

Jan. 24, 1961

F. B. K. GREEN

2,969,113

PULP MANUFACTURE

Filed Dec. 18, 1957

8 Sheets-Sheet 1

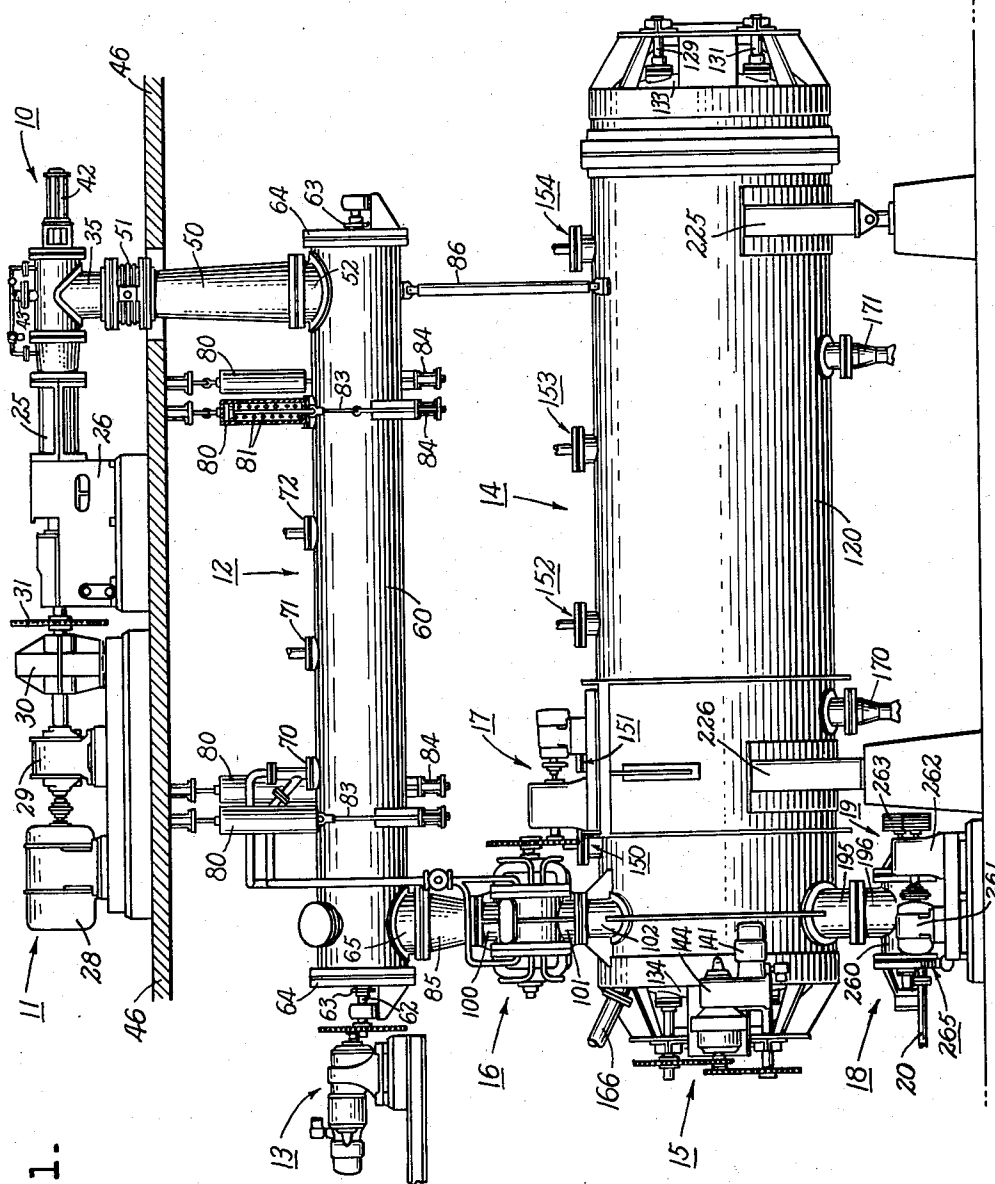


Fig. 1.

