May 8, 1934. J. CAMPBELL ET AL 1,957,937

PROCESS OF BLEACHING FIBROUS CELLULOSE MATERIAL

Filed Oct. 10, 1930 2 Sheets-Sheet 1

Fig. 1.

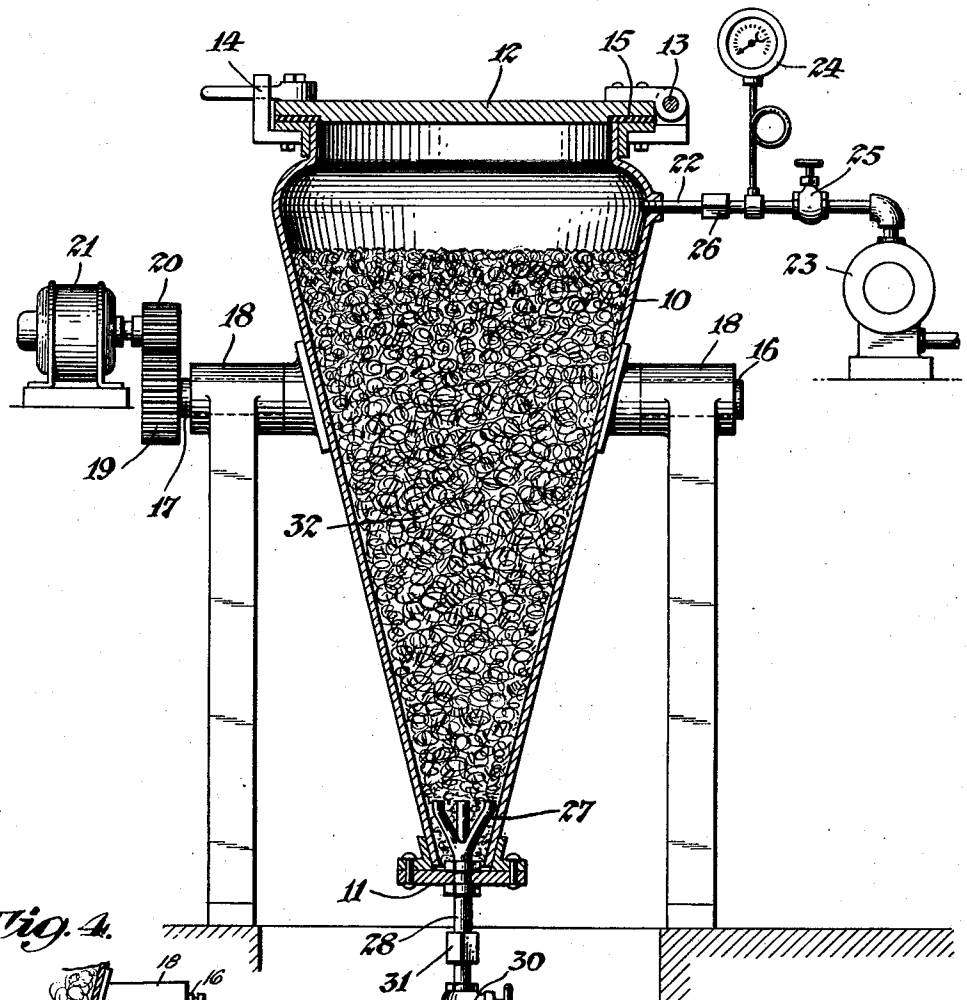
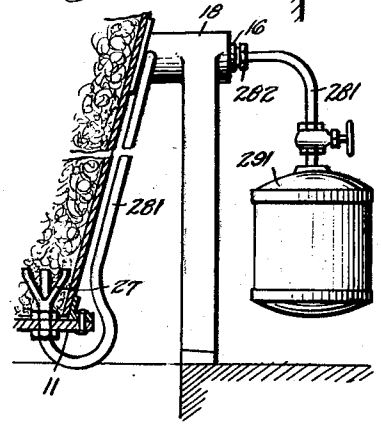



Fig. 4.




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Fig. 3.

