

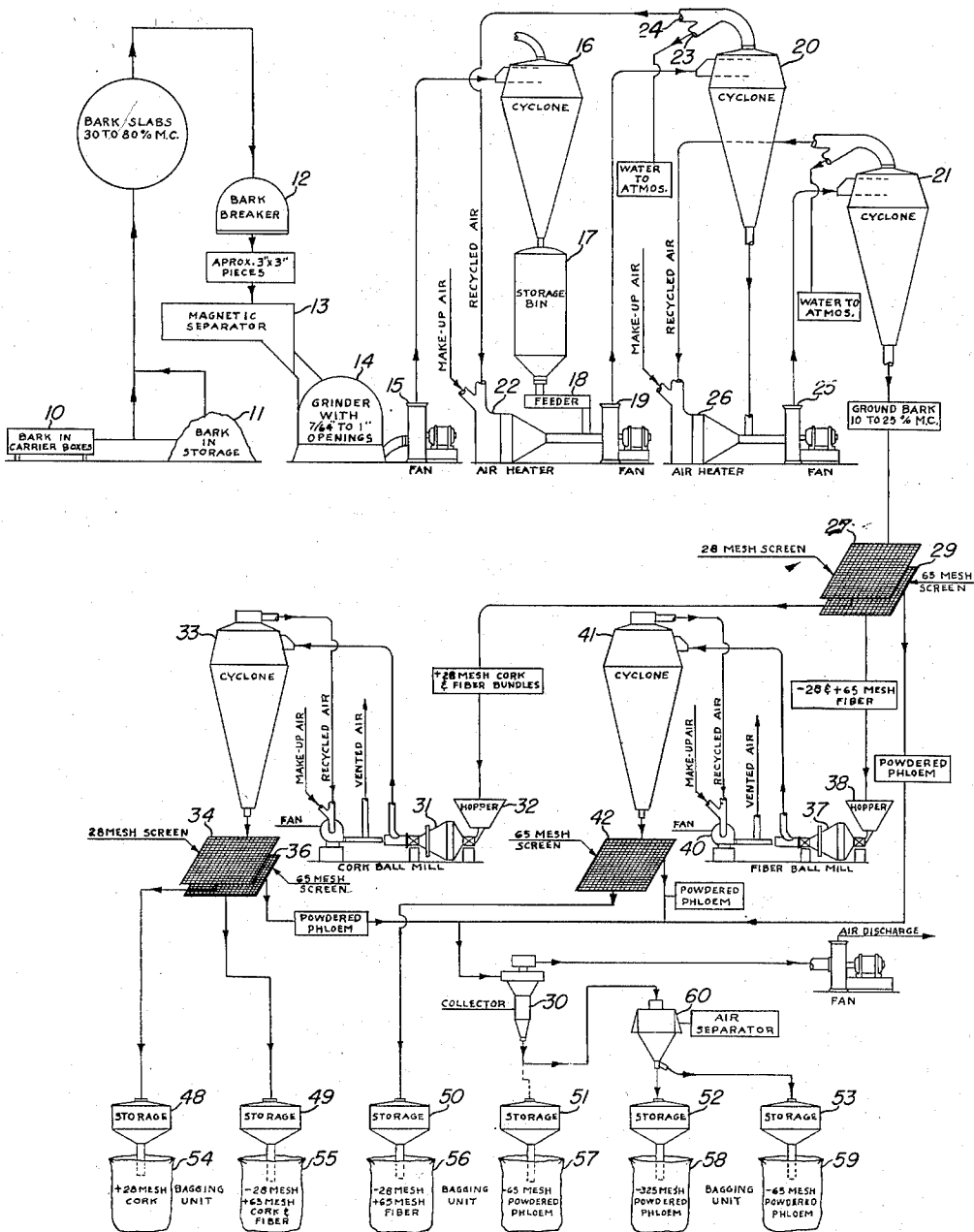
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SEPARATION OF BARK COMPONENTS

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SEPARATION OF BARK COMPONENTS

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This invention relates to the treatment of bark, and has particular reference to an improved method of treating bark of the pinaceous and coniferous trees of commerce to provide in commercial volume fractions of the bark components of high purity quality or of predetermined proportions.

The bark of trees generally consists of phloem which is formed outside of the cambium layer, this tissue being pushed outwardly of the tree year by year as new phloem forms under it, and eventually ceasing to function as living tissue. This results in the formation of an outer bark which consists of dead phloem more or less bounded by zones of secondary periderms in the form of short arcs or anastomosing lunes consisting of corky tissue produced by secondary periderms and forming more or less isolated islands of dead phloem. The phloem consists of a mixture of parenchyma tissue and frequently bast fibers or stone cells. Pieces of bark from separate trees show a wide variation of relative amounts of cork and phloem, grading from pieces consisting almost entirely of phloem and having but thin lunes of cork, to those consisting of large masses of cork or phelloderm with small islands of phloem existing in the cork. The relative amounts of these constituents of bark apparently are affected by such factors as the species of the tree, its age, the conditions of growth, the position of the bark on the tree, etc. Following is a table showing the components of the barks of several of the coniferous trees of commerce and the approximate percentages in which these components are present in the several barks:

|                                                                                                         | Douglas Fir | Western Hemlock | White Fir (Abies concolor) | Ponderosa Pine |
|---------------------------------------------------------------------------------------------------------|-------------|-----------------|----------------------------|----------------|
| I. Cork.....                                                                                            | 25          | 5               | 40                         | 5              |
| II. Phloem:                                                                                             |             |                 |                            |                |
| A. Sclerenchyma Tissue—                                                                                 |             |                 |                            |                |
| 1. Fiber.....                                                                                           | 40          | 45              | 45                         |                |
| 2. Stone Cells.....                                                                                     |             |                 |                            |                |
| B. Parenchyma Tissue—1. Most sieve tubes; also food storage cells, connecting cells and ray tissue..... | 35          | 50              | 15                         | 50             |
| III. Phelloderm.....                                                                                    |             |                 |                            | 45             |