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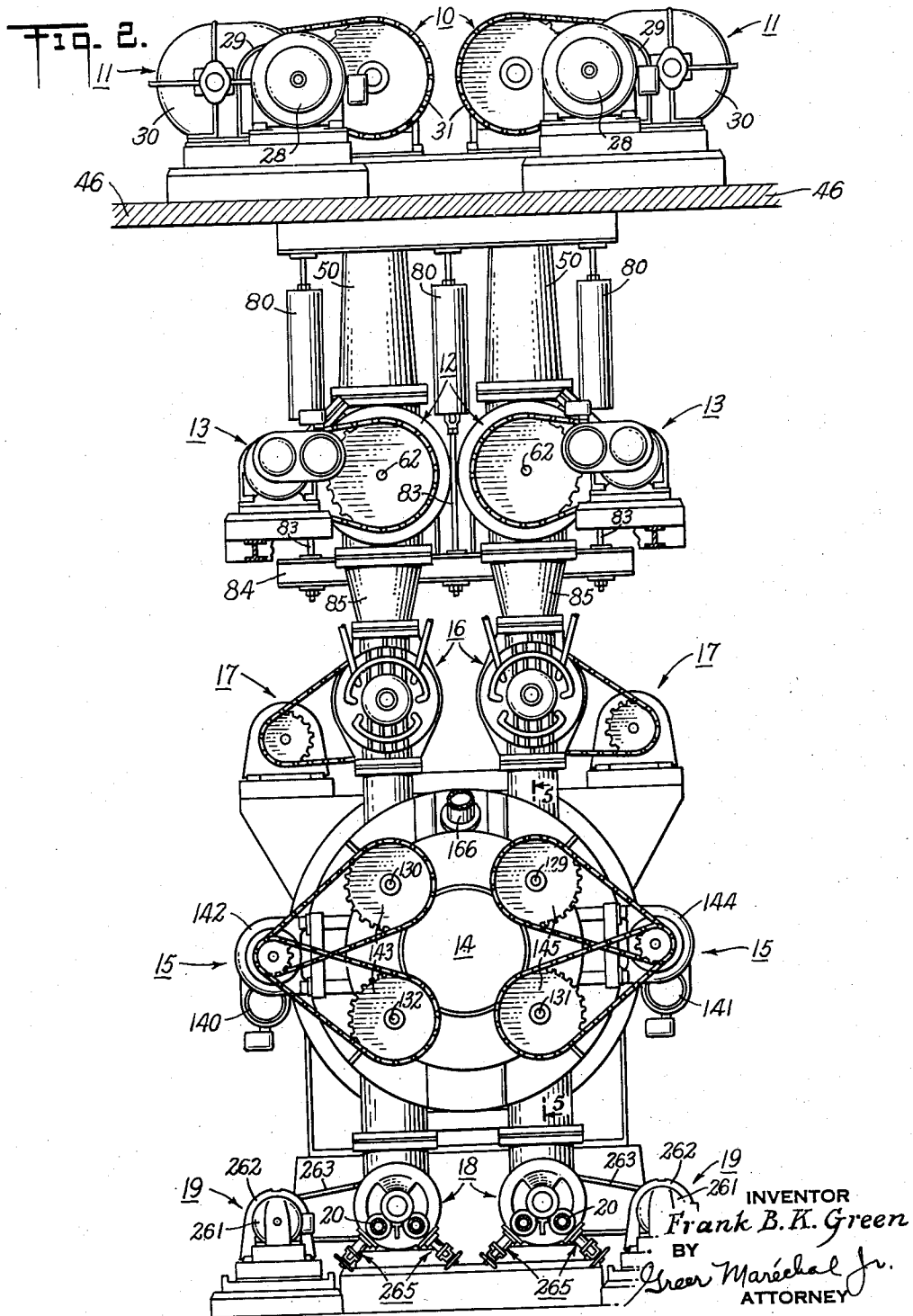
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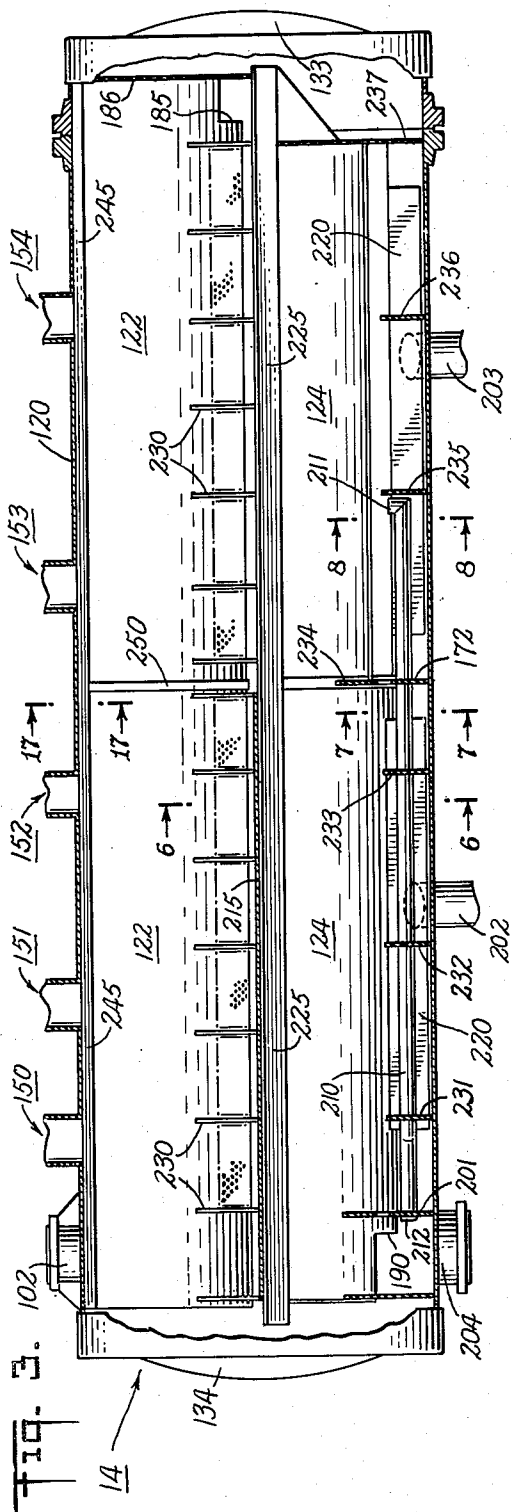
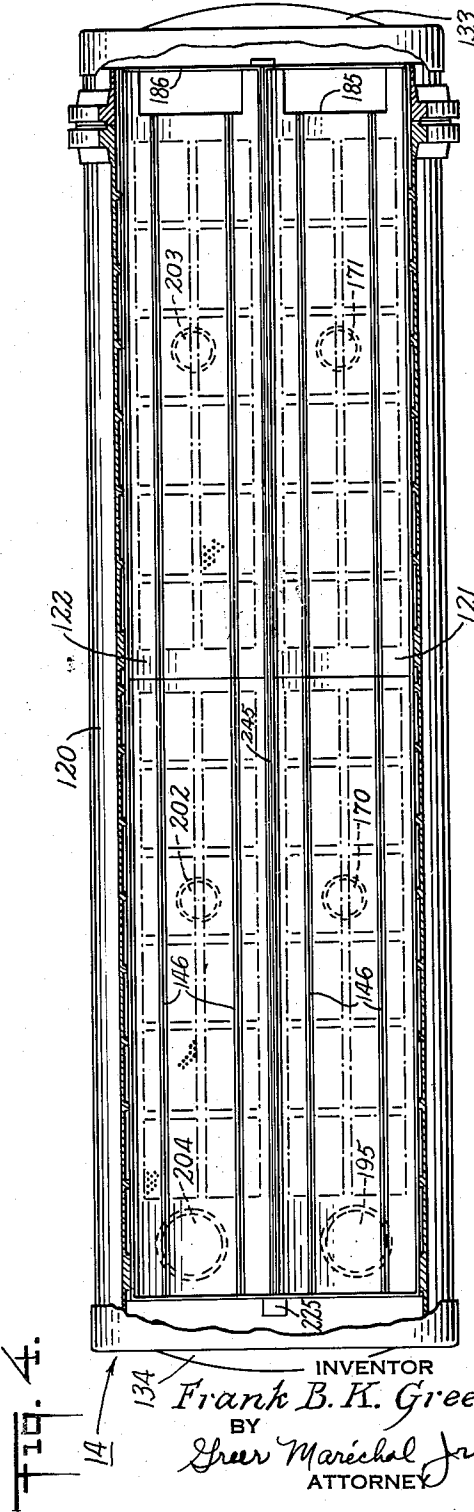
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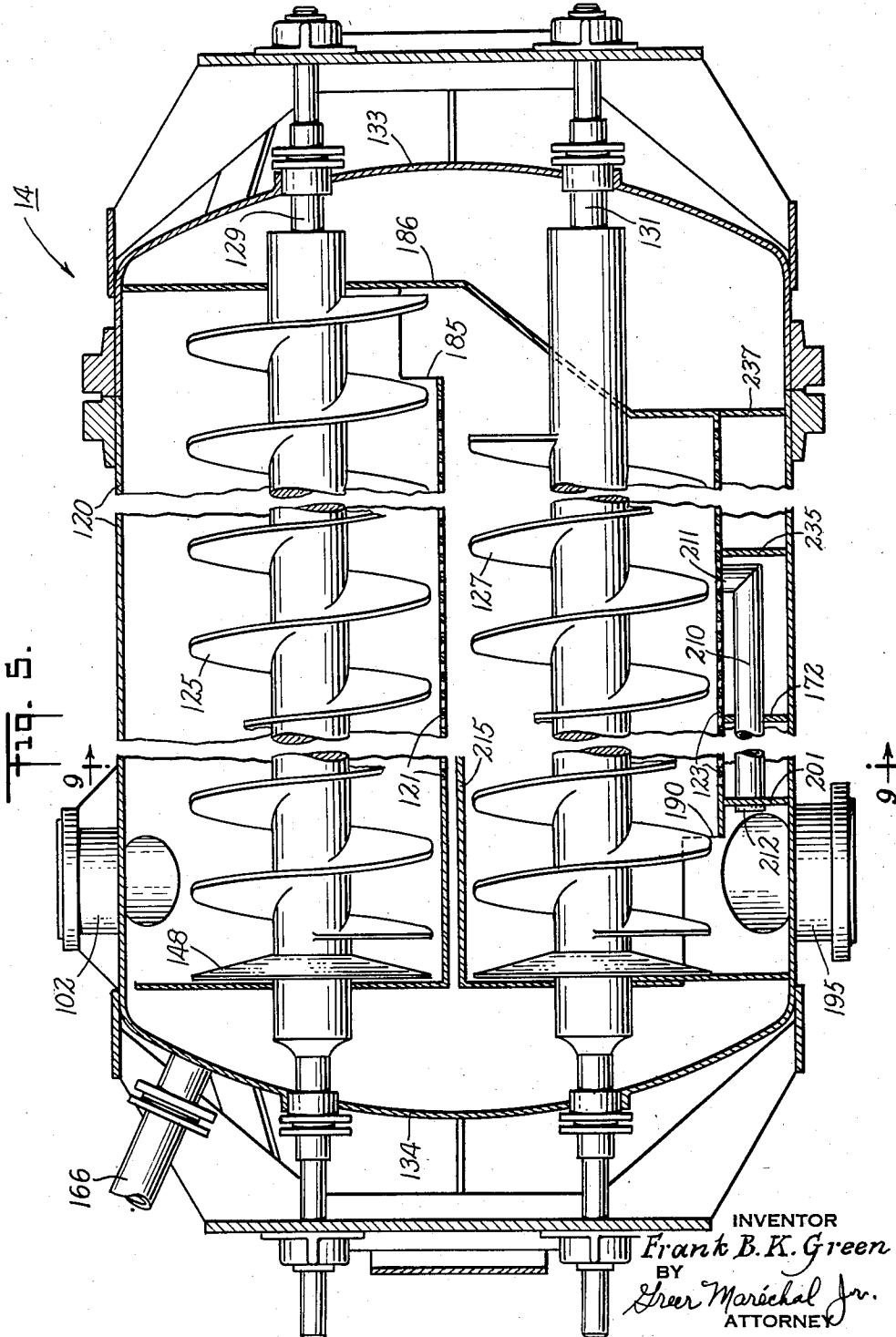
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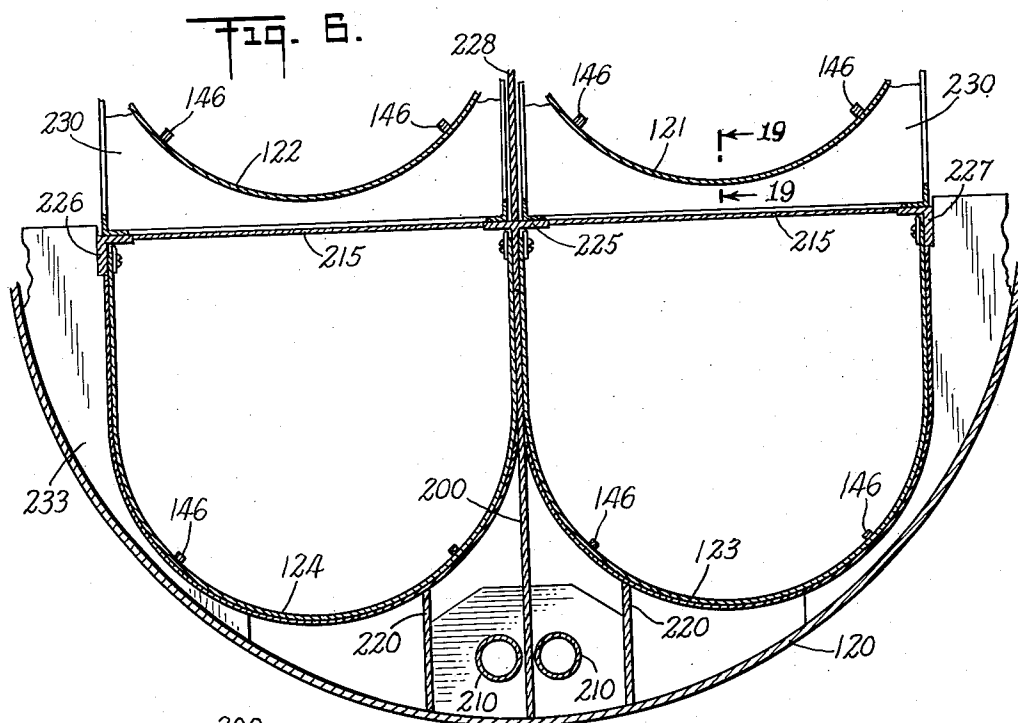
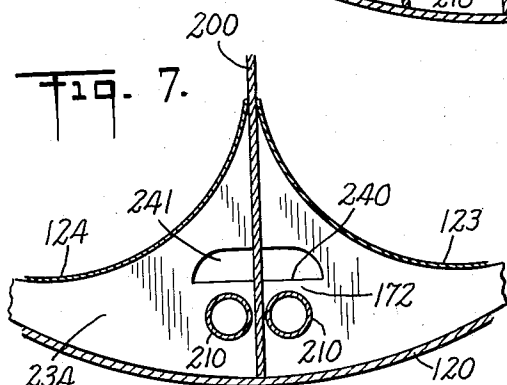
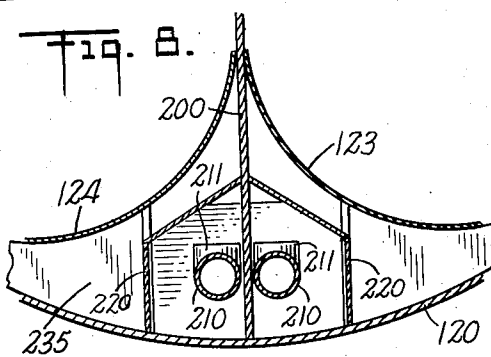
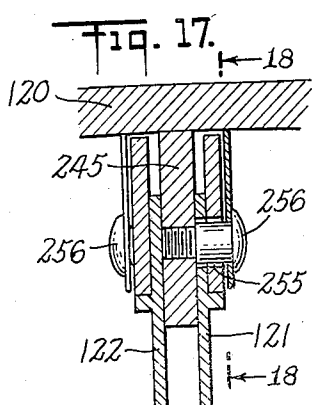
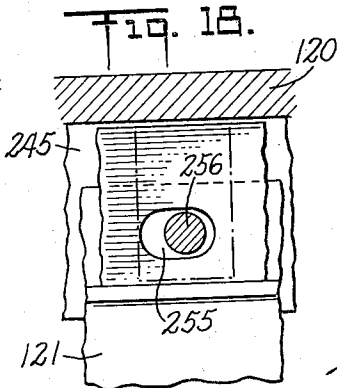
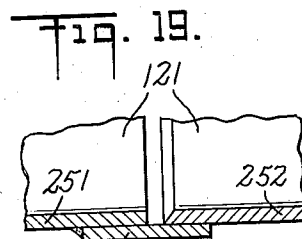
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Fig. 9.

