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PAPER PULP PROCESS AND APPARATUS

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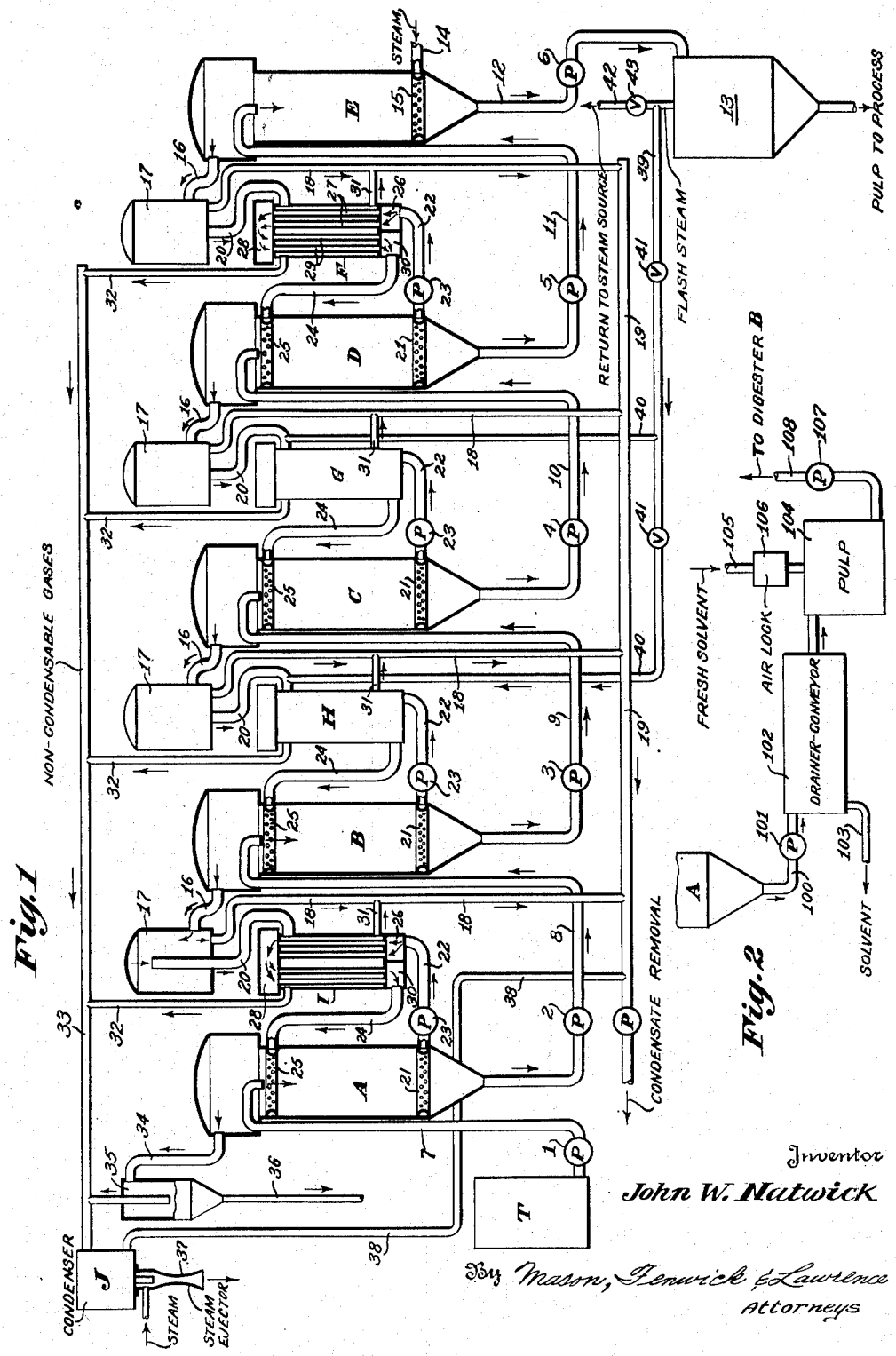


Fig. 1

Fig. 2

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PAPER PULP PROCESS AND APPARATUS

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This invention relates to new and improved methods for effecting the continuous digestion of fibrous materials such as wood chips and the like, and apparatus therefor.

