

Description

The present invention relates to macerators. One form of macerator, as shown, for example, in GB-A-1,569,672, includes primary and secondary parallel contra-rotating shafts, each having a plurality of alternate cutters and spacers of the same axial thickness. Each cutter has a plurality of teeth arranged at circumferentially spaced locations.

Mounted adjacent to the cutters, on the side walls of the housing, are side rails which have radially inner surfaces which are arcuate and closely adjacent to the teeth of the cutters as they rotate. Slots may be provided in the side rails inclined at an angle with respect to the axes of the shafts, in order to increase the fluid flow rate through the macerator whilst ensuring that the solid material is cut up satisfactorily.

The efficiency of a macerator is determined by a number of parameters including the diameters of the cutters and spacers on the primary and secondary shafts and the rotational speed of the primary and secondary shafts. A number of problems exist. Under certain operating conditions, material in the liquid becomes wrapped around the shafts, known as "ragging", which clogs the apparatus reducing its efficiency or even preventing it from working. Under different operating conditions, the cutters on the two shafts may cut material in the liquid into long strips. This is known as the "paper shredder effect" and may lead to problems downstream of the macerator due to the unacceptable lengths of material remaining in the liquid, particularly when processing fibrous materials.

It is an object of the present invention to provide a macerator which provides optimum cutting conditions in order to avoid ragging and/or the paper shredder effect.

Accordingly the present invention provides a macerator comprising a macerating chamber, side walls of said chamber, primary and secondary parallel contra-rotating shafts extending between said side walls, a plurality of alternate cutters and spacers of the same axial thickness mounted on each of said primary and secondary shafts the cutters of the primary shaft being interleaved with those of the secondary shaft, said cutters each including at least one tooth thereon, control means for rotating the shafts, characterised in that in use the control means ensures that the peripheral linear velocity of the cutters on the primary shaft exceeds the peripheral linear velocity of the cutters on the secondary shaft and ensures that the peripheral linear velocity of the cutters on the secondary shaft exceeds the peripheral linear velocity of the spacers on the primary shaft. With such an arrangement the problems of "ragging" and the "paper shredder effect" can be alleviated.

Looking at the problem in more detail, when using a twin shaft macerator to chop up waste, such as sewage sludge and waterborne solids, a zone exists in which optimum cutting conditions can be achieved. This zone is a function of a number of parameters including :

(i) The ratio of the peripheral linear velocity of the cutters on the primary shaft to the peripheral linear velocity of the cutters on the secondary shaft, denoted hereafter C_d

(ii) The ratio of the peripheral linear velocity of the cutters on one shaft to the peripheral linear velocity of the spacers on the other shaft.

If C_d is approximately equal to one, then there is a tendency for the paper shredder effect to occur. This is because, although a good scissoring action may occur between the teeth on the cutters of the primary and secondary shafts, material may pass through which is simply cut into long strips. The present invention advantageously provides a peripheral linear velocity difference between the corresponding cutters producing a shearing action which ensures that the material is cut up more effectively. In the following discussion it is assumed that the periphery of the primary cutters has a higher speed than that of the secondary cutters, ie $C_d > 1$, but clearly the labels primary and secondary could be reversed.

If the peripheral linear velocity of a spacer on one shaft is greater than that of the opposing cutter on the other shaft, then material can be dragged past the teeth on that cutter from behind without being effectively cut by the teeth on the cutter.

If the ratio of the peripheral linear velocity of a cutter to that of its opposing spacer is less than or equal to 1 then excessive ragging may occur because there is insufficient shear in the flow. With the condition $C_d > 1$, the peripheral linear velocity of the cutters on the primary shaft will always exceed that of the spacers on the secondary shaft. The ratio of the peripheral linear velocity of the cutters on the secondary shaft to the peripheral linear velocity of the spacers on the primary shaft is hereafter denoted L_d . The present invention provides a macerator in which $L_d > 1$ and therefore alleviates the problem of ragging.

The macerator preferably includes a motor for driving one of the shafts and gears connecting the two shafts for driving the other shaft at an appropriate rotational speed relative to said one shaft.

A specific embodiment of the invention will now be described by way of example, with reference to the accompanying drawings in which:

Figure 1 is a side elevation showing the contra-rotating shafts with a stack of cutting discs and spacers mounted thereon;

Figure 2 is a reduced cross-section in a plane perpendicular to the axes of the stacks;

Figure 3 is a graph of rotational speed of the primary shaft versus that of the secondary shaft showing the optimum cutting zone and regions in which excessive ragging and the paper shredder effect occur, for particular cutter and spacer sizes.

