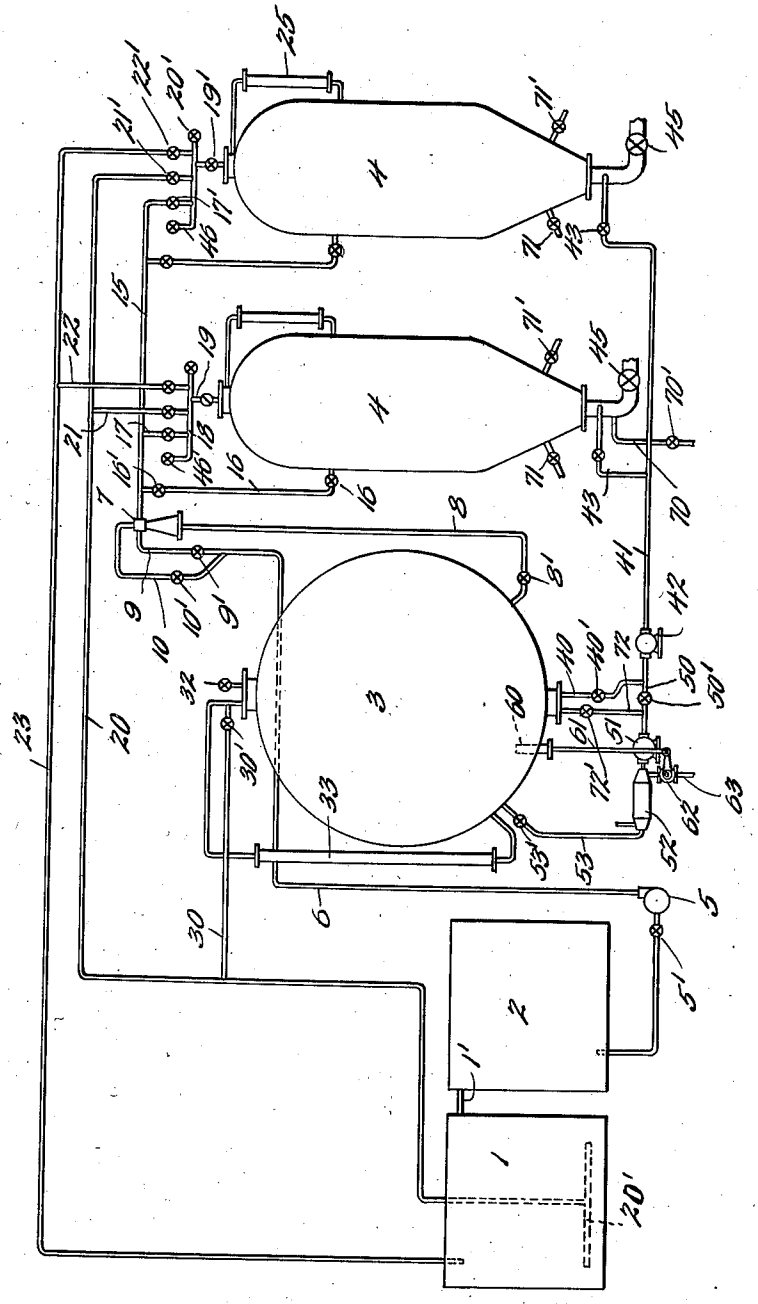
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METHOD AND APPARATUS FOR DIGESTING FIBROUS MATERIAL

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METHOD AND APPARATUS FOR DIGESTING FIBROUS MATERIAL

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This invention relates to an improved method of and apparatus for digesting fibrous cellulosic material.

In the typical older method of digesting wood chips by the so-called quick cook method, the digester is first completely filled with chips and acid is thereafter admitted. The mass is brought up to reaction temperature by admitting direct steam. In most cases the steam was admitted slowly for it was thought that such slow admission was necessary to permit the liquor to penetrate the chips and thus to insure cooking of the central portions of the chips. Hence, under the typical old practice, approximately two to five hours were generally allowed for bringing the digester up to temperature, that is to say the admission of steam was so controlled that the temperature of 110° to 120° C. was reached only after from two to five hours.