The object of this invention is to provide a process for the continuous digestion of a fibrous material such as wood chips, which will ensure thorough impregnation of the material with the treating liquor and substantially complete uniform cooking to produce improved pulp products.

Another object is to subject the fibrous material to a vacuum to accomplish thorough impregnation by the treating liquor and to super-atmospheric pressures to ensure thorough cooking in a single, continuous, easily controlled process.

Still another object is to produce high quality pulp products in greater yields per pound of wood than has hitherto been accomplished.

Another object is to provide a continuous process for digesting fibrous materials which is easily and completely controlled with a minimum of man-power and which is very economical with respect to steam consumption.

Another object is to maintain the chemical cooking liquor in a relatively high degree of concentration so as to considerably shorten the cooking time required.

Still other objects are to effect continuous removal and recovery of soap and resins and of volatiles, such as turpentine and oils, and to control obnoxious, non-condensable gases.

One sheet of drawings accompanies this application as part thereof, in which like reference numerals indicate like parts throughout.

In the drawings:

Figure 1 is a diagrammatic view of an embodiment of my invention; and

Figure 2 is a diagrammatic view showing a modification.

Referring to Figure 1 of the drawings, it will be noted that the pulp passes continuously through a series of digesters A, B, C, D and E. Although the illustrated embodiment shows five digesters, it will be understood that the number of digesters may be varied.

The wood chips are admixed with a suitable chemical cooking liquor in tank T. The chips should be in a relatively fine state of attrition to permit efficient penetration of the liquor, and to facilitate pumping into digester A. Preferably, the chips have been fiberized as for example by passage through an attrition mill. The uniform small size of the chips processed in this way results in increased yields and better quality of

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pulps produced. The cooking liquor may be any of the suitable, commonly used treating liquors such as sulfite, soda, sulfate or lime liquors. The admixed wood chips and cooking liquor are then transferred to the top of conventional digester A by means of pump 1 through pipe 7. The pulp travels down through digester A under the influence of gravity, and is then pumped by pump 2 through pipe 8 into digester B. The fibrous material is subsequently passed in similar manner through digesters C, D and E, which are connected in series by pipes 9, 10 and 11. Pumps 3, 4 and 5 similarly force the pulp from the bottom of the preceding digester to the top of the succeeding digester. The completely digested pulp leaves the final digester E by way of pipe 12 and with the aid of pump 6 is passed into tank 13 and then into suitable apparatus for subsequent conventional treatment, such as washing and evaporation.

The elevated temperatures and pressures required for the digestion process are provided initially by the direct injection of steam under super-atmospheric pressure into the final digester E, by way of inlet pipe 14 which is connected to perforated ring 15 inside the digester. In this way uniform distribution of the steam through the digester contents is assured. Due to this direct injection of steam, the final digester is under the highest conditions of temperature and pressure present in the system.

After passing through and heating the digester contents, the remaining steam, which carries with it vaporized volatile materials such as turpentine and oil and non-condensable gases, such as hydrogen sulfide and sulfur dioxide, exits through outlet pipe 16 and passes into separator 17. Condensate drains into branch pipe 18 which is connected to condensate header 19. The remaining high temperature, high pressure vapors and gases then pass through pipe 20 into indirect heat exchanger F. Perforated ring 21 is positioned in the bottom portion of digester D in the path of the descending pulp. The perforations are of a size which permits inflow of the cooking liquor but prevents passage therethrough of solid materials. The cooking liquor which strains into the ring passes into pipe 22 and is forced by pump 23 into indirect heater F where it is heated to a relatively high temperature by the hot vapors and gases from digester E, and then returns to digester D by way of pipe 24 which connects with perforated ring 25 positioned in the upper portion of the digester.

The indirect heat exchanger may be of any

known type, as, for example, the type illustrated in Figure 1. The cooking liquor is forced into chamber 26 by way of inlet tube 22, rises through pipes 27 into chamber 28, descends through pipes 29 into chamber 30 and exits by way of outlet pipe 24. The incoming steam enters through inlet pipe 20 and circulates around pipes 27 and 29. Condensate leaves by way of branch pipe 31 which drains into branch pipe 18. The uncondensed gases which largely comprise such non-condensable gases as hydrogen sulfide, sulfur dioxide and air, leave by way of branch pipe 32 which connects with header 33.

