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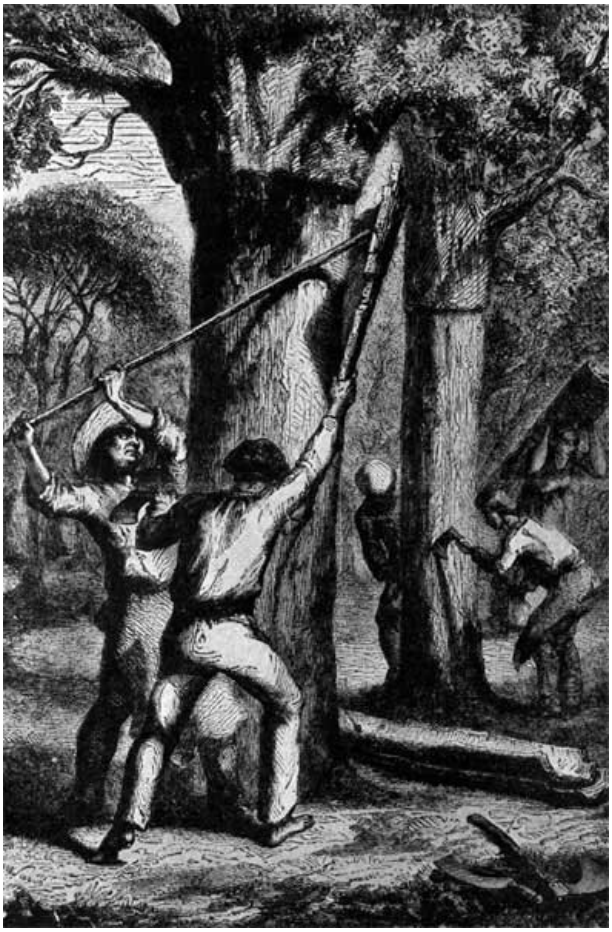

CORK:
Its Origin and Industrial Uses

BY

GILBERT E. STECHER

Illustrated

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PREFACE

[iii]

THIS monograph is not an attempt to put before the reading public a scientific exposition of the merits and qualities of the Quercus Suber or Quercus Liber (Linnæus), and carry it up into the heights of learning where none but the learned may go; but to set forth in as concise a manner as possible, the plain story of the corkwood stopper so well known to all. The corkwood as seen in the stopper and in many other articles of trade, has long been of service to man, and remained unnoticed in journals of science, but for a word here and there—and in trying to acquaint myself with its generalities, found it most difficult to get even these. This rather impressed me as being singular, a material so largely used and so little to its credit, in literature, that I pressed my investigations only to find that the farther I searched the less I found.

The few facts gleaned were of interest, and it occurred to me to put them together in some readable form, for future reference. But as I reflected upon the unsuccessful attempt to get information, which was made in behalf of my studies, I promptly decided to go into the subject deep enough to cover all the facts and the result is this monograph—Quercus Suber—

[iv]

It is presented with the hope that it will help others who seek a knowledge of corkwood and is

only intended as a résumé of a very interesting subject. I have endeavored to give credit to those to whom it is due and offer my results as a tribute to a material that stands in a class worthy of the scientists' as well as the commercialists' esteem.

G. E. STECHER.

June 15, 1914.

CONTENTS

[v]

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[3]

CORK:

Its Origin and Industrial Uses

QUERCUS SUBER—

"Cork"

THE material of which this monograph treats has become of double interest because of its shrouded mystery, which has never been pierced to the extent of giving the world a complete and comprehensive story. The mysticism does not encompass its utility and general uses nor its native land, as these are well known, but is more associated with its character, composition and chemical makeup.

Its uses may be traced far back into the misty past that is dim to us, but from the faint scroll of history looms up in the mind's eye as an epoch that we may have been glad to know, and although the references are few, by carefully analyzing them we may glean somewhat of its lineage.

[4]

The arcana attending it have been revealed to a few, who no doubt, through curiosity, have endeavored to penetrate its obscurity, but unfortunately have not written extensively upon the subject, instead leaving a meager memorandum of their findings. The years of its use have given very little knowledge of it to us, the reason perhaps being the lack of competition and therefore no necessity for a close scrutiny to find additional qualities to recommend it above others. And an

additional mystery is that it has been in use for so many years and so little said about it. Its latent qualities have mystified those who have handled it for years, and from them we can learn very little; so it will be of interest to peruse practically all that has been written, incorporated in this treatise, with the addition of the latest investigations upon the subject. To present this in a form which will give credit to the small but authoritative references and place them in their proper order, together with other recent data, was no small task, and in presenting the total matter in concise style meant the weeding out of all extraneous language or superfluous description.

In considering this material, it may be well to start with a few precursory remarks as to the etymology of the words by which it has been designated in the past and is now known, as by so doing it will convey a better understanding of the material to follow.

Quercus Liber (Linnæus) [5]

The above name is the true one of the material under discussion and is derived from the Latin. Quercus; Italian or esculent oak sacred to Jupiter. Liber; binding or surrounding; hence surrounding of the oak or bark of the oak, sacred to Jupiter.

"Quercus Suber"

This, its definite name, undoubtedly conveyed some particular meaning to the ancients, but research fails to reveal any definition of the word "Suber."[1] "The word is so far a puzzle to philologists. Forcellini in his great dictionary of Latin says that it is perhaps connected with the Greek word (συφαρ = suphar), which means 'an old wrinkled skin, as, for instance, the cast-off skin of a snake.' If this derivation be sound, the Romans, in using the word, thought at the outset primarily of the rough bark of the tree and then of the tree as a whole. Forcellini quotes also an opinion of Isidorus Hispalensis upon the longer form of 'Suber,' i.e., Suberies, to the effect that this form is derived from 'sus' (swine) and 'edo' (eat) because swine eat the acorns. But this is a purely popular etymology. I find too that Scaliger derived it from the verb 'Subio' 'to come up from below' because cork will not stay down in water. Vaniçek, in his Etymologisches Wörterbuch, classes 'Suber' among the dunkel words, and in the new and most elaborate [6] Historische Grammatic of Stolz the word is not mentioned at all in the treatment of roots. Even Otto Keller in his work on Etymologies has nothing to say about it."

"CORK" [7]

This name is as much of a mystery as the word "Suber" and its origin can only be guesswork. In the opinion of the writer it is the broadening of the first syllable of the word "Quercus" and has no bearing upon its usage, composition or lineage. Some dictionaries give other derivations, such as the mutilation of the Spanish "Corcho" or the French "Calk," and others that it is taken from the Latin Cortex,[2] meaning the outer shell or husk, the external part, but they do not present any convincing argument.

The meaning of the word "cork" as applied to-day is derived from the Arabic "Kalafa," to stop the seams of ships; the Latin "Stipo," to suppress; the French, "Calfeutrer," to stop. But these do not bear upon the origin of the word "cork," as in all probability the word was coined independent of these sources, but as we apply the word to a definite act, that of "stopping," the definition as given above is applicable, although the proper name would be "stopper," regardless of what material it is made. It is therefore plain that the word "cork" is a Latin phonetic abbreviation, for it appears to be the only logical root for the word.

The cork tree is called "Alcornoque" in Castilian language; Surn in Castalan; Sobreiro, Gallician; [8] Suvi y Sioure in provincialism; Chêne Liège in French; Keonge fernam or only fernam, in Argeline; Kork-baum or Korkeiche in German; and, as before stated, cork in English. [3]

ORIGIN [9]

The study of its origin leads us to that romantic part of the world bordering the Mediterranean Sea from which we have already received so much in all branches. The cork-producing country practically covering the whole of Portugal sweeping toward the East through the southern districts known as Andalusia and Estremadura, thence northeast, embracing thousands of acres of forests in Catalonia. Spain and Portugal dividing honors among the nations in the annual yield of raw material, with perhaps the advantage leaning slightly to the latter.[4] This being partly due

to increased area, no doubt, as the geographical situation is the same but with the irrigation feature slightly in favor of Spain, as through the corkwood country flows the Guadalquivir River in addition to the three which also pass through Portugal, consisting of the Douro, Tagus and Guadiana in the west, and the Ebro in the Gerona district.

Tunis and Algeria[5] rank next in importance with Southern France, including Corsica following closely. Italy (Tuscany) too with the help of Sardinia and Sicily continuing to be quite a factor in meeting the demand for the crude material, while across the Strait of Gibraltar the sun-scorched [10]
forests of Morocco at El-araish are as yet undeveloped, although rapidly being pressed into service.

The geographical formation of Portugal is extremely favorable for the rearing of cork trees, every evidence of this characteristic being well marked by the densely thick groups of cork trees to be seen in certain regions, especially in the Valley of the Tagus and the Sierra de Portalegre provinces of Alemtejo and Algarve, which are the chief bearing centers of this country,[6] the area devoted to their cultivation being approximately 366,000 hectares.

In Spain it is found in the Provinces of Gerona, Caceres, Andalusia, Huelvas, Seville, Cadiz, Ciudad Real, Malaga, Cordoba and Toledo in the order named.

According to a calculation made by the administration of forests the extent of cork forests in Spain is about 255,000 hectares,[7] viz. 80,000 in the Province of Gerona, 54,000 in Huelvas, 32,500 in Caceres, 28,000 in Seville, 20,000 in Cadiz, 11,500 in Ciudad Real and 9500 in Cordoba. The remainder is distributed between ten other provinces. [8]

In the Province of Gerona is included a large territory stretching northward towards the Pyrenees to the Valley of the Muge and Ter. In France, according to Consul Goldschmidt of Nantes, the [11]
cork-producing territory is divided as follows: Var, 280 acres; Lot-et-Garonne, 27 acres; Landes, 32 acres; Corsica, 40 acres; making about 379 acres in all.

This résumé of the cork-producing countries of Europe will convey some idea of the extent of the forests, and will also show the climate sort by the tree; for it is proven that it flourishes best in an altitude of 1600 to 3000 feet, in an average mean temperature of 55° Fahrenheit; and at points beyond 45° north latitude its successful propagation is doubtful.

The Mediterranean Basin is particularly suitable for the rearing of corkwood, and although many attempts have been made to transplant the seed, the results have proven fatal.

Notable among these attempts being the American ambition to introduce the tree in the United States. Portuguese acorns were brought to Wayne County, Mississippi, and planted in 1859; the result, as far as the growth was concerned, was splendid; but after a wait of eleven years, the final crop was not a commercial success. Another attempt was made in 1872, in southern California, but with no better outcome than the first, in which some of the trees attained to a height of thirteen feet (3.965 meters) and the stem, to a diameter of eleven inches (2.794 decimeters), including the cork, which attained a thickness of one inch (2.540 centimeters). This evidently rapid growth would infer that the American zone was all that could be desired for the [12]
favorable rearing of cork trees; but strange to say this was not the case. Although the growth of the tree had been exceptionally strong, the quality of its salient product turned out to be of an inferior character. The cork generally improves with the age of the tree; in this instance, however, even after years of maturity the cork harvest did not improve to any great extent, and indeed is still of a second-rate quality.[9] And Consul S. C. Reat, writing from Tamsui, recently reports the efforts of the Japanese Government to plant cork trees in Formosa and the Ogasawara Isles, in the endeavor to supply small corks to the Japanese merchants, the result of which, is yet to be learned.

