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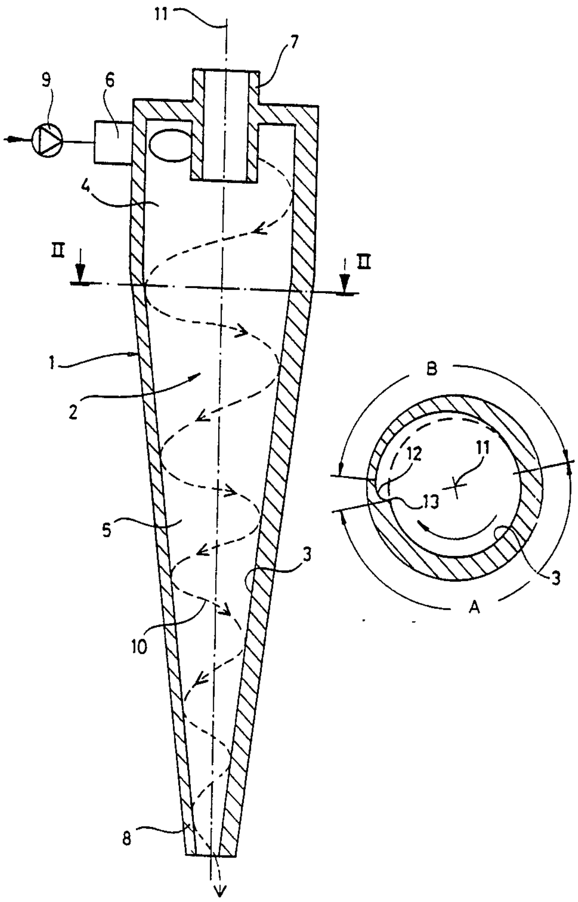
(54) Title: HYDROCYCLONE WITH TURBULENCE CREATING MEANS

(57) Abstract

In a hydrocyclone the separation chamber (2) has a circumferential wall (3) provided with at least one turbulence creating member (12), which extends along the circumferential wall and crosses a helical path (10), along which a liquid stream is generated during operation. According to the invention, the turbulence creating member is formed by a set-off (12) on the circumferential wall (3). The set-off is formed and dimensioned such that said liquid stream substantially looses its contact with the circumferential wall, as the liquid stream passes the set-off. As a result turbulence is created in a layer of the liquid stream situated closest to the circumferential wall, without the liquid stream becoming any substantial flow component directed inwards in the separation chamber.



Hydrocyclone with turbulence creating means

The present invention relates to a hydrocyclone for separating a liquid mixture into a heavy fraction and a light fraction, comprising a housing forming an elongated separation chamber with a circumferential wall and two opposed ends, an inlet member for supplying the liquid mixture tangentially into the separation chamber at one end of the latter, an outlet member for discharging separated heavy fraction from the separation chamber at the other end of the latter, and an outlet member for discharging separated light fraction from the separation chamber. The hydrocyclone further comprises means for supplying the liquid mixture to the separation chamber via the inlet member, so that during operation a liquid stream is generated along a helical path about a centre axis in the separation chamber, said helical path extending from the inlet member to said outlet member for heavy fraction, and at least one turbulence creating member extending in the separation chamber along the circumferential wall and crossing said path.

In a known hydrocyclone of this kind according to US 4.153.558 there are four turbulence creating members in the form of axial ridges on the circumferential wall. When such a ridge is passed by a liquid stream turbulence is created in a layer of the liquid stream located closest to the circumferential wall, which prevents growth of deposits on the circumferential wall. Unless growth of the deposits is not prevented during operation, the deposits might finally clog the outlet member for heavy fraction.

However, the liquid stream will become an inwardly directed component of movement into the separation chamber, when the liquid stream passes each ridge, which means that separated light fraction will contain a large amount of heavy components which were supposed to be discharged with separated heavy fraction. This is particularly a drawback when separating liquid mixtures constituted by fibre suspensions, which will be explained more closely in the following.

