

oughly washed to remove blood and adhering impurities. It is then chilled and hardened with a bath of ice water, after which it is finely comminuted by cutting machines and melted in steam jacketed caldrons at a temperature of about 160 degrees Fahrenheit. Slowly revolving agitators keep the fat moving until the melting process is complete, when the whole is allowed to settle. The settling process is accelerated by the addition of salt, which is scattered over the entire surface of the liquid and settles the fiber or "scrap" to the bottom. After the first settling, the clear oil is carefully siphoned to a second series of jacketed caldrons, usually on the floor below, where more salt is added, and the temperature controlled until a second settling is completed. This demembrized fat is now siphoned into mounted vats and allowed to stand from three to five days in a temperature favorable to the crystallization of the stearin, a part of which forms a crust over the top and the remainder settles to the bottom, leaving the clear oil between. It is a common phenomenon in the crystallization of various substances whose specific gravity is not greatly in excess of the mother liquid that, cooling first at the top, a portion of the substance which is being crystallized out forms a crust over the surface and the remaining portion is precipitated. When the vats have stood the required time the crust is broken into fine particles and the whole is given a thorough mechanical mixing which leaves it of a mushy consistency. It is then wheeled to a revolving table surrounded by skilled workmen who wrap the mixture into small packages with canvas cloths—each containing about three pounds—which are built into the presses. The oleo oil is then separated by great pressure, slowly and gradually applied, and flows from the presses into a large receiving tank on the floor below, from which it is piped to the oleomargarine department or is drawn into new oak tierces and allowed to harden in preparation for shipment to independent manufacturers or for export. Fig. 1 shows two presses, one filled and the other in process of being filled.

All manufacturers of oleo oil follow substantially the method above described, but the system of grading and the character of the fat selected differ greatly. The number of grades manufactured is from three to five, and, when the market is active and prices are high, about all the fat taken in slaughtering, both from cattle and sheep, is worked into one grade or another. The oil made from sheep fat cannot be neutralized, and retains the characteristic odor and flavor of the animal to such degree as to be unfit for the oleomargarine demanded in American markets. It is exported to Europe, where there is demand for cheaper oils. With the beef fats the character of the animal from which they are taken is the most potent factor in the selection. Some manufacturers work into their highest grade of oleo oil practically all the fat taken from a good steer, and make one or two lower grades from the fat of cows and "canners." Other manufacturers make their highest grade from the caul and other selected fats of the best beeves, using certain intestinal and other lower forms, together with that taken from poorer animals, in making from one to three lower grades. As previously indicated, the manufacture of oleo oil is more widely distributed than that of neutral lard, and, while it is largely confined to the big packing houses, considerable quantities are made in large cities, outside the centers of the packing industry, from fats collected in part from abattoirs and in part from retail butchers. The quantity of oleo oil obtained by the process described is, by weight, about 50 per cent of the fat treated. About 28 per cent is tallow and stearin and the remainder is lost in shrinkage. The quantity obtained from each beef is difficult of exact determination because it varies so greatly with the size and condition of the animal when slaughtered.

Compared with oleo oil, the manufacture of neutral lard is a simple process. Two grades are made—one from the leaf, the other from the back fat of the hog. Its manufacture is almost exclusively confined to large packing houses, but there are independent manufacturers of oleomargarine located near the packing centers who prefer to buy the fat as it is taken from the animal and work it into neutral by their own process. In the packing plants the leaf fat is taken from the animal immediately after killing, hung on mounted racks, and wheeled into refrigerators to remove as quickly as possible all animal heat. It is next chopped fine or reduced to pulp by machinery and melted in jacketed kettles exactly similar to those used for oleo oil. When the melting process is complete it is allowed to settle, the precipitation of the fiber being accelerated by the addition of salt, as in the case of oleo oil. After the settling process the clear oil is siphoned to a receiving tank, and what is not used in oleomargarine is tierced for shipment. A good quality of leaf fat will produce by careful handling about 90 per cent of its weight in neutral, and each animal will yield an average of eight or nine pounds. Comparatively little neutral is made from back fat. The amount used, however, depends much on the relative demand for neutral and ordinary lard products, as it is sometimes more advantageous to work fats into one form than another. The oil made from back fat retains more of the flavor peculiar to lard, and, like the lower grades of oleo oil, is less free from stearin or other undesirable constituents. Some packing houses mix a small per cent of back fat with the "leaf" in making their highest grade of neutral, and oleomargarine manufacturers sometimes use both grades of the finished oil in combination. The difference in price between the two is usually slight, and neutral made exclusively from "leaf" is generally sought. Independent manufacturers of oleomargarine, who make their own neutral lard, give the fat a more extended treatment than that described as the process of the packers. In addition to the separation of the fiber by the process of settling, the clear oil is drawn into a large vat of salt water at a low temperature, where it is again chilled and hardened, and is allowed to remain for several hours. It is then placed on shelves to drain, and is again melted when ready for churning. This treatment carries the neutralizing process to a higher degree of perfection, and improves the texture of the oil.

