PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : B02C 4/12, 4/08, 4/30

A1

(11) International Publication Number: WO 00/12216

(43) International Publication Date: 9 March 2000 (09.03.00)

(21) International Application Number: PCT/GB99/02705

(22) International Filing Date: 31 August 1999 (31.08.99)

(30) Priority Data:
9818997.0 29 August 1998 (29.08.98) GB

(71) Applicant (*for all designated States except US*): M G H RECYCLING LIMITED [GB/GB]; Woodhouse Grange Farm, Hatfield Woodhouse, Bawtry Road, Doncaster DN7 6DU (GB).

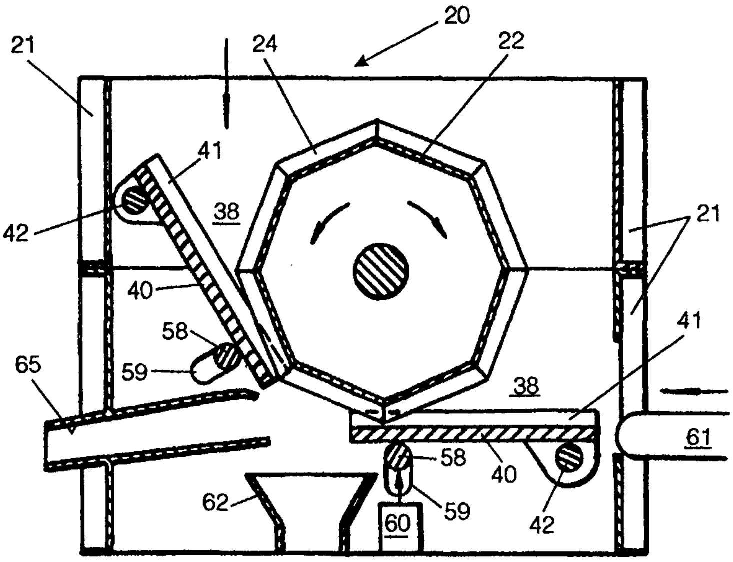
(72) Inventor; and
(75) Inventor/Applicant (*for US only*): HARRIS, Michael [GB/GB]; Woodhouse Grange Farm, Hatfield Woodhouse, Bawtry Road, Doncaster DN7 6DU (GB).

(74) Agent: GODDIN, Jeremy, Robert; Loven & Co., Quantum House, 30 Tentercroft Street, Lincoln LN5 7DB (GB).

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

Published
With international search report.

(54) Title: ROTARY CRUSHER



(57) Abstract

A rotary crusher (20) comprises first and second crushing means (22, 23) defining a crushing space (38) through which material is to be passed. The first crushing means (22) is defined by an outer surface (24) of a polygonal drum (22) which is rotated to move the outer surface (24) relative to the second crushing means (23) to alter the dimensions of the crushing space. The second crushing means (23) may be an outer surface (24) of a second polygonal drum (23), but may also be a surface (41) of an anvil (40) – see Figures 5 – 14. The crushing surfaces (24, 41) are preferably defined by teeth (24, 41) in the form of corrugations extending the direction of rotation of the drum (22). The two sets of corrugations are relatively offset transverse to the feed direction whereby they progressively apply a crushing load to the material and also a bending load to the material transverse to the feed direction.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

Rotary Crusher

Field of the Invention

This invention relates to a rotary crusher, for crushing materials such as stone, bricks, concrete and the like, and also to a method of crushing such material.

Background to the Invention

For thousands of years man has been breaking stones into workable or transportable pieces. This was done using simple tools such as hammers and chisels. However, machines have more recently been designed to break such materials down to a desired size.

One type of known crushing machine is the jaw crusher. In this type of machine two jaws are mounted in a housing, one adjacent the other. In some types of jaw crusher one of the jaws is movable towards and away from the other jaw. In other types of jaw crusher both jaws are movable towards and away from each other. With the reciprocating movement of one or both of the jaws any stone trapped therebetween is progressively crushed until it is small enough to pass through the space between the base of the jaws. A hopper is often mounted on top of the housing to hold a supply of stone.

One problem associated with jaw crushers is that they can easily become blocked by foreign articles such as pieces of wood or steel. Whilst this is not a problem in a quarry where it is known that the supply of stone is clean, it is a great problem where a crusher is being used to crush bricks, concrete blocks, or stone at a building site or a tip where there may well be contamination in the form of wooden beams, structural steel members, etc. If these items pass into and block a jaw crusher, then the machine has to be emptied manually. As a hopper for a jaw crusher typically has a capacity of 4 tonnes, manually emptying the hopper is an arduous and dangerous task, and renders the machine inoperative for several hours.

Another disadvantage associated with known jaw crushers is that they only crush during the time when the space between the jaws is decreasing. Thus during the reciprocating stroke of the or each jaw, crushing only takes place for half the stroke, the other half of the time being wasted.

Another disadvantage of known jaw crushers is that, in wet weather, they can become blocked by the material they are crushing. This is a particular problem when crushing bricks.

Another type of known stone breaking machine is the pulveriser. This type of machine comprises a rotating drum having a plurality of pivotally mounted blades extending radially from the periphery of the drum. These blades impact on stones passing through the machine and cause large stones to be broken up into small pieces. However, in order for the impact of the blades to break stones, its drum must operate at high speed. This results in a large amount of small stone particles being produced, commonly known as fines. Disposing of fines is very difficult, because of the limited use there is for them. Whilst there is a tendency to recycle concrete, bricks, stone, building blocks etc by crushing to form rubble, there is a problem in using pulverisers because they create a large amount of unusable material.

Another type of known crushing machine is the cylinder crusher, which comprises two contra-rotating cylindrical drums that may be provided with teeth projecting from the drum surface. This type of crushing machine is commonly used in the coal mining industry to crush coal. Whilst being efficient at crushing coal, which is a relatively weak brittle substance, they are not suitable for crushing hard substances such as granite, steel slag, or concrete. When a hard object hits the drums (or teeth thereof), which are rotating at high speed, it has the tendency to ricochet out of the machine rather than being crushed. Clearly this is potentially very dangerous.

It would therefore be desirable to provide a crushing machine which is capable of crushing a variety of materials such as stone, concrete, bricks, coal, building blocks, steel slag etc, without suffering from the disadvantages and drawbacks suffered by known crushing and stone breaking machines.

Summary of the Invention

According to one aspect of the invention, a rotary crusher comprises first and second crushing means defining a space through which material is to be passed, the first crushing means being defined by an outer surface of a polygonal drum, and a drive means arranged to rotate the polygonal drum whereby the outer surface will be moved relative to the second crushing means to alter the dimensions of the space.

The second crushing means may be defined by an anvil and a biasing means may be arranged to urge the anvil towards the outer surface of the polygonal drum. The biasing may comprise a spring, which may be a leaf spring, one or more coil springs, a rubber spring, or a hydraulic circuit for example. The biasing means may comprise a shock absorber. An adjuster may be provided and be operable to vary the spacing between the anvil and the outer surface of the polygonal drum.