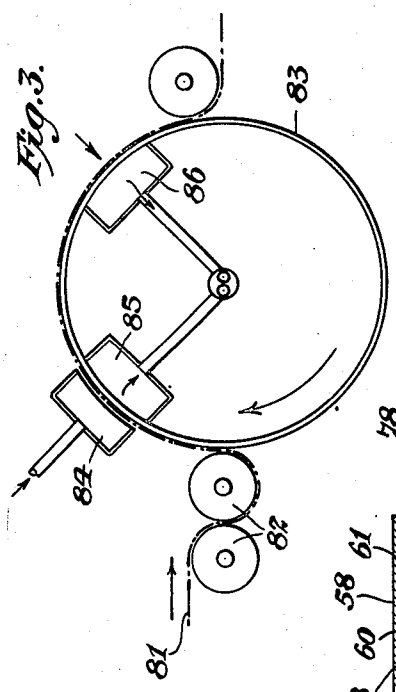
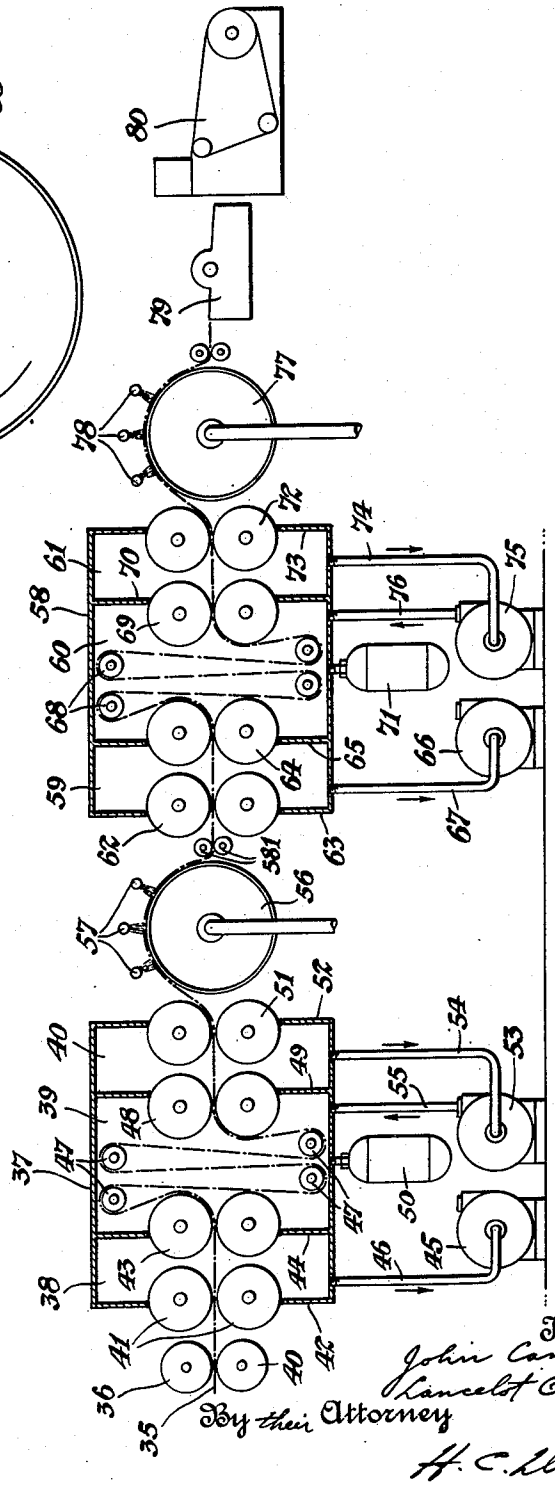



Fig. 2.




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# UNITED STATES PATENT OFFICE

1,957,937

## PROCESS OF BLEACHING FIBROUS CELLULOSE MATERIAL

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Application October 10, 1930, Serial No. 487,758

20 Claims. (Cl. 8—2)

This invention relates to the bleaching of fibrous, cellulose materials such as paper pulp, straw, bagasse, esparto grass, cane fibre and the like. It has reference to the methods used in the treatment of the pulp or other cellulose materials during the bleaching stages. The treatment contemplated is particularly suitable for the bleaching and purification of the pulp developed by the sulphate or alkaline process commonly known as Kraft pulp.

Heretofore it has been the common practice to bleach pulp by mixing with it a certain quantity of hypochlorite of lime, at the same time relatively large quantities of water are present in the pulp and in the hypochlorite of lime bleaching solution, the whole mixture being agitated in a large vat until the pulp has become white or turned the desired shade. The process has been conducted as a batch operation and normally in an open vessel under atmospheric pressure.

