reducing his overhead expenses.

The purpose of this paper is not to collect all these old recipes for preserving nets, but rather to review the literature of the subject and to present the fundamental principles in the light of chemistry so far as they are known, and to give for use those recipes which, from a chemical standpoint, seem best calculated to serve their purpose. It will be seen that while many methods as practiced are empirical and crude, they nevertheless contain the germ of correct chemistry, and not a little progress has been made in improvement of technique by chemists, notably Thv. Lindeman and Henrik Bull in Norway and J. T. Cunningham in England. Most of the work has been done by the Norwegians; as a matter of fact, only one important paper, that of Cunningham, has been found, in any language other than Norwegian, as shown by the list of references at the end of this paper.

NATURE OF DISINTEGRATION OF NETS.

MECHANICAL WEAR AND TEAR.

Before considering the various treatments that are given nets to prolong their usefulness, it may be profitable to consider the nature of the wear and tear that ruins nets. Obviously mechanical wear is one of the great enemies of nets. The threads rub against one another, against the gunwales of the boat, and against the floats and leads; this rubbing slowly abrades the threads and wears them out. Actual breakage by being caught on snags or by the struggles of large fish and the like must be reckoned with; such breakings, of course, become more numerous when the net becomes weaker by rotting. A factor in the destruction of nets that is sometimes overlooked may also be mentioned here: That when the threads are coated with thick tars and the like the total weight of the net is greatly increased and the preservative action of the tar is thus in part neutralized, the pull of the extra weight being added to other strains that may break the threads.

BACTERIAL DECOMPOSITION.

But of more importance than mechanical wear and tear in shortening the life of nets is the action—chemical in nature—of water and air, aided by other agencies, particularly bacteria, in causing a weakening and rotting of the fibers. This rotting deserves very careful study, for it destroys nets long before they would otherwise be destroyed by mechanical wear and tear, and its nature, while exceedingly complex, must be understood, at least in part, before remedial measures can be taken intelligently.

Up to this point chemistry has made some progress, and some valuable work has been done on the chemistry of preserving materials, but as a whole the fishing industry has never taken very kindly to chemistry, and most of the work that bears useful fruit for the net preserver has been incidental to work in other important fields—the tanning of leather, bacteriology, and textile science. We must admit frankly that we know very little directly about the intimate nature of the rotting of nets.

In the discussion of bacterial decomposition let it be assumed that cotton nets are being considered, because it is chiefly nets of this material that need preserving. They consist of fine fibers of almost pure cellulose, a substance very close to starch in composition, differing from it chiefly in being insoluble in water under all ordinary conditions, while starch, by simple treatment, may be made to dissolve. Cellulose can be made soluble in different liquids by severe chemical treatments. As bacteria are also capable of dissolving or rotting the fibers some detailed consideration will be given to their mode of action.

Bacteria are plants, so very small that they can be seen only by the aid of a microscope; they are not provided with many parts, as are the large plants of our acquaintance, as they have no roots, leaves, bark, or flowers; they are simple little rods or spheres, movable, reproducing under favorable conditions with the greatest rapidity. They have no claws, mouth, jaws, teeth, or any other offensive weapons. How, then, do they do the great damages that they are accused of? In a most interesting and important way. We know that land plants take nourishment from the ground and air by imbibing it and that they have no mouths or offensive weapons. So do bacteria, by absorbing or soaking up the food on which they live. But anything to be absorbed must first be made liquid; solids can not be soaked up, and it happens that very few natural foods are liquid. So the bacterium must secrete a digestive juice that causes the solid food surrounding it to liquefy, whereupon the liquid food is absorbed. This digestive juice acts in a way similar to that of the human digestive juice, and for the same purpose; the principal difference between our own digestion and that of bacteria is that ours takes place inside our bodies after the food is taken in, while the bacteria digest it before. So after all there is nothing incredible about it. Most bacteria are equipped for using a particular class of foods—they are meat eaters, sugar eaters, starch eaters, fat eaters—and they do not mix foods. They are able to secrete a digestive juice capable of liquefying that particular food on which they live.

Now, from what has been said, it is easy to see that the damage done to nets by bacteria must be done in either one of two ways, viz, the digestive juice itself or some of the changed products of digestion must attack the nets or else the waste products thrown off from the bacteria themselves (and some of these are active or virulent chemicals) must do so. If the digestive juices attack the cellulose fibers of the net, of course the fibers are dissolved, and this dissolution would be a very effective rotting. At any rate, what has already been said constitutes about all that can confidently be said about the intimate nature of bacterial decomposition of nets. If any more is to be known about it, a study must be undertaken.

For preserving nets against bacteria a number of possibilities suggest themselves. Since bacteria require water for activity, it is plain that if we keep the nets dry as much as possible we lessen the decomposition. But since the use of fish nets requires them to be wet, another step may be taken against the bacteria. It is possible to impregnate the fibers with substances that are poisonous to bacteria, or, quite as effective, which spoil the activity of the digestive juices produced by bacteria. Creosote and substances containing copper have been used for this purpose. Another method of preventing the destructive action of bacteria is to make the fibers insoluble and proof against the digestive action of bacteria. For hardening the fibers and making them harmful and indigestible to bacteria, tanning barks and extracts, such as birch bark, catechu, quebracho, quercitron, etc., have been used. These will be considered in detail later. Meanwhile other methods of resisting the action of bacteria are to cover the fibers with a protective coating, such as tar, linseed oil, etc.

OXIDATION.

Another enemy to nets is oxidation. The air consists of one-fifth oxygen, a colorless gas, which supports all fire and also is the active constituent of our breath. When one "sets fire to" a combustible material one so heats a small part of the material that the oxygen of the air combines directly with it. This combining releases more heat, which in turn hastens the combining of more oxygen with still more of the material, and so on, until the material is burning. While most combustible substances either burn rapidly or not at all, some things may oxidize slowly. For example, when nets are stored wet, covered with herring oil, blood, and slime, all of which are easily oxidizable, the oxygen of the air combines with these fish residues and probably also with the net. A heating thus begins, and the nets may even take fire; if not, the heat generated may be sufficient to weaken or destroy them.

To prevent this oxidation it may be sufficient to coat the nets with a covering like tar or linseed oil; it is, however, probable that tanning the fibers makes the fibers less likely to heat. The simple precaution of washing the nets clean and drying them while spread out is usually sufficient to prevent damage from overheating.

It is further possible that the products formed by the decomposition of fish slime and oil are injurious to nets.

Scarcely any treatment will confine itself to preventing any one of the attacks on nets mentioned above, but should be directed toward prevention of all causes of disintegration. The successful process must (*a*) destroy bacteria or prevent their action, (*b*) make the threads insoluble and proof against the digestive action of bacteria, and (*c*) prevent oxidation by coating the fibers or making them proof against oxidation.

COLORING OF NETS.

Before consideration is given to net-preserving materials, another purpose of curing nets should be mentioned. When nets are treated or cured, their color is usually changed, and it is argued that a less conspicuous net is less likely to frighten away fish. This is a disputed point (see Jessen, 1910),[a] though it might seem perfectly natural that an invisible or poorly visible net would be less likely to frighten fish. It must be remembered, however, that a fish does not see through human eyes but through fish eyes and that a color that is conspicuous to our eyes might not be readily discerned by a fish. The French sardine fishermen use (at least they did several years ago) a combination of soap and bluestone that imparted a bright green color to the nets; it was claimed that these caught more fish than nets not dyed. The Norwegians have a word, "*fiskelig*," that they apply to nets that are good catchers of fish. Bluestone is applied to nets (by methods to be mentioned later) to make them *fiskelig* by making them bluish green. This is done, of course, on the assumption that if the net is in color similar to sea water the fish can not see it well and so do not avoid it.

Many scientific investigations have been conducted to determine whether fishes can distinguish colors or not. Most of the evidence goes to show that they can; but perhaps they can see fewer colors than humans can. Some investigators have secured evidence that fishes do not distinguish color but that they get different amounts of light from different colors. Thus, a bright green would give more light, or appear lighter in shade, than a dark red, though a fish could get no effect of greenness or of redness. It is also possible, even probable, that different kinds of fish have different abilities to see colors. Thus, it is argued, light does not penetrate very deep into water, and so fishes living at some depth could not see colored objects, even if they had eyes equipped for color vision; and, since nature does not commonly provide useless organs or powers, color vision is not among the accomplishments of bottom-living fishes.

[a] Author's name, with year mentioned in parenthesis, refers to the "Citation of Literature" at the end of this paper. For example: Jessen (1910) refers to the paper by Peter Jessen, published in 1910, a reference to which will be found at the end of this paper.

But it is not necessary to go further into this disputed subject. It stands to reason that fish perceive differences of brightness, and probably of color, and that if we make a net similar to sea water in both shade and color it will not be so readily visible. Those who might wish to go into this subject are referred to the article by Reeves (1919).

PRESERVATION OF NETS BY TANNING MATERIALS.

The materials most widely used for curing nets are tanning materials—barks of birch, oak, spruce, hemlock; extracts of bark or wood, such as catechu, quercitron, quebracho, and the like. For preserving, the original process consisted of immersing or soaking the net in a decoction of bark, or in a solution of the extract. One of the earliest methods was the so-called "cold-tanning," a slow process described by Aase (1912). This writer says that the old Norse fishermen used the same nets over and over for from 30 to 50 years. He also says that while much of this superiority of their nets might be explained by the fact that their thread was selected and spun by hand, and therefore better than modern machine-spun threads, the difference between those times and the present, when one is lucky to use a net for from 3 to 10 years, is too great to be explained by the homespun theory. He accounts for the difference by the cold-tanning process, described as follows:

COLD TANNING.

Every net owner had his own large tanning vessel, which provided a place for both bark and net. In this vat was placed as much water as there was use for, and to every barrel of water was added 1½ vog (1 vog=36 pounds) of birch bark, well broken up. This was allowed to stand four or five weeks, but was daily stirred around with a stick so that it could not become thick and slimy. The nets were put into this mixture. In the bottom of the vat a hole was provided so that the finished liquor could be tapped into a tub and poured back over the net to cover thoroughly the upper part of the net which otherwise might not come under the bark. The net remained in this vat two or three days, and every day the liquor was poured over it several times.

Such a barking gives little color, but makes the net hard. To produce the desired color it must not go into the bark a single time only. Nay, it must be dried and again laid in the tan vessel if there is any bark left, as many as four or five times. After it is dried it is dipped into the sea, and it now takes on its right color for the first time—a color it will hold for years. If the barking is repeated every year the net becomes harder and harder as it grows older.