After a detailed description of the methods of manufacturing its principal ingredients, the manufacture of oleomargarine itself may be described briefly. In those

independent plants where both oleo and neutral lard are purchased for use, melting tanks are provided for each, in which they are melted separately, after being taken from the tierces in which they are shipped. They are then piped or pumped to a mixing tank mounted on weighing scales, where the exact proportions demanded by the working formula are ascertained. If cottonseed oil is required by the formula, a separate tank for it is usually provided. If butter is to be used instead of milk or cream, a separate melting tank is also provided for that. After the oils are melted and weighed into the mixing tank together, the mixture is piped or pumped into the churn, where it receives the milk and coloring matter. The whole mass is then churned together, as previously described. In the packing houses liquid oleo oil and neutral lard are piped from the oil room direct to the weighing tank. After churning, the liquid oleomargarine is allowed to flow into a vat of ice water, which chills and hardens it before crystallization can take place. It is next shoveled into mounted cars and wheeled to the "tempering room," where it stands for several hours, until sufficiently softened for the machine butter workers. After the salt has been worked through it, it is put up in marketable form and stored in refrigerators to await shipment. Fig. 2 represents an actual scene in a churning room of a large factory. At the left of the picture is seen a quantity of oleomargarine which has just been taken from the chilling vat after churning, and is ready for the "tempering room." At the right the contents of a churn are being drawn off into the chilling vat. The pipe descending from the ceiling brings a stream of ice water from a reservoir above into immediate contact with the stream of liquid oleomargarine for the purpose of chilling it as quickly as possible. Fig. 3 represents the working and salting process, and Fig. 4 a scene in the preparation of the finished product for market.

While there is substantial uniformity in the process of manufacture, there is great diversity in the grades and combinations of material used and, consequently, in the character of the finished article. The cheapest grades of oleomargarine found on the market are made from the lowest grades of oleo oil and neutral lard, to which is added the limit of cottonseed oil, and the whole is churned with skimmed milk or buttermilk, salted with common salt, and colored with the cheaper grades of coloring matter. These low-grade oils may be manufactured from "scrap" fat and made firm by the addition of more stearin or other similar substances so that a greater proportion of cottonseed oil can be added to the combination. Sometimes glycerin is added to give the product a glossy appearance, and sugar or glucose to sweeten or give texture. The highest grades are made from pure oleo oil and neutral lard of best quality, churned with whole milk, cream, or creamery butter, salted with Ashland salt, and colored with annatto or other coloring matter. The number of grades manufactured varies from two to six, but all large factories receive orders for special lots to be made in a prescribed way. One factory visited by the writer made only two grades—the higher from high-class oils churned with whole milk, the other from low-grade oils churned with the same. In this case the quality of the oleo oil and neutral was the only basis of grading the finished product. In another factory the lowest grade manufactured was a combination of the best oleo oil and neutral churned with whole milk. Three higher or more expensive ones were made with the same oils, each depending for its rank on the amount of pure cream or creamery butter added in the churning process. A large proportion of the independent manufacturers are making a specialty of the higher grades, which include only the best oleo oil and neutral, the grade being determined from the quantity and character of the dairy product added.—Twelfth Census.

LEATHER FOR BOOKBINDING.*

By DR. J. GORDON PARKER.

FOR many years past there has existed a growing dissatisfaction among librarians and owners of libraries with the quality of the leather put on books, owing to the fact that many books bound within comparatively recent years already show serious signs of deterioration and decay. This dissatisfaction grew in volume until a small committee of gentlemen interested in the subject, called together by Mr. Douglas Cockerell under the chairmanship of Mr. Cobden Sanderson, began to investigate some of the causes, and to take evidence on the subject. At this committee a certain amount of information was gleaned, but it was found generally that the exact causes of the decay were not known. Librarians were inclined to lay a good deal of the blame upon the bookbinder, who in turn blamed the leather merchant for the quality of the leather, and the leather merchant when questioned absolved himself of all blame by vaguely talking of new processes of tanning, even hinting as to the existence of some rapid process of transforming skin into leather by aid of acids and other chemicals.

After this, which I may term a preliminary inquiry, the Society of Arts took the matter up, determined that if possible the cause of the dissatisfaction should be investigated. To this end a very strong committee was appointed, under the chairmanship of Lord Cobham, and the members included representative bookbinders, librarians, leather merchants, leather manufacturers, and chemists who made a special study of the leather trade. Of this committee, I formed a humble member, and as a member of both sub-committees which were subsequently formed, as well as of the main committee, I have been asked by several to detail the various investigations which were carried out by the sub-committees, to show samples of the leather which was used and tested, and to give the actual proof and experimental work in detail on which the main committee based its report, which has now been before the public for some months.

I need hardly enlarge upon the work of the first sub-committee, whose object was to justify the cause of the complaint, to find out which leathers appeared to decay most rapidly, and the conditions under which the

books were kept, whether the decay was noticed as much in libraries lighted with gas or electric light, whether the bindings appeared to last longer when kept under glass cases, and if possible to note approximately the period at which general decay seemed to set in. This committee in its work visited nine of the most valuable and most important libraries in England, and found generally that most modern leather of all kinds showed signs of decay, and in many cases that bindings of not more than ten years already showed marked signs of deterioration and decay. The bindings of scientific works, proceedings of learned societies, on shelves, bound in calf, of which the date of binding could be very closely ascertained, were in many cases falling to pieces, and in several cases books bearing the dates of 1885, 1886 and 1887 could not be handled without the leather coming off in the form of dust. In another case the removal of the book from the shelf caused the back to come right off.

Generally speaking, as the report clearly states, most sign of decay was found in libraries where gas was used for lighting; and it was also found that, approximately, the most marked form of decay was noticed from 1860 onward. It was certainly noticeable on books bound at any earlier period, but it became more general, comparing all libraries, about 1860.

