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(54) **Title:** PLUG SCREW FEEDER FOR FEEDING CELLULOSE PULP/CHIPS

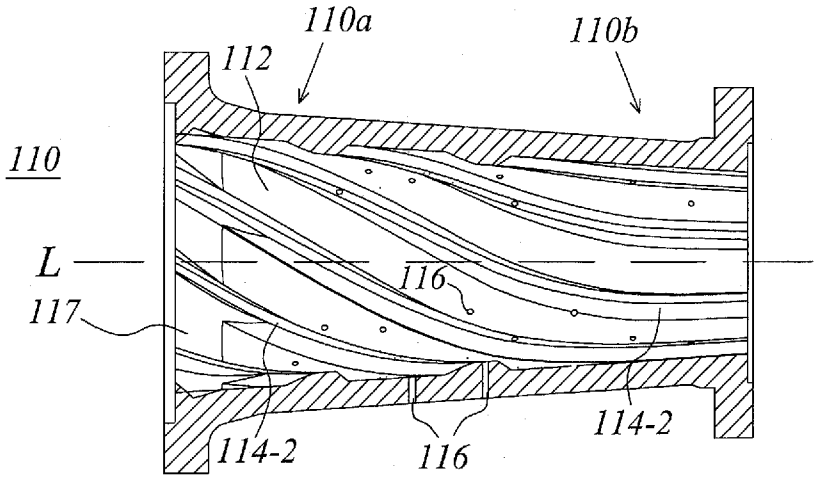

FIG.4

(57) **Abstract:** A screw pipe unit (110) intended to cooperate with and at least partly enclose a screw (120) in a plug screw feeder (100) for cellulose chips/pulp is provided. The screw pipe unit comprises a plurality of openings (116) for filtrate dewatered from chips/pulp in the screw pipe unit when the plug screw feeder is in operation. The screw pipe unit is, on at least a portion of its inner surface (112), provided with bars (114-2) inclined with respect to the longitudinal axis (L) of the screw pipe unit. The inclination of the bars decreases in the longitudinal direction, from a first portion (110a) of the screw pipe unit with maximum inclination to a second portion (110b) of the screw pipe unit with bars substantially parallel to said axis, the second portion being further away from the inlet end of the screw pipe unit than the first portion.

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Plug screw feeder for feeding cellulose pulp/chips

TECHNICAL FIELD

The present invention relates to a plug screw feeder for feeding cellulose pulp/chips.

BACKGROUND

In the pulp and paper industry, plug screw feeders are well known devices used in different applications for transporting cellulose pulp/chips in such way that a plug is formed, sealing against a higher (or lower) pressure at the output end of the feeder. The plug transport is achieved by a screw interacting with some kind of pipe member, often referred to as screw pipe. The screw pipe may, for example, present a tapering shape.

It is often desirable to dewater the material transported in the plug screw feeder, and openings may be provided in the screw pipe for the dewatered liquid. There can also be another pipe unit, such as a slotted plug pipe, arranged after the screw pipe ("after" referring to the feed direction), to prolong the dewatering zone.

In a number of known plug screw devices, straight bars are provided at the inside surface of the plug screw feeder. Similarly, straight bars may be provided at the subsequent pipe unit (e.g. the slotted plug pipe).

It has been proposed to make the bars of the screw pipe spiral-shaped, such as in the SpiralThroat^{TM} product by Metso Paper. The bars are then inclined with respect to the longitudinal axis of the screw pipe and the degree of inclination is typically the same throughout the screw pipe or slightly increasing towards the end. By means of screw pipes with spiral bars, an improved feeding effect is achieved. However, such spiral screw pipes result in a less efficient dewatering. Furthermore, spiral screw pipes could be inappropriate for use together with known types of slotted plug pipes with straight bars.

Accordingly, there is a need for an improved plug screw feeder providing efficient feeding and dewatering of the transported pulp/chips.

SUMMARY

A general object of the invention is to provide an improved arrangement for feeding cellulose pulp/chips. A specific object is to provide a screw pipe for a plug screw feeder by means of which efficient feeding and efficient dewatering can be achieved. Another object is to provide a screw pipe suitable for use together with slotted plug pipes with straight bars.

These objects are achieved in accordance with the attached claims.

Briefly, in accordance with the present invention a screw pipe unit is proposed which has bars inclined or spiral shaped at the beginning and then the inclination decreases in the feed direction such that the bars are substantially straight and parallel to the longitudinal axis at a portion of the screw pipe closer to the end of the screw pipe. The pulp/chip flow is efficiently fed through the improved feeding effect of the inclined bars at a first portion of the screw pipe and at a later stage in the screw pipe the dewatering properties increase. Thus, the pulp/chips can be efficiently fed and dewatered by means of one and the same plug screw feeder.

Preferred embodiments relate to a screw pipe unit with a gradual decrease in the bar inclination (stepwise or continuous), avoiding risking that comparatively abrupt change(s) in degree of inclination affect the shape and other properties of the plug in a negative manner.

