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(54) **Title**: CRUSHING APPARATUS AND METHOD

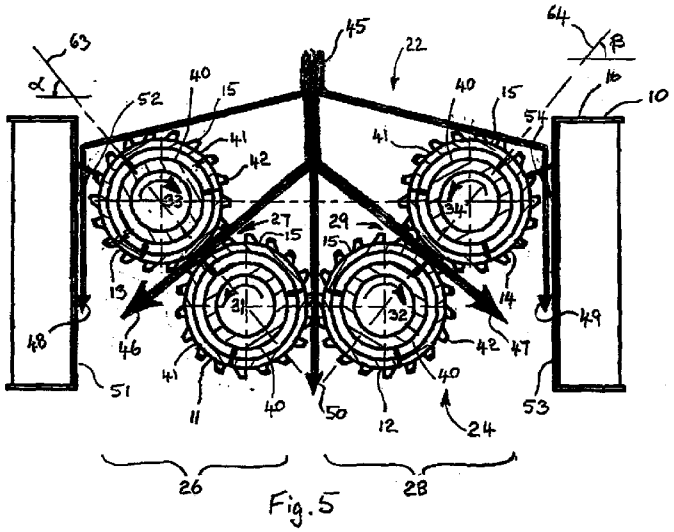


Fig. 5

(57) **Abstract**: A crusher (10) for mineral material has four rolls with (11-14) parallel horizontal axes (36-39). The rolls are in a casing (16) having a top opening (22) for ingress of the mineral material and a bottom opening (24) for its discharge after crushing. The rolls are arranged as two pairs (26, 28) with each pair positioned towards a respective side of the casing. For each pair the upper portions of the rolls rotate towards each other to draw the material into a gap (27, 29) therebetween. In each pair the axis of one roll is higher than the axis of the second roll. A plane (63) passing through the axes of one pair is inclined at greater than 45° while a plane (64) passing through the axes of the other pair is inclined oppositely at greater than 45°.

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CRUSHING APPARATUS AND METHOD

Field of the Invention

This invention concerns the use of crushers for crushing minerals such as rock, ore and coal.

Background to the Invention

Double roll crushers are well known in the mineral processing industry as a means for crushing minerals. They consist of a pair of inwardly rotating rolls mounted within a casing beneath a hopper which is loaded with the mineral material to be crushed. The mineral material is drawn between the rolls as they are inwardly rotated and the mineral is crushed. The rolls are spaced apart by a gap distance which is set according to the size of the crushed product desired. The feed material passes between the rolls when it is crushed sufficiently to fit through the gap.

The rolls typically have curved face plates (segments), fastened to the perimeter of the roll, which are replaced as they wear. The segments typically include outwardly extending protrusions or teeth which grip the mineral material and draw it into the gap between the rolls.

One type of such crusher is commonly referred to as a sizer. A sizer is essentially a double roll crusher with the distinguishing feature being that the rolls rotate relatively slowly. Typically, a sizer would operate below about 85rpm whereas a general purpose crusher would operate at a higher speed. The lower speed of the sizer reduces the amount of fines generation in the crushing operation. A consequence is that it significantly reduces the cost of washing the ore/mineral. The more uniform product produced also fetches a higher price, especially in the case of coking coal. There is also an environmental benefit because a coarser product is less prone to

generate airborne dust than is a fine product. For these reasons a sizer is often preferred over a crusher.

Sizers are commonly divided into two categories, namely secondary and tertiary sizers. The main difference is that a secondary sizer typically takes a 200 to 300mm nominal diameter feed product and reduces that down to about a nominal 125mm product whereas tertiary sizers typically take about a 125mm nominal diameter feed and reduce that down to about a nominal 50 to 60mm product. In normal mine operations, there would commonly be a preceding primary crushing to produce the 200 to 300mm lump size feed which is then fed to secondary and tertiary crushing operations.

A problem with inward rolling sizers is the relatively low throughput when compared with higher speed crushers. The cost to produce larger machines increases in a non-linear fashion so there is no economy of scale available from using larger machines. It can therefore be more cost effective to install two or more sizers of a smaller size rather than a single sizer having a larger capacity. However this increases the overall footprint of the crushing equipment.

Another problem is that it is awkward to replace the face segments on the rolls of a crusher of the type described above. Crushers of this type typically have rolls of about 600mm or 750mm diameter and 600mm, 900mm or 1200mm long. The segments are curved plates typically about 450mm to 600mm long. The components are therefore relatively heavy for manual handling and replacement of segments on a conventional roll crusher is notoriously awkward and difficult with the maintenance person having to climb into the crusher and stand on the rolls while replacing the segments.

An aim of the present invention is to provide a method and apparatus which overcome, or at least reduce, one or more of the abovementioned difficulties.

Summary of the Invention

Accordingly, in one aspect the invention provides an apparatus for crushing mineral material, said apparatus comprising four rolls, each said roll having a respective substantially horizontal longitudinal axis and each said roll being mounted parallel to the other said rolls in a casing which has an opening at the top for ingress of said mineral material and an opening at the bottom for discharge of said mineral material after said crushing, wherein:

- the rolls are arranged as two pairs of rolls with each said pair positioned towards a respective side of the casing;
- within each of said pairs the upper portions of the paired rolls rotate towards each other so as to draw said mineral material into a gap between them for crushing;
- within each said pair the axis of a first roll is higher than the axis of the second roll;
- a first plane passing through the axes of both rolls in a first of said pairs is inclined at a first angle of greater than 45° to the horizontal; and
- a second plane passing through the axes of both rolls in the second of said pairs is inclined at a second angle of greater than 45° to the horizontal.

Preferably said first angle has the same magnitude as said second angle. Preferably said first plane is inclined oppositely to said second plane.

Preferably said axes of said higher first rolls are at substantially the same height. Preferably said axes of said second rolls are at substantially the same height.

The lower of the rolls in each said pair may be located towards the centre of the casing. Alternatively the upper of the rolls in each said pair may be located towards the centre of the casing.

