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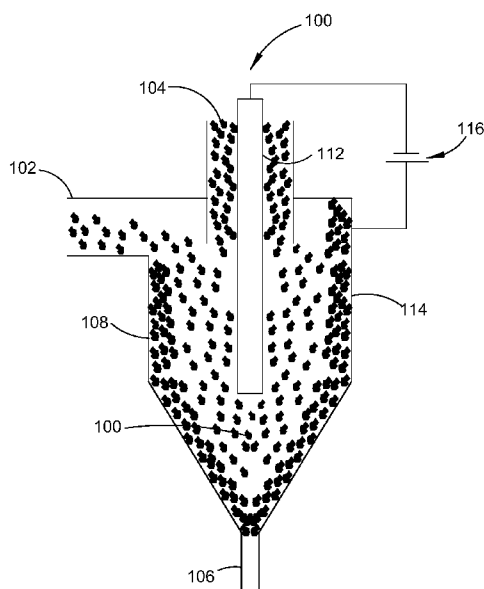


Fig. 1

(57) Abstract: The present disclosure provides apparatus for treating particles of a mined material in a slurry. The apparatus comprises a hydrocyclone for receiving a flow of the slurry. The hydrocyclone has a slurry inlet and a slurry outlet and is arranged to form an accumulation of a first group of the particles during the flow of the slurry. The hydrocyclone also comprises a high voltage applicator arranged to apply a high voltage to accumulated particles of the first group of the particles. The high voltage applicator comprises a high voltage generator that is arranged to generate a voltage that is sufficiently high such that micro-cracks are formed in at least some of the particles of the first group.

AN APPARATUS AND A METHOD FOR TREATING MINED MATERIALField of the Invention

- 5 The present invention relates to an apparatus and a method for treating mined material and relates particularly to an apparatus and a method for treating mined materials with a high voltage.
- 10 The term "mined" material is understood herein to include metalliferous material and non-metalliferous material. Iron-containing and copper-containing ores are examples of metalliferous material. The term "mined" material is also understood herein to include (a) run-of-mine material and
- 15 (b) run-of-mine material that has been subjected to at least primary crushing or similar size reduction after the material has been mined. Further, the term "mined" material includes mined material that is in stockpiles.

20 Background of the Invention

- Conventional comminution of particles of mined materials (such as ores) comprises mechanical grinding of the particles to a particle diameter that is suitable for
- 25 further processing.

- Particles of a mined ore usually include valuable material and gangue. The comminution needs to at least facilitate the liberation of the valuable material. Unfortunately,
- 30 the mechanical grinding process is a very energy intensive activity. Further, ideal comminution liberates valuable minerals from gangue at the largest grain size possible,

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but the mechanical grinding process is difficult to control and over grinding is a problem.

The present invention provides further improvements.

5

Summary of the Invention

The present invention provides in a first aspect an
10 apparatus for treating particles of a mined material in a slurry, the apparatus comprising:

a hydrocyclone having a slurry inlet for receiving a flow of the slurry and having slurry outlets, the hydrocyclone being arranged to divide the flow of the
15 slurry into a first slurry including a first group of the particles and a second slurry including a second group of the particles and in a manner such that an accumulation of particles of the first group is formed during the flow of the slurry into the slurry inlet; and

20 a high voltage applicator arranged to apply a high voltage to particles of the first group during or after formation of the accumulation of the of the particles of the first group, the high voltage applicator comprising a high voltage generator that is arranged to generate a
25 voltage that is sufficiently high such that micro-cracks are formed in at least some of the particles of the first group.

In one example the apparatus forms a part of a system for
30 treatment of mined material in which a slurry including high voltage treated particles of the first group is directed to a mill, such as a ball mill, for grinding of the particles of the first group to a diameter suitable

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for further processing. Embodiments of the present invention provide the advantage that an energy that is required for grinding of the particles in the mill is reduced due to the formation of the micro-cracks.

