Sept. 20, 1960 F. B. K. GREEN 2,953,202

CONTINUOUS DIGESTER

Filed July 15, 1955 4 Sheets-Sheet 1

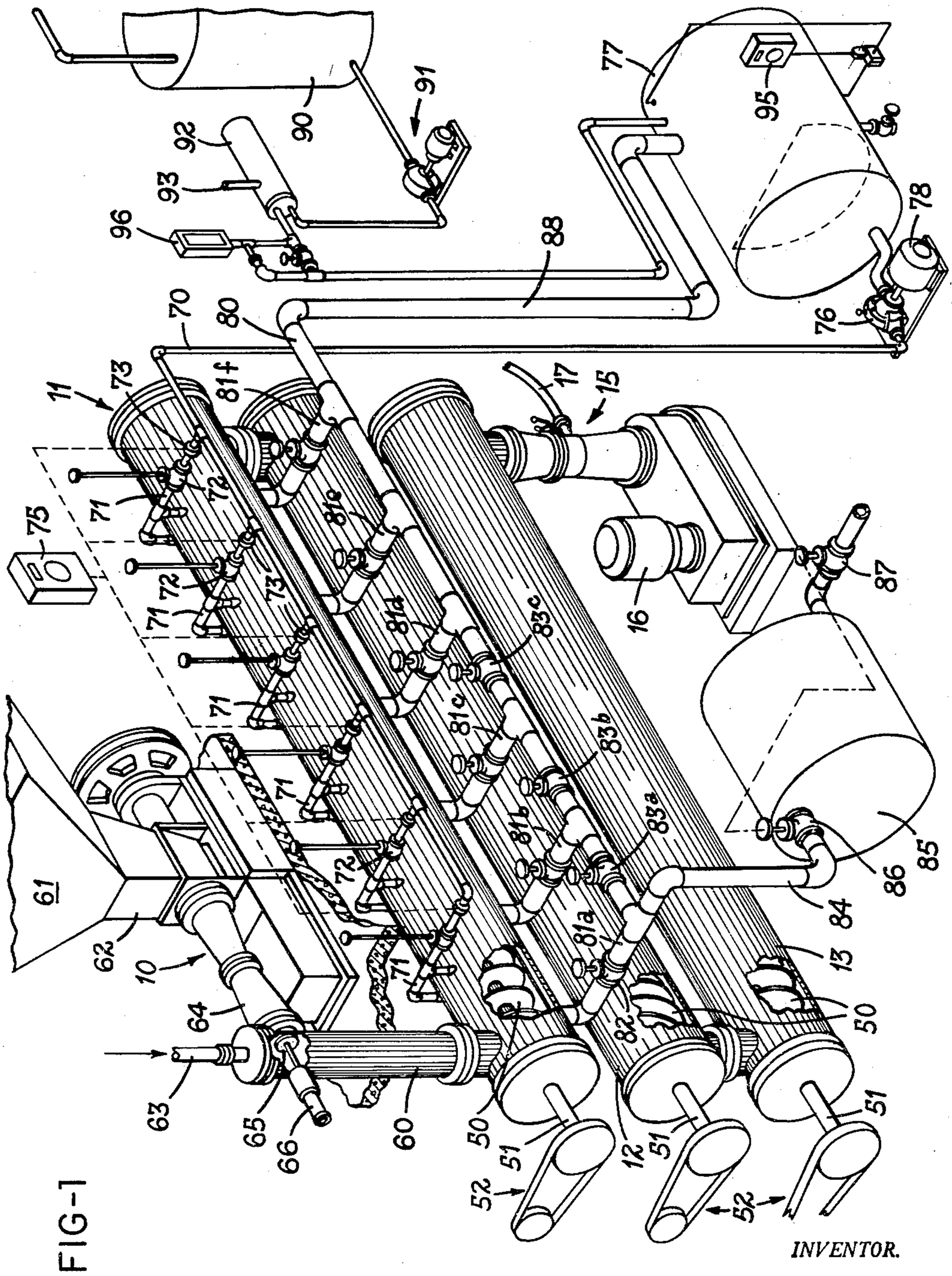

FIG-1

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CONTINUOUS DIGESTER

Filed July 15, 1955 4 Sheets-Sheet 2

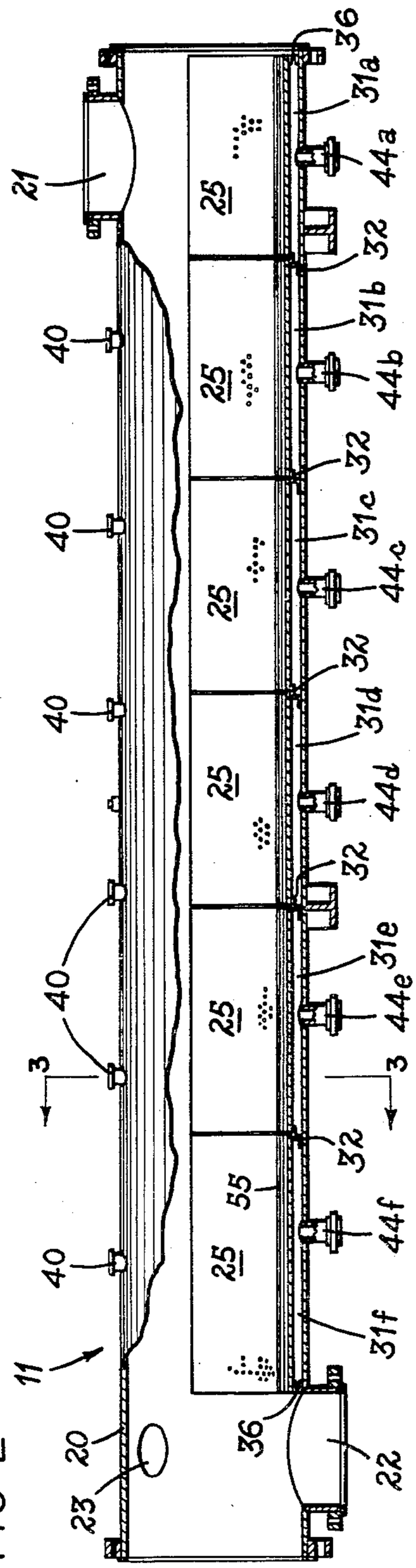

FIG-2

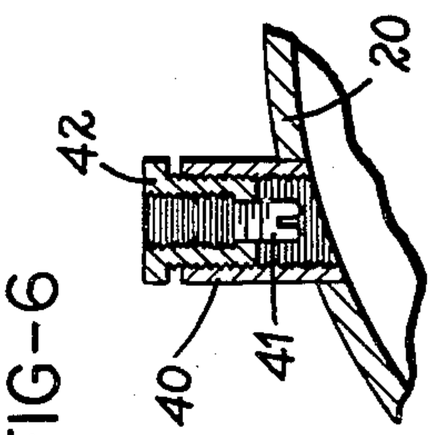

FIG-6

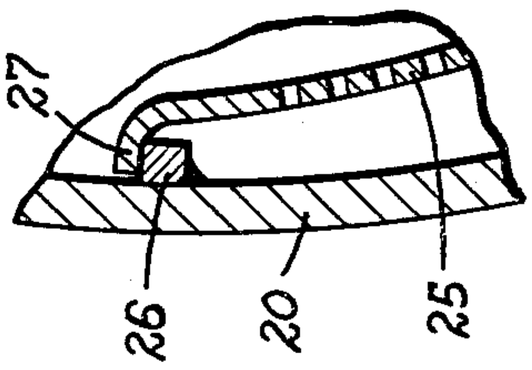

FIG-5

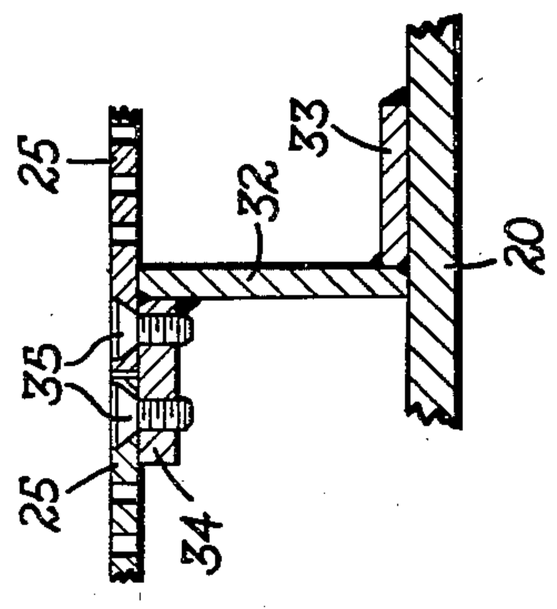

FIG-4

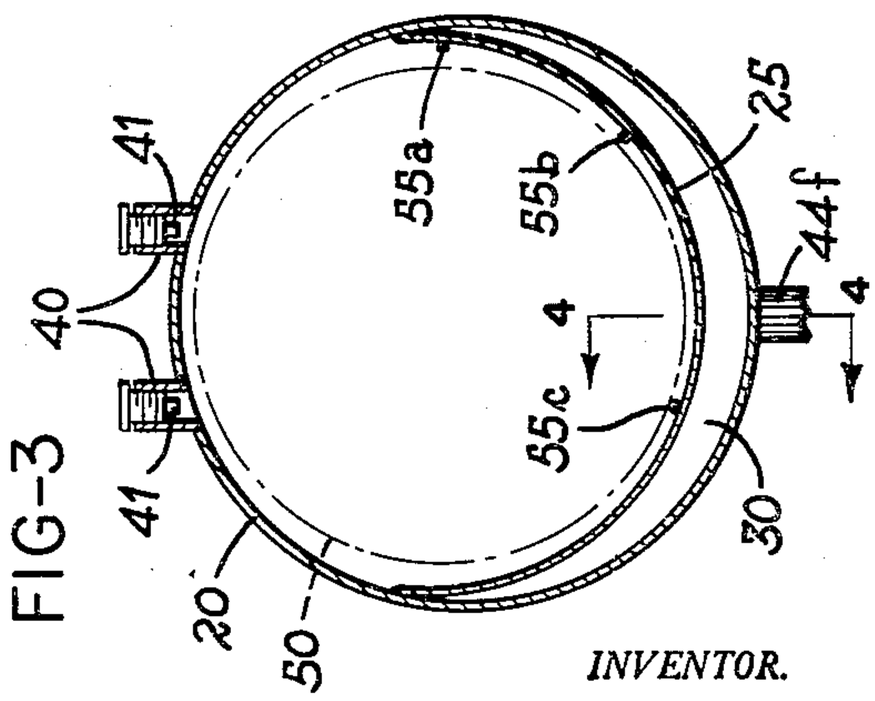

FIG-3

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CONTINUOUS DIGESTER

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FIG-8

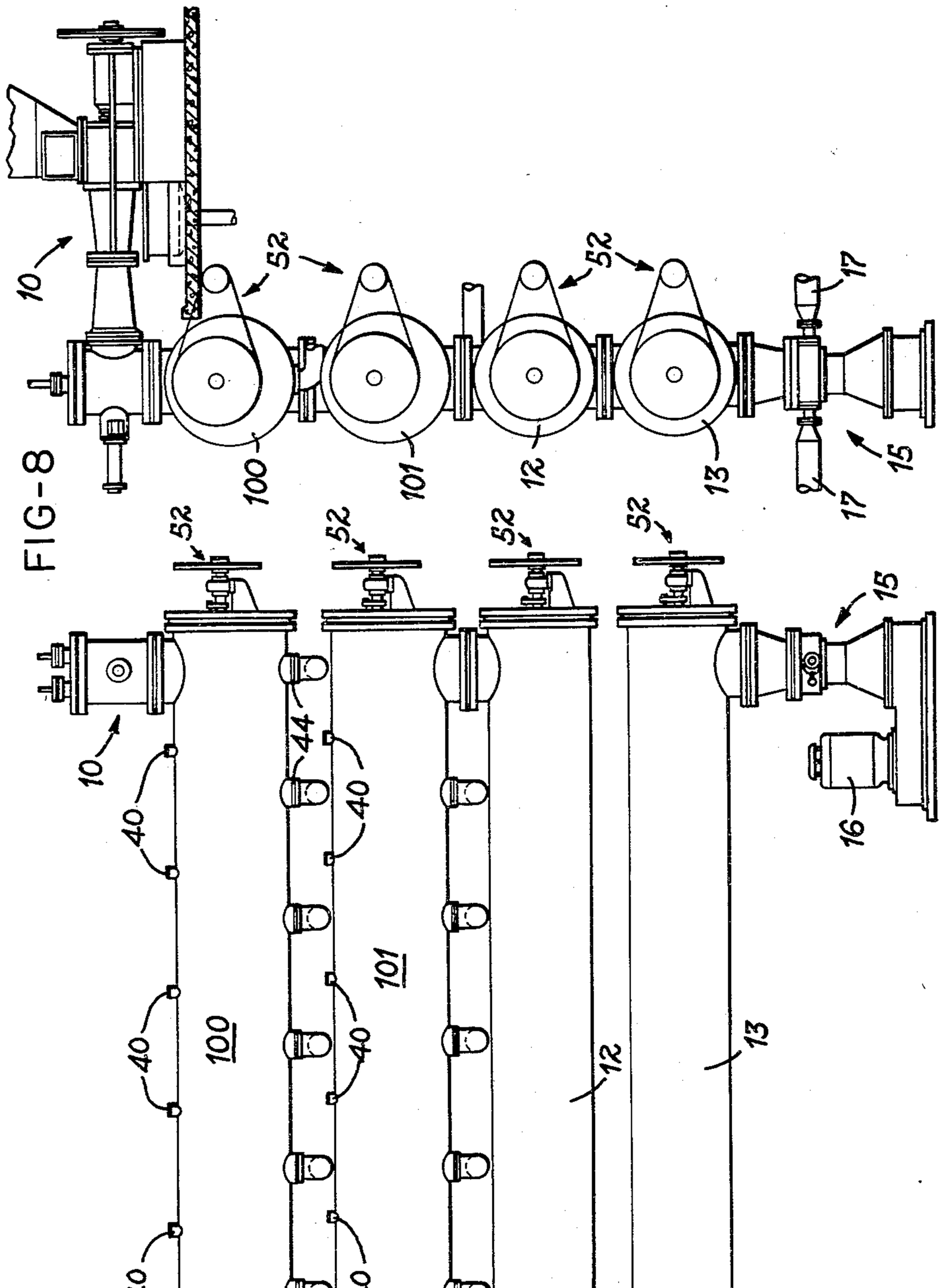

FIG-7

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CONTINUOUS DIGESTER

Filed July 15, 1955 4 Sheets-Sheet 4

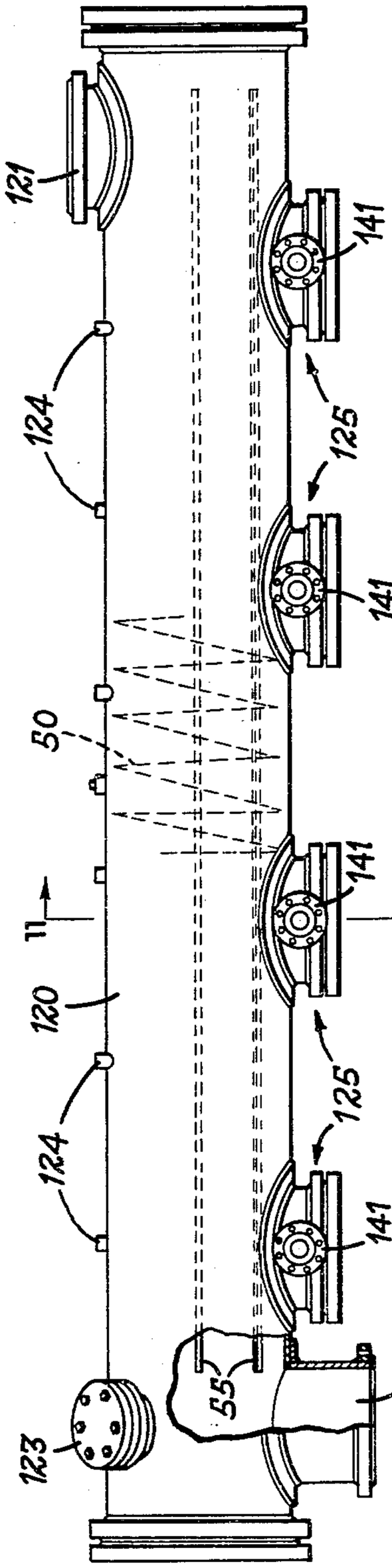

FIG-9

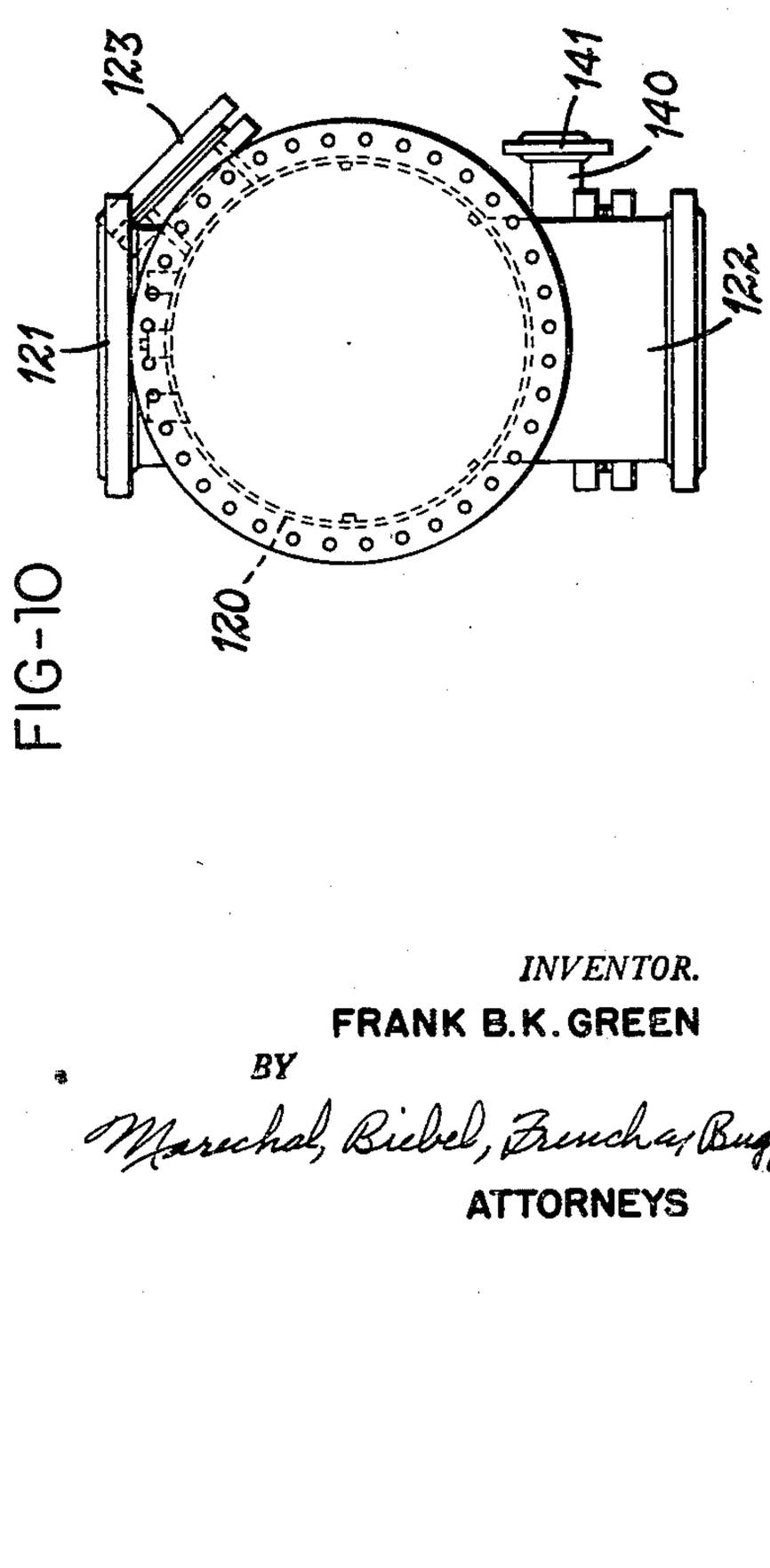

FIG-10

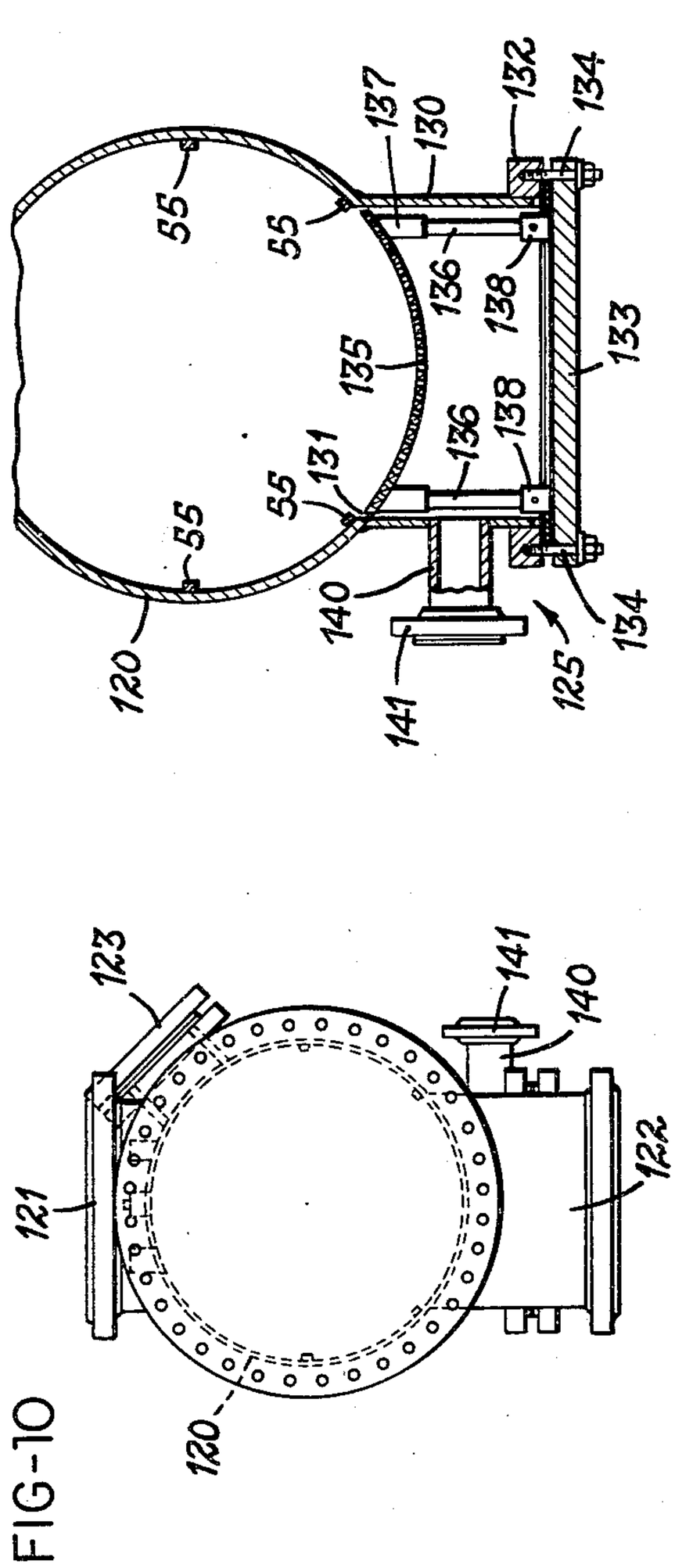

FIG-11

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United States Patent Office

2,953,202

Patented Sept. 20, 1960

2,953,202

CONTINUOUS DIGESTER

Frank B. K. Green, Massapequa, N.Y., assignor to Pandia, Inc., New York, N.Y., a corporation of New York

Filed July 15, 1955, Ser. No. 522,252

11 Claims. (Cl. 162—237)

This invention relates to apparatus for continuously digesting cellulosic materials for use in the manufacture of pulp and paper.

The invention has special relation to the provision of continuous digesting apparatus which will make it possible to effect adequate cooking of the raw cellulosic material in minimum time in order both to obtain maximum strength in the fibers together with maximum yield and also to reduce the size and space requirements for the continuous digesting apparatus. More particularly, since continuous digesting apparatus generally requires an elongated conduit through which the cellulosic materials travel during cooking