Preferably the casing is formed as two portions releasably fastened to each other and means are provided for separating the two portions to thereby provide access for a

person to enter between said pairs of rolls for maintenance of the rolls. Preferably the peripheral speed of one roll of each said pair is at least 5% greater than the peripheral speed of its paired roll.

In another aspect the invention provides an apparatus for crushing mineral material, said apparatus comprising a plurality of rolls, each said roll having a respective substantially horizontal longitudinal axis, and each said roll being mounted parallel to each other in a casing which has an opening at the top for ingress of said mineral material and an opening at the bottom for discharge of said mineral material after said crushing between the rolls, wherein said casing is formed as two portions releasably fastened to each other and means are provided for separating the two portions to thereby provide access for a person to enter between each portion for maintenance of the rolls.

Preferably said separation of the two portions is substantially along a centreline of the casing and parallel to said rolls.

In a further aspect the invention provides a method of crushing mineral material in a crusher comprising at least one pair of rolls, the rolls being mounted parallel to each other in a casing which has an opening at the top for ingress of said mineral material and an opening at the bottom for discharge of said mineral material after said crushing, wherein:

- the upper portions of said pair of rolls rotate towards each other so as to draw said mineral material into a gap between the pair; and
- the peripheral speed of one roll of said pair is at least 5% greater than the peripheral speed of the other roll of said pair.

Preferably the peripheral speed of one roll of said pair is in the range from 10% to 30% greater than the peripheral speed of the other roll of said pair and, more preferably, from 20 to 25% greater. The pair of rolls may rotate at the same rotational speed and said one roll has a greater diameter than said other roll. Alternatively, or in addition, said one roll may rotate faster than said other roll.

Brief Description of the Drawings

In order that the invention may be more fully understood there will now be described, by way of example only, preferred embodiments and other elements of the invention with reference to the accompanying drawings where:

Figure 1 is an isometric view of a crusher according to a first embodiment of the invention;

Figure 2 is a plan view of the crusher shown in Figure 1;

Figure 3 is an end view of the crusher shown in Figure 1;

Figure 4 is a side view of the crusher shown in Figure 1;

Figure 5 is a section view through A-A indicated on Figure 2 onto which is indicated the flow paths of mineral material through the crusher;

Figure 6 is an isometric view of the crusher in Figure 1 shown with its casing split and separated for maintenance; and

Figure 7 is a section view in the manner of Figure 5 through a crusher according to a second embodiment of the invention.

In Figure 7, components which are generally equivalent to components shown in Figures 1 to 6 are identified by a number which is 100 greater than the corresponding component in Figures 1 to 6.

Description of the Preferred Embodiment and Other Examples of the Invention

The crusher 10 shown in Figures 1 to 6 has four rolls 11, 12, 13 and 14 mounted in a casing 16. Roll 12 is hidden in Figures 1 and 6 but is shown in Figures 2 and 5. Each roll is independently driven by its own four-pole induction motor 18 driving through a reducer (gearbox) 20 having a reduction ratio of around 30:1. All four rolls have the same diameter, which is about 600mm, and are driven at the same speed. All the rolls therefore have the same nominal peripheral speed.

The casing 16 has a feed opening 22 at its top for ingress of the material to be crushed and an exit opening 24 at the bottom for discharge of the mineral material after it is

crushed. The casing 16 comprises a steel ladder-type frame 17 to which replaceable end frame liner wear plates 55 and side frame wall liner wear plates 57 are affixed from the inside of the casing.

Rolls 11 and 13 in combination form a first pair 26 of crushing rolls while rolls 12 and 14 in combination form a second pair 28 of crushing rolls. The direction of rotation of the rolls is shown by the arrows 31, 32, 33 and 34 in Figure 5. The upper portions 15 of the rolls 11 and 13 rotate inwards towards each other so as to draw the mineral material into the gap 27 between those rolls. Similarly the upper portions of the rolls 12 and 14 rotate inwards towards each other so as to draw the mineral material into the gap 29 between those rolls.

The rolls 11 to 14 have a journal (not visible in the drawings) at each end which engages with a respective bearing mounted into the casing 16. One end of each roll is driven by a respective motor 18 through a gearbox 20. The core portion 40 of each roll within the casing 16 carries curved wear plates (segments) 41 which are screwed onto the peripheral face of the core portion. Each segment 41 extends over one third of the circumference of the roll and, in the embodiment shown in Figures 1 to 6, each segment 41 extends for one third of the length of the roll within the casing 16. The segments 41 carry outwardly extending teeth 42.

A spring-loaded tramp relief mechanism 44 is provided on each of the rolls to reduce the maintenance required if a piece of steel is accidentally fed to the crusher.

As best seen in Figure 5, the feedstream 45 to the crusher 10 drops into the opening 22 at the centre of the top of the casing 16. Rolls 11 and 13 rotate inwards relative to each other, and rolls 12 and 13 rotate inwards relative to each other. The gap between rolls 11 and 13 and the gap between rolls 12 and 14 form the primary flow paths of material through the machine. These primary flow paths are indicated by the two large arrows marked 46 and 47 respectively in Figure 5. The discharge flows 46 and 47 are directed from the centre of the casing outwards towards the side wall liner wear plates 57.

There is a smaller clearance between rolls 11 and 12, and past the scraper comb 52 between roll 13 and the side wall 51 of the casing, and past the scraper comb 54 between roll 14 and side wall 53 of the casing. These clearances provide three secondary flow paths (shown by the smaller flow arrows 48, 49 and 50 in Figure 5) for material already undersize. Material passing through the secondary paths is not crushed in the apparatus and thus will not generate any additional fines. The material passing through the secondary paths reduces the amount of fines that has to pass through the primary flow paths 46 and 47 which accordingly reduces inter-particle crushing between lumps of material and thus reduces fines generation even further.

The capacity of the crusher 10 is theoretically estimated to be around 2.2 times the capacity of a crusher having only one pair of rolls of the same length and diameter, while the cost is less than twice that of the crusher having one pair of rolls.