Through the extreme kindness of several of the librarians and bookbinders I was allowed to detach portions of many of the worst specimens, in order that they might be laid before the second sub-committee for microscopical and chemical examination. This second sub-committee was also supplied with many old bindings and with various samples of bindings, the exact date, nature of the leather, and all particulars being clearly stated.

Turning now to the work of this second or scientific sub-committee, the problems before them were, therefore, of a definite nature. Having first convinced themselves of the almost universal tendency on the part of modern leather to decay, their work was to investigate the cause or causes of this modern decay, and to find out why books which were bound in the fifteenth to the early part of the nineteenth century were still in most cases in almost perfect condition. It was extremely unlikely that any change had taken place in the nature of the raw skins used. It was consequently taken for granted that the causes were to be found in some of the modern processes of leather manufacture. An examination of several pieces of old bindings revealed the fact that the bindings were, generally speaking, thicker than those of more modern date. A microscopical examination showed the fibers of these leathers to be in an upright condition, whereas in more modern leather this is not generally the case; the stretching and tight setting-out of the skin having a tendency to lay the fibers in a more parallel state. Another important factor was revealed by the chemical analysis, which showed that all the old samples of leather analyzed contained less tannin in proportion to the skin substance than was found in more modern bookbinding leather; in other words, it was evidently the custom in the eighteenth and nineteenth centuries to tan the skins in weaker liquors, with the result that the leather was lighter tanned than is the custom at the present time.

Further, and also another important factor was, that in most of the bindings examined which had stood the test of time the tanning material which had been used was in nearly every case either sumach or oak bark, and it was further noticed that in many cases where even fairly modern leather had stood for twenty or twenty-five years the tanning agent had been sumach. Here, therefore, there was indicated a special line of investigation likely to be productive of much useful information. Although sumach and oak bark are still used for the tanning of the better-class high-priced leather, very many skins are tanned with such materials as quebracho (a wood which comes from South America), larch bark, gambier and mimosa bark, and thousands of dozens of sheep, goat and calf skins are sent over ready tanned from India. These latter are tanned with turwar bark, *Cassia auriculata*. These are known in the trade as Persian moroccos, Persian sheep and E. I. calf. Some of these skins are simply scoured, dyed and finished; while the majority are stripped of the loose tannin by scouring in a weak alkaline bath, borax or carbonate of soda being used. As this treatment turns the skins an ugly dark brown color they are put into a bath of weak sulphuric acid. When supposed to be thoroughly freed from sulphuric acid by washing in water, they are retanned with sumach, and afterward dyed and finished in the usual manner.

In order to find out whether any special tanning material had or had not an advantage, and whether the tanning material, *per se*, was liable to cause decay or destruction of the leather, calf, goat and sheep skins were tanned out, one of each skin in each of the following tanning materials: pure sumach, pistacia, lentiscus, tamarix, oak bark, myrobalanus, quebracho, mimosa bark, gambier, larch bark, chestnut extract and oakwood extract. Two sets East India tanned goat, sheep and calf, one set washed, oiled and dried, the other set scoured, soured and sweetened and retanned in sumach as carried out in practice, were also prepared. When these skins were judged to be lightly but thoroughly tanned, one half of each skin was removed from the tan liquor, and the remaining halves were left in the liquors, these being strengthened up with more tannin, so that the second halves were more fully tanned, as is most commonly the case in modern leather. The leathers so produced were rinsed through water to remove superfluous tan, allowed to drip, and when in a semi-dry condition were oiled lightly upon the grain surface, and hung up and dried in the usual manner. Portions of these skins are before you on the table. Pieces of each of these leathers were so fastened upon boards that one half of the piece of leather was exposed, while the other part was carefully covered, so as to be protected from either light, heat or the action of the surrounding atmosphere. In all, eight such duplicate sets were arranged, and were subjected to the following tests for thirty days:

Board No. 1 was exposed to an ordinary direct sunlight. This was done in a large room facing south, and the tests were carried out during July and August.

* Read before the Society of Arts.

The second board was exposed to the action of gas-light. A small cupboard was arranged, and a No. 5 ordinary fish-tail gas-burner was placed in the center of the cupboard, and the boards so arranged round this that the leathers were about 18 inches from the lighted burner.

No. 3 board was arranged in a similar cupboard, and exposed to the light from an ordinary incandescent gas-burner.

No. 4 was also arranged in the same way, but in place of the gas-burner, a 16-candle power incandescent electric lamp was used.

The fifth board was subjected to the fumes of burnt gas. To carry out this experiment a similar room was used 8 feet high and 6 feet square. On the floor of this room was placed an ordinary fish-tail burner, turned about half on, and the boards, with the leather fixed upon them, were hung on the ceiling. A maximum and minimum thermometer was also hung on the ceiling, and the room so ventilated that the temperature was not allowed to exceed 90 degrees F. I may add that this was the temperature noted on the top shelves of two of the libraries which were examined, so in this case the worst library conditions were imitated as closely as possible.

The sixth board was subjected to moist and dry air alternately. This was done by drawing a current of moist and dry air over the leather through a vacuum oven. The temperature was kept at 60-70 degs. F.

The seventh board was subjected to an atmosphere of carbonic acid gas. This test was likewise carried out in an oven, the carbonic acid gas being dried before it was allowed to enter the bath.