A third crushing means may be defined by a second anvil, to define a second space through which material is to be passed. The first anvil may be positioned such that the space between its associated crushing means and the outer surface of the polygonal drum can receive a gravity feed of the material to be crushed. The second anvil may be positioned such that the space between its associated crushing means and the outer surface of the polygonal drum can receive a horizontal feed of material.

The anvil is preferably mounted from a housing so that its crushing means is at an acute angle the vertical. The anvil may be pivotally mounted in the housing, preferably being mounted on a shaft extending from one side of the housing to the other, each end of the shaft being mounted in a bush or bearing.

Each crushing means may comprise a plurality of teeth. The teeth may be defined by a corrugation extending along the outer surface in the direction of its rotation. Advantageously, the corrugations may be triangular in cross-section, the apex of the triangle pointing outwards to define the crushing face. The polygonal drum and the anvil may be mounted in the housing so that their corrugations or teeth mesh or intercalate.

The polygonal drum may, for example, have three, four, five, six, seven or more sides. If there are too few sides, the efficiency of the rotary crusher decreases. If there are too many, the crushing and sweeping effect is reduced. An eight-sided drum gives good results.

Alternatively, the second crushing means may be defined by the outer surfaces of a second polygonal drum, and the drive means is arranged to rotate both of the polygonal drums. Either or both drums may be resiliently mounted in a housing so that, in the event of a foreign body such as a piece of steel or wood coming between the first and second crushing means, the second crushing means can move away from the first crushing means, thereby allowing the foreign body to pass through the crusher. Preferably a biasing means is arranged to urge the outer surface of one of the polygonal drums towards the outer surface of the other polygonal drum. An adjuster is preferably operable to vary the spacing between the outer surface of the polygonal drums. For instance, the drum may be mounted on a shaft which is slidably mounted in the housing for movement towards and away from the first crushing means. Alternatively, the drum may be mounted on swing arms which are pivotally mounted on the housing.

The drum may comprise a frame having plates which are mounted on each side of the polygon to form the crushing means. These plates may have teeth and/or corrugations formed integrally therein and may be cast or forged.

The adjuster for regulating the minimum space between the first and second crushing means may comprise a plurality of differently sized spacer members, one of which is removably mounted in the housing to set the space between the first and second crushing means. Alternatively, the adjuster may comprise one or more hydraulic rams, extension or retraction of which moves the position of one of the crushing means, preferably the second crushing means, relative to the other.

A grid may be mounted in a housing underneath the or each polygonal drum. This grid is preferably sufficiently strong to act as a secondary crusher with the polygonal drum beneath which it is mounted.

The rotary crusher may be provided with an engine which drives the polygonal drum or drums, if required through a gearbox.

Preferably, the drum or drums are driven at a range of speeds up to 60 revolutions per minute. However, we have found that a speed of 3 to 4 revolutions per minute is particularly effective. Where the first and second crushing means are both polygonal drums, both drums are preferably driven at the same speed. One of the drums may be driven, and rotation may be transferred therefrom to the other drum by means of gears.

A hopper may be mounted on top of the housing so that a quantity of stone, brick, concrete or other material may be crushed without requiring constant feeding of the crusher. A conveyor belt may be positioned to transfer reinforced concrete beams into the space between the crushing means, and a chute may be provided for feeding the freed reinforcement bars.

The rotary crusher of the invention provides a simple machine which does not suffer from the disadvantages suffered by known machines. The crusher is constantly crushing as the or both drums rotate, since as each drum rotates the next crushing face on the drum commences its crushing action. The rotation of the drum means that significant shear or bending forces are exerted on the objects being crushed as well as the compressive crushing forces. Another advantage of the crushing machine of the invention is that it is self-cleaning. This is because the rotary drum tends to sweep the crushing face of the other crushing means, and centrifugal force inhibits any debris or fines from becoming attached to a crushing face of the drum.

The rotary crusher of the invention can allow foreign material to pass between the jaw members. This a great advantage over prior art jaw crushers, since there is no longer the requirement to empty a crusher manually whenever a large piece of steel or wood enters the crusher. Due to this operational capability it is possible to crush steel reinforced concrete.

Another advantage of the present invention is that the proportion of fines produced during crushing is very small, particularly when compared with a pulveriser.

The rotary crusher of the invention may be used for crushing a wide variety of substances and objects. It is particularly useful in re-cycling where the purity of the supply cannot be guaranteed.

According to another aspect of the invention, a method of crushing material includes progressively applying force to opposite sides of the material to crush the sides together whilst simultaneously applying a transverse bending load to the material. The method may include feeding the material between two tools each defining parallel corrugations, the corrugations being relatively offset transverse to the feed direction, and progressively applying a crushing load to material passing between the corrugations whereby the transverse offset of the corrugations produces a bending load to the material transverse to the feed direction.

Brief Description of the Drawings

The drawings illustrate, by way of example only, embodiments of a rotary crusher according to the invention and also the method of crushing material:

Figure 1 is a schematic side elevation of one form of rotary crusher;

Figures 2, 3 and 4 are diagrams illustrating the operation of the rotary crusher shown in Figure 1;

Figure 5 is a schematic side elevation of another form of rotary crusher:

Figure 6 is a plan of the rotary crusher shown in Figure 5;

Figure 7 is an enlarged scrap view of the adjustment means for the rotary crusher shown in Figures 5 and 6;

Figures 8, 9 and 10 are diagrams illustrating the operation of the rotary crusher shown in Figures 5 to 7;

Figure 11 is a plan of a further form of rotary crusher;

Figure 12 is a section along the line 12 – 12 in Figure 10;

Figure 13 is similar to Figure 12 but illustrates the crushing of gravity fed material, and

Figure 14 is also similar to Figure 12 but illustrates the crushing of a horizontally fed reinforced concrete beam.

Detailed Description of the Preferred Embodiments

In Figure 1, a rotary crusher 20 comprises a housing 21 having four vertical walls and a base. In plan view the housing is rectangular. The walls are made from one inch steel plate, and the base (not shown) is constructed from suitable structural members, such as I-beams or box-section steel. Within the housing there are mounted a first drum 22 and a second drum 23. The drums are octagonal in cross-section, each side of the octagon forming a crushing means in the form of a crushing face. Teeth 24 are provided on each crushing face and may be any suitable shape. However, it has been found that teeth in the form of corrugations of triangular cross-section are particularly effective.

The drums 22 and 23 are respectively carried by shafts 25 and 26 which are mounted in unshown bearings carried by the walls of the housing 21. The bearings for the shaft 26 are slidably mounted from the housing 21 so that the space between the two drums 22 and 23 can be adjusted. A pair of hydraulic rams 27 are mounted on opposite sides of the housing 21, each comprising a piston 28 and a cylinder 29. The end of the piston 28 has a bracket 30 attached thereto which carries the bearings of the shaft 26 so that extension or retraction of the piston 28 causes the space between the drums 22 and 23 to decrease or increase. The hydraulic ram 27 is operated by an hydraulic circuit 31 comprising a quick coupler 32 to which an external hydraulic supply can be connected to allow hydraulic fluid to be fed into or removed from the ram 27, and an accumulator 33. The accumulator 33 acts as a spring, allowing the piston 28 to move into the cylinder 29 when the drums 22 and 23 experience excess loads, for example if a piece of steel or wood were to become trapped between them. The components used in the hydraulic circuit are commonly available items and will not be described in detail.