thereof, the invention contemplates the establishment of cooking conditions such that the overall time requirements, and therefore the length requirements of the tube, are reduced to a minimum while at the same time the exposure of the fibrous material to the hot chemical atmosphere of cooking is similarly reduced to minimize the loss of useful fibers and the loss of strength in the fiber.

In general, tests in conjunction with the production of pulp from raw cellulosic material such as wood chips have indicated that a chip is capable of absorbing its own weight in digesting liquor. It follows that effective cooking of the chip as a whole cannot begin until such complete liquor saturation point has been reached, and this time required for such thorough saturating impregnation of the chips is one controlling factor on the overall requirements for cooking time. In addition, it is important from the standpoint of quantity and quality of yield in the cooking process that complete impregnation of the individual chips be accomplished as soon as possible after the chips are first heated, since the longer a chip is exposed to heat in the absence of liquor, the greater will be the tendency for acid hydrolysis to take place within the chip as a result of the formation of wood acids such as formic and acetic acids which attack the fiber instead of the lignins and thus cause degradation or deterioration of the fiber. It is therefore essential that such hydrolytic action be minimized by accelerating impregnation of the chips by the digesting liquor in order to check such destructive action.

The desired rapid impregnation of the chips with liquor is facilitated if the chips are treated to eliminate air from the interior thereof, as by exposure to steam, particularly steam at superatmospheric pressure, and it is an object of the present invention to provide apparatus for continuously digesting