F. F. STRONG.

PROCESS OF CONVERTING FIBROUS PLANTS INTO TEXTILE FIBER AND PULP.

APPLICATION FILED JUNE 10, 1910.

1,005,354.

Patented Oct. 10, 1911.

2 SHEETS—SHEET 1.

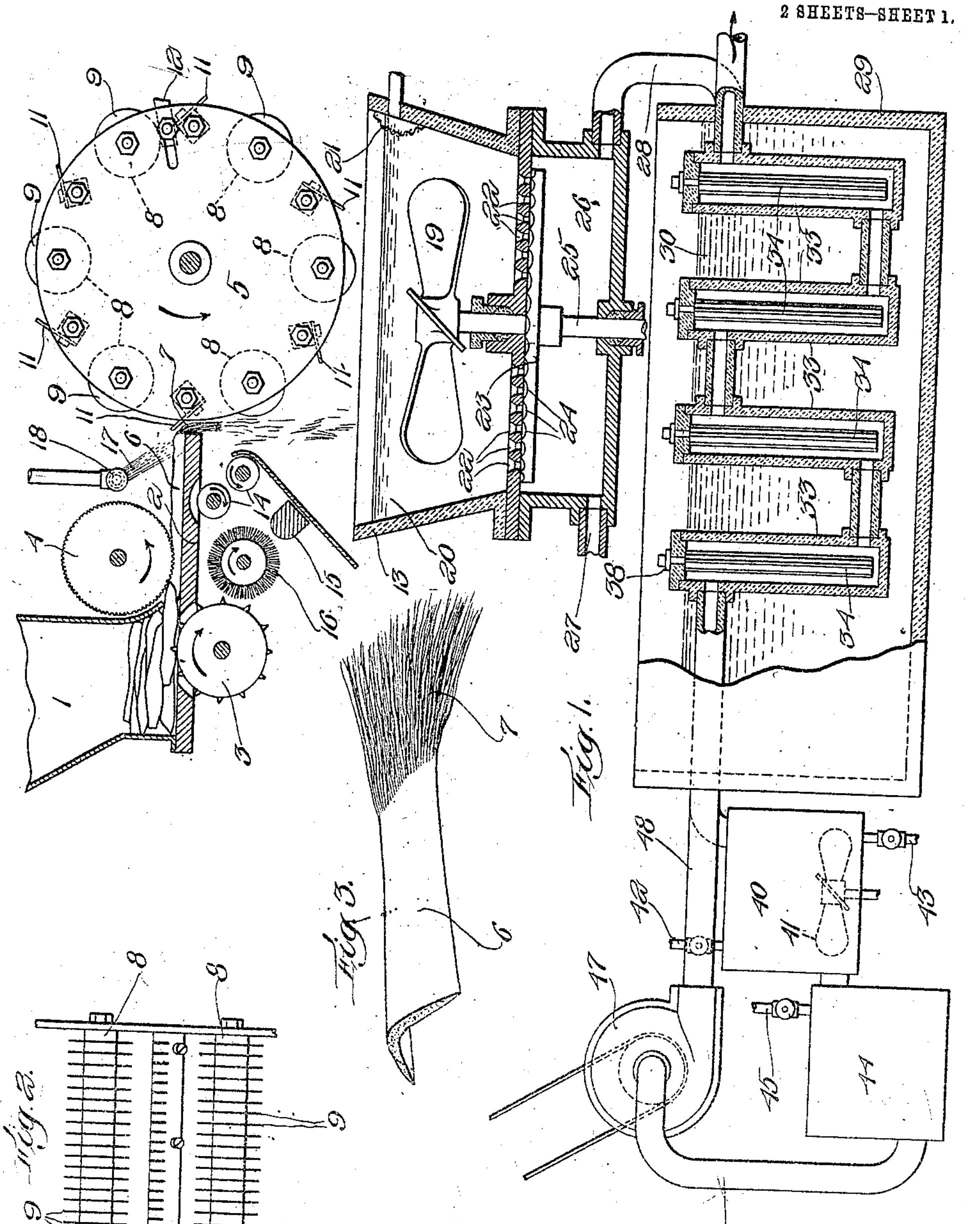

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Fig. 4.