Beneath the left hand drum 22 is a grid 34 which permits material such as stone passing through the crusher to be subjected either to a secondary crushing process, or to a screening process. This grid 34 may be made up of bars having elongate spaces therebetween, or it may comprise of an array of holes. Any material passing between the grid 34 and the crushing faces of the octagonal drum 22 may be subjected to a secondary crushing process as the drum rotates, depending on the size of the product.

Beneath the drums 22 and 23 are two conveyors 35, 36. The conveyor 35 receives crushed material falling from between the drums 22 and 23 as a result of the primary crushing process. Any foreign articles will also fall onto the conveyor 35. The conveyor 36 receives material screened by falling through the grid 34. This will include any material resulting from the secondary crushing process between the drum 22 and the grid 34.

A hopper 37 is mounted on top of the housing 21 to receive a supply of the material to be crushed. Usually the capacity of such a hopper would be in the region of four tonnes and may include features found in known hoppers, such as means to control the rate at which material flows out of the hopper.

The drums 22 and 23 are made up of a frame comprising steel structural members, and plates forming the outer crushing faces of the drum. Advantageously, the plates are removably attachable to the frame for easy replacement or repair. The plates may be cast or forged, and have integral teeth 24. A plurality of plates may be provided to define each crushing surface. The benefit of providing removably mounted plates is that as they wear they can be replaced, without the need to replace the whole drum 22 or 23. Where the drum is particularly large, it may be desirable to provide a number of plates for each section for ease of handling. Also, the crushing face may become damaged in an isolated area, and as such being able to replace only a part of the crushing surface saves cost.

The drums 22 and 23 are driven so that they rotate at the same speed, but in opposite directions, as indicated by arrows "x" and "y" respectively. In order to synchronise the rotation of the drums 22 and 23, rotary motion of one drum is transmitted to the other by gears.

Figures 2, 3 and 4 illustrate the relative positions of the polygonal drums 22 and 23 as they rotate through successive increments of 22½°.

From Figure 2, it will be noted that the polygonal drums 22, 23 define a space 38 to receive the material to be crushed. Although the maximum width A of the inlet for material to the space 38 could be used, we prefer to use the reduced inlet width B. It will be noted that the edges of the two polygonal drums 22, 23 define a small gap C which allows small pieces of material to fall through without wasting energy in unnecessary crushing them.

As the polygonal drums 22, 23 rotate from the position shown in Figure 2 to that shown in Figure 3, their opposed crushing faces move progressively towards each other to ensure that the material is reduced to a maximum width of D. However, during this movement it will be noted that the gap C increases until it becomes D, thereby allowing smaller pieces to fall through from the lower portion of the space 38 even though the upper portion of the space 38 is still being compressed.

As the rotation progresses, from the position of Figure 3 to that of Figure 4, the gap D increases until it becomes E which is, of course, the same as the original entry width B thereby ensuring that the crushed material can drop freely away. Although the drums 22, 23 illustrated in Figures 2 to 4 are shown with flat surfaces, these would be provided with teeth, preferably defined by corrugations, the corrugations on drum 22 being transversely offset from the corrugations on the drum 23 so that they intercalate thereby imposing a bending load to the material whilst it is being crushed.

The same reference numerals have been used to identify equivalent components in Figures 5 to 14 and only the points of difference will be described in detail.

Figures 5, 6, and 7, show another embodiment. The first crushing means is provided, as before, by an octagonal drum 22, each side of the octagon forming a crushing face having corrugations 24.

The drum 22 is mounted on the shaft 25 which is supported by bearings 39 which are themselves mounted on the walls of the housing 21.

The second crushing means is provided by an anvil 40 having teeth or corrugations 41 projecting towards the teeth or corrugations 24 on the drum 22. One end of the anvil 40 is attached to a shaft 42 which is rotatably mounted in bearings 43 carried the housing 21.

The free end of the anvil 40 is attached to a shaft 44 by an unshown bracket. A leaf spring 45, comprising four leaves, is secured to the shaft 44 by an integral flange 46 and a nut 47. The free ends of the longest leaf project through apertures 48 in the housing 21 (see Figure 7) and abut spacer blocks 49 which are carried by the housing 21 and react against respective flanges 50 projecting outwardly of the housing 21. Each spacer block 49 is held in place by a key 51which engages with a slot, and by bolts 53 which can be adjusted to permit or prevent its removal. The ends of the leaf spring 45 are located by a stepped portion 54 if each spacer block 49 to prevent the leaf spring from moving vertically.

Different spacer blocks 49 may be used to control the spacing between the crushing surfaces of the drum 22 and the anvil 40, thereby permitting materials to be crushed to different sizes.

The shaft 25 is driven by an engine 55 through a gearbox 56 using any suitable drive mechanism.

It can be seen from Figure 6 that the corrugations defining the teeth 24 on the anvil 40 are aligned with the spaces between the corrugations defining the teeth 24 on the crushing faces of the drum 22. This staggering, or intercalation of the teeth 24 assists in the crushing action.

Figures 8 and 9 illustrate the operation of the embodiment that has been described and reference to Figures 5 to 7, the drum 22 rotating 22½° between the position shown in Figure 7 and Figure 9.

As before, the maximum material inlet is indicated by arrow A in Figure 8, whilst the preferred inlet width is indicated by arrow B, the small gap C, between the drum 22 and the anvil 40, allowing smaller pieces of material to pass through the crushing space 38 without wasting energy in unnecessarily breaking them. The anvil 40 is biased, in the direction of arrow Z, to the position shown by the leaf spring 45 illustrated in Figures 5 to 7.

Figure 9 shows how rotation of the drum 22 reduces the lower portion of the crushing space 38, whilst simultaneously reducing the gap C to the smaller clearance F. Continued rotation, from the position shown in Figure 9, causes the material in the lower part of the crushing space 38 to be further crushed to the maximum width of C (see Figure 8) whilst the gap F is increasing to the gap C, thereby allowing crushed material from the lower portion of the crushing face 38 to fall free.

Figure 10 is generally similar to Figure 8, but illustrates how the intercalation of the corrugations 24 and 41 can provide additional crushing if the intercalation reaches the point at which the corrugations 24 pass, to some extent, between the corrugations 41. This enables the crusher to reduce material to a size less than the depth of the corrugations 24 or 41. However, the crusher would more often be operated with the corrugations 24 and 41 remaining spaced apart to provide the desired degree of material reduction, the offset of the corrugations 24, 41, transverse to the direction of material feed, being used to apply a bending load to the material transverse to the feed direction. In this manner, a crushing force is applied simultaneously to opposite sides of the material whilst the bridging of the material between the corrugations 24 and 41 simultaneously applies a transverse bending load to the material.

Figures 11 and 12 illustrate an elaboration of the crusher that has already been described with reference to Figures 5 to 7, and the same reference numerals are again used to identify equivalent components, only the points of difference being described.

The drum 22 is shown in much greater detail and it will be seen that the teeth 24 are provided by lengths of V-section steel welded together to form the drum 22 which is directly driven by an hydraulic motor 57 secured to the housing 21.