This older practice presented disadvantages, particularly in that the treatment did not to any material degree insure saturation of the chips and as a result differential cooking of the chips obtained.

Recently, as disclosed in the U. S. patent to Dunbar 1,859,384, it has been proposed to first saturate the chips with hot acid under a high hydrostatic pressure prior to actually beginning the cook and in this way to insure uniform cooking and accelerated digestion.

It is now found that if such cellulosic materials as wood chips are subjected to a thorough saturation or impregnation with the reagent employed for digestion under such circumstances as to insure an equalized temperature of the mass and an equalized water content, decided economies are insured. When this preliminary impregnation or saturation treatment is carried out under conditions involving the recirculation of hot acid under desirably high hydrostatic pressures and through a mass or dominant pool of the acid, decidedly improved results are obtained. In these circumstances the major portion of the inert gases and water solubles are washed or leached out of the chips, thus rendering the moisture content of the chips uniform before the actual cooking begins. Such precirculation of hot acid under pressure effects a thorough saturation of the chips into the core. At the end of the precirculation period therefore each chip is saturated with a potentially reactive reagent very close to reaction temperature so that upon admission of steam the reaction is insured throughout the body of the chip rather than, as in the past, progressively from the exterior of the chip towards the core.

An object of the present invention therefore is to provide an improved method of impregnating fibrous materials which are to be digested to produce pulp.

Another object is to provide an improved pulp digestion process in which marked heat economies are secured.

Another object is to devise a process of digesting pulp in which cellulose losses are reduced to a minimum.

With these and other equally important objects in view, the invention comprehends the concept of subjecting fibrous material, such as wood chips or the like, to a special preliminary or precirculation treatment by reason of which the chips are thoroughly saturated with a digestion reagent, are partially leached of certain of the non-cellulosic constituents and are uniformly preheated so that subsequent cooking of the impregnated chips insures a decidedly improved pulp product.

In order more clearly to explain the invention, there is shown in the single figure of the accompanying drawing a typical apparatus which may be employed to carry out the process.

As indicated hereinbefore, it is desirable to effect a thorough penetration of the cellulosic material with the digestion reagent prior to the actual chemical reaction. Such a thorough penetration is difficult to achieve due, as is known, to a number of factors. The wood or other cellulosic starting material is not a homogeneous substance; there may be a wide variation in the physical characteristics, such as density, and in the chemical characteristics, including the water content, of different portions of the cellulosic mass which is to be digested.

Under ordinary circumstances the digestion liquor tends to penetrate the chips rather slowly. This penetration may be increased, as has been suggested heretofore, by increasing the temperature of the impregnant. However, this method cannot be availed of beyond certain limits because if the temperature is raised too high, that is up to reaction temperatures, the chemical reaction takes place and the digestive reagent is then consumed in relatively large quantities. Such a reaction will initiate at the surface of the chips and even though penetration to the interior of the chip does continue, the digestive reagent becomes more dilute or weaker. In this type of operation therefore the reagent which is absorbed by the cellulosic material in most cir-

cumstances is not of uniform concentration. Such type of temperature impregnation may be considerably improved, as explained in Patent 1,859,384, by imposing a high hydrostatic pressure on the hot acid.

The present invention is developed along the lines of the process disclosed in Patent 1,858,384 and is based on the concept of employing hot preconditioned acid at elevated but below reaction temperatures and at a relatively high hydrostatic pressure for the purpose of saturating the chips and insuring optimum penetration as well as securing other advantages by recirculating the hot acid from a dominant pool maintained in an accumulator to and through the chips and back to the accumulator. By utilizing a dominant pool of this character maintained under pressure, and particularly by accurately controlling the temperature of the dominant pool, uniform or equilibrated thermal conditions may be established in the body of chips in the digester and in addition certain of the non-cellulosic constituents of the wood may be removed. Furthermore it will be appreciated that by recirculating the saturating liquor through a pressure accumulator, which is provided with means for preconditioning the acid discharged therefrom, uniform chemical characteristics of the saturated liquor may be maintained. Thus under such preliminary saturation the mass of chips is thoroughly impregnated with a digestive reagent which is of established and substantially uniform chemical characteristics, thus enabling more efficient standardization of the digestion process itself.