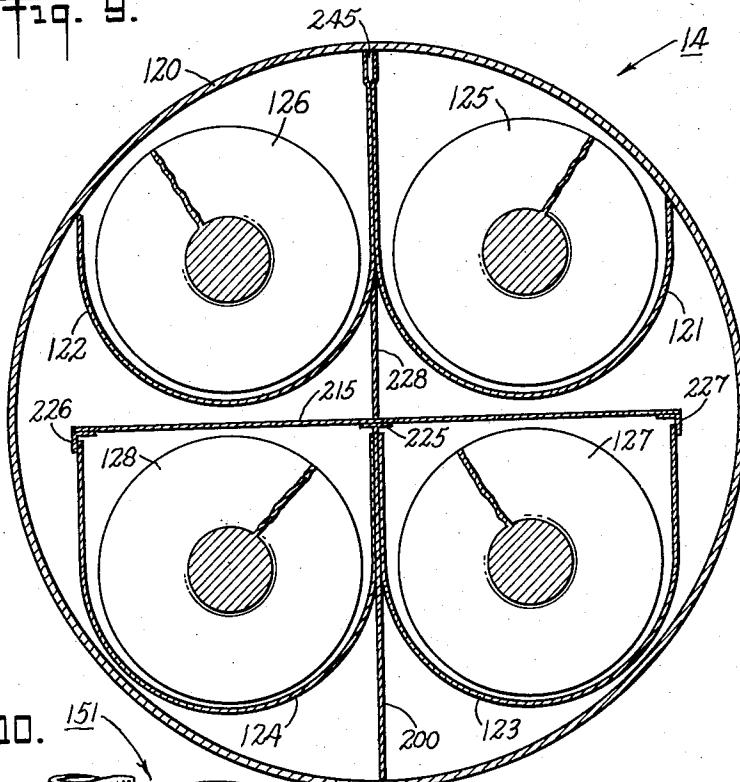


Fig. 10.

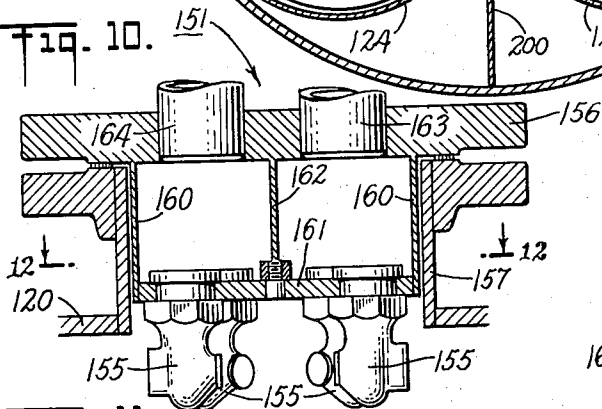


Fig. 11.

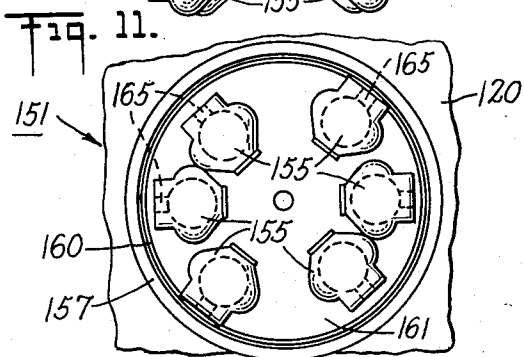
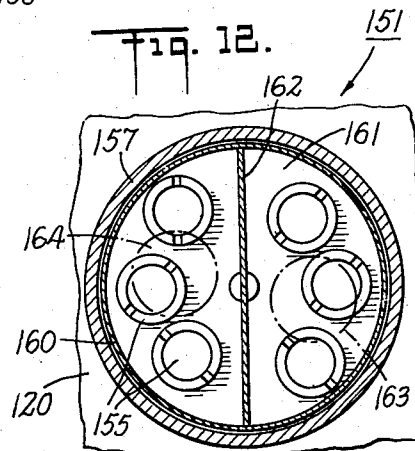


Fig. 12.