As best seen in Figure 12, the crusher is provided with two anvils 40 which are both pivoted from the housing 21 about respective horizontal shafts 42. The spacing between each anvil 40 and the drum 22 is controlled by respective cross bars 58 which are located in slots 59 in the housing 21, and are controlled by respective hydraulic rams 60. It will be noted that the left-hand anvil 40 is inclined downwards at an acute angle in the same way as illustrated in Figure 5, whereas the right-hand anvil 40 is disposed generally horizontally to receive material fed horizontally by conveyor 61. The hydraulic motor 57 is operated by an unshown hydraulic circuit which is arranged, in any convenient manner known in the art, to rotate the drum 22 in either direction and at a speed selected by an operative of the crusher. The hydraulic circuit would include an accumulator to enable variations in the speed of the drum 22, caused by variations in the crushing force, to be tolerated.

Figure 13 illustrates the operation of the crusher of Figures 11 and 12 for breaking up a gravity feed of material M into smaller pieces which fall into a chute 62 positioned to deliver the processed material onto a conveyor, such as the conveyor 35 shown in Figure 5. It will be noted that the drum 22 is driven anti-clockwise and that the lower portion of the anvil 40 is positioned so that the discharge of crushed material will fall cleanly into the chute 62.

Figure 14 also illustrates the operation of the crusher that has been described with reference to Figures 11 and 12, but shows its use in breaking up a reinforced concrete beam 63 which is fed into the crusher by the conveyor 61. In this configuration, the drum 22 is rotated clockwise and crushes the reinforced concrete beam 63 against the horizontal anvil 40 as shown. The action of the crusher is to promote cracks in the reinforced concrete beam 63 as shown, the transverse offset between the corrugations 24 of the drum 22, and the corrugations 41 of the horizontal anvil 40, serving to produce a bending load on the cracked beam transverse to the direction in which it is fed into the crusher. This effectively strips the concrete off the reinforcing bars 64 which are gathered together into a delivery guide 65 whilst the fragmented concrete falls clear into the chute 62 as shown.

Instead of the anvil 40 of Figure 5 to 7, or the anvils 40 of Figures 11 to 14, being adjusted relative to the housing 21 to control the dimension C (see Figure 8), the anvil or anvils 40 could be fixed to the casing 21 and the rotor 22 be adjustably mounted from the casing 21. With the embodiment described with reference to Figures 11 to 14, such adjustment of the position of drum 22 relative to the housing 21 is beneficial as it simplifies the mounting of the anvils 40 from the casing 21 and reduces the number of hydraulic rams necessary to control the position of shaft 25 relative to the housing 21.

It should be noted that the action of the drum 22 additionally serves to sweep the crushed material clear of the crushing area. In this manner the crushers taught by the present invention can handle difficult materials such as tarmac and wood. Such materials tend to clog existing machines whereas the crusher of this invention is generally self-cleaning, any materials adhering to the drum being wiped off as the drum either passes the second drum 23, or the anvil 40, or the grid 34. The combined crushing and bending action of the crusher reduces wood to small sticks which fall freely with the crushed material. In the event that any jamming does occur, the drum 22, or the drums 22 and 23, are simply reversed and then re-operated in the original direction.

Although the corrugations are shown as being of continuous V-form, they could be of other profiles and/or gapped along their lengths.

CLAIMS

1. A rotary crusher comprising first and second crushing means defining a space through which material is to be passed, the first crushing means being defined by an outer surface of a polygonal drum, and a drive means arranged to rotate the polygonal drum whereby the outer surface will be moved relative to the second crushing means to alter the dimensions of the space.

2. A rotary crusher, according to Claim 1, in which the second crushing means is defined by an anvil.

3. A rotary crusher, according to Claim 2, including a biasing means arranged to urge the anvil towards the outer surface of the polygonal drum.

4. A rotary crusher, according to Claim 2 or 3, including an adjuster operable to vary the spacing between the anvil and the outer surface of the polygonal drum.

5. A rotary crusher, according to any of Claims 2 to 4, including a third crushing means defined by a second anvil, to define a second space through which material is to be passed.

6. A rotary crusher, according to Claim 5, in which the first anvil is positioned such that the space between its associated crushing means and the outer surface of the polygonal drum can receive a gravity feed of the material to be crushed.

7. A rotary crusher, according to Claim 5 or 6, in which the second anvil is positioned such that the space between its associated crushing means and the outer surface of the polygonal drum can receive a horizontal feed of material.

8. A rotary crusher, according to Claim 1, in which the second crushing means is defined by the outer surface of a second polygonal drum, and the drive means is arranged to rotate both of the polygonal drums.

9. A rotary crusher, according to Claim 8, wherein including a biasing means arranged to urge the outer surface of one of the polygonal drums towards the outer surface of the other polygonal drum.

10. A rotary crusher, according to Claim 8 or 9, including an adjuster operative to vary the spacing between the outer surface of the polygonal drums.

11. A rotary crusher, according to any preceding claim, in which the or each outer surface defines a plurality of teeth.

12. A rotary crusher, according to Claim 11, in which the teeth are defined by a corrugation extending along the outer surface in the direction of its rotation.

13. A rotary crusher, according to Claim 12, in which the corrugations are substantially of V-section.

14. A rotary crusher, according to any of Claims 11 to 13, in which the teeth of the second crushing means intercalate with the teeth of the first crushing means.

15. A rotary crusher, according to Claim 12 or 13, in which the second crushing means defines a plurality of teeth defined by a corrugation which intercalates with the corrugation defining the first crushing means.

16. A method of crushing material, including progressively applying force to opposite sides of the material to crush the sides together whilst simultaneously applying a transverse bending load to the material.

17. A method of crushing material, including feeding the material between two tools each defining parallel corrugations, the corrugations being relatively offset transverse to the feed direction, and progressively applying a crushing load to the material as it passes between the corrugations whereby the transverse offset of the corrugations produces a bending load to the material transverse to the feed direction.