A screw pipe in accordance with the present invention with straight or almost straight bars near the pipe output end is suitable for being connected e.g. to a slotted plug pipe with straight bars, whereby the plug formation and dewatering is further improved.

According to one embodiment of the present invention, bars of a screw pipe unit are substantially helical in a first portion of the screw pipe unit.

According to other aspects of the invention are provided a plug screw feeder comprising a screw pipe unit, a system for treatment of cellulose chips/pulp comprising a screw pipe unit, and a use of a screw pipe unit.

According to one embodiment, a plug screw feeder of the invention comprises a screw pipe unit connected to a plug pipe unit with substantially straight bars, the screw pipe unit and the plug pipe unit being arranged with substantially non-interrupted straight bars in the area where the screw pipe unit is connected to the plug pipe unit.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects and advantages thereof, may best be understood by reference to the following description and appended drawings, in which:

Fig. 1 is a schematic and partially exploded perspective view illustrating components of a plug screw feeder in which the present invention may be used;

Fig. 2 is a schematic perspective view of a screw pipe unit in accordance with the prior art;

Fig. 3A is a schematic axial cross-section and Fig. 3B and 3C perspective views (pipe wall being partly removed in Fig. 3C) of a screw pipe unit in accordance with an exemp lifying embodiment of the present invention;

Fig. 4-7 are schematic axial cross sections of screw pipe units in accordance with exemplify ing embodiments of the present invention; and

Fig. 8 is a schematic block diagram of a system for treatment of cellulose chips/pulp according to an exemplifying embodiment of the present invention.

DETAILED DESCRIPTION

In the drawings, similar or corresponding elements will be denoted by the same reference numbers.

Fig. 1 shows key components of a plug screw feeder in which the present invention can be used. The plug screw feeder 100 (sometimes also referred to as screw conveyor, transport screw etc.) comprises a screw pipe 110, a screw 120 (also referred to e.g. as feed screw or

plug screw), and a plug pipe 130. Cellulose pulp or chips, depending on the application in which the plug screw feeder 100 is used, is in the illustrated example input to the horizontal plug screw feeder from above to reach an input end of the screw pipe. This is schematically indicated by the block arrow IN. The screw 120 is rotated about shaft 124 arranged along the longitudinal axis of the plug screw feeder 100, whereby the cooperation between the screw 120 and enclosing screw pipe 110 causes a feeding effect and generally also creates a plug flow. To facilitate the creation of a plug flow, the screw pipe 110 of the illustrated embodiment has an inner diameter that decreases in the feed direction F while the screw 120 has a substantially constant core diameter. By the term core diameter is meant the diameter of the screw if the threads were removed, i.e. the diameter in the parts between threads. The outer diameter of the screw 120 decreases in the feed direction, in order to fit within the inner diameter of the screw pipe 110. The same effect may alternatively be achieved by a screw pipe with constant inner diameter enclosing a screw that has a core diameter that increases in the feed direction. In that case, the outer diameter of the screw is constant. Combinations of these variants are also possible.

The plug pipe 130 is in the illustrated embodiment connected to the screw pipe 110 at the output end thereof, so as to prolong the area of plug flow. Normally, the screw pipe 110 encloses a threaded portion of the screw 120, while there are no screw threads 122 on the part of the screw 120 enclosed by the plug pipe 130. The screw pipe 110 is provided with openings (holes, slots, or the like) 116 for liquid dewatered from the pulp/chips in the plug screw feeder 100. To prolong the dewatering zone, the plug pipe 130 may also be provided with openings. In the example of Fig. 1, the plug pipe 130 has slots 136 in a first portion thereof as seen the in feed direction F. The plug screw feeder comprises means for collecting the liquid that passes through the openings, for example formed together with an outer casing (not shown) that encloses the screw pipe 110 and the plug pipe 130.

The plug obtained by the plug screw feeder serves as a sealing element between areas of different pressure. In general, the plug seals against an overpressure, for example in embodiments where the plug of pulp/chips output from the plug screw feeder (block arrow "OUT") is fed to a refiner. However, there are also applications where the pressure is higher at the input side of the plug screw feeder.

The inner surface 112 of the screw pipe 110, and possible also the plug pipe 130, is provided with elongated protrusions (hereafter referred to as "bars") 114 to achieve efficient plug screw feeding. Such bars generally serve to facilitate forward motion of the flow of chips/pulp in feed direction F and prevent rotation of the flow.

A screw pipe of the prior art intended to cooperate with and at least partly enclose a screw in a plug screw feeder is shown in **Fig. 2**. This prior art screw pipe 110 has spiral-shaped bars 114-1 at the inner surface 112, which is beneficial for the feeding of chips/pulp in the plug screw feeder. As compared to other known screw pipes, with straight bars parallel to the longitudinal axis of the screw pipe and plug screw feeder, a larger force component acting on the pulp/chips in the feeding direction F can be achieved by the inclination of the bars 114-1. The inclination of the bars 114-1 means that friction has less impact on the chips/pulp, resulting in an improved feeding whereby energy consumption, for example, can be reduced. However, as mentioned in the background section, a drawback of such so-called "spiral screw pipes" is that the dewatering function becomes less efficient.