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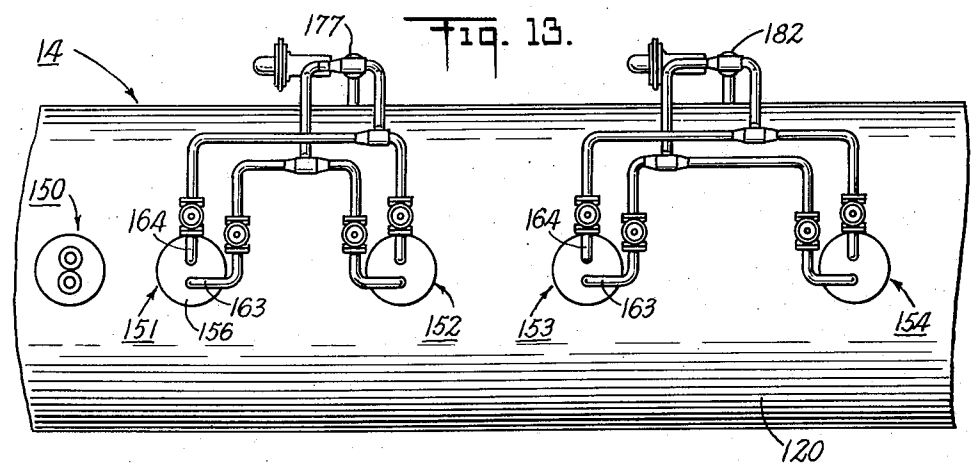
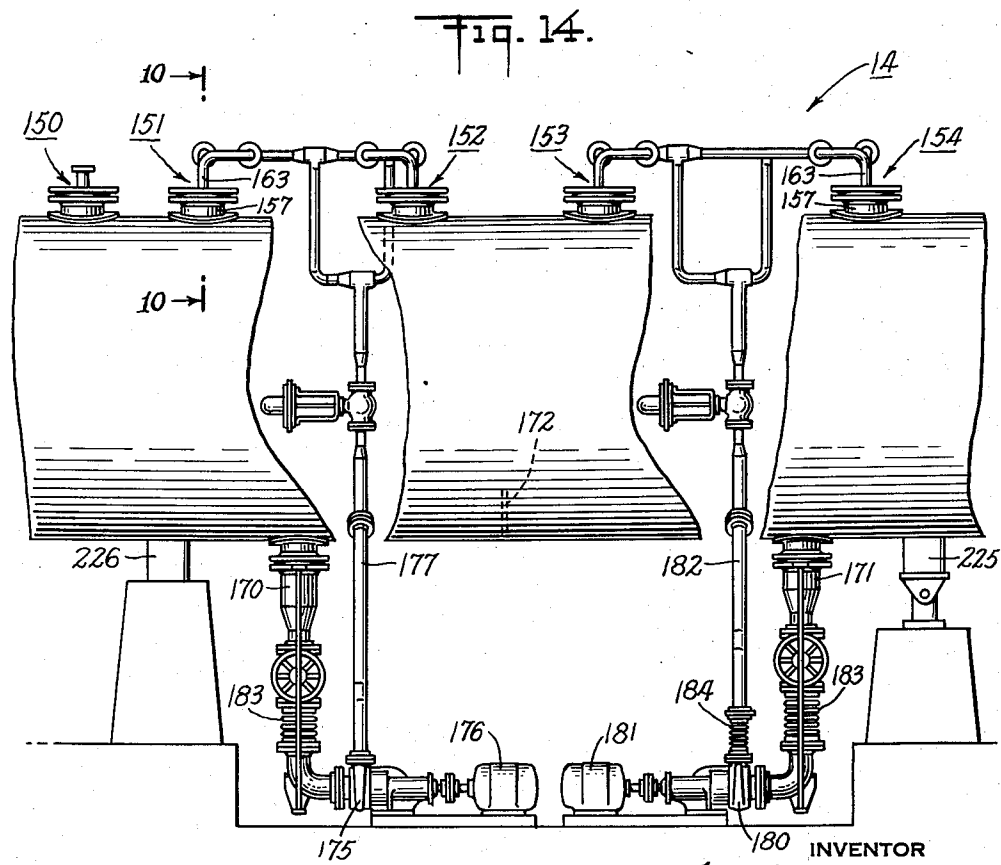
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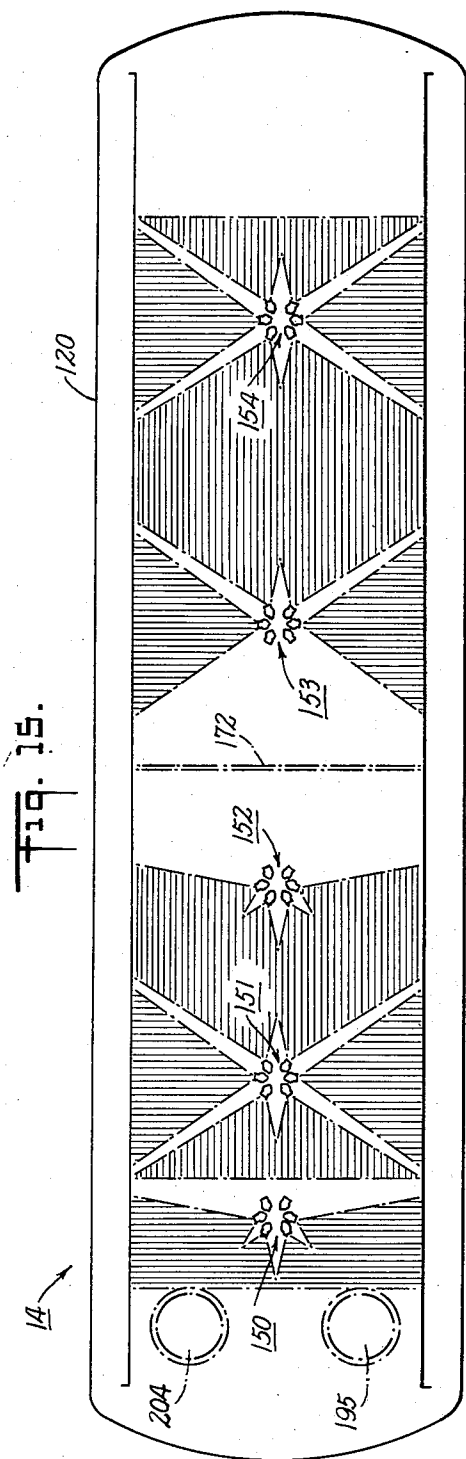
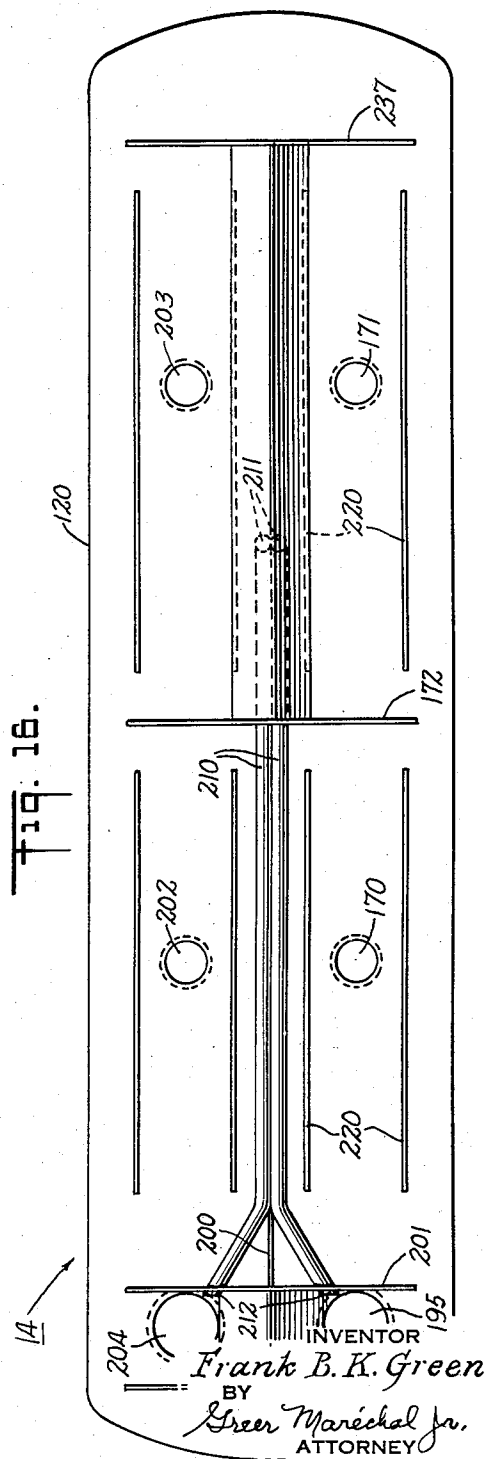
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PULP MANUFACTURE

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PULP MANUFACTURE

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Filed Dec. 18, 1957, Ser. No. 703,588

9 Claims. (Cl. 162—237)

This invention relates to the manufacture of pulp from wood or other fibrous material for making paper and the like and, more particularly, to methods and apparatus for cooking or digesting or softening the wood or other fibrous material to convert it into a pulp by a continuous operation.

As a result of technological and economic developments and considerations in the manufacture of paper, paper board and the like, from wood pulp or pulp of other fibrous materials, most of the operations in a pulp and paper mill other than the pulp cooking and digesting steps are carried on in a continuous fashion instead of in a batch-type manner. Accordingly, it may also be desired that the initial cooking and digesting steps wherein the ligneous and other non-cellulosic encrustants or binding materials in wood are softened or removed to render the wood fibres desirably separable for preparation of a pulp slurry also being carried out in a continuous manner for integration with the other continuous processes of the mill.

According to this invention, then, methods and apparatus are provided for continuously processing chips of wood through cooking and digesting steps wherein the wood is subjected to the softening or cooking or digesting action of chemical liquors at elevated temperatures and substantially super-atmospheric pressure for discharging the cooked wood into subsequent pulp mill operations and apparatus. The apparatus embodying and for practicing this invention also is provided for disposition in a pulp mill to occupy a minimum of space and yet provide a plurality of parallel separately controllable lines of flow for concurrently processing the same or different types of wood or other raw materials through a plurality of softening and cooking and digesting zones with an optimum efficiency in subjecting the raw material to a plurality of different cooking or digesting liquors and/or at a plurality of concentrations as the cooking proceeds for achieving optimum cooking efficiency and minimal degradation of the cellulose fibres during the cooking steps for optimum yield of finished product.

One object of this invention is to provide apparatus of the character described for continuously cooking or digesting chips of wood or the like at elevated temperatures or pressures and having provision for subjecting the chips to a plurality of different cooking or digesting conditions in a plurality of different cooking or digesting zones.

Another object of this invention is to provide apparatus of the character described for continuously processing chips of wood or the like at elevated temperatures and pressures through a plurality of different cooking or digesting zones and having provision for subjecting the chips to a plurality of different cooking liquors or to cooking liquors of a plurality of different concentrations.

A further object of this invention is to provide apparatus of the character described for continuously cooking or digesting chips of wood or the like for pulp manufacture by feeding the chips continuously through a plu-

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ality of different cooking or digesting zones, and including means for arranging the apparatus for continuous flow operation to occupy a minimum of space in the pulp mill.

5 A still further object of this invention is to provide, in continuous digester apparatus of the character described, a plurality of parallel separate lines of flow for continuous concurrent yet independent operation substantially all contained in a single unit.

10 Still another object of this invention is to provide, in continuous digester apparatus of the character described, means for arranging and supporting and interconnecting the various components of the apparatus for compensating for varying thermal expansion movement and strains and stresses within the apparatus and between the apparatus and other equipment operating at different temperatures and pressures.

15 A still further object of this invention is to provide, in continuous digester apparatus of the character described, a plurality of separately controllable continuous flow arrangements for both chips of wood and cooking or digesting liquor in a unitary structure.