The method takes a long time, and demands much labor; when more and greater nets began to be used, and prices of birch bark also rose, other methods of barking began to be tried.

HOT TANNING.

The next step in the development of processes of net curing was the employment of a warm barking. The bark is boiled, and the nets are treated in the hot decoction. Aase is authority for the statement that "with this method of tanning the net acquires color and hardness with one treatment, and much time can by this method be saved. But experience has shown that warm tanning does not endure, by a great deal, so long as cold tanning."

Then the extract, catechu, came into use. This extract is not so bulky, is readily soluble in water, and has been used successfully. The methods as practiced varied greatly, the variations being apparently not based on any particular reason. In general, the extract is dissolved in water—1 pound of catechu to from 1 to 3 gallons of hot water—and applied to the nets.

Nets preserved with tanning extracts are brown or tan in color and are more resistant to decay than untreated nets, as will be seen in figures to be given later. The tan, however, washes out, and it is necessary to repeat the treatment often.

CHEMISTRY OF TANNING MATERIALS.

Before going further with the methods of curing nets with tanning materials, it will be necessary to consider the chemistry of the latter.

It is not improbable that the treatment of nets by tanning was induced by the success of the treatment of animal skins by such materials to make leather. Tanning materials are bark or other parts of various trees which produce a reddish or brownish solution when steeped in cold water. There is scarcely a tree or shrub in some part of which tanning substances are not found.

The action of those materials may be illustrated by their effect on leather. Untanned hide when boiled for some time is nearly all dissolved; after it has been treated with tan liquor it is scarcely affected by boiling. When untanned hide is left in a moist condition for some time it putrefies; tanned hide does not. Thus a hide that is soluble in boiling water and putrefies in cold water is converted by tanning into a hide which is neither dissolved in hot water nor putrescible in cold. Just how these great differences are brought about can be illustrated by the effect of tanning materials on gelatin or glue. If a tanning extract be added to a solution of gelatin, the latter is coagulated and precipitated and is made permanently insoluble. Pure untreated gelatin readily swells in cold and dissolves in warm water and easily decomposes if left wet. But this tanned precipitate is resistant to the action of water and does not decompose. How is this important change brought about? The answer is given by a pair of balances. If we weigh a dry piece of gelatin, dissolve it, precipitate or curdle it with tan liquor, collect the precipitate or curd, wash, dry, and weigh it, we find that it has increased in weight. It can also be shown that the tan liquor has lost as much weight as the gelatin has gained—something from the tan liquor combined permanently with the gelatin to make the latter insoluble and resistant to change. This something is called tannin. It would be more correct to say these somethings, for there are several tannins, all closely akin, all affecting gelatin in the same way. It is they that, acting on hides, convert the soluble, putrescible gelatins in hides into insoluble substance, causing the hides to become leather.

The earlier method of analyzing tanning materials was to treat the solution with gelatin. This was done by taking first a definite volume of the solution and evaporating it to dryness and weighing the dry residue; then a like volume was taken from a sample that had been treated with gelatin, evaporated to dryness, and weighed. The sample that had been treated with gelatin had lost weight. The loss represents, of course, the substance taken up by the gelatin or tannin.

Since to the leather tanner the chief item of interest is the amount of substance actually taken up by hides, gelatin, as a measure of the tanning power of materials, has been supplanted by hide powder, which is clean oxhide dried and ground in a suitable mill. The liquor is drawn through this, and the difference in the weight of dried residue is noted and recorded as tannin. Account is also taken of the difference between weights of the liquor and dried residue, this difference representing water. There is also given the percentage of matter that does not dissolve in cold water, but which was filtered off of the liquor. Thus an analysis of a tanning material intended to represent its value for leather tanning gives four figures, of which the following is a typical example (Cunningham, 1902) of Burmah cutch or catechu:

	Per cent.
Tannins	46.6
Nontannins	20.0
Insoluble	11.5
Water	21.9
Total	100.0

There are some very significant differences between the treatment given to hides in making leather and that given to nets to preserve them and in the behavior of the treated materials. Hides, once they have taken up tannins, never let go, even though they are boiled or soaked in water; nets, however, lose their tanning materials rapidly in water, so that they must be tanned repeatedly if the method used for treating them is the same as that used for treating leather. It is thus obvious that the tannin does not combine in nets with any gelatin or other similar substance, but rather is merely deposited in the fibers. There is another important difference: Hides are tanned in a cold decoction of tan bark or extract, while nets are usually treated in hot liquors.

When catechu, for example, is dissolved in cold water, there always remains a residue, which appears in the analysis given above, as "insoluble." If the solution is heated to boiling, nearly all of this apparently insoluble material dissolves, only some pieces of leaves, sticks, and sand remaining. If the liquor is cooled off, the insoluble material again separates from solution. There is thus a comparatively large amount of substance insoluble in cold water but soluble in hot water. Upon examination, this substance, catechin, is found to be an active tanning material, and for the purpose of net preserving is better than that which is soluble in cold water, because it will not dissolve out in use. Cunningham tried to fix the tannin in nets by first impregnating them with glue (which is crude gelatin) and then treating them with catechu. The effort resulted in failure, apparently because the glue did not penetrate the fibers.

The coloring matters in barks and extracts are independent of the tannins and have no tanning power. Pure tannin (gallotannic acid from nut galls) is a light grayish yellow flaky powder, easily soluble in water.

Since the value of tanning material for net preservation depends upon the abundance of tannins, analyses should support important purchases. The following are analyses made of different samples of catechu, or cutch, by Cunningham, using the hide-powder method:

	Burmah.	Tuan.	Mudah.	Caller Herrin.
Tannins .... per cent..	46.6	46.0	45.2	50.8
Nontannins .... do....	20.0	9.8	15.6	14.9
Insoluble .... do....	11.5	17.1	4.8	2.2
Water .... do....	21.9	27.1	34.4	32.1
Total .... do....	100.0	100.0	100.0	100.0
Strength after exposure .... pounds; ounces..	5;6	8;0	2;4	2;9
Strength after exposure .... kilograms..	2.437	3.629	.964	1.161

It is seen from the above table that there is a considerable difference between the values of the various samples of catechu, a fact equally true of other tanning extracts. The last two figures under each sample (which the writer has given also in kilograms for convenience in comparing with the Norwegian figures that are to follow later) represent breaking strength. Cunningham explains as follows how these figures were obtained:

In order to test the actual preserving power of different samples of cutch, I adopted, in my investigations in Cornwall, the following method: I procured a machine for testing the strength of a net before and after the experiments. The principal part of such a machine, which is called a dynamometer, is of the nature of a spring balance. One mesh of the net is attached to the balance, the other at a certain distance to a hook or knob which can be pulled away gradually by turning a handle. As the strain increases the hand on the dial of the balance indicates in pounds and ounces the weight which is equal to the strain until one of the meshes breaks, when the hand shows the number of pounds equal to the breaking strain.

In comparing the value of the different materials or processes of curing, I took pieces cut from the same net, and, therefore, when new, of the same strength, cured them, then fastened them by mooring at the bottom of Newlyn Harbor. After they had been under water a certain time the pieces were taken up and tested on the dynamometer and found to be of very different strengths, which showed the differences in the preserving properties of the various materials or processes.

One of the earliest experiments carried out on this method proves the preserving power of that part of cutch which is insoluble in cold water. So far as I know, there is no natural cutch or tanning extract which is completely soluble in cold water for the very good reason that the cutch or extract is generally made by boiling. But some of the red cutches put upon the market by the Borneo companies are almost entirely soluble in the cold, either because they have been chemically treated or because the insoluble part has been removed from them.

In this experiment I tested four kinds of cutch [as above]. The last three were red or mangrove cutches from Borneo. In every case the strength of the solution used was 1 pound to 1 gallon of water, the net was dipped twice, being left half an hour in the liquor each time and dried between the two dips. The pieces of cured net were left under water, uncovered only at low water in spring tides, for five weeks, and then tested.

Further reference to the table above will show that the Caller-Herrin catechu which contained the highest percentage of tannin was one of the poorest in preserving power where the nets were actually exposed for a long time to water and tested for strength. The Tuan catechu was best, though it contained the greatest percentage of insoluble matter, which would ordinarily be considered objectionable. This fact shows that the insoluble matter may add greatly to the value of the catechu. The reason for this superiority has already been mentioned. The analysis is made by dissolving samples of material in cold water. That which does not dissolve in cold water is recorded as insoluble and is useless to the leather tanner. But a great part of this insoluble matter is readily soluble in hot water, and, inasmuch as the nets are treated in the hot solution, this matter is deposited in the fibers and stays in the nets while the cold-water-soluble tannins wash out when the nets are put to use.

It will thus appear that analysis of tanning extracts made for the leather tanner's purpose is not all that could be wished from the fisherman's point of view. Cunningham recommends that for the use of net preservers there be included in the usual analysis a figure representing the amount of tannins insoluble in cold but soluble in hot water.

It might prove to be profitable for chemical manufacturers to go a step further than this by separating commercial catechu into two parts, the cold-water-soluble part suitable for the leather industry, and the hot-water-soluble part, not suitable for leather tanning, but preferable for the preservation of fishing gear.

With the provision that the hot-water-soluble tannins be considered in making calculations, Henrik Bull's (1912) point may be regarded as important; that is, that when tanning extracts are bought by the pound without reference to their content of active tannins, very unprofitable purchases may be made. Thus, if a sample of catechu sells for $0.10 per pound, and contains 40 per cent tannins, the actual price we pay for tannin is 10/40, or $0.25 per pound. Further, as will be seen from the following table, the cheaper grades of catechu may (but do not necessarily) furnish tannin at a price considerably higher than would be paid for actual tannin in more expensive grades of extract.[a]

Sample.	Price per pound.	Percentage tannin present.	Price tannin per pound.
A	$0.09	35	$0.26
B	.10	45	.22
C	.11	55	.20
D	.12	65	.185

To calculate the actual cost of tannin where an analysis is available, use the formula:

$$\text{Cost of tannin per pound} = \frac{\text{cost of extract per pound}}{\text{percentage of tannin in extract}}$$

that is, divide the cost of extract per pound by the percentage of tannin in the extract, and the quotient represents the cost per pound of the tannin.

[a] The original table is in Norwegian øre per kilogram of extract. Since, however, the table is only intended to represent a comparison, the writer has assumed suitable figures for American readers.

TANNING MATERIALS USED FOR FISH NETS.

Up to this point attention has been given to catechu. There are numerous other tanning materials put upon the market as bark or wood or as extract. The extract may be liquid, solid, in lumps, or in a fine powder prepared by a recently developed process. The principal tanning materials, as given by Cunningham, are:

Oak bark, the bark of the common English oak, is largely used for tanning leather. The barks of another species in Turkey, and of the chestnut oak (*Quercus castanea*) of America are also used. The bark is stripped from the trees when they are about 15 years old.