Moreover, if a conventional straight bar plug pipe is arranged in connection with the screw pipe, the transition between screw and plug pipe will comprise an abrupt change from inclined to straight bars, which could cause problems. Removing the bars of the plug pipe would be one way of handling this but then the shape of the plug deteriorates and the compression of the plug/chips decreases. Another potential solution would be to make also the bars of the plug pipe spiral-shaped. However, this further reduces the dewatering of the plug screw feeder and it would also require a much more complicated and difficult manufacturing process if the plug pipe is to comprise slots or the like, which are typically cut, milled or spark-machined.

In accordance with the present invention a screw pipe unit is instead proposed which has bars inclined or spiral shaped at the beginning (referring to the feed direction F) and then the inclination decreases in the feed direction such that the bars are substantially straight and parallel to the longitudinal axis at a portion of the screw pipe closer to the end of the screw pipe. Such a screw pipe unit is for example shown in **Fig. 3**. The bars are inclined at a first portion 110a of the screw pipe unit and straight at a second portion 110b of the screw pipe unit, the second portion 110b being further away from an inlet end of the screw pipe unit than the first portion 110a. In this way, the pulp/chip flow is efficiently fed through the improved

feeding effect of the inclined bars 114-2 at the first portion 110a of the screw pipe 110 and at a later stage in the screw pipe 110 the dewatering properties increase. Thus, the pulp/chips can be efficiently fed and dewatered by means of one and the same plug screw feeder. A further advantage is that a screw pipe 110 in accordance with the present invention with straight or almost straight bars near the pipe output end is suitable for being connected e.g. to a slotted plug pipe (130 in Fig. 1) with straight bars, whereby the plug formation and dewatering is further improved.

A screw pipe unit in accordance with the present invention is adapted to, when arranged in a plug screw feeder, at least partly enclose a threaded part of the screw. Typically, a substantial part of the screw portion enclosed by the screw pipe unit is threaded, and preferably practically the entire screw portion enclosed by the screw pipe unit is threaded. The screw pipe unit could, as illustrated in the drawings, be formed of one pipe element seen in the longitudinal direction or, alternatively comprise two or more separate pipe elements (not shown) coupled together in series. Such a screw pipe unit can for example be connected to a plug pipe, which encloses an at least partly non-threaded part of the screw/axis. It is evident to the skilled person that several variants are possible, including those where the screw pipe unit comprises a screw pipe (or part of a screw pipe) formed together with the plug pipe.

In the circumferential direction, the screw pipe unit is preferably formed as two separate parts (see Fig. 1, 3B, 3C). When interconnected by appropriate fastening means, such as screw bolts (at 118), the parts form one substantially cylindrical screw pipe unit, which may be divided to facilitate installation and service. The cylindrical unit is typically tapered in the feed direction. Such a divisible screw pipe unit may with advantage comprise two identical cylinder halves, but other arrangements for dividing the screw pipe unit such that it can be mounted/dismounted by lifting one or more separate parts are possible, e.g. employing more than two separate parts in the circumferential direction and/or parts "cutting" the cylinder differently. Embodiments where the screw pipe unit is formed as a whole cylindrical (possibly tapering) element also lie within the scope of the invention.

The bars 114-2 are provided on the screw pipe 110 using any suitable manufacturing method. Such a method can for example include welding the bars onto the inner surface 112 of the

screw pipe (or screw pipe portion) or casting the bars integral with the screw pipe (or screw pipe portion).

The screw pipe unit according to the present invention has at least one and preferably a plurality of openings in the pipe wall so as to allow liquid dewatered from the chips/pulp to exit through the screw pipe wall. The opening(s) in the screw pipe wall was, for clarity, left out in Fig. 3A-C, but **Fig. 4** shows a view corresponding to Fig. 3A with openings included. The illustrated openings 116 comprise holes extending through the pipe wall. The skilled person understands that the number, shape and arrangement of the openings may vary within the scope of the invention. There could, for example, be slots in the screw pipe instead of or in addition to the holes.

Fig. 4 also illustrates a feature, which may optionally be included in a screw pipe unit of the present invention. At an input section 117, the screw pipe 110 widens, e.g. by adapted bars 114-2, to enlarge the space enclosed by the inner surface 112 of the screw pipe in the area around the inlet end. Such an enlarged space around the inlet end facilitates the feeding of media (cellulose pulp/chips) into the screw pipe 110, which leads to an enhanced capacity.

In **Fig. 5**, another exemplifying embodiment of the invention is shown, illustrating the fact that the angle of inclination of the bars with respect to the longitudinal axis L of the screw pipe can vary. The bars 114-3 according to this embodiment has a smaller angle of inclination at the first portion 110a of the screw pipe 110 as compared to the previously described embodiments.

The first portion of the screw pipe typically has bars with an angle of inclination with respect to the longitudinal axis in the interval of 10-60°. Specific embodiments have an angle of inclination with respect to the longitudinal axis of in the interval of 15-35° at the beginning of the screw pipe. In order to obtain an inclination that will have an effect on the feeding, an angle of over 10° should be used. However, if the angle is too large, the bars might impede the feeding. The angle of inclination should therefore preferably not exceed 60°.