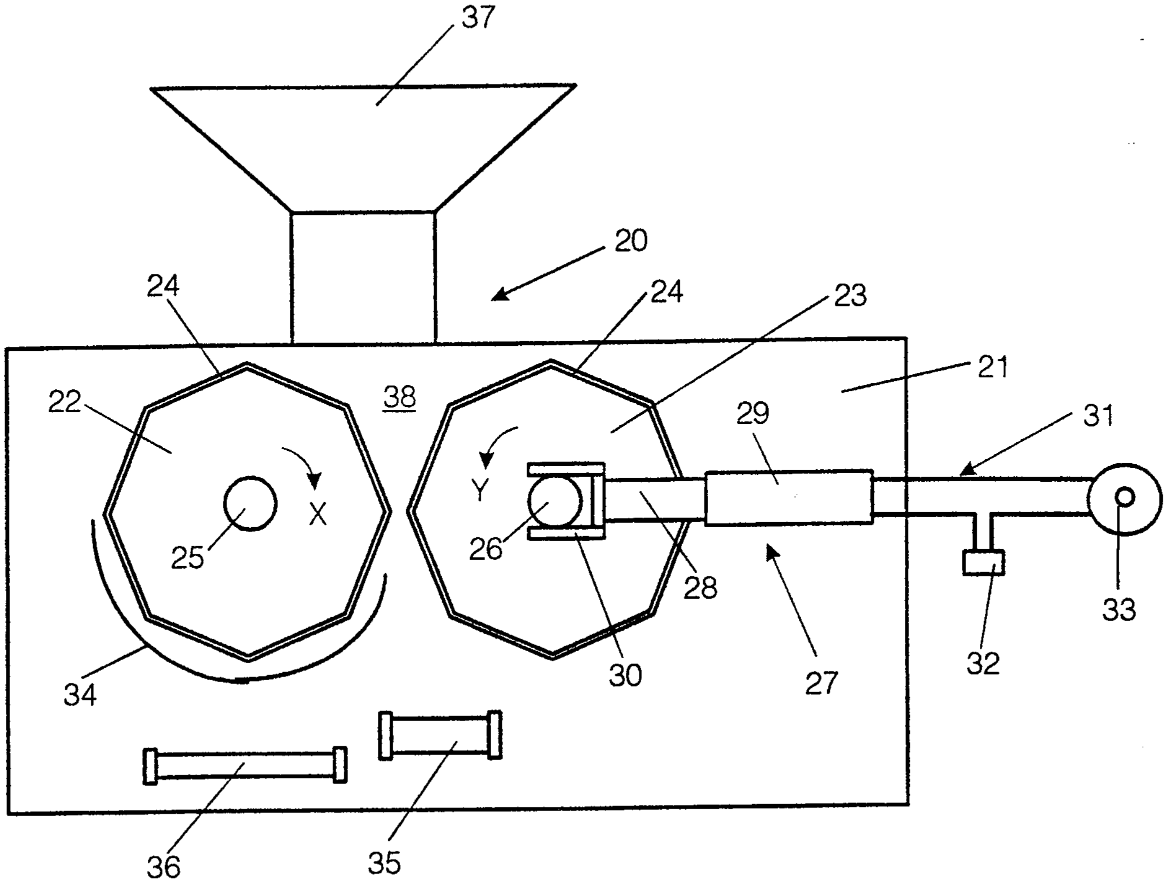


Fig. 1

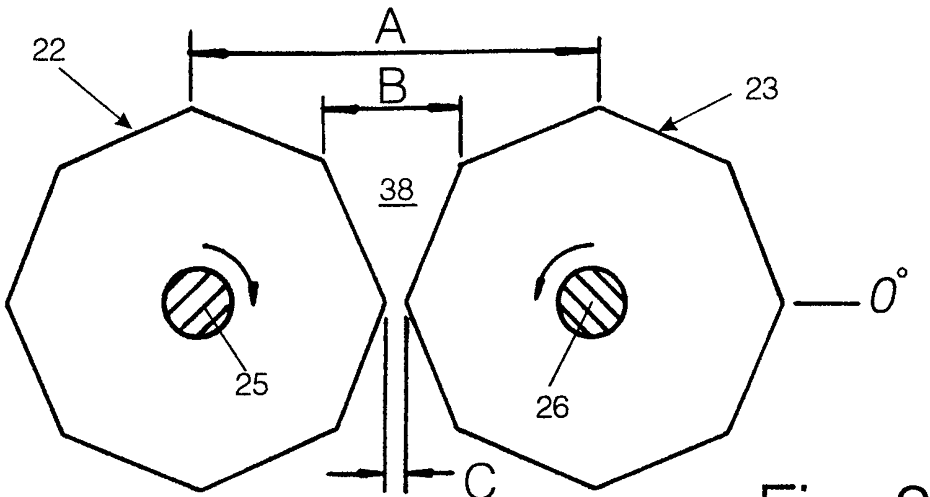


Fig. 2

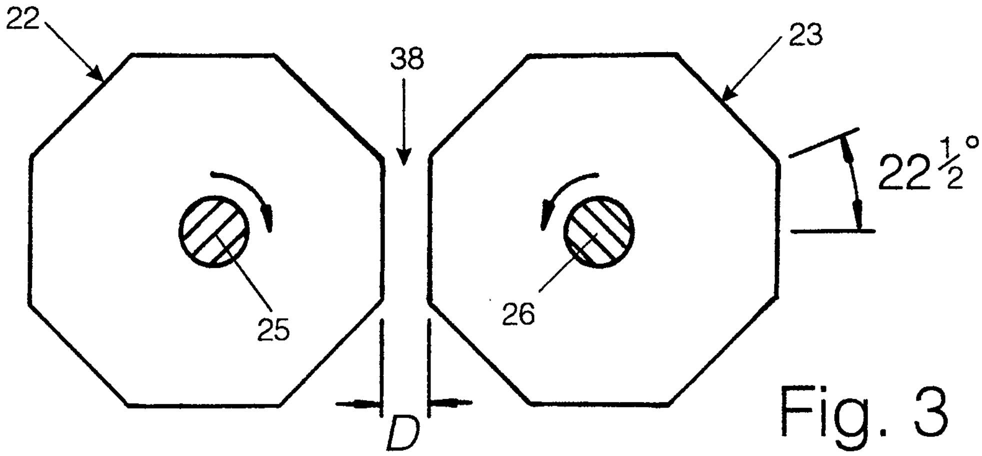


Fig. 3

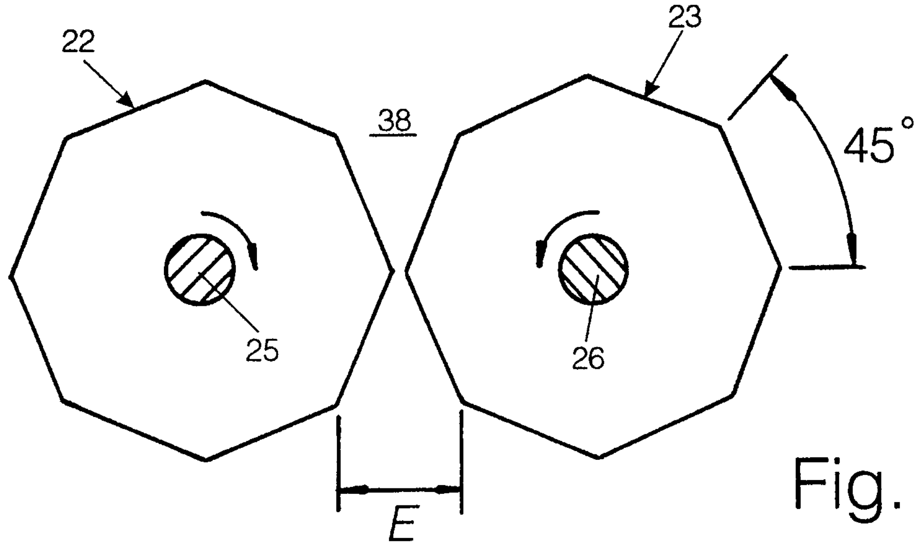


Fig. 4

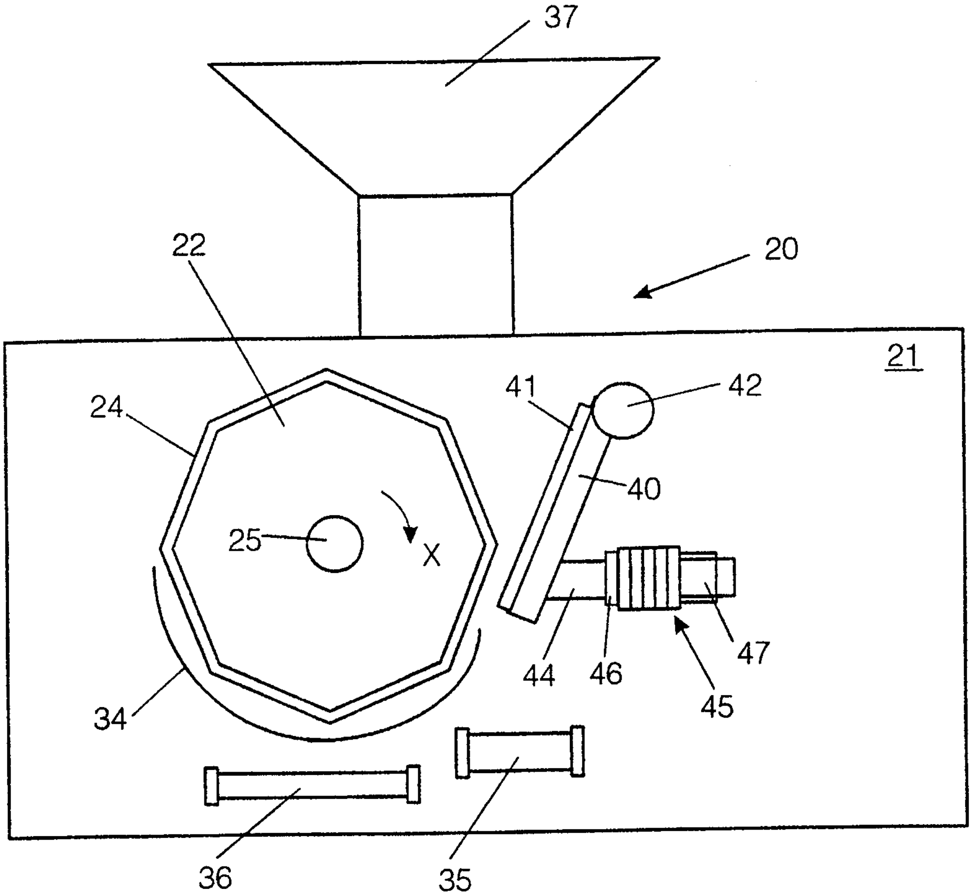


Fig. 5

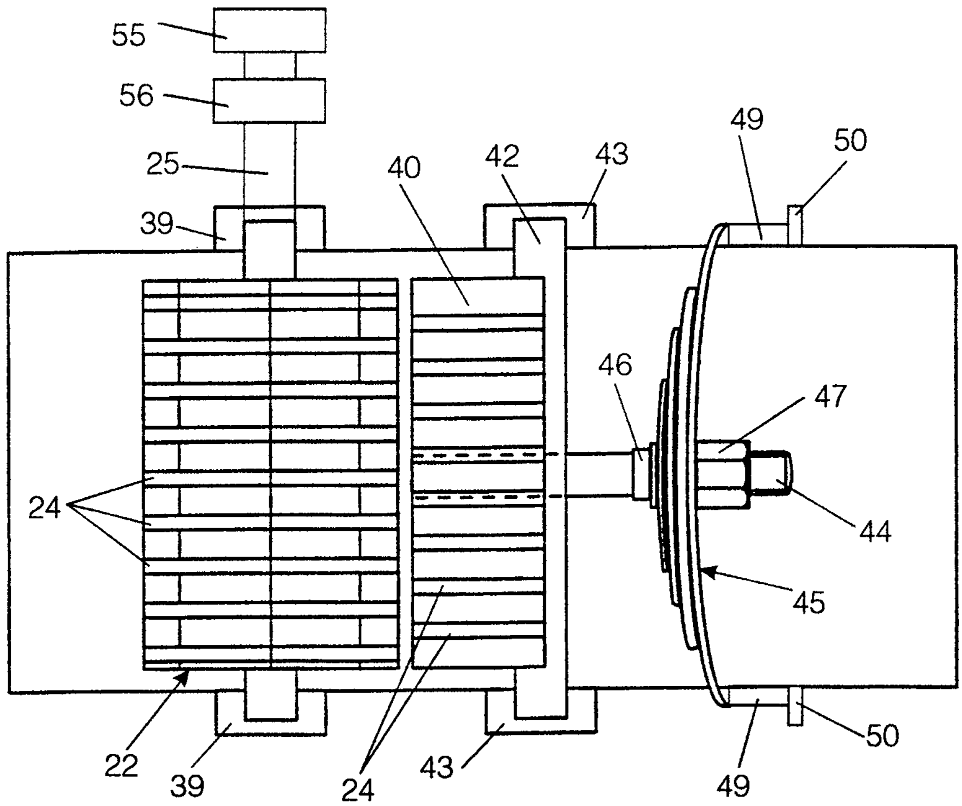

55
56
25
39
40
42
43
49
50
46
47
24
44
45
22
39
24
43
49
50

Fig. 6

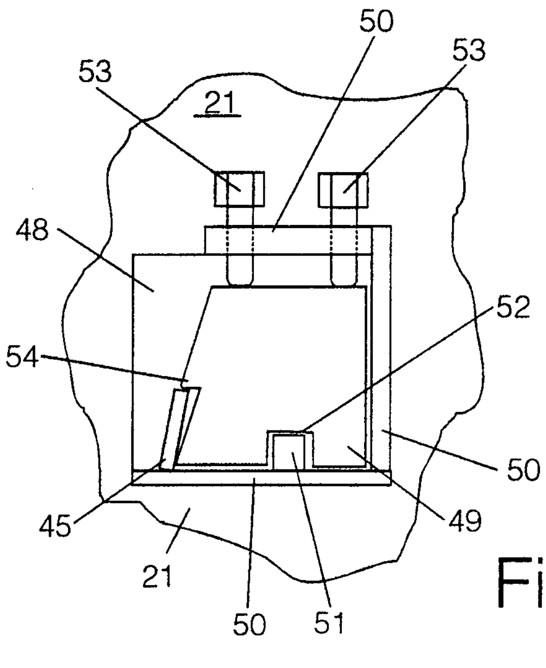

50
53
53
21
48
52
54
50
45
49
21
50
51

Fig. 7

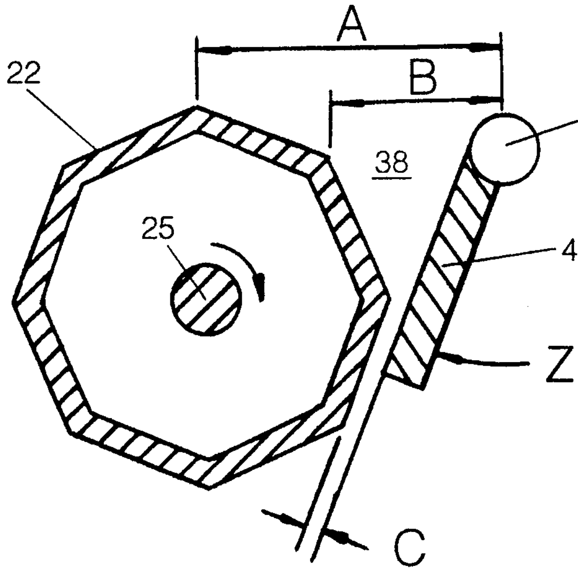


Fig. 8

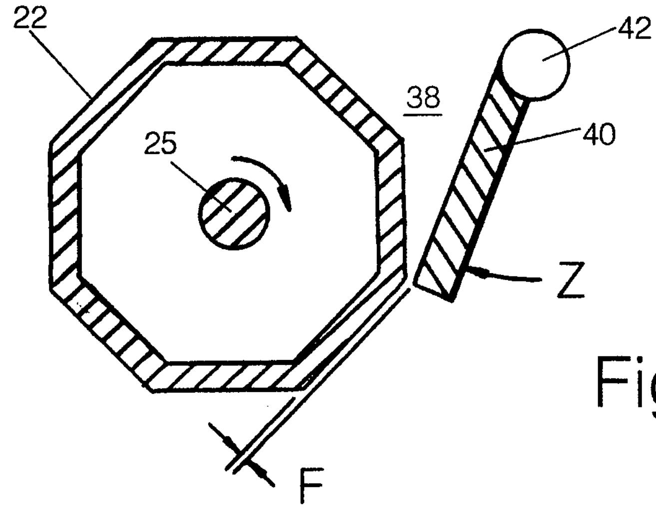


Fig. 9

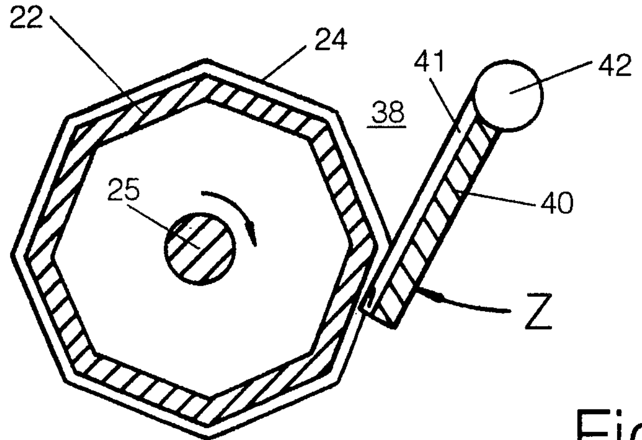


Fig. 10

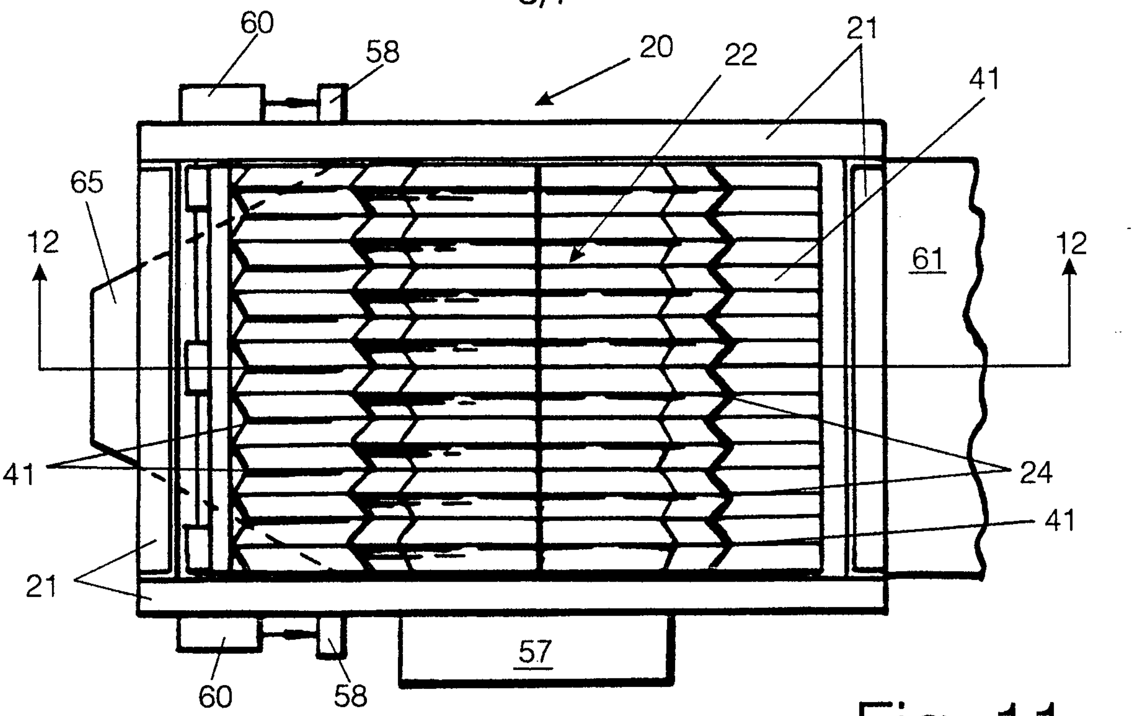