The phellem or cork is composed of non-elongated thin and thick walled cells converted into cork tissue by development of suberin. The thin walled cells probably are not heavily suberized, and tend to collapse in the radial direction. The cork cells are partially filled with air and are

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of low specific gravity. The cork component occurs in layers ranging in thickness from the barely visible of about  $\frac{1}{32}$  inch to  $1\frac{1}{2}$  inches with the great bulk occurring in layers ranging from about  $\frac{1}{8}$  to  $\frac{1}{2}$  inch in thickness. When coniferous bark, such as that from Douglas fir, is reduced to comparatively small pieces and then partially dried, the corky layers retain a larger proportion of moisture than the dead phloem tissue, which factor combined with the natural resilient character of the cork cells, renders the cork cell aggregates elastic and resistant to further abrasion or pulverization, while the dead phloem tissue becomes brittle and hard. The cork when recovered is in the form of flake-like particles, light brown in color, ranging upward in size to the size of the screen openings of the grinding unit employed.

The sclerenchyma fiber tissue found in certain barks, Douglas fir in particular, comprises a tough fibrous portion of the phloem known as bast fiber. The fibers occur naturally in the wood in tightly cemented bundles which, upon grinding or subsection to mild attrition, are reduced to individual or ultimate fibers. The individual fibers, viewed under a microscope, appear to have a spindle shape with a length approximately ten times the diameter. Variations in particle sizes of individual fibers have been noted of from .016 to .090 inch in length and from .002 to .008 inch in thickness at the midsection with the bulk of the particles having an average length of about .054 inch and an average thickness of about .005 inch. These individual fibers are very resistant to further comminution and still tend to maintain their

identity, even when subjected to the severe pulverizing action by which other portions of the phloem, and cork at low moisture content, are reduced to powder.

The non-fibrous portion of the phloem, generally characterized under the name of parenchyma

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tissue, and consisting of sieve tubes, food storage cells and connecting ray tissue, partially disintegrates to a fine powder at relatively high moisture content, and readily disintegrates to a fine powder at moisture contents at which the cork and fiber fractions are still highly resistant to disintegration.

It is an object of the present invention to effect the segregation of the different components of bark by selecting a series of comminuting and screening steps in relation to the control of moisture content at each comminuting step determined to provide the most favorable condition for optimum separation of the components.

The present invention contemplates broadly an initial grinding of the bark at a moisture content at which the corky material is still sufficiently elastic and resilient to resist comminution and at which the fiber bundles are partially broken down to ultimate fibers and a substantial portion of the non-fibrous phloem is reduced to powder. The moisture content is then further reduced to the percentage desired for the next comminuting step at which the cork and fiber particles are refined. However, prior to this next comminuting step, the bark, as ground and further dried, is separated into three fractions, a coarser fraction containing principally all the cork, a second fraction containing a substantial portion of the fiber, and the remainder containing the powdered non-fibrous phloem broken down during the grinding operation. The cork and fiber fractions are next comminuted, preferably by ball milling, at a moisture content and under conditions best suited for refining these two products to ultimate cork and fiber particles.

It will be apparent from the above that a novel principle of the invention resides in the separation following the first grinding step and before further comminution of a fraction containing principally the cork and another fraction containing principally fiber and relatively free from cork. The separation of these two fractions enables separate refining treatments of the two types of material thus separated, thereby providing opportunity to adjust the nature and type of treatment to the more uniform nature of the particles obtained by the first separation than would otherwise be the case in processes wherein the cork and fiber are intermingled in a combined treatment.

Also, because an initial rough separation of the bark components has already been made under conditions best adapted to separate one of the components, to-wit the cork, the difficulties involved in classifying the particles after the second comminuting step are greatly reduced. This is particularly true with respect to the production of a pure ultimate fiber product. It is ordinarily difficult to separate the ultimate fibers from the cork, after comminution of the combined material at the lower moisture content, because a good portion of the cork particles will then have a particle size less than the length but larger than the thickness of the fiber particles. In accordance with the present invention, the substantially pure fiber product is obtained from the second fraction of the initial separation and is relatively free of cork.

Control of the moisture content is of importance in at least three respects. In the first place, it is desirable for successful operation of the process that the steps wherein relatively large pieces of bark are first reduced to a size suitable for subsequent comminuting operations

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be carried out at a moisture content of between about 30% and about 80% by weight, based on the weight of the dry bark. At this moisture content the phloem portion is rendered susceptible to comminution by attrition, whereas the cork content is not substantially dehydrated and, therefore, retains its resiliency and resistance to abrasion.

If the bark as it is obtained from logging or other operations should have a higher moisture content than 80% by weight, as it well may have, the bark should be allowed to dry in the open air until the moisture content has been reduced to the specified amount. The moisture content of the bark slabs obtained from milling operations at the mill at which the invention is in operation generally runs from 40% upward.

