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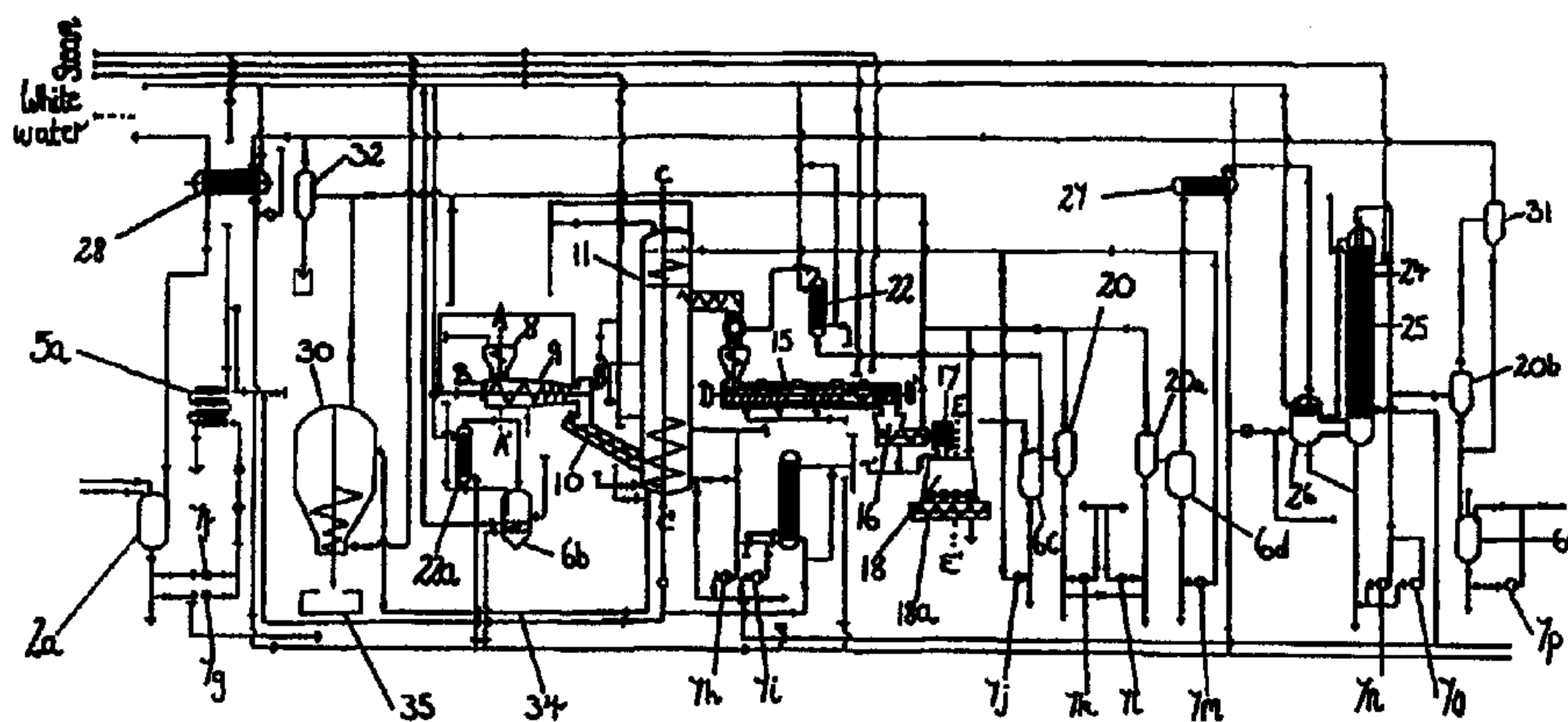
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(54) **PROCEDE ET APPAREIL DE FABRICATION DE PATE**

(54) **PULP PRODUCTION METHOD AND APPARATUS**



(57) L'invention se rapporte à un appareil de fabrication de pâte à partir de matières végétales. L'appareil comprend, dans l'ordre, un premier doseur (9) destiné à réguler la quantité de matière première entrante, un bouilleur (11) servant à la cuisson de la matière première et à l'obtention d'une pâte, un deuxième doseur (13) maintenu à une pression plus basse que le bouilleur (11), un appareil (15) d'extraction de liquides, un dispositif de déchargement (16) dans lequel la pâte est traitée à la vapeur, un réservoir d'accumulation (18) et un dispositif pour extraire la pâte du réservoir d'accumulation. Le premier doseur (9) peut comprendre une vis sans fin (90, fig. 4) possédant une tige (91, fig. 4) qui dépasse du filetage de la vis; la tige comporte un canal à travers lequel on injecte la solution pour bouilleur. Le bouilleur peut être pourvu d'une vis sensiblement verticale (111, fig. 5) possédant un arbre rotatif perforé. L'appareil (15) d'extraction de liquides peut comprendre un appareil à vis pourvu d'au moins un jeu de cames rotatives, chaque jeu de cames ayant une largeur différente. Le réservoir d'accumulation (18) peut comprendre un fond muni d'un système assurant le mouvement continu de la pâte.

(57) Apparatus for production of pulp from plant material comprising, in sequence, a first feeder (9) for regulating the input of raw material, a boiler (11) for cooking the material to generate pulp, a second feeder (13) maintained at lower pressure than the boiler (11), a liquid extraction apparatus (15), an unloader (16) in which material is treated with steam, an accumulation reservoir (18) and means for removing pulp from the accumulation reservoir. The first feeder (9) may contain a screw (90, Fig. 4) having a stem (91, Fig. 4) which extends beyond the screw thread, the stem having a passage through which boiler solution is injected. The boiler (11) may contain a substantially vertical screw (111, Fig. 5) having a rotatable, perforated shaft. The liquid extraction (15) apparatus may comprise a screw apparatus containing at least two sets of rotatable cams, each set of cams being of different width. The accumulation reservoir (18) may have a bottom comprising means for keeping the pulp in constant motion.

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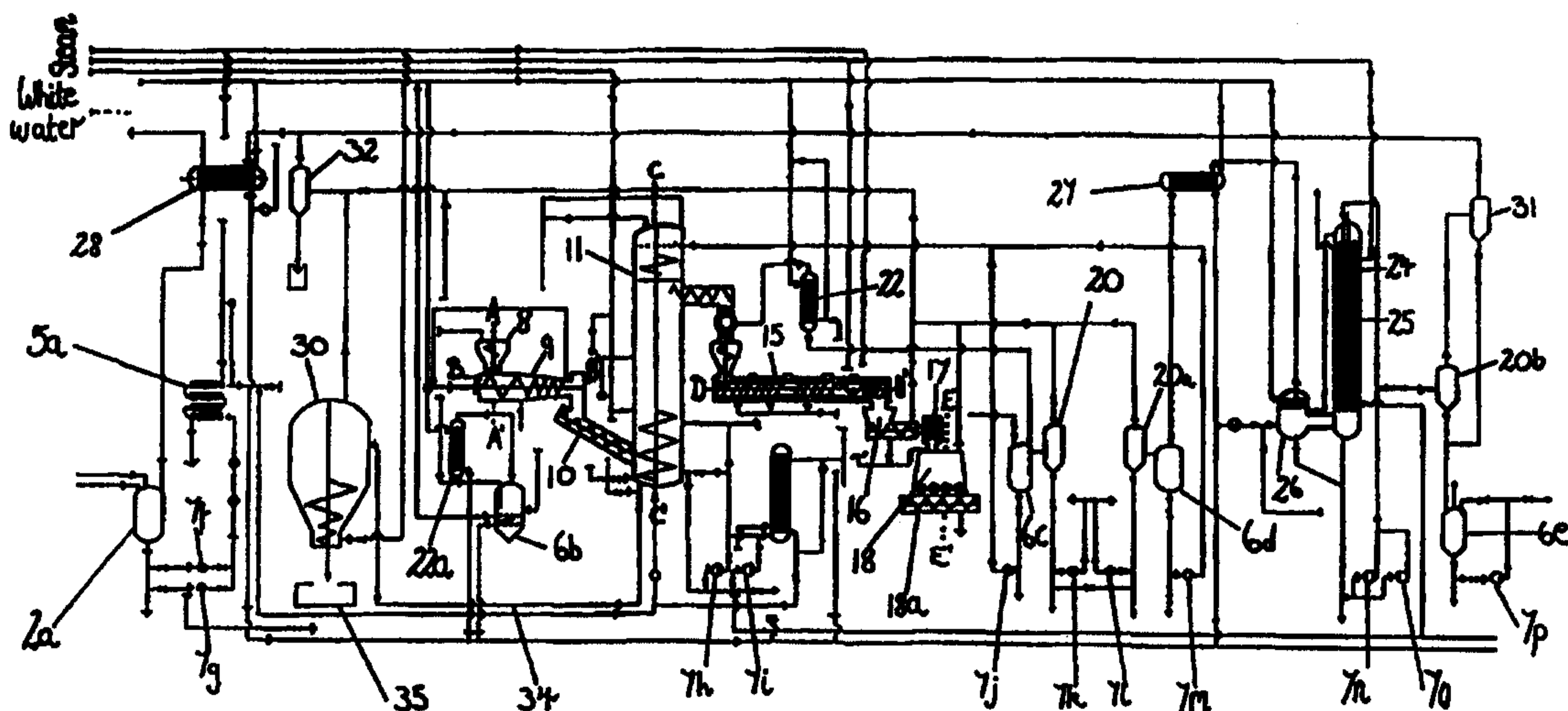
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(54) Title: PULP PRODUCTION METHOD AND APPARATUS



(57) Abstract

Apparatus for production of pulp from plant material comprising, in sequence, a first feeder (9) for regulating the input of raw material, a boiler (11) for cooking the material to generate pulp, a second feeder (13) maintained at lower pressure than the boiler (11), a liquid extraction apparatus (15), an unloader (16) in which material is treated with steam, an accumulation reservoir (18) and means for removing pulp from the accumulation reservoir. The first feeder (9) may contain a screw (90, Fig. 4) having a stem (91, Fig. 4) which extends beyond the screw thread, the stem having a passage through which boiler solution is injected. The boiler (11) may contain a substantially vertical screw (111, Fig. 5) having a rotatable, perforated shaft. The liquid extraction (15) apparatus may comprise a screw apparatus containing at least two sets of rotatable cams, each set of cams being of different width. The accumulation reservoir (18) may have a bottom comprising means for keeping the pulp in constant motion.