According to the present invention simply chlorine, or similar bleaching agents, in the gaseous state is employed for bleaching the pulp and the bleaching is done with the materials in a relatively dry state, that is substantially in the absence of the water medium heretofore employed.

The present invention constitutes a modification of the process set forth in our co-pending application Ser. No. 484,733 filed September 27, 1930. It differs from the process set forth in that case primarily in the condition or state of the pulp and in the method of handling the same, together with the manner of subjecting the pulp with or without previous impregnation with certain chemicals, such as alkaline substances, salts, and the like, to the action of the gaseous bleaching agent employed. It is contemplated that the pulp may be subjected to treatment in just the form in which it is normally produced at the mills for shipment or for further handling in the course of manufacture of cellulose products. This is usually in the form of relatively thick sheets, say one-eighth of an inch in thickness, and completely dry insofar as any apparent moisture is concerned. Of course all pulp, and even paper in the finished form, has a certain moisture content but the moisture in what may be termed the dry material is held as a relatively thin film over the surfaces within the individual cellulose cells and on the outer surfaces of these cells. What may be termed dry pulp in the proper sense may in fact have a water content of 85% and an actual solid content of only 15%. The water content would be so situated, however, within the material that it would not be apparent in a casual inspection of the pulp. When reference is made to dry pulp herein it should be understood to mean pulp which may have as much as 85% water content, although normally it will have less, say between 70% and 60% water, and it may be dried to such an extent as to have only 2% or 3% of water. In any case the dry pulp will have substantial body so that it will retain its form and will stand in bulk without support or confinement.

According to this invention dry pulp of the type mentioned is treated directly by chlorine or other gaseous bleaching agent without first putting the agent into solution in water. Air is withdrawn from the interior of the cellulose cells and from the interstices between the cells by the application of suction and the air is replaced by free gaseous chlorine or the like which then becomes so intimately associated with the pulp as to effect a thorough and almost instantaneous bleaching reaction. Subsequently the remaining free chlorine may be withdrawn from the pulp as by the use of suction and the material may be subjected to washing and similar treatment to remove the various objectionable impurities.

In the further treatment of the pulp it may advantageously be subjected to the action of sulphur dioxide in the gaseous state. This gas may be brought into intimate relation with all portions of the pulp in the same way as the bleaching gas, if desired. Thus, after washing the bleached pulp and getting it back in substantially the same state of dryness as outlined above, the air may be withdrawn from the interstices of the fibers by the production of a suitable vacuum. Gaseous sulphur dioxide may then be introduced under atmospheric or somewhat greater pressure and permitted to replace the air. This gas will serve to react with certain chlorinated impurities which may not be eliminated by simply washing the pulp. Subsequently the unabsorbed free sulphur dioxide may be withdrawn by suction or in some other way and the pulp may be washed and subjected to any desired further treatment. The process may be conducted as a continuous operation in which the pulp is continually or intermittently being advanced through the various stages to effect the bleaching and purifying reactions or the process may be conducted on a more or less batch basis in a suitable vessel in which the pulp may be alternately or successively subjected to the various treatments. As an alternative to this further treatment of

the pulp with sulphur dioxide gas, the pulp that has been treated with chlorine or other gaseous bleaching agent may advantageously be subjected to the action of a hypochlorite bleaching agent or to washing with water, or both, or the pulp that has been treated with chlorine or other gaseous bleaching agent may advantageously be subjected to further treatment by ozone, or oxygen, or oxides of carbon, or oxides of nitrogen, or oxides of chlorine in a gaseous state or any combination of these gases in the same manner as has already been described for the treatment with sulphur dioxide gas.

Furthermore, the treatment as outlined above may be augmented by impregnating the pulp, before the chlorine treatment previously explained, with any one or a combination of a number of alkaline substances and various salts of these earths, such as sodium, potassium, calcium or magnesium oxides, hydroxides, peroxides, carbonates and bicarbonates, ammonia or ammonium salts, and the like. By the addition of these substances it is possible to increase the effectiveness of the bleaching reaction.

With this general explanation of the nature and some of the features of the present process, several illustrative ways in which it may be carried out will now be described in further detail in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating a form of apparatus which may be employed in the conduct of the process on a batch basis.