cellulosic materials wherein the raw material is initially subjected to a preliminary treatment by steam at high pressure to effect rapid elimination of air therefrom wherein the steamed chips are then treated with digesting liquor under controlled conditions in the substantially complete absence of condensate and dilute liquor such that effectively complete impregnation of the chips with liquor is accomplished in minimum time, and wherein the subsequent cooking of the impregnated chips is then carried out at superatmospheric pressure in a hot vapor-bearing atmosphere substantially free of unabsorbed liquid.

Another object of the invention is to provide continuous digesting apparatus as outlined above such that raw cellulosic material is continuously advanced with accompanying agitation through a plurality of successive treatment zones, the first zone being a heating zone wherein the cellulosic material is subjected to high pressure steam simultaneously with the withdrawal of condensate therefrom a facilitate delivery of the resulting heated material to the next zone substantially free of air bubbles and condensate, the next zone being an impregnation zone comprising in effect a plurality of supplemental zones in each of which liquor is applied to the cellulosic material from above while unabsorbed liquor is drained therefrom from below to assure repeated exposure of all particles of the material to fresh liquor, and the final zone is a cooking zone wherein the liquor-impregnated cellulosic material is exposed to a hot vapor-bearing atmosphere substantially free of unabsorbed liquid.

A further object of the invention is to provide an impregnation tube for use in continuous digesting apparatus as outlined above which incorporates perforate false bottom portions throughout the length thereof and defining drainage chambers therebelow within the conduit for effectively continuous draining of condensate and unabsorbed liquor from the cellulosic material advancing therethrough and facilitating separate removal of condensed steam and unabsorbed liquor.