Referring to Figs. 1 and 2 the macerator comprises primary and secondary parallel rotatable shafts 10, 12 extending through a macerating chamber 14 having side walls 16, 18. Cutters 20 are mounted on the two shafts, and spacers 22 are mounted between the cutters and are of the same axial thickness as the cutters. The cutters 20 are spaced apart by the spacers 22 and these are fixedly mounted on the shafts 10, 12. The cutters of one shaft are interleaved with those of the other shaft and the teeth 24 of the cutters are in close proximity to the spacers of the opposite shaft and to the side walls.

The side walls 16, 18 preferably have associated side rails 26, each side rail comprising a plurality of spaced ribs 28, the ribs forming there between slots 29.

The macerator includes control means for rotating the shafts. In the preferred embodiment the control means comprises a motor 30 with a gearbox 32 for driving the primary shaft 10, and gears 34, 36 connecting the two shafts for driving the secondary shaft 12 so that it contra-rotates with respect to the primary shaft 10 at an appropriate rotational speed relative to the primary shaft 10. While this arrangement is according to the preferred embodiment it will of course be understood that the motor may drive the secondary shaft 12, or that both shafts may have motors with or without gears connecting the two shafts, provided the criteria relating to the peripheral linear velocity of the cutters and spacers are met. The criteria, in broad terms, are that the peripheral linear velocity of the cutters 20 on the primary shaft 10 should exceed the peripheral linear velocity of the cutters 20 on the secondary shaft 12 and that the peripheral linear velocity of the cutters 20 on the secondary shaft 12 should exceed the peripheral linear velocity of the spacers 22 on the primary shaft 10.

In the preferred embodiment the cutters on the two shafts are all of approximately equal diameter and the spacers on the two shafts are also of approximately equal, smaller diameter. In one example of a macerator the cutters have a diameter of 150 mm and the spacers have a diameter of 90 mm. The graph in Fig. 3 relates to a macerator with the above dimensions. Referring to Fig. 3 the condition $C_d = 1$, which corresponds in this example to equal rotational speeds of the shafts, is shown by the lower diagonal line in this figure. As the operating condition approaches this line, then the paper shredder effect may occur; therefore optimum cutting conditions must lie in the regions on either side of this line. For the purpose of this description, the primary shaft is defined as the shaft having the higher peripheral linear cutter velocity and since in this example the two shafts have cutters of the same diameter, the optimum cutting zone must lie in the region in which the rotational speed of the primary shaft exceeds the rotational speed of the secondary shaft.

In this embodiment, since the cutters are of the same diameter, it is necessary to drive the shafts at different rotational speeds in order to avoid the condition of C_d being approximately equal to one. It will of course

be appreciated that if, for example, the two shafts are to be driven at the same rotational speed, then the same condition can be fulfilled by making the respective cutters on the two shafts of different diameter.

If the rotational speed of the primary shaft is increased by too much relative to that of the secondary shaft, then the linear velocity of the periphery of the primary spacers will approach or exceed the linear velocity of the secondary cutter teeth, the parameter L_d will approach or become less than 1 and excessive ragging may occur. This happens when the ratio of the rotational speed of the primary shaft to the secondary shaft is approximately equal to the ratio of the secondary cutter diameter to the primary spacer diameter. The upper diagonal line in Fig. 3 shows the operating conditions at which L_d equals 1 and excessive ragging begins to occur. It has been confirmed experimentally for this apparatus that at a primary shaft rotational speed of 83 rpm and a secondary shaft rotational speed of 49 rpm excessive ragging occurs. Similarly it has been found that with primary and secondary shaft rotational speeds both equal to 69 rpm that the paper shredder effect occurs.

For a primary shaft rotational speed of 83 rpm satisfactory cutting can be achieved with secondary shaft rotational speeds of 65, 69 and 73 rpm at which the values of L_d are 1.31, 1.39 and 1.47, respectively, and the values of the parameter C_d are 1.28, 1.20 and 1.14, respectively.

Thus the zone of optimum cutting conditions shown in Fig. 3 is bounded by the conditions that C_d should be greater than 1.14 to avoid the paper shredder effect, and L_d should be greater than 1.31 to avoid excessive ragging.