Secondly, it is of particular importance and critical to the successful separation of the bark fractions that the pulverizing operation subsequent to the initial grinding of the large pieces of bark to relatively small particle sizes be carried out at a reduced moisture content. For best results, this operation is practiced upon material having a moisture content of between about 10% and about 25% by weight, oven dry basis. When the moisture content of the treated material has been reduced to this level, much of the moisture is contained in the cork cell aggregates. In part, because of their relatively high moisture content, the cork aggregates are resistant to the action of a ball mill or other grinding equipment whereas the non-fibrous phloem tissue is relatively dry and brittle and particularly susceptible to grinding treatment. In a suitable refining process the cork particles are thus cleansed of the phloem and may be separated therefrom by suitable techniques hereinafter more fully described. Likewise, the fiber bundles or aggregates are readily disunited to ultimate fibers to enable their separation from the larger cork aggregates. If, on the other hand, the moisture content of the mixture of cork and phloem is reduced to a value of below about 10% by weight, the cork particles become desiccated and hard and tend to pulverize along with the non-fibrous phloem material, thereby passing out of the range at which the cork tissue is differentially resistant to comminution or abrasion. On the other hand, the greater tendency of the cork to pulverize at low moisture content as compared with the tendency of the fibers results in the differential pulverization of the cork as compared to the fiber and affords a means of refining the fiber product when contaminated with small amounts of cork.

Control of the moisture content in the production of cork from the bark of trees is of still further importance when considered from the standpoint of the properties of the cork product. When the moisture content of the bark treated is not maintained during the comminuting and screening operation at a level sufficiently high to insure that the cork is moist, the cork cells, which are originally turgid, collapse into hard, horny aggregates from which the resiliency customarily associated with cork is almost completely absent. Since this valuable property may be restored to the dried cork cell aggregates only with great difficulty, if at all, over-drying results in destroying the usefulness of the cork product for many applications.

The reduction of the moisture content in a manner suitable for use in a continuous commercial process introduces the problem of avoidance of explosion and fire hazards. A consider-

able amount of drying is required to reduce the moisture content from, say, 50% to 15% in a continuous operation. It is well known that powdered organic material, such as wheat flour, wood flour, and coal dust, constitute explosion and fire hazards. Ground bark is no exception. Accordingly, a drying process is employed wherein the temperature of the bark powder and surfaces of the apparatus with which the ground bark comes in contact is kept below the ignition or kindling temperature of the bark.

The cork, fiber, and parenchyma or non-fibrous phloem components of bark have been found to have commercial uses singly and in selected combinations and proportions. The cork for instance is useful in insulating materials and as a substitute for flake or granulated cork in lieu of the cork oak. The cork imparts certain characteristics when used as an ingredient in molding compounds. The bast fiber imparts structural strength when used as an ingredient in molding compounds. The non-fibrous phloem can be used as an active constituent in molding compounds and adhesives. Different characteristics in molding compounds may be obtained at will by using one or more of these materials in variant proportions. In order to standardize and reproduce such formulations it is necessary, therefore, to separate these components of bark into relatively pure products or mixtures of products of standardized quality as to composition and particle size. It is, therefore, a further object of this invention to provide a commercially useful process for the recovery of substantially pure bark component products and mixtures of said bark components of standardized quality as to composition and particle size.

Other objects and advantages of the invention will be apparent from the following detailed description wherein reference is made to the single figure of the drawing, illustrating diagrammatically the functional steps in the process.

Reference is made to the drawing which illustrates a practical embodiment of the invention in a plant designed for a capacity of 2300 pounds of products per hour at approximately 15% moisture content on an oven dry basis. Bark may be brought to the plant in carrier boxes 10, or by other means such as conveyors. As previously stated, bark may have a range of moisture content from 30% to 80% on an oven dry basis. More commonly, in practice, the range is between 30 and 60. At 60% moisture content approximately 3200 pounds of raw bark must be fed to the plant per hour in order to yield 2300 pounds per hour of products at 15% moisture content. A bark storage station 11 is provided at the plant in order to take care of fluctuations in the delivery of bark to the plant, the bark storage receiving excess deliveries from the carrier boxes supplying bark to the plant or supplementing delivery to the plant when the delivery from the carrier boxes is below operating level.

The bark is first fed to a bark breaker machine 12 which breaks the bark to pieces having maximum dimensions of approximately 3" by 3" in preparation for feeding to the grinding machine. A magnetic separator 13 is provided to remove from the bark tramp iron present in the form of nails, wire, etc. This is to protect the machinery and to free the end product from contamination with such matter. The grinder 14 in use is a hammer mill provided with a screen

discharge. Screens may be used with mesh openings of from  $\frac{3}{4}$  to 1 inch. A preferred size opening is  $\frac{7}{8}$  inch.

The grinding operation accomplishes two objectives. First, it reduces the bark to particles of substantially unitary component composition, whether the particles be ultimate particles or aggregates of particles, and secondly, it reduces the bark to a particle size from which the moisture can be quickly evaporated in a mechanical drying apparatus to the moisture content desired for the next comminuting operation.

The particle size selected should be such as to effectuate the breaking up of the cork layers as they occur in the bark into aggregates or particles of cork which are relatively freed from other bark tissues or components, and at the same time keep the breaking-up of the cork aggregates to a minimum in order to obtain cork of maximum particle size, unless a granulated type of cork is desired. These desiderata aim at antipodal sizes, to wit, the maximum and minimum thicknesses of the cork layers. In practice a compromise must be made with reference to the conditions of operation and the products desired. No particular problem of particle size is presented by the other components. Because of the greater friability of these components at the moisture content specified, the fiber content is readily reduced to individual fibers and fiber bundles and the non-fibrous phloem is substantially comminuted to a powder or particle size such that it readily passes through a 65 mesh screen.