Thus in one preferred method of operation, chips are first charged to a typical digester, either by gravity feed or by chip charging device, in the manner well known to those skilled in the art. After the digester has been charged to the desired level with the chips, the cover is bolted on and hot preconditioned acid under pressure is forced by a pump into the digester. During the admission of the acid the upper portion of the digester may be vented. During the initial introduction of the acid the digester may be vented to the room until the air contained in the digester has been displaced and SO_2 gas begins to come off. Then the digester may be vented to an absorption tank, such as the typical storage tank, to recover the SO_2 evolved from the acid. When the digester has been filled such vent line may be closed and the charging pump continued in operation until a high hydrostatic pressure, say of the order of 40 to 90 or more pounds per sq. in. is developed. The digester is then placed in communication with a pressure accumulator and a stream of hot acid circulated through the digester to the accumulator. During this circulation period heat units are added to the recirculating stream in controlled amounts so as to maintain optimum thermal conditions for the precirculation treatment. Preferably, as will appear more fully hereinafter, such temperature maintenance is secured by utilizing a thermostatic element, responsive to the temperature of the acid within the accumulator, to control the amount of heating medium admitted to the heater employed for controlling the temperature of the recirculating stream.

The hot high pressure acid is thus recirculated through the mass of chips for a given period of time, depending upon the characteristics of the chips. In most circumstances such precirculation period may be run from one half hour to eight hours, more or less. The length of time of the period will of course be governed by the character of the material undergoing treatment and will be continued until the temperature and water content of the chips is substantially equalized throughout the digester and the desired degree of leaching and penetration of acid into the chips is secured. In these circumstances, as a result of the precirculation penetration treatment the chips are in excellent condition for digestion. To initiate the cook the recirculation lines to the accumulator may be closed and the digester again pumped to the desired pressure. The digester pump may then be shut down and steam admitted to rapidly bring the digester up to cooking pressure and temperature. The cook is initiated quickly and uniformly due to the thorough impregnation of the chips with the hot digestion liquor. As a result of this treatment the actual cooking time from steam to blow is very considerably reduced with the production of pulp of decidedly improved characteristics.

The principles of the invention as above expressed will be readily appreciated from a consideration of a specific process in which they are embodied and an apparatus in which they are effectuated. As shown in the drawing, a unit capable of carrying out the present invention may include as the major elements an absorption tank 1, an acid storage tank 2, a pressure accumulator 3 and a series of digesters 4. Storage tank 2, as is known to those skilled in the art, is supplied with relatively cool acid from the acid make-up system. This storage tank may be the typical atmospheric tank used in the art. The absorption tank 1 may be of the same type of construction and, if desired, may be built to carry some pressure. The absorption tank is connected by the overflow line 1' to the storage tank 2.

As noted, the acid in the storage tank 2 is relatively cool. If desired, this may be given a mild degree of preheat by utilizing closed heating coils or other heating means in the tank. It is to be noted that the liquor in absorption tank 1 is preheated and preconditioned by direct contact with relief fluids evolved in the process in a manner more particularly to be described.

The accumulator 3 which, as shown, is preferably spherical in shape, is of relatively large size and preferably holds two and one half charges of acid. This member subserves a number of important functions in the process. As will be seen, it serves as a heat regenerative member in which the heat units of the hot fluids withdrawn from the digester are imparted to a body of cooler acid admitted from the storage tank. Similarly such cooler acid absorbs the free gas evolved and vented during cooking. In the present improvement the accumulator is so designed and constructed that the temperature, pressure and concentration of the acid may accurately be controlled. This is of particular importance for, as noted, the present invention involves the utilization of the optimum temperature of acid during the penetration period and particularly the maintenance of such temperature.

To subserve the several functions noted, the accumulator is connected with the storage tank through the pump 5, controlled by valve 5', line 6, eductor 7 and drop leg 8. The drop leg 8 is connected to the accumulator through the branch controlled by valve 8'. If desired and as described for example in copending application Serial No. 758,318, filed December 19, 1934, a second eductor and a recirculating line may be connected to the bottom of drop leg 8. The cold

acid flowing through the line 6 may pass either through the branch 9 controlled by valve 9', or through the branch 10, controlled by valve 10', or through both, so that plural streams of the cooler acid may be contacted with hot relief fluids in the eductor 7, at spaced zones therein as more particularly described in copending application Serial No. 28,580 filed June 26, 1935.