Claims

1. A macerator comprising a macerating chamber (14), side walls (16, 18) of said chamber, primary and secondary parallel contra-rotating shafts (10, 12) extending between said side walls (16, 18), a plurality of alternate cutters (20) and spacers (22) of the same axial thickness mounted on each of said primary and secondary shafts (10, 12), the cutters (20) of the primary shaft (10) being interleaved with those of the secondary shaft (12), said cutters (20) each including at least one tooth (24) thereon, control means (30, 32, 34, 36) for rotating the shafts (10, 12), characterised in that in use the control means ensures that the peripheral linear velocity of the cutters (20) on the primary shaft (10) exceeds the peripheral linear velocity of the cutters (20) on the secondary shaft (12) and ensures that the peripheral linear velocity of the cutters (20) on the secondary shaft (12) exceeds the peripheral linear velocity of the spacers (22) on the primary shaft (10).
2. A macerator according to claim 1, wherein the con-

trol means includes a motor (30) for driving one of the shafts (10) and gears (34,36) connecting the two shafts (10,12) for driving the other shaft (12) at an appropriate rotational speed relative to said one shaft (10).

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3. A macerator according to claim 1 or 2, wherein all the cutters (20) are of equal diameter and all the spacers (22) are of equal diameter.

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4. A macerator according to claim 1, 2 or 3, wherein in use the control means ensures that the ratio of the peripheral linear velocity of the cutters (20) on the primary shaft (10) to the peripheral linear velocity of the cutters (20) on the secondary shaft (12) is greater than or equal to 1.14 to 1.

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5. A macerator according to any one of the preceding claims, wherein in use the control means ensures that the ratio of the peripheral linear velocity of the cutters (20) on the secondary shaft (12) to the peripheral linear velocity of the spacers (22) on the primary shaft (10) is greater than or equal to 1.31 to 1.

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6. A macerator according to any one of the preceding claims, wherein said macerating chamber (14) comprises the side walls of a channel.

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7. A macerator according to any one of claims 1 to 5, wherein the macerating chamber (14) comprises the interior of a housing having an inlet and an outlet port on opposite sides of the nip formed between the rotating cutters.

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8. A macerator according to any one of the preceding claims, wherein the side walls (16,18) of the macerating chamber (14) have associated side rails (26), each side rail (26) comprising a plurality of spaced ribs (28), the ribs forming therebetween slots (29).

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Fig.1.