The Tree and Growth

Many botanists consider the cork oak of Europe as belonging to two species, one chiefly characterized by annual fructification and the persistence of the leaves for two or three years (Quercus Suber, Linnæus); the other by biennial fructification and annual persistence of the leaves (Quercus Occidentalis, Gay). [10]

In the French departments of the Landes and Gironde the Quercus Occidentalis forms extensive woods, as also in Spain, Algeria and in some parts of Italy, while the Quercus Suber is a native of the Atlantic side of France and Portugal, where this tree grows to the greatest perfection, and to [13]
which countries we are indebted for the major part of our supply. The cork tree bears a general resemblance to the broad-leaved kind of (Quercus Ilex, Holm) or evergreen oak, of which species some authors consider it only a variety; but when full grown it forms a much handsomer tree.

“In the localities to the north the cork is better than those exposed to the south. It grows and develops in ground of very little depth, and sometimes in ground, in appearance very stony. It is seldom found in calcareous soil, preferring always a soil of feldspar, and like the chestnut flourishes best in a sandy one.” [11]

The cork-oak attains a height of from six to eighteen meters, at times reaching fifty meters[12] and measures as much as 1.22 meters in diameter.[13] Its branches are covered with small evergreen leaves, which are rather spongy and velvety to the touch, have a glossy appearance and a saw-tooth edge, measuring about three to five centimeters[14] long and one and one-half to two wide. The roots are strong and spread considerably, and frequently are to be seen on the surface of the [14]

ground. The flowers or blossoms make their appearance in May; the fruit ripens in the fall or winter, from September to January, and falling from the tree as soon as ripe. Three qualities of acorns are to be observed according to their time of ripening and are called, “brevas primerizas de San Miguel,” which ripen in September; the second or middling “Martinencas,” which ripen in October and November; and finally the “tardias Ó palo-Meras,” which ripen in December and January. These acorns form one of the forest’s chief sources of revenue, since fed to swine, they give a peculiarly piquant flavor to the meat, Spanish mountain hams being noted for their excellence. [15]

In the following paragraphs I will quote principally from Consul Schenck’s Report, 1890, relating to the growing and procuring of the bark for shipment, with interpolated sentences and slight changes, made necessary by other data at hand. The most common practice is to cultivate this plant by sowing, which is frequently done, above all, in ground somewhat manured, making alternate furrows with vines. Up to their twentieth or twenty-fifth year the ground is cultivated as if it were a vineyard, rooting up at that age the vines on account of producing less fruit, and also on account of the cork trees being pretty well grown up and no longer requiring the shelter of the vines. At the end of even one year it is difficult to transplant the cork tree on account of the [15] length of the roots, principally the central one, and if the trees are put out with the intention of transplanting they are generally sewn in a false ground bottom made artificially at a certain depth with layers of stones or bricks. French silviculturists recommend about 110 to 120 trees to the hectare (2.471 acres).

The cork tree gives but little shade, which contributes greatly in causing the soil to become dry. To avoid all these inconveniences, which are highly unfavorable to the good production of cork, it is requisite that young plants grow up with sufficient foliage, so that the branches touch each other, and even overreach, till they are about twenty-five years old. It may be convenient, if there is not sufficient foliage from the cork trees themselves, to introduce secondary species, such as the elm tree, ash and pine, known as (pi meli), these being depended upon to supply the requisite coolness and manure to the ground. If the soil is poor, the cork is thin but of fine quality and very appropriate to make the best stoppers. If, on the contrary, it is rich, the cork is thick but spongy. Consequently it is requisite to treat the cork tree in such a manner that whilst the cork grows thick it will at the same time be fine in texture. This is of course an agricultural problem and may differ from year to year in the necessary details.

DISEASES [16]

The cork tree has in no wise escaped from disease and infections; on the contrary it has its full allotted share which worries the growers more than the acquiring of a perfect texture, and unless great care is taken will greatly reduce the value of a crop. The larva of the Coroebus undatus (corch) attacks the interior of the cork, penetrating frequently into the tree itself, which causes an undervaluation in the quality of the cork, and, moreover, these perforations unite so closely and in such a manner even in the trunk of the tree that in peeling off the cork, part of the skin of the trunk itself comes off, causing much damage to the tree.

The larva of the Cerambyx cerdo, as well as the ant, Formica rufa L. hormigas, destroys the fine cork with their numerous borings and galleries. Jaspered (Jasperado) is the name by which is known one of the defects of the cork which reduces it greatly in value and as far as can be learned comes from the tree itself. The porosity of cork is greatly increased by the presence of cork-meal, resulting from the disintegration of the Sclerenchyma, or stone cells, which penetrate the cork fiber and falling to a powder facilitate the entrance of infection.[16]

STRIPPING [17]

[17]The corkwood or cork of commerce is the external part or “periderm” of the cork-oak; and when it has attained a diameter of approximately 12.7 centimeters or the tree measures forty centimeters in circumference according to the Spanish governmental regulations, which the tree does usually by the time it is twenty years old, the bark may be removed. The stripping generally takes place during July and August, and it is a process which demands skill and care, if injury to the bark is to be avoided. In Algeria the French strippers sometimes use crescent-shaped saws, but under the usual Spanish method a hatchet, with a long handle, is the only implement employed. The bark is cut clear through, around the base of the tree, and a similar incision is made around the trunk, just below the spring of the main branches; the two incisions are then connected by one or two longitudinal cuts, following, so far as possible, the deepest of the natural cracks in the bark. Inserting the wedge-shaped handle, the tree’s covering is then pried off. The larger branches are stripped in the same manner, yielding, generally, a finer grade of cork than that of the trunk. The thickness of the bark ranges from 1.27 centimeters to 6.85 centimeters,

while the yield also varies greatly from twenty to 75 kilograms[18] per tree, depending upon its size and age. After the first stripping the tree is left in the juvenescent state to regenerate, and great care must be taken in the stripping not to injure the inner skin or epidermis at any stage of the process, for the life of the tree depends upon its proper preservation, for if injured at any point, growth there ceases and the spot remains forever afterward scarred and uncovered. It is also necessary to avoid stripping during the prevalence of a sirocco, which would dry the inner skin too rapidly and therefore exclude all further formation of cork. [18]

The Capgrand-Mothe system, which, as known, consists of dressing the trunk with the same cork just removed, and leaving it so dressed for a couple of months, has not met with approval, as being impracticable on a large scale. After the stripping, the phellogen, the seat of the growing processes, undertakes at once the formation of a new covering of finer texture, and each year this, the real skin, with its life-giving sap, forms two layers of cells, one within, increasing the diameter of the trunk, the other without, adding thickness to the sheathing of bark. After eight or ten years this sheathing is removed, and while more valuable than the first stripping, it is not as fine in quality as that of the third and subsequent strippings, which follow at regular intervals of about nine years. At the age of about forty years the oak begins to yield its best bark, continuing productive as a rule for almost a century.[19] The cork of the first barking is called Corcho-Bornio, Borniza or virgin, and is so coarse, rough, and dense in texture that it is of little commercial value. The second barking is called “pelas,” or secondary cork, and this and subsequent barkings constitute the cork of commerce. As the bark is removed it is gathered up in piles (rusque) and left for a few days to dry. Having been weighed, it is next carried either in wagons or on the backs of burros to the boiling station, where it is stacked and allowed to season for a few weeks. It is then ready for the boiling process. The outside of the bark in its natural state is, as may well be imagined, rough and woody, owing to exposure to the weather. After boiling this useless outer coating is readily scraped off, thereby reducing the weight of the material almost twenty per cent. The boiling process also serves to remove the tannic acid, increases the volume and elasticity of the bark, renders it soft and pliable and flattens it out for convenient packing. After being roughly sorted as to quality and thickness, the bark is then ready for its first long journey, and as the forests are generally located in hilly or even mountainous country, the faithful burro must again be called into service. Truly the Spaniards’ best friend, though the worst treated of all, these patient little animals present a most grotesque appearance when loaded from head to hind quarters with a huge mass of the light bark. Down from the hills they go in trains of thirty, forty or even a hundred, threading the rocky bridle paths in single file and wending their way through the narrow streets of quaint villages where traces of Moorish occupancy may still be seen, to the nearest railway station. The corkwood is there freighted to the various sea-port warehouses in Spain and Portugal, Seville, Spain being perhaps the largest depository and user of raw material.[20] This historic city, situated on the banks of the Guadalquivir, presents a very animated sight in the summer months, and plays a very important part in the cork industry, for besides the numerous warehouses for storing and shipping there are factories for the manipulation of cork and its conversion into the many useful forms in which it has proven of value. Before shipping, the bales are opened, the edges of the bark trimmed and the bark then sorted into the various grades of quality and thickness again. The importance of this last mentioned operation cannot be overemphasized, as the whole problem of the successful and economical manufacture of corks center about it. After sorting it is ready to be rebaled for shipment, this generally being done by placing the large, flat pieces called planks or tables, at the bottom of the bales, and above them the small pieces which are covered in turn with larger sections; then the whole mass being subjected to pressure to render it compact, afterward being bound up securely with steel hoops or wires. Each bale carefully marked indicating the grade or quality, loaded directly into ocean-going steamers and shipped to the ports of the world. [19] [20] [21]

From this meager description we at least can learn what “corkwood” is, the limited sphere of its growth, the constant care necessary to insure a successful harvest or gathering, the peculiarities of the tree, its longevity and the general mode of preparing the bark for shipment; the narration in no wise doing justice to this most interesting material, in its natural state, for its growing is a fascinating tale in itself; but for the purpose of this writing the foregoing has been deemed sufficient to convey an understanding of it.

As we have now seen how this wonderful material grows, its haunts and dwellings, we will look at it more closely and see what it really is, how this particular formation comes about and its peculiarities.