In the pulp and paper industry hydrocyclones are frequently used for cleaning fibre suspensions from undesired heavy particles. Thus, the fibre suspensions are separated into heavy fractions containing said undesired heavy particles and light fractions containing fibres. A typical hydrocyclone plant for this purpose has hydrocyclones arranged in several stages of hydrocyclones coupled in parallel (normally three or four stages), the hydrocyclone stages being coupled in series with each other. Separated heavy fraction from the first hydrocyclone stage is once more separated in the second hydrocyclone stage, since said heavy fraction also contains fibres, whereafter separated heavy fraction from the second hydrocyclone stage is separated in the third hydrocyclone stage, and so on. In this manner fibres are recovered step by step from created heavy fraction. Light fraction containing recovered fibres formed in a hydrocyclone stage is supplied back to the preceding hydrocyclone stage. In this connection it is important that the hydrocyclones, at least in the first hydrocyclone stage, separate efficiently, so that the light fraction contains as few heavy undesired particles as possible.

A problem in connection with separating a fibre suspension by means of a hydrocyclone is that tight mats of fibres can be developed on the circumferential wall of the separation chamber. Heavy undesired particles are easily caught in such mats of fibres, which can result in clogging of the outlet member for heavy fraction. This problem is eliminated by the prior art kind of hydrocyclone described above, whereby the creation of tight mats of fibres on the circumferential wall of the separation chamber is counteracted by said ridges. However, a drawback to the prior art hydrocyclone is that during operation each ridge gives the flowing fibre suspension an inwardly directed component of movement in the separation chamber, whereby an increased share of the undesired heavy particles follows separated light fraction containing fibres.

The object of the present invention is to provide a new improved hydrocyclone of the prior art kind, which is capable of separating a liquid mixture such that created light fraction will be substantially free from heavy components.

This object is obtained by means of a hydrocyclone of the kind described initially, which mainly is characterized in that immediately upstream the turbulence creating member in the separation chamber the circumferential wall has a smooth surface along a first zone of the circumferential wall, which is situated at a substantially constant distance from said centre axis along at least a fifth part of the circumference of the separation chamber; that the turbulence creating member is formed by a set-off on the circumferential wall, which set-off extends from said first zone of the circumferential wall to a second zone of the circumferential wall situated at a larger distance from the centre axis than the first zone, the second zone extending forwards from the set-off, as seen in the flow direction of said liquid stream; and that the set-off is formed and dimensioned such that during operation said liquid stream substantially looses its contact with the circumferential wall, as the liquid stream passes the set-off. Hereby, turbulence is created in a layer of the liquid stream situated closest to the circumferential wall, without the liquid stream becoming any substantial flow component directed against said centre axis.

When separating fibre suspensions by means of the new hydrocyclone a light fibre fraction thus is created containing substantially fewer undesired heavy particles as compared to the light fraction created at a corresponding separation by means of the above mentioned prior art hydrocyclone. In addition, it has surprisingly been proved that the heavy fraction created by means of the new hydrocyclone contains substantially fewer fibres than the heavy fraction created by means of the prior art hydrocyclone. This surprising effect probably depends on that the underpressure generated closest to the circumferential wall of the separation chamber, when the liquid stream passes the set-off, causes the flocks of fibres close to the circumferantial wall to expand, so that the fibres in said fibre flocks are released from each other. The released fibres having a relatively large specific surface separate easier in direction inwards in the separation chamber than said fibre flocks having a relatively small specific surface.

Thus, the new hydrocyclone is capable of separating fibre suspensions, such that the created heavy fraction will be relatively thin. For the pulp and the paper industry the use of the new hydrocyclone means the advantage that fewer hydrocyclones than previously are needed for cleaning fibre suspensions from undesired heavy particles, since created heavy fraction from a hydrocyclone stage need not be diluted so much before it is supplied to the next hydrocyclone stage.

Practical tests have proved that said first zone of the circumferential wall of the separation chamber should be at least a fifth part of the circumference of the separation chamber, which means that at most four set-offs can be arranged equally divided around the circumference of the separation chamber. However, an optimum turbulence creating effect is achieved already with one or at most two set-offs.

Said second zone extends suitably along at least a fifth part of the circumference of the separation chamber, the distance between the second zone and the centre axis decreasing along the circumference of the separation chamber in direction away from the set-off, as seen in the flow direction of said liquid stream. At the end of the second zone, the second zone has suitably substantially the same distance to the centre axis as the first zone.