5

In one embodiment the high voltage is sufficient for formation of micro-cracks in the particles of the first group, but insufficient for fracturing of at least the majority of the particles of the first group. However, the apparatus may be arranged such that fracturing of the particles that have the formed micro-cracks is imparted by mechanical impact. For example, the energy for fracturing of particles including the micro-cracks may be provided by the mechanical impact between the particles and a wall of the hydrocyclone as the particles follow a spiral path to the cone discharge of the hydrocyclone.

The particles of the first group may include particles that are larger and heavier than the particles of the second group and may in use travel in downward direction in the hydrocyclone to be discharged from a slurry outlet of the hydrocyclone, such as a cone discharge.

The smaller particles formed by fracturing of the larger and heavier particles in the hydrocyclone may then become particles of the second group and depart the hydrocyclone from a further slurry outlet, such as at top discharge through a vortex finder of the hydrocyclone.

Similarly, larger and heavier particles in which micro-cracks are formed, but which do not fracture in the hydrocyclone, may be discharged from the cone discharge to be returned to a mill where the particles are fractured by

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imparting relatively less energy to the particles as compared to the energy required for particles that have not previously been micro-cracked.

5 In one embodiment of the present invention at least a portion of the high voltage applicator is positioned within the hydrocyclone such that the apparatus is arranged to apply the high voltage within the hydrocyclone during or after the accumulation of the particles of the
10 first group.

In an alternative embodiment the high voltage applicator is spaced apart from at least an interior region of the hydrocyclone and the apparatus is arranged to feed the
15 slurry including the particles of the first group, after formation of the accumulation, from the interior region of the hydrocyclone to the high voltage applicator.

The high voltage source may be arranged to generate a
20 voltage that is sufficient such that at least some of the particles of the first group experience an electrical energy of 0.5 - 1, 1 - 2, 2 - 3 or 3 to 4 kWh/t.

The slurry outlet may be one of two outlets and the
25 apparatus may have a first slurry outlet for exit of the first slurry and a second slurry outlet for exit of the second slurry.

The particles of the first group may comprise particles
30 that are larger in diameter than the particles of the second group. For example, the particles of the second group may have a P80 diameter that is smaller than 150µm, 160µm, 170µm, 180µm, 190µm, 200µm, 210µm, 220µm, 230µm,

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240µm or 250µm and the apparatus may be arranged such that particles having a larger size are included in the first group of particles.

5 The high voltage applicator may comprise any type of electrode that is suitable to apply the high voltage to the particles of the first group. For example, if the apparatus is arranged for applying the high voltage within the hydrocyclone, the electrode may comprise a first
10 electrode portion that is positioned at a central location of hydrocyclone and a second electrode portion may be provided in the form of a housing portion of the hydrocyclone such that the high voltage is applied between the central electrode portion and the housing portion.

15 The first electrode portion may comprise a generally cylindrical portion. Alternatively, the first electrode portion may have a shape that approximates that of a portion of the hydrocyclone, such as a conical portion of
20 the hydrocyclone. The first electrode portion may comprise a mesh of a metallic material. The mesh may have apertures that have a diameter that is larger than that of at least the majority of the particles of the first group.

25 The present invention provides in a second aspect a method for treating mined material in a slurry in a manner that is continuous during flow of the slurry, the method comprising:

providing the flow of the slurry including particles
30 of the mined material;

separating the particles into first and second groups of particles and forming an accumulation of the first group of the particles using a hydrocyclone;

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applying a high voltage to at least some particles of the first group, the high voltage being sufficiently high such that at least micro-cracks are formed in at least some of the particles of the first group; and

5 directing first and second slurries including the particles of the first and second groups, respectively, for further processing.

The step of applying the high voltage may be performed
10 such that the applied high voltage is insufficient to fracture at least the majority of the particles of the first group without mechanical impact. Further, the method may comprise the step of imparting mechanical impact to fracture at least some of the particles of the first group
15 that include the formed micro-cracks.