Figure 2 is a diagrammatic view illustrating apparatus suitable for the conduct of a continuous bleaching process embodying the present invention.

Figure 3 is a diagrammatic view illustrating a modified form of apparatus suitable for the conduct of a continuous bleaching operation.

Figure 4 is a diagrammatic view illustrating a modification of the apparatus shown in Figure 1.

Referring now to the form of apparatus shown in Figure 1, there may be provided a chamber or vessel 10 in which the bleaching operation is adapted to take place. This vessel, as shown, may suitably be of conical form, although a cylindrical, spherical or other form may be employed if desired. The bottom of the vessel is closed by a plate 11 which may be secured to a flange formed at the lower end of the vessel. The plate 11 should form an air-tight closure so as to permit the creation of a vacuum or the maintenance of a pressure within the vessel. At the top there may be provided a closure or lid 12 which may conveniently be pivoted as at 13 to a bracket secured to the wall of the vessel. Any suitable form of clamp 14 may be provided for securing the lid in closed position. Preferably this clamp or fastening means is of simple construction and manually operable so as to permit the lid to be readily opened to allow the introduction and discharge of material through the top. A gasket 15 of any suitable material should be provided around the edge of the lid so as to form an air-tight seal between the lid and the rim of the vessel. Trunnions 16 and 17 secured to the sides of the vessel and extending horizontally therefrom may be suitably journalled in bearings 18 provided in suitable supporting standards. The trunnion 17 may have secured thereto a pinion 19 adapted to mesh with a pinion 20 mounted on the shaft of a motor 21. Through the connections indicated, the vessel may be partially rotated whenever desired from the position shown in Figure 1 to an inverted position to permit dumping of the contents of the vessel. If the vessel is relatively small, it may be turned by hand in lieu of providing the motor shown.

Near the top of the vessel 10 an outlet 22 is provided in communication with a vacuum pump 23 adapted to create any desired degree of vacuum within the chamber. A pressure gauge 24 may be provided to indicate at all times the pressure or vacuum maintained within the chamber. By means of a valve 25 in the outlet 22 the vacuum pump 23 may be disconnected from or connected into the system at will. In order to permit the rotation of the vessel about the trunnions 16 and 17 in the manner explained, a coupling 26 is preferably provided in the line 22 so as to allow disconnection of the vessel from the vacuum pump, gauge, and other portions of the system.

At the bottom of the vessel there is provided a nozzle 27 of any suitable construction for the introduction of a gaseous bleaching agent. This nozzle is preferably so constructed as to insure dispersion of the gaseous agent over the entire area at the bottom of the vessel. An inlet line 28 communicating with the nozzle 27 may be passed through an opening in the plate 11 in such a way as to provide an air-tight seal at this point. A tank 29 containing the bleaching agent in compressed form is connected to the line 28 and a valve 30 is provided for regulating the discharge of the bleaching agent through the nozzle 27. A detachable coupling 31 is provided in the line 28 to permit the partial rotation of the vessel whenever it is desired to dump its contents. If desired, the connection from the tank may be carried through one of the trunnions which support the vessel 10 so as to avoid the necessity of uncoupling the tank whenever the contents of the vessel are to be discharged. Thus, the tank 291, shown in Figure 4, may be connected by a pipe 281 passing through the trunnion 16 and connected in any suitable way to the nozzle 27. A stuffing box 282 may permit the necessary relative turning between the parts of the pipe connected to the tank and nozzle, respectively. Any suitable form of gaseous bleaching agent may be retained in the drum or tank 29. If chlorine is used, it may be maintained under a sufficient pressure to hold it in the liquid state at normal temperatures. Other normally gaseous bleaching agents may be substituted, if desired, as for example the oxides of chlorine, oxides of nitrogen, oxides of sulphur, oxides of carbon, ozone or oxygen in the free state, and the like. These gaseous bleaching agents may be used individually or two or more of them may be used. Where two or more bleaching agents are used, they may be used jointly, although preferably they will be employed separately and successively. In the latter case the material may be subjected to a washing or other purification intermediate to the treatment by the different gaseous bleaching agents.