60
58
20
22
21
41
65
12
61
12
41
24
41
21
60
58
57

Fig. 11

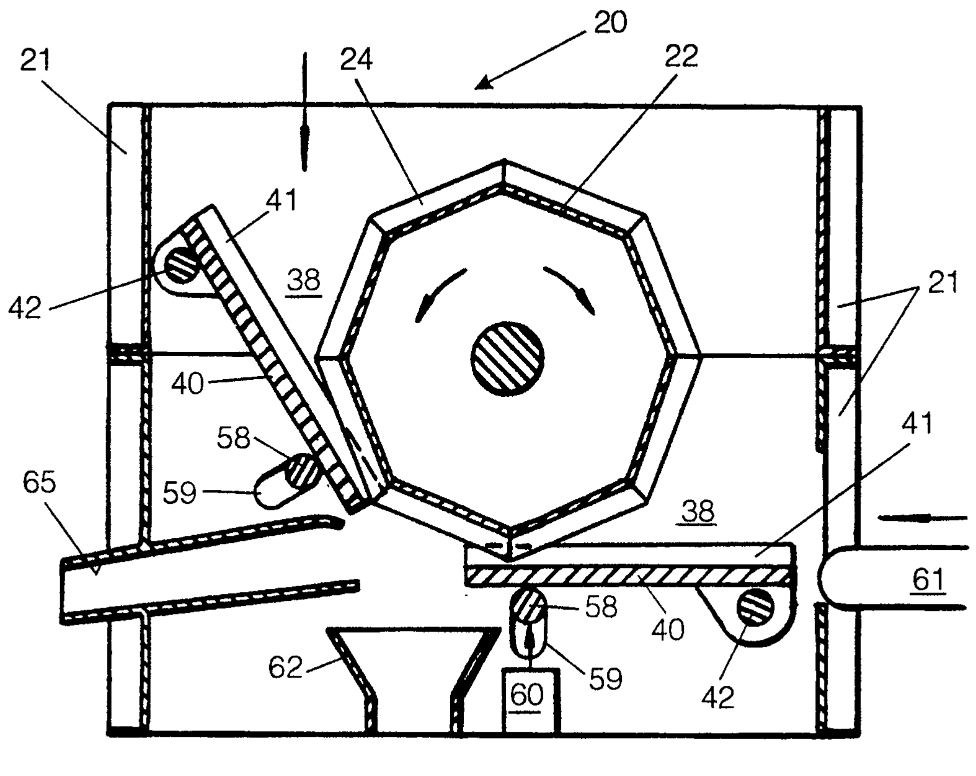

20
21
24
22
41
42
38
21
40
58
59
65
41
38
61
58
40
62
60
59
42

Fig. 12

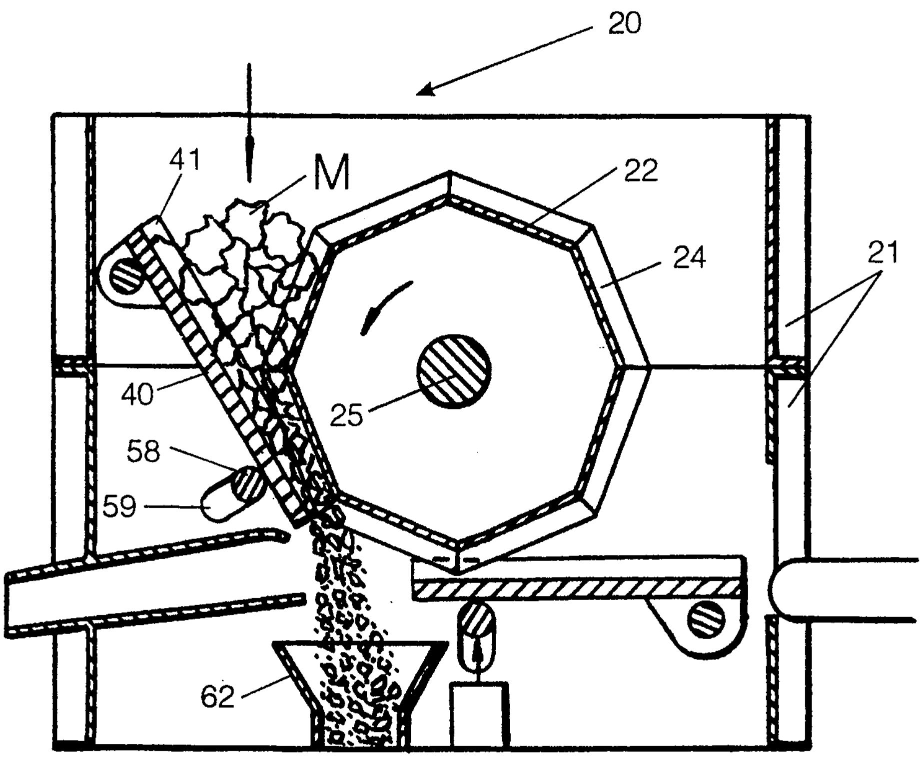

20
M
41
22
24
21
40
25
58
59
62

Fig. 13

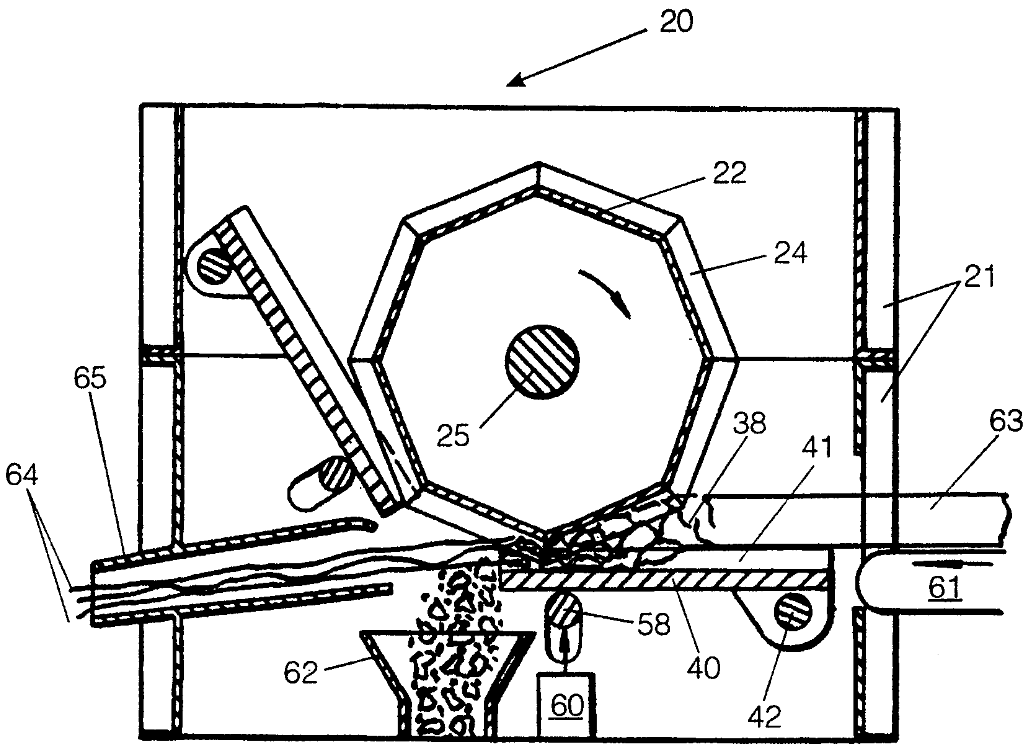

20
22
24
21
65
25
38
41
63
64
61
58
62
40
60
42

Fig. 14

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/02705

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B02C4/12 B02C4/08 B02C4/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B02C

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 practical, 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.