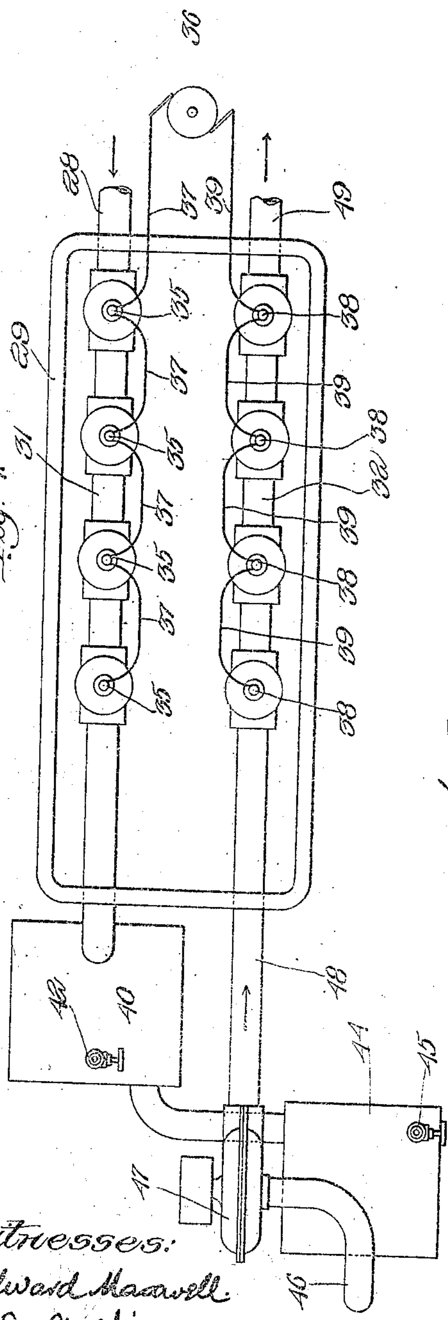


Fig. 6.

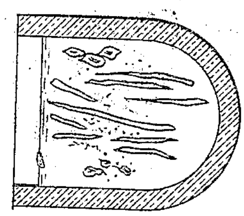
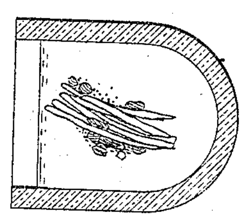


Fig. 5.



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UNITED STATES PATENT OFFICE.

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PROCESS OF CONVERTING FIBROUS PLANTS INTO TEXTILE FIBER AND PULP.

1,005,354. Specification of Letters Patent. Patented Oct. 10, 1911.

Application filed June 10, 1910. Serial No. 566,220.

To all whom it may concern:

Be it known that I, FREDERICK F. STRONG, a citizen of the United States, and resident of St. Petersburg, in the county of Hillsboro and State of Florida, have invented an Improvement in Processes of Converting Fibrous Plants Into Textile Fiber and Pulp, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

In the tropics there is a vast amount of unutilized fibrous material, which it is the object of my present invention to make practically available for the manufacture of paper, textiles, artificial hard rubber, artificial ivory, vulcanized fiber, etc.

While my invention is not limited to the utilization of the fibrous plants of the tropics, but can be applied to various other approximately similar plants and growths, it is particularly intended for the production of crude paper pulp, textile and cordage fiber, etc., from the leaves, leaf-stalks, stem-sheaths, trunk-wood, and roots of such practically inexhaustible sources of supply as the cabbage palm or palmetto tree, the saw palmetto or scrub palmetto, the everglade saw-grass (which at present are not used at all); the century plant, the plantains, New Zealand flax, Adam's needle, Spanish bayonet (at present used only for coarse cordage fiber); the pineapple and the banana (at present grown for their fruit but otherwise not put to use). I have succeeded in developing the hereinafter described mechanical and chemical process whereby the somewhat coarse natural fibers of the plants are easily broken up into fine white fibers suitable even for spinning into fabric having the wearing qualities of linen and the luster of silk, and the cellular tissue is converted into a valuable pulp-product from which tough paper may be produced, as well as other articles hereinafter mentioned. All these trees and plants contain long parallel fibers or bundles of fibers running continuously from root through trunk, leaf-stalk, and leaf, the large stalk bundles in some cases separating in the leaf into radiating smaller bundles, and it is one object of my process to isolate these fibers without breaking them or lessening their strength. These fibers in their natural state are contained in masses of pulp cells or parenchyma containing green chlorophyl granules and cellular skins or laminæ of a tough and dense character, bound together by natural cementives.