Now, in the operation of the apparatus described, the cellulose material, such as paper pulp 32, or the like, is introduced into the vessel 10 through the opening at the top of the same in a relatively dry state. This material may either be introduced in the form of large sheets or rolls or may be in the form of small lumps, scraps, or bits of dry pulp, or other fibrous, cellulose material. It may be in the natural state in which

it ordinarily leaves a wet machine or screw press or it may have been impregnated with one or more of the alkaline materials previously mentioned. Having a relatively small water content the material is not in a fluid state, although it is preferably so sub-divided or arranged as to be readily introduced into or discharged from the vessel. The lid 12 is then clamped tightly over the open end of the vessel while the valve 30 is closed and the valve 25 opened so that the suction pump 23 may be operated to establish a vacuum of any desired degree within the vessel. In the creation of the vacuum the air which is held in the interstices of the fibrous material, or between the cells of the structure of the material, will be released and will be withdrawn by the pump to an extent dependent upon the degree of the vacuum. A vacuum of, say, 15 inches of mercury may be satisfactory for the purposes, although a higher degree of vacuum is preferable. After a suitable portion of the air has been evacuated from the vessel and from the material, the valve 25 is closed and the valve 30 is opened to permit the introduction of chlorine, or any other suitable gaseous bleaching agent, into the vessel. This gaseous agent may be introduced until atmospheric pressure is established or until superatmospheric pressure is brought about, as desired; a slight pressure above atmospheric is deemed preferable. As the chlorine, for example, enters the vessel it will find its way into the spaces between the cells or fibers of the material from which the air has been previously expelled and due to its intimate contact with all portions of the material, and its natural chemical affinity, will produce an almost instantaneous bleaching action. Within a brief period of say five minutes it should be possible to completely permeate the vessel and the material in it with the gaseous bleaching agent. If the water content of the pulp is extremely low, as for example below 10%, care should be exercised not to leave the chlorine in contact with it too long as it will have a tendency to char the dry pulp and reduce it to a pulverulent condition. When the reaction has been completed, the valve 25 is again opened and the vacuum pump 23 is permitted to draw off the excess unused portions of the gaseous bleaching agent and this may, if desired, be sent to any suitable storage vessel for re-use. If the chlorine has been removed by the creation of a desired degree of vacuum within the chamber, the suction may be discontinued and air admitted to the vessel by opening the lid 12. This air will then fill the spaces between the fibers and cells of the material as in its original condition. The material may now be dumped from the vessel by a partial rotation of the same through operation of the motor 21 and may be subjected to any further treatment desired.

Further bleaching or other treatment of the material may be carried out within the same vessel, if desired. For example, after exhausting the excess chlorine by the operation of the vacuum pump in the manner explained, another bleaching agent may be introduced into the vessel from a vessel similar to the tank 29 and adapted to discharge its contents through the nozzle 27, or some treating or purifying agent such as gaseous sulphur dioxide may be introduced. As previously stated, the material may, if desired, be subjected to a washing reaction between the several treatments by the gaseous agents. This is particularly desirable where a sulphur dioxide treatment follows a chlorine treatment inasmuch as all traces of chlorine should first be removed to prevent the formation of sulphuric acid.

All portions of the apparatus which are brought into contact with the bleaching agent, as for example the vessel 10 and the vacuum pump 23, as well as the intermediate connections, should either be formed of or lined with suitable material not subject to attack by the particular agent employed. For example where chlorine is used as the bleaching agent these portions of the system should either be formed of or lined with a molybdenum nickel steel alloy, or with glass or stone or any other substance not appreciably attacked by chlorine.

In Figure 2 there is diagrammatically illustrated a form of apparatus which may be employed in the conduct of the process on a continuous basis. As here shown, the cellulose material may be in the form of a relatively thick sheet 35 which is in a substantially dry state. It may conveniently be directly in the form in which it leaves the rolls 36 of a wet machine, having a thickness of approximately one-eighth of an inch; and it may either be in the normal state in which pulp leaves such a machine or if chlorine is used as a bleaching agent the pulp may contain a suitable quantity of one or more of the alkaline materials previously mentioned with which the pulp has been impregnated prior to its formation into a sheet on the wet machine. The bleaching process may conveniently be carried out in an enclosed chamber or housing 37 having a plurality of compartments 38, 39 and 40. Upon leaving the rolls of the wet machine the material may be passed through a plurality of rollers 41 mounted in suitable bearings carried by the end member 42 of the housing. These rollers are preferably formed of suitable flexible or yielding material which is adapted to completely fill the opening in the member 42. They will yield slightly, however, to permit the passage of the strip of material 35 and will at all times exclude the entry of any appreciable amount of air through the wall 42 of the housing. Another pair of rollers 43 may be suitably journalled in bearings carried by a partition wall 44 forming the opposite side of the compartment 38. The strip of material 35 is fed between these rollers, which are formed of flexible, yielding material similar to the rolls 41 and serve to form a substantially air-tight seal for the opening in the wall 44. The air may be partially or completely exhausted from the compartment 38 by means of a suction pump 45 connected by a line 46 to the interior of the compartment. It will be apparent that as the strip of material passes through the compartment, which is maintained under any desired degree of vacuum, the air held between the fibers or cells of the material will be partially or completely released.