PULP PRODUCTION METHOD AND APPARATUS

This invention relates to percolation organic solvent boiling of raw plant materials. Most particularly the invention relates to a unit for cellulose
5 production from ground hemp stocks from the preliminary hemp processing at the fibre plants.

From the point of view of pulp production, bast-fibre plants consist of two different raw materials, the bast which comprises 20-25% of the plant, and the woody fibres that comprise the remainder of the plant. It was found
10 initially when using these plants as raw materials that typical pulping conditions may be optimum for the bast portion but may not be optimum for the fibrous portion. A more progressive, modern pulping technology of bast fibre plants such as hemp, flax, and kenaf is based on the separation of stalks into its two parts: bast (fibre) and woody (shive). The mechanical separation
15 of stalks by this conventional technology, typically involving stock preparation and its processing on breaking, scutching and hackling machines, is not only expensive, but also generates large quantities of waste, including both dust and chemical waste. A significant proportion of the waste is irretrievably lost, leading to pollution of the environment. Further, shive
20 formed during the mechanical separation and cleaning of bast fibres is not very suitable for pulping by modern methods. In the pulp and paper industry only the bast portion of hemp is used.

At present only one technology is known that is capable of eliminating such wastefulness and converting 60 - 65% of stalks into high quality bleachable pulp. This technology is based on pulping using aqueous organic (aqueous alcohol) solutions of ammonia and sulphur dioxide as pulping
5 liquors. This is known as alcohol-based ammonia-sulphite (AAS) pulping. AAS pulping is unrivalled in both the selectivity and the extent of delignification of the raw plant materials.

In the International Review for the Pulp and Paper Industry, Sterling Publishing Plc, 1994, pp. 67 - 70, V. Krotov discusses a method of using AAS
10 technology involving drip percolation. The principle involves the trickling and drip percolation of pulping liquor (consisting of alcohol based ammonia-sulphite) through the layer of lignocellulosic material (chopped hemp, straw, shive, etc) in vapour / gas medium. The pulping was carried out at low liquor ratio close to that of vapour phase digestion. The liquor is continuously
15 recovered by condensation before trickling.

A unit incorporating this technology was reported by Krotov V. S. and Lavrinenko T. F. in the 4th International Symposium of Scientists from Comecon Countries, Theses, Zinatne, Riga, 1982. This was a closed cycle system unit which contained the following components sequentially: a tank
20 for chemical mixing, a first scrubber to which an exhauster is connected, a second mixing tank for ammonia water, a condenser, a second scrubber, third and fourth tanks, a hopper, a feeder, a spiral conveyor, a digester, a discharge

unit, a fluffer, a discharge tank, an evaporator, a flasher, a moisture trap and a cyclone.

The most immediate advantage of this single unit plant was that it could integrate all major processes of pulp production including raw material
5 impregnation and cooking, stock washing and dewatering, recovery of the liquid fraction of a spent solution, collection and utilisation of dirty condensates, utilisation of secondary steam and condensate heat, and collection and removal of non-condensable gases without air entrapment.

One factor that contributes to the efficiency of this pulping method
10 within this unit is the retention of initial shape of the raw material particles during the whole process of AAS delignification. The delignified stock is turned into pulp under very limited mechanical action.

A significant advantage of this drip percolation and the unit disclosed
15 by Krotov et al. was the effective reduction in environmental pollution. It is ensured by the closed-cycle production which is carried out in a space entirely isolated from the environment, with complete absence of effluents, including dirty condensates. Non-condensable gases are collected without entrained air and can be taken for neutralisation. This differs from multi-unit plants with a
20 great number of unpressurized vessels where gas emissions are distributed along the production line, entrain air and are inevitably released into the atmosphere.

Before the raw material enters the digester, it undergoes a process known as Prex impregnation. A small portion of the raw material within the feeder apparatus (for a digester) is compressed and then expanded. At the point of expansion, the pulping liquor is injected into the feeder apparatus, 5 whereby the raw material acts as a sponge and absorbs the liquid. This technique allows a significant proportion of the raw material to come into contact with the pulping liquor. However, it is unlikely that using the disclosed apparatus results in all the material being saturated. There thus exists the possibility of improving the technique by developing an improved 10 feeder apparatus. Further, the prior art document does not discuss variations in condition, such as temperature for example that might improve this method of impregnation.

In this prior art unit the only cooking of the raw material occurs within the digester. It is possible that the efficiency of delignification could be 15 improved by allowing some preliminary cooking prior to the material entering a digester or equivalent apparatus. There is also the problem with the design of the digester disclosed that the means by which the cooked and washed pulp is removed from the digester into the discharge unit is inefficient and this can lead to a congestion of material. There is scope for improvement of the means 20 by which the material is removed from within any cooking device used.

Within this unit there is significant recovery of the components of the spent pulping solution / liquor. For example, up to 60-70% ammonia and up

to 50% sulphur dioxide can be recovered quantitatively. Organic solvent can also be recovered quantitatively. However, there still exists the possibility of improving the recovery of the liquid fraction of the spent solution.

The present invention seeks to create an improved single, closed unit which can be operated continuously for cellulose production from fibrous raw plant material. The unit in an embodiment must use AAS pulping technology and drip percolation and thus retains the advantages of these methods of delignification. As with the previously disclosed pulping unit using this technology, the unit must simultaneously perform the operations of saturation of the raw plant material by boiler solution, boiling (delignification) of the raw plant material, washing of the fibrous product, regeneration of the organic solvent, residue water and chemicals from the used boiler - washing solution, dehumidification of the washed fibrous product, collection and absorption of the steam and gases and preparation of the boiler solution from the recovered and fresh chemicals. However, most importantly, the unit according to this invention seeks to provide for improved Prex impregnation of the raw material.

A further object of the invention is to improve the processing of the washed and cooked plant material and in particular to improve the efficiency of the collection - particularly from the cooking apparatus - dewatering and predrying of the fibrous product (pulp). Also the invention seeks to improve the collection, condensation and absorption of vapours released in the

delignification, the collection, cleaning and centralised discharge for neutralisation and utilisation of non-condensable gases and also the preparation of pulping liquor from the recovered chemicals.

Another object of the invention is to produce a unit which realises few
5 waste products, and does not need fresh water technology or gas treatment facilities for processing the raw plant material into high quality cellulose. The unit should be raw material, cost and energy efficient.

According to the present invention there is provided an apparatus for the production of pulp from raw material by drip percolation comprising in
10 sequence a first feeder for regulating the input of raw material into a boiler, containing a screw having a prolonged stem which extends beyond the screw thread, the stem having a passage through which boiler solution is injected into the first feeder, a boiler for cooking the raw material to generate pulp, a
15 second feeder which receives cooked material from the boiler and which is maintained at a lower pressure than the boiler, a liquid extraction apparatus for extracting liquid from the cooked material passed into it; an unloader which is maintained at a lower pressure than the liquid extraction apparatus, in which material received from the liquid extraction apparatus is treated with
20 steam, an accumulation reservoir for receiving pulp from the unloader and a means for removing pulp from the accumulation reservoir.

Preferably the unit is composed of two sections whereby the first section for the preparation of the boiler solution comprises: a first mixing

device into which water is fed, a plunger pump with adjustable inputs, a first scrubber into which ammonia is fed by a first output tank, a first 'tube in tube' heat exchanger, a second scrubber the contents of which are fed into a second tank; and the section for the boiling of the raw material comprises; an

5 input bunker, a spiral feeder, an inclined spiral conveyor, a boiler, a second mixing device, a second 'tube in tube' heat exchanger, a rotor feeder, a dividing bunker, a screw apparatus, a screw unloader, a fluffer, an accumulation reservoir, a screw conveyor, a first casing tube heat exchanger, a fourth output tank, a first vaporising apparatus, a steamer, a second casing

10 tube heat exchanger, a fifth output tank, a second vaporiser apparatus, a third vaporiser apparatus, a first cyclone, a third casing tube heat exchanger, a second cyclone, an emergency tank, a helper bunker, a fourth casing tube heat exchanger, and a system of pumps and interconnecting tubes.

The construction of the unit is described by reference to the appended drawings in which:

Figure 1 is a schematic of the boiler solution preparation section of the unit;

5 Figure 2 is a schematic of the section of the unit for boiling the raw plant material;

Figure 3 is a cross-section along the line A - A' through the input bunker for the raw material;

10 Figure 4 is a cross section taken along the line B - B' through the spiral feeder of the unit;

Figure 5 is a cross-section taken along line C - C' through the boiler of Figure 2;

Figure 6 is a cross-section taken along the line D - D' of the screw apparatus;

15 Figure 7 is a section taken along line E - E' of the accumulation reservoir of Figure 2; and

Figure 8 is a section taken along the line F - F' of Figure 7.

20 The two sections that together comprise the unit are respectively shown in Figures 1 and 2. The two sections are not separate entities but are constructed to interlink through specific pieces of apparatus; the two sections together form the closed cycle of the unit.