There is a chosen clearance between the faces of rolls 11 and 13 and between the faces of rolls 12 and 14 and this clearance controls the maximum size (in one dimension) of a lump of mineral material which can pass through the crusher.

The longitudinal axis 38 of roll 13 is higher than the longitudinal axis 36 of roll 11, and the longitudinal axis 37 of roll 14 is higher than the longitudinal axis 39 of roll 12. A plane 63 passing through axes 36 and 38 is inclined at an angle α of 60° to the horizontal, and a plane 64 passing through axes 37 and 39 is similarly inclined at an angle β of 60° to the horizontal. Angles α and β have the same magnitude but are oppositely inclined. Angles α and β need not have the same magnitude in other embodiments. When described as being inclined oppositely it is meant the slope of the planes 63 and 64 are in opposite directions.

An advantage of having rolls 13 and 14 mounted above rolls 11 and 12 is that it reduces the footprint of the casing 16 when compared with a casing having the four rolls side by side. It also provides for better distribution of the material into the roll gaps. The advantage of having rolls 13 and 14 raised falls away quickly if the angle is

less than 45°. However the angle can be increased to almost 90° whereby rolls 13 and 14 are almost directly above rolls 11 and 12 respectively and may become close enough to provide an additional crushing function therebetween for the material then being fed into the crusher. This means that a single crusher can be operated as both a secondary and tertiary sizing operation in the one machine. This is a large advantage since a user can reduce the number of crushers in his processing plant.

As a modification of the embodiment described above, larger diameter rolls can be substituted for rolls 13 and 14 which are the higher rolls in the crusher 10. If driven at the same rotational speed as rolls 11 and 12, this would provide the rolls 13 and 14 with a higher peripheral speed than that of rolls 11 and 12 with which they respectively engage. An advantage of providing a speed differential between engaging rolls is that the material being crushed will be acted upon by greater shear forces as well as compressive forces. A peripheral speed differential between the opposing surfaces of engaging rolls could alternatively be provided by altering the rotational speed at which one roll in an engaging pair is driven. This could be achieved by using a different reduction ratio gearbox 20 on the respective drive assembly, or by using a variable speed drive on the respective electric motor 18 and then controlling the speed differential by electronic control of the variable speed drive.

The bearings supporting rolls 13 and 14 may be adjusted horizontally in the casing 16 in order to adjust the position of those rolls and the gap between them and rolls 11 and 12.

The casing 16 of the crusher is split along its centre 25 for maintenance purposes. As shown in Figure 6, the two halves 67 of the casing 16 can be separated by rolling one or each half on its respective wheels 59 (shown in Figure 3) until there is a gap 61 of at least 800mm. An operator can then enter through the gap 61 in the casing in order to easily replace the segments 41 on the rolls. Maintenance personnel then do not have to climb up on top of the crushing gap in order to perform this maintenance. During use of the crusher 10, the two halves of the casing are held together by simple

bolted fastenings. There is not a great load on those bolted fastenings during operation of the crusher as the rolls 11 and 12 are not being significantly pushed apart from each other by the material being crushed.

Each half of the crusher, with its rolls and drive assemblies, is identical to the other half. A mortise type joint 65 at each interface provides for improved rigidity of the join.

There is a large degree of commonality of parts in the casing, the drive motors and speed reducers, the roll assemblies and their replaceable wear components. This means there is less cost involved in keeping an inventory of spare parts. There is improved access for maintenance and improved maintenance ergonomics. The design creates more product streams through the crusher and a smaller footprint for the throughput. There is a natural feed distribution which results in uniform wear of the components. The crusher has a lower mass for its throughput and therefore has a reduced infrastructure cost. It provides for less fines generation so producing a higher quality crushed product. There is also partial redundancy in drives which results in improved plant availability. This is because if the pair of rolls on one side of the crusher are for some reason inoperative, the pair of rolls on the other side may still be operable thus still providing an output of up to about 50% of the fully operational throughput.

The invention also provides for a lower start-up torque under choked conditions compared with a twin roll crusher of the same capacity.

The crusher 110 shown in Figure 7 shares most of the features of the crusher shown in Figures 1 to 6. It has four rolls 111, 112, 113 and 114 mounted in a casing 116. All four rolls have the same diameter, which is about 600mm and are driven at the same nominal speed.

Rolls 111 and 113 in combination form a first pair 126 of crushing rolls while rolls 112 and 114 in combination form a second pair 128 of crushing rolls. The direction

of rotation of the rolls is shown by the arrows 131, 132, 133 and 134. The upper portions of the rolls 111 and 113 rotate inwards towards each other so as to draw the mineral material into the gap 127 between those rolls. Similarly the upper portions of the rolls 112 and 114 rotate inwards towards each other so as to draw the mineral material into the gap 129 between those rolls.

The feed to the crusher 110 drops into the opening 122 at the top of the casing 116. The gap 127 between rolls 111 and 113 and the gap 129 between rolls 112 and 114 form the primary flow paths of material through the machine. These primary flow paths are indicated by the two large arrows marked 146 and 147. The flow paths 146 and 147 are directed from near the side wall liner wear plates 157 inwards towards the centre of the casing 116.

There is a smaller clearance between rolls 111 and 112, and past the scraper comb 152 between roll 113 and the side wall 151 of the casing, and past the scraper comb 154 between the roll 114 and side wall 153 of the casing. These clearances provide three secondary flow paths (shown by the smaller flow arrows 148, 149 and 150) for material already undersize. Material passing through the secondary paths is not crushed in the apparatus and thus will not generate any additional fines.

The longitudinal axis 136 of roll 111 is higher than the longitudinal axis 138 of roll 113, and the longitudinal axis 139 of roll 112 is higher than the longitudinal axis 137 of roll 114. A plane 163 passing through axes 136 and 138 is inclined at an angle α of 60° to the horizontal, and a plane 165 passing through axes 137 and 139 is similarly inclined at an angle α of 60° to the horizontal.