Upon leaving the rollers 43 the material is passed around a series of idler rollers 47 and then between a pair of flexible feed rollers 48 carried by the opposite wall 49 of the compartment 39. During the period of time, say one to ten minutes, required for the travel of the material through the compartment 39, it may be exposed to the action of a suitable bleaching agent in gaseous form. For this purpose the bleaching agent may be carried under pressure within a tank or drum 50 which is in communication with the interior of the compartment 39. If chlorine is to be used as the bleaching agent, for example, it may be held in the liquid state in the tank 50 and may be forced under its own pressure, upon

the application of steam or heat in other form, into the compartment 39. Being under atmospheric, or preferably superatmospheric, pressure of possibly 25 pounds, the chlorine in the compartment 39 will penetrate into the material and lodge itself in the spaces between the fibers and cells of the material from which the air has been displaced. The bleaching reaction will be almost instantaneous as the gaseous agent penetrates into all portions of the material. If the pulp is quite dry, i. e. has an exceptionally low water content say below 10%, the bleaching action is exceedingly rapid and there is danger of charring or otherwise harming the pulp if it is left in the chlorine atmosphere too long. The speed of travel of the pulp through the bleaching compartment should be varied in accordance with the dryness of the material and should be so regulated as to insure proper bleaching without detriment to the pulp.

As the strip passes between the rolls 48 into the compartment 40 and is fed between a pair of rollers 51, of the same sort of flexible material, journalled in the end wall 52 of the housing it may be again subjected to a vacuum of suitable degree. Any free chlorine which may remain in the space between the fibers of the material will be largely withdrawn in this way. For this purpose a vacuum pump 53 connected by a line 54 to the interior of the compartment 40 may be provided. Any chlorine which is withdrawn from the material in this way may be returned to the compartment 39, if desired, by a line 55 leading from the discharge outlet of the vacuum pump 53. In a similar way any of the bleaching agent which may have leaked past the rollers 43 into the compartment 38 may be recovered from the pump 45 and utilized in any way desired.

Upon leaving the bleaching chamber the material may be passed over a continuous rotary filter 56 against the surface of which a series of sprays 57 may discharge streams of water or other suitable washing agents. The filter, through the provision of the usual suction, will remove the greater portion of the water and various impurities washed from the material by the water. Certain impurities produced by the bleaching agent will remain in the material and may best be removed by further treatment of the pulp by another reagent. Where chlorine is used as the bleaching agent, it will be found, for example, that certain chlorinated impurities may be removed by treatment of the pulp with sulphur dioxide. According to the present invention this subsequent treatment may be carried out in substantially the same way as the bleaching reaction itself. The sulphur dioxide may be applied in the gaseous state. For this purpose a second chamber 58, having three compartments 59, 60 and 61, may be provided. Before passing the material into the chamber 58, it should preferably be reduced to substantially the same dry state in which it originally entered the chamber 37. For this purpose it may be passed between a pair of squeezing rollers 581. The material is then fed into the compartment 59 between a pair of flexible rollers 62 journalled adjacent an opening in the end wall 63 of the chamber. The material is discharged from the compartment 59 between a pair of flexible rollers 64 filling an opening in a partition wall 65. A vacuum pump 66 connected by a line 67 with the interior of the compartment 59 may serve to remove the air from the chamber and from the spaces between the fibers or cells of the material.