Figure 1 relates to the section for the preparation of the boiler solution. For this, ammonia water with an ammonia concentration between 25 and 27% is used, as well as sulphur dioxide, technical (95%) ethanol and water. Water for the preparation of the boiler solution is supplied into the mixing device 2, which can also serve as a pot for the preparation of hard or liquid chemicals. The water is sent via the means of the plunger pump with adjustable input 7, 7a (working and spare respectively) from the mixing device 2 to the first scrubber 3 which is in the tail. Condenser 28 supplies non-condensable gases in to the first scrubber 3 where they are absorbed by the water which thus removes impurities. Non-purified gases also enter the first scrubber from the second scrubber 4.

The section for the preparation of the boiler solution is hermetic and works under raised pressure. The first scrubber 3 works under atmospheric pressure, and in the all the following apparatuses the pressure is slowly raised depending on the aerohydrodynamic resistance.

The weak solution from the first scrubber 3 goes via the pump 7b through the first 'tube in tube' heat exchanger 5 to the second scrubber 4. The 'tube in tube' heat exchanger has a different temperature within the tubes than between the tubes. The temperature within the tubes is considerably lower than that between them, typically the inside of the tubes being between 25 and 75 degrees celsius and that between the tubes being about 100 degrees.

When gases are absorbed in the scrubbers, heat may be emitted and the solution is warmed up to 45 - 50°C. The heat exchanger 5 ensures that the temperature of the solution is no more than 20°.

Sulphur dioxide is fed into the second scrubber 4 from the tank system. Sulphur dioxide feeding is also provided for the scrubber 3 as well. The scrubber 4 is also supplied with ammonia water for irrigation from the output tank 6 by the pump 7c. The output tank 6 is equipped with injectors, from which water is supplied to ensure safety of the servicing.

The solution from the second scrubber 4 is fed by the pump 7d to the tank with ready boiler solution, the mixing device 2a.

Plunger pumps with regulated flow 7a, 7b, 7c and 7d work without reserve but the scheme allows for these pumps to be interchanged.

Figure 2 shows the section of the unit for the boiling down of the raw plant material, typically composed of ground down hemp stock from the fibre plants. The raw material comes from storage into the input bunker 8. Unlike the hopper used in the prior art units, the input bunker 8 is situated immediately above the loading carbine of the spiral feeder 9 as illustrated in Figure 2.

The input bunker 8 itself is illustrated in Figure 3. It is equipped with a stirring device 80 which prevents raw material from getting stuck, as well as with a screw 81 for pressing the raw material. The stirring device 80 is typically rotated at between 0.25 and 0.52Hz (15 and 31 rotations per minute).

The number of arms of the stirring device 81 is not limited to the two illustrated in the figure, but can be varied according to the required input rate of the raw material. The amount of raw material passing through the input bunker 8, and also the extent to which the raw material is pressed are
5 controlled by changing the spinning speed of the screw 81, the speed being controlled by a thyristor converter. Such a converter serves as a control over the engines driving the equipment.

Preferably, the input bunker 8 according to this invention will have a working volume of not more than 1.8 cubic metre. This volume ensures that
10 the raw material is efficiently pressed before passing out of the bunker 8. Input and output from the bunker 8 are closely controlled such that the productivity of bunker 8 is within the range of 3.7 to 10.0 cubic metres / hour.

The pressed raw plant material is loaded from the input bunker 8 directly into the spiral feeder 9 situated immediately beneath it. A cross-
15 section through the feeder 9 (along the line illustrated in Figure 2) is illustrated in Figure 4. The purpose of the feeder 9 is to further regulate the movement of the raw material to ensure a continuous flow of raw material into the boiler 11. The feeder 9 consists of cylindrical and conical parts, as well as a screw 90 which extends the entire length of the feeder 9. The shape
20 of the screw by analogy to the shape of the feeder itself, has both cylindrical 90a and conical 90b parts. The diameter of the screw decreases as it passes from the cylindrical to the conical part of the feeder 9, as illustrated in figure

2. Unlike prior art feeders 9, the screw of this feeder has a prolonged stem 91 which extends beyond the screw thread in the conical region 90b of the screw 90.

In the conical part of the feeder 9 the raw material is compressed, and
5 because of the slow decrease in the diameter of the screw, a plug is formed which resists the pressure of the boiler 11 - the relative positions of the boiler 11 and the spiral feeder 9 being illustrated in Figure 2 - and ensures the boiler 11 is airtight. The purpose of the prolonged stem 91 of the screw is to create a
10 hole in the centre of the compressed plug. When the plug comes off the end part of the screw 90, the raw material is depressurised. In the zone where this depressurization occurs there is a hollow shaft 92 through which boiler solution is injected. With the help of needle valves situated around the
perimeter of the output opening of the spiral feeder 9, the boiler solution irrigates the outside surface of the raw material plug. Also as the raw material
15 is depressurized it, similarly to a sponge, absorbs the injected boiler solution such that a fast saturation of the raw material occurs. When the load drops to 70% the feeder engine is shut off and the output opening of the feeder is closed off by closing the disc of a hydrocylinder.

The boiler solution is fed through the hollow shaft 92 in the spiral
20 feeder 9 by the pump 7f, 7g (working and spare respectively) from the apparatus 2a. The solution from 2a passes through the heat exchanger 5a, where it is heated to temperature of 75°C.

As with the input bunker 8, the spinning speed of the spiral feeder's screw 90 determines the efficiency of compression of the raw material. The speed of rotation also determines the time for which the raw material remains in the feeder 9; typically the throughput of the feeder 9 is maintained at a similar level to that of the input bunker 8. However, unlike the input bunker 8 which is at room temperature, the spiral feeder 9 is maintained at a temperature of approximately 100°C. This preliminary temperature increase of the raw material enables some preliminary cooking of the material when it is first impregnated with boiler solution in the depressurization zone of the feeder 9. Obviously most cooking occurs in the boiler 11 later in the unit, but the temperature increase in combination with this initial impregnation ensures increased cooking efficiency within the unit as a whole. The impregnation of the material is further improved by the hole in the centre of the plug generated by the prolonged stem of the screw 91.

The feeder contains attachments such that different screws 90 can be mounted within it. Obviously these screws will have both cylindrical 90a and conical 90b parts in correspondence to the shape of the feeder 9 but can differ in the length and diameter of the prolonged stem 91. This allows for the possibility of varying the size of the hole formed in the plug as it is extruded from the conical end 90b of the screw. As discussed, the hole is important for the impregnation of the central part of the raw material plug. However, no batch of raw material will be identical and changing the prolonged stem will

allow for more efficient impregnation of material that may vary in fibrous or bast composition. It is also useful where the unit is adapted for use in processing different types of bast-fibred plants.

With the help of the inclined spiral conveyor 10, the raw material is
5 sent to the lower part of the boiler 11, which is equipped with a vertical screw 111 that moves the raw material up and down and rods that both loosen the pulp and preclude the appearance of dense and stagnant zones in the boiler 11.

In the lower part of the boiler 11 the raw material is submerged in boiler solution. This is pumped from the second mixing device 2a by pump 7f
10 into the boiler through the vertical screw 111 which has a perforated shaft. The level of the liquid is regulated by controlling the flow of the solution entering the boiler 11 and also by pumping away the used solution, through two circular pockets (not shown), protected by two to three rows of circular sieves (not shown), using the pumps 7h and 7i. The pockets together with the
15 sieves are vital for changing the liquid level; this control is essential as it allows for the efficiency of the delignification process to be maintained even if slight fluctuations in raw material volume entering the boiler 11 occur. Any solution pumped out through the pockets in this way is heated in the casing tube heat exchanger 19 and returned to the boiler 11 through the perforated
20 shaft of the vertical screw 111.

Importantly, the temperature and pressure conditions of the boiler 11 are strictly controlled. The temperature is maintained at $170 \pm 10^\circ\text{C}$ throughout

the circulation of the boiler solution. The working pressure of the boiler is held at not more than 1.3MPa. The boiler 11 is equipped with a preventive valve, which will open at the pressure of 1.5MPa and also with features which allow for unloading of the boiler 11 when the pressure is raised. Unloading
5 the material from the preventive valve is done into the tank 6b with the casing tube heat exchanger 22a. Those gases that do not condense in heat exchanger 22a, pass through cyclone 32 into the heat exchanger 28.

Raw material in the boiler 11 is raised from the liquid and enters into a steam and gas zone, where it is subjected to boiling and irrigation with drops
10 of liquid condensed from the steam of the used solution on the surface of heat exchanger-condenser 25. Consequently, there is simultaneous washing and boiling of the fibrous product. The boiler-washing liquid used for irrigation becomes saturated with the reaction products. As the raw material rises further from the level of liquid it can be additionally heated by steam, supplied
15 through a carbine in the middle part of the boiler 11.

In the upper part of the boiler 11 a coil of the reverse screw 116 with spirally welded ribs 117 is provided. The reverse screw 116, besides preventing the pulp from entering the steam portion of the boiler 11, also serves to distribute the irrigation liquid. As boiling liquid enters the boiler 11
20 it strikes the reverse screw 116 and the ribs serve to break up the stream and thus disperse the liquid over a larger area. This ensures that as large a portion

of the raw material as possible comes into contact with the irrigation liquid and improves the effectiveness of the drip percolation.

It is also possible to change the spinning speed of the boiler shaft 112 using a thyistor converter. Typically, the shaft is rotated at about 0.53 Hz (32
5 rotations/min.).

The rate at which the pulp is raised through the boiler 11 is controlled such that it spends between 1 and 4 hours within the boiler 11. This ensures sufficient boiling and washing of the raw material. Additionally any gases released from the upper part of the boiler are blown away through tank 6b.

10 In the prior art unit shown in the 4th International Symposium of Scientists from Comecon Countries, Theses, Zinatne, Riga, 1982, the pulp passes from the boiler into a stepped series of screw feeders referred to as the discharge unit. The pulp is subjected to limited compression within this
15 apparatus, which serves to press out some of the pulping liquor remaining in the material. In the present invention the raw material passes through a sequence of apparatus components which greatly improves the ease of removal of the material from the boiler 11 and which result in far more
20 effective removal of liquid from the washed and boiled pulp.