My invention has for one object the dissecting or separation of the fibers mechanically so as to avoid slow rotting and weakening processes (my process preserving all the natural strength of the fibers), and the separation of the pulp-material in such a way as not to completely remove the natural resins (leaving the latter in proper amount to self-size the paper, etc.), and to bleach and treat this pulp-material without subjecting the same to the usual strong chemicals and severe action which, in the case of sulfite pulp as commonly made, tends to weaken the fiber.

The details of my invention will be more readily and fully understood with reference to the accompanying drawings illustrative of a preferred mechanism for carrying out the process.

In the drawings, Figure 1 is a vertical longitudinal sectional view of the entire apparatus, parts being in side elevation and parts being broken away for clearness of illustration; Fig. 2 is an enlarged detail in front elevation of the dissector wheel; Fig. 3 is a perspective view of a leaf-stalk showing the fibers thereof mechanically dissected by my process; Fig. 4 is a top plan view of the electrolytic portion of the apparatus; and Figs. 5 and 6 are views to illustrate the cathodic electrolytic action which presumably takes place on a bundle of fibers and tissue as seen under a microscope, Fig. 5 showing the bundle before the action of the current and Fig. 6 during said action.

In handling the plants by my process, the raw material (leaves and stalks) is brought to the mill in large low-draft scows, from which it is automatically discharged over a low breakwater into a collecting pool of salt water. Thence the material is lifted by any suitable means, as by a belt conveyer, to a hopper 1 whose bottom extends forward to constitute a table 2 along which the fibrous material is fed endwise by a spiked or toothed feed drum or roll 3 beneath a compressing feed wheel 4 to a dissector wheel 5.

While various mechanisms may be provided for accomplishing the dissecting action of the plant fiber, and therefore the particular form of dissector herein shown is not essential, it is essential that the dissecting step in the process shall be fully and clearly understood, as I regard the same as one of the most important features of the invention. Instead of rotting or otherwise chemically disintegrating or partially disintegrating the plant fiber, it is treated in its natural state, as indicated for instance at 6, Fig. 3, being fed endwise to a whipping, slitting, combing, rubbing, and washing device, with the result that the pulp tissue is mechanically removed from about the individual fibers, leaving the latter projecting like a fringe, as shown at 7, Fig. 3. As the plant, stalk, leaf, or other raw material 6 is in its natural state, the result is that the fibers are not weakened but retain their natural strength, length, and structure. I regard the cleaning of the fibers mechanically, as distinguished from a rotting process or chemical action, as an important feature of novelty of my invention. To accomplish this, the stalk 6 is slitted lengthwise with a multitude of parallel slits made therethrough dissimultaneously, a few at a time in such number that there is no liability of tearing or breaking the fibers, and yet in the end each individual fiber becomes isolated from its fellows, and, in the process, the pulp tissue is pushed, rubbed, and stripped carefully and yet rapidly from each fiber, this dissecting and stripping operation taking place little by little progressively lengthwise of the stalk as the latter is slowly fed endwise forward to the dissector. The dissector 5, as herein shown, comprises a series of rolls 8, each consisting of a plurality of thin, knife-like disks 9 mounted on a shaft 10, as best shown in Fig. 2, the disks of the successive rolls being offset slightly in staggered relation to each other so that, in the course of one complete rotation of the dissector 5, each disk will make its own individual cut through the fiber just out of the path of all of the corresponding preceding disks. Thus, as herein shown, as there are six rolls 8, there will be six cuts in the stalk-end in the space of two adjacent disks, said cuts, however, being made only one at a time. By this means the stalk is cut practically as closely as the fibers are to each other, and yet this cutting takes place with an entire freedom of movement and absence of pulling or tearing tendency on the stalk because only part of the cuts are made at one time, viz. those cuts which correspond to the disks of any one roll 8. Between the disks are combs 11 which coöperate with the disks in further separating the fibers and combing out or rubbing away the pulp tissue which originally envelops each fiber.