For an optimal performance of the plug screw feeder, it is preferred that the inclination of the bars decreases in a substantially continuous manner, as illustrated in Fig. 3-5. In other words, if there are interruptions in the continuous decrease from a position with maximum inclination

to a position with practically straight bars, such interruptions (i.e. portions where the inclination is constant or even increases) relate to portion(s) of the screw pipe of a limited extension in the longitudinal direction.

Nevertheless, embodiments where the gradual decrease of the bar inclination instead is in the form of a stepwise decrease are also possible. This is illustrated in **Fig. 6**. The inclination of the respective bars 114-4 decreases in a plurality of steps (at least three but preferably more than three steps). Also in this case, there could be portion(s) where the inclination increases, as long as the overall impression of the bar pattern is that of a less and less angled spiral in the relevant pipe section.

Combinations of Fig. 3-5 and Fig. 6 i.e. screw pipes with zones of continuous and stepwise inclination decrease, respectively, are possible.

A gradual (or smooth) decrease in the bar inclination, such as in the embodiments of Fig. 3-6, results in a screw pipe unit without any abrupt changes in the degree of inclination. The plug can be formed, transported and dewatered in the screw pipe in a smooth manner without disturbances caused by abrupt bar pattern changes. In particular, such a screw pipe unit can be used together with a conventional straight bar plug pipe in a plug screw feeder with most efficient feeding and dewatering and no abrupt bar transitions at all, neither in screw pipe unit nor in the connection between screw pipe unit and plug pipe unit.

Fig. 7 illustrates another embodiment, where the bars 114-5 goes directly from maximum inclination (first portion 110a of screw pipe 110) to being substantially straight (second portion 110b) in one step. Like the previously described embodiments, such a variant may also provide for efficient feeding at the beginning and improved dewatering at a later section of the plug screw feeder. However, the embodiment of Fig. 7 could affect the shape and other properties of the plug in a negative manner due to the comparatively abrupt change in degree of inclination. Therefore, a screw pipe unit with a gradual decrease in the bar inclination (stepwise or continuous) would normally be preferred, in order to obtain as efficient plug feeding as possible.

The actual length of the areas with inclined and straight bars, respectively, as well as the length of the preferred area of gradual decrease of the inclination should be selected to suit the application. Generally, there will be a tradeoff between efficient feeding (large angle of inclination and/or large area with inclined bars) and efficient dewatering (large area with small/no inclination).

Fig. 8 is a schematic block diagram of a system 1000 for treatment of cellulose chips/pulp according to an exemplifying embodiment of the present invention. In this example, the plug screw feeder 100 is arranged to provide a plug flow of chips to be input to a refiner 400. A flow of chips are input to the plug screw feeder 100, which in accordance with the previous description comprises a screw pipe 110, a screw 120, and an optional plug pipe 130 (preferably but not necessarily slotted). A drive means 200 for the plug screw feeder 100 rotates the screw 120 about a shaft. As indicated by a dashed line, the plug formed by the plug screw feeder 100 divides the processing system into a first area of pressure P1 and a second area of pressure P2. The pressure P2 on the refiner side is typically higher than the pressure P1 on the input side, but there are also applications where the pressure P1 on the input side is higher than the pressure P2 on the refiner side.

The system 1000 of Fig. 8 further comprises an optional intermediate unit 300 arranged between the plug screw feeder 100 and refiner 400 to illustrate the fact that the plug screw feeder 100 need not necessarily be arranged in direct connection with the refiner 400. There may be one or several intermediate units 300, for example transport units which normally do not alter the plug flow created by the plug screw feeder 100 in any significant manner.

As mentioned, the plug screw feeder 100 can also be used to feed other processing units than a refiner. The refiner 400 in Fig. 8 could in such a case, for example, be replaced by an impregnator or a preheater.

Although the invention has be described with reference to specific illustrated embodiments, it is emphasized that it also covers equivalents to the disclosed features, as well as changes and variants obvious to a man skilled in the art. Thus, the scope of the invention is only limited by the appended claims.

CLAIMS

1. A screw pipe unit (110) intended to cooperate with and at least partly enclose a screw (120) in a plug screw feeder (100) for cellulose chips/pulp, said screw pipe unit comprising at least one opening for filtrate dewatered from chips/pulp in the screw pipe unit when the plug screw feeder is in operation, and said screw pipe unit on at least a portion of its inner surface (112) being provided with bars (114) inclined with respect to the longitudinal axis (L) of the screw pipe unit,

characterized in that the inclination of the bars (114-2; 114-3; 114-4; 114-5) decreases in the longitudinal direction, such that a first portion (110a) of the screw pipe unit (110) has maximum inclination and a second portion (110b) of the screw pipe unit has bars substantially parallel to said axis (L), the second portion being further away from an inlet end of the screw pipe unit than the first portion.