The eighth board was subjected to direct sunlight, but the leather was protected from the air by a sheet of glass being laid upon it. This was exposed at the same time, and in the same room as board No. 1.

The leather after this treatment gave some most interesting and instructive results. It showed:

1. That the leathers tanned with certain tanning materials were less affected than those tanned with other materials.

2. That the fumes of burnt gas appeared to act more strongly on all the leathers than any other agent.

3. That artificial light had only a slight effect upon the leather, provided it was protected from the products of combustion.

4. That direct sunlight and air appeared to have a very strong disintegrating action upon most of the samples, but when the leather was protected by a covering of glass the action was less intense.

5. Moist and dry air appeared to have no special deteriorating action. The same thing was noticed in the set exposed to carbonic acid gas. The electric incandescent light appeared to have even less effect than either ordinary gas-light or the incandescent gas burner, probably on account of the less heat evolved and the absence of products of combustion.

On examining all these sets side by side it was noticed that in each case the leathers tanned with sumach were the least affected of any, followed in regular rotation being less affected by myrobalanus, chestnut extract, oakwood extract, oak bark, gambier, larch bark, quebracho, pistacia and tamarix; and the worst set was the leather tanned with turwar bark, especially the sample which had been scoured, soured and retanned. Further, it was also noted that the samples of leather which had been only lightly tanned, were less affected in each case than the samples which had been finished in stronger tanning material, and were thus more heavily tanned. These results showed that the tannins which belong to the pyrogallol class of tanning materials, viz., sumach, myrobalanus, chestnut and oakwood extracts, were the least affected; while, on the other hand, those of the catechol series, represented by gambier, larch bark, quebracho, and turwar bark, became dark red in color and hard in texture. The fibers of the leather appeared to be disintegrated, and in the worst cases the leather could not be rubbed even with a soft cloth without removing a layer of red powder. The tannins of the catechol series appear to part readily with water when exposed to the action of light, heat, or acids, and are converted into red, resinous-like substances which appear to thoroughly disintegrate the fibers of the leather, causing it to become hard and lose all strength.

These above detailed experiments were first carried out at Wrexham by Mr. A. Seymour-Jones, and were afterward repeated by myself in London, and both sets were confirmed by Prof. Proctor in Leeds, so as to leave no doubt about the accuracy of the work. A similar set was treated for sixty days, and some leathers were exposed for three full months. These samples are before you this evening, and can be examined by anyone interested. This was the first stage of the work, and it revealed clearly that tanned goods of which sumach was the tanning material were the least affected of all the tanning materials, and that the East India tanned portions were the most sensitive to either gas fumes, light or heat.

To further test these latter goods, a fresh set of leathers were obtained. An ordinary tanned East India goat and also a sheep skin were purchased in the usual manner, and each skin divided into four parts. A quarter of each was left in its state as purchased; a second quarter was rinsed through water, lightly pressed out, oiled and dried; a third quarter was scoured in alkali, then washed through sulphuric acid, afterward well rinsed in water and then retanned in sumach; and the fourth quarter was simply washed well in water, struck out, and afterward retanned in sumach. These portions of skins were subjected to a similar series of experiments, to the action of gas fumes, direct sunlight, and to diffused daylight for sixty days. Each sample was more or less affected. The quarters which had been stripped with alkali, treated with acid, and afterward sumached showed most deterioration. The portions exposed to the action of burnt gas fumes were absolutely rotten at the end of the time, and could not be handled without breaking or falling into powder. The best sample was that which had been simply washed in water, oiled, and dried, but even this was badly damaged, and turned a deep red color, but it showed that the removal of some of the tannin tended to lengthen the life of the leather; while, on the other hand, the usual trade custom of stripping with an alkali and souring with acid, after-

ward retanning in sumach, appeared to about halve the already short wearing life of these leathers.

Thus far, then, the committee had discovered the best and the worst leather in its natural tanned state. The next point was, if possible, to find out the cause of the decay in modern oak bark tanned calf. For this purpose several samples of tanned calf skins were purchased and obtained from librarians and bookbinders. None of this leather had been used or exposed in libraries, and most of the samples contained varying quantities of free sulphuric acid, which had evidently been used to brighten the color. Several other samples were therefore obtained free from sulphuric acid. Portions of each of these skins were subjected to the method of testing described, with the result that acid free leather stood the tests in a very satisfactory manner, while the other samples which contained quantities of sulphuric acid, varying from two-tenths to eight-tenths of a per cent, had changed to a red brown color, become hard and brittle, and were easily abraded by friction.

I may say, in passing, that this custom of brightening the color of bark tanned calf with acid, is of comparatively recent date, probably becoming general twenty or thirty years ago. It has a wonderful effect upon the leather; it removes stains or any unevenness in color, generally brightening the somewhat reddish tone, and transforming it into one of a yellower shade, thus giving to the skin a better appearance from the buyer's standpoint. Further tests with bark tanned calf, showed that the heavier it was tanned, the more rapidly it appeared to decay.