The bark from the screen discharge of the grinder is elevated by a fan or blower 15 to a cyclone 16 which, as illustrated, is provided with a storage bin 17 for receiving the ground bark. A feed control mechanism 18 is provided to regulate the flow of the ground bark to the remainder of the plant system at a continuous even feed rate. The feed rate may be adjusted to meet different conditions of operation or to accommodate flow changes through the plant which may be required for desired variations in particle size or composition of end products.

The discharge from the feeder 18 is fed by fan or blower 19 to a two-step drying system represented by cyclones 20 and 21 and associated equipment. A stream of air, heated to a temperature not greatly in excess of 240° F. by heater 22, carries the ground bark to cyclone 20 where the bark particles are impelled in a vortical movement during which the particles are mixed in intimate contact with the air, thereby facilitating evaporation of the moisture content. As the particles settle in the cyclone chamber the moist air is separated and either discharged to atmosphere as at 23 or recycled to the heater by conduit 24. Ordinarily about 60% of the exhaust heated air may be recycled.

A major portion of the moisture content is removed during this first drying step. If, for example, the moisture content is reduced from approximately 60% at the grinder to approximately 15% at the ball mills, the moisture content in this first drying step is reduced to approximately 25%. Some moisture may have been removed by frictional heat during the grinding and by any drying occasioned in the first cyclone.

The drying process is repeated in the second cyclone 21 by means of the fan or blower 25 and air heater 26. The moisture content is reduced

at this drying step to the final amount desired, being in the range of 10% to 25% and preferably about 15%. In view of the smaller amount of moisture to be removed during the second drying step, either the temperature of the air or the amount of the heated air employed, or both, may be reduced. In one modification, 14,000 cu. ft. of air per minute is used in the first drying step while 8000 cu. ft. per minute is used in the second drying step with the temperature of the heated air being the same in both steps.

Great care must be taken during the drying process to avoid explosion and fire hazards. It has been found that certain fractions of the bark powder will char at approximately 335° F., and that the charring point may be regarded as the kindling temperature or as the danger point for ignition. In order to provide sufficient margin for caution, the drying system is designed so that any metal surfaces which the bark contacts more than momentarily will not be heated to a temperature in excess of 300° F.

The two-step drying system serves to accomplish the necessary safety, and at the same time provides for the more efficient drying of the ground bark in that by removing the moisture in two stages, a supply of air at maximum operating temperature is supplied at the second stage, which is more capable of absorbing additional moisture than the partially cooled and saturated air would be in the case of a single drying step. It will be obvious that the capacity of the drying system must be correlated with the designed capacity of the plant. The drying may be accomplished by a single cyclone one-step system, although undoubtedly much less efficiently, by constructing it of considerably larger dimensions. Likewise, the drying may be accomplished by a drying system with three or more steps where conditions require.

The initial segregation of bark components is obtained by feeding the dried ground bark to a 28-mesh standard screen 27 which separates as overs the larger particles of cork and the majority of the fiber bundles which were not disunited by the grinding operation. This first fraction is herein sometimes referred to as the cork fraction. The fines or throughs fall on 65 mesh screen 29 arranged as a lower deck, which removes as overs a minus-28 plus 65-mesh fraction material, herein sometimes called the fiber fraction, consisting principally of individual fibers which have become disunited during the first grinding and drying operations, together with the smaller fiber bundles and small particles of cork.

Inasmuch as the individual fibers and fiber bundles are longer than the mesh openings of the 28 mesh screen, these entities must pass through the screen openings endwise. The screens are set at an angle of approximately 30 degrees with the horizontal and are actuated normally to the screening surface. These factors, together with the state of congestion of material on the screen, are such as to provide the fiber particles opportunity to pass endwise through the screen.

The minus-65 mesh fines from screen 29, consisting primarily of parenchyma tissue and finely comminuted fiber and cork, are carried to a collector 30 to be united with the fines from other parts of the process.

Results of typical analyses of the above fractions of Douglas fir bark, where all results are

reported in terms of percentage of the whole bark sample, are as follows:

| Whole Bark Composition  |      | Fractionation                     |      |
|-------------------------|------|-----------------------------------|------|
| Cork.....               | 34.6 | +28 mesh (cork fraction).....     | 37.2 |
| Fiber.....              | 54.0 | -28+65 mesh (fiber fraction)..... | 41.1 |
| Non-fibrous phloem..... | 11.4 | -65 mesh (Fines).....             | 21.7 |
|                         | 100  |                                   | 100  |

COMPONENT ANALYSIS OF FRACTIONS

|                         | Cork Fraction (37.2) | Fiber Fraction (41.1) | Fines (21.7) |
|-------------------------|----------------------|-----------------------|--------------|
| Cork.....               | 18.9                 | 11.3                  | 4.4          |
| Fiber.....              | 17.6                 | 29.0                  | 7.4          |
| Non-fibrous phloem..... | .7                   | .8                    | 9.9          |
|                         | 37.2                 | 41.1                  | 21.7         |

It will be obvious that the mesh size of screens 27 and 29 may be varied within limits which will accomplish the desired segregation from the ground bark of two fractions, the one consisting primarily of the cork particles and the larger fiber or phloem aggregates which have not been disunited by the grinder, and the other fraction consisting primarily of the disunited fibers, or stone cells in the case of barks containing this component.