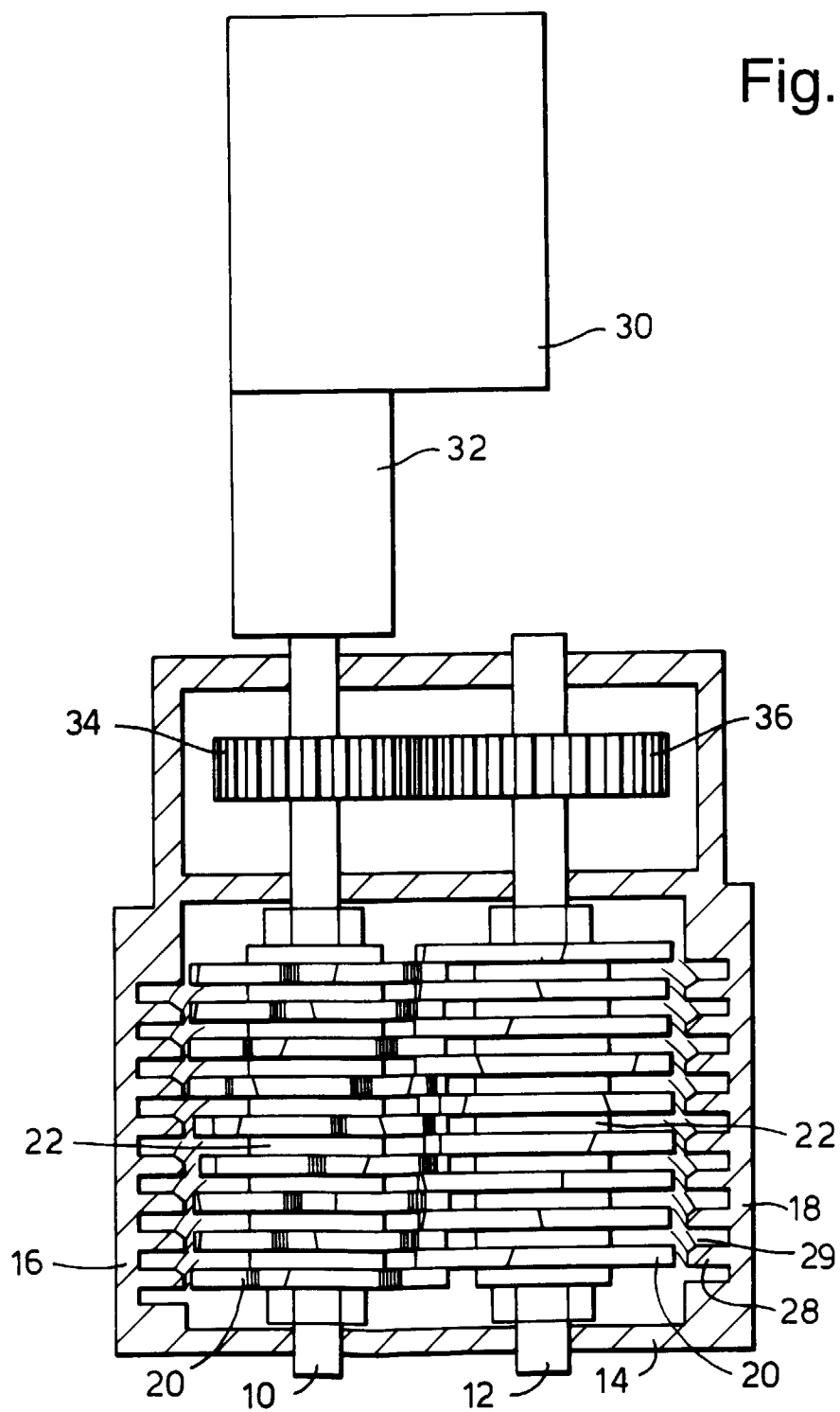


Fig.2.