It is also an object of the invention to provide apparatus for the continuous digestion of cellulosic materials as outlined above wherein localized treatment of the raw cellulosic material with steam and with liquor and the removal of condensate and unabsorbed liquor is facilitated by repeatedly causing the cellulosic material along the bottom of the treatment zones to form temporary liquid permeable sealing masses retarding flow of unabsorbed liquid lengthwise of the zone and promoting draining of such unabsorbed liquid from each zone directly downwardly to drain outlets.

Additional objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

Fig. 1 is a somewhat diagrammatic view in the nature of a perspective illustrating a complete continuous digesting system in accordance with the invention;

Fig. 2 is a side elevational view, partly broken away in vertical section, illustrating the uppermost tube in Fig. 1;

Fig. 3 is an enlarged section on the line **3—3** of Fig. 2;

Fig. 4 is an enlarged fragmentary section on the line **4—4** of Fig. 3;

Fig. 5 is an enlarged fragment of Fig. 3 showing the mounting of the perforate false bottom within the tube;

Fig. 6 is an enlarged fragment of Fig. 3 illustrating one of the liquor supplying nozzles at the top of the tube;

Fig. 7 is a side elevational view illustrating continuous digesting apparatus in accordance with the invention and embodying a pair of impregnation tubes;

Fig. 8 is an end elevational view looking from right to left in Fig. 7;

Fig. 9 is a view similar to Fig. 2 and showing another construction of impregnation tube in accordance with the invention;

Fig. 10 is an end view of the tube of Fig. 9; and

Fig. 11 is an enlarged section on the line **11—11** of Fig. 9.