The step of imparting mechanical impact may comprise use of a ball mill.

20 The high voltage may be sufficient such that the particles of the first group experience an electrical energy of 0.5 - 1, 1 - 2, 2 - 3 or 3 to 4 kWh/t.

The particles of the first group may comprise particles
25 that are larger in diameter than the particles of the second group. For example, the particles of the second group may have a P80 diameter that is smaller than 150µm, 160µm, 170µm, 180µm, 190µm, 200µm, 210µm, 220µm, 230µm, 240µm or 250µm and the apparatus may be arranged such that
30 particles having a larger size are included in the first group of particles.

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The step of providing the slurry may comprise grinding particles of the mined material in a first mill, such as a Semi-Autogenous Grinding (SAG) mill.

- 5 The step of directing the first and second slurries for further processing may comprise directing the first slurry to a first mill, such as a ball mill.

10 The steps of separating the particles and applying a high voltage may be performed within the hydrocyclone. Alternatively, the steps of separating the particles and applying a high voltage may be performed at separate locations and the method may comprise feeding the first slurry, after formation of the accumulation of the
15 particles of the first group, to a region for applying the high voltage.

The step of directing the first and second slurries for further processing may also comprise directing the first
20 slurry including the particles of the first group after high voltage treatment through a first outlet of the hydrocyclone and directing the second slurry including the particles of the second group through a second outlet of the hydrocyclone.

25

The present invention provides in a third aspect a system for treatment of mined material, the system comprising components for liberating valuable materials included in particles of the mined material, the components
30 comprising:

a first arrangement for providing particles of the mined material at a diameter that is less than a predetermined diameter;

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an apparatus for throughput of a slurry, the slurry including the provided particles of the mined material, the apparatus comprising a high voltage applicator that is arranged to apply a high voltage to a selection of the
5 particles, the voltage being sufficiently high such that at least micro-cracks are formed in at least some of the particles of the selection; and

a second arrangement positioned to receive a slurry including the high voltage treated particles from the
10 apparatus, the second arrangement being arranged to reduce a size of the received particles to a second diameter that is smaller than the first diameter.

The first arrangement may comprise a first mill, such as a
15 SAG mill, rod mill or a ball mill. The second arrangement may comprise a ball mill.

The first arrangement may be arranged to provide particles of the mined material at diameter that is less than 150 μ m,
20 160 μ m, 170 μ m, 180 μ m, 190 μ m, 200 μ m, 210 μ m, 220 μ m, 230 μ m, 240 μ m or 250 μ m. The second arrangement may be arranged to grind particles of the mined material to a diameter that is at least 10 to 20 μ m smaller than that.

25 The system may comprise the apparatus in accordance with the first aspect of the present invention. Further, the system may comprise a concentrator facility arranged for floatation and may be arranged such that a slurry including the particles of the second group is directed to
30 the concentrator facility for floatation.

The present invention provides in a fourth aspect a system for treatment of mined material, the system comprising

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components for liberating valuable materials included in particles of the mined material, the components comprising:

a hydrocyclone arranged for receiving a slurry
5 including the particles of the mined material and for forming an accumulation of a first group of the particles of the mined material, the hydrocyclone comprising a high voltage applicator arranged to apply a high voltage to particles of first group, the high voltage being
10 sufficiently high such that at least micro-cracks are formed in at least some of the particles of the first group; and

a mill for grinding particles of the mined material, the mill being positioned to receive high voltage treated
15 particles from the hydrocyclone.

The mill may be a ball mill that is arranged to grind particles of the mined material to a P80 diameter that is less than 1mm, 0.9mm 0.8mm, 0.6mm or 0.5mm
20

The high voltage applicator may comprise any suitable type of electrode that is suitable to apply the high voltage to the particles of the first group. For example, the electrode may comprise a first electrode portion that is
25 positioned at a central location of the hydrocyclone and a second electrode portion may be provided in the form of a housing portion of the hydrocyclone such that the high voltage is applied between the central electrode portion and the housing portion. The first electrode portion may
30 comprise a generally cylindrical portion. Alternatively, the first electrode portion may comprise a portion that approximates a shape of a portion of the hydrocyclone. For example, the first electrode portion may comprise a

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portion that has a shape that approximates that of a conical portion of the hydrocyclone.