Hemlock bark is really the bark of a kind of pine abundant in America, called Canadian pine (*Abies canadensis*). It is the principal tanning material of the United States. The extract of this material in liquid form has been recommended for net curing under the name of Canada cutch, and is sold in tins containing about 8 pounds weight.

Mimosa, or wattle bark, is obtained from various Mimosæ or acacia trees growing in Australia, where this is the staple tanning material.

Quebracho is obtained from several kinds of South American trees. It is imported largely in the form of both dry and liquid extracts.

Valonia consists, not of the bark, but of the cups of the acorns of a certain oak (*Quercus ægylops*) growing in the Levant.

Sumach consists of the leaves of a plant dried and ground. The plant grows in the south of Europe.

Gambier, or terra japonica, is a dry extract prepared from the leaves and twigs of a tree called *Uncaria gambier* in the Malay Peninsula. It is imported from Singapore. There are two forms, block gambier, in large masses, and cube gambier, in small, light-yellow cubes. It is not much used for net curing, but I believe has been used in former times at some places, such as Clovelly, under the name of catechu.

True cutch, or catechu, is a dry extract made from the wood of a tree called *Acacia catechu*, which grows in India and Burmah. It may be distinguished as Burmah cutch, as its manufacture is carried on chiefly by natives, according to their own traditional methods, in Burmah. It is imported from Rangoon. Until recently it was used everywhere around the British coasts for net curing, and was used in far larger quantities than any other tanning material.

Red cutch or mangrove cutch is made from the bark of mangrove trees, which grow in swamps at the mouths of rivers in tropical countries. This cutch is now manufactured extensively by two British companies in Borneo, and is largely used for net curing, having replaced Burmah cutch to a considerable extent.

Myrobalans, divi-divi, and algarobilla are raw materials consisting of the dried fruits or seed pods of different trees. They are imported for use in the leather industry, but are not used for net curing. Canaigre is also a raw material, consisting of the root of a plant growing in New Mexico and Arizona, not used for the fishing industry.

To this list should be added quercitron, a large timber oak (*Quercus velutina*) of the eastern United States, having foliage resembling that of the red oak, but with yellow inner bark. It is on the market as rough bark, rossed bark, ground bark, and solid and liquid extracts. As will be seen later, Bull found this to be one of the best materials for curing nets.

It is thus seen that there are a great many tanning materials, that in common they have tannin, and that this tannin in some way prevents rotting of nets, probably by destroying the digestives with which the bacteria seek to rot the net, or by making the thread indigestible. At any rate, actual measurements of strength show that tannins do preserve nets, and that the principal objections to them as ideal preservatives are that if used unaided they wash out of the nets, and that if the preservation is to last the application must be often repeated.

FIXING OR MORDANTING OF TANNED NETS.

The next step, therefore, is to cause the preserving tannin to stay in the net, and to do this it is necessary to know something of the chemistry of the tannins. It has already been shown that tannins combine with gelatin to form a permanently insoluble substance, this combination being the essential principle in converting hides into leather. Gelatin exists naturally in hides, but there is nothing naturally occurring in cotton corresponding to gelatin with which the tannin can form an insoluble compound.

Tannin is readily oxidized; that is to say, it readily takes up and combines with the oxygen of the air, and when so combined is insoluble and much darker in color. Why, then, does not the tannin oxidize and stay in nets? In fact it does, to a certain extent, as any fisherman who has used "barked" nets knows the nets never regain their original whiteness. But the oxidation takes time, and in practice the net is put into the water before much of the tannin is oxidized, whereupon the unoxidized tannin promptly washes out. To store the net for a time after barking would do little good, for in a dry condition the oxidation proceeds very slowly or not at all. Repeated wetting and drying was credited by Bull in his comments on the paper by Aase referred to above, with the eventual thorough impregnation of nets by the old-time, cold-barking method. It is probable that by holding the nets wet for a long time after barking and allowing free access of air the tan might be fixed permanently in the fibers.

There is, however, no need to do this, for once the chemistry of the process is understood the same end may be achieved by quicker chemical means. There are a number of chemicals which contain oxygen in large quantities, and which yield up this oxygen easily. One such chemical is potassium bichromate. If a solution of potassium bichromate be added to a solution of catechu, a dark-colored, insoluble compound is formed—the combination of tannin with oxygen, the oxygen coming from the potassium bichromate. Advantage is taken of this principle in dyeing; catechu or some other natural wood dye is applied to the fibers and then darkened and fixed by a solution of potassium bichromate. This process is used primarily in the leather and textile industries for the coloring it gives, but no modification is needed to use the method for preserving nets.

The bichromate acts not only on the tannins that are soluble in cold water, but upon the catechin that is soluble in hot water.

The oxidation of tannins is greatly accelerated by alkalis—lye, soda, potash, etc.—but these all have a very objectionable characteristic in that they cause to dissolve in cold water the tanning substance which in its natural state is soluble only in hot water. These alkalis are therefore not used.

CUNNINGHAM'S EXPERIMENTS.

The very thorough work done by Bull in Norway and Cunningham in England has made it possible to preserve nets at much less labor and expense by use of potassium bichromate. To quote Cunningham:

Accordingly I made at Newlyn a large number of experiments * * * to test whether by the use of bichromate the net could be preserved more successfully or more cheaply, and the results were very favorable. One of the most striking of these experiments was made entirely with Burmah cutch, of the Double Eagle brand. The pieces of net used were cut from the net made at Bridport, 25 rows to the yard, 12-ply cotton. The strength of the net when tested new and uncured, or "white," was 15½ pounds * * *. Four pieces of net, cured with and without bichromate, as shown below, were put down in Newlyn Harbor on January 31, 1900, and taken up and tested on March 3, so that they were in the water between four and five weeks. The strengths given are the averages of five trials on the testing machine:

	Pounds.	Ounces.
1. Dipped once in Burmah cutch, 1 pound to 1 gallon of water	4	2
2. Dipped *twice* in Burmah cutch of same strength, dried after first dip	6	5
3. Dipped once in Burmah cutch, same strength, with 1 ounce bichromate potash added to 1 gallon cutch liquor	5	3
4. Dipped once in Burmah cutch, same strength, then dipped separately in hot solution of bichromate, one-half pound to 1 gallon water	14	5

It will be seen that of these four pieces of net, which were placed in the harbor at the same time, fastened to the same piece of rope, three were practically rotten, while the fourth was nearly as strong as when new, and this fourth piece was the one that had been cured with bichromate of potash.

Dipping twice in cutch alone (No. 2) seems to improve the net very little. Experiment No. 3 shows that the bichromate does no good if added to the cutch solution, but must be applied *separately* to be effective. The reason for this, as will be seen above, is that the bichromate makes the tannins insoluble, so that they do not get into the fibers at all.

The bichromate solution used above was strong.

The following series of tests shows the results with weaker bichromate solution, and different combinations, nets submerged January 31, taken up March 30, put down again May 14, finally taken up and tested May 28:

	Pounds.	Ounces.
1. Burmah cutch, 1 pound to gallon, net put in hot liquid and left to soak 24 hours	4	14
2. Mangrove cutch A, a somewhat insoluble kind; same treatment	5	12
3. Mangrove cutch B, another brand; same treatment	7	6
4. Burmah cutch, same treatment; net then dipped in hot bichromate, 1 ounce to 1 gallon water	13	5
5. Mangrove cutch A, same treatment, following by hot bichromate, same strength	14	9
6. Mangrove cutch B, same treatment, followed by hot bichromate, same strength	13	5
7. Mangrove cutch B, 1 pound, with 1 ounce bichromate, boiled together in 1 gallon water, net left to soak 24 hours	1	13
8. Burmah cutch, 1 pound, with 1 ounce washing soda, boiled together in 1 gallon water, net left to soak 24 hours	6	12
9. Mangrove cutch A and soda; same treatment	4	2
10. Burmah cutch, 1 pound to 1 gallon sea water instead of fresh	5	13
11. Mangrove cutch A, in sea water; same strength	6	5

Here, again, it is shown that no treatment appears to do much good without the after treatment with bichromate. The use of bichromate *with* the cutch destroys any preserving power the cutch alone may have. The small differences between the different varieties of cutch and the different modes of handling, exclusive of the bichromate after treatment, are not significant.

The following is another series of experiments made by Cunningham in which quebracho and cube gambier were tried:

The pieces in this case were left in the harbor from May 28 to July 15, a period of seven weeks. The pieces of net were cut from another new net, which seems to have been of better quality than that previously used, as the pieces cured with cutch alone were not so weak after exposure as in previous experiments:

	Pounds.	Ounces.
1. Mangrove B, alone, 1 pound to 1 gallon water, dipped once, soaked 10 minutes	12	5
2. Quebracho alone, same strength, same treatment	9	5
3. Cube gambier alone, same strength, same treatment	5	
4. Mangrove B, as before, then dipped in hot bichromate, 1 ounce to 1 gallon water	13	8
5. Quebracho as before, followed by bichromate, 1 ounce to 1 gallon	12	8 14
6. Gambier as before, followed by bicromate, 1 ounce to 1 gallon	11	5
7. Mangrove B, 1 pound, soda 1 ounce to 1 gallon water, net dipped in mixture then dipped in bichromate, 1 ounce to 1 gallon water	7	8
8. Gambier with soda, then bichromate in above proportions	7	12
9. Mangrove B, one-half pound to one-half gallon water, mixed with one-half pint bichromate solution, 1 ounce to 1 gallon	7	8
10. Quebracho mixed with bichromate, same proportions	10	10
11. Quebracho. one-half pound, bichromate one-half ounce to 1 gallon water, together	5	10

Again, it is shown that bichromate, if used as a separate after-treatment, greatly increases the preserving effect of the tanning materials; it also further confirms the conclusion that bichromate mixed with the tanning material does harm rather than good. Soda added to the tanning extract previous to use is rather harmful than otherwise, as shown by trials Nos. 7 and 8.

LINDEMAN'S EXPERIMENTS.

Thv. Lindeman (1897), in the prize-winning paper submitted in competition before the Trondhjem Fishery Society in 1896 for the best paper on preservation of nets, seems to have been first to use the dynamometer, or breaking-test, method of studying the preservation of nets. On two kinds of thread, hemp and cotton, he tried 12 preserving materials in comparison with untreated thread, as follows:

I. Thread, without treatment.

II. Bluestone.—1½ kilos (3.3 pounds) bluestone, 1 barrel water. Net lies in this 1 day, washed out without drying, and then put directly into the sea.

