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PRODUCTION OF PULP, ETC.

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This invention relates to improvements in the production of wood pulp from wood and similar cellulose-bearing materials, whereby materially increased yields of improved pulp can be obtained, and whereby woods which are ordinarily considered of little or no value for the production of pulp can be utilized for the production of high grade pulp.

The common methods of producing wood pulp chemically, are the so-called soda, sulfate and sulfite processes. In the so-called soda process, the main cooking operation is dependent upon caustic soda. In the so-called sulfate process the main cooking operation is dependent upon caustic soda assisted more or less by sodium sulfide, although some sodium carbonate and sodium sulfate may be present. In the so-called sulfite process the main cooking operation depends upon bisulfites in the presence of sulfurous acid. In the soda and sulfate processes, accordingly, the cooking liquor is strongly alkaline, while in the sulfite process the cooking liquor is strongly acid; and it has been considered impractical to cook wood successfully, for the production of chemical pulp, unless the cooking liquor was either strongly acid or strongly alkaline.

In all three of the processes mentioned, the cooking liquors employed act not only upon the encrusting and so-called non-cellulose constituents or so-called lignine or lignified tissues of the wood, but also to a greater or less extent upon the cellulose or pulp making fibres, and usually destroy or injure a considerable portion of the valuable fibres or cellulose, or convert an appreciable portion thereof into constituents which are removed from the pulp. Sometimes the residual liquors from the process are also of such a character that they leave in the pulp constituents which make the pulp difficult to bleach with the usual bleaching materials and operations, so that the fibres may be still further injured by the severe bleaching treatment which it is necessary to employ.

The rapidly decreasing supply of woods suitable and available for pulp making purposes and the high cost of equipment and operation of chemical pulp mills makes it of great national and economic importance to materially increase the yield of pulp from woods which are commonly used for the purpose, and to make available for pulp making purposes woods ordinarily considered of little or no value for the production of high grade pulp. Furthermore, if a sufficiently high yield of suitable pulp can be obtained by an economical chemical process, the necessity for making ground wood by utilizing a certain limited class of trees and using hydraulic power to grind such woods, is obviated, this making available a large amount of hydraulic power for other industrial uses. The pulp obtained by chemical methods of disintegrating wood, even those now employed, is far superior in quality, including strength, to that obtained by the ground wood process, and a much wider range of woods can be used.

As the result of our investigations, we have been impressed with the fact that a considerable portion of the pulp content of the wood treated was not being recovered in the form of pulp and we have therefore studied the cooking processes with the view of determining whether an increased yield of pulp could be obtained from the same amount of wood by other chemical methods than those heretofore employed.

In the course of our investigations, we modified the ordinary soda process by substituting neutral sodium sulfite for part of the caustic soda commonly employed, so that the cooking liquor was a composite cooking liquor containing both neutral sodium sulfite and caustic soda, for example, in equal proportions, and we found that an improved result was obtained as compared with the ordinary soda process.

In the course of our further investigations we omitted entirely the caustic soda from the cooking liquor in order to determine the effect of a neutral sodium sulfite liquor when used as the cooking liquor; and we have found that not only could a greatly increased yield of wood pulp be obtained, but that the resulting wood pulp was of a superior character. This discovery was the more surprising as it has heretofore been considered essential to

use either a strongly caustic or acidic liquor for producing pulp from wood by a chemical cooking treatment. Our investigations showed further that the neutral sodium sulfite cooking liquor had no such injurious action upon the desired pulp fibres as a strongly acid or strongly alkaline cooking liquor, and that, even when the amount of sodium sulfite employed was double the strength of the reagents commonly employed in other processes, there was no objectionable effect upon the fibres produced or the pulp yield.

Our investigations have also shown that there are greater or less differences in the various kinds of wood, but we have found that woods can be divided, generally, into three classes, namely, (1) those woods which contain little or no resinous constituents, such as poplar, birch, cotton wood, aspen, bass wood and similar woods; (2) woods which contain moderate amounts of resinous constituents, such as spruce, fir, hemlock, balsam and the like; and (3) woods which contain relatively large amounts of such constituents such as Georgia pine, white pine, jack pine, long leaf pine and other similar pines.