Preferably, the circumferential wall has a sharp edge where the first zone borders to the set-off, in order to facilitate that said liquid stream will loose its contact with the circumferential wall, as it passes the set-off.

According to a preferred embodiment of the new hydrocyclone the separation chamber in a way known per se (see US 4,156,485) is formed by a plurality, axially consecutively arranged cylindrical chamber portions, which are formed such that the cross-sectional area of the separation chamber decreases step by step towards the outlet member for heavy fraction, the chamber portions being touched by an imaginary straight line extending in parallel with the chamber portions. The advantage of a separation chamber formed in this manner as compared to an ordinary conical separation chamber is that the circumferential walls of the cylindrical chamber portions will not give rise to forces on separated heavy particles directed against the axial flow direction of the liquid mixture. Therefore, separated heavy particles are prevented from rotating along the circumferential wall of the separation chamber without an axial movement relative to the separation chamber and from causing local wear of the circumferential wall. Instead, heavy particles are entrained by the liquid mixture to shelves extending between the chamber portions in the circumferential direction of the separation chamber. Via breaks formed in said shelves the heavy particles are entrained by the liquid mixture axially further in the separation chamber towards the outlet member for heavy fraction.

Preferably, said set-off is situated in front of said imaginary straight line touching the cylindrical chamber portions. The chamber portions are suitably formed such that the one of two adjacent chamber portions which is located next to the outlet member for heavy fraction has a transversal extension from said imaginary straight line to the set-off which amounts to the corresponding transversal extension of the other chamber portion reduced by at most the transversal extension of the set-off. As a result the separation chamber can be formed such that the shelves are provided with an additional break at the set-off, which means the advantage that separated heavy particles are entrained by the liquid stream axially in the separation chamber also at the area of each set-off.

The invention is explained more closely in the following with reference to the accompanying drawing, in which figure 1 shows a hydrocyclone according to the invention, figure 2 shows a section along the line II-II in figure 1, figure 3 shows a cross-section through an alternative embodiment of the hydrocyclone according to figure 1, figure 4 shows a preferred embodiment of the hydrocyclone according to the invention, and figure 5 shows a part view of a section along the line V-V in figure 4.

The hydrocyclone shown in figure 1 comprises a housing 1, which forms an elongated separation chamber 2 with a circumferential wall 3 and two opposite ends. At one end the separation chamber 2 has an inlet part 4, which has a constant cross-sectional area along the axial extension of the separation chamber 2. The inlet part 4 of the separation chamber passes into a conical part 5, which has a decreasing cross-sectional area in direction towards the other end of the separation chamber.

An inlet member 6 is arranged at the inlet part 4 for feeding a liquid mixture to be separated tangentially into the separation chamber 2. At one end of the separation chamber 2 the housing 1 is formed with a tubular outlet member 7 situated centrally in the inlet part 4 for discharging separated light fraction from the separation chamber 2. At the other end of the separation chamber 2 the housing 1 is formed with an outlet member 8 for discharging separated heavy fraction from the separation chamber 2. A pump 9 is adapted to pump the liquid mixture to the separation chamber 2 via the inlet member 6, so that during operation a liquid stream is generated along a helical path 10 about a centre axis 11 in the separation chamber 2 from the inlet member 6 to the outlet member 8 for heavy fraction.

The circumferential wall 3 has a smooth surface in a first zone I, which is at a substantially constant distance from the centre axis 11 along half the circumference of the separation chamber 2. A set-off 12 on the circumferential wall 3 extends axially along the entire separation chamber 2 with a constant transversal extension. (As seen in a cross-section through the separation chamber 2 the transversal extension of the set-off 12 should not be less than 1 % or more than 40 % of the distance between the circumferential wall 3 and the centre axis 11). Along the circumference of the separation chamber 2 the set-off 12 extends from the zone I at the end of the latter, as seen in the flow direction of said liquid stream, to a second zone II of the circumferential wall 3 situated at a greater distance from the centre axis 11 than the first zone I.

The second zone II has a smooth surface and extends forwards in the flow direction from the set-off 12 to the first zone I, the distance between the second zone II and the centre axis 11 decreasing successively along the circumference of the separation chamber 2 in direction from the set-off 12. At the end of the second zone II, as seen in the flow direction, the zone II has the same distance to the centre axis as the first zone I.