An advantage of the configuration of crusher 110 compared with that of crusher 10 is that there is a further reduction in the generation of fines because there is less roll surface in contact with the stationary or slow moving feed material. Another advantage is that the more central discharge of crushed product from the rolls results in less wear on the chute (not shown) mounted below the discharge opening 124. In contrast, an advantage of the configuration of crusher 10 compared with that of

crusher 110 is that it would incur more symmetrical wear when used with an unchoked feed. This is because, with an unchoked feed at the opening 122 of the casing 116, the flow of material would in practice be unevenly distributed with more flow going to one pair of rolls than to the other, so the crusher 110 would suffer non-symmetrical wear.

A difference in the peripheral speeds of engaging rollers in a crushing pair in the crusher 110 can be created as described above in relation to crusher 10. To achieve this, larger diameter rolls can be substituted for rolls 113 and 114 in crusher 110, or the rolls can be driven at differing rotational speeds by using different ratio gearboxes or different speeds for the respective electric motors.

Whilst the above description includes the preferred embodiments of the invention, it is to be understood that many variations, alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the essential features or the spirit or ambit of the invention.

It will be also understood that where the word "comprise", and variations such as "comprises" and "comprising", are used in this specification, unless the context requires otherwise such use is intended to imply the inclusion of a stated feature or features but is not to be taken as excluding the presence of other feature or features.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that such prior art forms part of the common general knowledge.

Claims

1. An apparatus for crushing mineral material, said apparatus comprising four rolls, each said roll having a respective substantially horizontal longitudinal axis and each said roll being mounted parallel to the other said rolls in a casing which has an opening at the top for ingress of said mineral material and an opening at the bottom for discharge of said mineral material after said crushing, wherein:

- the rolls are arranged as two pairs of rolls with each said pair positioned towards a respective side of the casing;
- within each of said pairs the upper portions of the paired rolls rotate towards each other so as to draw said mineral material into a gap between them for crushing;
- within each said pair the axis of a first roll is higher than the axis of the second roll;
- a first plane passing through the axes of both rolls in a first of said pairs is inclined at a first angle of greater than 45° to the horizontal; and
- a second plane passing through the axes of both rolls in the second of said pairs is inclined at a second angle of greater than 45° to the horizontal.

2. An apparatus according to claim 1 wherein said first angle has the same magnitude as said second angle.

3. An apparatus according to claim 1 or 2 wherein said first plane is inclined oppositely to said second plane.

4. An apparatus according to any one of claims 1 to 3 wherein said axes of said higher first rolls are at substantially the same height.

5. An apparatus according to any one of claims 1 to 4 wherein said axes of said second rolls are at substantially the same height.

6. An apparatus according to any one of claims 1 to 5 wherein the lower of the rolls in each said pair is located towards the centre of the casing.

7. An apparatus according to any one of claims 1 to 5 wherein the upper of the rolls in each said pair are located towards the centre of the casing.

8. An apparatus according to any one of claims 1 to 7 wherein said casing is formed as two portions releasably fastened to each other and means are provided for separating the two portions to thereby provide access for a person to enter between said pairs of rolls for maintenance of the rolls.

9. An apparatus according to any one of claims 1 to 8 wherein the peripheral speed of one roll of each said pair is at least 5% greater than the peripheral speed of its paired roll.

10. An apparatus for crushing mineral material, said apparatus comprising a plurality of rolls, each said roll having a respective substantially horizontal longitudinal axis, and each said roll being mounted parallel to each other in a casing which has an opening at the top for ingress of said mineral material and an opening at the bottom for discharge of said mineral material after said crushing between the rolls, wherein said casing is formed as two portions releasably fastened to each other and means are provided for separating the two portions to thereby provide access for a person to enter between each portion for maintenance of the rolls.

11. An apparatus according to claim 10 wherein the separation of the two portions is substantially along a centreline of the casing and parallel to said rolls.

12. A method of crushing mineral material in a crusher comprising at least one pair of rolls, the rolls being mounted parallel to each other in a casing which has an opening at the top for ingress of said mineral material and an opening at the bottom for discharge of said mineral material after said crushing, wherein:

- the upper portions of said pair of rolls rotate towards each other so as to draw said mineral material into a gap between the pair; and
- the peripheral speed of one roll of said pair is at least 5% greater than the peripheral speed of the other roll of said pair.

13. A method according to claim 12 wherein the peripheral speed of one roll of said pair is in the range from 10 to 30% greater than the peripheral speed of the other roll of said pair.

14. A method according to claim 13 wherein the peripheral speed of one roll of said pair is in the range from 20 to 25% greater than the peripheral speed of the other roll of said pair.

15. A method according to any one of claims 12 to 14 wherein said pair of rolls rotate at the same rotational speed and said one roll has a greater diameter than said other roll.

16. A method according to any one of claims 12 to 14 wherein said one roll rotates faster than said other roll.

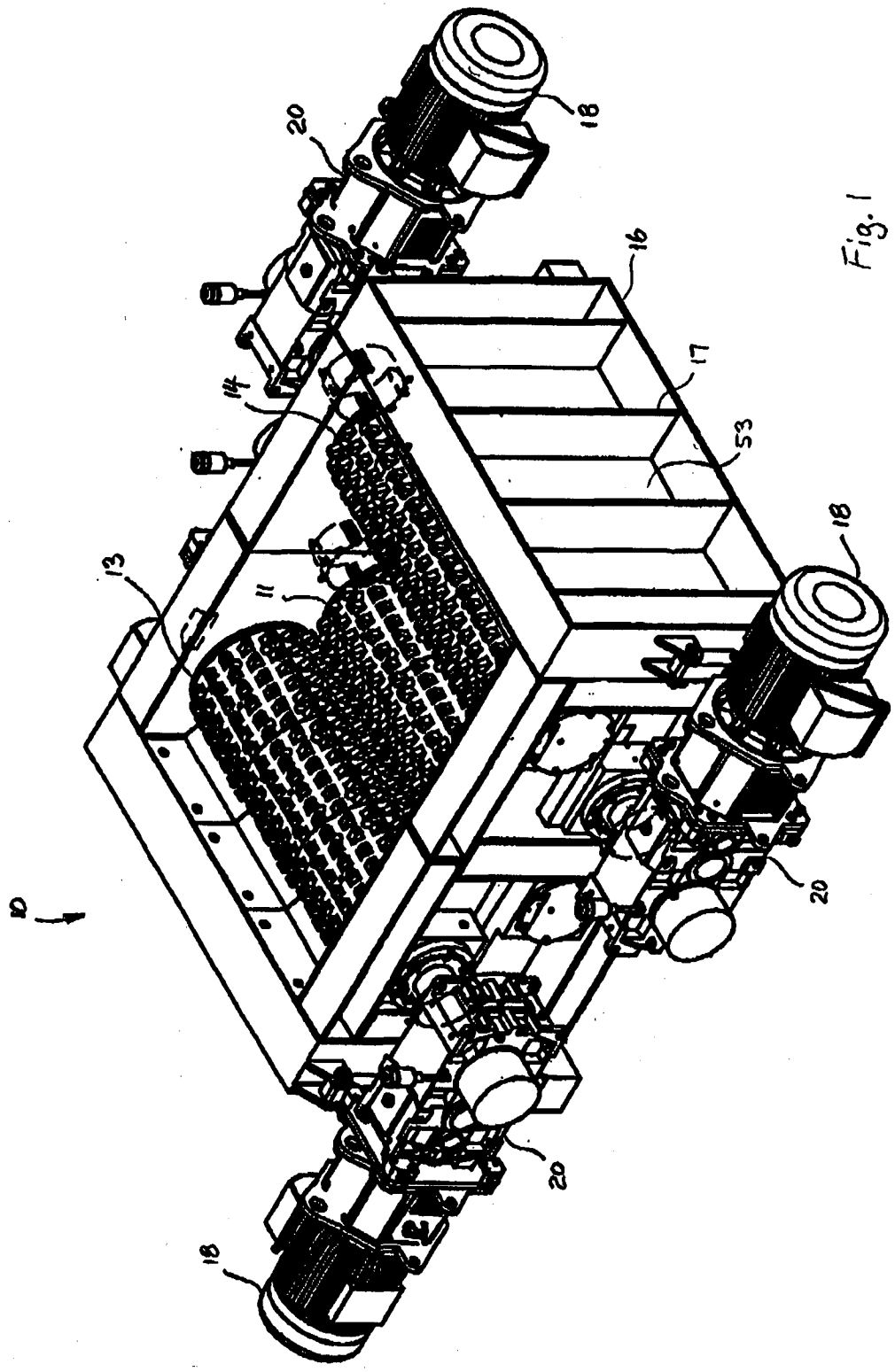


Fig. 1

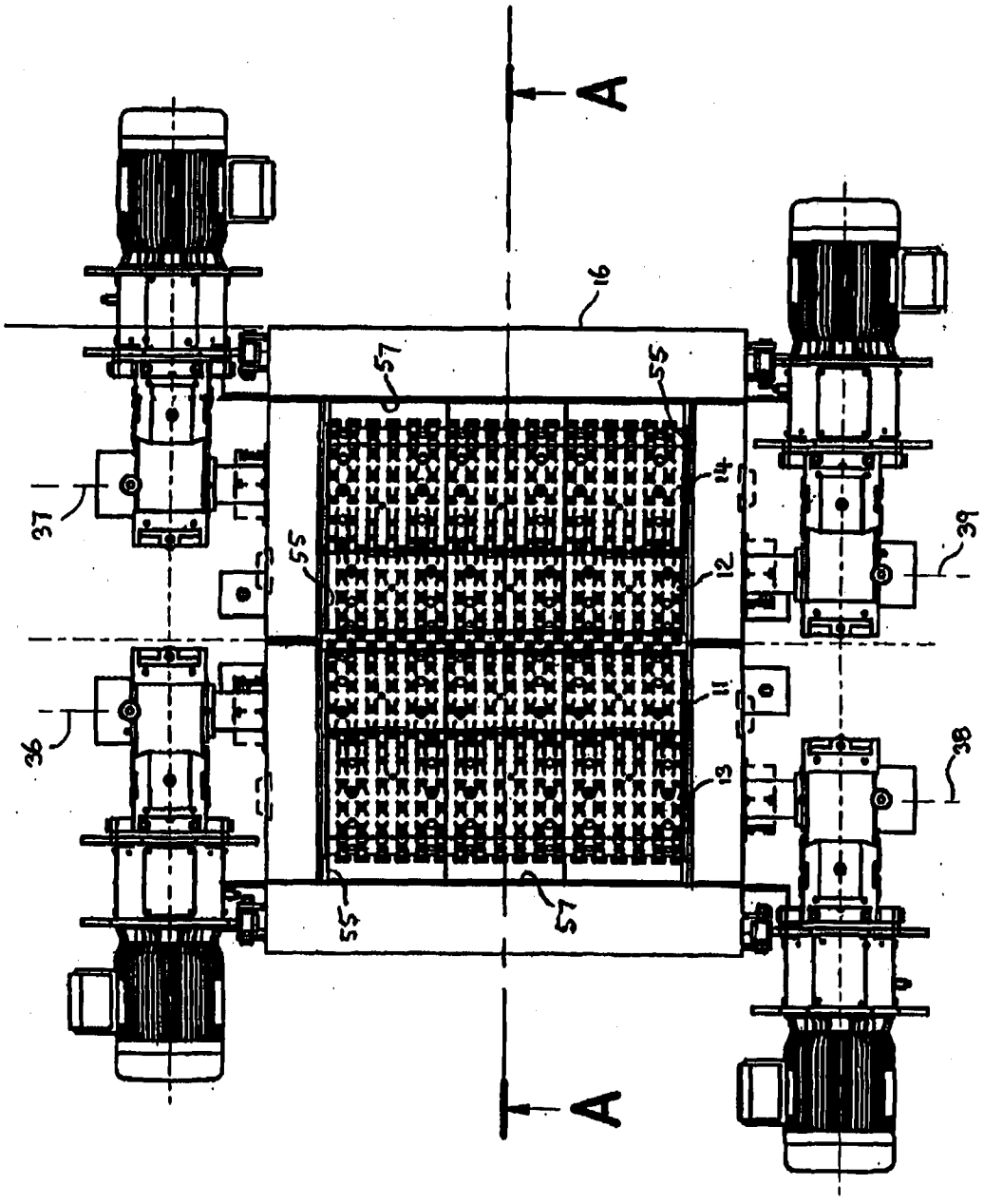


Fig.2

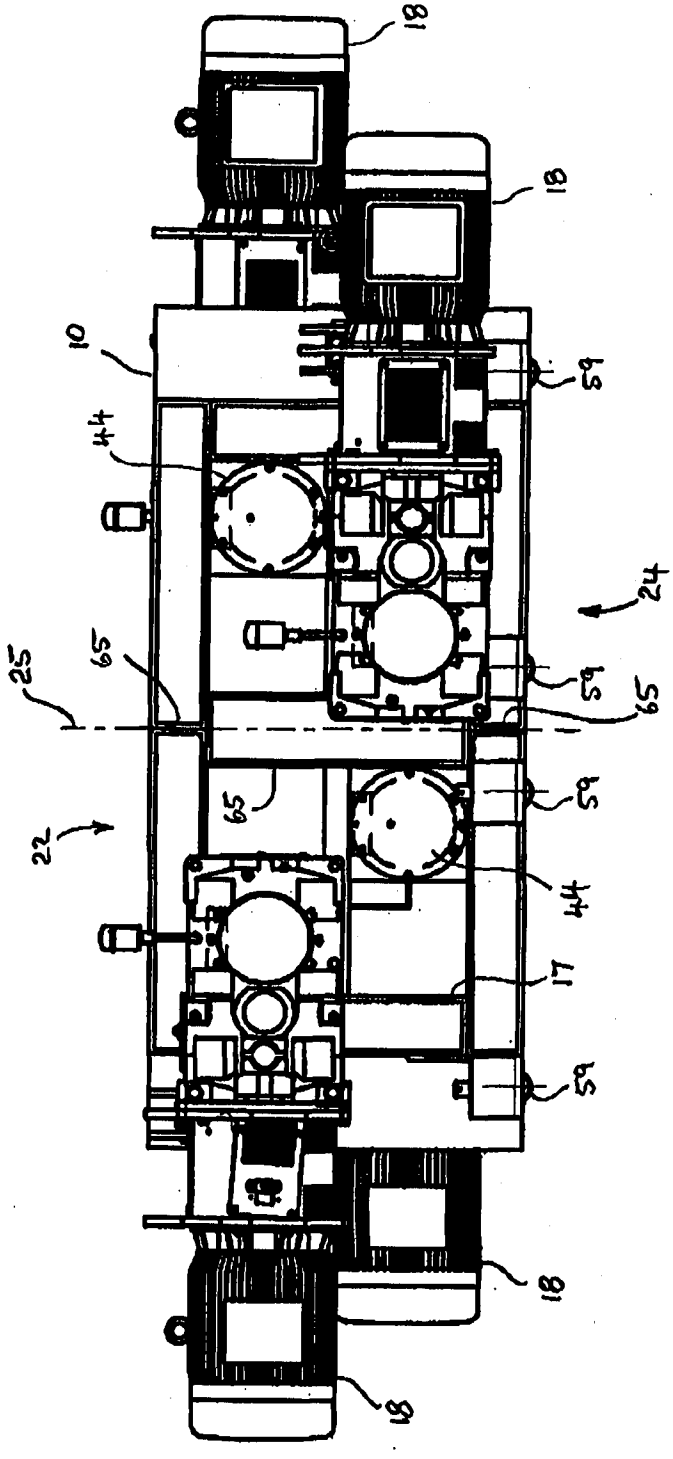


Fig. 3

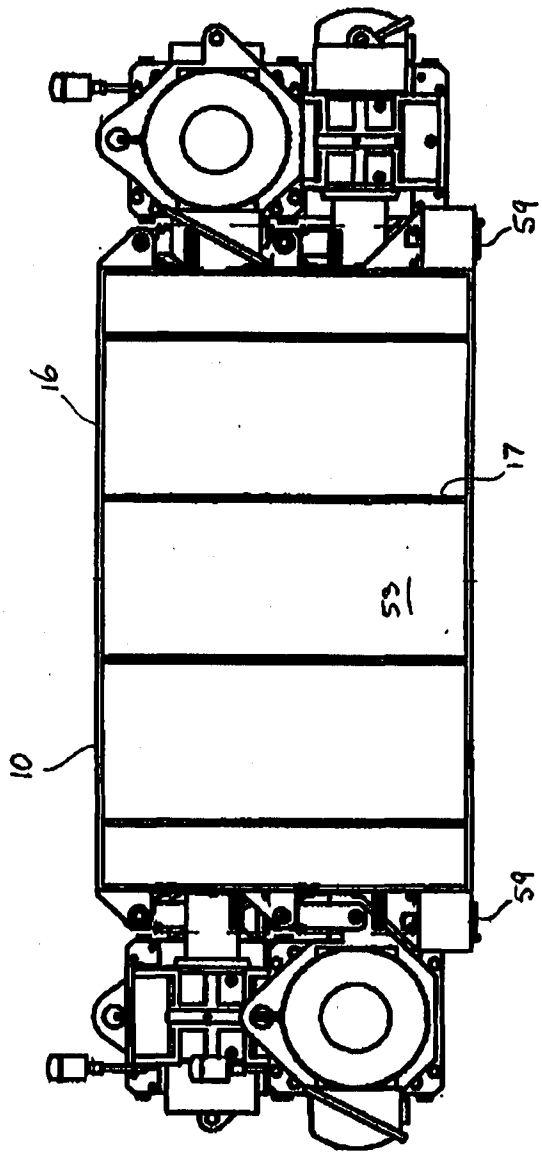


Fig. 4

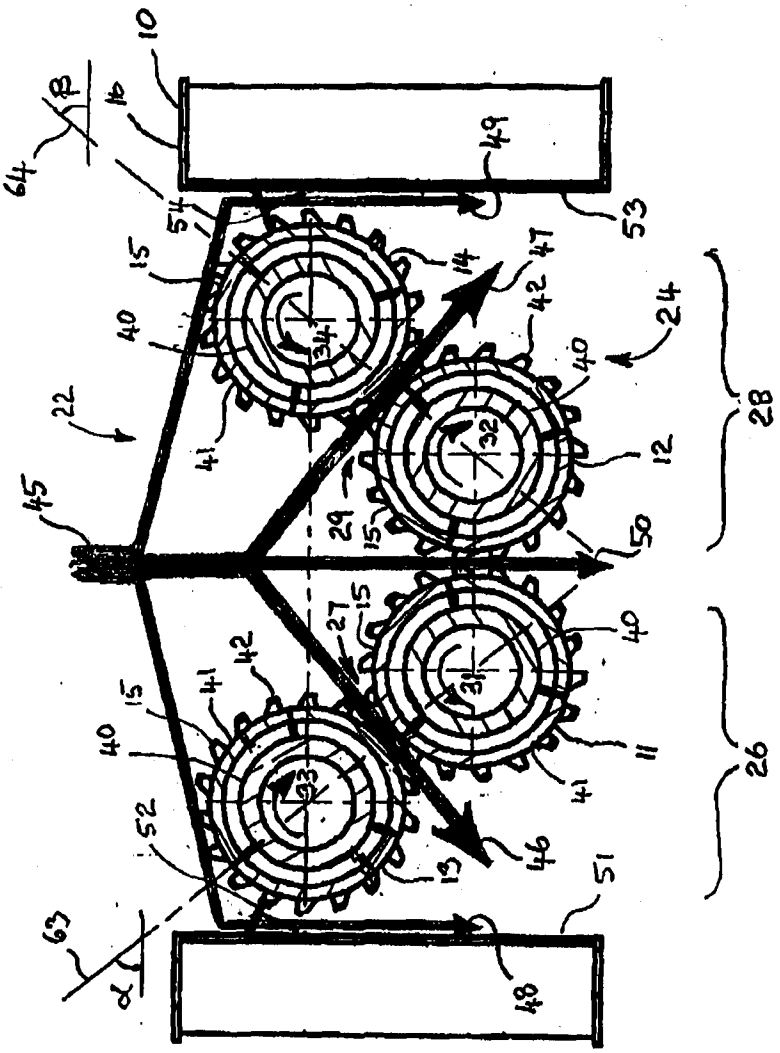

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Fig. 5

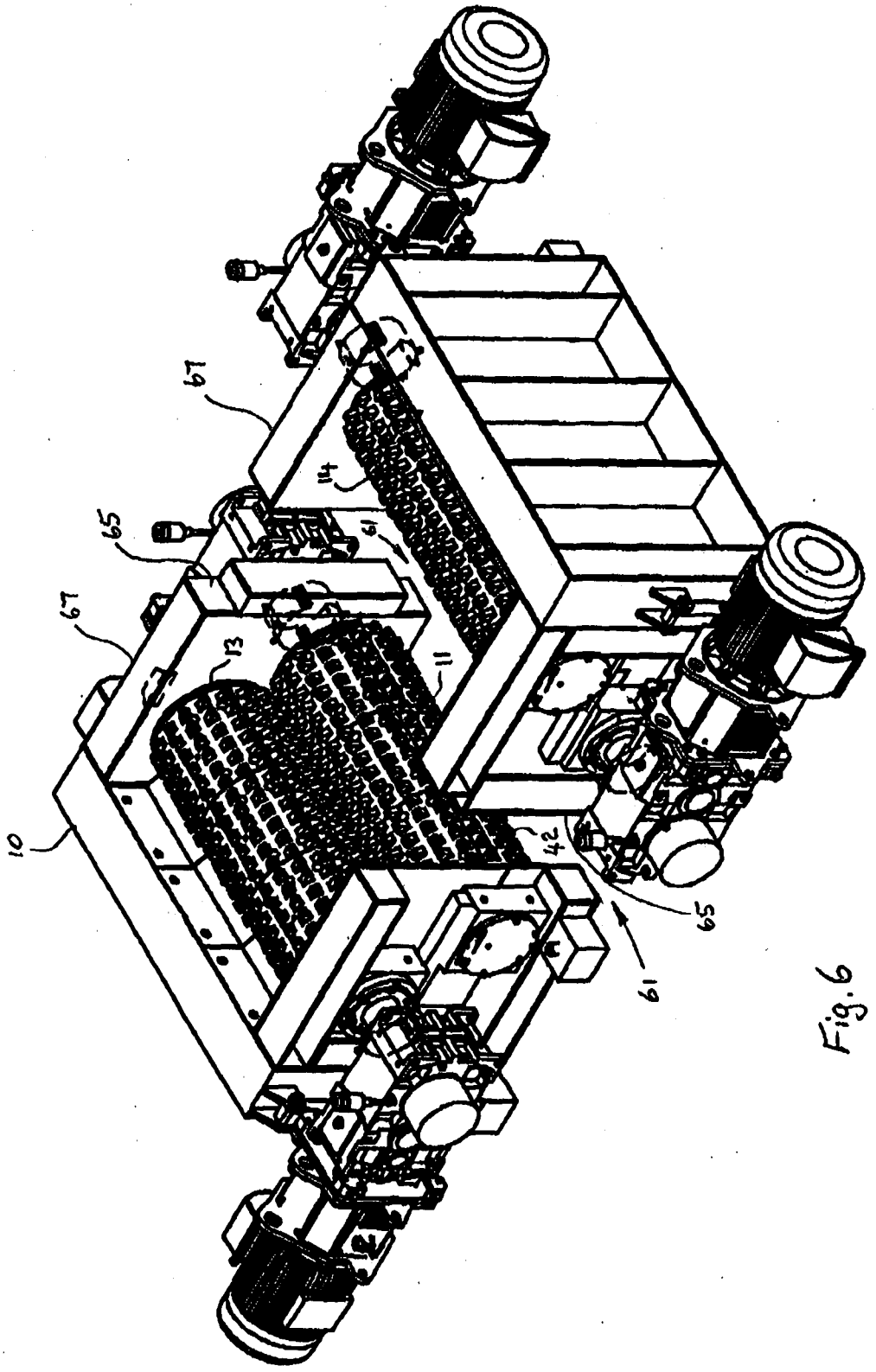


Fig. 6

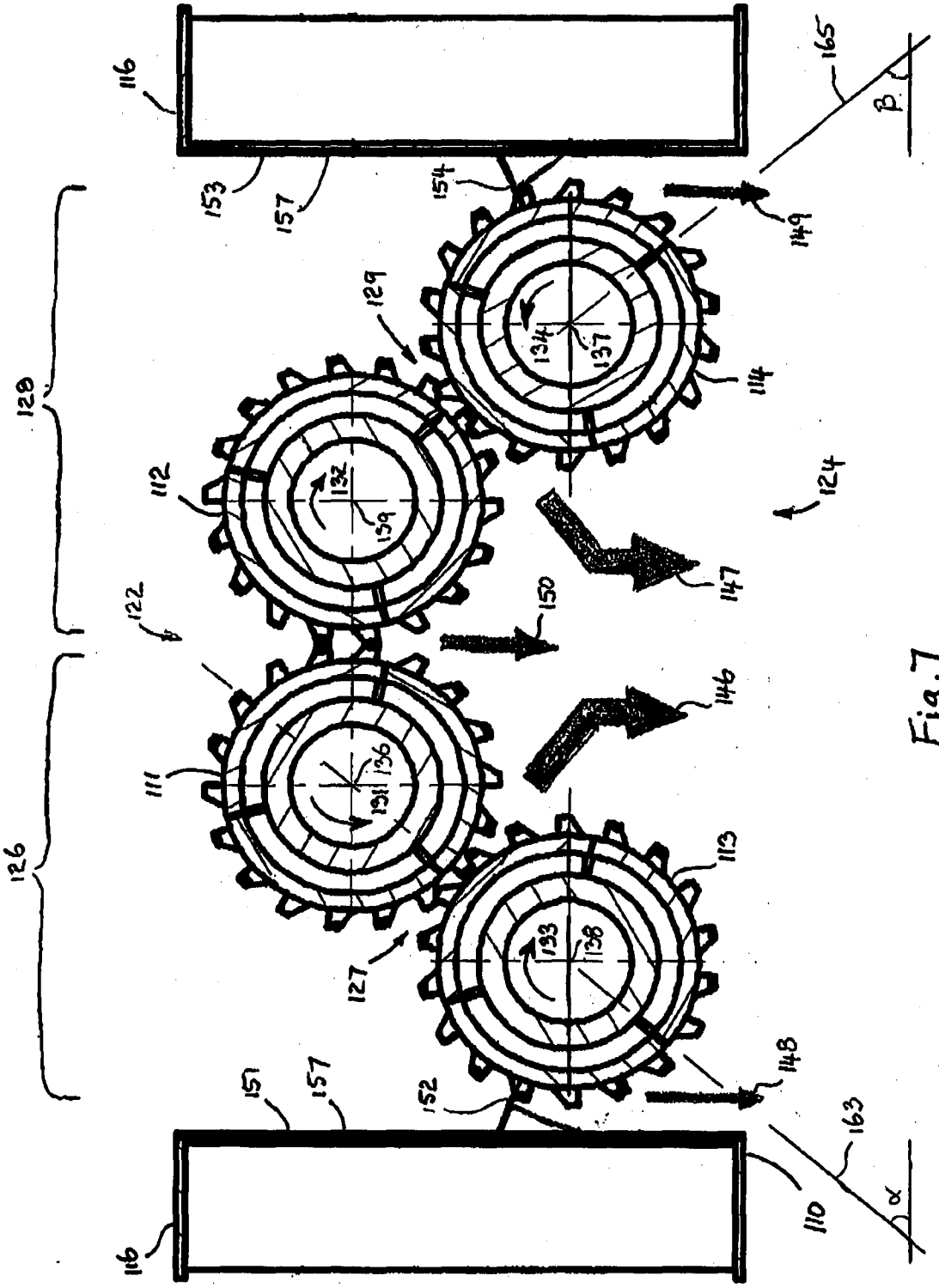