We have found that woods of the first class can be treated in a satisfactory and advantageous way with the normal sodium sulfite cooking liquor alone, and without the addition of caustic soda, inasmuch as such woods contain little or no resinous or other constituents, other than the fibres themselves, which are not acted upon by the hot solutions of sodium sulfite. For cooking woods of the second class we have found it advantageous in some cases to use a small or moderate amount of caustic alkali, e. g., sodium hydroxide, near the end of the cook, in addition to the required amount of normal sodium sulfite. We have found that a moderate amount of caustic alkali is of great assistance near the end of the cook in removing or dissolving certain constituents, such as resinous constituents, associated with the fibres, but that the amount of caustic alkali required for this purpose is sufficiently small so that there is substantially no injurious action upon the yield of the fibres. In treating woods of the third class, we have found it advantageous to add an amount of caustic alkali, near the end of the cook, somewhat greater than that required for a corresponding amount of the woods of the second class; but that the amount of caustic alkali required in this case is such that good results can be obtained without materially injuring the yield of fibre or its quality.

The present invention is based upon the discoveries above mentioned, and involves the cooking of the wood chips with a cooking liquor consisting essentially of a solution of a normal alkali sulfite, at a suitable temperature and pressure, for example, corresponding to saturated steam at 60 to 180 pounds per square inch, whereby the cooking operation is carried out without any objectionable injury to the fibres and with the production of an increased yield of superior pulp.

If wood chips are cooked under pressure with water alone, for example, at about 120 pounds per square inch of saturated steam pressure, more or less disintegration of the wood takes place and considerable amounts of organic matter are found in the solution at the end of say 4 or 5 hours treatment at such temperature and pressure; and the solution is acid in reaction to litmus. If wood chips are cooked with only a small amount of sodium sulfite, we have found that the liquor will also become acid during the cooking operation and a satisfactory pulp will not be produced without subsequent treatment; but we have found that if a sufficient amount of sodium sulfite is present during the cooking operation, a satisfactory pulp can be readily produced. The sodium sulfite appears to combine with the constituents which otherwise would give an acid reaction, thus preventing the development of an acid condition during the cooking operation. The amount of sodium sulfite required varies somewhat with different woods but a minimum of at least about 30% seems necessary with most woods, and with some woods a minimum of at least about 35% or somewhat more appears necessary. For example, in treating old poplar wood containing about 20% of water, we have found that an amount of sodium sulfite corresponding to about 12 or 15 or even 20% of the air-dried weight of the wood (i. e. wood containing 10% of water) did not completely cook the chips and gave a residual liquor acid in reaction; while with about 25% of the normal sodium sulfite based on the air-dried weight of the wood the liquor was about neutral; and with 30% or more of sodium sulfite no difficulty was had in obtaining a satisfactory pulp and avoiding an acid reaction in the cooking liquor. We have increased the amount of sodium sulfite up to as high as 45 and 50% of the air-dried weight of the wood and have found that even such excessive amounts of sodium sulfite did not injure the fibres although there appeared to be no advantage in using such an excess in the process.

We have found the following percentages of sodium sulfite to give good results with the woods indicated, the percentages being by weight and based upon the air-dried weight of the wood:

	Per cent
Old poplar	30 to 35
Old birch	30 to 40
New poplar or birch	30 to 40
Pine or spruce	35 to 45
Hemlock	30 to 40

It is one advantage of the present process

that an amount of the sodium sulfite can be used considerably in excess of the amount actually required, since such an excess does not have injurious action upon the fibres. It is possible, accordingly, to use a more concentrated cooking liquor without injury to the fibres due to the concentration.

In carrying out the present process, digesters of iron or steel are well adapted for use, as the cooking liquor employed is inert to these materials. It is unnecessary to provide the digesters with an acid-resisting lining, such as is now commonly provided in digesters used in the sulfite process, and, where the digesters contain such a lining, it can be removed, thus correspondingly increasing the capacity of the digester.

The normal sodium sulfite utilized in the present process, can be obtained from any suitable source of supply. It is an advantage of the process that the sodium content can be recovered if desired from the residual liquors for reuse, thus eliminating the necessity for a continued fresh supply of this material other than that required to make up for losses.