2. The screw pipe unit of claim 1, wherein the bars (114-2; 114-3; 114-4; 114-5) are substantially helical in the first portion of the screw pipe unit.

3. The screw pipe unit of claim 1 or 2, wherein the inclination of the bars (114-2; 114-3; 114-4) gradually decreases in the longitudinal direction, from the first portion (110a) of the screw pipe unit (110) to the second portion (110b) of the screw pipe unit.

4. The screw pipe unit of claim 3, wherein the inclination of the bars (114-2; 114-3) decreases in the longitudinal direction in a substantially continuous manner.

5. The screw pipe unit of claim 3, wherein the inclination of the bars (114-4) decreases in the longitudinal direction in a plurality of steps.

6. The screw pipe unit of any of previous claims, wherein the bars (114-2; 114-3; 114-4; 114-5) of the first portion (110a) of the screw pipe unit (110) present an angle of inclination with respect to the longitudinal axis (L) in the interval of 10-60°.

7. The screw pipe unit of claim 6, wherein the bars of the first portion of the screw pipe unit present an angle of inclination with respect to the longitudinal axis (L) in the interval of 15-35°.

8. The screw pipe unit of any of previous claims, comprising one single pipe element (110) in the longitudinal direction.

9. The screw pipe unit of any of claims 1-7, comprising two or more separate pipe elements in the longitudinal direction coupled together in series.

10. The screw pipe unit of any of previous claims, being divisible in a plane extending in the longitudinal direction.

11. A plug screw feeder (100) for cellulose chips/pulp comprising a screw (120) and a screw pipe unit (110) according to any of previous claims.

12. The plug screw feeder of claim 11, further comprising a plug pipe unit (130) provided with substantially straight bars, the screw pipe unit (110) and the plug pipe unit being arranged with substantially non-interrupted straight bars in the area where the screw pipe unit is connected to the plug pipe unit.

13. A system (1000) for treatment of cellulose chips/pulp comprising a plug screw feeder (100) according to claim 11 or 12 and a processing unit arranged such that the screw pipe unit feeds chips/pulp to the processing unit.

14. The system of claim 13, wherein the processing unit is selected from the group of a refiner (400), a preheater, and an impregnator.