Within the compartment 60 the material may be passed over a series of idler rollers 68 and it may be discharged from this compartment between the rollers 69 journalled in and completely filling an opening in a partition wall 70. Sulphur dioxide or other similar purifying agent may be held under pressure in a tank or drum 71 and may be introduced in a gaseous state into the compartment 60. Here it will enter the spaces between the fibers or cells of the material and will react with the impurities which have not been eliminated by the washing treatment. The purified material is then passed through the compartment 61 and is discharged from the latter between a pair of feed rollers 72 mounted at the end of the chamber. A line 74 connecting the interior of the compartment 61 with a vacuum pump 75 may be employed for creating a vacuum within the compartment and thus removing the greater portion of the free sulphur dioxide held by the material. This sulphur dioxide may be returned to the compartment, 60, if desired, through a return line 76. Upon leaving the purifying chamber the material may be passed over another continuous rotary filter 77 on whose surface it may be washed by a series of sprays 78 adapted to discharge water or other washing agent.

The bleached and purified material may now be passed to a beater 79 for treatment prior to use in a paper making machine 80, or the like, for ultimate manufacture into the desired final product.

It will be understood that the chamber 37 should be formed of or lined with material capable of largely or completely resisting the corrosive action of the bleaching agent and that similarly any portions of the system subjected to the agent will be so formed or lined. While gaseous chlorine is considered to be the preferred type of bleaching agent, any gaseous agent such as those previously mentioned may be employed singly or in combination or in successive stages, if desired. If successive bleaching stages are to be used, a chamber having a greater number of compartments should be provided.

The continuous bleaching and purification of the dry pulp may be conducted in a somewhat modified manner. Referring to Figure 3, the cellulose material may be in the form of a sheet 81, as in the process just explained. It may be in the ordinary state in which it is normally received from the final rolls 82 of a wet machine or it may previously have been impregnated with a suitable quantity of an alkaline substance, as described previously. This material may be passed over the surface of the rotating drum 83 of a continuous rotary filter. During the rotation of the drum the material may be passed beneath a hood 84 adapted to maintain an atmosphere of chlorine or other gaseous bleaching agent over a portion of the surface of the drum. Radially in line with the hood 84 there may be provided an area 85 within the drum over which a continuous suction may be maintained as is ordinarily done in rotary filters. Thus, as each portion of the material is carried between the hood 84 and the suction area 85 upon continuous rotation of the drum the air will be withdrawn from the interstices of the material and it will be simultaneously replaced by the chlorine which will in turn be sucked through and disposed of in any suitable way by the suction system of the filter. In its passage through the material the chlorine or other gas will have effected a substan-

tially instantaneous bleaching reaction. To insure complete removal of the chlorine from the bleached material a second suction area 86 may be provided within the drum 83 so that air may be drawn through the material and serve to completely expel the chlorine.

Subsequent treatment of the bleached material may include washing of the same as by the means disclosed in Figure 2 and purification, for example, by the passage of sulphur dioxide or a similar agent through the material in the same way that the chlorine is passed through it. Another rotary continuous filter drum similar to the drum 83 may be provided for this purpose.

Where it is desired to add alkaline substances, of the type previously mentioned, to the cellulose material prior to the bleaching reaction, the quantity of the substances employed will, of course, vary with the nature of the ones employed and with the extent of bleaching desired. If sodium carbonate is employed to subsequently react with chlorine, it may be found desirable to add between 100 and 500 pounds to a quantity of unconcentrated pulp containing a ton of dry fiber, although a greater or less amount may be used under particular circumstances.

While the present process has been disclosed in considerable detail and several forms of apparatus suitable for the conduct of the process have been specified, it is to be understood that many variations may be adopted in the process and in the apparatus on which it is conducted without departing from the general spirit and scope of the invention.

What we claim is:

1. A method of bleaching fibrous cellulose material which comprises removing the air from the interstices of the material while it is in a substantially dry state and replacing said air by a gaseous bleaching agent.

2. A method of bleaching fibrous cellulose material which comprises first removing the air from within the material while it is in a substantially dry state, and then introducing a gaseous bleaching agent into the spaces from which the air has been removed.

3. A method of bleaching fibrous cellulose material which comprises first removing the air from within the material while it is in a substantially dry state, then introducing a gaseous bleaching agent into the spaces from which the air has been removed and then replacing the excess gaseous agent in the material by air.