20 Firstly, the resultant boiled and washed pulp is unloaded from the upper part of the boiler by the spiral conveyor 12. The pulp is supplied to the conveyor 12 by means of paddles 118 which are illustrated in Figure 5. The

paddles are mounted on the rotating boiler shaft and thus the unloading process is regulated by varying the speed of rotation.

One important feature of the spiral conveyor is its high speed of rotation. The screw within it is rotated at approximately 16.7 Hz (1000 rot /
5 min). This ensures a very high rate of throughput and helps to prevent congestion of the pulp at the top of the boiler.

Pulp unloaded in this way passes from the spiral conveyor 12 into a rotor feeder 13. The pressure in the rotor feeder 13 is lower than that of the boiler (1.3MPa), and is typically maintained at c. 0.7MPa to ensure an
10 approximate pressure difference of 0.6MPa. Secondary boiling gases from the boiler 11 expand on entering the rotor feeder 13 allowing for their separation and removal.

The rotor feeder 13 supplies the pulp into a dividing bunker 14. This is constructed in the same way as the input bunker 8 and thus consists of both
15 conical and cylindrical parts, and also comprises a corresponding stirrer 14a (within the conical part) and a pressing screw 14b (within the cylindrical region). The action of the stirrer 14b prevents the raw material getting stuck as in the input bunker 8. Again the screw 14b serves to compress the pulp and consequently squeeze liquid from the material.

20 The use of a dividing bunker 14 gives far more efficient pulp compression. The spinning speed of the pressing screw 14b can be varied

which allows for greater control of both the throughput of pulp and the extent to which the pulp is actually compressed.

From the dividing bunker the cellulose pulp is loaded into the screw apparatus 15, where extra liquid is pressed out. This apparatus is illustrated in Figure 6. The loading sequence is maintained airtight by fitting the screw apparatus 15 with a closing device. In emergency situations the rotors of the closing device are set to a closed position, by which a steep decline of pressure of the system is prevented.

After closing the device the cellulose pulp is ground in the block of cams. These blocks are shown in detail in Figure 6: Along the length of the screw apparatus 15 the cams is varied; in Figure 6 there are three identified types of cam (150, 151, 152) which are interchanged as illustrated. This arrangement of cams is in no way limiting. Other cams can be used, or the order of the cams changed. The variation of cams within the screw apparatus 15 means that the pulp is ground with variable intensity along its length, which improves the efficiency with which extra liquid within the pulp is squeezed out. The rotation of the screw is typically maintained between 1.6 and 3Hz (100 to 180 rotations / min). It is also possible for each different type of cam to be rotated at a different frequency by connection of each part to a different driving engine.

Having passed through the screw apparatus 15 the pressed pulp is unloaded into the screw unloader 16 which serves to both unload and steam

the cellulose pulp. Typically the screw unloader 16 is maintained at a pressure between 0.1 and 0.2 MPa such that gases are removed by the lowering of pressure. Additionally the screw unloader 16 is supplied with steam to take away the remnants of alcohol. The temperature of the pulp entering the screw unloader 16 is approximately 150°C but within this apparatus the temperature is set at 100°C.

From the screw unloader, the pulp is transported to the fluffer 17, which is designed to divide larger pieces of the pulp into separate packs of fibre so as to facilitate the process of blowing away and removal of the highly volatile fraction of any liquid still contained in the pulp. The fluffed up pulp then is sent to the conical accumulation reservoir 18 shown in Figure 7. In the upper part of this reservoir 18 there is an aperture through which steam is blown for the purpose of removing alcohol and other volatile species from the pulp. To prevent significant condensation of this steam, the reservoir 18 is maintained at a temperature of approximately 100°C.

Unlike the discharge tank shown in the unit in the 4th International Symposium of Scientists from Comecon Countries, Theses, Zinatne, Riga, 1982, this accumulation reservoir 18 has a 'live bottom' formed by four screws, as illustrated in the cross-section of Figure 8. Preferably the four screws have identical diameters and are divided into two sets 181, 182 each set rotating out of step with the other. The screws are driven by a motor such

that they rotate at a speed of between 15 and 30 rotations per minute. This serves to keep the pulp in constant motion.

The choice of identical screws is only one possibility. Conceivably, the diameter of each screw or set of two screws could be different, or each
5 screw could be attached to a different motor such that they rotate at different speeds if this improves the efficiency with which the steam blown into the apparatus removes alcohol or other remaining volatile liquids still remaining in the pulp after fluffing.

The cellulose pulp passes out of the accumulation reservoir on to a
10 screw conveyor 18a for packing. The screw acts upon the pulp to press out any further liquid (filtrate) from it; liquid collected in this way is gathered in the apparatus 6c, which also receives the condensate from the heat exchanger (condenser) 22. The apparatus 6c is maintained at the same pressure as the screw apparatus 15, c. 0.7MPa. From apparatus 6c the boiler solution is
15 recycled by pump 7j to the boiler 11 for use in irrigation of the raw material. The extra solution flows from the apparatus 6c to vaporising apparatus 20, where the pressure is lowered. When necessary the extra solution is sent by the pump 7k out of the system.

Used boiler solution is concentrated in a steamer apparatus 24
20 equipped with a flowing down pellicle consisting of a series of parallel tubes 25 as illustrated in Figure 2. This steamer apparatus 24 is made with a separate heating tank and a separator 26. The temperature within the tubes is

maintained about 15°C lower than the temperature in between the tubes. Preferably, the temperature in the tubes is set at 175±5°C whilst that in between the tubes is set at 190±5°C. In line with the main theme of the unit the pressure inside the steamer apparatus is also closely controlled. Preferably
5 the working pressure inside the tubes is set at 1.25±0.05MPa and that between the tubes is also set at 1.25±0.05MPa. For effective boiling down of the used boiler solution the steamer must have a large surface area; the working surface area of a typical steamer according to this invention is about 25m².

From the boiler the solution enters the separator 26 from where it is
10 pumped by pumps 7n and 7o (working and spare respectively) into the upper part of the steamer apparatus 24; the solution comes through a distribution device in the steamer apparatus 24 and flows down evenly on the inner surface of the tubes 25 in the form of a thin layer. Simultaneously the solution is being boiled down to the required concentration. The gases
15 released in the steamer pass into the heat exchanger 27 (condenser). The condensed boiler solution is collected is gathered in tank 6d and later sent by pump 7m to the boiler 11 for irrigation. The extra solution from the tank 6d flows into the vaporiser apparatus 20a - which is maintained at a lower pressure - and if necessary is pumped away to be used in preparation of the
20 boiler solution.

The concentrated boiler solution from the steamer apparatus is sent away to the vaporiser apparatus 20b, where it is further boiled down and collected in the an output tank.

The gases separated in the vaporiser 20b are sent through a first cyclone 31 to the 'casing-tube' heat exchanger 28. Secondary gases from the screw unloader 16, from the vaporisers 20 and 20a are also sent to this heat exchanger 28 through the second cyclone 32. The purpose of both cyclones 31, 32 is to catch fibres supported within the gases of the boiler solution. Both cyclones are held at a temperature of 100°C and work at atmospheric pressure. The first cyclone 31 has however a smaller working volume than the second cyclone 32 which directly relates to the relative volumes of gas circulated to each of them.

The condensed liquid is sent to the tank 2a and non-condensable gases go to scrubber 3 for the absorption and cleaning process. The pulp caught in the second cyclone 32-is periodically unloaded from it into a helper tank.

In the unit a means of emptying the contents of the boiler 11 in emergency is provided. There is an emergency tank 30, equipped with a stirrer and a net for removing drops of liquid. The lower part of the boiler 11 is connected through a blower tube 34 to the middle part of the emergency tank 30. When the pressure is lowered - the tank's working pressure is typically atmospheric pressure - secondary boiling gases form in the emergency tank 30, which pass through the second cyclone 32 into the condenser 28 and later

into the first scrubber 3. The incoming solution from the boiler has a temperature of approximately 170°C but this is lowered to 100°C within the tank 30. At this point it is needed to maximise the usage of cooling water for the condenser 28 and the irrigation liquid C1. The emergency tank 30 is
5 unloaded periodically into the movable helper bunker 35.

Compared to the prior art unit of Krotov the unit of the embodiment of the present invention comprises two more vaporisers throughout (described as flashers in the prior art document). The function of each vaporiser apparatus is to lower the pressure and temperature of the boiler solution passing through
10 it. The three vaporisers are of identical volume and all work at atmospheric pressure. Their increased number and their respective positions within the unit serve to improve the temperature efficiency of the apparatus. This contributes to an improvement in the preparation of the pulping liquor from recovered chemicals in this embodiment compared to the prior art unit.

15 Before a planned stop of the unit, the boiler solution must be taken away from the boiler. For this purpose, pump H7 directs the boiler solution into a diversionary path not encountering the heat exchanger T.

A number of the apparatus components are of standard construction within the field of pulping. The standard equipment include the mixing
20 devices 2, 2a which are fixed with turbine mixers, the tanks (6 to 6e) and all pumps. With respect to the standard pumps used, these have a maximum working pressure flow of 16 kg/cm². The automation scheme of the unit

provides for blocking of the pumps when the pressure inside exceeds this value.

The basic construction material for the unit is steel and more particularly most component apparatus are constructed from carbon steel.

5 However, it is possible that the unit could be constructed from other materials with similar mechanical and chemical properties as steel, for example the resistance to the pH conditions within the boiler. The carbon steel may also be treated to enhance its resistance to corrosion or subjecting it to other preservation processes.