Likewise, the mesh size of the screens may be varied to provide larger or smaller fractions of the cork and phloem components, depending on the percentage composition or size of the aggregates in the whole bark. Still again the mesh size may be varied to produce larger or smaller percentages of the end products formed from the respective fractions, although ordinarily increase in the percentage of a particular component as an end product is accomplished at the expense of the purity of the component product.

The cork fraction separated as overs from the 28 mesh screen 27 is fed to cork ball mill 31 which is equipped with a storage bin or hopper 32 to accommodate minor changes in the flow of material. The variables of the ball milling step such as size of the mill, speed of rotation, sizes and proportions of grinding media, etc. are correlated with the feed rate, the physical nature of the particles of cork and fibers and their moisture content so as to provide the rolling, beating action desired to cleanse the cork particles of any adhering fibrous or non-fibrous constituents and to complete the disunification of the fiber bundles and puerization of any non-fibrous phloem aggregates present with a minimum of comminution of the cork and fiber. In a typical operation for the designed plant, a 6' diameter 22" cylindrical-conical ball mill is charged with 10,000 pounds of steel balls, ranging in size from two to three inches and rotated at a speed of 24 R. P. M.

The discharge from the ball mill is fed to a cyclone 33 and thence to a 28 mesh screen 34. This screen separates as overs a final product consisting primarily of cork. The product obtained in the plant process with but one passing over the screen, which is satisfactory for most intended uses, contains a considerable quantity of individual fibers. However, if desired, a substantially pure cork fraction can readily be obtained by repeated screenings, or by providing additional screens in sequence, in order to remove the fibers by causing them to up-end and pass through the screen as explained in connection

with the screening action of 28 mesh screen 27. Similarly, a high purity cork product can be obtained by enlarging the screening surface or by passing the material over the screen at a slower rate in order to provide the fibers opportunity to up-end and pass through the mesh openings. The cork product from Douglas fir thus obtained is in the form of light brown flake-like particles ranging in size from approximately 0.02", the size openings of the 28 mesh screen, to the size of the screen openings of the grinding unit 14.

The fines from the 28 mesh screen 34 fall on a 65 mesh screen 36 below of the same size area as screen 34 which separates as overs a mixed cork and fiber product and as fines any parenchyma tissue and other non-fibrous phloem powder attached to the cork aggregate particles or fiber bundles separated by 28 mesh screen 27. The minus-28 plus 65 mesh mixed cork and fiber product can be further refined, as desired, to substantially complete the separation of the cork and fiber by extended screening or control of screening conditions in the manner pointed out for the purification of the plus 28 mesh cork product. However, the minus-65 mesh fines will consist mostly of comminuted cork and broken or comminuted fibers when the plant is operated to provide optimum conditions with reference to all the bark components rather than the cork alone.

Continuing with the typical analysis of a bark sample in its progress through the process, the 37.2% of whole bark reported as the cork fraction hereinbefore, upon mesh analysis after the cork ball milling, provided the following results, wherein the figures shown are expressed in percentages of the whole bark:

|                         | Cork Fraction (37.2) | Mesh analysis after cork ball milling |      |
|-------------------------|----------------------|---------------------------------------|------|
| Cork.....               | 18.9                 | +28 mesh.....                         | 6.5  |
| Fiber.....              | 17.6                 | -28+65 mesh.....                      | 18.2 |
| Non-fibrous phloem..... | .7                   | -65 mesh.....                         | 12.5 |
|                         | 37.2                 |                                       | 37.2 |

It will be apparent from the above tabulated results that the cork and fiber content of the cork fraction have been reduced in part by the comminuting action of the ball mill to material of less than 65 mesh particle size which results in an artificial increase in the content of powdered phloem product.

The fraction separated as overs from 65 mesh screen 29 is fed to a fiber ball mill 37 equipped with a storage bin or hopper 38 for receiving same and designed to smooth out any irregularities in the flow to the ball mill. The function of the fiber ball mill is to complete disunification of any fibers still joined together; to cleanse from the fibers any non-fibrous material attached thereto, and to complete pulverization to a powder of such non-fibrous material together with any non-fibrous phloem aggregates present. The variables of the ball mill operation are controlled to achieve this result. Although the fiber ball mill may be of the same size and type as the cork ball mill, a typical variation of the charge from that of the cork ball mill is illustrated by a typical operation in which 4000 lbs. of steel balls 1½ to 2 inches in size are used. Other variations may also be made to accomplish the desired function.

The discharge from the fiber ball mill is carried by means of a pneumatic system including a fan 40 to cyclone 41 and thence to 65 mesh

screen 42 which separates as overs in high quality purity the final fiber product. The fibers from Douglas fir bark, generally known as bast fibers, are stiff, brown, elongated spindle-shaped particles ranging in length from .016 to .090 inch and in thickness at the midsection from .002 to .008 inch.

It will be observed that the fibers are of a size that they could relatively easily pass endwise through the 65 mesh screens 29, 36 and 42 if given opportunity. The 65 mesh screen openings are approximately .0082 inch which is larger than the fiber thicknesses generally. However, the difference in mesh opening size of .0082 of the 65 mesh screen as compared with .0232 of the 28 mesh screen is sufficient to reduce the probability of the individual fibers from up-ending and passing through the screen under the conditions of screening and rate of feed so that a satisfactory yield of fiber is obtained as overs from 65-mesh screen 42.

The fines from screen 42 are united with those from minus-65 mesh screens 29 and 36 and collected at collector 30.