III. Catechu with mordant.—To 7½ kilos (16.2 pounds) net, take 1 to 1¼ kilos (2.2 to 2.75 pounds) catechu, which is boiled until dissolved; add 60 grams (2 ounces) bluestone. The net is put in this bath while it is warm (60° C. or 140° F.) and allowed to stand over night. The next day it is well drained and brought into a bath (80° C. or 176° F.) in which is dissolved 180 grams (6.4 ounces) potassium bichromate.

IV. Catechu with linseed oil.—The net is prepared according to III, dried by artificial drying, and brought into warmed raw linseed oil, in which it lies until next day; it is then taken out, freed as much as possible from the oil, and dried in air.

V. Birch bark, cold.—20 kilos (44 pounds) birch bark is added to 1 barrel water; to this is added 1 to 2 kilos (2.2 to 4.4 pounds) of soda. This stands cold about 8 days to extract. The net lies in this 1 to 2 days.

VI. Linseed oil, raw.—The net is first artificially warmed; it is then laid in raw linseed oil for 1 day. It is then taken out, freed of oil, and dried as in IV.

VII. Spruce cones.—To one-half barrel of water a quarter of cones is taken. This is boiled vigorously about 3 hours. After it is cooled off the net lies in it about 2 days.

VIII. Wood tar, Norwegian.—The net is artificially dried as in VI, laid under warm wood tar for a sufficient time to assure that it is thoroughly penetrated, after which it is taken out and freed of excess.

IX. Quebracho wood.—10 kilos (22 pounds) to about 150 liters (40 gallons) water, boiled for 1 hour, after which the net is laid in it while it is still warm and allowed to lie in it a couple of days.

X. Zinc chloride.—1 kilo (2.2 pounds) zinc chloride to 100 liters (30 gallons) water; net is allowed to lie in this 1 day.

Before treatment a series of trials was made on different places in the skein of thread used. The results of these stretching tests were as follows:

	A. Hemp.	B. Cotton.
Average breaking load	14.9 kilos (av. of 13 tests).	8.5 kilos (av. of 10 tests).
Weight per meter	0.623 gram.	0.494 gram.
Breaking length	23.9 kilometers.	17.1 kilometers.

It will be observed that in addition to the breaking load, Lindeman also gives the weight per meter of the thread and "breaking length." This latter figure denotes the length of thread that will hold itself up, or the length of thread in a ball whose weight is the breaking load. The strength of thread as ordinarily understood means strength for a given size or weight, for of course a thread can be made of any strength if it is only large enough. The smaller and lighter a thread of given strength, the better. This figure, breaking length, probably furnishes a better basis, if proper precautions are taken, than breaking load, of the quality of a net. Since the weight of a meter of thread is given and the breaking load is given, the breaking load divided by the weight of a meter will give the breaking length in meters (1 kilometer=1,000 meters, or 0.6 mile).

This breaking-length figure is particularly valuable in judging such preservatives as tar and linseed oil, preservatives that add considerable weight to the net. This figure may go to show that where a net must support its own weight, one that appears to be well preserved may be, in fact, poorly preserved because of the greatly increased weight.

After testing the original thread, Lindeman treated different samples by the methods described above, and put them, along with untreated samples, in the sea, and after varying lengths of time measured strength and weight.

The nets were put in the sea October 6 (1895).
First test, 8 days afterward.
Second test, February 1 (1896), after about 14 weeks.
Third test, May 3, about 13 weeks after second test. After the third test the samples were destroyed by a passing boat. A new series was prepared and hung out in the sea July 7.
Fourth test, October 1 (1897), after 12½ weeks.
Fifth test, January 1 (1897), after 13 weeks.

The test pieces taken up October 1 were covered with mussel spat, and were greatly reduced in strength. By the time the fifth test was made the nets had so far disintegrated that they could not be tested on the dynamometer; the investigator therefore made notes with the letters, *a*, *b*, and *c* to indicate how far gone they were, meaning something like poor, poorer, poorest.

It is apparent that the pieces of net used for the fourth and fifth tests underwent decomposition much more rapidly than the earlier ones. While Lindeman offers no explanation of this difference, it may be readily explained by the warm weather, since it is common experience that nets rot more rapidly in warm weather than in cold.

The results of these tests are summarized in the accompanying table. Each figure represents an average of from 5 to 13 trials, so that differences in particular places on the thread are ironed out to some extent.

Strength and weight of thread.	I. Without preparation.	II. Bluestone.	III. Catechu with mordant.	IV. Catechu with linseed oil.	V. Birch bark.
A. HEMP.					
Test 1:					
Breaking load.......kilogram..	13.3	12.6	13.7	10.9	11.5
Weight per meter.......gram..	.600	.675	.696	.910	.628
Breaking length.......kilometer..	22.2	18.7	19.7	12.0	18.3
Test 2:					
Breaking load.......kilogram..	8.6	11.2	12.2	14.0	9.1
Weight per meter.......gram..	.554	.593	.723	1.000	.660
Breaking length.......kilometer..	15.7	18.9	16.8	14.0	13.8
Test 3:					
Breaking load.......kilogram..	6.4	11.8	12.1	13.2	9.7
Weight per meter.......gram..	.509	.646	.687	.837	.652
Breaking length.......kilometer..	12.5	18.3	17.6	15.8	14.9
Test 4:					
Breaking load.......kilogram..	...	9.0	7.7	7.9	4.6
Weight per meter.......gram..	...	.804	.688	1.200	.732
Breaking length.......kilometer..	....	11.2	11.2	6.6	6.3
Test 5:					
Breaking load.......kilogram..	...	...	9.1	7.5	...
Weight per meter.......gram..	...	(*b*)	.765	1.045	(*c*)
Breaking length.......kilometer..	....	....	11.9	7.1	....
B. COTTON.					
Test 1:					
Breaking load.......kilogram..	7.8	8.2	7.9	5.6	7.8
Weight per meter.......gram..	.558	.507	.566	.961	.538
Breaking length.......kilometer..	13.9	16.1	13.9	5.8	14.5
Test 2:					
Breaking load.......kilogram..	3.7	7.7	8.5	7.5	6.1
Weight per meter.......gram..	.497	.493	.610	.894	.530
Breaking length.......kilometer..	7.6	15.6	13.9	8.4	11.5
Test 3:					
Breaking load.......kilogram..	2.3	7.0	9.3	7.4	3.8
Weight per meter.......gram..	.530	.564	.610	.865	.577
Breaking length.......kilometer..	4.4	12.8	15.2	8.5	6.6
Test 4:					
Breaking load.......kilogram..	...	2.7	6.7	7.1	2.8
Weight per meter.......gram..	...	.489	.580	.822	.536
Breaking length.......kilometer..	....	5.5	11.5	8.6	5.2
Test 5:					
Breaking load.......kilogram..	...	...	5.8	6.3	...
Weight per meter.......gram..	...	(*c*)	.570	.764	(*c*)
Breaking length.......kilometer..	....	....	10.2	8.2	....

NOTE.—*a*, *b*, and *c*, meaning something like poor, poorer, poorest, indicate that nets had disintegrated too far to be tested on the dynamometer.

Strength and weight of thread.	VI. Linseed oil.	VII. Spruce cones.	VIII. Tar.	IX. Quebracho.	X. Zinc chloride.
A. HEMP.					
Test 1:					
Breaking load....kilogram..	12.6	13.4	10.8	12.5	11.4
Weight per meter....gram..	.821	.852	.987	.720	.679
Breaking length....kilometer..	15.3	15.7	10.9	17.4	16.8
Test 2:					
Breaking load....kilogram..	11.5	12.4	13.1	11.9	8.1
Weight per meter....gram..	.704	.678	.958	.686	.588
Breaking length....kilometer..	16.3	18.3	13.7	17.3	13.8
Test 3:					
Breaking load....kilogram..	12.9	12.6	11.9	12.7	6.6
Weight per meter....gram..	.642	.712	.792	.803	.622
Breaking length....kilometer..	20.1	17.8	15.0	15.8	10.6
Test 4:					
Breaking load....kilogram..	7.8	3.5	9.3	5.0	...
Weight per meter....gram..	.840	.700	1.030	.738	...
Breaking length....kilometer..	9.3	5.0	9.0	6.8	....
Test 5:					
Breaking load....kilogram..	...	...	...	...	...
Weight per meter....gram..	(c)	(b)	(a)	(b)	...
Breaking length....kilometer..	....	....	....	....	...
B. COTTON.					
Test 1:					
Breaking load....kilogram..	7.0	8.5	7.8	8.1	7.2
Weight per meter....gram..	.727	.585	.974	.559	.647
Breaking length....kilometer..	9.6	14.5	8.0	14.5	14.0
Test 2:					
Breaking load....kilogram..	8.4	8.6	7.6	8.2	3.0
Weight per meter....gram..	.734	.571	.848	.564	.487
Breaking length....kilometer..	11.4	15.1	8.8	14.6	6.2
Test 3:					
Breaking load....kilogram..	8.5	8.5	8.4	8.1	2.9
Weight per meter....gram..	.710	.600	.830	.590	.523
Breaking length....kilometer..	12.0	14.1	10.1	13.7	5.5
Test 4:					
Breaking load....kilogram..	6.0	3.7	6.8	2.9	...
Weight per meter....gram..	.660	.510	.856	.495	...
Breaking length....kilometer..	9.1	7.3	7.9	5.9	...
Test 5:					
Breaking load....kilogram..	...	...	...	...	...
Weight per meter....gram..	(c)	(b)	(a)	(b)	...
Breaking length....kilometer..	....	....	....	....	....

Of the methods that depend on tannins for their activity, Nos. III, IV, V, VII, and IX, only two may be considered at all successful; they are Nos. III and IV. These two received identical treatment—i. e., catechu with copper sulphate and potassium bichromate—but No. IV received a subsequent treatment with linseed oil. If judged by the breaking strength alone, the linseed oil adds a very little; but if judged by breaking length, it is not so good as the previous one. Of methods of tanning nets this is additional evidence that the use of a fixer or mordant, potassium bichromate, greatly increases the preserving quality of tanning materials.

The use of zinc chloride suggested itself to Lindeman because it converts cellulose into so-called hydrocellulose and is used as a preservative for railroad crossties. It is a failure for preserving nets.

The nontannin preserving materials will be considered later.

Another point about the table worthy of notice is that tannins have an effect on hemp nets similar to that on cotton, but not so great.

It should also be noted that Lindeman's paper appeared five years earlier than Cunningham's paper, or that of Bull, next to be considered.

BULL'S EXPERIMENTS.