When it is desired to make the entire plant material into pulp stock, a knife 12 is provided to coöperate with the end of the table 2, which in such instance is made of steel, in chopping or shearing off the fibers into small lengths so that they fall down into a receptacle 13 along with the separated pulp matter. When, however, the fibers are not to be made into pulp, but are to be separated therefrom for textile uses, they are caught between two pressure feed rolls 14 and fed thence over a scrubbing block 15, where they are subjected to a rapid brushing action of a brush 16, the knife 12 not being used in such case. The material which is to be made into pulp-stock, whether it includes all the plant substance (when the chopping device is used) or only the matter which is pushed out and otherwise removed from the stalk or plant-material, is caught in the receptacle 13, jets 17 of salt water from a transverse pipe 18 being driven against the fringed ends of the plant-material as it is being cut, combed, and cleaned, and in this receptacle 13 it is thoroughly mixed and washed by an agitator 19 in the strong salt water solution 20 contained in said receptacle, thereby removing much of the microscopic chlorophyl granules and also soluble pigments and finely divided debris which rise toward the surface and pass through a fine wire screen 21 and out to evaporating and settling tanks for further refining in the production of minor by-products such as resins, gums, alcohol, oils, etc. The material left in the receptacle, having been freed from its green juices and chlorophyl, consists of nearly pure tough cellulose, admirably adapted for the production of paper pulp and various other articles. By my process, this cellulose mass reaches this finely divided condition in a chemically uninjured condition, inasmuch as practically its only treatment has been mechanical, so that its tough character still remains (as distinguished from the common methods of producing pulp), and also it is in a condition easily reached and acted upon by any chemical agents used for refining and bleaching it.

The importance of my process in the respects noted will be more apparent when it is borne in mind that I have succeeded in eliminating the special digester treatment and all the usual steam or other heat treatment heretofore considered essential for treating the plants most nearly allied to those heretofore enumerated, such as are used for the manufacture of book and writing papers. I take the green plants directly from the salt-water pool, and by rapidly cutting them longitudinally along the lines of least resistance into a fine fringe in the presence of a continuous pushing, rubbing, whipping action and jets of washing water, I convert the plants into either separated bodies of fiber and of pulp tissue or into a combined fiber and pulp mass of such a nature that the desired fine pulp can be obtained therefrom simply by soaking the mass in a cold mechanically agitated solution, preferably of salt. After the separation in this salt solution of the coloring matter from the pulp body as stated, the latter, having settled to the bottom of the receptacle 13, is drawn through the foraminous bottom 22, preferably by a rotating plate 23 provided on its upper side with grooves or passages 24 which squeeze out, rub and grind the pulp to some extent as said plate is rotated by the shaft 25 of the stirrer 19. Here the pulp collects in a collecting chamber 26, where it is mixed with a strong solution of common salt, additional solution being admitted when required at 27. The pulp mass, having become thoroughly impregnated with the salt solution, flows through a pipe 28 to the electrolytic bath. In a tank 29 partially filled with a suitable electrolyte 30, such as salt solution, I provide two pulp-solution conveyers 31, 32, each composed of porous material such as clay or unglazed porcelain, preferably including a series of vertical jars 33 for more conveniently holding the carbon electrodes 34. The terminals 35 of the electrodes in the conveyer 31 are connected in parallel to the negative or cathode side of a source of energy 36 by wires 37, and the terminals 38 of the electrodes in the other conveyer 32 are connected in parallel to the positive or anode side of the source of electric current by wires 39.

Negative electrolysis of the saline solution occurs in intimate relation with the suspended pulp elements passing from pipe 28 through conveyer 31. The salt osmotically penetrates to a certain extent in and between the cells and fibers (during their maceration in strong brine in the receptacle 20) which pass close to the surfaces of the cathode 35, and being carried or suspended in a weaker salt solution, the fibrous masses become, in a sense, extensions of the cathode surface, so that the cathodic products, viz. hydrogen gas bubbles and caustic soda, are liberated in intimate relation with the elements of the fibrous material, the gas bubbles acting to an extent as minute forces which mechanically assist in the disruption and separation of the cells and fibrous units.

It may be well to direct particular attention to the two reasons already mentioned for the extremely small percentage of chemicals required in my process,—the first being the fact that the raw material has been scientifically sub-divided by the dissector approximately into its structural elements of fibers and cells, thereby giving easy access for the penetration of the solution among the smaller fibers without in any way chemically weakening said material, and the second being the fact that the active power of the slight chemical agent used is normally increased by being liberated in an approximately nascent condition.

It is to be especially noted, also, that my process makes it practicable to partially saponify the oils and resins, as distinguished from entirely eliminating them. Because of the absence of heat, and the predominance of mechanical treatment, I am enabled to effect this partial removal of the resins so that enough resinous material is left to size the paper when the pulp is passed under the heat rolls of the paper machine. This is especially true with palmetto stock, which is unusually rich in resinous material.