The experiments carried out thus far, as will be noticed, were only done with the rough-tanned skins. But it was necessary to find out whether the methods of dyeing and finishing leather in any way impaired its wearing qualities. For this purpose, several kinds of skins, including calf, sheep, goat, seal, and pig, were obtained, and each skin was divided into four portions. The first portion was retained in its rough tanned state; the second portion was struck out, dyed, freed from superfluous dye by rinsing in water, and dried out; the third portion was struck out, dyed, and finished in the usual manner, being glazed after applying an ordinary albumen seasoning, and no acid being added to the dye-bath to develop the color; the fourth portion was struck out, dyed with the addition of an ordinary amount of sulphuric acid, and finished in the usual manner. These series were, as before, exposed to direct sunlight and to the fumes of burnt gas. The results showed at once that the dyeing of the leather where no acid had been used, did not in any way affect the life of the leather. The finishing appeared to protect the surface of the leather somewhat. This would, of course, be expected, as the ordinary finishing process consists of coating the leather over with a thin layer of albumen, and afterward polishing either by hand or machine. This thin layer would naturally protect the tannin from oxidation, and preserve the leather for a certain time. The portions of the skins with which acid had been used in the dye-bath, however, showed signs of decay, and had become hard and brittle. Of the five different skins used, the calf and sheep appeared to be the weakest, while the goat, seal and pig skins appeared the least affected of the five.

In order to ascertain whether the use of sulphuric acid, either as a brightening agent or in the dye-bath, had become universal, from various sources we collected a large number of samples of different kinds of leathers. I have not the details of the number of samples examined by Prof. Proctor, who fully confirms my results, but I personally analyzed 38 different samples of moroccos, and found that 36 contained free sulphuric acid; 18 different samples of skivers were examined, of which 12 contained acid; 32 different samples of calf, out of which 27 contained free sulphuric acid; 18 Persian goat and 23 Persian sheep were also examined, and in all cases free sulphuric acid was found to be present. Six different samples of pig skin were all tested, and in each of the six free acid was found. These were all of English manufacture, some obtained direct from the manufacturers, others from leather merchants and bookbinders.

Knowing that of recent years a large quantity of French and German skins had been used for binding purposes, eight different samples of French Levant moroccos were obtained, and in each of the eight samples a large quantity of free sulphuric acid was found; the lowest contained six-tenths and the highest 1.3 of acid. Twelve samples of German bookbinding leather were in like manner tested, and eleven found to contain acid. The highest percentage found in any was .85 per cent.

It would, perhaps, be unfair to draw a definite conclusion from the few French and German skins examined, but those which passed through our hands were certainly much inferior from the bookbinder's standpoint to any of the English skins. Although the French skins were of a bolder grain and larger in area, they were split down to such an extent that they were little better than paper, added to which a higher percentage of acid was found in this class of goods than in any of the English samples.

It is evident, therefore, that sulphuric acid is of almost universal use, either as a brightening agent or to liberate the dye in the dye-bath.

As it is always customary in tanyards to rinse the skins well through water after souring with acid, it was somewhat surprising to find such a high percentage of free acid still present in the finished leather. Tests were therefore undertaken to ascertain the amount of washing or rinsing necessary to remove the acid. To this end, several pieces of skin were treated with known quantities of sulphuric acid, and then washed for varying periods in running water. It was found to be practically impossible to remove the whole of the acid by rinsing or washing in ordinary water. One piece of "Persian" leather, containing 1 per cent of sulphuric acid, was washed for five days and nights in running water, and at the end of that period it was found that it still contained slightly over two-tenths of a per cent of sulphuric acid, showing that sulphuric acid, as stated in Prof. Proctor's Cantor Lecture, delivered before this Society, appears to dissolve in the leather and adheres most tenaciously to the fibers. It was, however, found that if skins were washed in water containing either potassium or sodium lactate or

acetate, the free sulphuric acid was neutralized; where, therefore, it is absolutely necessary to use sulphuric acid the committee recommend that this means of neutralization be adopted.

The committee then turned their attention to the various processes of tanning. Without wearying you with all the details of the experiments made, I will merely state that it was found in general that skins which had come from abroad preserved in salt were when tanned weaker in texture than either dried or fresh skins. Skins which were in any way tainted, or even only slightly decomposed, were extremely weak.

Many sheep skins arrived in this country from New Zealand and Australia in what is known as the pickled condition. These skins are pickled in a solution of salt and sulphuric acid. Several of these skins were tanned and compared against unpickled skins, and it was found that the leather produced from skins which had been pickled was much inferior in strength and durability to the unpickled.

Low liming and the use of the stale limes containing quantities of free ammonia, were found to weaken the pelt, as also over-puering, a process which is used to rid the skin of lime, and, at the same time, to pull down its thickness, and to make it soft and pliable.

Many of the finished leathers examined microscopically by us showed that the skins had been distinctly over-puered. This was very noticeable in a series of pig-skin bindings of one of the large public libraries.

Another interesting feature, already referred to, was that leather appeared to lose in strength and durability the more heavily it was tanned, and this point is one which leather manufacturers should watch. I am of opinion, as expressed in the report, that the skins for bookbinding purposes should be lightly but thoroughly tanned; not what would be termed "dead tanned." They should then be rinsed lightly through water, should not be tightly set out, and should not be dried in a stretched condition. It is the custom to dry many kinds of leather strained tightly over boards. This tends to lay the fibers in a flatter and more parallel condition, and to keep the fibers all taut, removing from the skin its elasticity and also what I may term the cushion effect which is produced when the fibers run transversely to the skin.

Many of the different samples examined, both on and off books, were found to be shaved down or split so that only the thin grain surface remained. It required no investigation to prove that this was contrary to all reason, and that shaving the skin down to the thin substance could not but reduce the leather to about the level of brown paper as a binding agent.