Bull (1901), in Norway, carried on a similar series of experiments, using a greater number of combinations, including oak bark, quercitron extract, and coal tar. He also carried out more elaborate processes of preparation, including such manipulations as three or four baths and combinations of second treatments. The table following gives Bull's results and carries brief descriptions of the methods used. In the text Bull says he barked the nets in "the customary way."

Lindeman used the bluestone (or copper sulphate, copper vitriol, blue vitriol, as it is variously called) in the same bath with the tanning material. On this point Bull (1901) says:

> When I began this investigation, since I used quercitron extract in as pure a condition as was obtainable, in lieu of catechu, I observed that in solution in water it has, with copper-vitriol solution, a reaction that produces a precipitate which dissolves with difficulty in water, for which reason the coloring method must be regarded as disadvantageous, because the precipitate is formed rather on the thread and is not in the solution. In addition, I found that the second bath may be also harmful in the use of very warm (80° C. or 176° F.) solution of potassium bichromate, since this strong agent, with the high temperature used, may very well cause a weakening of the thread.

Bull also says:

> As a barking material quercitron extract has shown itself to be the best. * * * A noteworthy result is shown in experiment 17, in which the net is barked twice with quercitron extract and afterwards treated with the oxidation mixture. It is shown that the net, after 11 weeks, is of the same strength as before it was immersed in the sea, namely, 23 kilograms.

Quercitron, as well as other tanning extracts and barks, can be secured from American dealers in tanners' supplies.

The copper may have some preserving action; Cunningham thinks it is injurious. It appears to the writer that, while it may strengthen the defense against certain organisms, its chief use on nets is to impart a dark, durable color.

Experiment No.	Method of preparing the thread. After treatment, No. — I.	II.	III.	IV.	Breaking load, after— Preparing.	Sunlight 14 days.	Stored moist 14 days.	Moistened with herring offal 14 days.	1 week in sea water.	5 weeks in sea water.	7 weeks in sea water.	9 weeks in sea water.	11 weeks in sea water.	Weight of 10 meters.	Thread takes up water.	Breaking length.a
					Kilograms.	*Kilograms.*	*Kilograms.*	*Kilograms.*	*Kilograms.*	*Kilograms.*	*Kilograms.*	*Kilograms.*	*Kilograms.*	*Grams.*	*Per cent.*	*Kilometers.*
0	Untreated				1.95	1.75	1.85	1.65	1.98	0.0	0.0	0.0	0.0	1.45	227	13.5
1	Catechu				2.13	1.90	2.02	2.09	1.88	.48	.12	.0	.0	1.514	282	14.1
2	do	Bluestone and potassium bichromate.			2.00	1.77	1.84	1.88	2.00	1.88	1.7	1.87	1.58	1.656	254	12.0
3	Spruce bark				2.02	1.95	2.00	1.35	2.04	.20	.0	.0	.0	1.576	250	12.8
4	do	Bluestone and potassium bichromate.			2.00	2.07	1.84	2.00	2.09	1.82	1.97	1.79	1.42	1.514	232	13.1
5	Birch bark				2.03	2.15	2.59	2.24	2.19	.39	.0	.0	.0	1.53	248	13.2
6	do	Bluestone and potassium bichromate.			2.19	2.01	2.24	2.03	2.17	2.21	2.20	1.67	1.97	1.61	123	13.6
7	Oak bark				2.13	2.02	2.45	2.17	1.88	.19	.0	.0	.0	1.45	228	14.7
8	do	Bluestone and potassium bichromate.			2.11	1.95	1.99	2.17	2.10	2.15	1.71	1.97	1.95	1.50	145	14.0
9	Quebracho				2.15	2.03	2.32	2.03	2.19	2.13	.0	1.83	.0	1.65	206	13.0
10	do	Bluestone and potassium bichromate.			1.97	2.06	2.06	2.04	2.10	.41	.0	.0	.0	1.65	203	11.9
11	Quercitron				1.77	1.84	1.98	1.79	2.00	.42	.0	.0	.0	1.52	179	11.7
12	do	Bluestone and potassium bichromate.			2.00	1.96	1.95	2.16	2.07	2.18	2.11	2.15	2.03	1.58	134	12.6
13	do	Bluestone			2.09	1.97	2.00	1.55	1.82	.48	.0	.0	.0	1.472	237	14.2
14	do	Manganese chloride and potassium bichromate.			2.15	2.04	2.15	1.97	2.15	2.08	1.1	.46	.28	1.57	170	13.6
15		Zinc vitriol potassium bichromate.			2.16	2.02	2.14	1.93	2.10	2.03	1.34	.50	.0	1.57	188	13.7

16	Quercitron	Quercitron			2.04	1.99	2.20	2.21	2.08	.34	.45	.0	.0	1.55	216	13.1
17	do	do	Bluestone and potassium bichromate.		2.34	2.11	2.19	2.37	2.55	2.48	2.45	2.36	2.32	1.79	137	13.0
18	do	Bluestone and potassium bichromate.	Quercitron		2.15	2.15	2.19	5.15	2.19	2.27	2.36	2.15	2.06	1.65	191	13.1
19	do	do	do	Bluestone and potassium bichromate.	2.06	2.06	2.11	2.14	2.06	2.02	2.37	2.15	2.02	1.72	144	11.9
20	Catechu	do	Catechu		1.83	1.88	1.95	1.69	1.85	1.90	1.86	1.81	1.88	1.82	164	10.0
21	Coal tar and carbolineum.				2.09	1.88	2.13	2.02	2.16	1.32	.94	1.04	.44	2.697	85	7.8
22	Quercitron	Coal tar and carbolineum.			2.25	2.16	2.25	2.25	2.04	2.34	2.11	2.17	2.09	3.214	70	7.0
23	do	Wood tar			1.99	2.16	2.22	2.26	2.24	2.37	2.48	2.20	2.39	3.15	54	6.3
24	do	Bluestone and potassium bichromate.	Wood tar		1.99	2.01	1.53	1.95	1.95	1.95	1.9	2.0	1.99	3.5	49	5.7
25	do	do	Coal tar and carbolineum.		2.08	2.01	1.90	1.99	2.06	2.06	2.2	1.88	2.06	3.45	45	6.0

[a] By "breaking length" is to be understood the length of thread, expressed in kilometers, required to cause the thread to break of its own weight.

Lime may also be used as a mordant or fixer for the tanning material. The lime is applied in the form of a solution as follows: Add slacked lime to water in a large container, and let stand with occasional stirring for several days. The clear liquor that remains after the excess lime has settled is to be applied to the nets in lieu of the potassium-bichromate-and-bluestone solution in the method to be given below, after they have been barked. No measurements of the strength of nets so preserved have been found.

A rather elaborate process of tanning employing lime fixation is described in an article in Norsk Fiskeritidende (1886). A translation of this article by Herman Jacobson was published in the Bulletin of the United States Fish Commission (Vol. VI, No. 7, June 12, 1886, pp. 97–104). The method consists of three applications of catechu, one of lime water, and a final treatment of a mixture of Stockholm (pine) tar and coal tar. That method appears to be too elaborate for use in the fisheries of to-day. A point of value in this paper, however, is that where more than one bath of the tanning extract is used the first one should be much weaker than the others.

IMPROVED RECIPE FOR TANNING NETS.

This section of the paper, treating preservation by tanning materials, is to be concluded with a recipe regarded as the best, and a summary. The recipe, given by Bull (1902), is:

To 220 pounds of net (cotton or hemp, the method is best suited to cotton) take 33 pounds of solid extract of quercitron, or 143 pounds of oak bark. (Catechu does not give such good results, but if used, take 53 pounds.)

The extract is boiled[a] until dissolved in 130 gallons of water. Stir continuously in the vessel to prevent the extract from burning to the bottom; the warm solution is poured over the net, which is laid in the vessel. With a flat board, if necessary, push the net down under the liquor. Cover the vessel well with a tarpaulin or sail canvas so that it can cool off only very slowly. After the vessel is completely cooled off the net is taken out and as much of the water as possible is wrung out before beginning the after treatment. If this is done at once, without preliminary drying, some of the tannin will dissolve out and the net will lose.

The after treatment is carried out as follows: To 220 pounds of net take $2\frac{1}{5}$ pounds bluestone and $3\frac{1}{5}$ pounds potassium bichromate, and dissolve them in 150 gallons of cold water.[b] After the substances are entirely dissolved and the whole stirred well, the net is put into the bath. It is best to move the net about in the liquid from time to time so that it works evenly on the entire net. In this bath the color of the net is much darkened; if quercitron is used a uniform brown color is produced, like that of a barked net that has been used a long time. After two hours the net is taken out.

It is the safest plan now to wash the net in water—for example, by putting it in a tub—but perhaps this is not necessary, so it can be spread out at once to dry, or be taken aboard. The water from the after treatment is quite worthless, for the salts added have been completely used up.

By way of comment it may be remarked that the best way to dissolve the extract is to put it in a coarse bag and to suspend the bag in hot water. This prevents débris from going into the solution. In heating the large amount of water the exhaust steam from an engine, or any other steam of a pound or two pressure may be used.