Referring to the drawings, which illustrate preferred embodiments of the invention, Fig. 1 illustrates a com-

plete system in accordance with the present invention which is generally similar in some aspects to the systems shown in Beveridge et al. Patent 2,323,194 and the co-pending application of Frank B. K. Green Serial No. 420,033, filed March 31, 1954, now abandoned, such patent and application both being assigned to the assignee of the present application. The main components of this system may be identified generally as a feeder **10** for the chips or other raw cellulosic material to be digested, an elongated conduit which receives the raw material from the feeder **10** and which is composed of an impregnation tube **11** forming the impregnation section of the conduit and a plurality of cooking tubes **12** and **13** arranged in vertically spaced relation to form the cooking section of the conduit, and a discharge unit **15** for the digested material.

The feeder **10** in Fig. 1 may be of any type capable of introducing an effectively continuous supply of solid material into conduit **11—13** without substantial loss of gas pressure from within the conduit, and it is shown by way of illustration as a pressure feeder of the type shown in the above Beveridge et al. patent. Similarly, the discharge unit **15** should be of a type capable of effectively continuously discharging the digested material, preferably accompanied by a defibering action, while maintaining the desired pressure cooking atmosphere within the conduit **11—13**. The discharge unit **15** is accordingly shown by way of illustration as of essentially the construction disclosed in Kehoe et al. Patent 2,616,802, issued to the assignee of the present application, and which has a drive motor **16** and delivers the cooked and partially defibered pulp to a discharge conduit **17** for conducting such pulp to a refiner or other further treatment station.

The impregnation tube **11** has special structural characteristics in accordance with the invention as illustrated in Figs. 2–6 which impart special features to the construction and operation of the system as a whole. Referring to Fig. 2, the impregnation tube **11** includes a main outer cylinder **20** having an inlet **21** at one end of the upper side thereof and an outlet **22** at the opposite end of the lower side of the cylinder, and a hand hole **23** is provided on the side of the cylinder adjacent the outlet **22**. Within the cylinder **20** is a perforate false bottom shown as formed by a plurality of arcuately curved perforate plates **25** arranged in end-to-end relation for convenience of fabrication and removal. These perforate plates **25** are supported along their outer edges by a pair of rods **26**, shown as of square section, welded along the side wall of the cylinder, and the outwardly turned side edge portions **27** of the plates **25** seat on these rods **26**.

The bottom plates **25** extend from the inlet end of the cylinder **20** to a position immediately adjacent the outlet **22**, and they define in the bottom of the cylinder a crescent-shaped chamber as indicated at **30** in Fig. 3. This chamber **30** is in turn separated into a plurality of individual compartments, identified as **31***a* to **31***f* by means of partition plates **32** of generally crescent shape which also cooperate with reinforcing straps **33** and **34** to form members of generally **Z**-shape in cross section for supporting the plates **25** against the pressures thereon incident to use of the unit. As shown in Fig. 4, the strap **33** is welded to the bottom wall of the cylinder **20**, the plate **32** is welded to both the straps **33** and **34**, and one strap **34** underlies the adjacent ends of each pair of perforate plates **25** and is removably secured thereto by screws **35**. As an example of satisfactory dimensions for these parts, in a cylinder **20** having an inner diameter of 35 inches and a wall thickness of ½ inch, the parts **25** and **32–34** may all be formed of quarter-inch plate stock. The outer ends of the two end plates **25** are similarly supported by and secured to channel members **36** otherwise similar to the generally **Z**-shaped members **32–34**.

A plurality of inlet ports **40** are provided in spaced relation along the upper side of the cylinder **20** for connection to a line for supplying digesting liquor, and these ports **40** are arranged in pairs as shown in Fig. 3. Each port **40** is provided with a spray nozzle **41** for spraying the liquor outwardly and downwardly on the cellulosic material passing therebelow in cylinder **20**, each nozzle **41** being supported by a suitable coupling **42** as shown in Fig. 6. In addition, and referring to Fig. 2, the first partition plate **32** is located in a vertical plane spaced between the supply inlet **21** and the nearest pair of inlet ports **40**, and the first compartment **31***a* is provided with an individual drain port **44***a*, each of the remaining compartments **31***b*–**31***f* having similar drain ports **44***b*–**44***f*.

When the impregnation tube **11** is incorporated in a digesting system as shown in Fig. 1, it also includes a screw conveyor as indicated at **50** in Fig. 1 for causing the cellulosic material which is introduced into the supply inlet **21** to be continuously advanced to the outlet **22** with accompanying continuous agitation. A drive for the screw conveyor shaft **51** is located at one end of the tube as indicated at **52** in Fig. 1 and also in Figs. 7–8, and the other end of the screw conveyor shaft is supported in a suitable bearing assembly **53**. The cooking tubes **12** and **13**, which may be cylindrical tubes without special drainage means, also are provided with screw conveyors **50** having similar drive means as indicated in Fig. 1.

The outer diameter of the screw conveyor is indicated at **50** in Fig. 3 and is somewhat less than the distance between the top of cylinder **20** and the perforate plates **25** as measured along a vertical center line. For example, a screw conveyor 30 inches in diameter may be used where the inner diameter of the cylinder **20** is 35 inches, the plates **25** having an inner radius of 16⅝ inches on a center 2⅜ inches above the axis of the cylinder, and the screw conveyor is centered vertically between the plates **25** and the top of the cylinder. Fig. 3 also shows the tube as provided with a plurality of spline bars **55***a*–**55***c* which cooperate with the screw conveyor as described hereinafter. Three of these spline bars are shown, the bar **55***a* being located on the horizontal center line of the cylinder **20** and on the upturning side of the screw, the spline bar **55***b* being located 45° below the spline bar **55***a*, and the spline bar **55***c* being located at 22½° beyond the vertical center line from the spline bar **55***b*.

When the impregnation tube **11** is embodied in a complete system as shown in Fig. 1, the inlet **21** is connected to a **T**-piece **60** which receives the chips or other raw cellulosic material from the feeder **10** and its hopper **61** and bin **62**. The **T**-piece **60** also provides a convenient connection for a steam line **63** through which steam at superatmospheric pressure is admitted to the interior of the tube **11**. If the feeder **10** is generally of the construction described in the above Beveridge et al. patent, it incorporates a feed screw or a reciprocating ram which compresses the raw cellulosic material into plug form in the pipe **64** to prevent substantial loss of pressure from within the tube **11** and **T**-piece **60**. With such feeders, a valve **65** may be provided for preventing the pressure from blowing back through the feeder in the event that the feeder should stall or otherwise fail to maintain a properly sealed condition, the valve **65** being operated by a hydraulic cylinder **66** connected to operate automatically in response to a predetermined drop in the load on the operating motor for feeder **10**.

As shown in Fig. 1, each pair of inlet ports **40** is connected to a liquor supply line **70** by individual branch pipes **71** each having a manual control valve **72**. Each of the pipes **71** is also shown as having an electric regulating valve **73**, with all of the valves **73** being connected for automatic remote operation by a flow regulating recorder **75**. The main liquor suppjy line **70** leads from

a pump **76** at the liquor tank **77**, pump **76** being shown as having its own motor **78**.

In accordance with the invention, a special drainage system is provided for the impregnation tube **11**. For convenience and flexibility of operation, a main drain header **80** is connected with each drain port **44***b* by individual branch pipes **81***a*–**81***f*. Each branch pipe **81** includes a control valve **82**, and additional control valves **83***a*–**83***c* are provided in the header **80** between adjacent pipes **81***a*–**81***d* to provide for separately controlled drainage from opposite ends of header **80**. A drain line **84** for condensate leads from the end of header **80** adjacent the supply inlet **21** to a condensate tank **85**, and control valves **86** and **87** operate in unison to provide for intermittent drainage of tank **85** without loss of the steam pressure within tube **11**.