Mr. Douglas Cockerell was good enough to obtain for me from different sources sets of samples of six different substitutes for leather for bookbinding purposes. It would be better for me on this occasion not to mention the names of these substitutes, although they are all well known to bookbinders. These mostly consisted of cloth or cotton foundations, covered over with some material of a waterproof nature, which by skillful processes could be made to imitate almost any class of skin. These samples were each subjected to a series of tests similar to those that the leathers had undergone, and although sunlight or artificial light appeared to have little or no effect upon these substitutes, they were more easily affected by the fumes of burnt gas than even the poorest qualities of leather. Moreover, in dry atmosphere they become hard and somewhat brittle.

Examination was next made of some of the methods used by bookbinders for brightening the leather and for sprinkling, and also of the pastes which were employed by them in their workshops. To this end the committee were willingly supplied by various binders with samples of sprinkled leathers and treed calf, also samples of leather which had been washed with oxalic acid to brighten the color. It was found that sprinkled leather soon went into holes, and leather which had been washed with oxalic acid also rapidly darkened in color, and became very hard and brittle when exposed to the sun's rays.

The pastes on the whole were found to be harmless, but from the leather standpoint we cannot too strongly emphasize the damage which must be caused to the leather by stretching it out too tightly over the back of the book in binding.

Before concluding this somewhat lengthy account of the different series of experiments carried out, I would point out one fact which at first was somewhat puzzling. We found that sumach-tanned leathers in every case stood all the tests better than any other, but that some samples of sumach-tanned leathers deteriorated, while others showed no sign after even sixty days of sunlight. On examining carefully the leathers referred to it was found that some of the rough-tanned sumach skivers contained free sulphuric acid. As the source of supply in two cases was known, the firms in question were written to, and it was acknowledged that a small quantity of sulphuric acid had been put in the sumach tanning vats to give the skins a slightly thicker feel.

But another cause for the differences in sumach-tanned leather is the fact that cheap brands of sumach are invariably adulterated with the leaves of two other materials, viz., pistacia and tamarix, and it was the presence of these adulterants which caused some of the sumach-tanned leathers to show deterioration. This discovery led us to tan out skins with tamarix and pistacia, in order to see how they behaved in comparison with sumach tannage, and as the first series of experiments showed, they were considerably worse than even larch or gambier-tanned skins.

It was our duty to give if possible some advice to librarians and others as to the preservation of books bound in leather, and Prof. Proctor undertook an elaborate series of experiments with glasses of various tints in order to find out whether the disintegrating effect of sunlight could be minimized by the use of lightly tinted glasses. His experiments were eminently satisfactory. He found that the violet or actinic rays which affected photographic printing paper also affected the leather, so that any glass which would keep out the actinic rays could be recommended for the glazing of library windows.

I have endeavored to state as clearly as possible the details of the chief experiments which were carried out by us, in order that the leather trade may be able to judge whether the grounds on which the report is

based are sufficiently strong. Many other experiments were done, but I will not lengthen this paper by detailing them, as they were of lesser importance than the ones I have given. I need only say that every statement and recommendation made in the report, the grounds for those statements, and the experimental and practical work on which they are based, were confirmed by each individual member of the sub-committee, so that their conclusions cannot, as has been stated by some critics, be considered as being simply the "opinions or fads of professional men."

Before bringing this paper to a conclusion, I should like to refer to a fact that impressed us very forcibly, viz., the number of disguises under which the ordinary sheep skin masqueraded. We found books bound, nominally, in levant morocco, hard grain morocco, straight grain morocco, pig skin, calf skin, crocodile, and alligator leathers; which leathers on close microscopic examination, were found to be the ordinary common sheep skin, on which had been stamped, probably by electrotype rollers, the special grains and markings of the skins they were got up to imitate. In many cases both the bookbinders and the librarians had bought these leathers under the impression that they were buying the genuine article, the buyers having probably been tempted by the low price which would naturally be charged in a case of this sort.

The question of price brings us, I think, to one of the most important points in connection with this investigation. I may be wrong, and it may be that I am not sufficiently connected with the commercial side of the leather trade to form a definite opinion, but I venture to give my views on the subject for what they are worth. I believe that a good deal of the leather of the cheaper sort which has been found to decay is largely the fault of its cheapness. The librarian has stipulated that his books must be bound at a certain contract price. The bookbinder has, in consequence, to procure a cheap class of leather. This he has in most cases easily found, as there is always a large quantity of cheap leather on the market, splendidly finished, and to all appearances of first-class quality, which owes its high finish and good appearance to the use of materials in manufacture which are injurious to its strength. I think it is therefore clearly the duty of the librarians, if they are determined to have a leather which will last, to put in their specifications, when high-class work is required, that the leather must be of pure sumach tannage; secondly, that no mineral acids must have been used in any process connected with the manufacture of the leather; and thirdly—also an important point—that the skins used must not have been pared down or split to paper thickness. For small books, small and thinner skins must be used in the binding.