The composition of the minus 65 mesh material from screen 42 is substantiated by continuing with the typical analysis of the Douglas fir bark sample. The 41.1% of the whole bark reported as the fiber fraction hereinbefore, on screen analysis after the fiber ball milling, provided the following results, wherein the figures shown are expressed in percentages of the whole bark:

|                         | Fiber Fraction Composition (41.1) | Mesh Analysis after Fiber-ball Milling |      |
|-------------------------|-----------------------------------|----------------------------------------|------|
| Cork.....               | 11.3                              |                                        |      |
| Fiber.....              | 29.0                              | +65 mesh.....                          | 23.2 |
| Non-fibrous phloem..... | .8                                | -65 mesh.....                          | 17.9 |
|                         | 41.1                              |                                        | 41.1 |

It will be apparent from the above results, and especially when taken in consideration with the fact that the plus 65 mesh fiber product contains but a minor amount of cork (usually about 10% which in relation to the 23.2% above reported would be 2.3%), that substantially all the cork and some of the fiber are apparently reduced to minus 65 mesh material by the comminuting action of the ball mill. This results in a still further artificial increase in the non-fibrous phloem powder content.

Provision is made for receiving each of the final products, plus 28 mesh cork, minus 28 plus 65 mesh cork and fiber, minus 28 plus 65 mesh fiber and the minus 65 mesh powder, in storage bins 48 to 51 feeding into bagging units 54 to 57. If desired, the powder product collected at storage bin 51 may be separated by means of an air separator 60, or other device, into still finer fractions. In the process as illustrated, a minus-325 mesh fraction is prepared and collected in storage bin 52. The remainder of the minus 65 mesh powder component after the removal of the minus 325 mesh fraction is collected in storage bin 53. About one-fifth of the total powder product collected at collector 30 is recovered as minus 325 mesh powder.

Composition analysis of the minus 65 mesh powder product obtained from the analysis of the sample of Douglas fir bark of which the analysis of the other component products has hereinbefore been given is tabulated in the first column below. Tabulated in the second and third col-

umns are typical composition analyses of different bark samples for the minus 325 mesh powder product 58 and the minus-65 mesh powder product 59 obtained after separation therefrom of the minus 325 mesh powder. Note that the percentages shown are not of the whole bark, but rather, of the product.

|                         | -65 Mesh Powder Before Separation | -325 Mesh Powder | -65 Mesh Powder After Separation of -325 Mesh Powder |
|-------------------------|-----------------------------------|------------------|------------------------------------------------------|
| Cork.....               | 19.4                              | 5.0              | 13.0                                                 |
| Fiber.....              | 30.7                              | 2.0              | 46.0                                                 |
| Non-fibrous phloem..... | 49.9                              | 93.0             | 41.0                                                 |
|                         | 100                               | 100              | 100                                                  |

No limitation is intended by reference to a particular type of apparatus for practicing the method of the invention, the same being limited only by the scope of the appended claims. In particular, applicants do not wish to be limited to the specific apparatus referred to for performing the grinding and comminuting steps, nor do applicants wish to be limited to specific sizes of screen openings or specific fiber dimensions, except as may be specified in certain claims. References in the specification to particular apparatus and screen openings are made by way of illustration only, to describe a preferred manner of carrying out the steps of the method in a continuous process best suited for a production plant. Other apparatus for grinding and comminuting may be devised by those skilled in the art and some variance may be made in the screening apparatus by properly coordinating the variables mentioned in the specification, and all such modifications and variations are included in the invention.

Having now described our invention and in what manner the same may be used, what we claim as new and desire to protect by Letters Patent is:

1. The method of treating Douglas fir bark for the production therefrom of a substantially pure fiber product, which comprises selecting bark having a moisture content of not substantially less than 30% nor more than 80%, based on the weight of the dry bark, grinding said bark to particles of varying size with the larger particles containing substantially all the cork content while at the same time disuniting some fiber aggregates into ultimate fibers, reducing the moisture content to not substantially less than about 10% nor more than 25% based on the weight of the dry bark, screening the ground bark to remove as overs a first fraction consisting primarily of cork and fiber aggregates, feeding the fines from said first screening operation to a second screen having mesh openings smaller than said first screen to obtain as overs a second fraction consisting primarily of fibers and some smaller particles of cork, subjecting said second fraction to a comminuting action of a type to differentially pulverize the cork particles and any non-fibrous phloem adhering to the fibers without substantial comminution of the ultimate fibers, and screening the comminuted second fraction to remove as overs a substantially pure fiber product.

2. The method of treating Douglas fir bark for the production of cork, fiber and a powder residue containing the non-fibrous phloem content, comprising the steps of selecting bark having a moisture content of not substantially less than