The circumferential wall 3 has a sharp edge 13 where the first zone I borders to the set-off 12. As seen in a cross-section through the separation chamber 2 the set-off 12 is curved from the edge 13 forwards relative to the flow direction of the liquid stream and outwards relative to the separation chamber 2 to the second zone II of the circumferential wall 3. The set-off 12 is connected to the second zone II of the circumferential wall 3 such that no edge is formed on the circumferential wall 3.

During operation of the hydrocyclone according to figures 1 and 2 the liquid mixture to be separated is pumped by means of the pump 9 tangentially into the separation chamber 2 via the inlet member 6, so that a liquid stream is generated along the helical path 10 about the centre axis 11. As the liquid stream passes the set-off 12 it looses its contact with the circumferential wall 3, whereby a local underpressure is created behind the set-off 12 as seen in the flow direction. Said underpressure gives rise to turbulence in a layer of the liquid stream located closest to the circumferential wall, which prevents growth of deposits on the circumferential wall 3. Created heavy fraction of the liquid mixture is emptied from the separation chamber 2 via the outlet member 8, while created light fraction of the liquid mixture is emptied from the separation chamber via the outlet member 7.

In figure 3 there is shown an alternative embodiment of the hydrocyclone according to the invention, in which the circumferential wall of the separation chamber is provided with two opposed set-offs 14 and 15. In this case the circumferential wall has a smooth surface along a zone III immediately upstream each set-off, which zone III is situated at a substantially constant distance from a centre axis 16 in the separation chamber along a fourth part of the circumference of the separation chamber.

The hydrocyclone shown in figures 4 and 5 comprises a housing 17, a separation chamber 18, a circumferential wall 19, an inlet member 20, an outlet member 21 for light fraction, and an outlet member 22 for heavy fraction, which have the same function as corresponding components in the above-described hydrocyclone according to figure 1. The separation chamber 18 is formed by a plurality, axially consecutively arranged cylindrical chamber portions 23 having various cross-sectional areas, the cross-sectional area of the separation chamber 18 being decreased step by step towards the outlet member 22. Between adjacent chamber portions 23 there are formed shelves 24 extending in the circumferential direction of the separation chamber 18. The chamber portions 23 are oriented such that they are touched by an imaginary straight line 25 extending in parallel with the chamber portions 23, whereby breaks are provided in the shelves 24 at the imaginary straight line 25. In contrast to a conical circumferential wall the circumferential wall in the cylindrical chamber portion 23 will not give rise to forces on separated heavy particles directed away from the outlet member 22 for heavy fraction.

A set-off 26 on the circumferential wall 19 extends axially along the entire separation chamber 18 with a constant transversal extension and is situated in front of the imaginary straight line 25 which touches the chamber portions 23. Each chamber portion 23 has a cross-sectional area which in principle corresponds with the cross-sectional area of the separation chamber 2 shown in figure 2. The chamber portions 23 are designed such that the one of two adjacent chamber portions 23a and 23b which is next to the outlet member 22 has a transversal extension from the imaginary straight line

25 to the set-off, which is equal to the corresponding transversal extension of the other chamber portion 23a reduced by the transversal extension of the set-off 26. As a result breaks are also formed in the shelves 24 at the set-off 26. In figure 4 two adjacent shelves are designated with 24a and 24b, respectively, which also are shown in figure 5.

During operation of the hydrocyclone according to figures 4 and 5 separated heavy particles will be entrained to the shelves 24 and leave these via said breaks at the imaginary straight line 25, which touches the chamber portions 23, and via said breaks at the set-off 26. In other respects the function of the hydrocyclone according to figure 4 is analogous to the above-described hydrocyclone according to figure 1.