BOTANY AND CHEMISTRY [22]

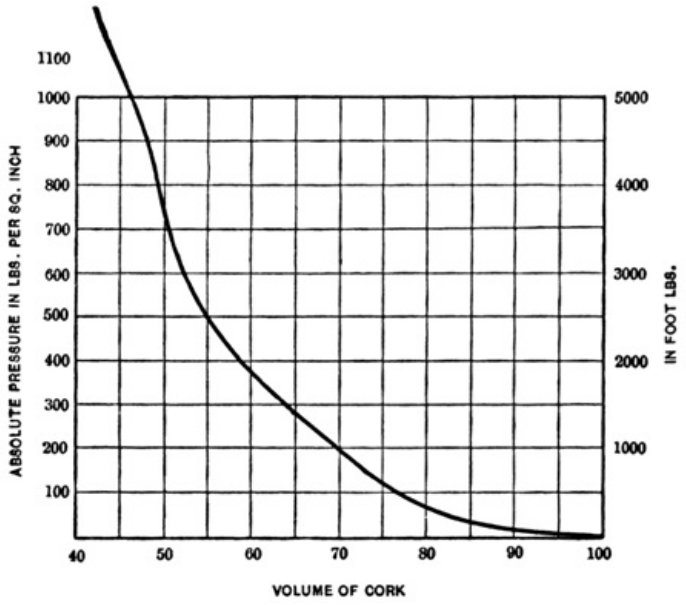
IN considering “cork” for the purpose of ascertaining its characteristics, texture and composition we will, instead of analyzing the material after it has reached the market, look at it from the standpoint of botany and learn of its formation upon the tree, from which it is procured. It appears that the word “cork”[21] in botany signifies a growth peculiar to all plants and pertaining to none in particular, being described as “a peculiar tissue in the higher plants forming the division of the bark (which name is sometimes restricted to the dead tissues lying outside the cork); consisting of closely packed air-cells nearly impervious to air and water and

protects the underlying tissues."[22] Again, "It is produced by the activity and division of certain merismatic cells known as phellogen or cork cambium which are situated immediately within the epidermal covering of the young growth. As the cork cells grow older, their protoplasmic contents disappear and are replaced by air. In order that this formation may be clearly understood, I will quote from a paragraph entitled "Cork and Epidermal Formations Produced by It" contained in "A Text Book on Botany," by Sacks.

"When succulent organs of the higher plants, no longer in the bud condition, are injured, the [23]
wound generally becomes closed up by cork tissue, i.e., new cells arise near the wounded surface by repeated division of those which are yet sound, and these forming a firm skin separate the inner tissue from the outer injured layers of cells. The walls of this tissue offer the strongest resistance to the most various agencies, similar to the cuticular layers of the epidermis in their physical behavior, flexible and elastic, permeable only with difficulty by air and water, they for the most part soon lose their contents and become filled with air. They are arranged in rows lying at right angles to the surface or parallelopipedal form, and form a close tissue without intercellular spaces. These are the general distinguishing features of cork tissue. It is formed not only on wounded surfaces, but arises in much greater mass where succulent organs require an effectual protection (e.g., potato tubers) or where the epidermis is unable to keep up with the increase of circumference where growth in thickness continues for a long period. In these cases the cork tissue is formed even before the destruction of the epidermis, and when this splits under the action of the weather and falls off, the new envelope formed by the cork is already present. The cork tissue is the result of repeated bipartitions of the cells by partition walls, rarely in the epidermis cells themselves, more often in the subjacent tissue. The partition walls lie parallel to [24]
the surface of the organ, divisions also taking place in a vertical direction, by which the number of the rows of cells is increased. From the two newly formed thin-walled cells of each radial row one remains thin walled and rich in protoplasm, and in a condition capable of division; the other becomes transformed into a permanent cork cell. Thus arises, usually parallel to the surface of the organ, a layer of cells capable of division, which continues to form new cork cells, the cork cambium or layer of phellogen. In general this is the innermost layer of the whole cork tissue, so that the production of cork advances outwardly and new layers of cork are constantly formed out of the phellogen on the inner surface of those already in existence. When in this manner a continuous layer of cork arises, steadily increasing from the inside, it is termed "periderm." As the epidermis is at first replaced by the periderm, so in turn is this replaced by cork (the dead tissue). The development and configuration of the cork cells may change periodically during the formation of periderm. Alternate layers of narrow, thick-walled and broad, thin-walled cork cells are formed; the periderm then appearing stratified, like wood, showing annual rings as in the periderm of the Quercus Suber, Betula Alba, etc."

Mr. Sacks, as a botanist, has clearly set forth the explanation of the formation of the periderm of the Quercus Suber in the foregoing, and although the story of the life producing this formation would be an acceptable sequel to this explanation, it would in no wise assist in the ultimate [25]
findings, and therefore it is dispensed with. Mr. William Anderson, in a paper read at the Royal Institution of Great Britain in 1886, has the following to say on cork formation, which is very interesting: "In considering the properties of most substances, our search for the cause of their properties is baffled by our imperfect powers and the feeble instruments we possess for investigating molecular structure. With cork, happily, this is not the case; an examination of its structure is easy and perfectly explains the cause of its peculiar and valuable properties. All plants are built up of minute cells of various forms and dimensions. Their walls or sides are composed chiefly of a substance called cellulose, frequently associated with lignine, or woody matter, and with cork, which last is a nitrogenous substance found in many portions of plants, but is especially developed in the outer cork of exogenous trees, that is, belonging to an order, the stems of which grow by the addition of layers of fresh cellulose tissue outside the woody part and inside the bark. Between the bark and the wood is interposed a thin fibrous layer, which in some trees is very much developed. The corky part of the bark which is outside is composed of closed cells, exclusively, so built together that no connection of a tubular nature runs up and down the tree, although horizontal passages radiating toward the woody parts of the tree are numerous. In [26]
the woody part of the tree, on the contrary, and in the inner bark, vertical passages or tubes exist, while a connection is kept up with the pith of the tree by means of medullary rays. In one species of tree, known as the cork-oak, this is strongly developed." It appears that Mr. Anderson enlivened his lecture by microscopic projections, for he goes on to say: "First I project on the screen a microscopic section of the wood of the cork tree. It is taken in a horizontal plane, and I ask you to notice the diversity of the structure and especially the presence of large tubes or pipes. I next exhibit a section taken in the same plane of the corky portion of the bark. You see the whole substance is made up of minute many-sided cells about $1/750$ of an inch in diameter and about twice as long, the long way being disposed radically to the trunk. The walls of the cells are extremely thin and yet they are wonderfully impervious to liquids. Looked at by reflected light, bands of silvery light alternate with bands of comparative darkness, showing that the cells are built on end to end in regular order. The vertical section next exhibited shows a cross section of the cells like a minute honeycomb. In some specimens large crystals are found. These could not be distinguished from the detached elementary spindle-shaped cells, of which woody fiber is made up, were it not for the powerful means of analysis we have in polarized light. I need hardly explain that light passed through a Nicol's prism becomes polarized, that is to say, the vibrations [27]
of the luminiferous ether are all reduced to vibrations in one plane and consequently if a second prism be interposed and placed at right angles to the first, the light will be unable to get through; but if we introduce between the crossed Nicol a substance capable of turning the plane of vibration again, then a certain light will pass. I have now projected on the screen the feeble light

emerging from the crossed Nicol. I introduce the microscopic preparation of cork cells between them, and you see the crystals glowing with many colored lights on a dark ground. Minute though these cells are, they are very numerous and hard, and it is partly to them that is due the extraordinary rapidity with which cork blunts the cutting instruments used in shaping it." In his research or experimentations Mr. Anderson was most deeply impressed with the elasticity of cork, and has the following to say upon his findings: "It would seem difficult to discover any new properties in a substance so familiar as cork, and yet it possesses qualities which distinguish it from all other solid or liquid bodies, namely, its power of altering its volume in a very marked degree in consequence of change of pressure. All liquids and solids are capable of cubical compression or extension, but to a very small extent; thus water is reduced in volume by only .00005 part by the pressure of one atmosphere. Liquid carbonic acid yields to pressure much more than any other fluid, but still the rate is very small. Solid substances, with the exception of cork, offer equally obstinate resistance to change of bulk; even India rubber, which most people [28] would suppose capable of very considerable change of volume, we find it really very rigid. Metals, when subjected to pressure which exceed their elastic limits so that they are permanently deformed, as in forging or wire drawing, remain practically unchanged in volume per unit of weight. Not so with cork, its elasticity has not only a very considerable range, but it is very persistent. Thus in the better kind of corks used in bottling champagne and other effervescing wines, you are familiar with the extent to which the corks expand the instant they escape from the bottles. I have measured this expansion and find it to amount to an increase of volume of seventy-five per cent; even after the corks have been kept in a state of compression in the bottles for ten years.[23] When cork is subjected to pressure, either in one direction or from every direction, a certain amount of permanent deformation or permanent set takes place. This property is common to all solid elastic substances when strained beyond their elastic limits, but with cork the limits are comparatively low." To take advantage of the peculiar properties of cork in mechanical applications it is necessary to determine accurately the law of its resistance to compression, and for this purpose Mr. Anderson instituted a series of experiments of this kind. Into a strong iron vessel of five and one half gallons' capacity he introduced a quantity of cork [29] and filled the interstices with water, carefully getting out all the air. He then proceeded to pump in water until definite pressures up to one thousand pounds per square inch had been reached, and at every one hundred pounds the weight of the water pumped in was determined. In this way, after many repetitions, he obtained the decrease of volume due to any given increase of pressure. The observations have been plotted into the form of a curve which is discernible on the accompanying diagram.



The base line represents a cylinder containing one cubic foot of cork divided by the vertical lines into ten parts; the black horizontal lines, according to the scale on the left-hand side, represent the pressures in pounds per square inch which were necessary to compress the cork to the [30] corresponding volume. Thus to reduce the volume to one half, required a pressure of two hundred and fifty pounds per square inch. At sixteen hundred pounds per square inch the volume was reduced to forty-four per cent, the yielding then becoming very little, showing that the solid parts of the cells had come together and formed a solid, compact mass, thus corroborating Mr. Ogston's determination that the gaseous part of cork constitutes about fifty-three per cent of its bulk.

In further study it has been found that no matter what compression is used, providing there is no disintegration, the corkwood will retain just that slight spongy character that so marks its growth.

In analyzing this solid matter, Ure found by treating it with nitric acid the yielding was:

White fibrous matter (cellulose)	0.18 parts
Resin	14.72 "
Oxalic acid	16.00 "
Suberic acid	14.4 "

45.30 parts

Chevruel in an analysis of corkwood states that he found the following constitutents, but he does not give percentages:

Cerin, a soft fragrant resin.
Yellow and red coloring matter.
Quercitannic acid.
Gallic acid.
A brown nitrogenous substance. [31]
Salts of vegetable acids.
Calcium.
Water.
Suberic acid.
Suberin (cellulose).

I am inclined to think that Chevruel selected a poor grade of cork, full of stone cells and Jasperado, as his findings include much that would indicate that was the case.

In further defining the various substances which go to make up the body of corkwood the one that is most impressive is that substance that is peculiar to cork itself, the others being readily known, but suberic acid is the one of interest, and this is described by Fownes as a product of the oxidation of cork by nitric acid; is a white crystalline powder, sparingly soluble in cold water, fusible and volatile by heat, the chemical formula given being ($C_4H_{14}O_4$). Suberic acid is also described as a dibasic acid which forms small granular crystals very soluble in boiling water, alcohol and ether. It fuses at 300 degrees Fahrenheit and sublimes in acidular crystals. It is also produced when nitric acid acts on stearic, margaric or oleic acid. The chemical analysis is given as ($C_8H_{14}O_4$) and I am inclined to believe it is the truer one, as it is much later than Fownes'.

This suberic acid has been further broken up to ascertain its fundamental characteristics and it was found to partake of the two compounds suberone and suberate.