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Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000535

A. CLASSIFICATION OF SUBJECT MATTER

B02C 4/02 (OCT 2005) B02C 4/30 (OCT 2005)

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)

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

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

WPI, EPODOC: IC/EC (B02C4/-) & Keywords (PAIR, ROLLERS) and like terms

ESPACENET, USPTO, GOOGLE PATENTS & Keywords (CRUSHING, MULTIPLE, PAIR, ROLLERS) and like terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[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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Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2012	22 June 2012

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INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2012/000535**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 887322 A (SIMON LTD HENRY) 17 January 1962 page 2, line 89 - page 3, line 54; figures 3 - 4	1 - 16
A	CN 201807395 U (DALIAN BAOFENG MACHINERY MFG CO LTD) 27 April 2011 abstract - english version retrieved from EPODOC database	
A	SU 1494972 A1 (KOMMUNARSK METALL KOM [SU]) 23 July 1989 abstract - english version retrieved from EPODOC database	

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2012/000535**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
GB 887322 A	17 Jan 1962	CH 356010 A	31 Jul 1961
		DE 1116517 B	02 Nov 1961
		GB 887322 A	17 Jan 1962
CN 201807395 U	27 Apr 2011	None	
SU 1494972 A1	23 Jul 1989	SU 1494972 A1	23 Jul 1989

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.