The present invention provides in a fifth aspect a system
5 for treatment of mined material, the system comprising components for liberating valuable materials included in particles of the mined material, the components comprising:

an apparatus for receiving a flow of a slurry
10 including the particles of the mined material, the apparatus having a slurry inlet and a slurry outlet for throughput of the flow of the slurry and comprising a high voltage applicator for applying a high voltage to a selection of the particles, the high voltage being
15 sufficiently high such that at least micro-cracks are formed in at least some of the particles; and

a ball mill for grinding particles of the mined material, the ball mill being positioned to receive high voltage treated particles.

20 The invention will be more fully understood from the following description of specific embodiments of the invention. The description is provided with reference to the accompanying drawings.

25 Brief Description of the Drawings

Figures 1 and 2 are schematic representations of an apparatus for treating particles of mined material in
30 accordance with embodiments of the present invention; and

Figures 3 - 5 are flow charts illustrating a system and a method for treating particles of mined material in

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accordance with an embodiment of the present invention

Detailed Description of Specific Embodiments

5 Embodiments of the present invention relate to an apparatus and a method for treating particles of mined material. The particles of the mined material typically comprise valuable material that is embedded or surrounded by gangue. The mined material may for example be an ore,
10 such as iron or copper ore.

In embodiments of the present invention the particles of the mined material are initially crushed and otherwise treated (for example using a suitable crusher and mill)
15 such that the particles have a P80 feed size of between 0.5mm and 2.2mm (as will be described in details further below). A continuous flow of slurry is then formed and the particles are entrained in the slurry.

20 Embodiments of the present invention generally relate to continuous treatment of the particles of the mined material in the slurry using high electric voltages that are applied in a manner such that at least micro-cracks are formed in the particles. The high voltage is selected
25 so that the micro-cracks are formed, but fragmentation of the particles due to the high voltage is largely avoided. However, subsequent fracture of particles including the micro-cracks is imparted by mechanical impact (for example in a hydrocyclone or a ball mill).

30

The slurry including the high voltage treated particles may then be directed to a mill, such as a ball mill, for further processing towards liberation of valuable

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materials included in the mined material.

Prior to the high voltage treatment the particles are crushed to a P80 diameter of 80 - 120mm, such as 100mm and
5 then ground in a mill, such as a Semi-Autogenous Grinding (SAG) mill. The SAG mill grinds the ore particles down to a P80 product size of between 2mm to 3mm, such as 2.4mm. The slurry with the particles is then pumped to a hydrocyclone in which the particles in the slurry are
10 divided into a first group of larger and heavier particles and a second group of smaller and lighter particles.

The function of a hydrocyclone may be summarised as follows. A slurry including particles of the mined
15 material is directed tangentially into cylindrical section of the hydrocyclone and follows a circulating path. Circulating velocities are typically relatively high and generate large centrifugal fields inside the hydrocyclone. Particles that experience this centrifugal field will tend
20 to move outwards relative to the carrier fluid because of their relatively greater density. The larger, heavier particles will migrate rapidly to outside walls of the cylindrical section and will then be forced to move downward on the inside of a conical wall of the
25 hydrocyclone towards a first exit port. The smaller and lighter particles, will be dragged inwards by the fluid as it moves toward a vortex finder and will be directed towards a second exit port.

30 The larger and heavier particles are not considered suitable for concentration and are directed to a fine grinding mill, such as a ball mill, for further grinding. The smaller and lighter particles are sufficiently small

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for further processing and an accept slurry including these particles is directed for further processing at a concentrator facility including vessels for flotation or other liberation processes. For example, the smaller and
5 lighter particles may have a diameter less than 0.15 - 0.25, such as 0.2mm.