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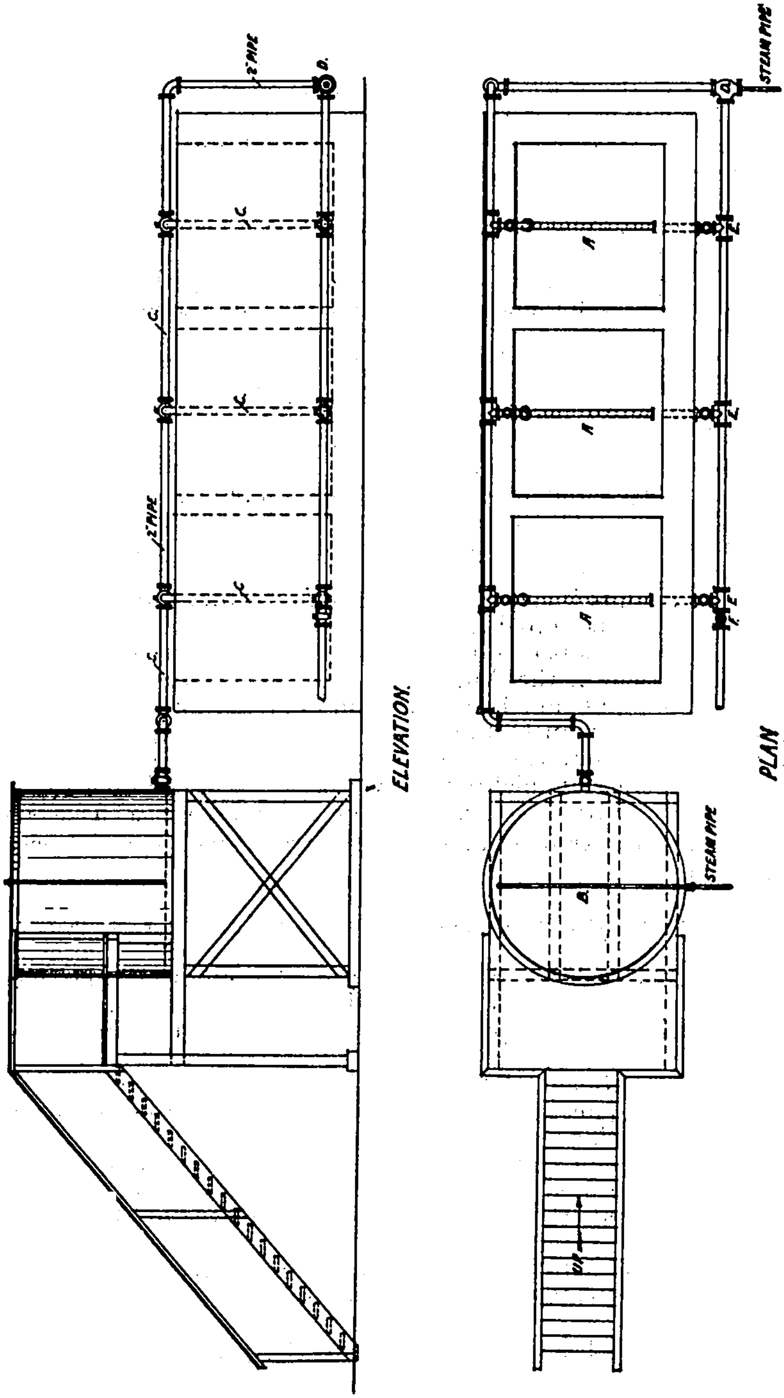
[a] The advisability of boiling the tan liquor is disputed. It appears the safer procedure to heat the water during the process of dissolution of the extract to about 175° F. (80° C.).

[b] Bluestone attacks metal vessels, and it should, therefore, be dissolved in barrels or other wooden vessels.



Plant for tanning nets. (From Barclay, 1905b.)

The accompanying drawing (Barclay, 1905*b*) represents a plant as used in Scotland for barking nets. Catechu or other extract is dissolved in tank *B*, which is heated by steam from a steam pipe. A system of pipes, the arrangement of which is obvious in the drawing, provides for drawing off the liquor into tanks where the nets are treated. *D* is a steam injector or siphon used for convenience in transferring the liquor from one vat to another, or returning it to the dissolving tank.

It is assumed in these recipes that the nets are perfectly clean and free from oil before tanning. Preferably, nets should be tanned before they are ever used. If they are dirty or greasy they should be washed in warm water and soap, well rinsed in warm water, and dried before tanning.

It will be noticed from Bull's figures that a double treatment of quercitron extract before mordanting (experiment No. 17) gave best results. If it is desired to do this—and this procedure is recommended—the first tan should be much weaker than the second; that is, use half the total amount of quercitron for first bath, add the remaining half to the same liquor for second bath, following with mordant, or after treatment. The net should be dried between first two baths of quercitron. This procedure is in keeping with the practice in the leather-tanning industry.

While this method is usually referred to in the literature as "Bull's method," it should be stated that an after treatment with a chromate (sodium chromate) was used before; for example, mention was made of it in the article in the Allgemeine Fischerei-Zeitung (1896) referred to, and potassium bichromate in combination with catechu was tested by Lindeman (1897). Olaus Tyskø, in a paper submitted in the Trondhjem contest, states that the method using catechu, copper sulphate, and potassium bichromate had been "used in Fosen for the last 20 years." (Konserveringsmidlers indflydelse paa fiskegarnstraad. Tillæg til Årsberetning for 1898 fra Trondhjems fiskeriselskab, pp. 4–7.)

SUMMARY OF METHODS OF PRESERVATION OF NETS BY TANNING.

1. Tanning methods are suitable for preservation of nets, leave the nets soft and pliable, and afford a high degree of protection.
2. Very little increased protection is afforded by treating tanned nets with lineseed oil or tar.
3. An after treatment of potassium bichromate following the application of tan liquor greatly increases the preserving power of tanning materials, such as quercitron, catechu, gambier, etc.
4. Copper sulphate (bluestone, copper vitriol) contributes to the color of nets when used as an adjunct to tanning methods, but does not add much, if anything, to the protecting power of the tanning material.
5. So far as the data go, hemp threads are protected by tanning materials just as is cotton, but not such a great degree of protection is afforded.
6. No data have been found regarding the preservation of linen thread.

7. All the methods of tanning impart a dark color to the nets, which color may be advantageous in making the nets less conspicuous in the water.

PRESERVATION OF NETS BY METHODS NOT DEPENDENT ON TANNING MATERIALS.

The methods of prolonging the life of nets which make no use of tanning materials, or make use of them only as adjuncts, employ linseed oil, pine tar, coal tar, bluestone, soap and bluestone, salt, smoke, and creosote.

Of these, linseed oil and tars are physical protections to the net; they fill up the spaces between the fibers and to a large extent keep the water from coming into contact with the materials of which the threads are composed. Naturally these materials are very efficacious, but that there are many and serious objections to the general use of linseed oil and tar will appear later. Linseed oil will be considered first.

LINSEED OIL.

For practical purposes the animal and vegetable oils are looked upon as being divided into two principal groups, the nondrying oils and the drying oils. The nondrying oils, of which coconut, peanut, cottonseed, and olive oils are examples, are used for soaps, foods, lubricants, and the like; they do not "dry"; that is, they do not form a skin upon being exposed to air, but under storage conditions may become rancid. The drying oils, such as linseed and menhaden oil, when exposed to air "dry"; that is, they form tough, somewhat elastic skins, which, when a pigment is incorporated with them, constitute paints. The conspicuous properties of these oils, that is, the turning rancid of the first class, and the drying to a skin of the second, are both traceable to the same cause—oxidation, or absorption of oxygen from the air. Both classes possess a keen appetite for oxygen, and the process of absorption is attended with the generation of heat; if the oil is distributed in such a way that great surface is offered for oxidation and at the same time little opportunity is afforded for the heat to escape, so much heat will be generated as to start a fire, as it is well known that oily rags will do, and also nets. Another peculiarity about this heating is that the hotter the rags or nets become, the faster the oxidation.

Linseed oil is the great drying oil, used the world over as the body for paints. It has been used in Holland (Barclay, 1904) for many years for preserving nets and to a considerable extent in the same way in England, particularly at Lowestoft and Yarmouth. This method, according to Cunningham, is simple: The nets are given one bath of catechu, thoroughly dried; and then one bath of linseed oil, drained, and dried. After drying, which takes two or three weeks or more, they are again bathed in catechu, which removes any undried oil. In use they are occasionally given a treatment of catechu, like any other net. The method, as used by the Dutch, according to Jessen (1903), is as follows:

Any grease on the net is first removed in water, to which a little more than 2 quarts of slacked lime is added, per barrel of water. The net is then thoroughly dried, and introduced into a bath of 18 pounds catechu to 35 gallons of water; the water is boiled and stirred till the catechu is dissolved. The liquor is kept hot while the net is put into it. It is left in until the knots have had time to be thoroughly penetrated; then taken out, drained, and the moist net packed in a vessel till next morning, when it is taken out and dried very thoroughly. As soon as completely dry it is ready to receive the same treatment again, and so on until it has had 6 to 8 treatments, between each two of which it is thoroughly dried out, care being taken that the interior of knots is soaked at each treatment and dried with each drying.

The net, perfectly dried, is now brought under raw linseed oil—1 pound of oil for each pound of net. The oil is kept as cold as possible. The excess of oil is drained off in a vessel with a false bottom. This done, the net is laid out in a field to dry, which drying takes two or three weeks or more. Much rain will injure the net, but under no circumstances should the net ever be heaped up until absolutely dry, even if it does rain. If it is heaped up it is certain to heat, and, aside from the danger of fire, it may be ruined by the heat generated.

There is no doubt that this is an excellent preserving method for nets and deserves all the esteem in which it has been held for so many years. But, because of its laboriousness and the present cost of linseed oil, it is not at all likely to receive consideration under present conditions in the United States. Neither is it every fisherman that has idle land on which he can lay out nets for three weeks or more to dry. Nor is the method necessary in many cases, for if the figures by Lindeman and Bull, given above, are reliable, the threads may be as well preserved by catechu or other tan, followed by a mordant, at much less cost and labor. The threads of hemp, preserved with catechu and mordant, were reduced in strength from 13.7 to 12.1 between first and third tests (28 weeks); preserved with catechu, mordanted, and then oiled, the figures are 10.9 and 13.2, or an apparent increase in strength. With cotton the results were similar, only both appeared to become stronger. But it will be noticed that the oiled nets are 50 per cent or more heavier than the other and the breaking length is correspondingly shorter.

Nets oiled with linseed oil are stiffer and harder than nets not oiled; in some cases, such as the gill nets for shad, this would be a serious objection; but for nets that stay constantly in the water, such as trammel or moored nets, oiling might be well justified. Cunningham said he left oiled nets in the water two months and found no diminution in strength in that time. Barclay (1905) concludes that improved tanning methods are good where there is opportunity for occasional drying of nets, but where there is no opportunity for drying it may be desirable to oil the nets after they are tanned or "barked."

TAR.

Preservation of nets by tar is the principal method used in the United States. The nets are simply passed through hot tar, freed from excess, and partially dried. On use the drying continues until the tar is hard and tough. Of this method Cunningham says:

This method of treating a net is very cheap and tested by the method above described—breaking tests—on pieces of net exposed in a harbor, the preservation is very perfect. A piece of net lost scarcely any strength after two months in the water, and, moreover, a tarred net is distinctly stronger than a cutched net, because the dry tar increases the strength of the cotton fibers by gluing them together. As an antidote to putrefaction coal tar is perfect, no septic organisms being able to live in it. The fibers of the cotton, being covered by the tar, do not come actually into contact with water. For these reasons tar is an excellent preservative for coarse nets for rough use, such as trawl nets.

But for drift nets there are many objections to its use in the manner considered. The net is too rigid and stiff, and, therefore, does not usually mesh the fish well although to some extent the net is made more flexible by occasional dips in hot cutch, which softens the tar and removes a portion of it. The rigidity of the net causes it to wear out mechanically; after two or three years it is apt to give way at the knots, owing to the breaking of the stiffened fibers under the constant bending.