20 Other objects and advantages will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings:

25 Fig. 1 is a side elevation view of a continuous pulping system including apparatus embodying and for practicing this invention;

30 Fig. 2 is an end elevation view of the system of Fig. 1 from the left end thereof;

35 Fig. 3 is a side view partly in section and with parts broken away of a digester vessel embodying and for practicing this invention;

40 Fig. 4 is a top view similar to Fig. 3;

45 Fig. 5 is a vertical axial section partly broken away on an enlarged scale of digesting apparatus embodying and for practicing this invention along the line 5—5 of Fig. 2;

50 Fig. 6 is a partial transverse section along the line 6—6 of Fig. 3;

55 Fig. 7 is a partial transverse section along the line 7—7 of Fig. 3;

60 Fig. 8 is a partial transverse section along the line 8—8 of Fig. 3;

65 Fig. 9 is a partial transverse section along the line 9—9 of Fig. 5;

70 Fig. 10 is a vertical transverse section on an enlarged scale of one of the cooking liquor inlets of digesting apparatus embodying and for practicing this invention along the line 10—10 of Fig. 14;

Fig. 11 is a bottom view of the detail of Fig. 10;

75 Fig. 12 is a horizontal section on the line 12—12 of Fig. 10;

80 Figs. 13 and 14 are top and side elevation views, respectively, of the cooking liquor piping arrangements of digesting apparatus embodying and for practicing this invention;

85 Fig. 15 is a diagrammatic top view indicating the cooking liquor spray patterns within the digesting vessel of Fig. 4;

90 Fig. 16 is a view from above of the inside bottom portion of the digester of Fig. 4 with some of the internal structure removed for clarity;

95 Fig. 17 is a partial section on an enlarged scale along the line 17—17 of Fig. 3;

100 Fig. 18 is a partial section along the line 18—18 of Fig. 17; and

105 Fig. 19 is a partial section along the line 19—19 of Fig. 6.

Continuous digesting apparatus embodying and for practicing this invention, as will be understood, may be

satisfactorily utilized in a variety of different systems or processes for cooking or digesting wood or other fibrous material in the production of pulp for the manufacture of paper, paper board, and the like. In order to achieve a more complete understanding of the structure and functioning and mode of operation of apparatus according to this invention, it will be here described in connection with a pulping system and process as disclosed in more detail in my copending application Serial No. 703,632, executed and filed on even dates herewith.

Referring to the drawings, in which like characters of reference designate like parts throughout the several views thereof, a preferred pulping system including continuous digesting apparatus embodying and for practicing this invention is indicated generally in side view and end view respectively in Figs. 1 and 2 as comprising feeding apparatus 10 for introducing chips of wood to be cooked into the digesting system and having driving means 11 operatively connected thereto, pre-steaming apparatus 12 for subjecting the chips of wood or other material to a preliminary steaming treatment or step and having its driving means 13 operatively connected thereto, cooking or digesting apparatus 14 with its associated drive means 15 for subjecting the wood chips or other material being cooked to the progressive cooking steps according to this invention, rotary valve means 16 with its associated drive means 17 for delivering and metering chips from pre-steamer 12 into digester 14, and discharge apparatus 18 with its associated drive 19 for discharging the cooked chips from digester 14 through blow line 20 for further processing and treatment to provide the character and quality of pulp or other fibrous material desired.

As indicated more particularly in the end view of Fig. 2, each of the aforementioned elements is preferably provided in pairs side by side (although the pair of digesting elements 14 as illustrated are both enclosed within the same outer shell as hereinafter described) to provide two independent parallel vertical processing lines or flows for handling continuously and concurrently two lines of material being processed. This preferential parallel arrangement provides extra operational latitude and through-put control since, as described hereafter, one kind of material or cooking chemicals may be processed through one line of flow while, at the same time, either the same or a different material and cooking chemicals are processed through the parallel line of flow as may be required or desired by the capacity requirements of the mill. Although only one of each of the duplicated general elements of this apparatus may be described in detail, it should be understood that the corresponding member of the second parallel line of flow is substantially a duplicate of the one described with, in some instances, the drive means being mirror images, as indicated in Fig. 2.

The feeding apparatus 10 is preferably of the form shown in more detail in my above mentioned copending application and comprises a generally horizontal elongated barrel or casing 25 having a feed opening or hopper-like inlet 26 in flow communication with an overhead supply of chips to be cooked such as a conventional pulp mill chip bin (not shown). The chips are dropped by gravity into inlet 26 where a screw feeder (not shown) rotatably driven by a motor 28 through a suitable reduction gear and drive 29—31, urges the chips in a more or less compacted mass to the right of the drawing through barrel 25 so that the chips drop by gravity into and through the vertical outlet 35.

As indicated in Fig. 1, the entire feeding apparatus and its drive are preferably mounted on an elevated floor 46 above the remainder of the apparatus, with the chips being dropped by gravity through outlet 35 and into subsequent apparatus through a hole in the floor. The chips drop from outlet 35 through a conduit 50 into the pre-steaming apparatus 12, and an expansion joint 51 or other expansion compensating means is preferably inter-

posed at some point between the outlet 35 of feeding apparatus 10 and the inlet 52 of pre-steaming apparatus 12.

Pre-steaming apparatus 12, which is considered a preferred although optional portion of the overall system and is described in more detail in my above mentioned copending application, comprises essentially a cylindrical tube or casing 60 having therein a conventional screw conveyor or feeder (not shown) driven by a conventional drive 13. The direction of rotation and pitch of the screw flights of the conveyor are such as to urge chips introduced into the inlet 52 of pre-steamer 12 to the left in the drawing to traverse substantially the entire length of the casing 60 and to drop by gravity out of the outlet 65 thereof. During passage through pre-steamer 12 the chips are subjected to the action of super-atmospheric steam introduced into the interior of casing 60 at one or more steam inlets indicated as 70, 71 and 72 to achieve the preliminary steaming, saturation, and softening of the chips prior to actual contact with cooking or digesting chemicals. As will be understood, of course, for certain applications it may also be desired to introduce some chemicals in addition to steam for a preliminary softening or preparatory step to condition the chips better to receive the principal or primary cooking actions in the subsequent digester 14.

As shown in Figs. 1 and 2, pre-steaming apparatus 12 is preferably supported above the subsequent apparatus and suspended resiliently from the floor 46 as by hangers 80 including springs 81 and depending tie rods 83 engaging beams 84 on which rest casing 60. In this manner substantially the entire weight of pre-steaming apparatus 12 is carried from above, rather than having to be supported on the remainder of the apparatus below pre-steamer 12, yet the height of pre-steamer 12 with respect to the following apparatus is completely and automatically adjustable as required by the differential thermal expansion movements of the various elements of the whole system which may be subjected to varying degrees of temperature at various times without unduly straining the conduit connections at inlet 52 and outlet 65 of pre-steamer 12. A link or heated pipe tie rod 86 interconnects the end of casing 60 opposite to outlet 65 with the corresponding end of digester 14 and is heated with steam to aid in maintaining substantial axial parallelism between 60 and 14 during heat expansion movements thereof.

From outlet 65 of pre-steamer 12 the treated chips drop by gravity through a conduit 85 into a rotary valve apparatus 16 which delivers and meters chips into digester 14 and, since the cooking pressure in digester 14 is maintained at a level substantially above the pressure in presteamer 12, rotary valve apparatus 16, also is for preventing the escape of such higher pressure from digester 14 back into pre-steamer 12.

Although the rotary valve apparatus 16 may satisfactorily be constructed in a number of different ways to provide the desired functioning, a preferred construction is as shown in my copending application Serial No. 703,590, executed and filed on even dates herewith. Rotary valve 16 receives chips from pre-steamer 12 and drops them through chip outlet 101 where they enter the digester 14 through chip inlet 102 thereof to be subjected to chemical cooking or digesting.

A preferred construction for digester 14 comprises an outer substantially cylindrical shell 120 within which are mounted a plurality of troughs 121—124. In these troughs are screw conveyors 125—128, respectively, rotatably mounted on shafts 129—132, respectively, journaled in the end plates 133 and 134 of shell 120 and rotatably driven from drive means 15 mounted at one end of digester 14 and comprising electric motors 140 and 141 with corresponding reduction gear and chain- and-sprocket drives 142—145 (see Figs. 5, 6, and 9).

The screw conveyor flights and direction of rotation are arranged to provide for urging chips dropped into the upper troughs 121 and 122 from the chip inlets 102 axially toward the right in Figs. 1 and 5, while the lower screw conveyors 127 and 128 urge chips in the lower troughs 123 and 124 axially to the left in Figs. 1 and 5. A plurality of longitudinal splines 146 are preferably provided in troughs 121—124 to combat any tendency for the chips merely to rotate with the screws 125—128 instead of traveling axially along the troughs.

As will be understood in the structure here illustrated, four troughs and screw conveyors are shown as a part of the system having the two independent parallel lines of flow mentioned above. Thus, troughs 121 and 123 are in one line of flow whereas troughs 122 and 124 are in the separate parallel line of flow and are operated independently of troughs 121 and 123 regardless of the fact that all four are contained within the single cylindrical casing 120 of digester 14. As with the foregoing elements of the apparatus embodying and for practicing this invention, only one set of troughs and screw conveyors 121, 123, 125, 127 will be discussed in detail, the corresponding set of troughs and screw conveyors being understood to be substantial duplicates.

As chips enter chip inlet 102 from rotary valve 16, they fall upon trough 121 and are conveyed axially therealong (to the right in Figs. 1 and 5) by screw conveyor 125, which is preferably provided with a circular baffle or flange member 148 at the left or entrance and thereof. In progressing axially along trough 121 the chips are passed beneath a plurality of cooking or digesting liquor inlets 150—154 from which cooking or digesting liquor is sprayed onto the chips. Each of these liquor inlets comprises a plurality of sprayheads 155 mounted on a circular cover 156 carried by inlet collars or flanges 157 in the top of shell 120 of digester 14.