In accordance with embodiment of the present invention the larger and heavier particles are exposed to high voltages
10 to induce the micro-cracks before these particles are directed to the ball mill. The micro-cracks formed in these particles reduce the grinding energy required by the ball mill to grind the particles to a size that is at least of the same order as that of the particles in the
15 accepts slurry.

The high voltage treatment may be applied in any suitable vessel or conduit. In one embodiment the vessel or conduit is positioned to receive the rejects slurry including the
20 larger and heavier particles of the first group from the hydrocyclone before the rejects slurry is directed to the ball mill.

In another embodiment the vessel or conduit is positioned
25 to receive the slurry from the SAG mill to treat the slurry with high voltage before being fed to the slurry inlet of the hydrocyclone.

In an alternative embodiment of the present invention the
30 high voltage treatment is applied within the hydrocyclone. An apparatus that combines the functions of a hydrocyclone and a high voltage applicator in accordance with an embodiment of the present invention will now be explained

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in further details with reference to Figures 1. The apparatus in the form of a hydrocyclone 100 has a slurry inlet 102 for receiving slurry. The hydrocyclone 100 has a top discharge slurry outlet in the form of a vortex finder 104. The hydrocyclone 100 has a cone discharge slurry outlet known as the apex 106. The hydrocyclone 100 has a generally cylindrical and a generally conical body portion. The apex 106 is positioned at the narrow end of the generally cylindrical body portion and the vortex finder 104 is positioned at the opposite end of the hydrocyclone 100. The slurry inlet 102 is positioned such that the flow of the slurry forms an accumulation of larger and heavier particles 108 within the body of the hydrocyclone 100 as the centrifugal forces of the hydrocyclone push the larger and heavier particles 108 against the wall 114. The accept slurry including the smaller and lighter particles 110 of the mined material exits the hydrocyclone 100 via the vortex finder 104. The smaller and lighter particles 110 may have a diameter less than 0.15 - 0.25, such as 0.2mm, and the larger and heavier particles 108 have a diameter that is larger than that. The reject slurry including the larger and heavier particles 108 exits the hydrocyclone 100 via the apex 106.

The hydrocyclone 100 also comprises a high voltage electrode 112 that in this embodiment is positioned at a central location of the hydrocyclone 100, extending through the vortex finder 104. The electrode 112 extends to a position below the vortex finder 104, located centrally within the body of the hydrocyclone 100. The hydrocyclone 100 further comprises a high voltage generator 116 that is arranged to generate the high voltage that is applied between the electrode 112 and a

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metallic body portion forming the wall 114 of the hydrocyclone 100. The high voltage is thus applied such that the particles in the hydrocyclone are between the electrode 112 and the wall 114. The high voltage is
5 sufficiently high such that the accumulated particles 108 experience micro-cracks. In this embodiment the high voltage is sufficient such that the particles 108 experience an electrical energy of 0.5 - 1, 1 - 2, 2 - 3 or 3 to 4 kWh/t.

10

The rejects slurry including the larger and heavier particles 108 is then directed to a ball mill (not shown) and subsequently redirected back to the inlet 102 of the hydrocyclone 100, and this will be described in detail
15 further below. The formation of the micro-cracks facilitates the grinding in the ball mill and reduces an energy that is required for grinding of the particles to a diameter that is sufficient for subsequent flotation processing steps (for example).

20

While the high voltage is sufficient for formation of micro-cracks in the larger and heavier particles 108, the high voltage typically is insufficient for fracturing of at least the majority of the particles 108. However, the
25 particles 108 may fracture due to the additional energy imparted by the mechanical impact between particles 108 and between the particles 108 and the wall 114 as the particles 108 follow a spiral path to the apex 106.

30

The smaller particles formed by fracturing of the larger and heavier particles 108 fractured in the hydrocyclone may then become smaller and lighter particles discharged via the vortex finder 104.