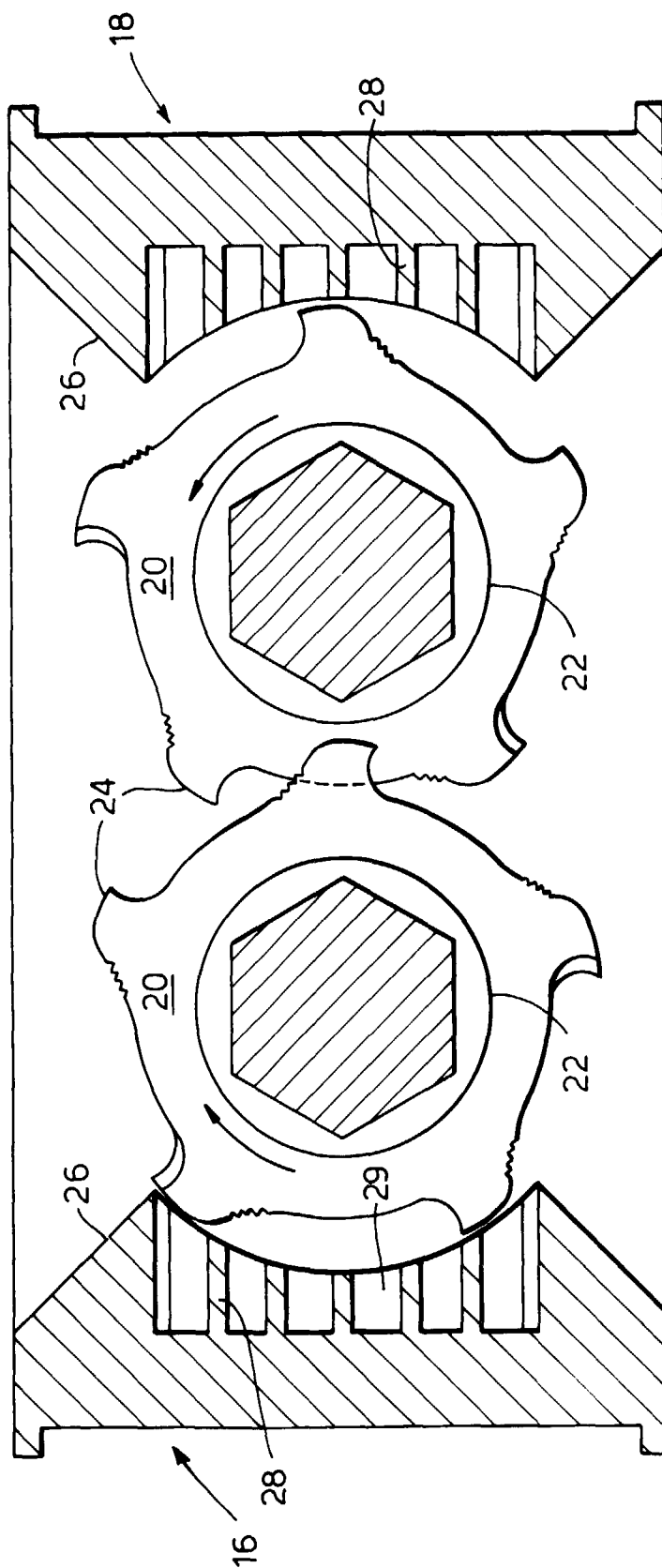
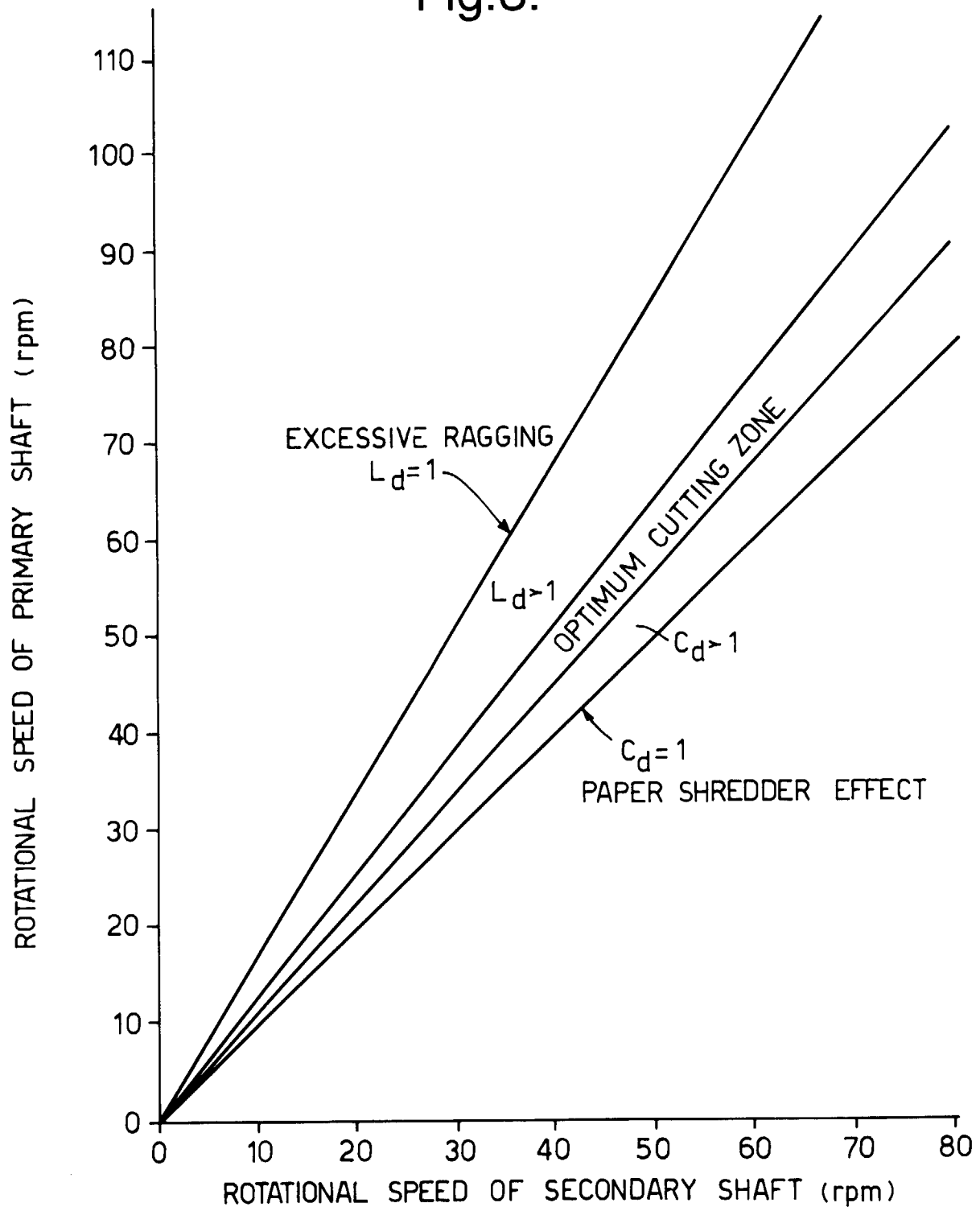


Fig.3.





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 0984

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US-A-4 723 717 (N.A. FAGNANT) * column 5, line 53 - column 7, line 67; figures 2,3,5 *	1-8	B02C18/24 B02C18/14
Y	GB-A-2 259 260 (MONO PUMPS LTD.) * the whole document *	1-8	
Y,D	GB-A-1 569 672 (J.W. CHAMBERS) * the whole document *	1-7	
A	US-A-5 048 764 (G.J. FLAMENT) * column 4, line 62 - column 7, line 60; figures 4,5 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B02C
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 25 April 1996	Examiner Verdonck, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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