15. Use of a plug screw feeder according to claim 11 or 12 for refiner feeding.

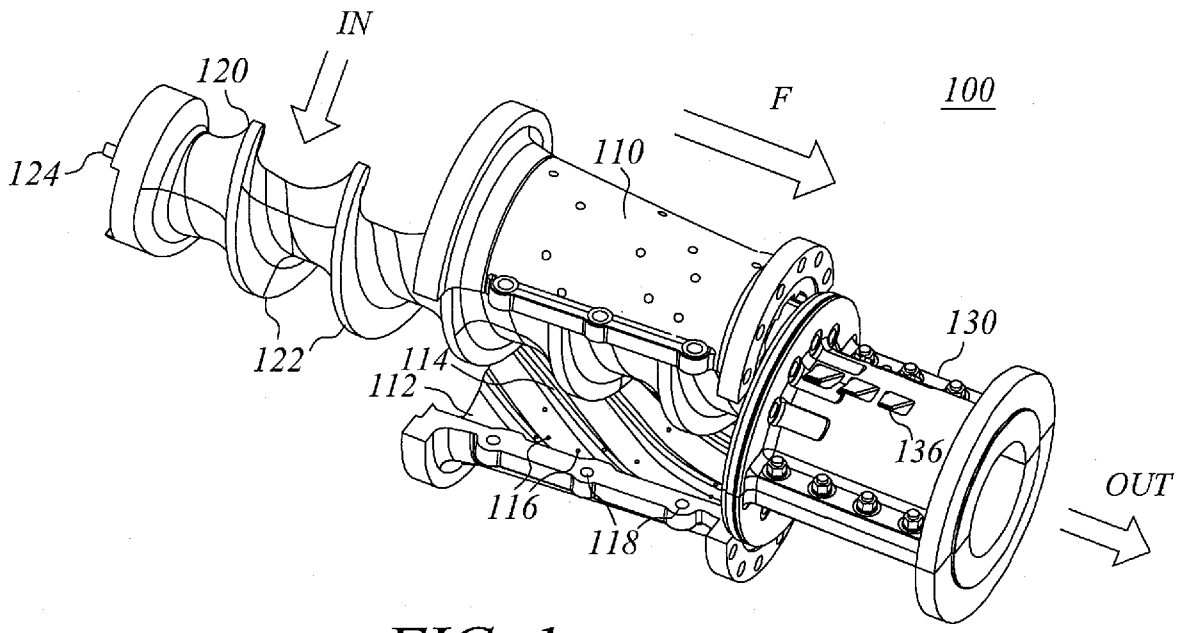


FIG. 1

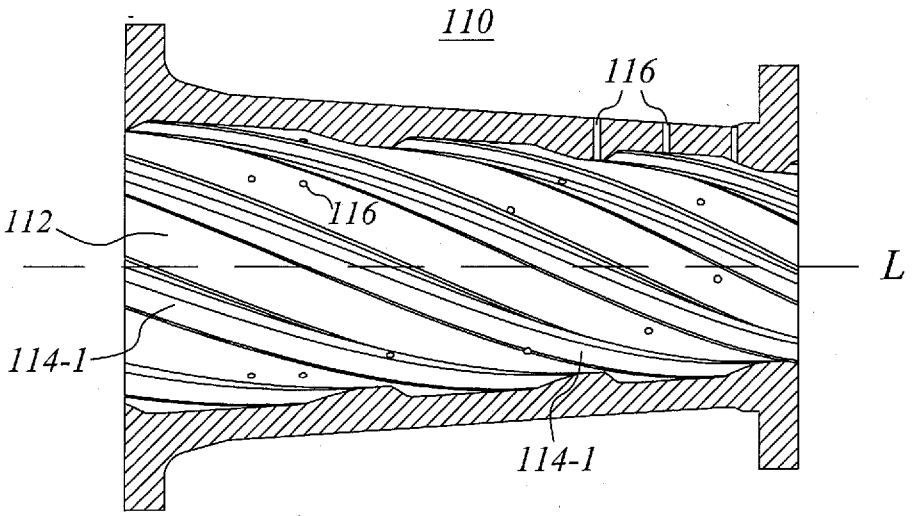


FIG. 2 (Prior Art)

FIG. 3A

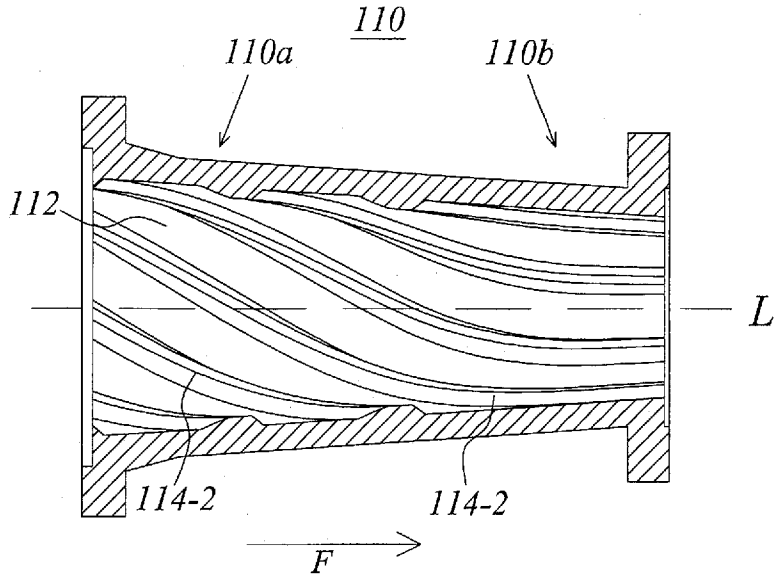


FIG. 3B

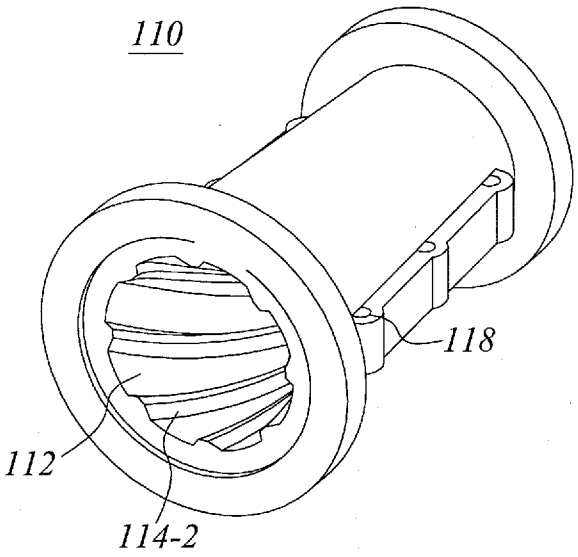
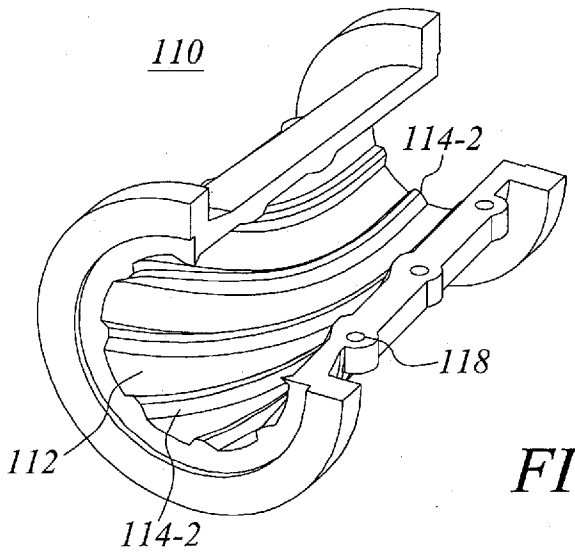