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Figure 2 shows a hydrocyclone 200 that is related to the hydrocyclone 100 and like reference numerals are used for like components. However, in contrast to the hydrocyclone 100, the hydrocyclone 200 has an electrode 202 that has a lower portion 204 that has shape that is similar to that of the body portion of the hydrocyclone 200. The lower portion 204 is in this embodiment provided in the form of a metallic mesh that has openings that are sufficiently large such that the particles of the mined material can pass through the openings. This embodiment provides the additional advantage that the high voltage is applied across a shorter distance within the hydrocyclone 100 (which reduces voltage losses across the slurry and particles other than the larger and heavier particles 108). Further, the high voltage is applied more evenly.

It will be appreciated by a person skilled in the art that in an alternative embodiment the hydrocyclone 100 or 200 may be replaced by a hydrocyclone that is arranged to separate the slurry into an accepts slurry and a rejects slurry. The rejects slurry may then be directed to a further vessel or conduit in which the high voltage is applied to the particles of the rejects slurry.

Referring now to Figure 3, a system and a method for treatment of mined material in accordance with an embodiment of the present invention is now described.

The system 300 comprises various components for the liberation of valuable materials that are included in mined material and is arranged for continuous operation. The fragments of the mined materials are initially fed through a primary crusher 302. The primary crusher 302

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crushes the mined material to P80 product size of between 50mm to 150mm, such as 100mm. The primary crushed particles are then stock piled 304 and subsequently fed into a SAG mill 306 in the form of a slurry. The SAG mill

5 306 grinds the particles down to a P80 product size of between 2mm to 3mm, such as 2.4mm and had a P80 trommel oversize of 25mm. The slurry including the particles then passes through a screen 308. A slurry including particles that do not pass through the screen 308 is sent to a

10 Recycled pebble crusher 310 for further reduction in size and is returned to the SAG mill 306. The recycled pebble crusher 310 crushes the ore particles down to a P80 product size of between 10mm to 15mm, such as 13.2mm. The slurry including the particles that pass through the

15 screen 308 is pumped by pump 309 to the slurry inlet 102 of a hydrocyclone 312. A discharge of a ball mill 316 is added (this will be described further below) and the resulting hydrocyclone P80 feed size is approximately 1mm. The hydrocyclone 312 may be provided in the form of the

20 hydrocyclone 100 or hydrocyclone 200 described above with reference to Figures 1 and 2. Alternatively, the hydrocyclone 312 may comprise a hydrocyclone and a separate vessel or conduit for application of high voltage to the particles, which will be described further below

25 with reference to Figures 4 and 5. The hydrocyclone 312 is arranged for an operation that is continuous during flow of the slurry. The hydrocyclone 312 is in this embodiment arranged for P80 passing of particles having a diameter of the order of 0.15 - 0.25, such as 0.21mm. and the slurry

30 including these particles is then directed to a concentrator facility 314 for further processing and liberation of the valuable materials included in the particles. Particles in the hydrocyclone 312 are high

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voltage treated and the larger and heavier particles that do not fracture in the hydrocyclone are then directed to a ball mill 316 for further grinding and reduction in size. The hydrocyclone is arranged such that the particles that
5 are directed to the ball mill have a P80 product size of between 2mm to 3mm, such as 2.5mm.

The ball mill typically grinds the ore particles down to a P80 product size of between 0.5mm to 1mm, such as 0.85mm.
10 The slurry including the particles ground by the ball mill 316 is then directed back to the hydrocyclone 312 via the pump 309.

As mentioned above, the hydrocyclone and a high voltage
15 applicator may also be provided as separate components of as system for treatment of mined material, which is now illustrated with reference to Figures 4 and 5. Figures 4 and 5 illustrate a system and a method for treatment of mined material in accordance with further embodiment of
20 the present invention. The systems 400 and 500 are related to the system 300 illustrated in Figure 3 and like reference numerals are used for like components. However, in contrast to the system 300, the hydrocyclone is provided separate to a vessel or conduit for application
25 of high voltage to the particles. In the system 400 a high voltage applicator 402 is positioned between a hydrocyclone 401 and the ball mill 316 and in the system 500 a high voltage applicator 502 is positioned between a hydrocyclone 501 and the ball mill 316.

30

A person skilled in the art will appreciate that a number of variations are possible.

The Claims:

1. An apparatus for treating particles of a mined
5 material in a slurry, the apparatus comprising:
a hydrocyclone having a slurry inlet for receiving a
flow of the slurry and having slurry outlets, the
hydrocyclone being arranged to divide the flow of the
10 slurry into a first slurry including a first group of the
particles and a second slurry including a second group of
the particles and in a manner such that an accumulation of
particles of the first group is formed during the flow of
the slurry into the slurry inlet; and
a high voltage applicator arranged to apply a high
15 voltage to particles of the first group during or after
formation of the accumulation of the of the particles of
the first group, the high voltage applicator comprising a
high voltage generator that is arranged to generate a
voltage that is sufficiently high such that micro-cracks
20 are formed in at least some of the particles of the first
group.
2. The apparatus of claim 1 wherein at least a portion
of the high voltage applicator is positioned within the
25 hydrocyclone such that the apparatus is arranged to apply
the high voltage within the hydrocyclone during or after
the accumulation of the particles of the first group.
3. The apparatus of claim 1 wherein the high voltage
30 applicator is spaced apart from at least an interior
region of the hydrocyclone and wherein the apparatus is
arranged to feed the slurry including the particles of the

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first group from the interior region of the hydrocyclone to the high voltage applicator.

4. The apparatus of any one of the preceding claims wherein the apparatus is arranged such that fracture of at least some of the particles that include the formed micro-cracks is imparted by mechanical impact.

5. The apparatus of any one of the preceding claims wherein the high voltage source is arranged to generate a voltage that is sufficient such that at least some of the particles of the first group experience an electrical energy of 0.5 - 1kWh/t.

6. The apparatus of claim 6 wherein the apparatus has a first slurry outlet for exit of the first slurry and a second slurry outlet for exit of the second slurry.

7. The apparatus of any one of the preceding claims wherein the particles of the first group comprise particles that are larger in diameter than the particles of the second group.

8. The apparatus of any one of the preceding claims wherein the particles of the second group have a P80 diameter that is smaller than 250 μ m and the apparatus is arranged such that particles having a size larger than that are included in the first group of particles.

9. The apparatus of any one of the preceding claims wherein the particles of the second group have a P80 diameter that is smaller than 200 μ m and the apparatus is

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arranged such that particles having size larger than that are included in the first group of particles.

10. The apparatus of claim 2 or anyone of claims 4 to 9
5 when dependent on claim 2 wherein the high voltage applicator comprises a first electrode portion that is positioned at a central location of the hydrocyclone and a second electrode portion is provided in the form of a housing portion of the hydrocyclone such that the high
10 voltage is applied between the central electrode portion and the housing portion.

11. The apparatus of claim 10 wherein the first electrode portion comprises a generally cylindrical portion.

15

12. The apparatus of claim 10 wherein the first electrode portion has a shape that approximates that of a portion of the vessel or conduit.

20 13. A method for treating mined material in a slurry in a manner that is continuous during flow of the slurry, the method comprising:

providing the flow of the slurry including particles of the mined material;

25 separating the particles into first and second groups of particles and forming an accumulation of the first group of the particles using a hydrocyclone;

applying a high voltage to at least some particles of the first group, the high voltage being sufficiently high
30 such that at least micro-cracks are formed in at least some of the particles of the first group; and

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directing first and second slurries including the particles of the first and second groups, respectively, for further processing.

5 14. The method of claim 13 wherein the step of applying the high voltage is performed such that the applied high voltage is insufficient to fracture at least the majority of the particles of the first group without mechanical impact.