With woods such as poplar, birch and hemlock, the entire cooking operation can be carried out with the normal sodium sulfite cooking liquor and without the presence of caustic soda either during or near the end of the cooking operation. With resinous woods such as spruce and pine the normal sodium sulfite cooking liquor will remove the greater part of the non-fibrous constituents but it leaves certain of the resinous and similar constituents with the fibres. For some purposes the presence of such constituents in the resulting pulp may be unobjectionable, or even advantageous, as they may supply a certain amount of sizing; but the pulps containing such resinous constituents are darker in color, and, for many purposes, are less valuable than with the resinous constituents removed. We have found that such resinous constituents can be readily removed by the use of a small amount of caustic soda near the end of the cooking operation, that is, after the main portion of the cooking operation has been carried out with the normal sodium sulfite cooking liquor. If the caustic soda is added at the beginning of the process, a darker pulp and residual liquor, are obtained, and the presence of caustic alkali during the early portion of the cooking seems to be without advantage and even objectionable in some cases, although a small amount of caustic alkali can be tolerated. But we have found that if the caustic alkali is used after the wood has been subjected to the action of the normal sodium sulfite cooking liquor, it will act upon the remaining portions of the wood and will free the fibres from the resinous constituents which the sulfite liquor itself has not removed. By carrying out a two-stage cook of this character, accordingly, we have found it possible to produce a light colored and easily bleachable pulp with the use of only a small amount of caustic soda added near the end of the cooking operation or utilized as a subsequent cooking liquor after the residual liquor from the sodium sulfite cook has been removed.

Resinous woods can also be subjected to a cooking operation with a normal sodium sulfite cooking liquor until the cooking operation is nearly finished, the charge can then be blown from the digester and screened and the screenings treated with dilute caustic soda solution or the pulp can be washed with dilute caustic soda solution to remove resinous constituents which have not been acted upon and removed by the sodium sulfite cooking liquor.

The knots in coniferous woods, which frequently give difficulty in the ordinary acid sulfite process do not appear to interfere in the carrying out of the present process and they are acted upon in much the same manner as the other parts of the wood so that a substantially uniform pulp is produced. The process of the present invention therefore presents the advantage of producing pulp from knots of spruce and other woods.

The cooking operation of the present invention is carried out at an elevated temperature and under a high pressure. For example, the digester can advantageously be heated by direct steam at a steam pressure varying from about 110 to 140 pounds and for a suitable period of time, e. g., from 10 to 3 hours, to bring about the desired separation of the fibres and the setting free of the non-fibrous constituents therefrom.

During the carrying out of the digestion, when resinous woods are treated, the turpentine can be removed from the digester by "bleeding" the digester, that is, by permitting part of the gases to escape from the digester at successive time intervals. The cooking operation can be somewhat hastened by using higher temperatures and it is an advantage of the present process that it permits higher temperatures to be used without objectionable injury to the resulting fibres. For example, at temperatures corresponding to steam pressures approaching 140 pounds, e. g., between 130 and 140 pounds, the time required for the cooking operation can be reduced to around 3 hours or somewhat more, thus greatly increasing the number of cooks which can be completed in a single digester per day, and correspondingly increasing the output of the plant. Pressures materially in excess of 140 pounds may also be used, e. g., saturated steam pressures up to around 180 pounds, as hereinbefore pointed out.

The present process also makes more feas-

ible the cooking of mixed wood, that is, mixtures of different woods of a like character at the same time, as prolonged cooking of one of the woods until the other wood is sufficiently cooked does not injure the fibre.

The cooking process of the present invention seems comparable to an extraction process in which the non-fibrous constituents of the wood are extracted without objectionable action or injury to the fibres, so that the fibres are obtained in a substantially uninjured condition.

The fibres produced by the present process have the appearance and structure of uninjured fibres. The fibres thus have a characteristic sheen or silky appearance much like that of the original wood. The pulp may therefore be considered to contain practically all of the fibres of the original wood freed from non-fibrous substance and in a substantially uninjured condition.