X	GB 772 107 A (G. TEESINK) 10 April 1957 (1957-04-10) the whole document	1,8,11, 14,16
Y		2-4, 11-15,17

X	SOVIET INVENTIONS ILLUSTRATED Section PQ, Week E38, 3 November 1982 (1982-11-03) Derwent Publications Ltd., London, GB; Class P41, AN m5179 XP002125158 & SU 880 466 A (KOMM MINING-METAL), 25 November 1981 (1981-11-25) abstract	1,8,9
Y		2-4, 11-15,17

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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
9 December 1999	22/12/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Verdonck, J

1

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 523 708 A (R. A. GILBERT) 15 February 1946 (1946-02-15) page 1, line 100 -page 2, line 36	2-4, 11-15,17
A	DE 89 03 718 U (NORICUM MASCHINENBAU UND HANDEL GMBH.) 20 July 1989 (1989-07-20) page 8	1,8,9
A	FR 2 091 172 A (KLOECKNER HUMBOLDT DEUTZ AG) 14 January 1972 (1972-01-14) the whole document	1,8,16, 17

1

INTERNATIONAL SEARCH REPORT

.nformation on patent family members

Inte onal Application No
PCT/GB 99/02705

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 772107 A		NONE	
SU 880466 A	15-11-1981	NONE	
GB 523708 A		NONE	
DE 8903718 U	20-07-1989	NONE	
FR 2091172 A	14-01-1972	CH 514354 A	31-10-1971
		DE 2021735 A	25-11-1971
		NL 7105655 A	08-11-1971