The heated cooking liquor percolates through the fibrous material in digester D, thus maintaining the contents at an elevated temperature. The cooking liquor vaporizes to form steam which, together with other vaporized volatile materials and non-condensable gases, maintains a positive pressure in the digester. The vapors and gases generated in this way pass out of the digester by way of separator 17 into indirect heat exchanger G which heats the cooking liquor from digester C. The temperature and pressure in digester D are lower than those maintained in digester E, due to absorption of heat units by the pulp and by the cooking liquor in the vaporization process. The temperature and pressure are also decreased by the condensation of steam and volatiles in heater G.

Similarly, the contents of digesters C, B and A are heated by circulation of the cooking liquor through heaters G, H and I, respectively, and the heating medium for each of these heaters is derived from the vapors and gases generated in the subsequent digester in the manner aforedescribed in connection with digester D and heater F. The pressures and temperatures decrease progressively towards the forward part of the system. Preferably, the system is so regulated that the pressure in digester C is at approximately atmospheric pressure.

The vapors and gases from digester A pass through pipe 34 into separator 35. Condensate from the separator passes by way of outlet pipe 36 into condensate header 19. The remaining vapors and non-condensable gases pass into an efficient condenser J of any suitable type, preferably a surface condenser equipped with a suitable ejector 37, where the water, vapor and volatiles, such as turpentine and oils, are substantially entirely condensed into liquids which proceed to condensate header 19 by way of pipe 38. Header 33 which carries the non-condensable gases from the various heat exchangers, empties into condenser J. All of the non-condensable gases, including those from digester A, are then removed by ejector 37, and may be suitably and efficiently disposed of, as for example, by recovery of desired components or by burning.

The removal of non-condensable gases from the heat exchangers may also be accomplished apart from the condenser. This may be desirable if the quantity of such gases is relatively high. Although my preferred embodiment shows a condenser and ejector means, it will be understood that any suitable evacuating means may be employed which will accomplish my purpose.

The reduction in back pressure by condenser J produces a vacuum in digester A, the degree of which may be readily controlled by regulating the conditions in the condenser and the temperature of the admixed chips and cooking liquor entering the digester. The degree of vacuum is a factor in determining the temperature of the contents in digester A, inasmuch as it affects the degree of vaporization which occurs within the digester. Digester B may be maintained in a condition of partial vacuum of lesser degree than in digester A by the action of heater I which acts as a surface condenser, inasmuch as it condenses vapors from digester B and removes non-condensable gases and entrained air. Because of the reduction in temperatures which occurs pregressively from the latter to the forward portions of the system, the temperature in digester B is lower than that in digester C where the pressure may be maintained at approximately normal pressures by proper regulation of the system. Condensation of the vapors from digester B will therefore result in subatmospheric pressures.

Flash steam which leaves the system with the completely digested pulp from digester E may be returned to the system at advantageous points. For example, it may be piped into either heater H or G by way of conduit 39 and branch conduits 40 equipped with suitable valves 41, depending upon the temperature and pressure conditions desired in these portions of the system. If conditions in the system do not require the injection of steam at any point other than digester E, the steam leaving with the pulp may be recovered by returning it to the steam generator by way of pipe 42 controlled by valve 43.

Condensate removed via header 19 may be suitably treated to recover turpentine, oils and the like.