The yield of pulp obtained by the process of the present invention is also radically higher than is commonly obtained by the ordinary chemical pulp methods. We have found that the yield of pulp can be increased as much as 25% to 40% over that commonly obtained, for example, by the ordinary soda process from poplar wood. We have found that the ordinary yields of, for example, 38 to 45% of pulp from poplar wood can be increased to as high as 60% or higher of pulp, figuring the pulp on an air-dried basis, (i. e. 10% of H_2O). We have also found that a greatly increased yield can be obtained in the case of spruce wood and pine wood, when treated by the present invention, as compared, for example, with the ordinary sulfite process. With old poplar wood, we have obtained a yield of around 61% of pulp based on the air-dried weight and using an amount of sodium sulfite equal to 30% of the weight of the air-dried wood and we have obtained the same yield with an amount of sodium sulfite equal to 50% of the air-dried wood; with hemlock we have obtained a yield of pulp equal to about 50% on the air-dried basis; with new poplar wood, a yield of about 67%; and with new birch, a yield of about 60%. It is one advantage of our process that heavy woods, such as birch, beech, locust, southern pine, tamarack, etc., give more pulp per cord and per digester charge than do the lighter woods so that a correspondingly less amount of liquor and less steam can be safely used than with the caustic soda and sulfate processes.

The pulp produced by the present invention is different in character from the pulp commonly rpoduced by the present methods in that the fibres are obtained in a substantially uninjured condition, and we according regard the pulp as a new and improved pulp. It contains long fibres possessing great strength. Georgia pine wood, spruce and hemlock for examples, when treated according to the present invention, and after bleaching, yielded an excellent snow-white fibre of great strength and beautiful lustre.

Inasmuch as different woods differ in their fibrous structures, it will be evident that the pulps produced therefrom will differ somewhat from each other. The process of the present invention accordingly will give different kinds of pulp with different kinds of fibres, each fibre being more or less characteristic of the wood from which it is produced.

Owing to the differences in the pulp itself, it is possible to use the pulp for purposes for which pulp from the same kinds of wood could not heretofore be used. For example, it is customary in the art to mix the short fiber pulp made from poplar wood by the soda process with the long fibre pulp made from spruce by the so-called sulfite process, in order to obtain a paper of suitable strength. The present invention, however, makes possible the production of a stronger paper from poplar fibres (made by treating poplar wood according to the present invention) that has heretofore been commonly made from a mixture of poplar fibres made by the soda process, and spruce fibres made by the so-called sulfite process. In other words, the present invention gives a pulp from short fibre wood such as poplar which possesses many of the properties of pulp heretofore made from long fibre wood. The present invention accordingly makes possible the production of a strong paper from poplar pulp without the necessity of obtaining and admixing long fibred pulp.

The present invention is also applicable to the production of a high quality of pulp from various species of wood which heretofore have been considered of little or no value for the manufacture of high grade pulp. In particular, we have found that resinous woods, such as pine wood, can be advantageously treated by our improved process without difficulty arising from the resinous constituents which the wood contains, particularly if a small amount of caustic alkali is used during the latter part of the cooking operation. In general our new process is applicable to the various woods now commonly treated for the manufacture of pulp and in addition to the treatment of other woods, both coniferous and deciduous, which heretofore have not been considered available for the production of high grade pulp.

We have found further that the residual liquors obtained from one cook can be used over again, with the addition thereto of a further amount of sodium sulfite, for cooking a further charge of wood. In fact, we have successfully used the same cooking liquor in this way, with additions of sodium sulfite before each successive use of the liquor, for as many

as five successive charges. The present process, accordingly, is well adapted for use in a plant having a series of digesters and with the treatment of successive charges with the same cooking liquor, with suitable additions of sodium sulfite thereto. This repeated use of the cooking liquor, with suitable additions of sodium sulfite, can also be used to advantage in two-stage cooks where the first part of the cook is carried out with the sodium sulfite liquor which is then removed, and the last part of the cook is carried out with a liquor containing a small amount of caustic soda. The liquor from the first stage of the cook can be transferred to the next digester, with added amounts of sodium sulfite, and used therein as the cooking liquor during the first stage; while the second stage of the cook in each digester will be carried out with the special cooking liquor containing a small amount of caustic soda.