10 The unit of the embodiment does contain more component parts than the aforementioned prior art pulper. The importance of the increased number of vaporisers has already been discussed. Despite this increase the unit can be constructed in compact form such that it requires little more floor space than the known unit. The embodiment can be constructed as a highly-profitable
15 low-capacity plant which even offers scope for the development of mobile units that can be used in the growing regions for the raw materials. The integration of the individual parts and assembly units of the invention is indicated by its high level of unification. The invention has a typical coefficient of unification of 52%.

20 The unit, although particularly suitable for ground hemp stocks, is not restricted to this type of raw material. Other bast-fibred plants such as flax or kenaf are obvious alternatives. These would require a different composition of

pulping liquor i.e. a different relative proportion of components and also a different cooking and treatment time. The throughput of material through the unit can readily be varied to allow for this.

Example:

5 The following example illustrates the typical construction and operation details for a unit according to this invention. The unit described hereafter may be used for the production of cellulose at a rate of no more than 300 kg/hr. The conditions listed are the optimum for this total productivity limit.

Table 1

Component	Productivity/ kg/hr	Working Pressure / atm	Maximum Working Temperature/C	Working Volume / cubic metres	Working surface area / square metres	Frequency of screw / shaft / stirrer rotation if relevant / rot / min
Boiler 11	250	1.3	170	14.7		32 (shaft)
Input bunker 8	3.7 - 10.0			1.8		15 - 31
Dividing bunker 14	5.8	0.7	170	6.2		18
Spiral feeder 9	2.9 - 12.8		100			1000
Spiral conveyor 10	1000	1.3	170			1500
Spiral conveyor 12	1000	1.3	170			1500
Rotor feeder 13	2.89 - 5.8	0.7 - 1.3	170	0.00754		16 - 32
Screw apparatus 14	1000	0.7	150			100 - 180
Accumulation reservoir 18	1.5 - 4.5		100			15 - 30
Screw conveyor 18a	4.5				45	4.5
Emergency reservoir 30		1	100	13	45	45 (stirrer)
Steamer apparatus 24		1.25	175 (in tubes) 190 (bet. tubes)		25	
Vaporisers 20, 20a, 20b		1	150			
First cyclone 31		1	100	0.11		
Second cyclone 32		1	100	0.85		
Scrubbers 3,4	40 (gas) 154 (liquid)	1	25 - 65	0.25		
Output tank 6, 6b, 6e		1	20	2.65		
Output tank 6a, 6c, 6d		1	170	1		
Screw unloader 16	600	1	110		0.710	19 - 32 (screw)
'Tube in tube' heat exchangers 5, 5a		2 (in tubes) 0.15 (bet. wecn)	25 (in tubes) 110 (between)			
Fluffer 17	600	0.1 - 0.2	100			

Other technical characteristics are:

Maximum working pressure of the steam supplied for heating, Mpa;

	- to the boiler (11)	1.6
	- to the steamer (24) and the heat exchanger (19)	1.3
5	- to the screw unloading device (12)	0.05
	- to the second 'tube in tube' heat exchanger (5a)	0.05

Working temperature

	- of the cooling water	25°C
	- of the cooled water	7 - 18°C
10	Time pulp spends in the boiler	1 - 4 hrs
	pH of the environment	4.5 to 13
	Density of raw material in the input bunker	80 - 125 kg/m ³
	Specific energy consumption, kWt/ton, kg/hr, not more than	676
15	Maximum steam usage, kg/hr	
	- with pressure of 1.6 MPa	40
	- with pressure of 1.3 MPa	481
	- with pressure of 0.05 MPa	84

20 The volumes and operating temperatures and pressures represent the preferred values but are not limiting. The size of each component of the unit can be varied according to its location. For example, if a mobile unit is required, the dimensions of each piece of apparatus comprising the unit will

be reduced correspondingly in scale. The unit is of direct importance to countries where wood supplies are limited and the unit must be sized according to the regional growth of bast-fibred plants and the associated demand of paper.

5 The amount of ethanol used is not given. This raw material is only supplied for the start-up of the unit since during pulping methanol, ethanol and acetone as formed from the components of the fibrous raw material, this being a well-known effect of the AAS delignification method. Subsequently, as organic components are accumulated in the pulping liquor, ethanol can be
10 recycled. Excess organic solvent can be drawn and processed as a market chemical. Hence in a continuously operating unit there is no need to supply ethanol.

15

CLAIMS

1. An apparatus for the production of pulp from raw plant material comprising in sequence;
- 5 a first feeder for regulating the input of raw material into a boiler, containing a screw having a prolonged stem which extends beyond the screw thread, the stem having a passage through which boiler solution is injected into the first feeder;
- said boiler for cooking the raw material to generate pulp;
- 10 a second feeder which receives cooked material from the boiler and which is maintained at a lower pressure than the boiler;
- a liquid extraction apparatus for extracting liquid from the cooked material passed into it;
- an unloader which is maintained at a lower pressure than the liquid
- 15 extraction apparatus, in which material received from the liquid extraction apparatus is treated with steam;
- an accumulation reservoir for receiving pulp from the unloader; and
- means for removing pulp from the accumulation reservoir.
- 20 2. An apparatus according to claim 1 whereby the first feeder consists of both cylindrical and conical parts, the prolonged stem of the screw extending beyond the conical part of the screw thread.
3. An apparatus according to claim 1 or claim 2 wherein the prolonged stem
- 25 is of variable length and diameter.
4. An apparatus according to claim 1 wherein the boiler for cooking the raw material to generate pulp contains a substantially vertical screw having a rotatable, perforated shaft.

5. An apparatus according to claim 4 wherein the boiler further comprises a reverse screw of opposite sense to the substantially vertical screw.
- 5 6. An apparatus according to claim 5 wherein the reverse screw has at least one spirally extending rib.
7. An apparatus according to any of claims 4 to 6 wherein the boiler further comprises paddles for removing cooked material from the boiler, said paddles
10 being mounted on the shaft of the substantially vertical screw.
8. An apparatus according to claims 1 to 7 wherein the liquid extraction apparatus for extracting liquid from the cooked material comprises a screw apparatus containing at least two different rotatable cams.
15
9. An apparatus according to claim 8 whereby each cam within the screw apparatus is arranged to be rotated at a different frequency.
10. An apparatus according to any of claims 1 to 9 wherein the accumulation
20 reservoir has a bottom which comprises means for keeping the pulp in constant motion.
11. An apparatus according to claim 10 wherein the bottom of the accumulation reservoir is formed by rotatable screws.
25
12. An apparatus according to claim 11 wherein at least one of said screws in the accumulation reservoir rotates out of step with the other screws.

13. An apparatus according to claim 12 wherein two of said screws in the accumulation reservoir rotate at the same frequency.

5 14. An apparatus according to any of claims 11 to 13 wherein each of said screws in the accumulation reservoir may be of different diameter.

10 15. A apparatus according to any of claims 1 to 14 further comprising a first bunker, positioned on top of the first feeder and which supplies raw material into the first feeder, said first bunker including a stirring device and rotatable screw.

15 16. An apparatus according to any of claims 1 to 15 further comprising a conveyor, positioned between the boiler and the second feeder, which receives cooked material removed from the boiler.

20 17. An apparatus according to any of claims 1 to 16 further comprising a second bunker for compression of the cooked material, positioned between the second feeder and the liquid extraction apparatus, said second bunker comprising a stirrer and a pressing screw.

25 18. An apparatus according to any of claims 1 to 17 further comprising a fluffer, positioned between the unloader and the accumulation reservoir, which divides the cooked material into separate packs of fibre to facilitate liquid removal from the material.

19. An apparatus according to any of claims 1 to 18 wherein the means by which pulp is removed from the accumulation reservoir comprises a screw conveyor.

20. An apparatus according to any of claims 1 to 19 further including means for producing boiler solution and supplying this boiler solution to the boiler and / or first feeder, said means comprising;

a mixing device into which water is supplied;

5 a first scrubber which receives water from the mixing device and into which sulphur gas is supplied to generate a weak solution;

a heat - exchanger through which the weak solution from the first scrubber passes;

10 a second scrubber which receives the weak solution from the heat exchanger and which is supplied with ammonia water and sulphur dioxide gas;

an output tank into which the solution from the second scrubber is passed and in which the boiler solution is generated;

15 means for transferring the boiler solution from the output tank to the boiler; and

one or more pumps for regulating gas and / or liquid flow.

21. An apparatus according to claim 20 wherein the heat - exchanger comprises a 'tube-in-tube' heat-exchanger.

20

22. An apparatus according to any of claims 1 to 21 further comprising a means for regenerating boiler solution from the used solution formed within the boiler, said means comprising in sequence;

a separator which receives used solution from the boiler;

25 a steamer apparatus for boiling down used solution to a required concentration, said steamer apparatus being adapted to receive steam and including a heater and means for removing gases released from the boiling down of the used solution; and

means for returning the regenerated solution from the steamer apparatus to the boiler.

5 23. An apparatus according to claim 22 wherein the steamer apparatus further includes a distribution device for distributing used solution received from the separator, and a series of parallel tubes.

10 24. An apparatus according to claim 23 in which the temperature inside the parallel tubes is different to that outside the parallel tubes.

25. An apparatus according to claims 22 to 24 wherein said means for returning the regenerated boiler solution to the boiler includes a tank for temporary storage of the solution.

15 26. An apparatus according to any of claims 22 to 25 wherein said means for returning the regenerated boiler solution to the boiler includes a vaporiser apparatus in which the used solution is further boiled down.

20 27. An apparatus according to claim 26 further comprising a cyclone which receives gases generated in the vaporiser and removes fibres of material supported within the gases.

25 28. An apparatus according to any of claims 1 to 27 further including means for treating fluids generated in the boiler, said means comprising two vaporisers, a cyclone for removing fibres supported in the gases entering the cyclone from the vaporisers, and a heat exchanger to condense the gases received from the cyclone.