Claims

1. A hydrocyclone for separating a liquid mixture into a heavy fraction and a light fraction, comprising a housing (1, 17), forming an elongated separation chamber (2, 18) with a circumferential wall (3, 19) and two opposed ends, an inlet member (6, 20) for supplying a liquid mixture tangentially into the separation chamber at one end of the separation chamber, an outlet member (8, 22) for discharging separated heavy fraction from the separation chamber at the other end of the separation chamber, an outlet member (7, 21) for discharging separated light fraction from the separation chamber, means (9) for supplying the liquid mixture to the separation chamber via the inlet member, so that during operation a liquid stream is generated along a helical path (10) about a centre axis (11) in the separation chamber, said helical path extending from the inlet member to said outlet member for heavy fraction, and at least one turbulence creating member (12, 16), which extends in the separation chamber along the circumferential wall and crosses said helical path, c h a - r a c t e r i z e d i n

- that immediately upstream the turbulence creating member (12, 26) in the separation chamber (2, 18) the circumferential wall (3, 19) has a smooth surface along a first zone (I) of the circumferential wall which is situated at a substantially constant distance from said centre axis (11) along at least a fifth part of the circumference of the separation chamber (2, 18),

- that the turbulence creating member is formed by a set-off (12, 26) on the circumferential wall (3, 19), which set-off extends from said first zone (I) of the circumferential wall to a second zone (II) of the circumferential wall situated at a larger distance from the centre axis (11) than the first zone (I), the second zone (II) extending forwards from the set-off, as seen in the flow direction of said liquid stream, and

- that the set-off (12, 26) is formed and dimensioned such that during operation said liquid stream substantially looses its contact with the circumferential wall (3, 19), as the liquid stream passes the set-off, whereby turbulence is created in a layer of the liquid stream situated closest to the circumferential wall, without the liquid stream becoming any substantial flow component directed against said centre axis (11).

2. A hydrocyclone according to claim 1, c h a r a c t e r i z e d i n that said second zone (II) extends along at least a fifth part of the circumference of the separation chamber (2, 18), the distance between the second zone (II) and the centre axis (11) decreasing along the circumference of the separation chamber in direction away from the set-off (12, 26), as seen in the flow direction of said liquid stream.

3. A hydrocyclone according to claim 1 or 2, c h a r a c t e r i z e d i n that at the end of said second zone (II), as seen in the flow direction of said liquid stream, the second zone (II) has substantially the same distance to the centre axis (11) as said first zone (I).

4. A hydrocyclone according to any of claims 1-3, c h a r a c t e r i z e d i n that the circumferential wall (3, 19) has a sharp edge (13) where said first zone (I) of the circumferential wall borders to the set-off (12, 26).

5. A hydrocyclone according to any of claims 1-4, c h a r a c t e r i z e d i n that in a cross-section through the separation chamber (2, 18) the transversal extension of the set-off (12, 26) is between 1 to 40 % of the distance between the circumferential wall (3, 19) and the centre axis (11).

6. A hydrocyclone according to any of claims 1-5, c h a r a c t e r i z e d i n that the set-off (12, 26) has a constant transversal extension axially along the separation chamber (2, 18).

7. A hydrocyclone according to claim 6, in which the separation chamber (18) is formed by a plurality, axially consecutively arranged cylindrical chamber portions (23), which are formed such that the cross-sectional area of the separation chamber decreases step by step towards said outlet member (22) for heavy fraction, the chamber portions (23) being touched by an imaginary straight line (25) extending in parallel with the chamber portions, c h a r a c t e r i z e d i n that in each chamber portion (23) said set-off (26) is situated in front of said imaginary straight line (25).

8. A hydrocyclone according to claim 7, c h a r a c - t e r i z e d i n that of two adjacent chamber portions (23a, 23b) the chamber portion (23b) next to said outlet member (22) for heavy fraction has a transversal extension from said imaginary straight line

(25) to the set-off (26) which amounts to the corresponding transversal extension of the second chamber portion (23a) reduced by at most the transversal extension of the set-off (26).