With this type of connection it will be seen that the cool or slightly preheated acid may be fed from the storage tank 2 under any desired pump pressure through line 6 and eductor 7 and thence through the drop leg 8 into the accumulator. Eductor 7 is connected as shown with the high pressure header 15. The high pressure header is connected with the side relief line 16 having the control valves 16'. Preferably the side relief line 16 connects with the digester 4 at a point considerably below the normal operating liquid level so that a large hydrostatic head may be employed for discharging liquid on side relief. The high pressure header 15 also communicates through the line 17, controlled by valve 17', with the upper part of the digester through the manifold 18 and digester overhead line 19. The flow of fluids through this latter line is controlled by the valve 19'.

It will thus be seen that since the eductor 7 is in communication with the header 15 the flow of cooler liquor from the storage tank through the eductor will aspirate or induce gases and vapors in the line 15. This establishes a desirable diminished pressure or suction in line 15 and accelerates the withdrawal of fluids therethrough. Such hot gases and vapors are contacted by the cooler acid and are absorbed therein, thus building up the chemical concentration and temperature of the cooler acid. The combined stream then flows downwardly through the drop leg 8 into the accumulator.

The upper part of the digester, as shown, is connected through the manifold 18 to the vent 20, which discharges to the atmosphere. Low pressure gases and vapors may be discharged from the digester through the line 21 controlled by valve 21' into the low pressure header 20. As shown, the low pressure header communicates with the absorption tank 1 and the hot fluids discharged therethrough are absorbed in the liquor in tank 1, being discharged therein through the distributor head 20' positioned at a low point in the absorption tank.

The low pressure gases discharged from the digester during filling may be sent through line 22, controlled by valve 22', and thence through the header 23 to the absorption tank as shown, or, if desired, to the acid makeup system.

The digester is provided with the gauge glass 25 and with automatic temperature and pressure recording instruments (not shown) in a manner well known to those skilled in the art.

As has been intimated hereinbefore, according to the present invention pressure and temperature conditions within the accumulator are carefully controlled. To establish such pressure control the accumulator is provided with the overhead vent line 30 in which is interposed the pressure regulating valve 30'. This line 30 discharges into header 20 so that gases vented from the accumulator are absorbed in the absorption tank 1. The presssure control valve 30' may be so set and regulated that whenever the pressure in the accumulator rises above any predetermined chosen value, say of the order of from 25 to 100 lbs. more or less, gases are automatically vented through the line 30 to be absorbed in the liquor in either the absorption tank 1 or storage tank 2. If desired a by-pass line (not shown) provided with a pressure regulating valve may lead from the header 15 to the top of the accumulator. The valve in this by-pass line may be set at any desired pressure differential, say of the order of from 1 to 3 or more lbs., such that when the pressure in the header 15 exceeds the pressure in the accumulator by this amount, fluids may be by-passed around the eductor and may be discharged directly into the accumulator. The accumulator is also provided with the top vent 32 through which excess pressure may be released.

In the usual manner the accumulator is provided with the gauge glass 33 and with automatic temperature and pressure recording instruments.

As will be understood, the hot acid from the accumulator 3 is adapted to be forced to and discharged into the digesters for the purpose of saturating and cooking the chips. For this purpose the accumulator is provided with a bottom drawoff line 40 controlled by valve 40' which communicates with the line 41. In the line 41 is interposed the pump 42. Line 41 is provided with the branches 43, controlled by valve 43', which discharge into the blowoff elbow of the digester. The horizontal arm of the blowoff elbow is provided with blowoff valve 45 in the usual manner.

Steam may be admitted to the digester through the line 70 controlled by valve 70', and also if desired through the lines 71 controlled by valve 71' connecting to the lower section of the digester. Steam may also be admitted through the line 46' to the top of the digester for the purpose of cleaning the upper strainer located under the connection 19.