The residual liquors produced by the present process are of characteristic composition and properties and different in color, consistency, composition, reaction with acids, etc., from the residual liquors from the soda or sulfite or sulfate processes, when the like kinds of woods are treated. They are free, or substantially so, from the products of degradation of cellulose, inasmuch as the cellulose of the fibres is little, if any, acted upon by the present process. The residual liquors are usually of a mahogany color which may vary in intensity. In consistency, they are thinner than the so-called "black liquors" from the soda and sulfate processes. When the residual liquors, for example, from poplar wood, are treated with acids, to give an acid reaction, the color is discharged, although the color is again developed or restored on again making the liquor alkaline in reaction. The acidified residual liquor can be filtered and will then contain less organic matter than the corresponding black liquor from the soda process. The organic constituents of the residual liquors differ somewhat, according to the wood treated. With different woods treated, accordingly we obtain somewhat different characters of by-products, and of precipitated matter upon acidification. It will thus be evident that different by-products can be obtained from the residual liquors resulting from the treatment of different woods, and that the residual liquors can be treated according to various methods of treatment for the recovery of these by-products. The residual liquors can advantageously be treated for the regeneration of the sodium sulfite, for further use in the process.

When the same liquor is used repeatedly for successive cooking operations, with successive additions of sodium sulfite thereto before each successive cook, the amount of dissolved matter in the liquor will be greatly increased until finally the liquor becomes practically saturated. The resulting liquor will be of a much more concentrated character and will be correspondingly more valuable, for example, for recovering the by-products or sodium sulfite therefrom, inasmuch as there is less water present and less liquor to evaporate or to handle.

The present invention will be further illustrated by the following more detailed description of certain specific applications thereof:

Poplar wood which has been partly dried or seasoned and from which the bark has been removed, and is as free as practicable from cinders, sand and other dirt and fungus, is chipped or broken into pieces about three-eighths of an inch to an inch long, the chips are screened to remove sawdust and fine dirt and the screened chips are conveyed to the chip storage bin from which they are fed to the digester. The water content of the chips should be fairly uniform but it may range in practice up to about 30 percent or more.

A suitable digester is one made of iron construction, and unlined, and of a stationary vertical type, a welded digester being preferred to a riveted digester. The digester is preferably covered with a non-conductor or heat insulating material for the purpose of conserving heat. Digesters of various sizes can be used, varying in height from 15 to 50 feet or even more, and in diameter from 4 to 18 feet or even more. The digester should be provided with an opening at the top for charging which can be closed and which is able to withstand the pressures developed during the cooking process. The discharge outlet at the bottom of the digester should also be provided with a valve or closure of proper strength and construction to withstand the pressure developed during the cooking and to permit the discharge of the cooked chips at the completion of the cooking operation. The digester may be provided with a false bottom and with inlet and outlet connections, valves, etc. and may advantageously have a suitable vertical pipe arranged therein through which the cooking liquor may be circulated. The discharge pipe or outlet from the bottom of the digester delivers the cooked chips to a blow-pit usually situated at a level above that of the vats or other washing tanks in which the residual liquor is separated from the pulp and wherein the pulp is washed, so that the chips can be forced from the digester, at the end of the cook, by means of the residual pressure in the digester. The cooking liquor can be supplied from a suitable storage tank therefor.

For a digester of about 8 feet in diameter and 25 feet high, about 4,000 gallons or more of a suitable cooking liquor may be used for cooking a digester full of the poplar chips, the liquor containing an amount of normal sodium sulfite equal to about 35 to 40% of

the air-dried weight of the wood. The chips may be charged into the digester while it is still hot from the previous cooking operation, or the liquor and chips can be run together into the digester simultaneously. When sufficient chips and liquor have been run in to permit the establishment of the circulation of liquor, steam can be turned on both below the main body of chips and so as to direct the liquor upward through the circulating pipe so that circulation of the liquor is established and maintained while the chips are being run into the digester. When the digester has been filled and closed, it is then brought up to temperature and pressure as rapidly as practical, using direct steam. The temperature and pressure are thereafter maintained fairly constant, for example, at pressure of about 120 pounds per square inch, until the cooking operation is finished. The time required to bring the digester to the desired temperature and pressure may be, for example, about one or two hours, and the cooking operation may require from four to six hours at pressure for its completion, although a longer or shorter period may be used. So also, the amount of sodium sulfite may be somewhat increased or decreased from that above indicated, since even a large excess does not injure the pulp. So also, different pressures may be used, e. g., from about 110 to about 140 pounds per square inch, with a corresponding temperature (that is, the pressure will depend upon the temperature of the steam or water within the digester).