29. An apparatus according to claim 28 whereby said means for treating fluids also receives gases generated in the unloader.
- 5 30. An apparatus according to claim 28 or 29 whereby said means for treating gases also receives gases generated in the fluffer.
31. An apparatus according to any of claims 28 to 30 whereby said means for treating gases also receives gases generated in the accumulation reservoir.
- 10 32. An apparatus according to any of claims 28 to 31 further including a tank which receives condensed liquid from the heat exchanger.
- 15 33. An apparatus according to any of claims 28 to 32 further comprising means for supplying gases not condensed in the heat exchanger to the first scrubber for use in the preparation of the boiler solution.
34. An apparatus according to any of claims 1 to 33 further including an emergency tank connected to the boiler through a blower tube.
- 20 35. An apparatus according to any of claims 1 to 34 further including a helper bunker into which pulp caught in the emergency tank or cyclones is unloaded.
- 25 36. An apparatus for the production of pulp from raw plant material as substantially described herein with reference to the accompanying drawings.

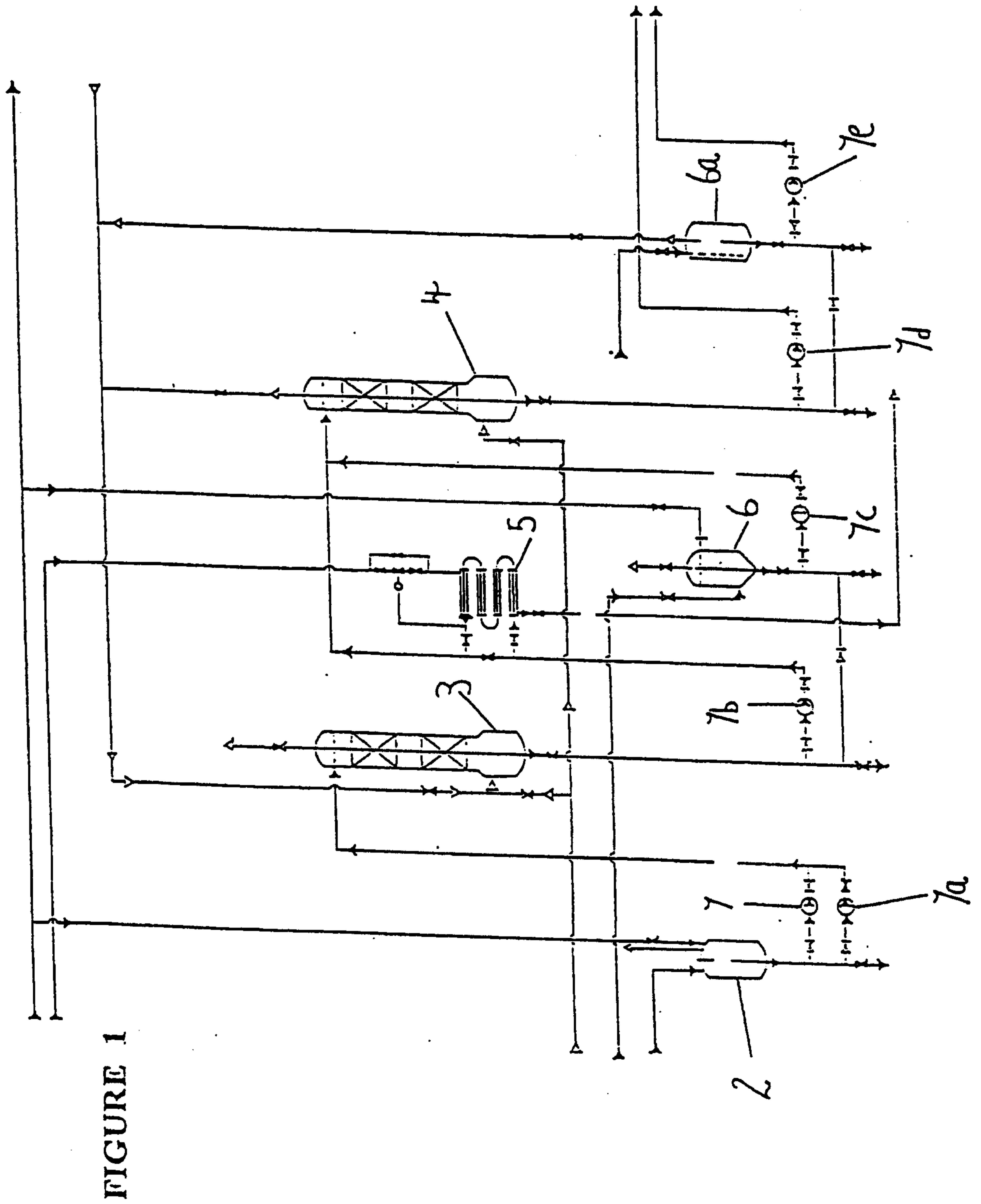
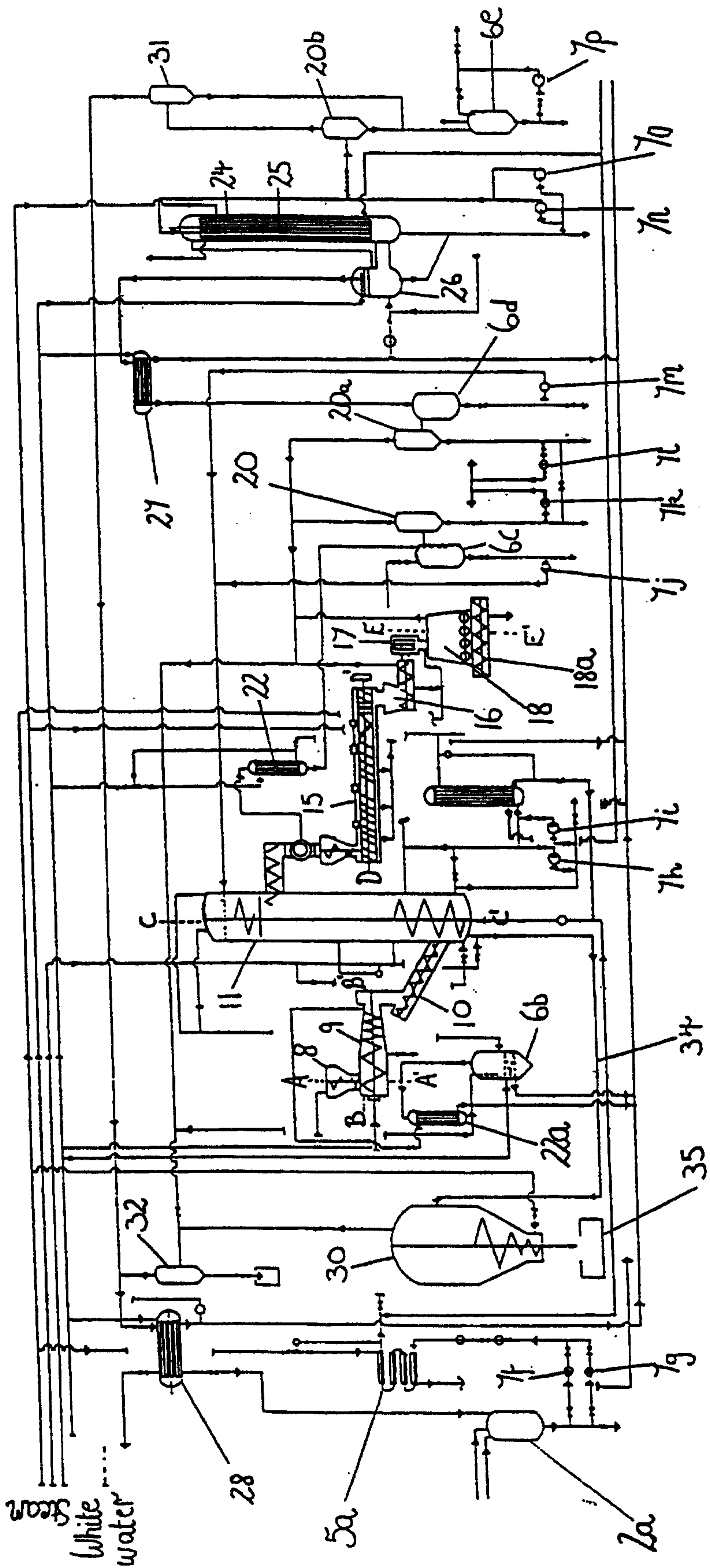