As indicated more particularly in Figs. 10—11, each cover 156 has a depending flange 160 and a bottom plate 161 through which are mounted sprayheads 155. A transverse partition 162 divides the interior of cover 156 into two separate chambers whereby the liquor introduced through pipe 163 may be separately controlled and, indeed, of completely different composition than the liquor introduced through pipe 164. A portion of the sprayheads (indicated as three in Figs. 11 and 12) are arranged with their outlet orifices 165 directed to spray liquor from pipe 163 toward one side of digester 14 to accommodate, for example, trough 121 while the remaining sprayheads 155 are directed to spray liquor received from pipe 164 to the opposite side of the digester to accommodate trough 122. That is, covers 156 are oriented in collars 157 in casing 120 so that the partitions 162 run axially of casing 120.

In this fashion, a liquor spray pattern is achieved as indicated somewhat diagrammatically in Fig. 15 with liquor being introduced to the chips in the upper digester at a plurality of points spaced axially of the digester and with, at each point, a separately controllable spray pattern directed independently to each of the two parallel lines of flow. As pointed out hereafter, the provision of a plurality of separate liquor inlets 150—154 has the advantage, according to this invention, of subjecting the chips being cooked or digested to cooking or digesting liquor of varying concentrations in various zones of the digester as the chips progress therethrough so that substantially raw chips entering the digester at chip inlet 102 may first be subjected to highly concentrated cooking liquor at inlet 150, thereafter somewhat less concentrated cooking liquor through inlets 151 and 152, and, after the chips have progressed substantially through the upper trough of the digester, to substantially less concentrated cooking liquor through inlets 153 and 154 whereby an optimum efficiency and use of cooking chemicals is achieved as well as a minimum of degradation

of the cellulose as might be experienced if chips in an almost cooked condition were subjected to the harsh action of strong cooking liquor. The internal pressure within casing 120 is maintained at the desired high level as herein described by the admission of steam through steam inlet 166.

Since it is desired, according to this invention, to saturate the chips with cooking liquor and thereafter subject them to high steam pressure—rather than to maintain the chips immersed in liquid phase cooking liquor—the bottoms of upper troughs 121 and 122 are perforated so that liquor sprayed on top of the chips in these troughs will slowly drain through the chips as they are continuously being agitated by screw conveyors 125 and 126, will saturate the chips as completely as may be, and then any excess will drain off through the perforated trough so that, at various points along the travel of chips through the digester, the chips are being subjected to cooking liquor which they may soak up, but are not being agitated or maintained in a liquid pool of liquor.

The excess liquor draining from trough 121 is ultimately collected, as described hereafter, at the bottom of digester 14 and removed through liquor outlets 170 and 171. Because of the arrangement of dam 172 and overflow arrangement hereafter described in the bottom section of casing 120 of digester 14, liquor draining from the left half of trough 121 is collected through outlet 170 separately from liquor draining from the right half of trough 121, which is collected through outlet 171. These separately collected batches of liquor, then, being of different concentrations since they are collected at different points in the cooking cycle, may be recirculated as indicated in Fig. 14 for reapplication to chips moving through the digester.

Thus, fresh and highly concentrated cooking liquor is introduced initially through the first liquor inlet 150 and drains down to the left side of dam 172 still substantially concentrated. This liquor is collected through outlet 170 and is recirculated by pump 175 driven by motor 176 up through conduit 177 to be introduced at liquor inlets 151 and 152 through pipe 163. After the chips have progressed approximately one-half the length of trough 121, however, a substantial cooking or digesting effect has been obtained. Accordingly, the chips in the right half of trough 121 may be subjected to a substantially less concentrated cooking liquor, and this less concentrated liquor is withdrawn from a pool on the right side of dam 172 through outlet 171 and recirculated by pump 180 driven by motor 181 through conduit 182 to be sprayed on the chips in the right half of trough 121 through liquor inlets 153 and 154 in substantially the same manner as above described.

The right-hand end 185 of trough 121 is spaced from the inside 186 of end plate 133 of shell 120 of digester 14 so that, as the chips in trough 121 reach the end 185 thereof, they drop by gravity onto lower trough 123 along which they are conveyed toward the left of the drawing by screw conveyors 127 until they reach the left end 190 of trough 123 which is spaced from the inside surface of end plate 134 of casing 120 of digester 14, at which point the chips now completely cooked, drop by gravity through chip outlet 195 into the inlet 196 of discharger apparatus 18, described below.

The bottom of trough 123 is also perforated as with trough 121 so that liquor continues to drain through the chips and out of the troughs. It will also be noted that trough 123 is positioned within casing 120 of digester 14 spaced above the bottom thereof to provide beneath trough 123 a collecting pool of sump for collecting the liquor draining through the chips for recirculation, as above described. The aforementioned dam 172 extends across this sump beneath trough 123 approximately at the axial midpoint of the digester 14 whereby, as noted in Fig. 16, the collecting sump beneath the lower trough is

divided into approximately two equal size pools for collecting the liquor for recirculation.

Partition 200 extends axially along the centerline of casing 120 to divide the liquor collecting pool beneath the lower trough axially so that there is a pool or sump for each of the parallel lines of flow mentioned above. An additional dam 201 is provided immediately adjacent chip outlet 195 to prevent the uncontrolled flow of liquor in the pool or sump out of chip outlet 195. The foregoing arrangements are diagrammed in Fig. 16 where the elements designated as 202—204 represent the liquor and chip outlets for the other one of the parallel lines of flow mentioned above.

The heights of dams 172 and 201 are correlated with dam 201 being higher than dam 172. Thus, as liquor collects in the left sump and the level therein rises, the cooking liquor will overflow dam 172 into the right-hand sump before the level of liquor behind dam 201 reaches a height to overflow and escape out chip outlet 195. In this manner, the more highly concentrated liquor in the left half of the digester automatically and constantly replenishes the less concentrated liquor in the right half of the digester, but diluting of the more highly concentrated liquor at the left with spent or weak liquor at the right is avoided.

An overflow pipe 210 is also provided leading from an open overflow end 211 at the right of dam 172 directly through dam 201 to discharge liquor out of the end 212 of pipe 210 directly into chip outlet 195. The height of overflow 211 is lower than the dam 172 so that the level of spent liquor to the right of dam 172 should build up sufficiently to overflow that dam and dilute the more concentrated liquor. The level of spent liquor to the right of dam 172 will build up and such liquor is automatically drawn off through over-flow 211 and pipe 210 and discharged directly out of inlet 195.

It will be noted that the arrangement described above as illustrative of apparatus embodying and for practicing this invention results in a continuous digester arrangement whereby the chips are subjected to three distinct cooking zones in the digester 14. First, the raw chips in the left half of trough 121 are subjected to the action of concentrated cooking liquor for the period of time it takes them to travel about halfway along trough 121. Secondly, a longer cooking zone wherein the chips are subjected to more dilute liquor is provided in the right half of trough 121 and the right half of trough 123. A third and final zone wherein the chips are subjected only to vapor phase or steam pressure without the addition thereto of any cooking liquor may be provided in the left portion of trough 123 immediately prior to the discharge of the chips through outlet 195. To this end, a transverse solid horizontal partition 215 is provided beneath the left half of trough 121 and overlying the entire width of trough 123 so that liquor draining out the perforated bottom of the left half of trough 121 flows across partition 215 and down around the outside of trough 123 to the sump in casing 120 therebelow but does not come in contact with the chips in the left half of trough 123. This partition 215, however, extends for only about half the length of the digester so that the more dilute liquor draining from the perforated bottom of trough 121 at the right half thereof will drain directly onto chips in the right half of trough 123.

It will be understood, of course, that, although the aforementioned three distinct cooking zones are described here, suitable arrangement of a plurality of liquor outlets and liquor pool dams and recirculation piping and pumps may be made to provide any number of distinct cooking zones and treatment effects as may be desired in practicing this invention, or, if desired, liquors of the same, instead of different, strength or concentration may be introduced and/or recirculated throughout. It should also be noted, as diagrammed in Fig. 16, that axial baffles 220 are provided on the bottom of casing 120 and

extend throughout a substantial portion of the length of each half thereof and spaced from liquor outlets 170 and 171. The purpose of these baffles is to force liquor in the separate pools beneath the lower troughs to flow or circulate around the baffles as it is withdrawn through liquor outlets 170 and 171 to maintain solid matter in suspension in the liquor and avoid deposition of suspended solids in the sump portion at the bottom of casing 120 of digester 14.

Satisfactory structures for mounting and arranging the troughs 121—124 and the various above mentioned dams, baffles, partitions, etc., within the casing 120 of digester 14 are indicated in somewhat more detail in Figs. 3—8 and 17—19, from which the screw conveyors and moving parts have been deleted for clarity. A T-bar 225 is provided substantially along the axial centerline of casing 120, and axial side struts 226 and 227 are arranged along the sides of casing 120 substantially at the vertical midpoint thereof as the major supporting and aligning elements for the troughs 121—124. A vertical partition 200 divides casing 120 into sections axially below T-bar 225, while vertical partition 228 similarly divides the upper half of casing 120 into two axial sections to separate the two parallel lines of flow above mentioned.

At a plurality of points along the length of the casing 120 are spaced supporting plates 230 vertically disposed resting on T-bar 225 and longitudinal struts 226 and 227. The supporting plates 230 are arranged with semi-circular cutouts for receiving and supporting the perforated bottom portions of the upper troughs 121 and 122.

Also a plurality of supporting plates 231—237 are spaced along the length of casing 120 vertically below the T-bar 225 and longitudinal struts 226, and also have semi-circular cutouts for receiving and supporting the bottom perforated portions of the lower troughs 123 and 124. The structure of these supporting plates, particularly in the bottom part thereof, vary somewhat according to their position along the length of casing 120, since it is plate 234, for example, which includes in the bottom portion thereof dam 172 previously referred to. That is, as indicated in Fig. 7, dam 172 is defined by the bottom edge 240 of a cutout or opening 241 in plate 234. Also as noted in Figs. 6—8, overflow pipe 210 passes through the several supporting plates 231, 232, etc., in the left part of casing 120.