In order to promote circulation during the process of the digestion, it may be necessary or advantageous to relieve the internal pressure of the digester somewhat for a short period. This relief can be accomplished by opening a valve in the pipe line leading from the top of the digester to the blow pit. When a suitable reduction in pressure has been obtained, the valve is again closed and circulation of the cooking liquor within the digester continues, steam being fed in partly for this purpose.

When the cooking operation has been finished, the steam feed pipe is shut off and the pressure may be reduced to the proper point, for example, 75 pounds per square inch, or even more and the valve in the pipe leading from the bottom of the digester to the blow pit is then opened and the cooked chips and liquor are forced by the remaining pressure through said discharge pipe from the digester to the blow pit, this operation breaking up the cooked chips into pulp. The pulp and residual liquor can then be run into vats or tanks and the residual liquor separated more or less from the pulp, the pulp then washed in the usual way, and the washed pulp then subjected to further treatment such as is customary in the art.

The residual liquors can be separately treated for the production of further amounts of cooking liquor therefrom.

We have found that a more concentrated cooking liquor can be employed without objectionable injury to the pulp, so that a small volume of cooking liquor can be used. For example, the concentration of the sodium sulfite may be as high as 200 grams per liter and a reduced amount of liquor may be used for a given amount of chips, for example, poplar chips. The cooking may be carried out by heating under pressure to a temperature corresponding to a saturated steam pressure of about 120 pounds per square inch, either by direct introduction of steam, or by indirect heating and circulation of the liquor by means of pumps so that the cooking liquor is heated by a suitable heater outside the digester and circulated through the digester, preferably so that the cooking liquor is spread out at the top of the digester and caused to percolate down through and around the chips. In this way the chips can be cooked without being completely submerged; while the nature of the cooking liquor enables it to be handled by pumps at high temperatures and pressures. Also, with circulation of this kind the composition of the liquor can be changed during the cooking operation.

In treating woods of the second class above described, for example, spruce wood, the woods can be treated in a similar manner to that above described, except that it is advantageous to add a moderate amount of caustic soda to the normal sodium sulfite cooking liquor during the latter part of the cook, so that the fibres may be readily separated from resinous and similar ingredients. Care should, however, be taken not to use too much caustic soda as this will injure the fibres and decrease the yield. The spruce wood may be prepared in the customary manner, but it is unnecessary to remove knots from the wood before chipping as knots can be successfully handled in the process of the present invention.

Woods of the third class above described can be treated in a similar manner except that a somewhat larger amount of caustic soda is advantageously added near the end of the cook, on account of the greater percentage which these woods contain of resinous and other ingredients which are removed only with difficulty by a sodium sulfite cooking liquor alone.

For example, in treating highly resinous Georgia pine, which has been air seasoned, the wood can be freed from bark and chipped and the chips cooked in a digester for a suitable period (for example, about 4 hours or more) at a temperature corresponding to a saturated steam pressure of about 120 pounds per square inch, using a cooking liquor containing an amount of normal sodium sulfite

equal to about 35 to 40% of the weight of the wood (figured on an air-dried basis); then removing the larger portion of the cooking liquor from the digester, and introducing a further amount of cooking liquor containing a few percent of caustic soda (e. g., 3 to 10%) in addition to the sodium sulfite (e. g., 20 to 25%) and cooking the chips at a temperature corresponding to a saturated steam pressure of about 120 pounds per square inch for an additional period of about 4 hours. By proceeding in this way, the highly resinous pine wood can be thoroughly cooked and the cooked wood readily and easily pulped. The second residual liquor, obtained at the end of the cooking, is more saponaceous in character and of a dark mahogany color. The pulp of fibre is of a grayish color but is readily bleached to give a brilliant white pulp with exceptionally strong fibres which show under the microscope that they retain their characteristic markings to a high degree. The bleached pulp has a lustre or sheen such as that possessed by the freshly broken chips, thus indicating little, if any, damage to the fibres. A high yield of pulp is also obtained.