In accordance with the major principle of the present invention means are provided to establish a definite optimum high temperature on the acid in the accumulator and to maintain this optimum temperature for the purpose of providing an impregnant or saturant for the chips. As shown, a recirculation line having an interposed heater is associated with the accumulator. There is also associated with this circuit a thermostatically controlled valve so that the amount of heat imparted to the recirculating stream may carefully be regulated. The recirculation circuit includes the line 50, controlled by valve 50', which is connected to the bottom drawoff or discharge line 40 of the accumulator. If desired also a separate discharge line 72, controlled by valve 72', may connect the accumulator with the suction side of pump 51. Connected to the line 50 is the acid resistant pump 51. Liquor picked up from either line 40 or line 70 by the pump 51 is forced through the heat exchanger 52 and then through the discharge line 53 through valve 53' back into the accumulator. The pump 51 and heater 52 are of sufficient size and/or capacity to fulfill or satisfy the requirements noted above. In a typical installation, for example in one having an accumulator of approximately 30 ft. in diameter and which holds two and one-half charges of acid, a circulating pump having a 250 gal. per minute capacity and which circulates the acid through the heater at the velocity of approximately 17 ft. a second serves effectively. In this illustrative installation the heat exchanger 52 may have an overall length of 8 or 10' and a diameter of a foot or more. It will

be understood that pump, heat exchanger and lines in both the accumulator circuit and in the digester acid feed circuit are constructed of suitable acid resistant alloys and/or are protected with acid resistant surfaces.

The acid within the accumulator with this type of construction may be maintained at any predetermined temperature by any suitable type of recording temperature controller. Such a control may comprise a thermostatic element or bulb **60** which is located at any appropriate position within the accumulator and which, through suitable connections **61**, controls the operation of valve **62**. In a typical installation the acid flowing through the heat exchanger **52** is heated indirectly by steam admitted through line **63**. Thermostatic controlling mechanism opens and shuts the valve **62** to a predetermined degree, depending upon the temperature in the accumulator, and thus regulates the amount of heat imparted to the acid stream.

It will be appreciated of course that in lieu of heating the recirculating stream of acid indirectly by steam, other heating media, such as hot spent liquors, gases and the like, may be employed. Similarly the temperature control may also be effectuated by utilizing a substantially constant flow of heating medium in the heat exchanger **52** and varying the speed of pump **51** by means of a thermostatic controlled device.

It will also be understood that, if desired, control of the concentration of the acid within the accumulator may be rendered more accurate by associating with an accumulator a tank of SO_2 gas and automatically admitting predetermined quantities of the gas to the accumulator. Such automatic admission may be controlled by the SO_2 recorder controlling instrument of any effective type. It will thus be seen that with the apparatus described an effective control of the temperature, pressure and concentration of the acid in the accumulator may be established. Due to the connections of the accumulator to the storage tank **2** on the one hand, and to the vent lines from the digesters on the other, this element serves as a heat recuperative plant and as a preconditioning system, conserving all of the chemical and thermal values in the process.

The operation of the process will have been appreciated from the foregoing description. It may be assumed by way of example that the material within the second digester **4** is undergoing digestion and that relief fluids are flowing through the header **15** and eductor **7** and are admixed and absorbed therein by the stream of cooler acid forced through pipe **6**. The cooler acid is thus preheated and preconditioned and is discharged into the accumulator **3**. At this time #1 digester may be considered closed. In starting up the treatment in the first digester the manhole cover at the top is removed and the digester filled to the desired level with chips. The cover is then bolted on but valves **19'** and **20'** are opened and valves **16'**, **46'**, **17'**, **21'** and **22'** are closed. Valves **40'** and **43'** are opened and the digester filling pump **42** operated. Since a relatively high pressure obtains in the accumulator, hot acid flows rapidly into the digester. The pump **42** forces acid through the line **41** and branch **43** into the lower section of the digester. As the digester is gradually filled with such hot acid the air initially contained in the digester is automatically displaced and is vented through the valve **20'** to the atmosphere. Since hot high pressure acid is discharged from the accumulator into the digester, some evolution of SO_2 gas takes place. When the air contained within the digester is vented and SO_2 gas begins to flow through the vent valve **20'**, such valve is closed and valve **22'** is opened. The low pressure SO_2 gas evolved from the entering acid then flows through the line **22** and header **23** to the absorption tank **1** where it is absorbed in the liquid therein. It will be appreciated that, if desired, such low pressure gases may be vented through line **21** and header **20** to the absorption tank **1**.