30% nor more than 80% based on the weight of the dry bark, grinding said bark to particle sizes which will pass through a screen with mesh size openings in the range of  $\frac{3}{4}$  to 1 inch thereby forming larger particle aggregates containing the cork and reducing some of the fiber content to ultimate fibers and the non-fibrous phloem to powder, reducing the moisture content of said ground bark to not substantially less than about 10% nor more than about 25% based on the weight of the dry bark, feeding said ground bark onto a screen having openings smaller than the lengths of most of the fibers but considerably larger than the thicknesses of said fibers, said screen having sufficient screen surface area and being operated under conditions such that the fibers are up-ended and passed through the screen, recovering as overs the larger particle aggregates containing the cork and fiber aggregates not disuniting by the first grinding action, feeding the fines from said first screening operation to a second screen having openings smaller than said first screen but larger than the thicknesses of the fibers, the size of the openings and the surface area and conditions of operation of said second screen being such that the fibers are substantially prevented from up-ending and passing therethrough, recovering as overs the fibers and smaller particles of cork, differentially comminuting said first fraction to disengage from the cork aggregates phloem material adhering thereto and to complete the disunification of the fiber bundles into ultimate fibers without substantial differential comminution of the cork, comminuting said second fraction to disengage any non-fibrous phloem adhering to the fibers and to finely comminute the cork particles without substantial comminution of the fibers, feeding the comminuted first fraction to a screen having sufficient screening surface area and being operated under conditions such that the fibers are up-ended and passed through the screen, recovering as overs a substantially pure cork product, feeding the comminuted second fraction to a screen having surface area and conditions of operation such that the fibers are substantially prevented from up-ending and passing therethrough, recovering as overs a substantially pure fiber product, and collecting a powder residue from the fines of said first and second fraction.

3. The method of treating bark containing cork, fiber and non-fibrous phloem components for the purpose of enabling segregation of said components, which comprises comminuting the bark at a high moisture content preliminarily to effecting the segregation of the cork content and a part of the fiber content in larger size particle aggregates, and the formation of smaller size particles comprised primarily of fibers and smaller fiber aggregates and some cork, and the formation of still smaller particles comprising primarily the non-fibrous phloem component, reducing the moisture content of the ground particles, separating from said ground material according to size and as separate fractions the larger size particles and the intermediate size particles, and separately and differentially comminuting said fractions at a reduced moisture content at which the cork particles are cleansed of adhering phloem constituents, the fiber aggregates are reduced to ultimate fiber particles and the non-fibrous phloem is pulverized to a powder.

4. The method of treating bark containing cork, fiber, and phloem constituents for the production of cork, fiber, and powder residue prod-

ucts therefrom, which comprises grinding bark having a moisture content of a value to promote comminution to an aggregate of bark matrices of not to exceed a predetermined size and consisting essentially of the several constituents of the whole bark, and providing an aggregate of bark matrices of not to exceed said predetermined size, adjusting the moisture content of the bark matrices to a value at which, in subsequent comminuting actions, a cleavage is effected between the several constituents of the bark disuniting fiber aggregates, cork and the non-fibrous portion of the phloem, segregating the ground bark according to size into a coarse first fraction comprising primarily cork and fiber aggregates, and a second fraction of smaller particle size comprising primarily fiber content, and subjecting said fractions to separate comminuting actions wherein the particles of said fractions are differentially pulverized to reduce to powder the non-fibrous portion of the phloem and to reduce the fiber aggregates to ultimate fibers without substantial comminution of the cork particles and individual fibers, for promoting selective segregation of the cork, ultimate fibers and a powder residue containing the non-fibrous phloem component.

5. The method of producing cork, fiber and a powder residue from the bark of a tree containing cork, fiber and phloem constituents comprising grinding said bark to provide an aggregate of bark matrices of not to exceed a predetermined size, adjusting the moisture content of the bark matrices to a value at which, in subsequent comminuting actions, a cleavage is effected between the several constituents of the bark, disuniting fiber bundles, cork and the non-fibrous portion of the phloem, segregating the ground bark according to size into a coarse first fraction comprising primarily cork and fiber aggregates, and a second fraction of smaller particle size comprising primarily fibers and smaller particles of cork, differentially comminuting the said first fraction to reduce the fiber bundles to ultimate fibers and cleanse any non-fibrous phloem from the cork and fiber particles without substantial comminution of the cork, differentially comminuting said second fraction to reduce the cork content to powder and to cleanse any non-fibrous phloem from the fiber particles without substantial comminution of the individual fibers, and selectively segregating the larger particles of cork, the ultimate fibers, and the finely comminuted powder.

6. The method of treating bark containing cork, fiber, and non-fibrous phloem constituents for the production therefrom of cork, ultimate fiber, and powder residue products which comprises grinding bark having a moisture content of not substantially less than 30% nor more than 80% based on the weight of the dry bark, and providing an aggregate of bark matrices of not to exceed a predetermined size and consisting essentially of the several constituents of the whole bark, adjusting the moisture content of the ground bark to a value not substantially less than about 10% nor more than about 25% based on the weight of the dry bark, segregating the ground bark according to size into a coarse first fraction comprising primarily cork aggregates and fiber bundles, and a second fraction of smaller particle size comprising primarily fibers and smaller cork particles, subjecting said first fraction to a rolling, beating action to complete the reduction of the fiber bundles to ultimate

fibers and the differential pulverization to a powder of any non-fibrous phloem adhering to said cork and fiber particles, subjecting said second fraction to a rolling, beating action to substantially reduce to a powder the cork particles and to differentially pulverize to a powder any non-fibrous phloem adhering to said fiber particles, and separating the larger cork particles, fiber particles and the powder residue into separate products.

7. The method of treating bark containing cork, fiber, and non-fibrous phloem constituents which comprises grinding bark having a moisture content of not substantially less than about 30% nor more than about 80% based on the weight of the dry bark, and providing an aggregate of bark matrices of not to exceed a predetermined size and consisting essentially of the several constituents of the whole bark, adjusting the moisture content of the ground bark to a value not substantially less than about 10% nor more than about 25% based on the weight of the dry bark, segregating the ground material according to size into a coarse first fraction comprising primarily cork and fiber bundles, and a second fraction of smaller particle size from the product as ground comprising primarily disuniting fibers, smaller fiber bundles, and some cork particles, subjecting said first and second fractions to separate, differential comminution treatments, said separate treatments being adjusted to individually correspond to the different physical characteristics of the different particle content of the two fractions to disunit the fiber bundles in said fractions and refine the cork and fiber particles to remove any adhering non-fibrous phloem, screening a substantially pure cork product from said first fraction, screening a second product of cork and fiber from said first fraction, screening a substantially pure ultimate fiber product from said second fraction, and collecting the fines from the final screening operation of each fraction as non-fibrous phloem powder.