Suberone ($C_{14}H_{24}O_2$) being regarded as the ketone of suberic acid, an aromatic liquid compound [32] obtained when suberic acid is distilled with an excess of lime.[24] Also described as a colorless oil with an odor of peppermint and a boiling point of 179 to 181 degrees Centigrade, chemical formula, Suberone—Cycloheptanone—

$$\begin{array}{l} \quad CH_2 \,.\, CH_2 \,.\, CH_2 \\ \quad / \\ CO \\ \quad \backslash \\ \quad CH_2 \,.\, CH_2 \,.\, CH_2 \end{array}$$

Suberate ($C_8H_{12}M_2O_4$) is known as the salt of suberic acid having a metal cast,[25] and Suberin or cellulose[26]—is that portion remaining after nitration and is chemically expressed by the formula ($C_6H_{10}O_5$). Dr. Robert K. Duncan, Prof. of Industrial Chemistry in the University of Kansas, informs us that this material is the commonest of common things[27] and when dry, forms one third of all the vegetable matter in the world. This mysterious substance is the structural basis of the wood, but with all its prominence and use, we know nothing more about it than that which is expressed in the formula.

The presence of this cellulose is only a natural fact, as the greater part of plant life is cellulose; nor is the list of elements that go to make up the solid matter so strange and unaccountable, but [33] the quality that makes it a wonderful growth and so popular above its fellows is its lightness—this is its commendable feature and it is light indeed.

Ure puts the specific gravity at .24 and this is concurred in by Brisbane.

Test of Corkwood for Ascertaining the Possible Presence of an Essential Oil, by Steam Distillation

Two tests were made on this material to ascertain the presence of an essential oil. The first showed the presence of an oily film, resplendent in colorings, opalescent, variegated and beautiful, but odorless and of such small quantity that it may safely be said "No Oil."

The second proved the same as the first, and although the strong odor of cork or suberic acid was present, no oil appeared.

The results of these tests indicate that there is no essential oil in corkwood obtainable by steam distillation.

Test No. 1

4-4-1913.

A copper still, supported on two trunnions, fitted with a dome and goose-neck, which terminated in a tin coil (water cooled), and with a perforated bottom through which the steam passed, was used.

This measured two inches in diameter and two inches high, from the perforated plate to the top [34] of the pot, the dome being about one foot higher.

Into this still was placed 41 pounds of corkwood, as it comes from the cutters and punchers

(scrap pieces), no preliminary washing or preparing being done; this 41 pounds filled the pot or the still.

All things made tight, using an asbestos packing, the steam was turned on at 70 pounds and run for one hour.

Test No. 2

4-15-1913.

Same still used as in Test No. 1, thirty pounds of a clean, good grade Granulated Cork, of a fineness to pass a 1/16″ mesh, was put into the still—this half filling same.

Steam turned on at 70 pounds and run for one hour.

Tests made at A. J. Crombie & Co., Brooklyn, N. Y.

Anderson, Ure, Chevruel, Fownes, Watts, Brisbane, men of science; to these we are indebted for the little that is known of corkwood, and although perhaps much more could be said by elaboration, it will suffice to record the facts in this monograph for the purpose involved.

But to the data assembled may be added much in commentation, for the material becomes more interesting the more it is studied, and most naturally excites comparison with other materials and substitutes, as well as calling forth a discussion as to the dangers involved by its presence in the places where, by skill of hand and machinery, it is transformed into the many commercial forms, [35]
noted in this article. We comment upon its growth, which is truly wonderful and all-absorbing in its many interesting phases; it takes us to the romance of the East and the enchantment of the Moorish occupation; through which these forests of cork-producing trees passed and yet remain to furnish the present generation. We comment upon its lightness and buoyancy, due to the presence of air and excess of hydrogen, known to be lighter than air; and the small percentage of other matter which, being of less importance, make its other quality so renowned as to make it the most wonderful growth of its kind. Its imperviousness to water and other liquids have given us moments of reflection, upon this phenomenon, but now known to be because of the cellulose composing the cell walls and which, when the substance is under compression, practically is all that remains, except for the small quantity of resin, etc., to resist the passage of liquids or gases. But heretofore when these commentations have reached the burning point, its physical nature was entirely eliminated from the conjecturing and the important part neglected, that as the cork contained fifty-three per cent of air, heat of 450 degrees expands to the point of explosion, the contents of those cells nearest the surface, which giving up their oxygen feed the flames and in their passage help to disintegrate the cell walls and make them more easily ignited. Thus causing a rapid burning, flash fire which, in its fury, Pluto could not rival, only racing over the surface of [36]
the cork, burning but slightly, yet helped by other conditions, resulting in a fire destructive and fierce. This rapid burning leaves the outer surface of the cork charred and flaky and causes a discoloration beneath it attributed to the dissolving of the resins, etc. Of course where there is a large quantity of corkwood the extent of the burning must necessarily be greater and the depth of the char increased. But it appears that the first flash burning produces a sort of protection coat of carbon around the remaining unburned portions which a subsequent flame penetrates with difficulty. [28]

A simple experiment to show this depth of burning, and one that is easy to do, is the flash and flame test which was found of interest.

Two pieces of cork were taken, having the following measurements—8/16″ × 7/16″ × 11/16″—and the first piece held so that the flame of a gas jet would cause a flash over its surface; then the second piece is taken and held within the flame for a minute.

It will be found that the corkwood has expanded and the dimensions increased to the following:

Flash	Flame
8/16″ × 13/16″ × 11/16″	10/16″ × 14/16″ × 11/16″

showing the effects of the heat upon the tissue and contents of the cells. [37]

Now in scraping these samples clean of all char the dimensions will return to the following:

Flash	Flame
6/16″ × 11/16″ × 11/16″	8/16″ × 10/16″ × 11/16″

clearly setting forth the fact that the char is comparatively light in both cases, ranging from 1/8″ to 1/4″.

To this cause is ascribed the burnability of cork having by careful observation and experiment, extending over a period of two years, studied the results of numerous fires in premises where cork was being worked and also conducted heat applications on various grades of cork[29] resulting in the foregoing findings.[30] Thus it is found that cork contains sufficient air to supply any fire in it and precludes the necessity of free access to any outside supply which makes it a material worthy to be watched. To its many qualities of great service to man, giving him a material which from the ages past, till now, has proven of such value, must be added this one, no less important than others, which heretofore have been its commendable features. [38]

Rather than attend the “cork” through the many passages of commerce and manufacture, it is deemed propitious to deviate a little from a natural course, i.e., from the growing to manufacture

and rather advance to a knowledge of the many uses to which this material is put and its application to the innumerable arts, and then take up the manufacture.

USES AND APPLICATION

[39]

MR. H. G. GLASSPOOLE,[31] writing regarding the uses of cork by the ancients, states: "The cork-tree, and the application of its bark to useful purposes, was well known to the Egyptians, Greeks and Romans. The former used this material in the construction of the coffins for their dead. Theophrastus, the Greek philosopher, who wrote on botany four centuries B.C., mentions this tree among the oaks, under the name of 'Phellus' in Book Two of his 'Historia Plantarum,' and stated that it was a native of the Pyrenees, having a thick fleshy bark which must be stripped off every three years to prevent it from perishing. He adds that it was so light as never to sink in water, and on that account might be used for many purposes." It is the opinion of the writer that the attention of the ancients was undoubtedly called to this particular bark by its buoyancy, and as their fisheries were extensive its usefulness became readily apparent to float nets, etc., or to use even in the construction of their boats, and its sponginess and water-repellent properties not escaping their notice, it became a most likely material for stoppers of casks or amphorae as noted by Horace in Ode iii, 8: "Corticem adstrictum pice dimovebit amphorae." [40]
Pliny, in his "Natural History," XVI, 18, describes the tree under the name of Suber and relates everything said by Theophrastus of Phellus. From his account we learn that the Roman fishermen used it as floats to their nets and fishing tackle, and as buoys to their anchors. The use of these buoys in saving life appears to have been well known to the ancients, for Lucian, Epist. i, 17, mentions that when two men, one of whom had fallen into the sea, and another who jumped after to afford him assistance, both were saved by means of an anchor buoy. The use of this substance in assisting swimmers was not unknown to the Romans, for Plutarch in his Life of Camillus, who flourished in Rome 400 B.C., gives an account of its use by a messenger, sent to the Capitol, then besieged by the Gauls: "Pontius Cominius having dressed himself in mean attire under which he concealed some pieces of cork. He could not pass the river by the bridge, therefore took off his clothes, which he fastened upon his head, and having laid himself upon the pieces of cork swam over and reached the city." The use of cork as stoppers was entirely unknown to the Romans, but instances of its being employed may be seen in Cato's "De Re Rustica," Cap. 120, but this did not happen frequently or more would be said of it.

The convivial customs of those days had no connection with the bottle, glass bottles being of a much later invention. Instead of having champagne or hock to be liberated from the bottle by the [41]
corkscrew at their feasts, the guests filled their drinking cups of gold, silver, crystal or beechwood from a two-handled amphora, a kind of earthenware pitcher, in which their choice wines used to be kept. The mouths of these vessels were stopped with wood and covered with a mastic, composed of pitch, chalk and oil to prevent air spoiling the wine or evaporation taking place. Columella, who wrote one of the earliest works on agriculture, gives directions for preparing this cement.

The employment of cork for stoppers of bottles appears to have come into use about the seventeenth century, when glass bottles, of which no mention is made before the fifteenth century, began to be generally introduced. Before that period apothecaries used stoppers of wax, which were not only much more expensive but far more troublesome. In 1553, when C. Stephanus wrote his "Praedium Rusticum," cork stoppers appear to have been very little known in France, for he states that this material was used principally for soles in that country. It is not known when cork and corks began to be generally used, but in that very amusing and instructive diary of Mr. Samuel Pepys the following entry is found: "14 July 1666" After having written to the Duke of York for money for the fleet, I went down Thames Street and there agreed for four or five tons of cork to be sent to the fleet, being a new device to make barricados with instead of junts [42]
(old cable)," but he does not inform us how the material answered.[32]

In Evelyn's time (1664) cork was much used by old persons for linings to the soles of their shoes, whence the German name for it, "Pantoffelholtz" or slipper wood. The Venetian dames, Evelyn says, used it for their choppings or high-heeled shoes to make them appear taller than nature intended they should be. The poor of Spain lay planks of cork by their bedside to tread on instead of carpets. Sometimes they line the inside of their houses, built with stone, with this bark, which renders them very warm and corrects the moisture of the air. Loudon relates that in the celebrated convent at Cintra, Portugal, several articles of furniture are made of this tree. Virgin cork, or the first bark of the tree, is now very much used for window flower boxes, grottoes, etc., while the subsequent grades are used for small architectural and geognostic models. Cork was formerly employed in medicine even as far back as the time of Pliny, as he tells us that the bark of the cork tree, pulverized and taken in warm water, arrests hemorrhage at the mouth and nostrils, and the ashes of it taken in warm wine are highly extolled as a cure for spitting blood (see Pliny, "Nat. Hist." b. 124). In modern time powdered cork has been applied as a styptic and hung about the necks of nurses. It was thought to possess the power of stopping the secretion of milk. Burnt cork mixed with sugar of lead has been used as an application to piles. See Pereira's [43]
"Materia Medica."

Ground cork and India rubber formed the basis of Kamptulicon, the soft unresounding material

which covered the floor of the reading rooms of the British Museum." In further describing the many uses to which cork is applied, reference is made to the résumé of Mr. Good in "La Nature," which is incorporated with a few slight changes.

"The various applications of cork that we are now going to pass in review are worthy of description, as each of such applications has its *raison d'être* in one or more of the physical or chemical properties of cork bark. The manufacture of stoppers utilizes, in the first place, the impermeability of the bark, and, in the second, the latter's elasticity and imputrescibility, the remarkable lightness playing no rôle therein.

Before entering upon a study of the industrial applications of cork, in grouping them according to the various qualities of this product, we must return to the "male" cork, derived from the first barking of the tree. It has been said, because of its slight elasticity and numerous fissures, this product has but little commercial value, and shall have mentioned its principal application when we have stated that it is used in the decoration of parks and gardens. An endeavor has been made, but without success, to manufacture from it, mills for decorticating rice.

Certain parts of it can be converted into small stoppers. In the country where it is produced, it is [44] used for making water conduits, beehives and shelves on which to preserve objects from dampness. Mixed with a mortar of clay, the Kabyles use it for the walls of their dwellings, and also, in lieu of tiles, as a roofing material for their primitive habitations. It is used also by fishermen as floats for their nets.

These various applications were known to the Greeks and Romans, as shown by the works of Theophrastus and Pliny. The latter says of the cork-oak: "Nothing is utilized but its bark, which is very thick, and which is renewed in measure as it is removed. This bark is often used for the buoys of anchors and ships and of fishermen's nets, for the bungs of casks, and for women's winter foot gear. The Greeks called the cork-oak the 'bark tree'.... Cork bark is used as a covering for roofs." ("Hist. Nat.," xvi, 18.) As for the chips, they can be used as an isolating material to prevent freezing. Reduced to fragments, they furnish an excellent material for covering circus rings.

Let us return to "female" cork, which is much better adapted for being worked, and the grain of which is much more homogeneous. In this form cork bark constitutes a very bad conductor of heat and sound, and renders valuable services in the industries as a material for preventing the cooling of steam pipes and generators, and preventing the melting of ice in ice houses, or the heating of apparatus for producing cold.

It is the basis of a certain number of cements, and coatings for preventing the escape of heat, [45] which are applied to pipes, steam domes, hot water reservoirs, etc., and upon the composition of which we shall not dwell here. As for jacketing with cork alone; the first method consists in placing narrow strips of cork, whose edges touch each other, along steam pipes and cylinders, and fastening them by means of wire. A pipe thus jacketed is tangent internally to all these strips, and a section of the whole shows a circle inscribed in a polygon. In the second system thin strips of cork, fastened to canvas with India rubber cement, are wound around the pipe spirally. Finally, a third method of jacketing consists in the use of two half cylinders that exactly fit the exterior of the steam pipe. These cylinders, which can be made of any desired length, are made of powdered cork and starch, and are covered with a spirally wound strip of calico, which may be coated with tar or any suitable kind of paint. Each of these systems permits of obtaining a great saving in fuel.

As cork is likewise a very bad conductor of sound, it is successfully used on the doors of consulting rooms, and for making floors for hospitals, etc. Finally, in the manufacture of certain stringed instruments, it is used to prevent a loss of sound.

The slight density of cork, as compared with water, and its impermeability to liquids, make it an excellent float, capable not only of remaining on the surface, but also of supporting quite heavy [46] bodies thereon. We shall be content to mention the annular cork float used in night lamps, the square block in which bath thermometers are fixed, and the fisherman's dobber.

It is cork, too, that is used by preference in the manufacture of swimming and life-saving apparatus, to which inventors have devoted much thought. Very many vessels are provided with cork mattresses, which, in cases of shipwreck, render the greatest services. For example, the ship *Constant*, which sailed from Anvers for Brazil in 1845, was wrecked on the night of October 12th, at twelve miles from St. Thanes, but, thanks to the cork life preservers and mattresses that she had on board, not one of the crew was lost. As for life-saving buoys, properly so called, they consist of several cork planks which are given an annular form, and are provided with free ropes that are knotted here and there so that they may be easily grasped. From the stern of every vessel a buoy of this kind is suspended by a rope that may be at once cut when the cry of "A man overboard!" is heard. These buoys are usually covered with canvas coated with a paint that serves to preserve it. It is also possible to save a person who has fallen into the water at a certain distance from a wharf by means of floats. This device consists of a piece of rattan provided with points around which molten lead has been poured, and the whole is then surrounded with cork in chips, and covered externally with canvas and a network to protect the affair against wear. [47]

Fenders are canvas bags that are filled with cork and are placed along the sides of ships or along docks in order to deaden the shock in case of a collision. Such are the principal uses rendered to navigation by cork.

It has already been seen, by the extract from Pliny, that Roman ladies preserved their feet from cold by means of cork soles. Such a use of cork is still in vogue. In addition to these soles, which

are flat, there are others that have nothing to do with hygiene, and are merely connected with fashion. Such are the Louis Quatorze talonettes, designed to increase the stature without exaggerating the heel of the shoe. Female dancers wear linings of this kind in their shoes, which, as well known, have flat soles. A thin sheet of cork enclosed in the sole of the shoe would, we think, prove very useful to troops on a march during bad weather.

Cork is not only useful as an application to foot gear, but also renders great service in head gear, and, in the form of helmets, has preserved a large number of soldiers from death by sunstroke in tropical countries. We find it again, in the form of very thin sheets, in the interior of beaver hats, where it is used as a protection against heat. It is also used in these same hats as a sweat band, in lieu of leather. In ladies' toilets, the cork serves to make the carcasses of the birds that decorate their head gear. Manufacturers of dress trimmings use cork molds, which they cover [48] with silk or cotton, for ornamenting cloaks, etc. The lightness of cork can alone explain the great size of these balls, olives, etc., some of which are larger than a hen's egg.

A few years ago, a Paris house sold cork cravats, and we have recently seen, exposed in a show case, some children's costumes, in which the sailor's collar was of thin sheet cork decorated with colored designs. Although cork gowns have not yet appeared, we have waterproofs composed of thin sheet cork cemented between two pieces of silk. These cloaks have the advantage over those made of rubber of not allowing air to pass through them.

There is also a curious application of cork in the manufacture of a fabric that renders those who are clothed with it insubmergible.

We can mention but few of the many applications of cork, new ones of which are being discovered every day, so shall confine ourselves to recalling the services rendered by this valuable product in surgical prosthesis and for the use of naturalists, etc. In domestic life, it is used for bath steps, and for making rolling pins for crushing almonds without absorbing the oils as wood would do. Thin sheets of it are used for making fancy labels for wines. The ease with which it may be cut, turned and worked causes it to be employed in the manufacture of small objects, such as rural landscapes and the reproductions of monuments, some of which are [49] genuine works of art. We may likewise mention, among objects made of cork, cases of various forms for sending bottles by mail, spools for allowing of the cheap carriage of silk, the old-fashioned inkstand, the thick penholder for preventing writer's cramp, the cigar holder and many fancy objects that would take too long to enumerate. There is perhaps no calling that does not have to make more or less use of cork. Polishers of gold have used it from time immemorial, in the form of narrow strips, for rubbing their work with rouge. The wheels with which crystals are polished are faced with it, and watchmaker's lens mounted in cork, the lightness of which prevents the muscles of the face from tiring.

In the industries, driving pulleys are now beginning to be provided with cork in order to secure an adhesion of the belting. In carpenter shops these bands of cork are now advantageously replacing rubber ones for covering the pulleys over which the band saw runs. The stoppers of nursing bottles are now being replaced by hygienic ones of cork, which, being very cheap, can be changed as soon as the presence of ferments is suspected. Cork is likewise employed in the manufacture of children's toys; it serves, for example, for fixing the wig on dolls' heads. Is it necessary to recall the cork of pop-guns and pistols, and the cork battledores and shuttlecocks used for playing with indoors? These few data will serve to show that but few products are [50] capable of so many diverse applications as cork is; and the question may be asked whether it would be possible to substitute anything else for it, in case the supply should become exhausted.

The manufacture of stoppers and of the various objects that we have just enumerated furnishes a considerable quantity of chips, which along with the waste derived from the collecting of the material, and with old, second-hand corks, constitutes the crude material destined to supply certain important industries, which, for the sake of completeness, must be mentioned.

We have first the cork powder industry, which manufactures powders of various degrees of fineness. The coarsest powder is used for packing fragile objects, on account of its elasticity, coupled with its lightness, which permits of a great saving in freight charges.

The finest powder forms, "liegine" or "suberine," whose balsamic properties are well known to hygienists, and which may be used as a substitute for lycopodium, starch and fecula as an application to the skin of babes. Under the name of "zifa powder," an insect powder has been made composed of cork and phenol. Fire lighters have likewise been made from cork powder; but this and the last named application have not amounted to much.

We cannot enter into much detail in regard to the manufacture of linoleum, notwithstanding the interest that it presents. The manufacture began in Scotland, and is tending to settle in our own [51] country. Linoleum is made by intimately mixing cork powder with oxidized linseed oil. The paste thus prepared is spread over canvas if the intention is to manufacture carpets, but over paper if it is desired to make hangings. The color of linoleum, which is the same as that of cork, only a shade darker, can be enlivened by colored designs. When applied to damp walls, linoleum is capable of receiving oil paintings of a more stable nature than those executed upon wood, which warps, or upon other building materials, which crack, such as plaster, for example. It can also be used for decorated ceilings for public halls, cafes, etc.; and when such ceilings become black through smoke and dust, they can be washed.

As a carpet, linoleum renders flooring perfectly insonorous. It converts damp and unhealthy apartments into healthy and warm places of habitation. Used in kitchens and offices, it has the advantage of not being spotted by fatty matters. It has been generally adopted in our naval and

merchant ships, where the use of it has given a great setback to the oil cloth industry.

A new decorative product, “lino-burgau,” obtained by embossing linoleum, possesses the iridescent reflections of nacre, due to the application of colored varnish along with a bronzing of certain parts. Notwithstanding its expensive nature, we believe that there is a great future in store for it.

The manufacture of agglomerates of cork is becoming very widespread in France. We have [52] already mentioned the use of artificial cork for jacketing steam pipes, and we have stated that this product is obtained by mixing cork powder and starch under pressure. This dried paste can be given the most diverse forms, and be made of any thickness. Another substance, called brick paste, is obtained by mixing the coarsest cork powder with milk of lime, and, after compression and drying, constitutes, under the form of bricks and slabs, an excellent material for the construction of party walls, for covering damp walls and sloping roofs.

In the cellars of breweries, these bricks diminish the melting of the ice. In gunpowder works, they prevent the caking of the powder through dampness, and, in case of an explosion, their friability and lightness lessen the importance of the catastrophe. They are also used as a foundation for flooring in order to destroy its disagreeable sonorousness. In the spinning mills of Alsace and the west of France, they have given excellent results, both as regards their resistance to the passage of sound, heat and cold, and their cheapness.

Cork chips and waste, when distilled, furnish an illuminating gas that burns with more brilliancy than that made from coal, and does not, like the latter, give off sulphureous emanations that tarnish frames and other gilded objects. The city of Nerac was lighted with cork gas for a certain length of time, but the use of it had to be given up on account of the difficulty of storing the [53] chips, which, with but little weight, took up an enormous space. This gas, in view of its slight density and its purity, would prove an excellent one for the inflation of balloons.

Finally, cork parings and waste, properly carbonized, produce Spanish or cork black, one of the most beautiful and durable blacks known in painting.”

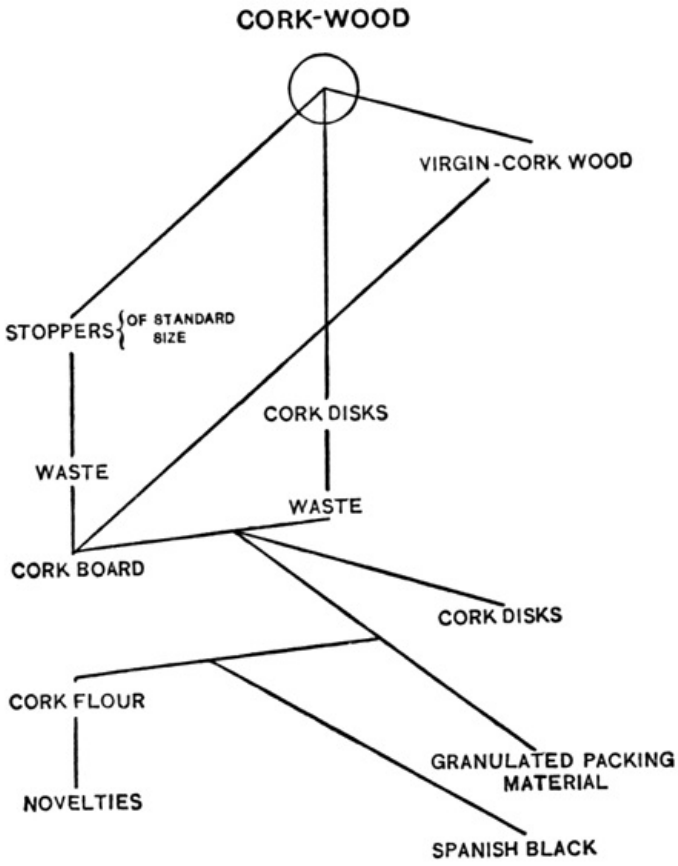
The recent uses for corkwood are, as a float in the carburetter of an automobile, the cork insert in the periphery of a pulley,[33] cork paper for cigarette tips, a wadding for shot-gun cartridges, cork-coated fabric for balloons, as a filling for automobile tires, as a disk in the non-refillable bottle, for the making of casks and barrels in which to store wine, and the ground cork wood for shipping fruit, etc. in, to prevent spoiling.

Substitutes

Of course, no matter what the substance, a substitute is always sought for, and this has been the case with cork, but with very unfruitful results. “A primitive material used for bottle stoppers consisted of the roots of liquorice; the spongy substance of another tree called ‘Spondies Lutea,’ which abounds throughout the marshy regions of South America and there called ‘Monbia,’ was also used in the same way, as also a product called ‘Myssa,’ which contains some of the elements [54] of cork.[34] Another substitute is mentioned in Henley’s “Twentieth Century Receipts” as follows: Wood pulp three parts; cornstarch pith one part; gelatin one part; glycerine one part; water four parts; 20 per cent solution formic aldehyde; and still another in the “Handyman’s ‘Inquire Within,’” by Haslock, called “Phellosene,” a French invention consisting of powdered cork mixed with a solution of nitro-cellulose in acetone: compressed and dried. The wood of Anona palustris growing in the West Indies, and called the alligator’s apple, is used by the negroes to stop their jugs and calabashes also, and a Mr. Brockedon invented a substitute as noted in “Knight’s Cyclopedia,” the core of which was cotton twisted into strands, wound with flax and the whole covered with India rubber. Cork’s competitor in buoyancy, “balsa wood,” is in no wise constituted to take its place, although 20 per cent lighter; as it is a fibrous growth and hygroscopic, requiring a coat of water-proofing solution before it can be used even for life-preservers; rubber, its close second, in the manufacture of stoppers is not to be compared with it, and although there have been many patent devices for sealing bottles, such as the porcelain stopper, crimped metal stoppers, etc., the cork stopper still reigns as the best of them all.

MANUFACTURE [55]

IN describing the manner and process of converting the corkwood into the various commercial forms, no attempt will be made to give a scientific exposition of all the details, as being inconsistent with the character of this monograph, nor will any other processes be described [56] than the ones in which the material being worked, is cork. This may exclude much of interest to the reader, but the intent of this little work is purely a corkwood exposition, and the desire to keep it so must prevail.



In taking up the processes of manipulation we naturally start from the beginning, but the beginning in this case has a peculiar significance as relating to the whole, for it is apparent to utilize corkwood to the fullest extent its qualities must be studied and the best, used first, so that the beginning of the corkwood industry is peculiar in this fact, that it takes the best part and leaves but scrap, which must be studied carefully to realize the value lost in the first process; therefore, in the manufacture of one article of corkwood it is necessary to make provision for the scrap created, and this is a characteristic of all such establishments.

Raw Stock

The baled cork, as received, is our first consideration, for its bulk, being out of all proportion to its value, attracts the attention at once.

As in all business where the raw stock is conveyed from a distance and there is a possibility of delay in shipments, a large stock must necessarily be kept on hand, and this feature is very pronounced in and about a “cork factory.” Great piles appear in the open or within large sheds, [57] covering much space, and sometimes in the factory itself.

This stock is carefully watched and care taken to keep it large enough to supply all needs for a long time as a shortage in raw material would not only mean no work, but the loss of business, due to the inability to supply first-grade material, for this is the prime factor, the various other grades being compelled to await a favorable market. Appended is a diagram that will give some idea of the utilization of corkwood.

The corkwood bale as received, measures as a general rule 2′ × 2′7″ × 4′ and is securely strapped with iron bands about one inch in width and a thickness of 1/16″ to 1/32″, and the weight depending upon the quality of corkwood ranging from 150 pounds to 200 pounds per bale.

Sorting

The first operation, that is, the first thing done with the corkwood, is the sorting. This is becoming more important as the uses of cork increase, as various grades can be used for so many particular things now, without the necessity of being called a by-product; but the principal divisions are: superfine, fine, common and coarse.

These of course are now extended to many classes, and is resulting in careful scrutiny of the shipments and stock, the sorter becoming an expert, and an increasing factor in the business. His knowledge not only including the grades of corkwood, but the uses to which the various grades [58] may be put so that waste is avoided and the full value gotten out of all.

Cork Stopper Making

After the sorting, the slabs are placed in steam boxes and subjected to a steam bath, which it is claimed softens the material and also prepares it for the scraper, who cleans and removes the dirt and callous or “raspa” accumulated in its mountain home. This scraping is done either by hand or machine, the handwork being done with a short handle, curved bladed knife called a “doladera,” raspador or raspeta: a workman being able to scrape from two to three metric quintals of cork in a day, or ten hours. The scraper machine being a vertical steel shaft carrying several knives placed at a very slight helix and making about 1400 revolutions per minute and will scrape from ten to twelve metric quintals[35] per day or ten hours. Cutting the slabs into strips or fillets (tiras ó’rebanadas) is the next step. These strips, the width of which is equal to the length of the cork to be cut, as the cutting is done across and not with the grain, were formerly cut by hand with a knife having a flat surface and curved edge called “cuchilla de rebanar,” but now replaced by the circular knife, which operates the same as a rip-saw. From here the strips go to the stopper-makers’ punches or blocking machines. This machine has a rotating tubular die with sharpened edges of the diameter of the cork to be cut, made to revolve about two thousand revolutions per minute, the operator having a foot lever attachment which permits him to thrust the die through the strips of cork as he holds it against a resisting piece parallel with the operating plane of the die. Thus, he can punch out many thousands of corks a day, the noise of the punches being a very characteristic sound in all such establishments. The operator, of course, must use care to avoid defective spots in the bark, and also to cut the corks out as closely together as possible so as to reduce waste to a minimum. For it is here that the cork manufacturer seems to lay his particular lament. If he could but make his corks the sizes most in demand, ship them and thereby do a business that would clearly figure up the year’s work, and perhaps keep a surplus on hand for unexpected orders. But this he cannot do, for almost every cork he cuts there is enough waste material to make three or four smaller sizes, and this he fain would discard if it were not for the possible profit there is in it; and consequently in almost every cork factory will be found a large surplus stock of all sizes, and the owner anxiously hoping that some one will take them off his hands. [59]

The stoppers which come from these machines are round with parallel sides. If tapered corks are desired, larger at the upper end than at the lower, the cylindrical or straight pieces must be passed through another machine which handles them deftly, holding them against the edge of another circular knife; seemingly motionless, the only outward indication of the speed with which the keen blade is revolving being a delicate shaving which curls upward for an instant, and then is drawn away by air suction to the waste bin, where this material is all collected and used in various, useful ways as will be shown later. In cutting the corks, although care is exercised, many will be imperfect and defective, and in order to utilize them they are cut into smaller sizes by men who sit at low tables and deftly handle the sharp-edged knife, which with one stroke reduces the cork to the size that it can fill, using a scale which is apparently standard with all cork dealers. [60]

The general standard of corks or stoppers, known as the United States standard, is as follows:

Scale Of Diameter Of Stoppers [61]

United States Standard, showing Diameter at Large End

No.	0	3/8	inch	No.	1	7/8	inch.
“	2	1/2	“	“	3	9/16	“
“	4	5/8	“	“	5	11/16	“
“	6	3/4	“	“	7	13/16	“
“	8	7/8	“	“	9	15/16	“
“	10	1	“	“	11	1 1/16	“
“	12	1 1/8	“	“	13	1 3/16	“
“	14	1 1/4	“	“	15	1 5/16	“
“	16	1 3/8	“	“	17	1 7/16	“
“	18	1 1/2	“	“	19	1 9/16	“
“	20	1 5/8	“	“	24	1 7/8	“
“	22	1 3/4	“	“	26	2	“

Length is generally designated as short, regular, extra long, and the shape as tapered, or straight.

This classification of necessity applies to the trade and gives a size for almost any character of work there is, though another general classification that is used principally abroad, is as follows: —

Thick corks having more than 31 millimeters[36] in diameter.
Ordinary or commercial, from 25 to 31 millimeters.
Bastard corks, from 23 to 25 millimeters.
Thin corks, having less than 23 millimeters.

These classes of sizes are of course divided again and again by the manufacturers. To this size classification must be added a quality distinction, and this generally takes the same as before described, in sorting the cork-board, grading down from the best which is tawny or pink in color, with a fine texture, free from cracks, stone cells, or other blemishes. [62]

As has been stated, the punch is now employed in most corkwood establishments, but there are still a few who do the work by hand and maintain that the best results are obtained in this manner.

Hand-cut corks or stoppers are used mostly for the high-class wine trade and are a little more expensive than machine cut. There is also a hand machine for shaping corks, which consists of a

knife, the blade of which is placed horizontally, joined generally to a piece of wood, to which a back and forward movement is given similar to that of a carpenter's plane. In moving, the knife turns the square cork, or whatever shape it may be, by a series of belt attachments, and takes off a strip of cork (palilla) more or less thick, according to the distance from the axis of the cork and the edge of the blade; the principle being the same in the power machine, if these are parallel the resulting cork will be cylindrical, and if not, it becomes conical.

The standard size stopper is the prime use to which corkwood has been put, and in the making of it the best material is used; this material coming in varying thicknesses, it sometimes is difficult to secure enough for making "champagnes," so some manufacturers produce a stopper that answers the requirements by fastening two pieces of thin superfine corkwood together with a rubber cement made by dissolving pure Para rubber in disulphide of carbon, which makes a very [63] good binder and not lessening the quality service to any appreciable degree.

After the corks are cut, the ends are not always as even and as smooth as desired, so they are taken to a sandpaper wheel which revolves very rapidly in an upright position, and against this the corks are held for a few seconds until the surface becomes smooth and straight, the dust created being collected and used in various ways. (See "Waste Utilization.")

Cork-disk Making

(See "Waste Utilization")

Since the Crown Seal stopper, for beer bottles particularly, has come into vogue, there has been a great demand for cork disks which form the medium for air tightness and this has given the cork-worker an opportunity to utilize a grade of corkwood that usually had but little commercial value, that is, a thin bark.

It may be well to state here for the uninitiated that the Crown Seal is made up of a tin cap, corrugated on the lapped edge, for gripping the top of the bottle, a corkwood disk and a water-proof paper between the disk and cap, a very ingenious device.

As you have already read in a previous chapter that corks are cut vertical parallel, or, to state [64] more clearly, the axis of the stopper must be parallel with the axis of the tree that furnished the bark; and the desired direction is easily recognizable by the colored striae due to the annual layers of suberous substance that are observed in the direction of its axis, this rule being followed because cork is found to be more impervious to liquids if cut in this manner. It will be readily seen that if disks are cut horizontally parallel, that is, the annual layers running at right angles to the axis of the disk, this grade of cork can be utilized to great advantage. The mode of cutting is by a horizontal revolving blade, which slices the cork to the desired thickness, usually a quarter of an inch, and then it follows the usual course of punching, etc. From these operations a great deal of waste accumulates, and this would be a great loss if methods were not devised for its utilization. Many firms work up this waste on the premises, but most of it is shipped out and its conversion forms a separate part of the corkwood industry, which will be described later. We might say now that the cork is made, for it has been cut and shaped into the desired commercial size; and all that remains is to sort them and ship them away. But if commerce desires sizes and quality, it has also exacted many other requirements of a cork before it is acceptable and we will now take up the further manipulation of cork before it leaves the factory. Naturally, this corkwood, coming such a distance and being handled by so many in the general processes just [65] described, gets more or less dirty, and aside from that perhaps in the growing the tissue has not remained as white as is desired, so before the cork can leave the factory it has to be washed or cleaned. And in this washing I will not say that there is not an attempt to improve the looks of the corks in order to get a better price. Now this washing or bleaching is carried on in the simplest manner and is just soaking the corks in water and a chemical and then placing them in a centrifugal spinner, which is nothing more than a perforated receptacle made to revolve within an iron jacket, which is connected to a drain, naturally forcing the material against the periphery and thereby causing the excess water and acid to pass out through the perforations, this system becoming quite common in cork factories to-day, greatly facilitating the drying, which is done mostly by the atmosphere. This is all there is to the mechanical part, but curiosity prompts us to inquire what chemicals are used to clean the corks, so I have ascertained the principal ones, but of course every manufacturer will have his own way of doing this part of the work, although the principle remains the same. An old way was to wash them in water containing chloride of tin or oxalic acid and then subjecting them to the fumes of burning sulphur, but the sulphur bleach has been discontinued. Bioxalate of potash has also been used in solution, as also chloride of lime, ammonia and sulphuric acid. Another way is to wash in a 10 per cent solution of hydrochloric [66] acid and then immerse in a solution of sodium hyposulphate and hydrochloric acid, finally washing with a solution of soda and water. All of these produce the desired effect when mere cleaning and bleaching is all that is required: but in the poorer grade of cork, mostly a thick cork that has been jaspered or contains micro-organisms, a system of treatment with formol or methylal, ethyl alcohol or spirit wine and formaldehyde and impregnating with casein has been used. These bleaches are applied to regular stoppers and disks alike, but in addition to this the disks are given a bath of hot paraffin, or glycerine and paraffin, which improves their resistance and retards discoloration. This generally being done in a steam-jacketed kettle, or tumbling barrel, and then placed in a centrifugal to remove the excess of water and paraffin.

In some factories, and when the customer requests it, the name is branded upon the stopper by irons heated by gas, gasolene or in a coal fire, automatic gas heated machines being most

general.

In the foregoing it has been shown how the stopper and disk are made, and although there are many different manufacturers of corkwood stoppers, it will be found that the *modus operandi* just described is followed generally, with perhaps a variation in the details. The waste material, "recortes" as stated is collected and used in various ways, but either in conjunction with other [67] materials or alone in a granulated or powdered state.

The following chapter will enumerate the three principal uses of waste corkwood, and as these cover the fundamentals of the other uses it will not be necessary to describe them, e.g., linoleum, made by mixing cork-flour and linseed oil.

WASTE UTILIZATION [68]

In giving the processes of the methods used in the conversion of the corkwood waste and virgin corkwood, which is classed as waste, it will not be possible to go too far into the details, as most of them are secret, and in justice to those who use them a résumé is all that will be incorporated in this monograph. But this will give a good idea and understanding of the utilization, which is all that is intended. As in the first processes of corkwood manipulation the best is taken first; so, in the department of waste utilization, a process is now used whereby the best scrap is made into cork disks for the Crown seal as described, and serves its purpose well.

This scrap is taken and granulated in an iron rotary cutter mill, to a degree of fineness that will pass a ⅛″ mesh, it is then screened and mixed with a secret binder that has a wonderful holding quality; it is then dried by steam and pressed into sheets by hydraulic presses, dried again, and then stamped out in the usual manner. There is no waste to this process as the unused portions go back to the grinders again and through the usual process.

Granulated cork is made by grinding the waste in ordinary metal roller, cage or bur mills, and then screening same for the various degrees of fineness; if cork-flour is desired, a tube mill may [69] be used.

These two uses are generally confined to the best scrap, but there still remains a large quantity which has a great value. A portion of this is made into Spanish black by carbonizing same in a closed iron kettle, or retort, and then grinding same in a regulation ball mill, until the desired fineness is obtained; this process producing a very fine black.

The above uses in no degree exhaust the amount of scrap corkwood that leaves the various factories here and abroad, nor is its usefulness expended, for there is one use to which cork scrap is being put that bids fair to rival the stopper industry in importance, and that is in the form of cork-board for insulating purposes.

The processes for the making of cork-board differ in many ways, widely divergent in principle. The corkwood waste and virgin cork are broken up and chipped in an ordinary iron mill as a preliminary to all processes; in one, claimed to be the best, this chipped material is poured into iron molds the desired shape of the slab, subjected to heavy pressure and run into an oven kept at about 800 to 900 degrees Fahrenheit. This oven, being a low brick type, resembling a lear and heated by coal fires, the slab molds being drawn through on an endless chain, which runs at a speed to keep the cork in just long enough, for the resin in same to exude and bind the little particles together; the cork is also charred in this process, thereby converting it into a [70] carbonized cellulose which makes it an excellent material for insulation. Steam-heated hydraulic presses are also used for making small tile, etc., being the same principle as above, without the charring.

The other process involves the use of tar, pitch or asphaltum, as a binder for the cork particles, and in one, the cork is mixed with a clay before being mixed with the asphaltum. The binder being heated in steam jacketed kettles, and in one it is mixed in the proportion of one to four, while in the other it is forced into the mass under pressure and then drawn out again by vacuum, both mixtures being poured into molds of the desired shape of the slab or in large molds, to be cut up after, and subjected to heavy pressure, the sawing being done by an ordinary rip-saw, cutting the block into any desired thickness of slab.

The above described processes do not include all of the various manipulations of corkwood, for there are innumerable things as stated under the "Uses" for which there is a necessity of mechanical operation, in their making; but the general processes are as stated and will cover most all.

EXTENT OF THE MANUFACTURING INDUSTRY [71]

The cork stopper industry had its permanent origin in Spain, in the Province of Gerona, town of Llacostera, towards the latter part of 1750 and was contemporaneous with the inception of the glass bottle, although corkwood was used many years before as a stopper for amphora, etc., as noted in a previous chapter.

The trade flourished there until wars and schisms rent the country and drove the industry to the mountains. There it slumbered and struggled for many years until the peace was restored and the people assured that the dangers were passed. Its revival was not very sudden, but slowly and surely it grew, and won itself a place in the trade life of Spain and finally became a necessity, so much so, that it began to attract attention and other countries sought to secure the secret. About 1828 the French agents at Catalonia found enough information to warrant them returning to France and there set up for themselves, the rivalry between the two becoming very keen, causing much excitement among the Spanish manufacturers; for up to that time they monopolized the trade and had a nice time of it. This lasted until 1849, when the trade assumed such proportions [72] that both had all they could attend to and more. This insured a steady increase of the trade, and before long it assumed proportions that has surpassed the dreams of its founders. The industry spread until the raw material began to show a shortage due to the heavy demands made upon it. More frequent cuttings were compulsory to supply the market, and in consequence the grade became poorer.

The realization of this caused the Spanish Government to step in and protect the forests as a national necessity, and the result was the passing of laws to govern the cutting of corkwood from the trees. But the trade kept on growing in other countries and the raw stock was in great demand.

The result of the heavy exportation of corkwood again caused some notable alarm among the manufacturers and trades-workers in Spain and Portugal, but principally in the former, as most of the largest factories are located in its cities; so that the principal representatives of the cork industry convened at Madrid in December of 1911, at which convention resolutions were passed to urge upon the Government the necessity of imposing an export tax or duty on corkwood ranging from five to fifty gold pesetas ($.0965 to $9.65) per 100 kilos (220 pounds). By so doing it was thought to remedy the shortage in the home market.

The competition between the foreign and Spanish buyers for the raw corkwood output was [73] largely in favor of the foreigner in 1911, owing to the unprotective export duties, and the result has been that the once flourishing national industry is now very badly handicapped for want of working material.

So simultaneously with the tariff revision, which went into effect on January 1, 1912, an endeavor was made to put in force the increase on export corkwood, but owing to the efforts of the American cork manufacturers, who have a great influence over the Spanish cork industry, the proposed increase did not meet with the desired success.