FIG. 3C



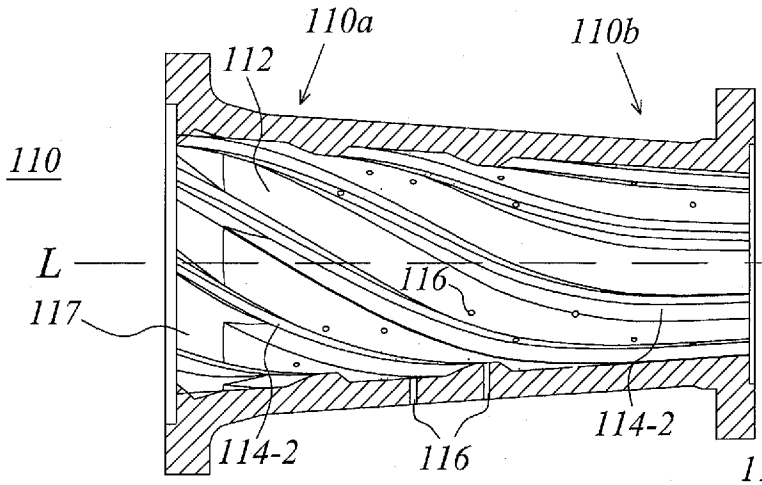


FIG.4

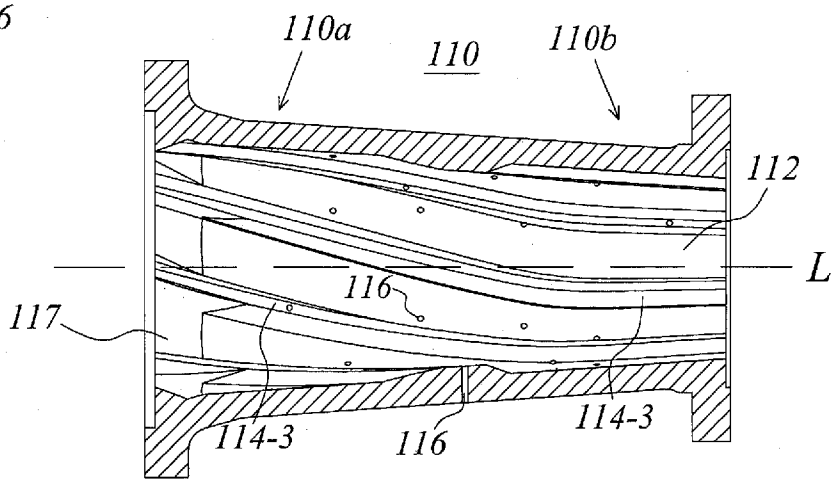


FIG. 5

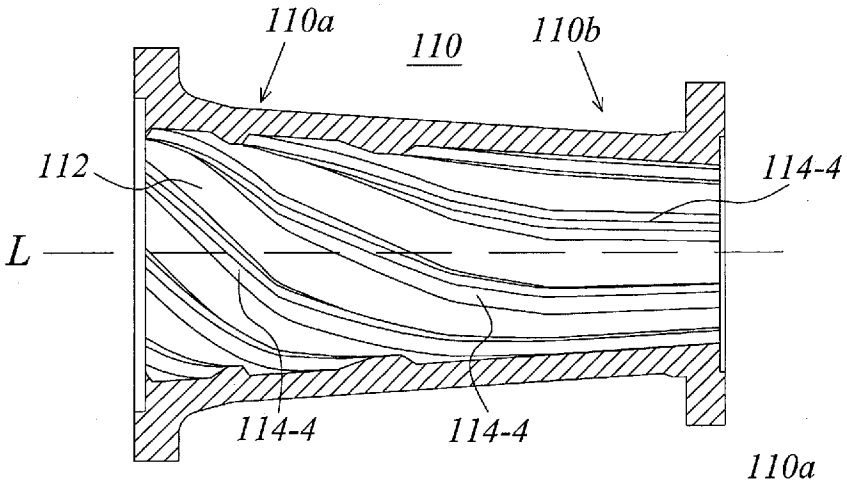


FIG. 6

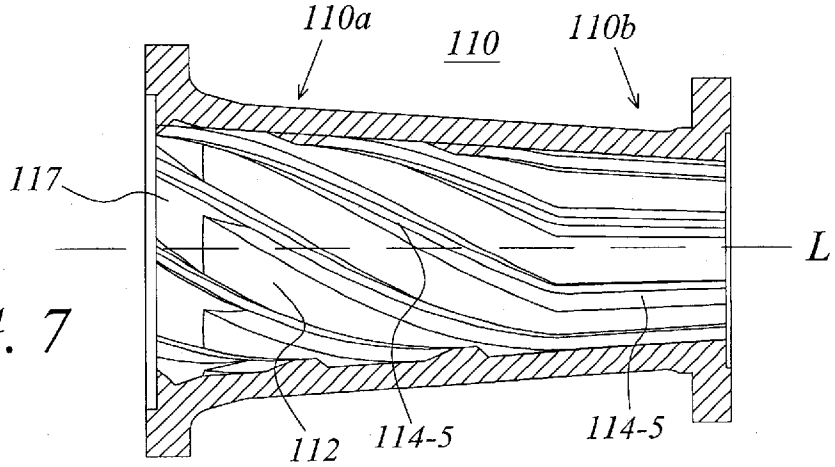


FIG. 7

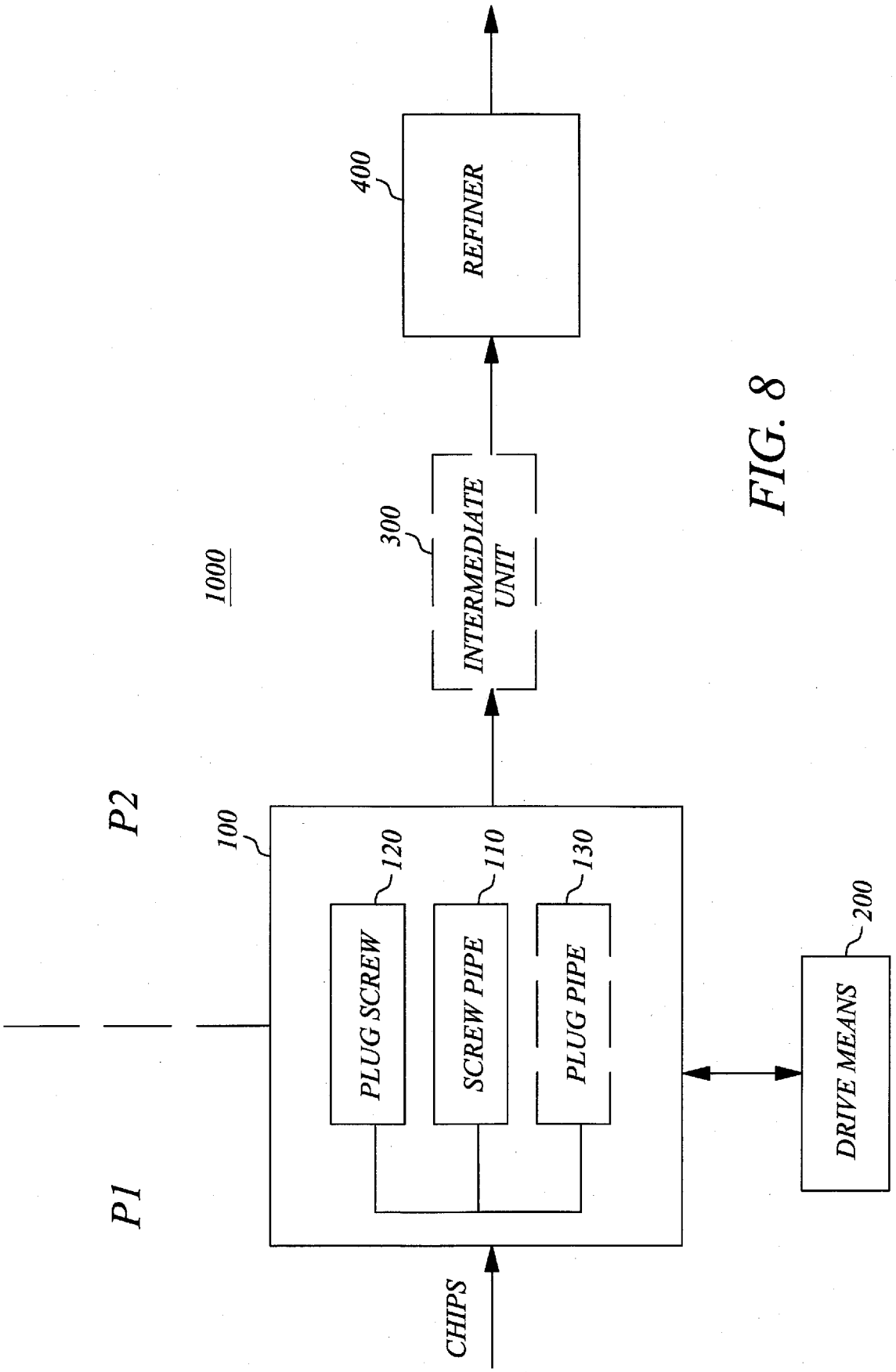

CHIPS
P1
P2
1000
100
PLUG SCREW
120
SCREW PIPE
110
PLUG PIPE
130
DRIVE MEANS
200
300
INTERMEDIATE UNIT
400
REFINER

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2008/050428

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: D21C, D21B, B30B, B65G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20060196370 A1 (KRAFT MICHAEL J. ET AL), 7 Sept 2006 (07.09.2006), figures 3,4,5, paragraphs [0028]-[0029]	1-15
A	US 4256035 A (NEUFELDT JACOB J.), 17 March 1981 (17.03.1981), column 3, line 46 - line 60, figures 2,3	1-15
A	US 4165283 A (WEBER ROLAND E. ET AL), 21 August 1979 (21.08.1979), column 10, line 36 - column 11, line 22, figures 1,10	1-15

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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B30B 9/12 (2006.01)
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