A second drain line **88** leads from the opposite end of header **80** to the liquor tank **77** to conduct to tank **77** the relatively dilute liquor which drains from the interior of tube **11** for recirculation to the ports **40**. This dilute liquor is reactivated or restored as required to maintain the desired concentration by the addition of fresh liquor from the supply tank **90** by way of a pump and motor **91** and a preheater **92** having a steam heating connection **93**. The specific nature and proportion of the liquor is not a part of the present invention, since the process and apparatus of the invention are applicable to both alkaline and acidic liquors, as well as to straight steam cooking if desired. The liquor supply system may be provided with suitable automatic controls as indicated by the liquid level control **95** for tank **77** and the rotameter **96**.

In the operation of this system as a whole, the raw cellulosic material which is continuously supplied to the T-piece **60** and to the supply inlet **21** of the induction tube **11** is subjected in the T-piece and in the inlet end of tube **11** to the continuous supply of steam at superatmospheric pressure from steam pipe **63**. It is therefore rapidly heated, possibly also accompanied by some degree of swelling, with resulting formation of condensate, and the desired elimination of air bubbles from within the chips takes place at the same time. The major portion of this heating action may therefore be controlled to take place before each given section or particle of the cellulosic material has traveled beyond the compartment **31***a*, and the condensate resulting therefrom will accordingly be drained into compartment **31***a* for continuous removal by way of pipe **84** to tank **85**, the valve **83***a* being closed to shut this condensate off from the liquor recirculating system. As an illustrative example, the speed and pitch of conveyor screw **50** and the other proportions of tube **11** may be selected to provide an average of approximately three minutes travel for each particle of the raw material in this preheating zone, and during this interval, the material will be continuously agitated by screw **50** to assure repeated exposure of all particles therein to the high pressure steam.

The cellulosic material which has thus been preheated and saturated with moisture, but which is otherwise relatively dry in the sense that it is substantially free of unabsorbed liquid, is then advanced into the series of impregnation zones provided by the other compartments **31***b*–**31***f* and the inlet ports **40**. As the cellulosic material reaches the first pair of ports **40**, it will be showered with fresh hot liquor which is substantially immediately absorbed by each particle with which it comes in contact, and the continuous agitation provided by the screw conveyor assures constant change in the surface of the cellulosic material exposed to the liquor. At the same time, some liquor will run through the mass to the drain compartment **31***b* along with the moisture displaced by the liquor from the swelled cellulosic material, and the resulting partially dilute liquor will be withdrawn by way of pipe **81***b* and drain line **88** to the liquor tank **77**.

This process is repeated throughout the advance of the cellulosic material through tube **11**. As the material reaches each pair of inlet ports **40**, it is again showered with fresh hot liquor while being alternately raised and tumbled by the screw conveyor so that all parts of the material are assured of exposure to liquor for the desired rapid and thorough impregnation. This result is materially contributed to by the spline bars **55***a*–**55***c*, since they cooperate with the screw conveyor **50** to help move the material forward in the tube at an essentially constant rate by minimizing the tendency of the material to revolve in the tube and the resulting slippage. This action also effects localized temporary packing of the cellulosic material along the perforate plates **25** in the space between these plates and the periphery of the screw conveyor to form a liquid-permeable sealing mass which cooperates with the baffling effect of the conveyor screw flights to retard flow of the unabsorbed liquor lengthwise of the tube and thus to promote draining of such unabsorbed liquor from each successive portion of the impregnation zone directly through the adjacent perforate plate **25**. This assures that all particles which are not properly impregnated will be successively flooded only with fresh hot liquor rather than with liquor which has already been diluted or otherwise lost a portion of its full strength, thus in turn assuring commencement of a cooking treatment which will be essentially uniform throughout each chip and which therefore can be carried on at maximum speed with equipment of minimum size for the particular results to be obtained.

In the system as shown in Fig. 1, when the cellulosic material reaches the discharge outlet **22** from tube **11**, it is thoroughly impregnated by liquor but is essentially free of unabsorbed liquor due to the continuous drainage through the compartments **32**. At the same time, the continuous supply of liquor to tube **11** and in the cellulosic material, together with the maintained high temperature and pressure throughout the conduit, establishes a hot vapor-bearing atmosphere throughout the cooking tubes **12** and **13**, and the cellulosic material is dropped throughout the discharge outlet **22** into tube **12** for travel lengthwise thereof and then back through tube **13** to the discharge unit **15** while it is continuously agitated by the screw conveyors in tubes **12** and **13** for repeated exposure of all particles therein to this hot vapor-bearing atmosphere. When this cooking phase of the process has thus been completed, the material is discharged in essentially defibered condition by the discharge unit **15** as described in detail in the above Kehoe et al. patent.

This system provides great flexibility in the control of all phases of the continuous cooking process. For example, if for some cellulosic material it is desired to increase the time of exposure to steam in the absence of liquor, this may be done by closing the first of the liquor control valves **72** and by opening valve **83***a* and closing valve **83***b*, thus in effect increasing the length of the presteaming zone and adding the condensate from the compartment **31***b* to that from compartment **31***a*. Conversely, if adequately thorough impregnation for a given raw material is obtained in less than the full length of tube **11**, one or more of the last pairs of inlet ports **40** can be shut off to increase the effective length of the cooking section of the conduit, and the effective lengths of the cooking tubes **12** and **13** can also be varied by regulating the speeds of the screw conveyors therein.

The flexibility of the invention is further illustrated by Figs. 7–8, which show a system in accordance with the invention incorporating a pair of impregnation tubes **100** and **101**, each of which may be substantially identical with tube **11** and both of which are accordingly shown as having their component parts designated by the same reference characters as in the case of tube **11** as previously described. The relevant other parts of this system are similarly designated by the same reference characters as in Fig. 1. The relative extents of the steaming and

impregnation sections of the combined tubes **100** and **101** can be varied as described for tube **11** in accordance with the particular desired conditions to be established and maintained. Thus for particularly large units, it may even be found desirable to use the upper tube **100** entirely for steaming the cellulosic material, in which case some or all of the ports **40** may be connected to the steam supply while any of these ports not required for steam can be plugged. The lower tube **101** may then be connected to the liquor supply system in the same manner as shown for tube **11** in Fig. 1. Otherwise the operation of this system is essentially the same as described in connection with Fig. 1.

Figs. 9–11 illustrate another construction of impregnation tube which is adapted for use in the system of Figs. 1 and 7 in the practice of the invention. This tube includes a main cylinder **120** having an inlet **121**, an outlet **122** and a hand hole **123** corresponding to the similar parts in the tube of Figs. 2–6, and multiple liquor nozzle means are indicated at **124**. This tube is provided with a screw conveyor as indicated at **50**, and also the interior of cylinder **120** is provided with a plurality of spline bars **55**, four of these bars being shown as located respectively on the horizontal center line of the cylinder, and below center at 45° on either side of the vertical center line of the cylinder. The means for continuously withdrawing condensate and unabsorbed liquor from cylinder **120** comprises a plurality of strainer outlet assemblies identified generally at **125** and shown in more detail in Fig. 11.

Each of the assemblies **125** includes a short cylindrical tube portion **130** forming a nipple welded to the under side of cylinder **120**, and cylinder **120** has a cutout **131** coinciding with each nipple **130**. The bottom end of each nipple **130** is provided with a flange **132** to which a closure plate **133** is bolted at **134**, and the closure plate **133** supports a strainer section **135** shaped and proportioned to fill the cutout **131**. This strainer section **135** is mounted on the plate **133** by means of a plurality of studs **136** supported at opposite ends in sockets **137** and **138** welded to the plate **133** and strainer section **135** respectively, the studs **136** being shown as threaded in sockets **138** and secured by set screws in sockets **137**.