8. The method of treating bark containing cork, fiber, and non-fibrous phloem for the production of cork, fiber and a powder residue, which comprises grinding bark having a moisture content of not substantially less than about 30% nor more than about 80% based on the weight of the dry bark to particle sizes which are adapted to pass through a screen with mesh size openings in the range from  $\frac{7}{16}$  to 1 inch, subjecting said ground bark in succession to a plurality of heated air streams under conditions where the ground bark is not heated above 300° F. in order to reduce the moisture content thereof to a value not substantially less than about 10% nor more than about 25% based on the weight of the dry bark, segregating the ground bark according to size into a first fraction comprising primarily cork and fiber aggregates, and a second fraction of smaller particle size consisting primarily of fibers and containing some smaller particles of cork, differentially comminuting said first fraction to disengage from the cork aggregates phloem material adhering thereto and to complete the disunification of the fiber aggregates into ultimate fibers without substantial comminution of the cork, differentially comminuting said second fraction to reduce the cork particles to powder and to disengage from the fibers any phloem material adhering thereto without substantial comminution of the ultimate fibers, screening a substantially pure cork prod-

uct from said first comminuted fraction, screening a substantially pure fiber fraction from said second comminuted fraction, and classifying the fines from said screening operations to produce a powdered residue product.

9. The method of treating bark containing cork, fiber, and non-fibrous phloem for the production therefrom of a relatively pure fiber product, which comprises comminuting the bark at a high moisture content at which the cork content is substantially segregated in the larger size particles and the fiber content is partially broken down into ultimate fibers, separating the ground bark according to size into a coarse first fraction comprising primarily cork and fiber aggregates, and a second fraction of smaller particle size consisting primarily of individual fiber particles and containing some smaller particles of cork; separately, differentially comminuting said second fraction to cleanse from the fiber particles any non-fibrous phloem adhering thereto and to finely comminute the smaller cork particles to a particle size smaller than the fibers, and screening from said material a substantially pure fiber product.

10. The method of treating bark containing cork, fiber, and phloem components to segregate the bark according to size into its separate tissue components, comprising grinding the bark to particle size not larger than a predetermined size at a moisture content between the limits of about 30% and about 80% on an oven dry basis, drying the ground bark to a moisture content between the limits of about 10% and about 25% by subjecting the bark to heated air in a plurality of drying steps and at temperatures and space area and volume such that the ground bark will not be heated above 300° F., segregating the ground bark according to size into a coarse first fraction comprising primarily cork and fiber aggregates and a second fraction of smaller particle size comprising primarily fiber and smaller cork particles, and separately, differentially comminuting each of said fractions, and separating therefrom a cork particle product, a fiber particle product, and a powder residue.

11. The method of treating bark to segregate the bark according to size into components of cork, fiber and non-fibrous phloem, comprising the steps of grinding bark having a moisture content of 30% to 80% on an oven dry basis, introducing the ground bark into a stream of heated air to remove a major portion of the moisture content and then into a second stream of heated air to finally reduce the moisture content to between the limits of about 10% to about 25%, the temperature of said air stream being less than 300° F., segregating the ground bark according to size into a coarse first fraction comprising primarily cork and fiber aggregates, and a second fraction of smaller particle size comprising primarily fiber and smaller cork particles, and separately, differentially comminuting each of said fractions, and separating therefrom a cork particle product, a fiber particle product, and a powder residue.

12. The method of treating bark having cork, fiber and non-fibrous phloem components, which comprises grinding bark having a moisture content of not substantially less than 30% nor more than 80% based on the weight of the dry bark, and providing particles of varying sizes with the larger particles being in the size range of the largest cork aggregates in the whole bark, reducing the moisture content of the bark particles to substantially not less than about 10 nor more than about 25% based on the weight of the dry bark under conditions where the ground bark will not be heated above 300° F., segregating the ground material according to size into a first coarse fraction comprising primarily cork particles and fiber bundles, and a second finer fraction comprising primarily fibers, comminuting said first fraction with a rolling, beating action to disengage any phloem constituents adhering to the cork particles and to complete the disunification of the fiber bundles to ultimate fibers, and comminuting said second fraction with a rolling, beating action to complete the pulverization to powder of any non-fibrous phloem adhering to said fibers and to finely comminute any cork particles in said fraction without substantial comminution of the fibers.

13. The method of treating bark containing at least three tissue components of cork, fiber, and non-fibrous phloem to segregate said components, comprising comminuting the bark at a high moisture content to effect a disunification of said components into particles of substantially unitary component composition, separating said comminuted bark according to particle size into three fractions, the first fraction being a coarse fraction comprising primarily cork and fiber aggregates, the second finer size fraction comprising primarily fibers and smaller cork particles, and the third fraction being a powder residue, and differentially comminuting the first and second fractions of larger particle sizes to separate the cork particles of adhering phloem constituents, to reduce the fiber aggregates to ultimate fiber particles, and to reduce the non-fibrous phloem to a powder.

14. The method defined in claim 13 in which the bark is Douglas fir bark.

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