Another method sometimes used employs cutch and tar together, the tar being stirred into the hot cutch and the net bathed in the mixture. Cunningham found this to be very little better than the cutch or catechu alone, for the reason that the tar does not mix uniformly with the cutch, but breaks up into little droplets which attach themselves to the threads. The threads are therefore not uniformly protected by the tar.

Tar consists of two parts, a liquid part which is separately known as creosote, and a black, solid part which is left behind when the creosote evaporates. When the tar is first applied both are present, but as time passes the liquid creosote gradually evaporates, while the solid part remains. Both assist in protecting the nets, the solid by gluing the fibers together, the liquid by killing bacteria; one protects, the other preserves.

If in the table given by Bull (p. 20) the samples prepared with tar are compared with samples prepared in other ways, it is seen that tar holds its own against all rivals, if we consider preservation of breaking strength only. But it is noticed that weight is increased from around 1.6 grams per 10 meters to around 3.5, or about 2¼ times; the breaking length is correspondingly reduced, while the absorption of water is reduced from about 250 per cent to about 50 per cent; that is, the amount of water the threads will absorb is reduced by the application of tar from about 2½ times its own weight to one-half its own weight.

The added weight of tar is a very material disadvantage in large nets, for it increases the labor of handling nets and prolongs the time of every move of the net. On the other hand, Bull's table shows that the tarred net soaks up much less water than the barked net and that, since absorbed water adds to the weight of the net just as tar does, the weight added by water must also be considered.

In the case of drift nets, where the poise of the net in the water is of greatest importance, the balance of the net has a bearing on the method of barking (Jessen, 1906). Jessen argues thus: A quantity of sea water of the same air and salt content and at the same temperature as that of the sea, will neither sink nor float, but will stay at whatever depth it is put, and when water thus soaks into a net it will tend neither to sink nor float the net, but is a dead weight. This dead weight, however, must be counterbalanced by a greater weight on the lead line than would be needed without it; that is, the weights on a water-logged net must be greater by an amount equal to the weight of the water in the net in order to keep the net vertical. Thus, if the untreated net in Bull's table took up 227 per cent water (No. 1) and required 24 kilograms stone sinkers, the barked net which took up 179 per cent water (No. 11) would require 21.6 kilograms sinkers, and with the barked and tarred net (No. 23) that took up 54 per cent of water, only 10.5 kilograms sinkers would be needed, and that with lead sinkers these figures are 14.6, 13.2, and 6.4 kilograms, respectively. Then, to show the practical force of his argument, he points out that with the untreated net (No. 1) with stone sinkers one must work with the weight of the net, 8.6 kilograms plus the water soaked up, 19.5 kilograms plus the stone sinkers, 24 kilograms, or 52.1 kilograms all together. While with the barked and tarred net and lead sinkers these weights are, net, tanning material and tar, 15.7 kilograms; absorbed water, 8.5 plus the necessary lead, 0.4 kilogram; a total of 30.6 kilograms. He also shows that the first net, requiring 17 men to handle it, can, if its weight is reduced by barking and tarring, be handled by only 10 men. No argument is required to show, also, that of two nets made of material exactly the same size and quality, but one weighted down to nearly twice the weight of the other, the heavier will wear faster than the lighter. While space does not permit of an extended review of the discussion of these matters,[a] it should be pointed out that Jessen appears to have overlooked the fact that if a tarred net of a weight of 3.15 increases in weight by 54 per cent, it will weigh 4.85 in all, while the untreated net of 1.45 will, when increased by 227 per cent, weigh 4.95, or more than the tarred one. Bull, in the article referred to in the footnote, gives the correct mathematics for making the calculations.

CUNNINGHAM'S FURTHER EXPERIMENTS.

At this point it is appropriate to introduce the remaining experiments conducted by Cunningham, using all the ordinary net preservatives in various ways.

PREPARATION OF SAMPLES.

1. Cutch alone (one-half pound cutch boiled in one-half gallon of water).—The pieces of net put in this until well soaked, then dried. Then put into cutch of same strength, steeped for two days, then dried.
2. Cutch and glue (one-half pound glue dissolved in 1 gallon of water).—The net dipped into this, then squeezed and put into hot cutch—one-half pound cutch to one-half gallon of water—then dried. Afterwards dipped a second time into cutch of same strength and dried again.
3. Cutch, glue, and bichromate of potash.—The net was dipped into glue, 1 pound to one-half gallon of water, with a little bichromate of potash added; then put into cold cutch and left to steep two days.
4. Cutch and copper sulphate.—The net was steeped two days in cutch, one-half pound to one-half gallon of water, then, while wet, put into copper sulphate, 1 pound to one-half gallon of water, and after a short soak rinsed in fresh water and dried.
5. Cutch and coal tar.—The net was first saturated with coal tar, then squeezed and wrung out several times with hot water, then dried for a week, and afterwards dipped in hot cutch, one-half pound to one-half gallon of water.
6. Cutch and coal tar mixed.—One-half pound cutch boiled in one-half gallon of water and then about a pint of coal tar stirred into the hot solution. The net was dipped into the hot mixture, then dried.
7. Cutch, tar, and green oil [a creosote distilled from coal tar].—The net was first steeped three days in cutch, one-half pound to one-half gallon of water. Then the same cutch was heated and the net passed hot from this through a mixture of coal tar, Stockholm [pine] tar, and green oil as thick as paint. The net was then passed through a wringing machine and dried.

[a] See further, Bull (1906). Reference is made by Bull to a discussion of the matter between Dr. Johan Hjort and Peter Jessen in the Bergens Tidende, presumably in 1906.

8. Coal tar and green oil mixed.—The net was steeped in the mixture, then passed through a wringing machine, and hung up to dry.

9. Cutch and green oil.—The net was steeped several days in cutch, one-half pound to one-half gallon of water, then dried and put into green oil, then passed through a wringing machine and hung up to dry.

10. Green oil alone.—The net was simply saturated with green oil, passed through a wringer, and hung up to dry.

11. Cutch and Stockholm tar, mixed (one-half pound cutch boiled in one-half gallon of water, and one-half pint Stockholm tar stirred into the hot solution).—The net dipped into the mixture, squeezed out, and dried.

12. Cutch, Stockholm tar, and green oil.—The net was steeped three days in cutch, one-half pound to one-half gallon of water, then dried and soaked in Stockholm tar warmed, with a little turpentine added. As the net was very hard and sticky, it was soaked with green oil and passed through the wringing machine.

13. Cutch and linseed oil.—The net was steeped in cutch (one-half pound to one-half gallon of water) for three days, dried, and then dipped in boiled oil, with driers added. After some weeks it was dipped again in cutch and dried.

14. Soap and copper sulphate (one-half pound soap boiled in one-half gallon of water).—The net soaked in this and then put into a solution of copper sulphate, one-half pound to one-half gallon of water.

15. Soap, copper sulphate and linseed oil.—The net, prepared as in 14, was saturated with boiled oil, with driers added, and hung up to dry.

The pieces were all cut from the same mackerel net, 24½ rows to the yard. 12-ply, and the following table shows the results of testing:

Mode of cure.	Strength when dry.		Strength after 4 weeks in water.		Strength after 2 months in water.	
	Lbs.	*ozs.*	*Lbs.*	*ozs.*	*Lbs.*	*ozs.*
1. Cutch only, two dips and steeped	15	9	16	8	6	6
2. Glue and cutch, one dip in glue, two in cutch	17	2	9	6		
3. Cutch, glue, and bichromate of potash	16	11	14	4		
4. Cutch and copper sulphate	13	8	10	9		
5. Cutch and coal tar, tarred first	18	4	21	0	18	0
6. Cutch and coal tar, mixed	17	12	18	6	8	1
7. Cutch, tar, and green oil, passed direct from the cutch into the tar	17	3	18	0	14	3
8. Coal tar and green oil, mixed	16	0	16	1	14	12
9. Cutch and green oil	15	14	18	4	17	0
10. Green oil alone	16	5	16	0	15	8
11. Cutch and Stockholm tar mixed	17	13	17	6	6	12
12. Cutch, Stockholm tar, and green oil	14	4	18	0	16	6
13. Cutch and linseed oil	15	1	16	12	15	8
14. Soap and copper sulphate	15	1	15	8		
15. Soap, copper sulphate, and linseed oil	15	1	15	4	14	8

It is evident that Cunningham did not carry his tests far enough to give decisive indications. In spite of this insufficiency, it is plain that those methods are good which depend on tar or oil as a protective covering, where these substances really cover, but when they are broken up into tiny particles or applied to a wet net, as in Nos. 6, 7, and 11, little protection is given.

SHRINKAGE CAUSED BY PRESERVING.

Cunningham also kept a record of the shrinkage caused by the various methods of curing nets. As stated above, the nets were 24½ rows per yard before treatment. After treatment they varied according to the following list. (Of course, the greater the number of rows there are the more the shrinkage that has taken place.)

No.		Rows per yard.
1.	Cutch only	26½
2.	Glue and cutch	25½
3.	Cutch, glue, and bichromate	25½
4.	Cutch and copper sulphate	25½
5.	Coal tar and cutch	28½
6.	Cutch and coal tar mixed	27
7.	Cutch, tar, and green oil	25½
8.	Coal tar and green oil	25½
9.	Cutch and green oil	26½
10.	Green oil alone	25½
11.	Cutch and Stockholm tar	27
12.	Cutch, Stockholm tar, and green oil	25½
13.	Cutch and linseed oil	27
14.	Soap and copper sulphate	27
15.	Soap, copper sulphate, and linseed oil	27

All the methods caused shrinkage, the greatest being caused by coal tar and cutch, but the other combinations of cutch and tar caused marked shrinkage. All the tanning methods cause shrinkage, and the shrinkage increases with each application of the preservative.

To conclude the discussion of tar as a preservative, it can be said that tar effects excellent preservation, is comparatively inexpensive, and requires much less labor and time than, for example, the combination of catechu and linseed oil. For the heavier and coarser kinds of nets that are anchored or moored in the water, such as trammel or pound nets or nets that are handled by machinery, the method is well suited. But for gill nets, the method is not at all suited, and for even the heavier seines that are hauled by hand, consideration should be given to the extra weight added by tar and the consequently increased number of men necessary to handle nets so preserved. In such cases, especially for nets that can be dried occasionally, the more improved barking methods, such as quercitron and potassium bichromate, are likely to prove to be better and to be little more expensive or laborious than methods employing tar.