The process as above described may be modified so as to subject the chips to different treating liquors without interrupting its continuity or disturbing the desired progression of increasing pressures and temperatures. For example, it is often desirable to remove resins and soap forming constituents by means of suitable solvents prior to treating the chips with digesting liquors. Figure 2 shows a modification which permits initial treatment of the wood chips with a solvent, and subsequent replacement of the solvent with digesting liquor. The wood chips are admixed with a suitable solvent in tank T and pumped, as aforedescribed, into the upper portion of digester A. Because of the low pressure conditions prevailing in the digester, the solvent rapidly penetrates the chips and dissolves such components of the wood as resins, soap forming materials and the like. The solvent and chip mixture is pumped from digester A through pipe 100 by means of pump 101 into a conventional drainer-conveyor 102. The solvent is removed through conduit 103 and then may be recovered by re-use in the system. Similarly, the dissolved components, such as the resins and soap forming materials, may be recovered and constitute valuable by-products. The remaining fibrous material passes into tank 104 where it is admixed with digesting liquor which is introduced into the tank through inlet pipe 105. This inlet is provided with any suitable air lock 106 to maintain the pressure in the system. The temperature of the fresh digesting liquor is controlled to maintain the progression of temperatures and pressures in the system, as described above. The temperature of the liquor should, therefore, be substantially the same as that of the withdrawn solvent. The fibrous material admixed with the fresh digesting liquor is then pumped by means of pump 107 through pipe 108 into digester B, where it is sub-

jected to subatmospheric pressures, which ensure thorough impregnation.

A modification, similar to the one aforedescribed, may be employed at any desired point in the system to drain off one type of digesting liquor and substitute a different type of liquor, or to remove spent liquor and substitute fresh liquor.

The desired conditions of elevated temperature and pressure may be obtained in the final digester by injecting the steam into an indirect heater through which the treating liquor from the digester is circulated. Although this involves some loss of heat units which is avoided by direct injection of the steam into the last digester, this method may be advisable where it is desired to avoid any dilution of the digester contents.

The process may be employed not only for the treatment of wood, but of other fibrous materials, such as straw, bagasse, flax, cotton and the like.

From the foregoing description it will be apparent that the present invention is concerned with a process for cooking fibrous material, such as wood chips, to obtain pulp, and a digesting system by which that process is carried out, wherein the chips and accompanying cooking liquor are subjected progressively to a plurality of cooking stages ranging from subatmospheric pressures and relatively low temperatures to super-atmospheric pressures and high temperatures, the flow of the chips and cooking liquor being in one direction and the flow of the temperature and pressure controlling medium being in the opposite direction. The cooking rate may be varied by controlling the temperature and pressure of the control medium at the point of admission, the action of the terminal condenser and ejector and the control temperature of the cooking liquor. When these factors are set, the intermediate stages of the system automatically come into balance to provide a uniform progression throughout the system. The steps of the progression necessarily will be in direct ratio to the control points at the ends of the system. The cooking rate may also be regulated by varying the rate of flow of the chips and cooking liquor through the system.

The table shows the interdependent progression of pressures within the digesters under the influence of variations in the initial pressure of the steam injected into the last digester and in the degree of vacuum produced by the evacuating means in the first digester.

Table

Digester	Initial Steam Pressures [1]					
	50 lbs.	50 lbs.	80 lbs.	80 lbs.	100 lbs.	100 lbs.
	Pressures in Digesters					
E	27.5 lbs.	18.5 lbs.	43.5 lbs.	30.5 lbs.	54.5 lbs.	39.5 lbs.
D	15.5 lbs.	4.5 lbs.	15.5 lbs.	10.5 lbs.	31.5 lbs.	15 lbs.
C	7 lbs.	8.75 in.	11.5 lbs.	4 in.	15 lbs.	0 lb.
B	0 lb.	19.75 in.	2 lbs.	18.25 in.	5 lbs.	17.25 in.
A	11 in.	26 in.	11 in.	26 in.	11 in.	26 in.

[1] The pressures in pounds per square inch denote the increment of positive pressure above normal.

It will be clear from the foregoing description of my process that the fibrous material and treating liquor are subjected to sub-atmospheric pressures in the first digester, and that the pressures and temperatures progressively increase in the subsequent digesters so that the contents in the final digester are under relatively high, positive pressure and elevated temperature. The initial subjection of the admixed wood chips and treating liquor to sub-atmospheric pressure results in rapid penetration of the liquor into the interior of the chips. This thorough, substantially complete, impregnation of the chips considerably shortens the necessary digestion period and ensures a uniform, high quality product since there is no overcooking with consequent weakening of the fibers at the surface of the chips, while the digesting liquor is slowly penetrating into the interior.

After leaving the evacuated portion of the system, the fibrous material and liquor continuously progress through the digesters under progressively increased conditions of temperature and pressure which ensure thorough, rapid and complete digestion. The rate at which the material moves through the system may be easily regulated so as to prevent either overcooking or undercooking.