It will thus be seen that the present invention includes a new method of cooking wood for the production of pulp therefrom without objectionable injury to the cellulose fibres, so that an increased yield of a new and improved pulp is obtained, which will differ somewhat with different woods treated, and that the process is of more or less general application to the treatment of coniferous and deciduous woods such as poplar, spruce, balsam, hemlock, pines, birch, basswood, beech, maple, etc. It will also be seen that the process of the present invention requires few changes in existing mills for its installation. Sulfite mills, so-called, can be greatly simplified, and the capacity of the digester increased by the elimination and removal of the lining therefrom, and by the fact that sulfurous acid recovery systems, such as are usually employed, are not required.

It will be evident that the present invention presents many advantages. Among these advantages may be briefly mentioned the following: The cooking liquors can be prepared and the residual liquors obtained economically; objectionable odors such as are produced by the sulfate process are avoided; digester linings, such as are commonly used in the so-called sulfite process, are not required, and can be removed, thus increasing the effective size of the digester and materially increasing its capacity; the pulp produced contains the fibres of the wood in a practically unchanged condition except for the removal of encrusting and non-fibrous constituents therefrom; the yield of pulp is very materially increased, while the residual liquors produced have a correspondingly reduced content of wood constituents; the pulps, especially those from pines, can be advantageously bleached by a mixture of hypochlorites and permanganates; the residual liquors can be advantageously treated for the regeneration or production of cooking liquor for reuse in the further carrying out of the process; and the cooking liquor is of more or less universal application to the treatment of various different kinds of wood.

We claim:—

1. The method of producing wood pulp from resinous wood, which comprises subjecting the wood to a cooking operation at a pressure of around 110 to 140 pounds per square inch and at a corresponding temperature with a cooking liquor containing an amount of normal sodium sulfite equal to at least about 30 to 35% of the weight of the wood (figured on an air-dried basis).

2. The method of producing wood pulp from resinous wood, which comprises subjecting the wood to a cooking operation under pressure and at a temperature corresponding to a saturated steam pressure of about 100 pounds or higher per square inch with a cooking liquor consisting essentially of a solution of sodium sulfite, the amount of sodium sulfite (Na_2SO_3) being in excess of about 30 per cent of the air dried weight of the wood.

3. The method of producing wood pulp from wood, which comprises partially cooking the wood with a cooking liquor consisting essentially of a normal sulfite and completing the cooking operation with the addition of caustic alkali.

4. The method of producing wood pulp from wood, which comprises subjecting the wood to a cooking operation under pressure and at an elevated temperature with a cooking liquor containing sodium sulfite, subsequently adding an alkali to the liquor and completing the cooking operation.

5. The method of producing wood pulp from wood containing resinous constituents, which comprises cooking the wood under pressure and at an elevated temperature with a cooking liquor, consisting essentially of a solution of normal sodium sulfite and containing sufficient sulfite to prevent the liquor from becoming and remaining acid and thereafter completing the cooking operation with a cooking liquor containing a small amount of caustic alkali, the amount of caustic alkali being sufficient to complete the removal of the non-fibrous constitutents from the fibres.

6. The method of producing wood pulp from wood, which comprises subjecting the wood to a cooking operation with a cooking liquor consisting essentially of a solution of a normal alkali sulfite, removing residual liquor from such cooking operation, adding

a further amount of a cooking liquor containing a normal alkali sulfite and caustic alkali and completing the cooking operation.

7. The method of cooking wood chips and knots of resinous woods simultaneously, which comprises subjecting them to a cooking operation under a temperature corresponding to a saturated steam pressure of more than 100 pounds with a non-acid cooking liquor containing essentially a normal alkali metal sulfite, the amount of alkali sulfite, expressed as Na_2SO_3, being more than 30 per cent and less than 50 per cent of the air dried weight of the wood.

8. The method of producing wood pulp from resinous wood which comprises subjecting the wood to a cooking operation at a temperature corresponding to a steam pressure in excess of 100 pounds, with a cooking liquor containing a normal alkali sulfite, expressed as Na_2SO_3, amounting to around 30 to 50% of the air dried weight of the wood.

9. The method of producing wood pulp from resinous wood which comprises subjecting the wood to a cooking operation at a temperature corresponding to a steam pressure in excess of 110 pounds, with a cooking liquor containing a normal alkali sulfite, expressed as Na_2SO_3, amounting to around 30 to 50% of the air dried weight of the wood.

10. The method of producing wood pulp from resinous wood which comprises subjecting the wood to a cooking operation at a temperature corresponding to a steam pressure of 120 pounds or higher, with a cooking liquor containing a normal alkali sulfite, expressed as Na_2SO_3, amounting to around 30 to 50% of the air dried weight of the wood.

11. The method of producing wood pulp from resinous wood which comprises subjecting the wood to a cooking operation at a temperature corresponding to a steam pressure around 130 to 140 pounds, with a cooking liquor containing a normal alkali sulfite, expressed as Na_2SO_3, amounting to around 30 to 50% of the air dried weight of the wood.

12. The method of producing resinous wood pulp from wood which comprises subjecting the wood to a cooking operation under pressure and at an elevated temperature with a cooking liquor containing essentially a normal alkali sulfite, the composition of the liquor being such as to avoid any strong alkaline reaction during the first part of the cooking operation and to avoid any acid reaction during the latter part of the cooking operation, the internal pressure of the digester being relieved for one or more short periods during the digestion, and volatile resinous constituents being thereby removed from the digester.

13. The method of producing wood pulp from wood which comprises subjecting the wood to a cooking operation at a temperature corresponding to a saturated steam pressure in excess of 100 pounds with a cooking liquor containing essentially a normal alkali sulfite, partially reducing the pressure in the digester at the end of the cooking operation, and then blowing the digester.

14. The method of producing wood pulp from wood which comprises subjecting the wood to a cooking operation under pressure and at an elevated temperature with a composite cooking liquor made up in part of residual liquor from the cooking of wood with a normal sodium sulfite cooking liquor and having added amounts of sodium sulfite combined therewith.

15. The method of producing wood pulp from wood which comprises subjecting the wood to a cooking operation under pressure and at an elevated temperature with a cooking liquor containing essentially normal sodium sulfite, the concentration of the sodium sulfite in the liquor being from about 100 to 200 grams per liter.

16. The method of producing wood pulp from heavy woods, materially heavier than poplar, which comprises subjecting a digester charge of such heavy wood to a cooking operation under pressure and at an elevated temperature with a cooking liquor containing a normal alkali sulfite in amount around 30 to 40% of the air dried weight of the wood, the liquor containing in excess of 100 grams per liter of the sulfite.

17. The method of producing wood pulp from resinous wood which comprises subjecting the wood to a cooking operation at a temperature corresponding to a steam pressure in excess of about 110 pounds, with a cooking liquor containing around 35 to 45 per cent sodium sulfite (Na_2SO_3) on the air dried weight of the wood.

18. The method of producing wood pulp from resinous wood which comprises digesting the wood with a liquor containing soluble monosulfite as substantially the only digesting reagent, the quantity of monosulfite used being sufficient to continue the cook and the cook being continued until encrusting materials have been dissolved and disintegrated and separable wood fibers characterized by extraordinary strength, flexibility, felting and bleaching qualities have been produced substantially as described.

19. The method of producing wood pulp from resinous wood which comprises digesting the wood with a liquor containing sodium monosulfite as substantially the only digesting reagent, the quantity of monosulfite used being sufficient to continue the cook and the cook being continued until encrusting materials have been dissolved and disintegrated and separable wood fibers characterized by extraordinary strength, flexibility, felting

and bleaching quality have been produced substantially as described.

20. The process of producing chemical pulp from wood which comprises cooking the wood with a liquor containing essentially sodium monosulfite in the form of a liquor containing in excess of about 80 grams per liter of sodium monosulfite, the amount of liquor employed being sufficient to leave an excess of sodium monosulfite in the liquor at the end of the digestion.

In testimony whereof we affix our signatures.

LINN BRADLEY.
EDWARD P. McKEEFE.