After passing through the conveyer 31, the now extremely fine pulp passes to a settling tank 40, where a stirrer 41 washes the fiber approximately clean of chemicals, fresh water being introduced at 42 and the wash water drained off at 43, and thence the washed pulp passes to a collecting tank 44, where it receives a fresh supply of strong salt solution from a pipe 45, and is then raised through a pipe 46 by a pump 47 and forced forward through a pipe 48 into the pulp conveyer 32, where the nascent chlorin evolved at the anodes bleaches and whitens the pulp and decolorizes any remaining green matter retained in the pulp cells.

It should be noted that the elements of the pulp produced by my process from the raw materials mentioned in the preceding pages, consist of practically colorless cellulose, and the bleaching process can be carried out more quickly and in a weaker chlorin solution, than with any other variety of pulp at present employed in making paper, inasmuch as the only elements to be decolorized consist of chlorophyl granules mechanically entangled or retained in the pulp material.

After passing from the conveyer 32 through the outlet pipe 49, the pulp is washed in fresh water, run into sheets on a cylinder machine, dried, baled, and shipped to the paper mills, or it can be run into a beating engine, and treated so as to be at once formed into paper without intermediate drying, or it can be made into artificial hard rubber, ivory, vulcanized fiber, or the like by any of the well known pressure and heat processes. In other words, the stock is of such a pure character and so finely subdivided that it is ready for general use.

The process is the same whether pure pulp is being treated or the fibrous stock, excepting that in the latter case the conveyers 31, 32 are preferably not tortuous but are straight for the better handling of long hanks of fiber. The disrupting effect of the cathode electrolysis is the same as already described, the relatively coarse fibers being broken up into small fibers which are fine and silky and suitable for spinning, and after bleaching, are dried in centrifugal driers and baled for shipment to the textile mills.

When my process is used in the separation of hemp or cordage fibers, the latter are washed and baled after coming from the dissector, and are not given the alkaline bath or electrolytic treatment. It will be understood that the latter part of the process is used where it is desired to subdivide the stock beyond its structural subdivisions, and where it is desired to bleach the product, as in making paper pulp. As the stock or pulp mass passes in a continuous stream through the cathode jars, it is refined both mechanically and chemically,—mechanically by the agitating action of the liberated hydrogen, and chemically by the caustic soda generated, as above described.

I have already mentioned various advantages of the pulp made by my process. Another peculiarity is the readiness with which the pulp parts with its water on the paper machine, and its relatively non-hygroscopic character. In other papers, the prolonged treatment in the beating and refining engines not only breaks up the ultimate fibers, but renders them water-soaked and boggy, so that great difficulty is experienced in freeing ordinary papers from their water content. My process deals primarily with raw materials in which the fibers are pointed with the very small lumens naturally closed, and a sufficient amount of the natural resin being retained to render the web practically non-hygroscopic. In other words, by my process the pulp never becomes water-soaked so that there is not so much water to be removed, and it is always maintained in a somewhat water-repellent condition so that it parts with its mechanically held water at once on the paper machine. Paper produced from pulp made by my process is also extremely light in weight, and it felts so readily and intimately that longer fibers may be used in making the pulp than in other processes, thereby giving the resulting paper the durability of a finely woven fabric. By suitable treatment, this paper or converted-paper can readily be used for clothing, as it can be cut and sewed the same as woven fabric. As only its surface will soil readily, it can be cleaned with a damp cloth and warm water. As already stated, the pulp is adapted to various other uses than paper, and the separately removed fiber is adapted to various other than textile uses.