Another factor which shortens the period of cooking by my process, is the gradual increase in concentration of the digesting liquor because of vaporization of fluid in succeeding digesters. The resulting reduction in fluid volume maintains the remaining active digesting chemicals in relatively high and effective concentration as the fibrous material progresses through the system.

The pulp product produced by my process is of uniformly high quality. Since there is no overcooking of any of the material there is no weakening or disintegration of any of the fibers. The thorough impregnation of the material and subsequent uniform digestion eliminates the knots and screenings which are usually present in pulp produced by the present commonly used processes and results in greater yields per pound of wood chips than is generally obtained. The removal of soap forming materials and volatiles such as turpentine, oils, and the like, in the course of the process, facilitates their economical recovery and results in a highly purified pulp with concomitant improved physical properties. The removal of soap forming materials is particularly advantageous since it eliminates the severe foaming which generally makes the subsequent washing of the pulp very difficult. The process, furthermore, permits complete control of obnoxious gases such as hydrogen sulfide which do not condense under the conditions of the process. The process, therefore, may be used without objection in any vicinity.

The process is highly economical with respect to the utilization of steam and digesting liquor. The heat units which are initially supplied by the direct injection of steam into the last digester, are efficiently and relatively completely utilized by the interrelated system of digesters and indirect heat exchangers. The consumption of digesting liquor is also reduced by the preliminary, thorough impregnation of the wood under

vacuum and the subsequent maintenance of a relatively high concentration because of vaporization and removal of the carrying fluid.

The process is also economical with respect to the amount of man power required. The process may be easily and completely controlled by suitable instrumentation. The apparatus itself is relatively simple to operate and maintain, since there is no need for a complicated system of valves and direct steam is injected at only one point in the system.

Although I have described my invention fully and clearly so that it may be readily comprehended by those skilled in the art, it will be understood that changes are possible within the scope of the appended claims.

Having thus described my invention, I claim:

1. Apparatus for continuously digesting fibrous materials comprising, a series of connected digesting chambers, means for moving the fibrous material and treating liquor from each chamber into the next chamber in the series, each chamber except the last chamber being connected with means including a pump for circulating the chemical treating liquor through the fibrous material in said chamber, exteriorly of said chamber and back into said chamber, an indirect heater exteriorly connected with said circulating means, conduit means for conducting the vapors and gases from the next subsequent digesting chamber into said heater, said vapors and gases serving to heat said treating liquor, conduit means connected with said heater for discharging condensate formed by said vapors, independent means for heating the pulp in the last digesting chamber thereby maintaining it at an elevated temperature and at super-atmospheric pressure, and evacuating means associated with the first digesting chamber for reducing the pressure in said chamber.

2. Apparatus for continuously digesting fibrous materials comprising a series of connected digesting chambers, means for moving the fibrous material and treating liquor from each chamber into the next chamber in the series, each chamber except the last chamber being connected with means including a pump for circulating chemical treating liquor through the fibrous material in said chamber, exteriorly of said chamber and back into said chamber, a heater exteriorly connected with said circulating means, conduit means for conducting the vapors and gases from the next subsequent digesting chamber into said heater, said vapors and gases serving to heat said treating liquor, conduit means connected with said heater for discharging condensate formed by said vapors, independent means for heating the pulp in the last digesting chamber, thereby maintaining it at elevated temperature and super-atmospheric pressure, evacuating means connected with the first digesting chamber for reducing the pressure in said chamber, and means for replacing the initial treating liquor with a different treating liquor at an intermediate point in the system, said means comprising a drainage chamber having outlet means for said initial treating liquor, a conduit for discharging fibrous material in admixture with initial treating liquor from one of the digesters in said series into said drainage chamber, conveyor means for discharging fibrous material from said drainage chamber into a chamber having inlet means for said different treating liquor, and pump and conduit means for discharging the fibrous material admixed with said different treating liquor into the next subsequent digester in the series.