FIGURE 1

FIGURE 2



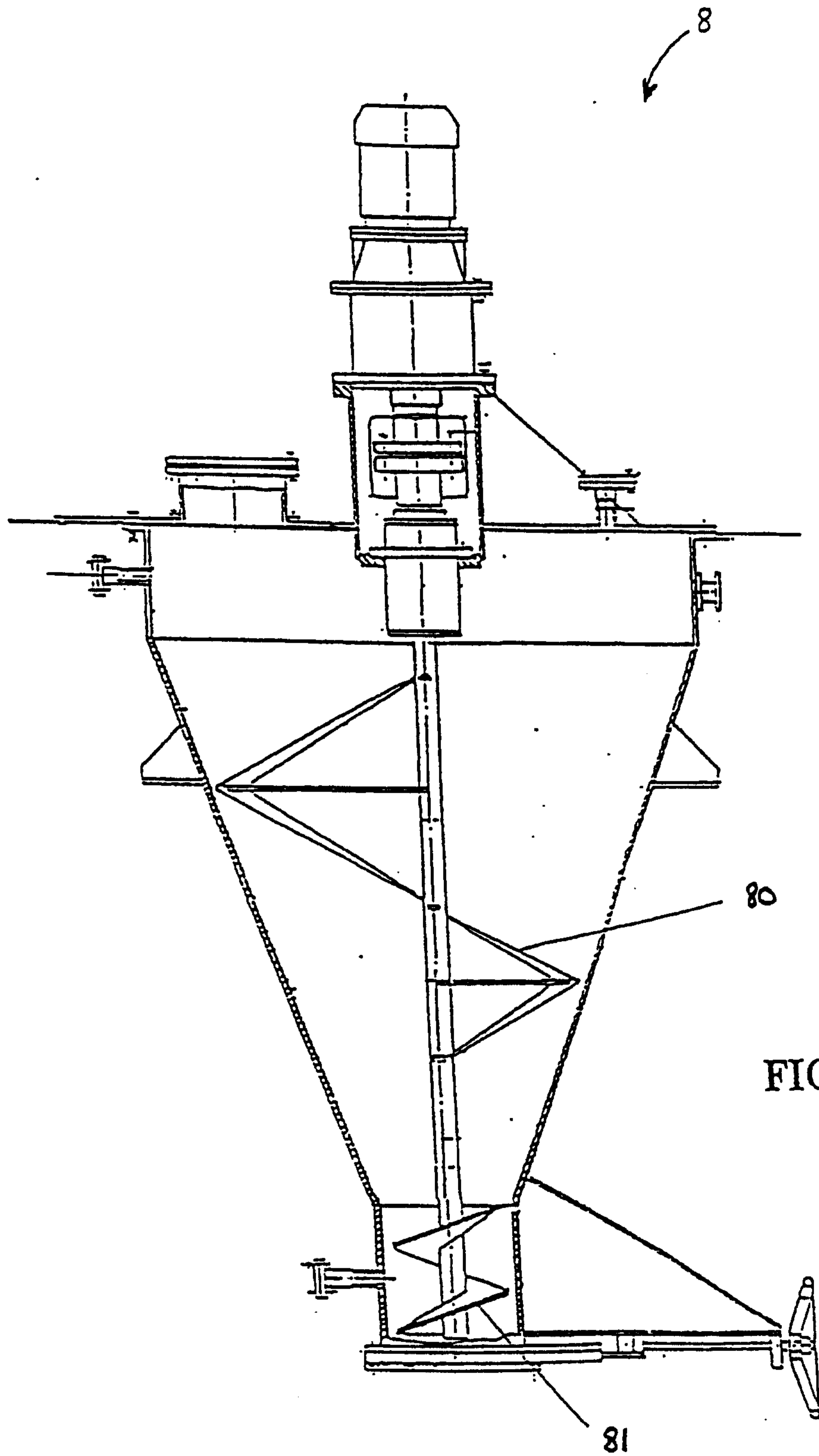


FIGURE 3

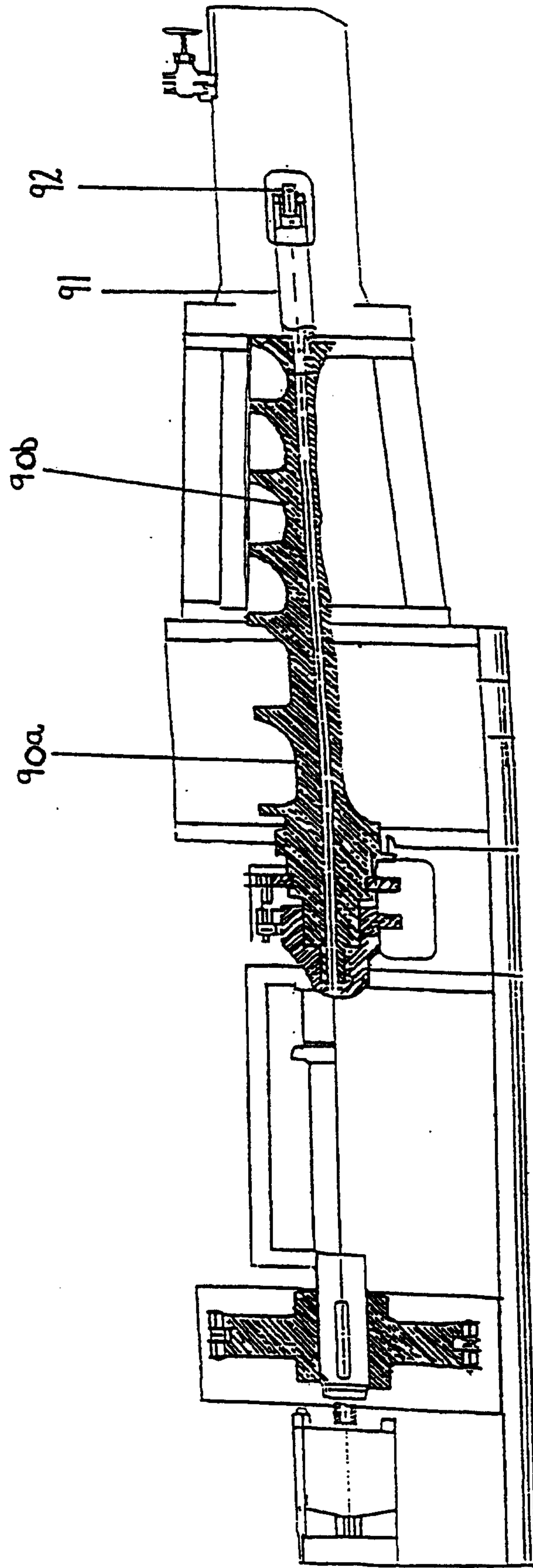


FIGURE 4

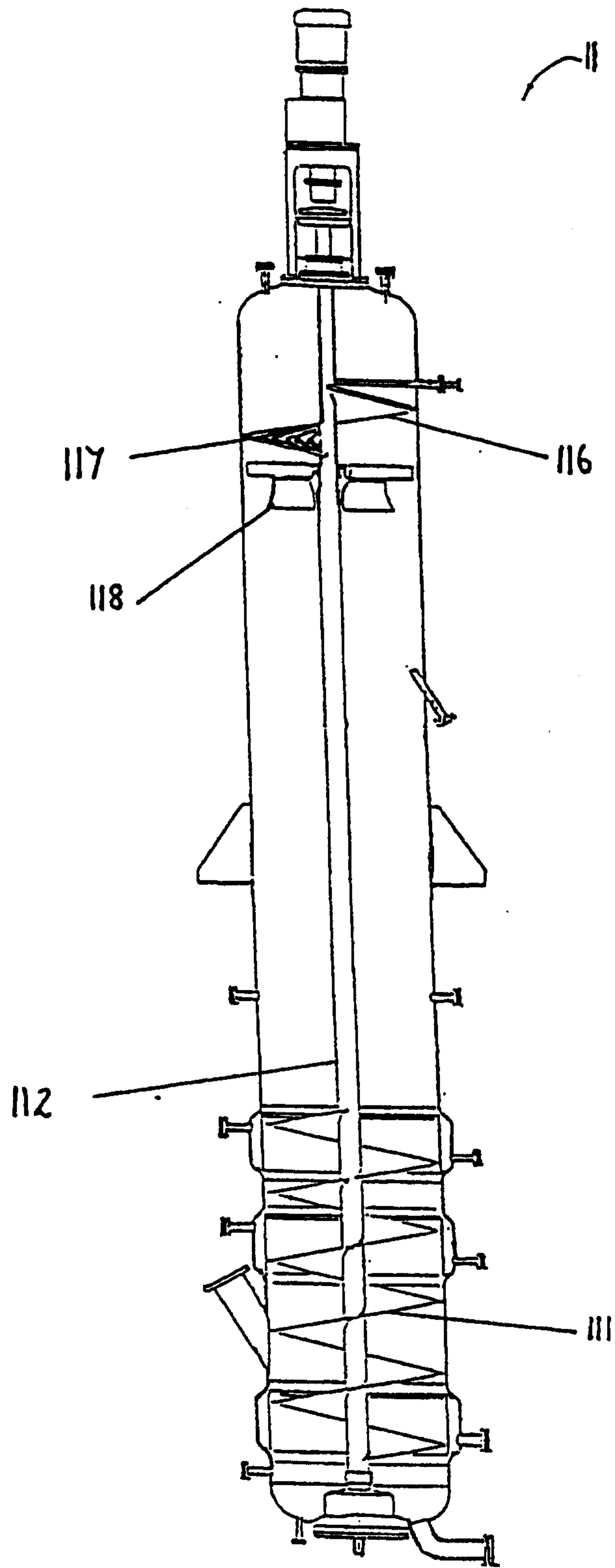