Sumach-tanned calf can be obtained and can be dyed to the brown shade so much liked in the case of ordinary brown calf; bark-tanned calf can also be used in binding, provided the leather is not over-tanned, and has not been brightened by the use of acid; but I think there is not the slightest doubt the librarians must in future, if they wish a leather to last more than from ten to fifteen years, insist on their specifications being carried out to the letter, and they must be prepared to pay a correspondingly higher price for a guaranteed article. Low quotations in most cases are to be regarded with suspicion. Chemists have now obtained sufficient knowledge to be able to test leather both chemically and microscopically (1) for the presence or otherwise of acids; (2) to ascertain if the leather is over-tanned; (3) the tanning material used, and (4) to ascertain whether the fibers are in a good healthy condition, or whether the skin has been damaged either in the early liming or puering, or in the later finishing processes.

I believe that in many cases the manufacturers themselves are not wholly responsible for their leather being spoilt. The buyers often demand high finishes, bold grains, and other characteristics in the leather, such as can only be obtained at the expense of its strength and durability. In many works the finishers use both alkalis and acids at different stages to produce certain results, and in nine cases out of ten they do not understand the action of the materials, and do not know that their use damages the leather. It seems to me that it would not have been necessary for this committee to sit, and for its members to spend so much time and trouble on this investigation, had the workmen, or, more important still, the leather manufacturers themselves, possessed greater knowledge of the principles underlying leather manufacture.

The work of the committee is not yet completed, as the question of the fastness of different dyes is still under investigation. The committee hope that this part of their work will be finished by next summer.

WATER TUBE BOILERS.—II.

By the ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE YARROW BOILER.

ANOTHER very satisfactory and serviceable type of water tube boiler, especially for torpedo boats and similar other small craft, is the Yarrow. It first came into significance on account of its remarkable durability and efficiency upon the torpedo boats for the Dutch government, which were constructed by Messrs. Yarrow & Co. at their Thames shipyard at Poplar. The attention of the British Admiralty was attracted by its success upon the vessels; and it was thereupon introduced into the British navy. But although it has been principally utilized for small warships, it has recently been installed with success upon the largest and heaviest vessels.

The first practical Yarrow boiler was constructed in 1889, and was the outcome of numerous experiments and investigations since 1877. It belongs to the "drowned" class of boilers, the steam being delivered into the upper drum below the water line. The inventor, as the result of his researches, was of opinion that this system of steam delivery into the drum was more successful than the foaming class of boiler, as circulation is more efficient and complete.

In general appearance it is not unlike the Thornycroft boiler. In form it resembles an inverted V with the fireboxes at each of the two lower corners of the

triangle. But its most important divergence from the Thornycroft pattern, in addition to the delivery of the steam in the upper drum being below, and not above, the water line, is that the tubes are straight. The question of whether straight or curved tubes are the most efficient has been one round which has raged spirited discussion among engineers; and when the pros and cons of the advocates of the two principles have been analyzed, the superiority of either type practically resolves itself into a question of individual taste. The curved tubes, as adopted in the Thornycroft boiler, have been conspicuously successful, and equally so have been the straight tubes of the Yarrow. In view of the fact, however, that the straight tube principle is utilized in the large majority of water tube boilers and offers special facility for cleaning, all things being equal it certainly has this preponderating advantage.

The two very conspicuous advantages of the straight tube boiler are the facility and expedition with which the tubes can be cleaned, and the ease with which a defective tube can be removed and replaced. The straight tube principle dispenses with the necessity of keeping a variety of tubes in stock, since the tubes are all of the same dimensions. In the early days of the water tube boiler, it was maintained that in the case of the straight tube boiler, owing to the fluctuating temperatures and the consequent unequal expansion and contraction of the tubes, a great strain was thrown upon the rigid portions of the boiler. No doubt this was an inherent defect of the earliest straight tube boilers, but it has now been efficaciously eliminated. In the Yarrow boiler there is a great elasticity of structure.

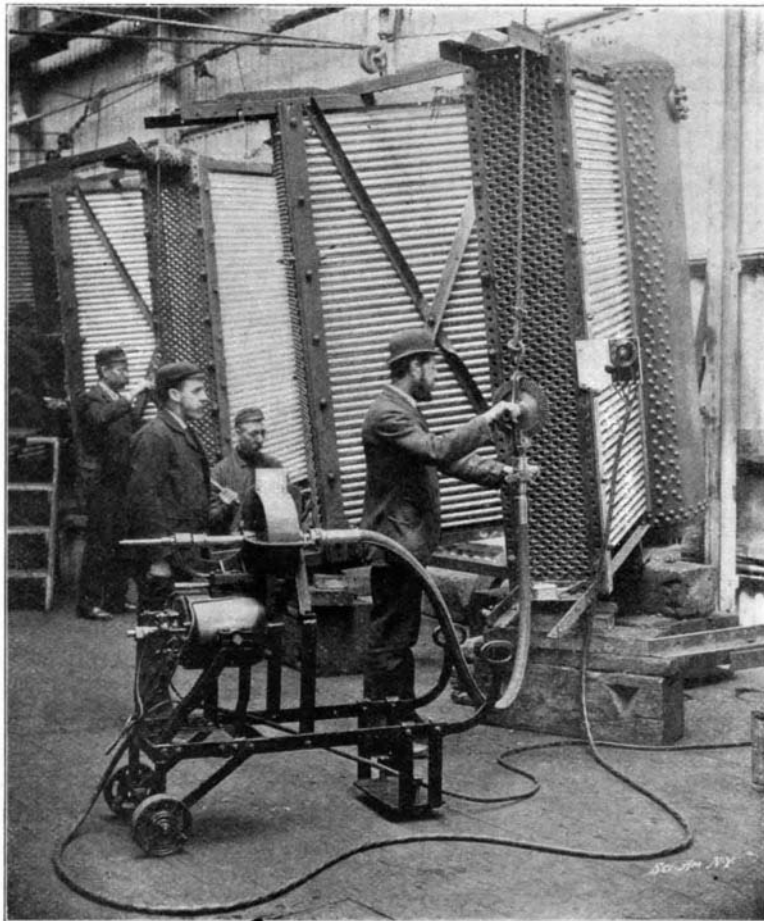
The accompanying design will comprehensively illustrate the principle of the Yarrow boiler. The upper or feed drum extends the full length from back to front. The tubes are expanded directly into this drum in two groups, one on each side. The lower ends of the