Tar should never be mixed with catechu solution or anything else containing water before application to the net and should never be applied to a wet net. It may be thinned with creosote, "green oil," turpentine, etc., without injury. If a net be cutched or barked before being tarred, it should be thoroughly dried before the tar is applied. While tar may be applied profitably to new, white nets, it seems likely that it will always yield a good return on the investment to tan the nets with quercitron and bichromate and to follow with a thorough drying before application of the tar.

CREOSOTE, SMOKE, ETC.

As stated above, tar consists of a solid and a liquid part. The liquid part really consists of a number of different liquids and volatile solids, such as carbolic acid, benzol (or benzene), napthalene, etc., mixed, which, when separated, have different important commercial uses. They are distilled off from coal tar. One portion (the third main portion distilling over at from 230 or 240 to 270° C.) is known as "green oil" or creosote oil, a greenish-yellow, oily liquid, heavier than water, and containing various antiseptic substances. It is used for the preservation of crossties, fence posts, telegraph and telephone poles, and has been used for the treatment of nets. Reference to Cunningham's table above shows that creosote oil alone is a good preservative for nets and causes little shrinkage; it also possesses this advantage, that it does not make nets stiff. The principal objection to its general use is that it washes out or evaporates rather rapidly from the net, and no method of fixing it is known. The net is oily or greasy for some time after it is treated and is therefore objectionable to handle.

Concerning the mode of application of creosote, Cunningham says:

There are many different ways of applying the green oil or creosote to the nets; the net may be well cutched first, then dried, soaked in the green oil when dry, then passed through a wringing machine, and spread out to dry; or the net may be passed straight from hot cutch, without drying, through the green oil, and then dried, or, instead of the oil alone, a mixture of tar and green oil may be used. In whatever way it was applied I found pieces of net treated with green oil had lost but very little strength after two months' exposure in Newlyn Harbor.

The principal preserving matters in creosote that comes from wood go over in the smoke when the wood burns in a smoldering fire. Upon this fact is based a method using smoke.[a]

It is stated in the articles referred to that this method had been used on the Gulf of Courland for many years in houses that had no chimneys by allowing the smoke to go through passages into a loft where the nets were hung. A direct method of applying the smoke is to fasten the net to the underside of boards which are supported above a smoking wood fire.

While this method appears to be primitive, there is nothing chemically unreasonable about it, and it may be that under certain circumstances the method would be applicable to-day. It would certainly be much better than nothing, provided the nets were not allowed to be overheated during the smoking process. It would be necessary to repeat the treatment, perhaps several times a year. The method has the advantage of depositing upon the fibers the volatile antiseptic substances of tar, without the heavy thick parts, and it would appear less likely to shrink the nets.

COPPER SULPHATE.

It was noticed in the figures of Lindeman, given above, that hemp threads were improved by every method that improved cotton threads; only one preserving material had a more marked effect on hemp than on cotton—that is, copper sulphate (or copper vitriol, bluestone, blue vitriol, etc., as it is variously known). This substance has long been used for nets, alone or in combination with other substances. According to a quotation in the Norsk Fiskeritidende (1906) this is used in Norway for the treatment of salmon nets. One kilogram (2¼ pounds) of copper sulphate is dissolved in a barrel of water. The nets are treated with this by allowing them to lie in it overnight. They are put into the sea as soon as they are taken from the bath, without preliminary drying. Lindeman's figures show that the method does not deserve serious consideration.

What is perhaps of much more importance is a method of using copper sulphate in combination with soap. A method of this kind is said to have been used in the French sardine industry to give the nets a color. Oils consist of two parts, glycerin combined with fatty acids. When the glycerin is taken out, and soda or potash substituted for it,

[a] See Mittheilungen des Westpreussischen Fischerei-Vereins (1896), Deutscher Fischerei-Verein (1885), and Norsk Fiskeritidende (1896).

ordinary soaps are produced. If, instead of the alkalis, any other metal—such as copper, mercury, aluminum, etc.—is used, insoluble soaps—such as copper soap, mercury soap, aluminum soap, etc.—are produced. The simplest method of preparing these "heavy metal soaps" is first to make ordinary soap, then treat it in solution with a compound of the metal whose soap is desired. Thus, if to a solution of ordinary soap aluminum chloride is added, an insoluble waxy precipitate falls—aluminum soap; if copper sulphate is employed instead of aluminum chloride, a bright green, insoluble copper soap is formed. The insoluble calcium soap is a very familiar substance formed when soap is dissolved in "hard" water—a tallowy stuff that gets on one's hands, the bathtub, etc. This is calcium or lime soap. A similar soap is used for temporary calking of small leaks in boats; a soap of aluminum is used to waterproof clothing, for it makes clothes difficult to wet, the water rolling off "like water from a duck's back."

Now, if the principal reason for using copper to preserve nets is that it kills bacteria and other injurious living things, and if the principal objection to its use as bluestone is that it washes out so readily, there will be no difficulty in seeing that the object of using it in the form of a soap is to take advantage of its protective property and at the same time to prevent it from escaping into the water. Since copper soap is quite insoluble in water, there would be no way to get it into the fibers if it were made before it is applied; it is therefore necessary to cause the copper soap to be produced inside the fiber by impregnating the threads first with soap solution and then with copper sulphate. In the practice of preserving nets the following process, according to Cunningham, is used:

> To treat a net by this process from one-half to three-fourths pound of ordinary soap, such as mottled soap * * * is used for each gallon of water, and the soap is dissolved by boiling in a copper or in a galvanized bath over a fire. The net is then soaked in the soap solution, taken out, squeezed through the hands, and allowed to drain. The copper sulphate, which is also known as blue vitriol or bluestone, must not be dissolved in an iron vessel, as it will attack and dissolve the iron. It must be put into a wooden or earthenware vessel, and it is not necessary to use heat to dissolved it, as it will dissolve in cold water if stirred up for a short time. The net while still hot from the soap solution is then passed through or put into the solution of bluestone, and the whole net becomes uniformly green. The net is then rinsed in cold water. About three-fourths pound of bluestone to a gallon of water is the proportion required.

This method preserves the net, according to Cunningham's figures, for about four weeks, but he says that after two months the sample treated was quite rotten. The process can, of course, be repeated as often as necessary, and by repeated treatments a net should be kept in condition for years. It causes strong shrinking of the net.

A similar method is recommended for ropes and canvas by the Norsk Fiskeritidende (1887). The procedure there given is as follows:

> Ropes are laid first for four days in a solution of copper vitriol (20 grams to a liter of water—two-thirds ounce to a quart) and then dried. They are then tarred in the usual way or laid in a soap solution (100 grams to a liter of water—3½ ounces to a quart) until they are saturated through. Canvas is treated only with the vitriol and soap.

GENERAL COMMENTS.

Only the more important and widely used or promising processes for the preservation of nets have been considered. To anyone who has searched literature it would be a surprise if a great many other methods and processes were not found to have been tried. The list given by Jessen includes, besides barking, smoking, alum, train oils, tallow, grease, bluestone, potassium bichromate, various compounds of mercury, iron vitriol, pine tar, wood oils, coal tar, aniline dyes, and various other products of gas works, salt, resins, soaps, lime, etc. But all the recorded data found that will have a material value have been included in this paper.

It should be obvious to most people that nets should always receive some preservative treatment. Coarse nets, pound nets, and the like should be both barked with catechu or quercitron, mordanted with potassium bichromate, and then tarred. Where it is not possible or suitable to tar the nets, they should receive the catechu or quercitron treatment and the mordant. It is preferable to use two baths of quercitron, the first containing only one-half the total amount to be used.

Though no actual figures have been brought forth to prove it, there is little doubt that nets are destroyed more rapidly in warm climates and warm weather than in cold. Fishermen should take note of this fact and be accordingly more careful of their nets where the weather is warm. It is also likely that foul, dirty water works more rapid destruction on nets than clean water.

One of the possible ways to avoid the disintegration of nets is, of course, the chance of using some material that is not subject to decay—metals, for example. A person signing the initials C. J. (1912) describes briefly in the Dansk Fiskeritidende some experiments with aluminum, brass, copper, and galvanized-iron wire for bow nets. The aluminum proved to be best.

No important results have come from efforts to substitute metals for plant fibers for nets.

CARE OF NETS.

When nets are piled up wet—especially if they are foul with slime, blood, fat, etc.—the rapid oxidation heats the net. Even if the net does not take fire the heat generated may very well cause a great weakening. This weakening will not be visible, but will tell in a much shorter life of the net. However carefully the net is barked or tarred, a very short life can be looked for if the net has been heated.

For a temporary preservative, where it is not possible to dry the nets, it is customary to salt them. This is a useful treatment, as far as it goes. Salt is not in itself poisonous or injurious to small organisms or bacteria (for they live in the sea which contains much salt) if the concentration is not too great. But it is well known that when any watery organism is exposed to a salt solution stronger than its own juice water will be extracted and usually the organism dies. The salt is injurious to living things not because of its saltiness, but because of its concentration; not because it is poisonous, but because it extracts the water necessary for things to live on. The rule is that a stronger salt solution will extract water from a weaker juice wherever it comes in contact with it.

This principle is made use of in many ways. Every fisherman knows that salt draws the water out of fish in the curing process. It is not so apparent, but it is equally true, that it draws the water from and kills the bacteria that would otherwise cause the fish to decay, and thus preserves it. Any equally concentrated substance would do the same. Thus sugar is used in very concentrated sirup to preserve fruits; if the preserves were sufficiently diluted with water, bacteria could live in them and they would spoil.

In this way salt preserves nets. It dissolves in the moisture on the threads to make a very strong solution; this strong solution kills bacteria and other small organisms by extracting the water from them. From this it is hardly necessary to say that the salt should be applied generously, and preferably in the dry condition, to a wet net. If brine is used, it should be very strong.

But salt will not prevent heating in an oily net that has just caught very fat fish, such as herring. The heating is caused by the air working on the fat. The only way to prevent this heating is either to get rid of the fat or to prevent the air from getting to it. Aboard a vessel it is not always convenient to wash the net out immediately, nor is there room to spread the net (if spread, the heat, of course, escapes as fast as produced and no harm is done). Bull (1905) suggests that to prevent this heating of recently used herring nets aboard a vessel, there be provided a wooden tank with a tight-fitting lid, filled with water or salt solution, and that the net be put into this and covered over with the lid until there is opportunity to wash it. The water or salt solution keeps out the air and prevents heating. The cheapest obtainable grade of salt may be used, since there is not likely to be anything in it that is injurious to nets.

Nets, as every fisherman knows, should be washed and dried at every opportunity.

CONCLUSION.

The most important methods of preserving nets are tanning, for which an improved recipe is given on page 22; tarring, found on page 26; and creosote, found on page 30. Other methods are also given.

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