FIGURE 5

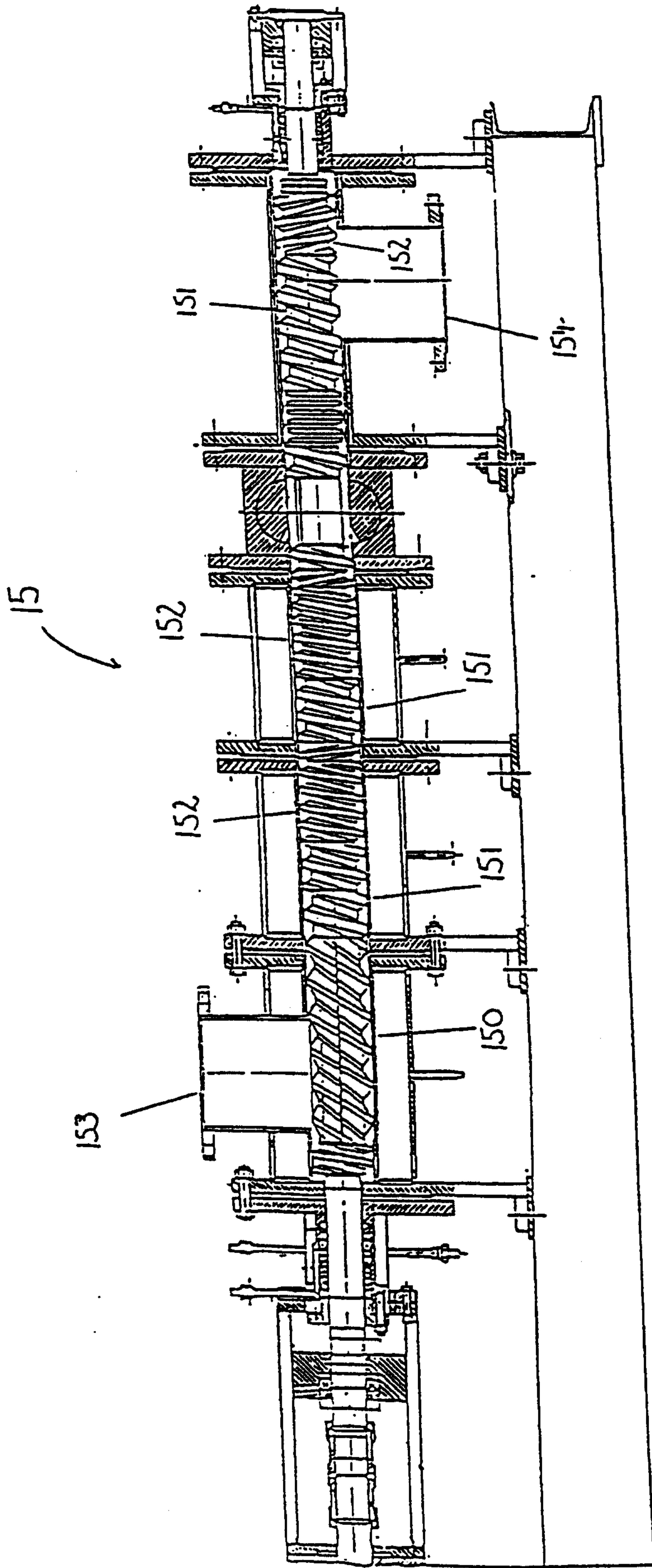


FIGURE 6

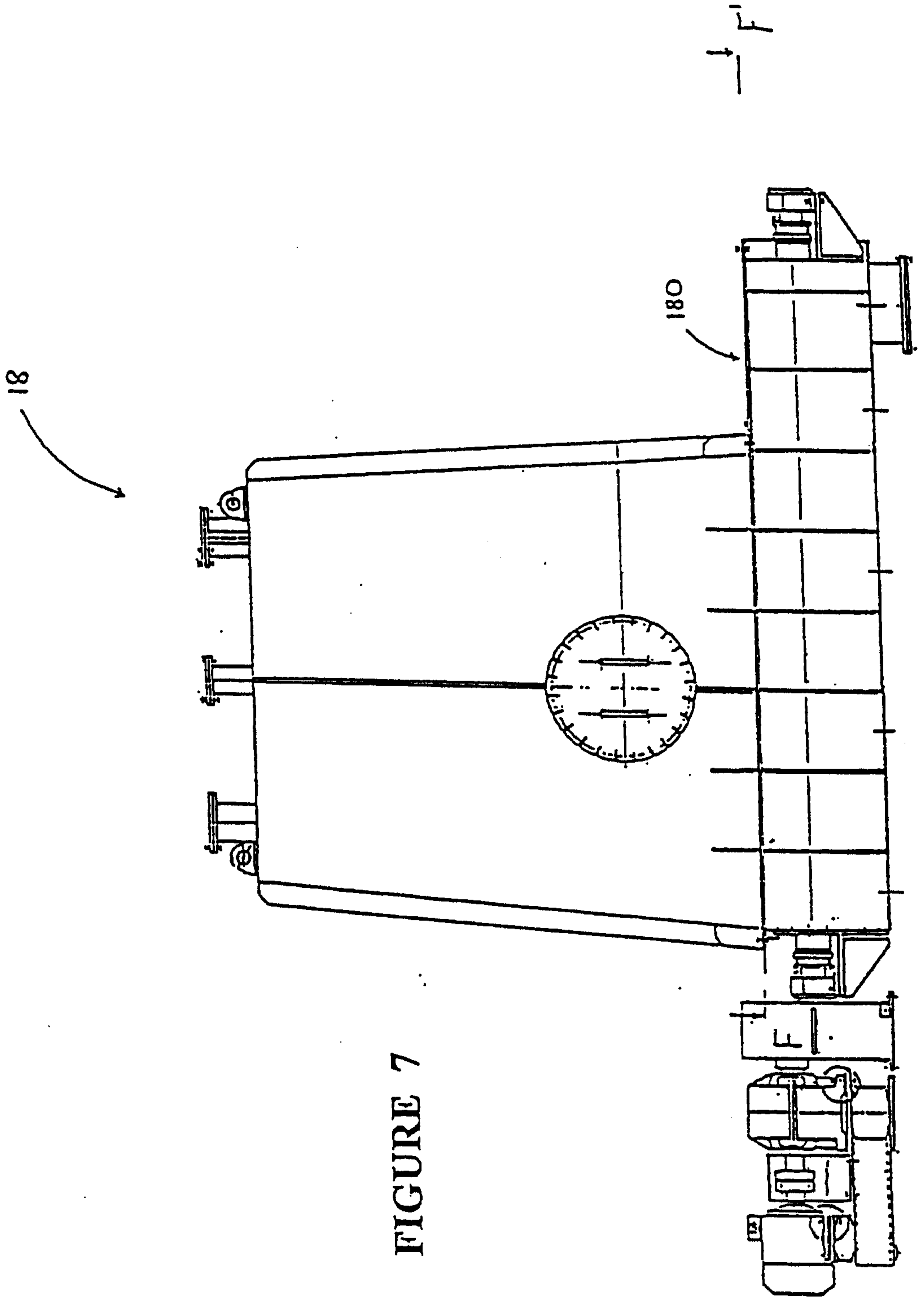


FIGURE 7

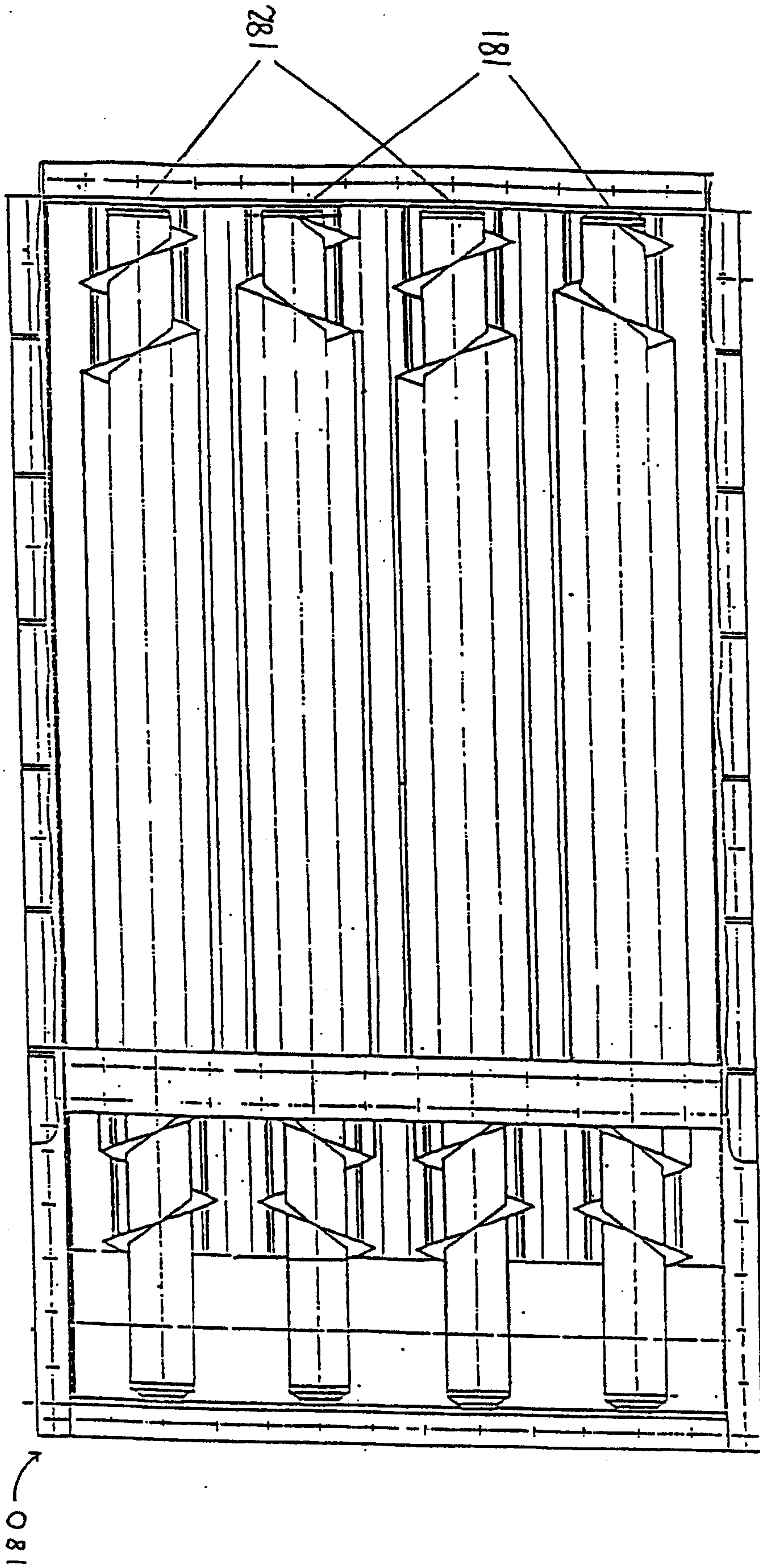


FIGURE 8