With this construction, each of the several nipples **130** forms a compartment for receiving condensate or unabsorbed liquor through its associated strainer section **135** from the interior of cylinder **120**. This liquid is continuously withdrawn from each nipple by an outlet provided by a short tube section **140** welded to a cutout in the side of each nipple and having a flange **141** at its outer end by which it may be attached to a separate drain pipe corresponding to one of the lines **81***a*–**81***f* in Fig. 1. As shown in Fig. 9, the assembly **125** closest to the inlet end of cylinder **120** is located between the inlet **121** and the first of the nozzle means **124**, so that this assembly provides for the desired removal of condensate before the cellulosic material within the tube reaches the first zone of liquor treatment. The remaining strainer assemblies **125** correspond to the several additional compartments in Figs. 1 and 2, and the above general discussion with respect to the systems of Figs. 1–8 applies also to the use of the impregnation tube shown in Figs. 9–11.

The number and proportions of the strainer assemblies **125** may be varied in accordance with desired operating conditions and the proportions of the impregnation tube as a whole. For example, Fig. 9 shows four of the assemblies **125** equally spaced with respect to each other and with the end assemblies located closely adjacent the inlet **121** and outlet **122** respectively. With the cylinder **120** having a diameter of 36 inches, satisfactory results are obtained with each of the nipples **130** approximately 24 inches in diameter. The construction of Figs. 9–11 also offers practical advantages of ease of assembly and maintenance, particularly since removal of each closure plate **133** brings with it the associated strainer section **135** for cleaning or other servicing, and this at the same time provides ready access to the interior of the cylinder **120**.

While the forms of apparatus herein described constitute preferred embodiments 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 which is defined in the appended claims.

What is claimed is:

1. Continuous digesting apparatus for cellulosic materials comprising an elongated generally horizontal tubular conduit having an inlet and an outlet and including an impregnation section and a cooking section adjacent said inlet and outlet respectively, means for continuously feeding raw cellulosic material into said inlet, means for continuously supplying steam into said inlet at superatmospheric pressure to effect rapid heating of said raw cellulosic material with resulting formation of condensate, means including a perforate member in the bottom of said conduit adjacent said inlet forming a drain compartment therebelow for receiving said condensate, means located at a plurality of spaced positions lengthwise of said impregnation section for supplying digesting liquor thereto from above, means for effecting continuous advance of said cellulosic material through said impregnation section while continuously agitating said material to cause exposure of all particles therein first to said steam and then to said liquor, all of said liquor supplying means being located downstream from said drain compartment to prevent application of liquor to said material prior to said heating thereof and the drainage therefrom of said condensate into said compartment and thereby to minimize dilution of said liquor and to assure application of said liquor at maximum concentration to said heated and drained material, means including a perforate member forming at least one additional compartment below said impregnation section and spaced from said first compartment, means for separately and continuously withdrawing said condensate from said first compartment and the liquor draining into the remainder of said compartments while maintaining said superatmospheric steam pressure to assure repeated application of fresh liquor to said cellulosic material from above and to establish a hot vapor-bearing atmosphere in said conduit, and means for effecting continuing advance of said cellulosic material throughout said cooking section while agitating said material for repeated exposure of all particles therein to said hot vapor-bearing atmosphere.

2. Continuous digesting apparatus for cellulosic materials comprising an elongated generally horizontal tubular conduit having an inlet and an outlet and including an impregnation section and a cooking section adjacent said inlet and outlet respectively, means for continuously feeding raw cellulosic material into said inlet, means for continuously supplying steam into said inlet at superatmospheric pressure to effect rapid heating of said raw cellulosic material with resulting formation of condensate, means including a perforate member in the bottom of said conduit forming a first drain compartment therebelow for receiving said condensate and at least one additional drain compartment spaced downstream from said first compartment, means located at a plurality of spaced positions lengthwise of said impregnation section for supplying digesting liquor thereto from above, means for effecting continuous advance of said cellulosic material through said impregnation section while continuously agitating said material to cause repeated exposure of all particles therein first to said steam and then to said liquor, all of said liquor supplying means being located downstream from at least said first drain compartment to establish a first zone in said conduit for heating of said cellulosic material by steam and drainage of said condensate therefrom in the absence of liquor and thereby to minimize dilution of said liquor and to assure application

of said liquor at maximum concentration to said heated and drained material, additional said compartments being spaced lengthwise of said impregnation section to define a plurality of additional successive zones wherein liquor applied to said material from above is drained therefrom from below before advance of said material to the next zone, means for selectively controlling said liquor supplying means to provide for treatment of said material with steam in the absence of liquor in selected said zones adjacent said first zone, separate drain outlets from each said compartment, selective control means for said drain outlets providing for continuously withdrawing condensate from said first compartment and each adjacent zone wherein no liquor is supplied and for continuously withdrawing liquor from said compartments in the remainder of said zones while maintaining said superatmospheric steam pressure to establish a hot vapor-bearing atmosphere throughout the remainder of said conduit, and means for effecting continued advance of said cellulosic material through said cooking section while agitating said material for repeated exposure of all particles therein to said hot vapor-bearing atmosphere.

3. In continuous digesting apparatus for cellulosic materials, the combination of an elongated impregnation tube, means defining an inlet at one end of the upper side of said tube and an outlet at the opposite end of the lower side of said tube, means for continuously supplying raw cellulosic materials and steam to said inlet to effect rapid heating of said material with resulting formation of condensate, means for advancing said material from said inlet to said outlet while agitating said material, perforate means extending within the bottom of said tube from said inlet end thereof to said outlet in upwardly spaced relation with the wall of said tube to form a perforate false bottom defining a chamber therebelow for receiving liquid draining therethrough, a plurality of inlet ports spaced along the upper side of said tube from a position adjacent said inlet to a position adjacent said outlet for connection to liquor supplying means, a plurality of generally radially arranged partitions separating said chamber into a plurality of compartments, the first said partition being located adjacent said inlet to define a first zone in said tube extending from said inlet to said first partition and a first compartment below said first zone for draining said condensate from said material prior to advance of said material therebeyond, the nearest said inlet port to said inlet being located downstream from said first partition to prevent application of liquor to said material prior to said heating thereof in said first zone and the drainage of said condensate therefrom into said first compartment and thereby to minimize dilution of said liquor and to assure application of said liquor at maximum concentration to said heated and drained material, additional said partitions being spaced lengthwise of said tube for cooperation with said inlet ports to define a plurality of further successive zones wherein liquor applied to material from above is drained therefrom from below before advance of said material to the next said zone, the last said partition being located between the last said inlet port and said outlet to minimize transmission of unabsorbed liquor to said outlet, and separate drain ports from each said compartment.