In the attempt to restrict the importation of raw material the Spaniards have failed, for its usefulness makes the demand too great and the foreigners have invaded the Iberian Peninsula and are now buying up even the raw stock on the trees. The corkwood markets are no longer confined to two or three, but extend round the world, the principal ones being: London, Paris, Rheims, Epernay, Maguncia, Dresden, New York, Pittsburgh, San Francisco, Buenos Ayres, Calcutta, Sydney, Melbourne and Yeddo. So it will be seen that a great demand is being made upon the forests, which must be cultivated for increased growth and production or an early investigation made for the growing of the trees in other countries.

Of course the industry remains very strong throughout Spain and Portugal, and particularly in [74] the Andalusia District of Spain, where the manufacturing establishments play an important part in converting the corkwood into useful articles of commerce. The Spanish yield of raw material has remained slightly behind Portugal, but this does not affect the former's influence in the trade. (See Appendix.)

It is inevitable that the greatest bulk of the trade should center around the countries in which the raw material is grown, for the greatest advantage is thus gained by those, so fortunate in their location.

But the spread of the corkwood's fame has aroused others to action, and it appears as though the monopoly will suffer because of that fame. The demand grows daily, and the rapid growth of the American trade bids fair to being a very close rival to the long-established European manufactures at least.

The waste is rapidly assuming great importance and to this the newer entrant in the business is turning all his energy. The doctrine of conservation and utilization has been heeded by the corkwood industry and the waste is no longer such, rather standing as a cork product second only to the stopper, when the fact is considered that the grower or farmer receives about $58 per ton for raw corkwood and the waste sells from $22 to $32 per ton; its value is apparent.

A notable feature of the shipments from Spain is the waste and shavings, which doubled from [75] 1906 to 1910, viz.:

1906—14,624 tons	1909—20,198 tons
1907—17,557 "	1910—29,257 "
1908—12,201 "	

The uses to which corkwood may be put are unlimited, and as has been seen the uses already

known are sufficient, in themselves, to make it a very important commodity. And yet when we speak of uses it is only those that have developed by reason of the corkwood's own peculiarity that makes it the subject of discussion, and not the great number that it has been adapted to, for perhaps its utility will have no end, and in my estimation its particular qualities are but little appreciated. Of course its application as a stopper is ideal for that purpose, but it appears most certain that this wonderful growth is designed to be of greater service to man than the mere function of filling the neck of a bottle. Chemically, I think it has possibilities; the ancients found it useful in Materia Medica, and there may still be a use in this line. At any rate, it is the most wonderful bark of its kind, its service has been a long one, and its benefits, even as a stopper, have been many. A wonderful material truly, and of interest, so full that it seems I have failed to do it justice in these few words presented in my endeavor to describe the Quercus Suber of Linnæus.

APPENDIX [76]

For those who may be interested in a few statistics of the trade is appended the following figures relating to the Spanish and American industry:

Spanish Industry, 1912

There were 892 factories throughout Spain in 1912, in 107 towns and cities, divided as follows:

Seville District	305 in 48	towns
Barcelona District	507 in 31	"
Other Districts	80 in 28	"

These factories employ approximately 40,000 people in the various branches of the industry at an average daily wage of 67 cents.

The raw material yield for 1912 is reported as: 7800 short tons, valued at $57.90 per ton to the grower, or $4,516,200.

It will also be of interest to show a few comparisons of values, for various years, in shipments to foreign parts, viz.:

1909 [77]

Description	Pounds	Value
Cork in sheets	11,009,939	$405,366
Cork squares	1,180,489	265,610
Corks	11,960,760	4,870,948
Cork shavings	66,435,426	363,563
Other manufactured cork	864,820	40,656
Total	91,451,434	$5,946,143

1910

Description	Pounds	Value
Cork in sheets	16,798,492	$618,489
Cork squares	2,055,865	462,472
Corks	14,924,052	6,105,294
Cork shavings	64,367,448	526,642
Other manufactured cork	1,190,789	57,382
Total	99,336,646	$7,770,279
Corrected figures showing totals as	109,336,646	$7,942,677

1911 [78]

Description	Pounds	Value
Cork in sheets	21,564,347	$741,029
Cork squares	2,076,881	467,298

Corks	17,817,037	7,288,787
Cork waste	73,510,473	591,468
Cork, manufactured in other forms	1,828,030	89,723
Total	116,796,768	$9,178,305

1912

Description	Pounds	Value
Corkwood	17,928,000	$528,810
Cork squares	1,492,000	356,229
Corks mfrd.	100,396,000	7,864,299
Cork waste		754,848
Other mfrs.	1,166,000	49,783
	120,982,000	$9,553,969

The following is a comparison of the first six months of 1909, 1910 and 1911. [79]

1909

Articles	Tons	Value
Corkwood	1,686	$158,644
Cork squares	262	129,646
Corks	2,624	2,361,620
Cork waste and shavings	9,589	172,604
Cork, other manufactures	211	25,987

1910

Articles	Tons	Value
Corkwood	3,157	$255,718
Cork squares	485	240,057
Corks	3,629	3,265,760
Cork waste and shavings	13,935	205,822
Cork, other manufactures	251	27,133

1911 [80]

Articles	Tons	Value
Corkwood	5,129	$415,432
Cork squares	442	218,755
Corks	4,057	3,669,075
Cork waste and shavings	18,143	326,573
Cork, other manufactures	248	32,657

The statistics showing the shipments to various countries are for 1909:

Countries	Cork-wood	Cork Sqs	Corks	Cork Waste and Shav.	Cork in Other Forms	Total
	Tons	Tons	Tons	Tons	Tons	Tons
United States	2,065	—	158	7,594	280	10,097
Great Britain	842	1,094	4	7,539	38	9,518
Germany	5	18	715	4,555	—	5,293
France	1,256	276	2,044	189	56	3,821

Italy	6	79	435	11	—	532
Belgium	164	—	136	215	11	526
Russia	463	—	1	—	—	464
Aust-Hungary	—	30	346	—	—	376
Argentina	164	123	57	—	—	344
Other	40	7	426	95	9	575
Total	5,005	537	5,412	20,198	394	31,546

American Industry [81]

In 1899, there were 62 factories in the United States of varying sizes and located in the following states: New York (Brooklyn), Pennsylvania, New Jersey, Illinois, Massachusetts, Rhode Island, Wisconsin and Ohio. Employing 2340 wage earners. Importing a raw stock of $2,404,000, and making products valued at $4,392,000.

In 1904, the factories decreased to 50 in number, the wage earners increased to 2895, the imported raw material to $2,459,197 and the products to $4,490,952.

In 1909, the factories increasing again to 62 in number, the wage earners to 3142, the imported raw material to $3,435,000 and the products to $5,940,000: corks selling from 3 cents to 40 cents per pound.

This of course does not appear to be a very extensive business, but the nature of the commodity will readily convince that the money figures are not at all in comparison to the bulk of corkwood, for it would really seem that if the trade should increase to an amount sufficient to vie with other prominent ones, the ships would be at loss how to stow the other freight. The imports of corkwood into this country and the exports, for comparison, may be seen in the following tables:

Imports [82]

January		Seven Months ending January		
1912	1913	1911	1912	1913
Corkwood, Free:				
$450,082	$367,884	$2,265,373	$1,849,550	$1,707,164
Corks mfrd., Dutiable:				
$181,252	130,580	1,380,109	1,137,504	1,180,816

Exports

	January		Seven Months ending January	
	1912	1913	1912	1913
Corkwood, Free:	$1,518	$1,195	$19,795	$22,393
Corks mfrd., Dutiable:	209	1,086	3,078	2,170

And the periods ending December, 1913 will be of interest also.

Imports

December		Twelve Months ending December		
1912	1913	1911	1912	1913
Corkwood, Free:				
$300,253	$468,937	$3,819,651	$3,182,131	$3,616,177
Corks mfrd., Dutiable:				
$164,711	194,457	2,070,672	2,440,399	2,370,527

Exports [83]

	December		Twelve Months ending December	
	1912	1913	1912	1913
Corkwood, Free:	$2,960	—	$34,404	$25,091
Corks mfrd., Dutiable:	—	$8,335	5,552	5,392

Footnotes:

[1] Letter from Prof. Nelson G. McCrea of Columbia University, June 12, 1910, to writer.

[2] According to “Spanish Dictionary” of Lopes et Bensley; Cortex: “La Parte exterior del Arbol.” Arbol in botany meaning “a tree.”

[3] Consul Schenck’s Report.

[4] Armstrong Cork Co.’s pamphlet.

[5] There are large forests of cork on the French Colony of Algeria, particularly on an estate granted by the Emperor Napoleon III to M. le duc de Montebello.—H. G. Glasspoole.

[6] Chambers Journal.

[7] One hectare = 2.471 acres.

[8] Consul Schenck’s Report.

[9] *Chambers Journal.*

[10] *Garden and Forest*, Vol. VIII, 52.

[11] Consul Schenck’s Report.

[12] Meter = 3.28 feet.

[13] In a cork-wood of Montenegro (municipal district of Quart, Province of Gerona) the property of D. Romulo Bosch, and near the place called La Mina, we measured in August, 1877, a tree that was 4.95 meters in circumference, breast high, and the trunk of the tree five meters high, calculating its age between one hundred and fifty and two hundred years old. Consul Schenck’s Report, 1890.

[14] Centimeter = .3937 inch.

[15] Consul Schenck’s Report, 1890. Authority M. Fee.

[16] *Scientific American*, 1906.

[17] Armstrong Cork Co.’s pamphlet.

[18] Kilogram = 2.205 pounds.

[19] Mr. Lamey, the author of a study upon cork in Algeria, published some interesting tables in this work regarding the annual increase and the mean thickness of cork. According to him cork-bark should not be removed before it has attained a thickness of 2.032 cm., and the formation of new cork has been well explained by Mr. Mathieu in his “Forestry Flora.”

[20] Armstrong Cork Co.’s pamphlet.

[21] See “Etymology of Word” in preceding chapter.

[22] “New English Dictionary,” Murray.

[23] Showing a permanent set of 12.5 per cent.

[24] “Standard Dictionary.”

[25] “Watt’s Dictionary” (“M” signifying metal).

[26] “Century Dictionary.”

[27] *Review of Reviews*, September, 1906.

[28] In the making of insulation material, the carbonization of the cork is accomplished without destruction of fibre and stands a high flame test.

[29] Using ordinary glass (armoured) thermometer for ascertaining degrees.

[30] One thousand degrees Fahrenheit, causing no greater combustion than the lower degree, other than the increased burning of remaining substance after the flash, due to the higher temperature.

[31] *Scientific American Supplement.*

[32] I have subsequently learned that this proved a failure.

[33] See Lawrence Whitcomb’s article in *Industrial Engineering*, September, 1910.

[34] *Chambers Journal.*

[35] The metric quintal is used officially in Spain, which is equal to 220.36 pounds, the Catalon quintal equaling 91.71 pounds.

[36] Millimeter = .0394 inch.

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