When the SO_2 gas has been vented and the digester is filled with acid, as indicated on the gauge glass, the valve **19'** is closed and the pump **42** continued in operation until a high hydrostatic pressure is built up on the acid within digester **4**. The saturating pressures used may vary within relatively wide limits, depending upon the type of installation and the character of the chips undergoing treatment. Thus pressures of from 40 lbs. or less to 90 lbs. or more may be established in the digester. As soon as the desired pressure is pumped on the digester, the top and side relief valves **17'** and **16'** respectively are opened and liquor is vented back through the high pressure header **15** to eductor **7** and thence to the accumulator. The pump **42** is maintained in operation and in these circumstances hot acid liquor under a controlled high hydrostatic pressure is precirculated from accumulator **3** through the digester and back to the accumulator. During this precirculation treatment the chips are progressively saturated with hot acid. Due to the continuous flow of the acid and to its relatively high temperature, certain non-cellulosic constitutents are leached out and removed from the chips. During this precirculation treatment, therefore, certain so-called water solubles are removed, the chips are uniformly preheated and are unified with respect to their water content. This forced circulation also entrains and removes certain of the occluded inert gases contained in the chips. The chips are thus evacuated of gases and are deleted of certain undesirable constituents while concomitantly being saturated by the high-temperature, high-pressure digestion fluid.

As noted above, the temperature of the saturant and the time of treatment may vary within wide limits. In ordinary circumstances the acid entering the digester from the accumulator may be maintained at a temperature of from 75 to 100° C. or thereabouts. Due to the effective thermal control in the accumulator, such temperature may be maintained substantially constant. By precirculating such hot acid through the mass of chips in the digester for a sufficient period of time, a uniform temperature condition of the chips may be established. Such condition may be established in a period of time varying approximately from one-half hour to eight hours.

When the chips within the digester have been thoroughly saturated and the top and bottom temperatures in the digester have been substantially equalized at the desired level, the top and side relief valves **16'** and **17'** are closed. If desired the valve **43'** may then be opened and the pump **42** started to pump in any desired pressure. Thereafter the valve **43'** is closed and the digester pump **42** stopped. At this point the digester is ready for steaming to quickly initiate and complete the cook. It will be appreciated that since, in view of the precirculation treatment, the chips are of uniform temperature

throughout the digester and throughout the body of each chip, and since they are thoroughly impregnated with hot digestion fluid close to reaction temperature, the initiation of the cook is very rapid. This is to say that the actual cooking time for steam to blow is very materially shortened.

To initiate the cook steam is admitted through the line 71 and/or, if desired, through steam lines 70. The admission of steam raises the temperature of the mass to reaction temperatures. As steam is continuously introduced, as is well known by those skilled in the art, some condensation occurs, resulting in an increase in the liquid content and the liquid level in the digester. Such level may be controlled, as is known, by operating the side relief line 16 and discharging fluids therethrough to the eductor 7 to be contacted by the cooler acid in transit to the accumulator. The pressure conditions may be controlled by opening valve 17' and venting high pressure gases through the header 15 to the eductor. The pressure and liquid level within the digester may thus be maintained throughout the period of the cook and at the desired values in the well known manner. If desired, during the actual digestion period liquor may be recirculated directly to and from the digester through a suitable circuit (not shown). The relief is controlled so as to maintain the pressure substantially constant down to the blow-down period. In typical operations conducted with the present system pressures during cooking are maintained in the same plant normally at an established pressure which varies at different plants from approximately 60 lbs. gauge to 100 lbs. gauge, and in addition optimum temperatures in the digester, if possible, are kept below 135° C. The pressure is then reduced gradually from the operating pressure of approximately 60 to 100 lbs. down to 20 to 30 lbs., after which the material is either discharged in the blow pit or is washed with water in the digester and then discharged. The pulp so discharged may be further treated by any typical method.