In addition to resting in the semi-circular cutouts of the vertical supporting plates, troughs 121—124 are additionally supported at the upper edges thereof by being affixed to longitudinal struts and/or T-bar 225 as the case may be. Thus, bottom troughs 123 and 124 are affixed to T-bar 125 and longitudinal struts 226 and 227 are indicated in Fig. 6. The corresponding upper troughs 121—122 are similarly affixed in the upper part of casing 120. That is, the upper edges of troughs 121 and 122 which are inwardly disposed along the centerline of casing 120 are affixed to a longitudinal strut 245 at the top of casing 120, while the upper outwardly disposed edges of troughs 121 and 122 are similarly affixed to longitudinal struts (not shown) adjacent the outer wall of casing 120 at approximately the 10 o'clock and 2 o'clock positions on a cross-section thereof.

Since it may be desirable to construct the troughs, various internal bracing, and outer shell 120 of digester 14 from a variety of different types of material (e.g., stainless steel and other steels), the extent of thermal expansion movement may vary among the various parts. For this reason, provision is made in the described structure for compensating for varying heat expansion movements therein. It has been found that the greatest amount of compensation for differential expansion movement is most satisfactorily applied axially of casing 120. To this end, the troughs and longitudinal struts are rigidly fixed to casing 120 against axial movement at but one end thereof—i.e., the left end in the structure illustrated—with the other end arranged to permit some limited axial move-

ment with respect to casing 120. Also, each of troughs 121—124 is provided in two sections, each of which is approximately one-half a trough long. As indicated in Fig. 19, a sliding expansion joint is provided where the troughs meet and comprises, as illustrated for trough 121, a plate 250 welded to the bottom 251 of the left section of trough 121 so that the bottom 252 of the right section of trough 121 rests slidably on plate 250 thus permitting a limited heat expansion movement compensation approximately midway of the axial extent of trough 121. Also, as indicated in Figs. 17 and 18, the upper edges of the troughs are affixed to T-bar 225 or the respective longitudinal struts 226, 227, 245, etc., in a manner permitting limited relative axial movement. That is, at each point where the upper edges of any of the troughs are to be bolted to any of the longitudinal struts, an oval or oversize hole 255 is made in the trough so that, with a bolt 256 tightly and threadably engaged in the longitudinal strut (illustrated in Fig. 17 as 245), a limited amount of axial relative movement is permitted between the trough and the strut as limited or defined by the length of hole 255.

As will be understood, the foregoing preferred structure provides, in digester 14, the desired feeding and supporting means for the perforated troughs, screw conveyors, etc., for moving the chips through the several cooking or digesting zones in digester 14 and subjecting the chips to the desired cooking or digesting liquor.

The entire digester 14 is preferably supported from below on supports 225 and 226 adequately above discharger 18. As will be noted, digester supports 225 and 226 then carry substantially the entire weight of digester 14 and its associated drive 15 as well as rotary valve 16 and its drive 17 as indicated in Figs. 1 and 2. Since pre-steamer 12 is preferably supported from above, as before described, from resilient hangers affixed to the floor above, this arrangement makes for satisfactory compensation for vertical thermally induced heat expansion movements of the various component parts without undue strain on the digester 14 or its supports 225, 226. The effect, in this connection, of expansion joints 51 in conduit 50 and of tie rod 86 has already been noted. Also expansion joints 183 and 184 are provided in liquor conduits and outlets 170, 171, 177, 182 etc., as desired or necessary.

Referring again to Figs. 1 and 2, in the system illustrated, the chips leave digester 14 through chip outlet 195 thereof after the cooking or digesting is completed to the degree desired, and drop into discharger 18 through inlet 196 thereof. Discharger 18 discharges the cooked wood into blow line 20 for washing, refining, and/or other subsequent operations to be performed on the pulp. As will be understood, a number of different blowing, discharging, or refining means may follow digester 14 in the line of flow and receive the cooked chips therefrom, as is well known. A preferred form of discharger for the system as illustrated is shown and described in more detail in my copending application 703,589, executed and filed on even dates herewith, as comprising an outer casing 260 within which is rotatably mounted a horizontal screw conveyor (not shown) driven by motor 261 through a suitable reduction gear and drive means 262, 263. As the cooked chips drop into casing 260 through inlet 196, the screw conveyor urges them to the left in Fig. 1, and a series of blades on the conveyor (described in more detail in my said copending application) sweeps the mass of chips and whatever cooking or digesting liquor may be present past a discharge orifice adjacent blow line 20 and controlled by blow valve 265. As the chips pass the orifice and entrance to blow line 20, the pressure in digester 14 (with which, of course, casing 260 is in flow communication) blows the chips through the orifice and out blow line 20.

Among the advantages of the foregoing apparatus will be noted enhanced operational flexibility. For example, as noted, different kinds of wood (e.g., soft wood such as

pine and hard wood such as gum) may be simultaneously processed through the apparatus if it is desired that the pulp being made into paper should consist of an admixture of different woods. Also it may be found that, for a certain type or quality of paper, part of the pulp furnished to the paper machine should consist of pulp cooked to one particular yield and another part to a different yield. As will be apparent from the foregoing description, such a situation is readily handled by the system embodying and for practicing this invention by controlling or adjusting the concentration of cooking liquor and/or the length of time required for the chips to pass through the cooking or digesting apparatus. Similarly, it may be desired for a certain type or quality of paper that part of the pulp be sulfate or kraft pulp and another portion be manufactured by the well-known sulfite or neutral sulfite processes, and both kinds of pulp can simultaneously be processed through the foregoing apparatus. Also, in such situations, the various kinds or degrees of pulp are readily mixed and metered by controlling relative speed through the digester, and, if desired, may all be discharged therefrom through a single common discharge apparatus.

Another important feature of apparatus embodying and for practicing this invention relates to the enhanced uniformity of cooking which can be achieved. Uniform cooking conditions for making pulp from wood depend upon a number of variable factors, one of the most important of which is uniform heat distribution. Obviously the desired uniform heat distribution is quite difficult to achieve in conventional batch-type pulp digesters because of their huge size, etc. Truly uniform conditions are also difficult to attain even in continuous digester apparatus where the arrangement consists of merely a cylindrical tube through which the chips are urged by a screw—much like the structure of pre-steamer 12 described above—since, with such a tube substantially filled with chips, there is only a relatively narrow surface or area near the top of the tube where the chips are directly exposed to steam, and a rather large and preponderate area around the sides of the tube for almost direct heat transfer from the chips through the tube walls.

In cooking or digesting apparatus according to this invention, by contrast, steam can circulate freely around and among troughs 121—124 for much more uniform heating of the chips within casing 120, and only a very minor portion of the chips in the digester is in contact with or directly exposed to the outer walls of casing 120. Also the surface of each batch of chips directly exposed to either a vapor area or cooking liquor spray, in this apparatus, is much greater than a continuous digester comprising merely one or more individual tubes as in pre-steamer 12—i.e., no matter how full of chips are troughs 121—124, still the top surface of the mass of chips directly exposed to a vapor area or to liquor spray is as wide as the greatest diameter of the trough or screw conveyor. Thus much more uniform cooking is achieved, both from the standpoint of uniform heat distribution as well as increased chip area directly exposed to the cooking liquor spray.

This advantage, as will be understood, is obtained whether the apparatus is constructed as illustrated with a separate trough for each screw conveyor or whether, as may be desired, the apparatus is constructed with a wider trough common to two or more screw conveyors, so long as there is a plurality of troughs and screw conveyors within a common outer casing 120 so that only a very minor portion, if any, of the chips directly contacts the outer casing, so that there are passages for vapor circulation between and among the troughs, and so that as large as possible a surface area of the mass of chips is directly subjected to vapor and cooking liquor spray.

It should also be noted that uniform cooking of wood chips to a uniform yield is rarely, if ever, obtained with pulping processes and apparatus heretofore used. As

will be understood, in conventional pulping processes and apparatus the actual yield of the pulp produced is a composite of different yields even within the same batch. Such variations stem from a variety of factors. Thus, since the yield varies with the cooking temperature, non-uniform heat distribution within the digester produces variations in yield as between chips in the center of the chip mass, other chips in contact with the outer shell of the digester, and other chips directly subjected to the admitted steam. Non-uniform liquor circulation is another factor, as well as localized dilution of the cooking liquor by the admitted steam and/or non-uniform liquor concentrations at various points in the digester. Variations in the moisture content of the chips entering the digester and variations in the density of the wood also have a non-uniform effect on the rate at which the cooking liquor will penetrate into the chips and, consequently, the rate at which the chips will be cooked. Another variation, and one of the most important, stems from variations in the size of the chips themselves since smaller chips will be penetrated more quickly by the cooking liquor than larger chips with, of course, variations in the rate of cooking and the final yield achieved.

If the chips are screened, however, prior to introducing them into hopper 26 of feeding mechanism 10 whereby smaller chips are fed into one of the parallel lines of flow while larger chips are fed into the other. In this manner, a greater uniformity of yield and cooking rate is achieved by subjecting the smaller chips to less cooking than the larger chips either by varying cooking liquor concentration or by varying the through-put rate at which the chips are fed through digester 14.