4. Continuous digesting apparatus for cellulosic materials comprising an elongated generally horizontal tubular conduit having an inlet and an outlet at opposite ends thereof, means defining a plurality of zones within said conduit including first and third zones adjacent and extending to said inlet and outlet respectively and an intermediate zone, means including a perforate member in the bottom of said first zone forming a compartment therebelow for receiving liquid draining therethrough from above, means for continuously feeding raw cellulosic material into said first zone, means for continuously supplying steam into said first zone at superatmospheric pressure to effect rapid heating of said raw cellulosic material in said first zone with resulting formation of condensate for draining into said compartment, means for continuously withdrawing said condensate from said first compartment, means located at a plurality of spaced positions lengthwise of said intermediate zone for continuously supplying digesting liquor thereto from above, all of said liquor supplying means being located downstream from said first compartment to prevent application of liquor to said material prior to said heating thereof and the drainage of said condensate therefrom into said first compartment and thereby to minimize dilution of said liquor and to assure application of said liquor in said intermediate zone at maximum concentration to said heated and drained material, means for effecting continuous advance of said cellulosic material through said first and intermediate zones while continuously agitating said material to cause repeated exposure of all particles therein first to said steam and then to said liquor, means including a perforate member in the bottom of said intermediate zone forming a second compartment therebelow for receiving unabsorbed liquor draining therethrough, means for continuously removing the liquor draining into said second compartment while maintaining said superatmospheric steam pressure to assure repeated application of fresh liquor to said cellulosic material from above while establishing a hot vapor-bearing atmosphere throughout said conduit, and means for continuing the advance of said cellulosic material throughout said third zone while agitating said material for repeated exposure of all particles therein to said hot vapor-bearing atmosphere.

5. Continuous digesting apparatus as defined in claim 4 comprising means for effecting localized temporary packing of said cellulosic material along the bottom wall of said first and intermediate zones in conjunction with the advance thereof to form a liquid-permeable sealing mass of said material along said wall retarding flow of unabsorbed liquor lengthwise of said zones and promoting draining of such unabsorbed liquor directly to said second compartment.

6. Continuous digesting apparatus as defined in claim 4 wherein said means for effecting advance of said cellulosic material through said first and intermediate zones comprises screw conveyor means extending lengthwise of said first and intermediate zones, and a plurality of splines extending generally axially of said two zones and projecting radially inwardly from the inner wall of the lower portion of said conduit in circumferentially spaced relation for cooperation with said screw conveyor means to effect localized temporary packing of said cellulosic material along the bottom of said intermediate zone into a liquid-permeable sealing mass of said material retarding flow of unabsorbed liquor lengthwise of said zones and promoting draining of such unabsorbed liquor directly to said second compartment.

7. An impregnation tube for use in continuous digesting apparatus for cellulosic materials comprising an elongated main cylinder, means defining an inlet for cellulosic material and steam at one end of the upper side of said cylinder and an outlet at the opposite end of the lower side of said cylinder, means including a perforate member in the bottom of said cylinder forming a plurality of compartments therebelow for receiving liquid draining therethrough, a plurality of inlet ports spaced along the upper side of said cylinder from a position adjacent said inlet to a position adjacent said outlet for connection to liquor supplying means, the first said compartment being located between said inlet and the nearest said inlet port to define a first zone in said tube providing for drainage of liquid from material within said first zone prior to passage of material therebeyond and thereby preventing application of liquor to said material prior to said drainage thereof in order to minimize dilution of said liquor and to assure application of said liquor at maximum concentration to said drained material, the other said compartments being spaced lengthwise of said cylinder to

define with the remainder of said inlet ports a plurality of further successive zones wherein liquor applied to material within said cylinder from above is drained therefrom from below before advance of said material to the next said zone, and a separate drain outlet from each said compartment.

8. An impregnation tube for use in continuous digesting apparatus for cellulosic materials comprising an elongated main cylinder, means defining an inlet for cellulosic material and steam at one end of the upper side of said cylinder and an outlet at the opposite end of the lower side of said cylinder, perforate means extending within the bottom of said cylinder from said inlet end thereof to said outlet in upwardly spaced relation with the wall of said cylinder to form a perforate false bottom defining a chamber therebelow for receiving liquid draining therethrough, a plurality of inlet ports spaced along the upper side of said cylinder from a position adjacent said inlet to a position adjacent said outlet for connection to liquor supplying means, a plurality of generally radially arranged partitions separating said chamber into a plurality of compartments and supporting said perforate means against compression, the first said partition being located between said inlet and the nearest said inlet port to define a first zone in said tube providing for drainage of liquid from material within said first zone prior to passage of material therebeyond and thereby preventing application of liquor to said material prior to said drainage thereof in order to minimize dilution of said liquor and to assure application of said liquor at maximum concentration to said drained material, additional said partitions being spaced lengthwise of said cylinder to define with the remainder of said inlet ports a plurality of further successive zones wherein liquor applied to material from above is drained therefrom from below before advance of said material to the next said zone, and separate drain outlets from each said compartment.

9. An impregnation tube for use in continuous digesting apparatus for cellulosic material comprising an elongated main cylinder, means defining an inlet at one end of the upper side of said cylinder for receiving said material and an outlet at the opposite end of the lower side of said cylinder for discharging said material, perforate means extending within the bottom of said cylinder from said inlet end thereof to said outlet in upwardly spaced relation with the wall of said cylinder to form a perforate false bottom defining a chamber therebelow for receiving liquid draining therethrough, a plurality of inlet ports spaced along the upper side of said cylinder from a position adjacent said inlet to a position adjacent said outlet for connection to liquor supplying means, a plurality of generally radially arranged partitions separating said chamber into a plurality of compartments and supporting said perforate means against compression, the first said partition being located between said inlet and the nearest said inlet port to define a first zone in said tube, additional said partitions being spaced lengthwise of said cylinder to define a plurality of further successive zones wherein liquor applied to material from above is drained therefrom from below before advance of said material to the next said zone, a screw conveyor extending lengthwise of said tube for causing said material to advance from said inlet to said outlet, a plurality of splines extending generally axially of said tube and projecting radially inwardly from said perforate means in circumferentially spaced relation for cooperation with said screw conveyor to effect localized packing of said cellulosic material along said perforate means into a liquid-permeable sealing mass of said material retarding flow of unabsorbed liquor lengthwise of said tube and promoting draining of such unabsorbed liquor from each said zone directly to the associated said compartment, and separate drain outlets from each said compartment.

10. An impregnation tube for use in continuous digesting apparatus for cellulosic materials comprising an elongated main cylinder, means defining an inlet at one end of the upper side of said cylinder and an outlet at the opposite end of the lower side of said cylinder, said cylinder having a plurality of drain openings located in spaced relation along the bottom thereof, a nipple secured to the under side of said cylinder at each said drain opening, a closure removably secured to the lower end of each said nipple and cooperating therewith to form a drain compartment, a perforate member carried by each said closure and supported thereby within the associated said drain opening for transmitting liquid therethrough while retaining said material within the interior of said cylinder, and means forming a separate drain outlet from each said compartment.

11. A strainer assembly for incorporation with an impregnation tube for use in continuous digesting apparatus for cellulosic materials and including an elongated main cylinder having an inlet at one end of the upper side of said cylinder and an outlet at the opposite end of the lower side of said cylinder and also having at least one drain opening located in the bottom thereof, comprising a nipple adapted to be secured to the under side of said cylinder at each said drain opening, a closure plate removably secured to the lower end of said nipple for cooperation therewith to form a drain compartment, a perforate member proportioned to be received within said drain opening, means supporting said perforate member on and in upwardly spaced relation from said closure plate to locate said perforate member within said drain opening for transmitting liquid therethrough while retaining said cellulosic material within the interior of said cylinder, and means forming a drain outlet from said compartment.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,953,202 September 20, 1960

Frank B. K. Green

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 10, for "a" read -- to --; column 6, line 35, for "32" read -- 31 --.

Signed and sealed this 11th day of April 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents