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(12) (19) (CA) **Demande-Application**

(21) (A1) **2,271,121**
(86) 1996/11/13
(87) 1998/05/22

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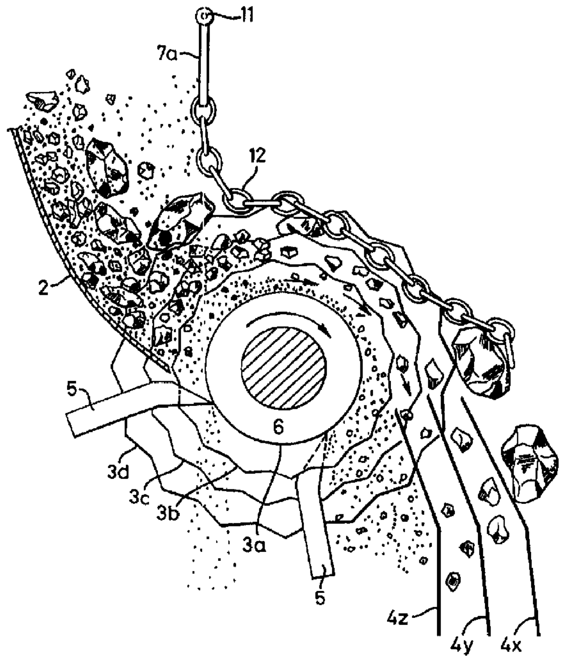
(51) Int.Cl.[6] B07B 13/04, B07B 1/15

(54) **SEPARATEUR DE SOLIDES**

(54) **SOLIDS SEPARATOR**



(57) Un séparateur de particules met en oeuvre plusieurs disques festonnés de diamètre différent tournant autour d'un axe avec des disques plus petits (3b) montés entre des disques de diamètre plus grand (3c) pour réaliser la séparation de matières de différentes gammes de dimensions dans l'alimentation. Le refus de tamisage est retenu à l'extérieur des disques de diamètre plus grand; les matières de dimension intermédiaire sont retenues à l'extérieur des disques de diamètre plus petit; et le tamisat passe entre les disques de diamètre plus grand et les disques de diamètre plus petit. Des collecteurs (4) sont utilisés pour séparer le refus de tamisage, les matières de dimension intermédiaire et le tamisat les uns des autres. Des sangles ou des chaînes (12) passés au-dessus du séparateur empêchent les matières de passer indûment dans la partie de refus.

(57) A particle separator is provided which uses a plurality of different diameter scalloped discs rotating on an axis with the smaller discs (3b) mounted between larger diameter discs (3c) to effect a separation of different size range materials in the feed. The oversize material is retained on the outside of the larger diameter discs; the intermediate size material is retained on the outside of the smaller diameter discs; and the undersize material passes between the larger and smaller diameter discs. Collectors (4) are used to separate the oversize, intermediate and undersize materials from one another. Straps or chains (12) draped over the separator discourage material from reporting falsely to the oversize fraction.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
B07B 13/04, 1/15

A1

(11) International Publication Number: **WO 98/20986**

(43) International Publication Date: 22 May 1998 (22.05.98)

(21) International Application Number: PCT/GB96/02754

(22) International Filing Date: 13 November 1996 (13.11.96)

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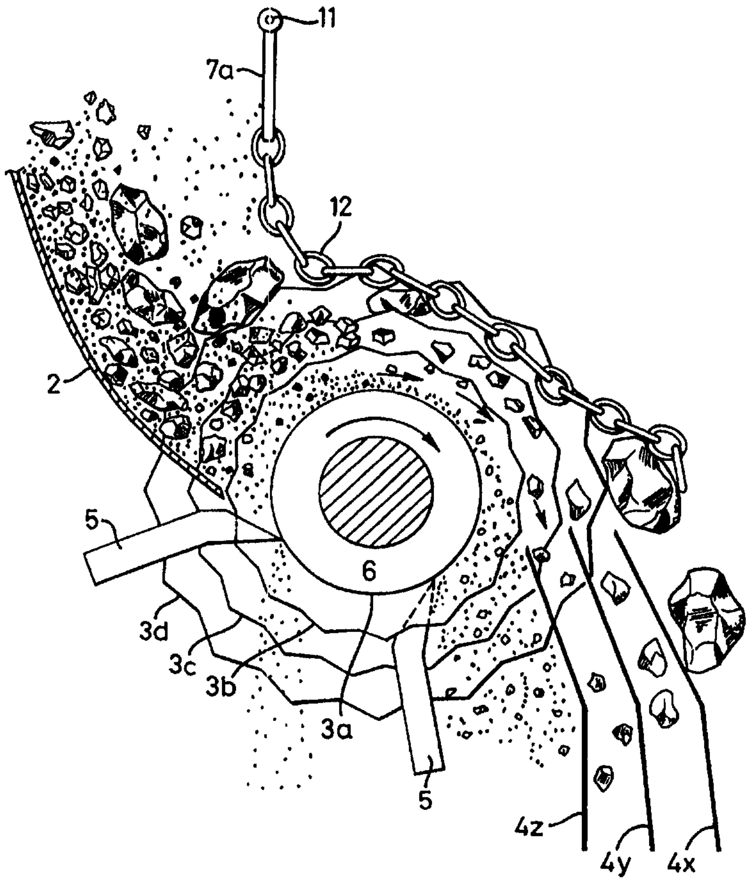
(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: SOLIDS SEPARATOR

(57) Abstract

A particle separator is provided which uses a plurality of different diameter scalloped discs rotating on an axis with the smaller discs (3b) mounted between larger diameter discs (3c) to effect a separation of different size range materials in the feed. The oversize material is retained on the outside of the larger diameter discs; the intermediate size material is retained on the outside of the smaller diameter discs; and the undersize material passes between the larger and smaller diameter discs. Collectors (4) are used to separate the oversize, intermediate and undersize materials from one another. Straps or chains (12) draped over the separator discourage material from reporting falsely to the oversize fraction.



SOLIDS SEPARATOR

The invention relates to a separator for particulate solids, for classifying particles according to size. The separator may be used for minerals such as coal or metallic ores, waste material such as hardcore, ash or soil, process feedstocks, foodstuffs such as in the form of granules, and other materials whether wet or dry.

The present invention seeks to provide a simple and efficient means of separating particulate materials and to dispense with a sizing bed, with consequent reduction in costs and liability to failure.

Conventional sizing apparatus, for example as disclosed in GB 448838 or GB 1087921, includes screens composed of interlocking arrays of eccentric rotating discs. Such apparatus contains many moving parts and is complex, expensive and liable to breakage, particularly when using coarse minerals.

According to the present invention a particle separator includes:

a rotor comprising a plurality of small discs mounted for coaxial rotation, a multiplicity of large discs having a greater radial dimension than the small discs and being mounted for rotation coaxially with the small discs, the small discs being located between the large discs via a spacer disc;

a feed adapted to provide a flow of particulate material impinging said rotor; and

a collector having means (such as a doctor with crenels or slots to accommodate the large discs, the merlons or edge of the doctor being arranged to co-operate with edges of the small discs) to collect material having a dimension allowing passage between the large discs but preventing passage between the small discs.

The edge of the doctor may abut the edges of the relevant discs or may be spaced from them, centrifugal force serving to propel a stream material outwardly from the centre of the rotor towards the collector. The collector may be positioned to catch correctly sized material taking into account the action of gravity on the outwardly moving stream.

A single rotor is preferred, although a succession of two or more apparatus in accordance with the invention may be used to make successive separations from a flow of material. The rotor may be perturbed e.g. vibrated radially.

The feed of unseparated material is preferably directed towards the rotor, more preferably towards the axis thereof, that is choke or partial choke feed. A tangential flow is not preferred for efficient separation. A free flow of unseparated material, that is under gravity, is preferred.

The large and small discs may be disposed alternately upon the rotor. Alternatively the discs may be arranged in any convenient sequence to suit the size analysis of the particulate material, for example each large disc may be separated by two or more small discs. The rotor may have an axle upon which the discs are mounted. Alternatively an axle may carry a drum upon which the discs are mounted, the drum having a diameter substantially larger than that of an axle, for example up to 1 m. The large discs may themselves have different diameters according to their axial location on the rotor, preferably being largest at the middle of the rotor axis and progressively smaller towards the ends.

More than two sizes of discs may be employed.

Intermediate discs having a dimension between that of the large and small discs may be disposed between the latter upon the rotor. A plurality of collectors may have doctors arranged to collect material from the edges of each of the intermediate discs.

A cleansing collector may be provided to clean the rotor during each revolution. The tines of the cleansing collector preferably pass between all of the discs to remove any particles lodged between them. Preferably, the circumferential locations of axially successive tines differ. The cleansing collector may be located at any convenient position between the first collector and feed during rotation of the rotor.

The discs are preferably circular. In a preferred embodiment of the invention, the large discs are provided with a segment removed to form a peripheral notch. This prevents oversize pieces of material from becoming stationary upon the rotor by engaging such pieces and impelling them forwards. Alternatively, those discs, or all the discs, may have a non-circular periphery, e.g. polygonal or scalloped-edged.

In a first embodiment of the invention all of the discs are arranged to rotate at the same speed and may be secured on a common axis.

In a second preferred embodiment of the invention selected discs or disc segments may rotate at a different speed or may be stationary. This has the advantage of reducing adhesion of material between the rotors. To prevent particles from being thrown out of the separator centrifugally or by bouncing outwardly when landing on a rotor disc, the separator according to the invention may have restraint means which, over part of the periphery, inhibit particles from leaving the separator radially of the discs.

Separators according to the invention can be made small enough to be conveyed more easily to temporary sites than is the case with conventional shaking-screen separators.

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

Figure 1 is a schematic elevation of apparatus in accordance with the invention,

Figure 2 shows a rotor in plan view for the apparatus in Figure 1,

Figure 3 shows a variant of the Figure 2 rotor in plan view,

Figure 4 shows an alternative rotor in plan view, with associated feed and collector arrangements,

Figures 5 and 6 show alternative patterns of disc which may be used in the rotors,

Figure 7 is a schematic end elevation in cross-section of apparatus using a rotor similar (but not identical) to that of Figure 4,

Figure 8 is a plan view and Figure 9 an end elevation of a further alternative rotor, and

Figure 10 shows an alternative embodiment of the invention having an adjustable collector.

The apparatus shown in Figures 1 and 2 comprises a conveyor 8 arranged to deposit particulate material, such as coal, after a drop of 1 metre upon a spreader or collector plate 1, at a rate of 50 tonne/hour for a typical mined coal feed. The spreader 1 is arranged to distribute material evenly across the surface of a 1-m-radius curved feed chute 2, which is arranged, as best seen in Figure 10, by reason of its lower (trailing) edge conforming fairly closely to a rotor 3 and pointing towards the axis thereof, to give a “choke” or “partial choke” feed 2a to the rotor 3. Returning to Figure 1, the spreader plate 1 is provided with an end pivot and adjustable portion 1a to control the flow to the rotor. The spreader 1 and chute 2 may co-operate to emulate a hopper chute (or a hopper chute may indeed be provided). A curtain of heavy chains or a resiliently sprung board (not shown) may hang from the lower end of the spreader plate 1/1a, to allow oversized particles to travel clockwise out of the feed area but to encourage normal particles to enter the rotor. The chute 2 need not be curved. It may be mounted at 50 to 70 to the horizontal and offset from being strictly radial to the rotor, i.e. its lower edge terminates at the height of the axis of the rotor or not much above it. The rotor, as shown in Figure 2, comprises an axle 6 carrying a multiplicity of circular discs. Alternate discs 3c have a radius of 200 mm, some 50 mm larger than smaller discs 3b disposed between them. In other versions, consecutive larger discs 3c have two, three or four smaller discs 3b between them. The discs are separated axially by spacers 3a some 10 mm thick in the axial direction and of radius around 90 mm. The spacers 3a may be mounted coaxially or eccentrically.

Figure 3 shows an alternative rotor. Here, consecutive larger discs 3c have three smaller discs 3b between them. The larger discs 3c are themselves graduated in size, from 500 mm at each end of the rotor 3 to 1 m at the centre. This arrangement counterbalances the tendency of any typical conveyor 8 to deliver more material along the centre line of the belt than at the edges, which could overload the "Fig 2" rotor at the centre notwithstanding spare capacity at its ends. The "Fig 3" rotor, by virtue of the graduated discs 3c, will tend to redistribute excess material delivered at the centre, towards the ends.

The feed 2 is adjustable to give a wide range of feed angles at its lower edge into the rotor, from 30-75 to the horizontal, preferably (as stated) 50-70, to suit the feed material size analysis, moisture content and specification (properties such as hardness, density and shape).

In use of the apparatus, material having a dimension less than the separation between the small and large rotors can pass between them and fall into a chute 9. Large particles of material which cannot pass between the large discs 3c are deflected from the periphery of the rotor into a second chute 10. Material having a dimension such that it may pass between the large discs 3c but not between the small discs 3b is collected by a slotted collector 4 which approaches to just short of the edges of the small discs and wherein the slots are to accommodate the large discs. This intermediate sized material may be collected in the chute 10 with the larger material or may have its own collection chute (not shown).

A cleanser has tines 5 arranged to pass between all of the discs up to just clearing the surface of the spacers 3a. The tines may be located downstream of the collector 4 at any position upstream of the chute 2. In this example, alternate tines 5 are at the "6 o'clock" position and the others at the "9 o'clock" position. Staggering their circumferential positions in this way minimises the risk of a seizure; when an oversized particle jammed between adjacent discs 3 hits a tine 5, the discs can flex to release the particle.

A heavy upright plate pivoted at its top edge forms a barrier 7 which serves to prevent material entering the apparatus from overshooting into the collector 10.

A peripheral notch, or serrated circular arc, or scalloping, cut from the edge of some or each of the large discs 3a as shown in Figure 5 serves to prevent large pieces of material becoming seated upon the rotor. The impulse given to a large piece by the notch or other shaping of the edge of the rotor causes the piece to be impelled through the barrier 7 into the collector 10. Thus, Figure 5 illustrates a disc wherein two peripheral segments are removed or the disc edges curve or are serrated to eject large particles from the rotor. The angular extent 2 of the notch may be determined by the size and shape of material. For example pieces of slate may require use of comparatively large notches or serrations. It is preferred that all of the material to be separated can pass between the largest discs, only exceptionally large pieces requiring use of the notches. The elliptical disc shown in the lower part of the figure may be used alternatively to achieve the same function. A further alternative disc shape is regular polygonal (e.g. 24 sides) or scalloped; this gives extra agitation to particles before they drop into an inter-disc slot, thus, especially in the case of damp "sticky" feed, assisting the accuracy of classification. The degree of agitation-enhancement is directly related to the radial height of the scallops. The greater the agitation, especially around the "12 o'clock" position, the more the separation action is improved; particularly, finer particles are less likely to ride on coarse particles and report erroneously to the "coarse" discharge. Scalloped discs also help prevent wet feedstock from forming a static immobile bed 2a. Preferably, and especially preferably where hopper chute feed is employed at 1/1a/2 or chains are present, all the discs 3 are scalloped, with the largest discs (3c, 3d or 3e as the case may be) having larger, deeper, more exaggerated scalloping than the smaller discs. Figure 6 shows an elliptical disc which could be used, with long axes either aligned or offset.

Referring to Figures 1, 7 and 10, material (under "free flow") enters the rotor assembly as a "choke" or "partial choke" feed (i.e. this could be at 30-45 degrees from the horizontal for example depending on disc aperture, material analysis and moisture). A change of direction is required as material is "conveyed" round the disc periphery. At this point acceleration of all particles occurs in the new direction of rotation causing:-

(i) Primary separation of particles upon impingement with the rotor and dependent on the degree of free flow feed conditions and "open area" presented;

(ii) Secondary separation as material changes direction and is accelerated/re-adjusted by the smaller disc tip (circumference) and larger disc sides;

(iii) Tertiary separation of previously adhered fine particles to larger/coarse material. This is caused through contact/rubbing between "oversize" particles and the disc sides/edges upon acceleration and material re-adjustment on the "peripheral conveyor".

All undersized material from (i), (ii) or (iii) is caused to be released between the small discs into the chute 9. Options of larger material are dependent on the position of the collector 4. In such cases the peripheral velocity of the discs could be greater than the flow of material onto the rotor (in that direction).

Figure 4 illustrates an alternative rotor having discs 3c, 3d with radii intermediate between those of the small discs 3b and large discs 3e. Material having a dimension greater than the separation between the outer discs 3e is excluded from the rotor. Material having a smaller dimension can enter the rotor.

Particles smaller than the separation between discs 3d and 3e but greater than that between discs 3c and 3d may be removed by a collector abutting the edge of the discs 3c. Smaller material which is able to pass between the plates 3c and 3d can similarly be collected by tines of a collector abutting the edges of the discs 3b. Fine material can pass unimpeded through the rotor. To exploit this separation, a collector 4, or as shown in Figures 4 and 7, a multiplicity of circumferentially spaced collectors 4 (4w, 4x, 4y, 4z), may be employed. Collector 4w, for the coarsest fraction, acts as a doctor and stands just clear of the largest discs 3e. Collector 4x, for the next-to-coarsest fraction, likewise acts as a doctor as it projects radially inwardly as far as the next largest discs 3d, with crenels in the form of slots or cut-outs to allow the discs 3e to rotate. Collector 4y, for the next-finer fraction, projects even further radially inwardly, namely up to the smaller discs 3c, and has cut-outs to clear the discs 3e and 3d. Finally, collector 4z, for the next-to-finest fraction, has interdigitations projecting radially inwardly to the smallest discs 3b, with slots or cut-outs to clear the discs 3c, 3d and 3e. The very finest fraction of particles passes into the gaps between the discs 3b and the adjacent discs and can drop out of the separator via the rear side of the collector 4z. (The separator shown in Figure 7 omits discs 3e and the corresponding collector 4w.)

The variety of sizes of disc 3 helps the preseparation of the particles as they fall into the separator and reduces the likelihood of fine particles reporting falsely to the coarse fraction.

The height of the drop from the conveyor 8 to the feed chute 2 (e.g. ½ m for dry feed, 1 m for damp feed), the abrasive action of the curtain of chains (not shown) and the abrasive action of the straps 12 all further help to reduce false reporting, by detaching small particles which are riding on larger ones. The separation is further improved by vibrating the axle 6, preferably vertically, at a high amplitude with low frequency (e.g. by cam action) if organised mechanically, or at a small amplitude with high frequency if organised electrically, thus e.g. 10 mm/50 Hz or 1 mm/500 Hz. This will afford a circumferential jigging action.

Figure 8 shows a plan view and Figure 9 an elevation of an alternative arrangement for separating fine material from larger pieces. The larger and smaller discs 20 and 21 are formed as a unitary construction so as to present a series of grooves into which fine matter may pass. Coarse material may be removed from the surface of the rotor by a collector 22 (the disc 20/21 being enclosed by larger carrying discs 30).

Figure 10 illustrates a modification of the invention having a collector movable about a pivot 14 to adjust the radius of the ends of the tines between a first position adjacent the edge of the rotor and a second position adjacent smaller discs 3b. This allows the size of material collected to be adjusted as required. The speed of the rotor may also be adjusted for example between 75 and 300 rpm to further control the degree of separation, a slower speed increasing the proportion of particles classified as “fine”, all other things (such as feedstock size distribution, feed rate, moisture content and chute angles/positions) being equal. Such adjustability is not readily achieved with previously known separation apparatus. In addition the collector may be moved radially around the rotor. This allows the position of the ends of the tines to be adjusted to compensate for the effect of gravity on the stream of material propelled from the rotor.

In alternative embodiments of the invention the spacing between some or all of the discs may be adjustable to regulate the sizes of particles separated.

Figures 7 and 10 show that the feed chute 2 need not be especially curved and can terminate either around the “10" or “11 o'clock” positions or even as low as the “9 o'clock” position, provided a bed of finer particles has already formed, in other words there is choke feed, shown as 2a, in which circumstances material to be classified can be conveyed uphill on such bed by the clockwise rotating rotor 3, even if wet (in which case scalloped discs are more reliable). Figure 7 also shows that the discharge duct(s) 4 may have its (their) upper (leading) edge level with, or lower than, the “3 o'clock” position, the discharge ducts - when there are more than one - preferably having their upper edges at the same height.

The cleanser tines 5 may be located at the “8 o'clock” position (to be clear of the chute 2), or at 5 or 6 o'clock, or, as shown, alternately, and serve not only to remove jammed particles but also to scrape the spacers 3a clean of adherent fine particles. An advantage of locating alternate tines at different positions is that when a tine engages a jammed particle, the discs can flex relatively unhindered to release the particle.

Figure 7 shows a variation of the pivoted barrier 7 of Figure 1. A heavy plate 7a as wide as the rotor 3 hangs from a pivot 11 above and parallel to the rotor 3, before top dead centre. Hanging from the lower edge of the plate 7a is a heavy curtain 12 of leather, rubber or other slightly flexible and not too slippery material. The curtain 12 is deeply fringed, and may be considered as a set of laterally abutting straps. More effectively still, the curtain 12 may consist of numerous closely spaced heavy chains welded to the bottom of the plate 7a, as shown schematically. The curtain rests draped generally on the “12 to 3 o'clock” quadrant of the rotor 3, and acts to restrain particles which bounce outwardly and would otherwise report falsely to the “coarse” collector 4x.

Indeed the curtain, by its weight, even tends to push particles radially inwardly, further reducing the incidence of undersized particles reporting to the coarser fractions. This action is enhanced in the case of scalloped discs 3d, which both drive particles clockwise against the friction of the curtain 12 and cause the curtain to ripple and bounce, giving a more dynamic impact of the curtain on the particles. These are all beneficial results of the effect of the curtain in lengthening the residence time of particles in the separator, thus lengthening their opportunity to undergo correct classification, without reducing the throughput of the separator. Friction between the particles and the curtain also helps to dislodge fine particles which are adhering to coarse particles, further improving the quality of the classification.

The curtain 12 may be alternative, or additional, to the chains hanging from 1/1a of Figure 1. The breadth of the chain links or straps and the spacing of the chains are optimised for the material. The chain links or straps may be small enough to go between discs 3c (Fig. 7) or larger, such that they ride on top of those discs, as drawn.

CLAIMS

1. A particle separator including:

a) a rotor comprising a plurality of small discs mounted for coaxial rotation, a multiplicity of large discs having a greater radial dimension than the small discs and being mounted for rotation coaxially with the small discs, the small discs being located between the large discs via a spacer disc;

b) a feed adapted to provide a flow of particulate material impinging said rotor;

c) a collector having means to collect material having a dimension allowing passage between the large discs but preventing passage between the small discs.

2. A separator according to claim 1 in which the large and small discs are disposed alternately upon the rotor.

3. A separator according to claim 1 in which each large disc is separated by two or more small discs.

4. A separator according to any preceding claim in which the large discs have different diameters according to their axial location on the rotor.

5. A separator according to any preceding claim in which more than two sizes of disc are employed.

6. A separator according to any preceding claim in which the rotor has an axle upon which the discs are mounted or in which an axle carries a drum upon which the discs are mounted.

7. A separator according to any preceding claim in which the feed of unseparated material is directed towards the axis of the rotor.

8. A separator according to any preceding claim in which two or more rotors are used to make successive separations from a flow of material.

9. A separator according to any preceding claim in which intermediate discs having a dimension between that of the large and small discs are disposed between the latter upon the rotor.

10. A separator according to claim 9 in which a plurality of collectors have tines arranged to collect material from the edges of each of the intermediate discs.

11. A separator according to any preceding claim in which a cleansing collector is

provided to clean the rotor during each revolution.

12. A separator according to claim 11, wherein the cleansing collector comprises tines projecting radially inwardly between the discs.

13. A separator according to claim 12, wherein the circumferential location of axially successive tines differs.

14. A separator according to any preceding claim, wherein at least some of the discs have a non-circular periphery.

15. A separator according to claim 14, in which the large discs are provided with a segment removed to form a peripheral notch or serrated circular arc.

16. A separator according to claim 14 or 15, wherein the said periphery is notched, polygonal or scalloped-edged.

17. A separator according to any preceding claim in which selected discs or disc segments may rotate at a different speed or are stationary.

18. A separator according to any preceding claim, further comprising restraint means which, over part of the disc periphery, inhibit particles from leaving the separator radially of the discs.

19. A separator according to any preceding claim, wherein the feed is a chute or hopper wherein the feed direction is towards the rotor axis between the horizontal and the vertical.

20. A separator according to any preceding claim, wherein the means to collect material having the said dimension is a doctor with crenels or slots to accommodate the large discs, the merlon or edge of the doctor being positioned just clear of the edges of the small discs.

21. A separator according to any preceding claim, further comprising means for perturbing the rotor radially.

22. A method of separating material using the separator of any preceding claim.

23. A method according to claim 22 in which the material is coal.

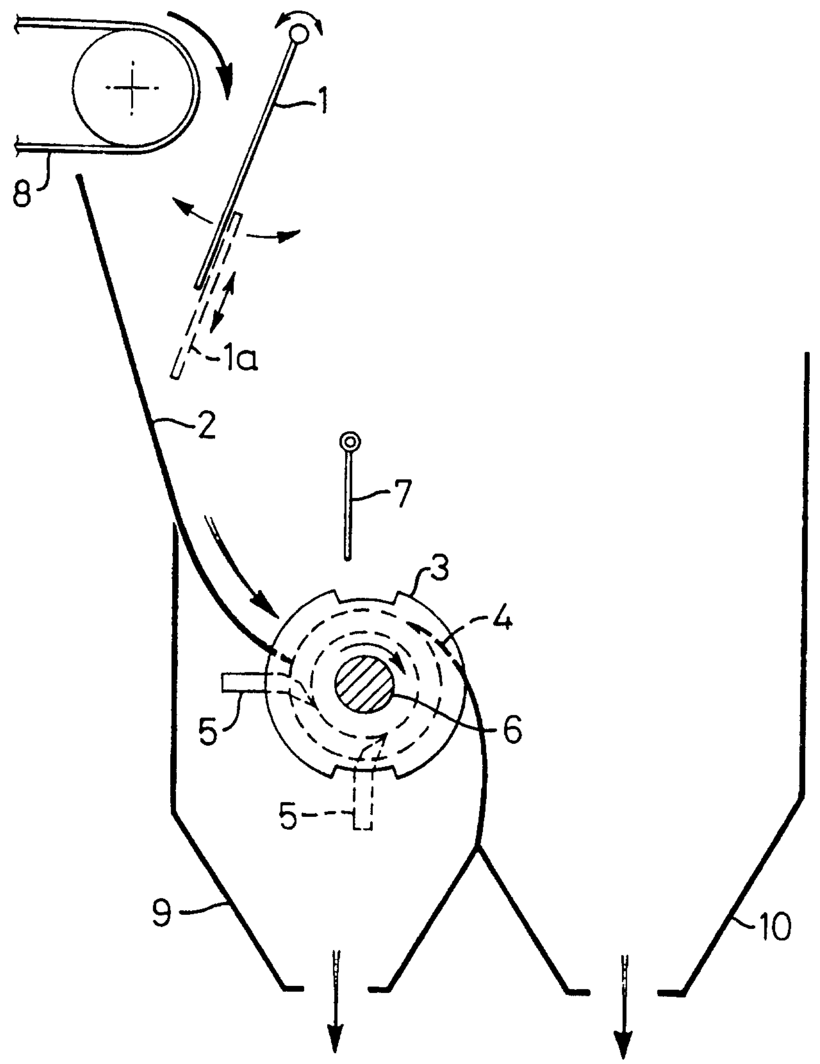


Fig.1

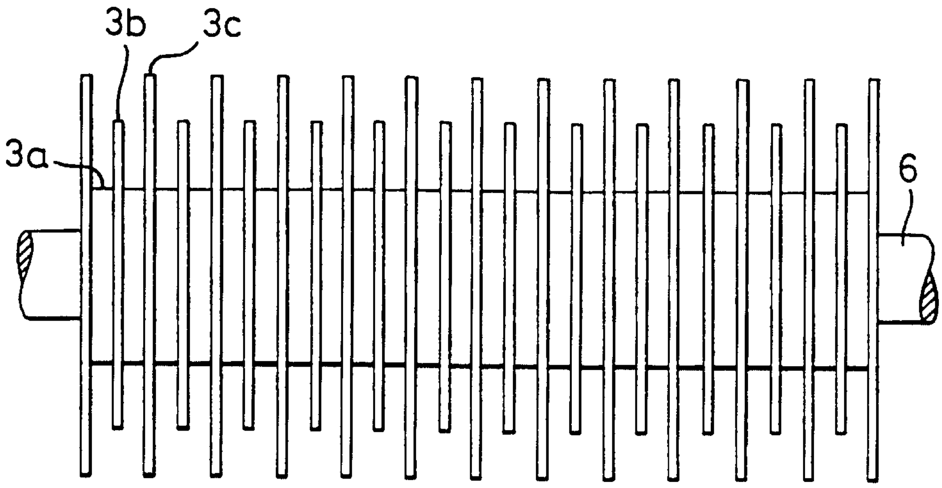


Fig. 2

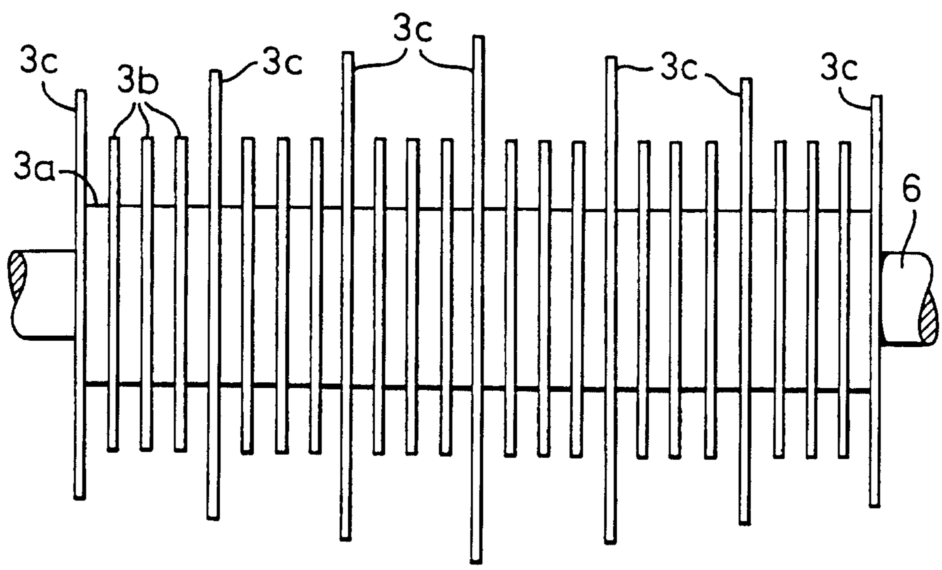


Fig. 3

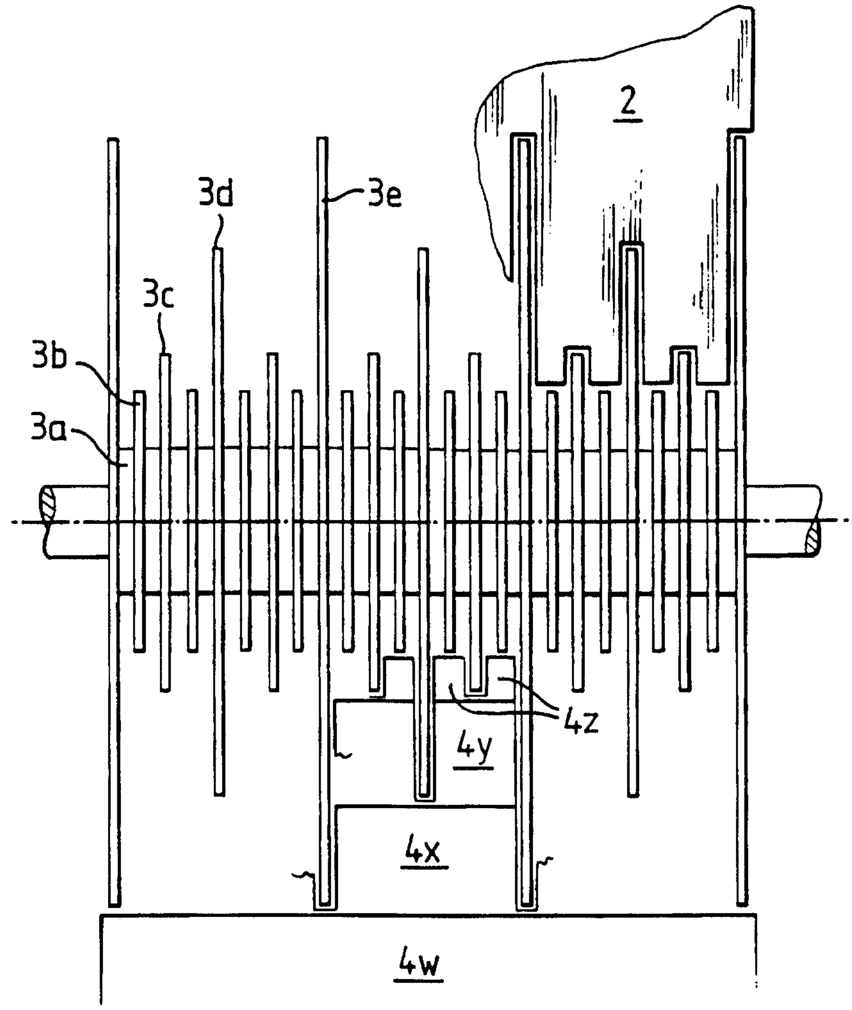


Fig. 4

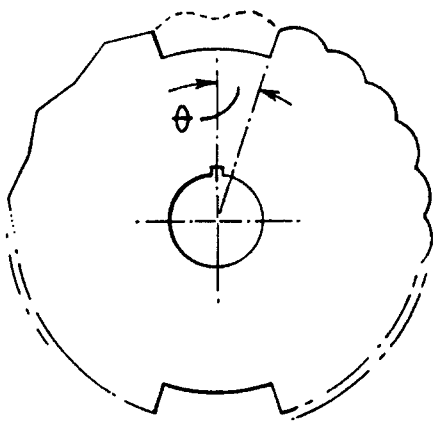


Fig. 5

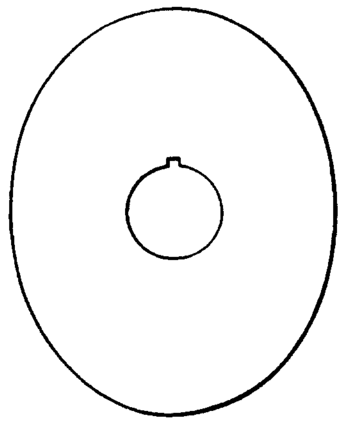


Fig. 6

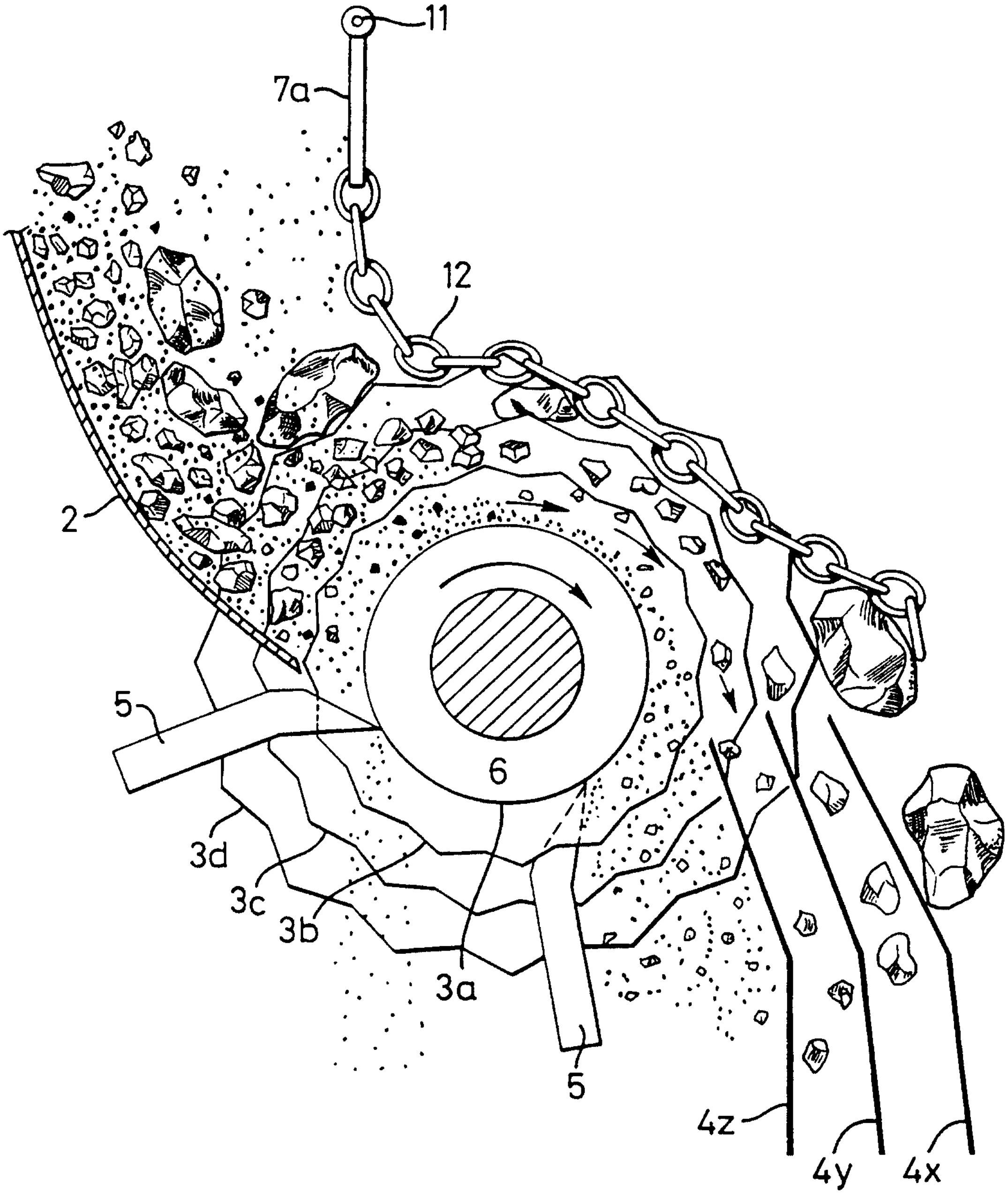


Fig. 7

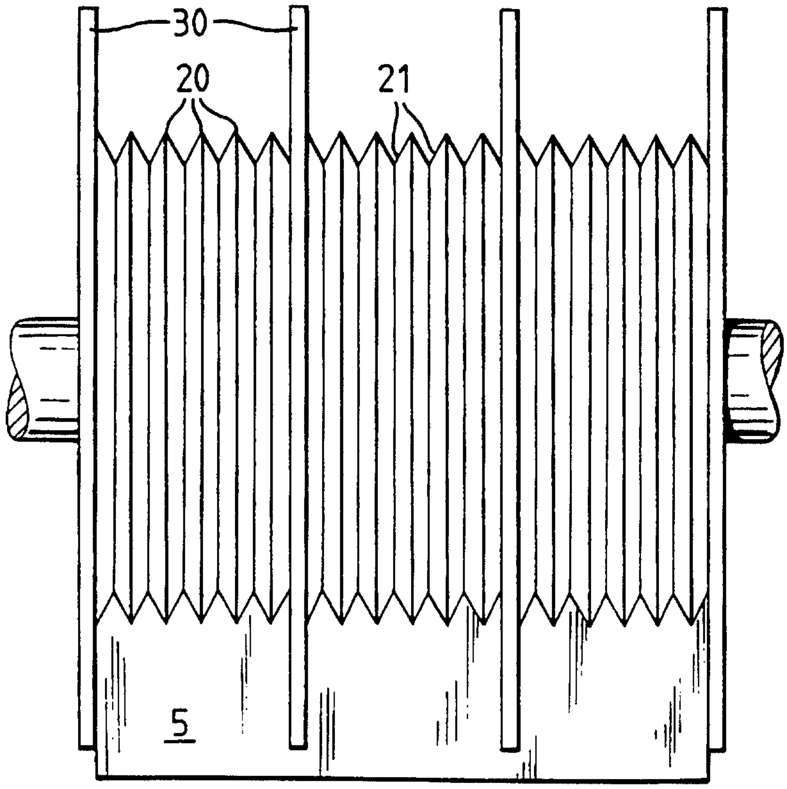


Fig. 8

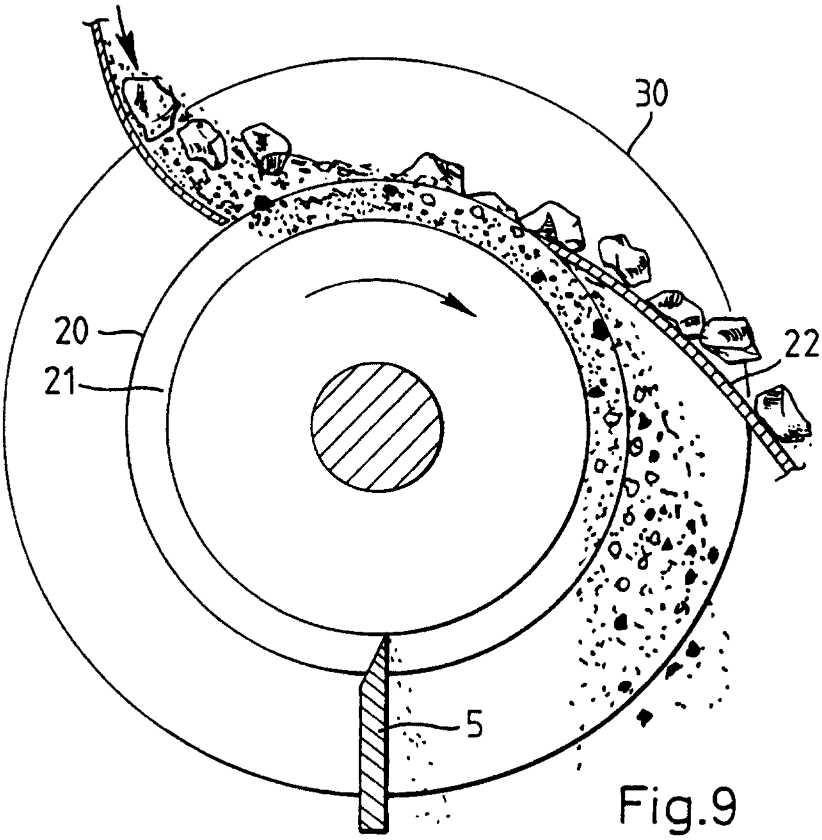


Fig.9

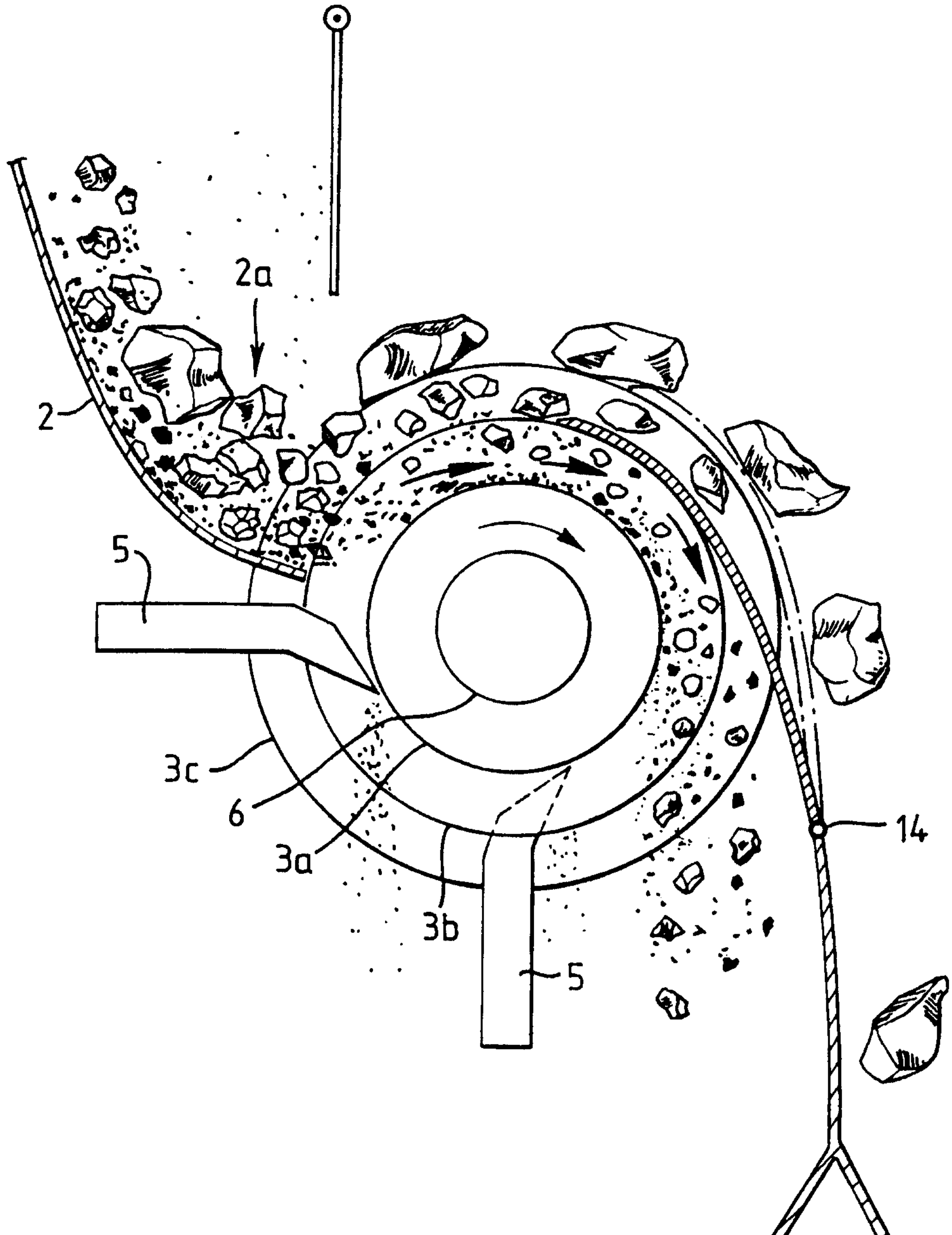
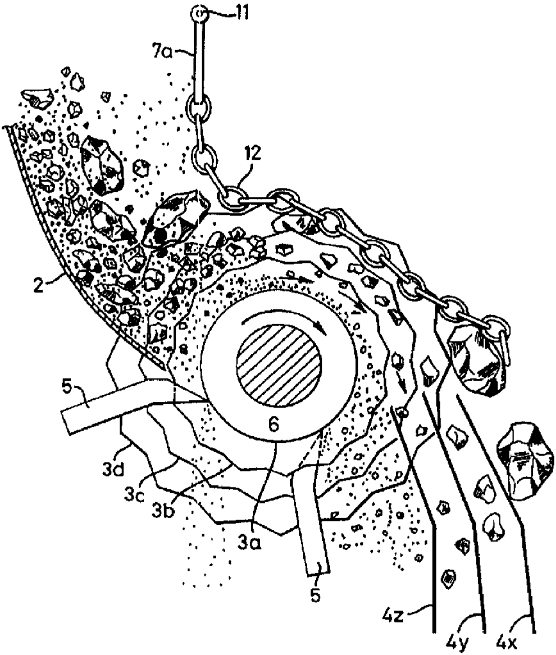


Fig. 10


11
7a
12
2
5
6
3d
3c
3b
3a
5
4z
4y
4x