Before entering upon the electrolytic portion of the process, the pulp or prepared plant-material or "half-stuff" is thoroughly impregnated with a strong solution of salt, a portion of the latter penetrating osmotically into the walls of the cells and fibers, in which the salt solution replaces by capillarity the juices whipped out in the dissector. Having thus filled the material with the strong salt solution, it is suspended in a weaker salt solution and then conducted through the electrolytic channels. As a strong salt solution is a better conductor of electricity than a weak salt solution, it results that as the fibers thus impregnated with salt are conveyed in a weaker salt solution through the conveyer 31, the electric current, choosing the best conductor, follows the path of least resistance, in the salt-impregnated fibers, or in other words spends its electrolytic efficiency in the mechanical disintegration and chemical disintegration of the fibrous elements, as previously explained in detail. When so saturated the same cells part with their salt very slowly, and as the weak brine is only added just before the pulp passes through the cathode channel, it follows that the bits of salt-saturated pulp, brushing against the surface of the cathodes in their passage through the porous conveyers or channels become in effect spongy extensions or branches of said cathode, and the electrolysis therefore actually does occur within their interstices. Thereupon the mass is washed thoroughly free of its caustic soda before being subjected to the bleaching process. This is necessary in order that the bleaching process may be effective. Having been washed thoroughly and thereby freed of its caustic soda, the cleaned fibers are again impregnated with a strong salt solution, so that when it then passes through the bleaching conveyer the electrolytic action is primarily a bleaching action. The chlorin expends itself in bleaching the fiber rather than in combining with any free alkali, which would be the case if the caustic soda had not been removed.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The herein described process, consisting of mechanically dissecting the cellular tissue from the smaller fibers of the plant-material, intermixing with the stock thus obtained a salt solution, and then as a continuous proceeding with the foregoing electrolytically refining the mixture while in said solution.

2. The herein described process, consisting of mechanically dissecting the cellular tissue from the smaller fibers of the plant-material, intermixing with the stock thus obtained and as fast as dissected a salt solution, and immediately electrolytically refining the mixture while in said solution and then at once electrolytically bleaching the refined product all being conducted and proceeding continuously.

3. The herein described process, consisting of mechanically dissecting the cellular tissue from the smaller fibers of the plant-material, intermixing with the stock thus obtained a salt solution, and partially dissociating the smaller fibers by electrolytic action while in

said solution and immediately and as a continuous procedure further refining the pulp material in the presence of caustic soda.

4. The herein described process, consisting of subdividing the plant-material cold and only partially removing the natural resin therefrom.

5. The herein described process, consisting of mixing the pulp mass with a salt solution, and subjecting the same to cathode electrolytic action, liberating bubbles of hydrogen gas at the electrodes among the smaller fibers and cell masses of the pulp body which are at said electrodes to assist in mechanically bursting apart and disrupting the same, and forming caustic soda for the further isolation of the cellulose ultimates.

6. The herein described process, consisting of subdividing the plant material cold, retaining an appreciable part of the natural resin, mixing the pulp body with a cold salt solution, causing the same to flow, and subjecting the flowing cold mixture to a cathode electrolysis.

7. The herein described process, consisting of mixing the pulp body with a salt solution, causing the same to flow, subjecting the flowing mixture to a cathode electrolysis, then separating to a greater or less extent the chemicals from the pulp body, subjecting the latter again to a salt solution, and passing the same through an anode electrolytic bath whereby the pulp is bleached by the nascent chlorin gas thus generated, all the foregoing proceeding continuously.

8. The herein described process consisting of mixing the pulp mass with a salt solution, and subjecting the same to cathode electrolytic action, liberating bubbles of hydrogen gas at the cathodes among the smaller fibers and cell masses of the pulp body which are against said cathodes to assist in mechanically bursting apart and disrupting the same, and forming caustic soda for the further isolation of the cellulose ultimates, then immediately washing the mass thoroughly free of its caustic soda prior to bleaching, and then impregnating the clean fibers with a strong salt solution and subjecting the same at once to anode electrolytic action.

9. The herein described process consisting of impregnating the pulp body with a strong salt solution, and at once suspending the strongly impregnated pulp body in a weaker salt solution and subjecting the same to cathode electrolytic action for mechanically and chemically disintegrating the fibrous elements, continuously progressing the mass through the foregoing and then through a washing process until the fibers are thoroughly free of the caustic soda, and thereupon at once again impregnating the fibers with a strong salt solution and subjecting this impregnated mass to anode electrolytic action.

10. The herein described process consisting of impregnating the pulp body with a strong salt solution, and at once suspending the strongly impregnated pulp body in a weaker salt solution and subjecting the same to cathode electrolytic action for mechanically and chemically disintegrating the fibrous elements, continuously progressing the mass through the foregoing and then through a washing process until the fibers are thoroughly free of the caustic soda, and thereupon at once again impregnating the fibers with a strong salt solution and subjecting this impregnated mass to anode electrolytic action, all the foregoing being done cold.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

FREDERICK F. STRONG.

Witnesses:

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