rod at each end, the upper extremities of which met this, forming, together with a rocking arm, a triangle, the apex of which served as a pointer upon a graduated scale placed behind it. A light cord with a small elongated bob attached to one end was placed in one of the tubes and the other end was suspended from one end of the rocking arm. This bob was grooved on its external surface. By means of this bob a comparative record was obtained of the rapidity of the flow of water, or water and steam in the pipes.

When everything was cold the indicator was deflected in the manner shown in the first illustration, the pointer standing at 45 or zero. One burner was then ignited and played upon the up tube, but the current thus set up was too intermittent in character to enable any useful data to be obtained. A second burner was then applied, and the bob was pulled down by the circulation until the pointer stood at 12; when the third lamp was brought into contact with the tube, the rocking arm was still more deflected until the indicator stood at 5—the maximum recorded by the current when heat was applied to the up tube only.

One of the Bunsen burners on the down tube was then brought into action and the pointer immediately traveled farther along the scale and stopped at the point 10; moved to point 15 when the second lamp was lit; and when the third lamp was brought into contact with the down tube, it reached its maximum point 20. At this juncture all six lamps were burning, three playing on the up and down tubes respectively. It must be clearly understood that the scope of this experiment was not to demonstrate the absolute rapidity of flow in feet per minute, but was simply a comparative test, and the object lesson clearly showed that application of heat to the down tube considerably increases circulation.

In another test, however, in order to substantiate conclusively Mr. Yarrow's contentions on this vital



EXPANDING THE ENDS OF TUBES INTO DRUMS WITH ELECTRICAL EXPANDER.

tubes are similarly expanded into the smaller lower drum at each corner. The lower drums it will be noticed are not circular, but semicircular, with the flat side uppermost to receive the tubes just below the fire level. The fire is between the two lower drums.

Circulation is accomplished in an ingenious manner, which insures the boiler being compact and economical. There are no down pipes to carry the water from the upper to the lower drums. In the earliest types of Yarrow boiler they were included, but the inventor in the course of some experiments discovered that they could be dispensed with altogether, and instead the water be carried from the feed water drum to those below, by the tubes nearest the outer casing of the boiler, which are played upon by the coldest gases of the furnace.

The question as to whether more efficient circulation can be obtained with boilers equipped with the external downcomers, than with steam generating tubes themselves, has been one of animated controversy among engineers. Mr. Yarrow himself is a firm advocate of the utilization of the steam generating tubes being used for this purpose. In order to support this theory, he carried out a series of experiments with an apparatus specially devised for the purpose before a number of the leading marine engineers in Great Britain, and we are enabled to reproduce herewith a number of photographs in which he clearly demonstrated his theory.

The initial experiments were carried out with the apparatus represented in one of our illustrations. It consists of two parallel glass tubes placed vertically. The lower ends of these tubes were joined together by a copper bend, while the other ends terminated in a drum. Three Bunsen burners were arranged beside each tube, and so arranged that they could be brought to bear upon any part of the tube as desired. An indicator was placed above the drum. This consisted of a rocking arm pivoted in the center, with a light

point, the apparatus was devised and equipped with a special recorder to illustrate the absolute rapidity of the flow. In the down tube, a screw of which the pitch was known, was suspended by a spindle at the upper end, and above the receiver drum was a worm which actuated a wormwheel connected to the pointer or counter to ascertain the speed of the current. When two Bunsen burners were playing upon the up tube the propeller registered a speed of 28 feet per minute, and by the addition of the third burner, the velocity was increased by 8 feet to 36 feet per minute. When one lamp was brought to bear upon the down tube the velocity was further augmented to 42 feet; 49 feet per minute with three lamps burning upon the up tube and two on the down tube; and a maximum of 55 feet when three burners were playing on each tube. It will thus be observed that the application of a degree of heat to the down tubes equivalent to that applied to the up tubes resulted in an increased flow of 19 feet per minute—approximately 50 per cent.

The third demonstration with the apparatus was of special interest relative to the arrangement of the tubes at a slight upward angle from the horizontal. The tubes leading to the receiving drum were in this instance bent sideways, thus reducing the vertical extension. In this experiment the heat brought to bear upon the tubes was not the same, as smaller burners were brought into contact with the down tube than those on the up tube, but nevertheless an appreciable increase in the rapidity of flow was obtained. There was one very important feature prominently apparent in the course of this experiment. The bubbles of steam generated in the down tube disappeared, a peculiarity considered due to the greater pressure in the lower part of the pipe.

In a fourth experiment another test in the same direction was made, though the arrangement of the tubes was somewhat different, approximating as far as possible to the general arrangement of the tubes