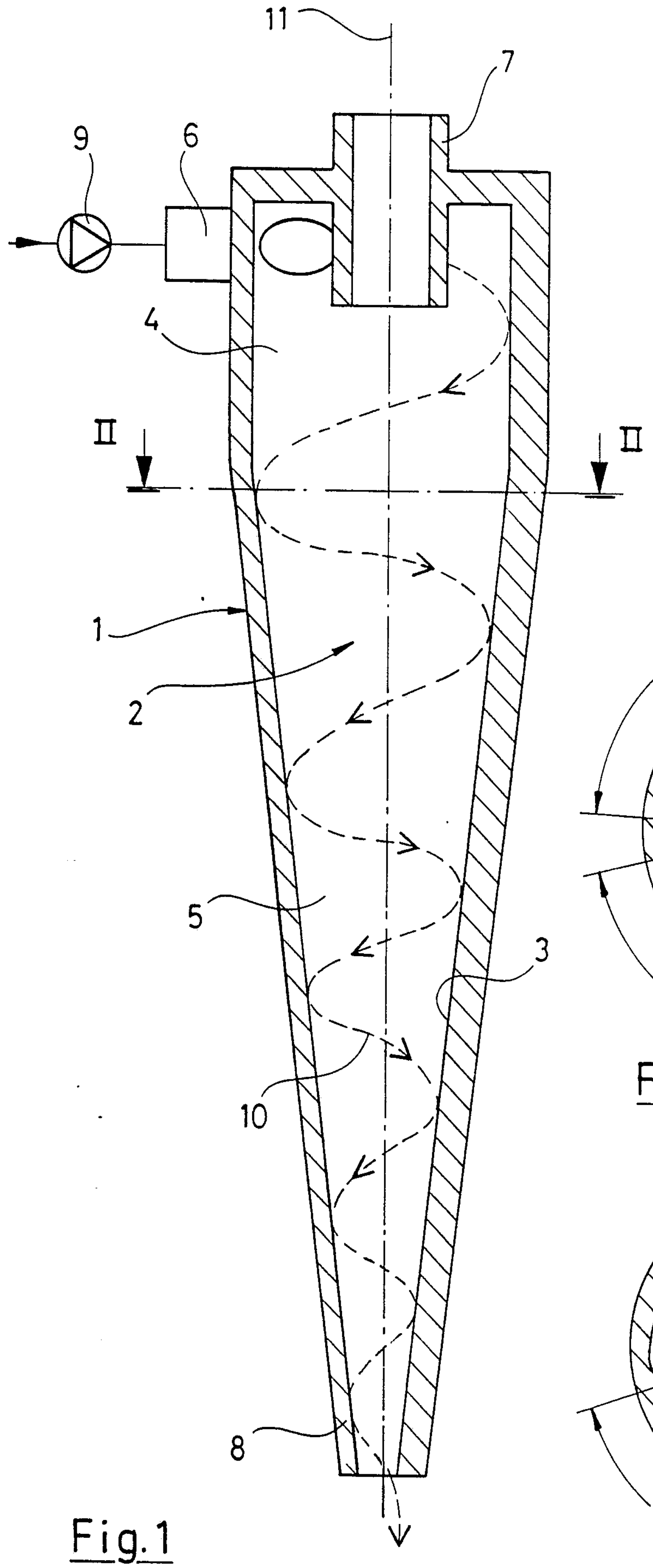


Fig.1

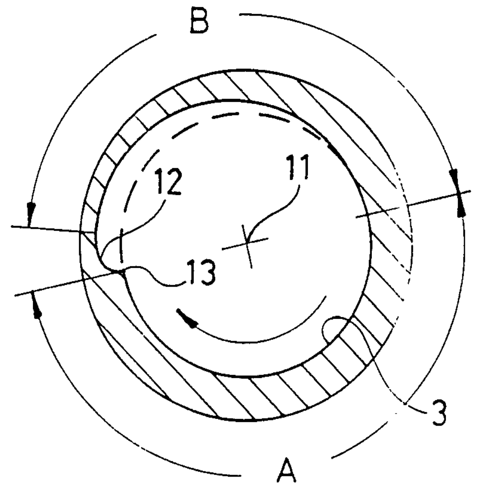


Fig.2

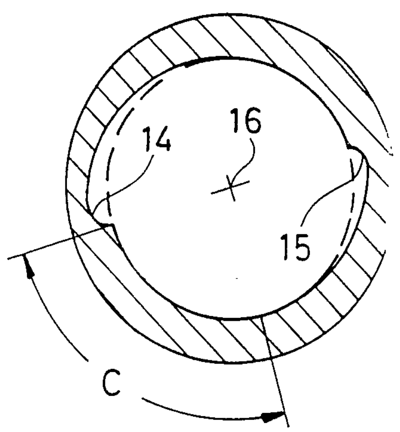


Fig.3

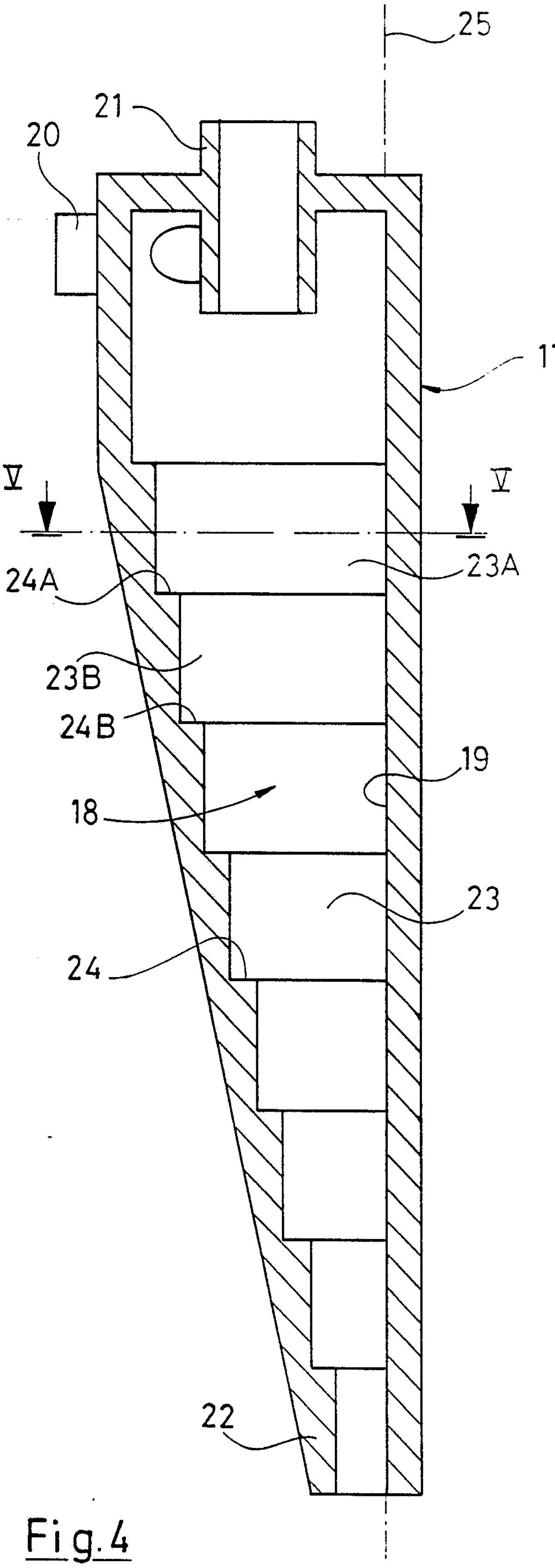


Fig.4

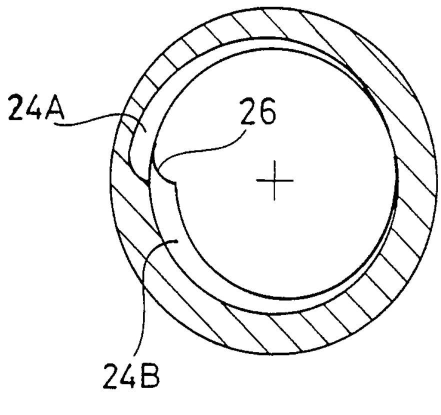


Fig.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 92/00814

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B04C 5/81, D21D 5/24
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)

IPC5: B04C, D21D, B03B

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent's abstract, No 49554 E/24, week 8224, ABSTRACT OF SU, 856560 (ORELESS CONS MAT), 25 October 1978 (25.10.78) --	1
A	DE, C2, 2809575 (AKTIEBOLAGET CELLECO), 19 March 1987 (19.03.87), figures 1-3, claim 1 --	1
A	DE, A1, 3244336 (AKTIEBOLAGET CELLECO), 16 June 1983 (16.06.83), figures 1-5, abstract --	1

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

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 March 1993	
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Ulf Nyström Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 92/00814

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US, A, 4156485 (KARL A. SKARDAL), 29 May 1979 (29.05.79), Document cited in the application -- --------	1

INTERNATIONAL SEARCH REPORT
Information on patent family members

29/01/93

International application No.
PCT/SE 92/00814

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