3. A process for continuously digesting wood comprising, continuously passing said wood in a fiberized state of attrition, in admixture with chemical treating liquor through a series of connected digesters and subjecting said mixture of fiberized wood and treating liquor to progressively increasing temperatures and pressures which progressively increase from sub-atmospheric pressures to super-atmospheric pressures, said progressively increasing temperatures and pressures being accomplished by injecting steam under super-atmospheric pressure into the last digester, indirectly heating the treating liquor in each of the preceding digesters exteriorly of said digesters by means of the vapors and gases from the next subsequent digester, said vapors and gases being at a higher temperature than said treating liquor, and maintaining a partial vacuum in the first digester.

4. A process for continuously digesting fibrous material comprising continuously passing fibrous material in admixture with chemical treating liquor through a series of connected digesters, maintaining the last digester at a relatively high temperature and high pressure by means of heat from an independent source, and heating the contents of each of the preceding digesters indirectly by means of the vapors and gases from the next subsequent digester, said vapors being discharged in the form of condensate, whereby the temperature and pressure increase progressively from the first to the last digester.

5. A process for continuously digesting fibrous material comprising continuously passing fibrous material in admixture with chemical treating liquor through a series of connected digesters, maintaining the last digester at a relatively high temperature and high pressure by means of steam from an independent source, and heating the contents of each of the preceding digesters indirectly by means of the vapors and gases from the next subsequent digester, said heating being accomplished by circulating the treating liquor in each of the preceding digesters exteriorly of and back into said digester and indirectly heating the liquor while exterior of said digester by means of the vapors and gases from the next subsequent digester, said vapors being discharged in the form of condensate, whereby the temperature and pressure increase progressively from the first to the last digester.

6. A process for continuously digesting fibrous materials comprising continuously passing said fibrous material in admixture with chemical treating liquor through a series of connected digesters, maintaining the last digester under relatively high temperature and high pressure by means of heat from an independent source, heating the contents of each of the preceding digesters indirectly by means of the vapors and gases from the next subsequent digester, said vapors being discharged in the form of condensate, and maintaining the first digester at relatively low temperature and at sub-atmospheric pressure, whereby the temperature and pressure increase progressively from the first to the last digester.

7. A process for continuously digesting fibrous material comprising continuously passing fibrous material in admixture with chemical treating liquor through a series of connected digesters, maintaining the last digester at a rel-

atively high temperature and high pressure by means of steam under pressure from an independent source, heating the contents of each of the preceding digesters indirectly by means of the vapors and gases from the next subsequent digester, said heating being accomplished by circulating the treating liquor in each of the preceding digesters exteriorly of and back into said digester and indirectly heating the liquor while outside of said digester by means of the vapors and gases from the next subsequent digester, said vapors being discharged in the form of condensate, and maintaining the contents of the first digester under partial vacuum and at relatively low temperature, whereby the temperature and pressure increase progressively from the first to the last digester.

8. A process for continuously digesting fibrous materials comprising continuously passing said fibrous material in admixture with chemical treating liquor through a series of connected digesters, maintaining the last digester at relatively high temperature and high pressure by heating with steam under pressure from an independent source, heating the contents of each of the preceding digesters indirectly by means of the vapors and gases from the next subsequent digester, said indirect heating being accomplished by circulating the treating liquor in each of said preceding digesters and the vapors and gases from the next subsequent digester through an indirect heat exchanger, each of said preceding digesters being connected with an individual heat exchanger, said vapors being discharged in the form of condensate, and maintaining the contents of the first digester under partial vacuum and at relatively low temperature, whereby the temperature and pressure increase progressively from the first to the last digester.

9. A process for continuously digesting fibrous materials consisting of continuously passing said fibrous material in admixture with chemical treating liquor through a series of connected digesters, maintaining the last digester at relatively high temperature and high pressure by injecting steam under pressure from an independent source, heating the contents of each of the preceding digesters indirectly by means of the vapors and gases from the next subsequent digester, said indirect heating being accomplished by circulating the treating liquor in each of said preceding digesters and the vapors and gases from the next subsequent digester through an indirect heat exchanger, each of said preceding digesters being connected with an individual heat exchanger, said vapors and gases being discharged in the form of condensate and uncondensed gases, and maintaining the contents of the first digester under partial vacuum and relatively low temperature, whereby the temperature and pressure increase progressively from the first to the last digester.