It will be seen that the present type of process presents many advantages. The precirculation period, as noted, is carried out with a digestion liquor, the temperature and pressure of which may accurately be controlled to insure a uniform temperature in the mass of chips and a complete saturation prior to actual cooking. In these circumstances therefore the actual heat units required for cooking are very much less than those required by prior processes. For example, as compared to a cold acid cook, the heat units necessary under the present process are only those required to raise the mass of raw material that is to be cooked from a temperature of from 75° C. or 100° C. up to the cooking temperature, as compared with the rise, when using the cold acid process, of approximately 30° up to the cooking temperature which, as stated before, is kept as close to 135° C. as possible.

It will be understood therefore that while a preferred modification of the invention has been described, it is to be understood that this is given to exemplify the underlying principles involved. It will be appreciated by those skilled in the art that these major principles may be embodied in other specifically different elements of apparatus. Thus, while the present invention has been described with respect to the treatment of a cellulosic material with a metal bisulphide, it will be apparent that the process is operable utilizing other digestive reagents. Also while the process has been described with respect to the quick cook method, i. e., utilizing direct steam for cooking, it is obvious that the mass of acid saturated material may be brought up to reaction temperatures by using indirect heat or by a combination of the two. It is thus to be understood that the invention is not to be considered as limited to the particular procedures described, except as such procedures are clearly imposed by the appended claims.

I claim:

1. The method of digesting fibrous cellulosic material which comprises charging a digester with fibrous material, accumulating a volume of hot digestion liquor under pressure in an accumulator tank, circulating such hot acid liquor through the digester and directly back to the accumulator until the fibrous material in the digester is uniformly heated to a predetermined degree, and during such circulation recirculating a separate stream of acid directly to and from the accumulator, and while heating such stream automatically controlling the degree of heat imparted thereto to maintain the temperature of the acid in the accumulator at between substantially 75° C. and 100° C.

2. The method of digesting fibrous cellulosic material which comprises charging a digester with fibrous material, accumulating a volume of hot acid liquor in a pressure accumulator tank, circulating such hot liquor through the digester and back to the accumulator, recirculating a separate stream of acid liquor through a heater directly to and from the accumulator, and thermostatically controlling the heater to automatically maintain the liquor in the accumulator at a temperature of between substantially 75° C. and 100° C.

3. An apparatus for digesting cellulosic material comprising a digester, a pressure accumulator, a feed line connecting the lower part of the accumulator with the digester, a pump in said line; a return line connecting the digester with the accumulator whereby liquor may be circulated from the accumulator through the digester and back to the accumulator, an automatic pressure valve connected with the accumulator and operable to maintain a predetermined elevated pressure on the accumulator, a separate circulating line communicating at each end with the accumulator and operable independently of the said circulating line between the accumulator and digester, a pump and indirect heater in such line, a thermostatic element positioned within the accumulator and connections from the element to the heater operable to automatically control the amount of heating medium flowing through the heater.

4. A method of digesting fibrous material which comprises charging a digester with fibrous material, accumulating a body of hot digestion liquor under pressure in an accumulator tank, circulating such hot liquor through the digester and directly back to the accumulator until the fibrous material in the digester is uniformly heated to a predetermined degree, and during such circulation independently recirculating a stream of acid directly to and from the accumulator through a heater and at a velocity in excess of 17 ft. a second and automatically controlling the degree of heat imparted to said recirculating stream to maintain the temperature of the acid

in the accumulator at a temperature of between substantially 75° C. and 100° C.

5. An apparatus for digesting cellulosic material comprising a digester, a pressure accumulator, a feed line connecting the lower part of the accumulator with the digester, a pump in said line, a return line connecting the digester with the accumulator whereby liquor may be circulated from the accumulator through the digester and back to the accumulator, a circulating line connecting at each end with the accumulator; a pump, an indirect heater in such line, means to connect such recirculation line with the said feed line, a thermostatic element positioned within the accumulator and connections from the element to the heater operable to automatically control the amount of heating medium flowing through the heater.

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