4. A method of bleaching fibrous cellulose material which comprises producing a sufficiently low sub-atmospheric pressure to remove the air from said material while it is in a substantially dry state, and then introducing a gaseous bleaching agent to replace the removed air.

5. A method of bleaching fibrous cellulose material which comprises removing air from the interstices of said material and then intimately intermingling the same in a substantially dry state with a gaseous bleaching agent.

6. A method of bleaching fibrous cellulose material which comprises continually advancing said material through a plurality of zones and subjecting each portion of the same successively in one zone to suction for the removal of air and in another zone to a reaction with a gaseous bleaching agent.

7. A method of bleaching fibrous cellulose material which comprises advancing said material in a substantially dry state through a series of stages of treatment, subjecting each portion of said material as it passes through one stage to suction for the removal of air, and introducing a gaseous bleaching agent in a subsequent stage.

8. A method of bleaching fibrous cellulose material which comprises advancing said material in a substantially dry state through a series of stages of treatment, subjecting each portion of said material as it passes through one stage to suction for the removal of air, introducing a gaseous bleaching agent in a subsequent stage, and in a further stage removing the excess bleaching agent and impurities after the bleaching reaction has taken place.

9. A continuous method of bleaching fibrous cellulose material which comprises treating successive portions of the material in a substantially dry state by removing the air normally held in the interstices of the material to the extent of a vacuum equal to at least 15 inches of mercury and replacing such air by a gaseous bleaching agent.

10. A method of bleaching cellulose material which comprises successively treating said material in a substantially dry state to first remove air from the interstices thereof, replacing the air held in and between the cells of the material by gaseous chlorine and subsequently replacing the chlorine by gaseous sulphur dioxide.

11. A method of bleaching cellulose material which comprises removing the air therefrom by suction, introducing gaseous chlorine into the interstices of the material, and then purifying the material by a gaseous agent adapted to react with the chlorinated products.

12. A method of bleaching cellulose material which comprises removing the air therefrom by suction, introducing gaseous chlorine into the interstices of the material, removing the chlorine and the then soluble impurities from the material, introducing gaseous sulphur dioxide into the material, and then washing the material and introducing air into the same.

13. A method of bleaching fibrous cellulose material which comprises removing the air therefrom by suction, introducing gaseous chlorine into the interstices of the material, removing the chlorine, introducing an agent into the material to convert reaction products of the chlorination into soluble substances and then washing the material and introducing air into the same.

14. A method of bleaching cellulose material which comprises producing the material in a substantially dry state with an alkali or an alkali earth distributed through the same, removing air from the interstices of the material to the extent of a vacuum of at least 15 inches of mercury and subjecting the dry material to the action of gaseous chlorine in the presence of said alkali.

15. A method of continuously bleaching cellulose material which comprises adding an alkali or an alkali earth to said material, forming said material into a substantially dry sheet, removing air from the interstices of the material, and replacing said air by gaseous chlorine in the presence of said alkali.

16. A method of bleaching fibrous cellulose material which comprises producing the material in a substantially dry state, removing the air from the interstices of the material by suction, replacing the air by ammonia gas, and subjecting the dry material to the action of chlorine gas.

17. A method of bleaching fibrous cellulose material which comprises producing the material in a substantially dry state, removing the air from the interstices of the material by suction, re-

placing the air by ammonia gas, and subjecting the dry material to the action of chlorine gas, removing the chlorine, ammonia and impurities from the material, introducing sulfur dioxide into the material to render insoluble products of the chlorination soluble and then washing the material.

18. A method of bleaching fibrous cellulose material which comprises subjecting the material to successive partial bleaching reactions, the first of said reactions comprising the reduction of the material to a substantially dry state and the subjection of the dry material to a vacuum of at least 15 inches of mercury for the removal of air from the interstices thereof and then to the action of free chlorine and another of said reactions comprising subjecting the material to the action of a hypochlorite solution.

19. A method of bleaching digested, fibrous, cellulose material which comprises removing water and air from the interstices of the material and then intimately intermingling the same, while in a substantially but not completely dry state and while the fibers are in an expanded, deaerated condition, with gaseous chlorine.

20. A method of bleaching digested, fibrous, cellulose material which comprises removing water and air from the interstices of the material, the material being reduced to approximately a 60 to 70% water content, and then intimately intermingling the material, while the fibers are in an expanded, deaerated condition, with gaseous chlorine.

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