10. The process of claim 8 wherein the initial treating liquor is replaced with a different treating liquor at an intermediate point in the system while maintaining substantially the same pressure and temperature prevailing at said intermediate point in the system.

11. The process of claim 9 wherein the initial treating liquor is replaced with a different treating liquor at an intermediate point in the system, said replacement of treating liquor being accomplished by discharging the fibrous material admixed with the initial treating liquor from one of the digesters in said series into a chamber, discharging said initial treating liquor, discharging the fibrous material into a second chamber, introducing the different treating liquor, said different treating liquor being at substantially the same temperature as the withdrawn initial treating liquor, and then passing the fibrous material admixed with the different treating liquor into the subsequent digester in the series.

12. A process for continuously digesting fibrous materials consisting of continuously passing said fibrous material in admixture with chemical treating liquor through a series of five connected digesters, maintaining the last digester at relatively high temperature and high pressure by injecting steam from an independent source under a pressure of about 80 pounds per square inch, heating the contents of each of the preceding digesters indirectly by means of the vapors and gases from the next subsequent digester, said indirect heating being accomplished by circulating the treating liquor in each of said preceding digesters and the vapors and gases from the next subsequent digester through an indirect heat exchanger, each of said preceding digesters being connected with an individual heat exchanger, said vapors being discharged in the form of condensate, and maintaining the contents of the first digester at relatively low temperature and under a partial vacuum equivalent to about 11 inches of mercury, whereby the temperature and pressure increase progressively from the first to the last digester.

13. Apparatus for continuously digesting fibrous materials consisting of a series of connected digesting chambers, pumping means for forcing the material from each chamber into the next chamber in the series, each chamber except the last chamber being connected with means for circulating chemical treating liquor through the fibrous material in said chamber, exteriorly of said chamber and back into said chamber, said circulating means including a pump and exterior conduit, an indirect heater exteriorly connected with said circulating means, conduit means for conducting the vapors and gases from the next subsequent digesting chamber into said heater, said vapors and gases serving to heat said treating liquor, conduit means connected with said heater for discharging condensate formed by said vapors, conduit means for discharging gases from said heaters, independent means for injecting steam under pressure into the last digesting chamber, evacuating means connected with the first digesting chamber for reducing the pressure in said chamber, and means for replacing the initial treating liquor with a different treating liquor at an intermediate point in the system, said means comprising a drainage chamber having outlet means for said initial treating liquor, a conduit for discharging fibrous material in admixture with initial treating liquor from one of the digesters in said series into said drainage chamber, conveyer means for discharging fibrous material from said drainage chamber into a chamber having inlet means for said different treating liquor, and pump and conduit means for discharging the fibrous material admixed with said different treating liquor into the next subsequent digester in the series.

14. Apparatus for continuously digesting fibrous materials comprising, a series of connected digesting chambers, means for moving the fibrous material and chemical treating liquor from each chamber to the next chamber in

the series, each chamber except the last chamber being connected with means including a pump for circulating the treating liquor through the fibrous material in said chamber, exteriorly of said chamber and back into said chamber, an indirect heater exteriorly connected with said circulating means, conduit means for conducting the vapors and gases from the next subsequent digesting chamber into said heater, said vapors and gases serving to heat said treating liquor, conduit means connected with said heater for discharging condensate formed by said vapors, means for injecting steam under pressure into the last digesting chamber, and evacuating means connected with the first digesting chamber for reducing the pressure in said chamber.

15. Apparatus for continuously digesting fibrous materials consisting of a series of connected digesting chambers, pumping means for forcing the material from each chamber into the next chamber in the series, each chamber except the last chamber being connected with means for circulating the chemical treating liquor through the fibrous material in said chamber, exteriorly of said chamber and back into said chamber, said circulating means including a pump and exterior conduit, an indirect heater exteriorly connected with said circulating means, conduit means for conducting the vapors and gases from the next subsequent digesting chamber into said heater, said vapors and gases serving to heat said treating liquor, conduit means connected with said heater for discharging condensate formed by said vapors, conduit means for discharging gases from said heater, independent means for injecting steam under pressure into the last digesting chamber, and evacuating means associated with the first digesting chamber for reducing the pressure in said chamber.

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