A similar advantage may be achieved by providing one or more additional rotary valves 16 for introducing into digester 14 chips at one or more additional points spaced along the digester so that the largest chips are introduced through chip inlet 102 and, thereafter, progressively, smaller chips are introduced at later positions along digester 14 so that, although all the chips are mixed together as they leave chip outlet 195, the smaller chips have been cooked for less time or at a less rate than the largest chips by virtue of being introduced to digester 14 at a later point in the travel of the chips through the digester.

When the chips are introduced into digester 14 and kept separate therein in different parallel lines of flow, the cooking time and rate is controlled by the speed of the conveying mechanism. When chips are introduced into the same line of flow at different points therealong, the cooking time is controlled by the positioning of the point of introduction, and with this apparatus either or both methods of cooking rate control can satisfactorily be utilized so that, by contrast to pulping processes heretofore known, wood chips, regardless of size can be cooked under controllable conditions to the same yield, or controllably to different yields by controlling or adjusting or altering the cooking time (i.e., through-put rate and distance of travel), cooking liquor concentration, liquor-to-wood ratios, etc.

The same advantages can also be obtained with apparatus embodying and for practicing this invention when it is desired simultaneously to cook different kinds of wood, such as hard wood and soft wood. By altering the type and/or concentration of the cooking liquor in the two sides of the digester and adjusting the speed of the screw conveyors, the cooking or digesting of pulp from hard woods on one side and soft wood on the other can be simultaneously accomplished and controlled for a substantially constant output of the two kinds of pulp in the desired relative ratio or proportions.

Particularly in installations where different sizes of chips are introduced into digester 14 at different points therealong, the size of the perforations in the bottoms of troughs 121-124 may advantageously be adjusted with respect to the chip size at various points. For example,

if chips which are retained by a one-half inch screen are introduced through chip inlet 102 with smaller chips being introduced at some subsequent point along digester 14, the perforations in the left end of trough 121 could be as large as $\frac{3}{8}$ " diameter thus permitting an increased initial liquor-to-wood ratio, since the larger perforations would promote drainage of excess liquor more readily. The perforations in the right-hand end of trough 121 and/or in trough 123, then, would be somewhat smaller to retain whatever chip size was present in those portions of the troughs with, for certain conditions, the left half of trough 123 having no perforations at all for the introduction thereof of "sawdust" for an extremely short cooking period immediately prior to discharging the cooked wood from outlet 195.

As illustrative of a satisfactory system utilizing digesting apparatus embodying and for practicing this invention, satisfactory results are achieved with the illustrated apparatus in the manufacture of sulfate or kraft pulp from southern pine woods. For a rated capacity of 42 tons of pulp per day for each of the two parallel lines of flow, the digester 14 may satisfactorily be of a size approximately 8 ft. in diameter by 31 ft. long with each of the four screw conveyors 125-128 having a diameter of approximately 34 in. and a pitch and speed of rotation to convey a given batch of chips completely through digester 14 from chip inlet 102 to chip outlet 195 thereof in 40 minutes when the level of chips in the troughs is such that the conveyors are 90% full. As will be understood, the other elements of the illustrated system are constructed and dimensioned to correspond to such size and through-put capacity of digester 14. As previously noted, the cooking rate of total cooking time may vary according to the size of the chips, etc., but is preferably maintained within the range of from approximately 20 minutes to approximately 40 minutes total dwell in the digester 14 for kraft or sulfate pulp adapted for the manufacture of kraft liner board. With such an installation, conventional kraft cooking liquor (comprising, as is well understood, sodium hydroxide and sodium sulfide) is supplied to liquor inlet 150 at a concentration of approximately 320 to 400 pounds active alkali (calculated as sodium oxide) per ton of pulp, supplied at a rate of approximately 32 to 40 gallons per minute, and superheated steam within the range of 350° to 375° F. is supplied through steam inlet 166 to maintain the pressure within digester 14 at approximately 120 to 170 p.s.i.

The cooking liquor collected, as above noted, in the sump at the bottom of casing 120 and withdrawn through liquor outlets 170 and 171 is recirculated by pumps 175 and 180 at approximately 200 to 400 gallons per minute through liquor inlets 151-154, and spent liquor is withdrawn through overflow pipe 210 and discharged out chip outlet 195 at the rate of approximately 30 to 40 gallons per minute under the satisfactory conditions described. With such conditions, wood chips at the rate of 70 tons per day are fed into each of the feeding mechanisms 10 to produce the aforementioned 42 tons of pulp per day out of each of the parallel lines of flow and cooked to a yield within the range of 55% to 65% finished pulp product.

While the methods and forms of apparatus herein described constitute a preferred embodiment of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a continuous digesting system for the manufacture of pulp from wood chips and the like at elevated temperatures and pressures with continuous flow of said chips through said system, the combination which comprises a cooking and digesting vessel having an outer shell enclosing a plurality of troughs through which said chips are conveyed during cooking and digesting thereof, means

for continuously conveying said chips through said troughs, means for introducing cooking and digesting liquor to said chips in said troughs for impregnation of said liquor into said chips, means for withdrawing from said troughs excess liquor which does not impregnate said chips, means for collecting said liquor withdrawn from said troughs for recirculation through said liquor introducing means, and means for introducing steam under pressure into said outer shell for maintaining said elevated temperature and pressure therein.

2. Continuous digester apparatus as recited in claim 1 in which at least some of said plurality of troughs are arranged directly one over the other, and in which said means for withdrawing excess liquor from said troughs includes perforations in at least a portion thereof.

3. Continuous digester apparatus as recited in claim 1 in which said plurality of troughs are arranged one above another in parallel vertical lines of flow whereby at least two parallel feeds of chips through said vessel are separately conveyed through said troughs within said single outer shell.

4. Continuous digester apparatus as recited in claim 1 in which said means for introducing cooking and digester liquor includes sprayheads at the top of said outer shell for spraying said liquor uniformly across the upper surface of chips in at least one of said troughs and also includes perforations in said trough through which liquor sprayed onto said upper surface of said chips therein drains onto the upper surface of chips in another of said plurality of troughs.

5. Continuous digester apparatus as recited in claim 1 in which said plurality of troughs undergoes a different extent of axial thermal expansion movement than does said outer shell and in which said plurality of troughs is anchored to said outer shell adjacent one end only thereof for free thermal expansion movement axially of said shell, and having means for suspending said plurality of troughs within said outer shell for accommodating and compensating for said different extents of thermal expansion of said troughs and said shell.

6. In a continuous digesting system for the manufacture of pulp from wood chips and the like at elevated temperatures and pressures with continuous flow of said chips through said system, the combination which comprises a cooking and digesting vessel having an outer shell enclosing a plurality of troughs through which said chips are conveyed during cooking and digesting thereof, means for continuously conveying said chips through said troughs, means for introducing cooking and digesting liquor to said chips in said troughs at a plurality of points therealong for impregnation of said liquor into said chips, means for withdrawing from said troughs excess liquor which does not impregnate said chips, means for collecting said liquor withdrawn from said troughs in a plurality of pools within said outer shell for recirculation through said liquor introducing means, said plurality of pools maintaining separated liquor of different concentrations for recirculation of liquor of different concentrations selectively through different ones of said plurality of liquor introducing means, and means for introducing steam under pressure into said outer shell for maintaining said elevated temperature and pressure therein.

7. Continuous digester apparatus as recited in claim 6 in which said means for collecting said liquor in a plurality of pools includes a transverse dam across the bot-

tom portion of said outer shell for maintaining separation of liquor collected from one portion of said plurality of troughs from liquor collected from other portions thereof, means for withdrawing liquor separately from said pools for separate recirculation thereof, and overflow means associated with said dam for withdrawing and wasting excess liquor accumulated in one of said pools before the level in said pool rises sufficiently to overflow said dam and mix with liquor in an adjacent said pool.

8. In a continuous digesting system for the manufacture of pulp from wood chips and the like at elevated temperatures and pressures with continuous flow of said chips through said system, the combination which comprises a cooking and digesting vessel having an outer shell enclosing a plurality of troughs through which said chips are conveyed during cooking and digesting thereof, means for continuously conveying said chips through said troughs, means for introducing cooking and digesting liquor to said chips in said troughs at a plurality of points therealong for impregnation of said liquor into said chips, means for withdrawing from said troughs excess liquor which does not impregnate said chips, means for collecting said liquor withdrawn from said troughs in a plurality of pools within said outer shell for recirculation through said liquor introducing means, said plurality of pools maintaining separated liquor of different concentrations selectively through different ones of said plurality of liquor introducing means, means for introducing steam under pressure into said outer shell for maintaining said elevated temperature and pressure therein, and means for effecting flowing and agitation of said liquor in said pools preventing settling therefrom of suspended matter therein.

9. In a continuous digesting system for the manufacture of pulp from wood chips and the like at elevated temperatures and pressures with continuous flow of said chips through said system, the combination which comprises a cooking and digesting vessel having an outer shell enclosing a plurality of troughs through which said chips are conveyed during cooking and digesting thereof, means for continuously conveying said chips through said troughs, means for introducing cooking and digesting liquor to said chips in said troughs for impregnation of said liquor into said chips, means for withdrawing from said troughs excess liquor which does not impregnate said chips, means for collecting said liquor withdrawn from said troughs for recirculation through said liquor introducing means, means for introducing steam under pressure into said outer shell for maintaining said elevated temperature and pressure therein, means for supporting said troughs within said outer shell for compensating for heat expansion movement of said troughs and said shell, and supporting means including means for positioning said troughs within said outer shell and spaced therefrom for free circulation of steam therearound and spaced from said outer shell for maintaining uniform heat conditions within said troughs and notwithstanding heat losses through said outer shell.

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