10

15. The method of claim 14 further comprising the step of imparting mechanical impact to fracture at least some of the particles of the first group that include the formed micro-cracks.

15

16. The method of any one of claims 13 to 15 wherein the high voltage is sufficient such that the particles of the first group experience an electrical energy of 0.5 - 4kWh/t.

20

17. The method of any one of claims 13 to 16 wherein the particles of the first group comprise particles that are larger in diameter than the particles of the second group and wherein the particles of the second group have a P80

25 diameter that is less than 250 μ m.

18. The method of any one of claims 13 to 16 wherein the particles of the first group comprise particles that are larger in diameter than the particles of the second group and wherein the particles of the second group have a P80
30 diameter that is less than 200 μ m.

19. The method of any one of claims 14 to 18 wherein

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the step of directing the first and second slurries comprises directing the first slurry to a ball mill.

20. The method of any one of claims 13 to 19 wherein
5 the steps of separating the particles and applying a high voltage are performed within the hydrocyclone.

21. The method of any one of claims 13 to 19 wherein the
10 steps of separating the particles and applying a high voltage are performed at separate locations and the method comprises a step of feeding the first slurry, after formation of the accumulation of the particles of the first group, from the hydrocyclone to a region for applying the high voltage.

15 22. The method of any one of claims 13 to 20 wherein the step of directing the first and second slurries for further processing comprises directing the first slurry including the particles of the first group after high
20 voltage treatment through a first outlet of the hydrocyclone and directing the second slurry through a second outlet of the hydrocyclone.

23. A system for treatment of mined material, the system
25 comprising components for liberating valuable materials included in particles of the mined material, the components comprising:

30 a first arrangement for providing particles of the mined material at a diameter that is less than a predetermined diameter;

an apparatus for throughput of a slurry, the slurry including the provided particles of the mined material, the apparatus comprising a high voltage applicator that is

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arranged to apply a high voltage to a selection of the particles, the voltage being sufficiently high such that at least micro-cracks are formed in at least some of the particles of the selection; and

5 a second arrangement positioned to receive a slurry including the high voltage treated particles from the apparatus, the second arrangement being arranged to reduce a size of the received particles to a second diameter that is smaller than the first diameter.

10

24. The system of claim 23 wherein the first arrangement comprises a SAG mill and wherein the second arrangement comprises a ball mill.

15 25. The system of claim 23 or 24 wherein the first arrangement comprises a mill is arranged to grind particles of the mined material to a diameter that is less than 0.15 - 0.25, such as 0.2mm and wherein the second arrangement also comprises a mill and is arranged to grind
20 particles of the mined material to a diameter that is at least 10 to 20 μ m smaller than that.

25 26. The system of any one of claims 23 to 25 comprising the apparatus in accordance with any one of claims 1 to 12.

27. A system for treatment of mined material, the system comprising components for liberating valuable materials included in particles of the mined material, the
30 components comprising:

 a hydrocyclone arranged for receiving a slurry including the particles of the mined material and for forming an accumulation of a first group of the particles

- 25 -

of the mined material, the hydrocyclone comprising a high voltage applicator arranged to apply a high voltage to particles of first group, the high voltage being sufficiently high such that at least micro-cracks are
5 formed in at least some of the particles of the first group; and

a mill for grinding particles of the mined material, the mill being positioned to receive high voltage treated particles from the hydrocyclone.

10

28. A system for treatment of mined material, the system comprising components for liberating valuable materials included in particles of the mined material, the components comprising:

15 an apparatus for receiving a flow of a slurry including the particles of the mined material, the apparatus having a slurry inlet and a slurry outlet for throughput of the flow of the slurry and comprising a high voltage applicator for applying a high voltage to a
20 selection of the particles, the high voltage being sufficiently high such that at least micro-cracks are formed in at least some of the particles; and

a ball mill for grinding particles of the mined material, the ball mill being positioned to receive high
25 voltage treated particles.

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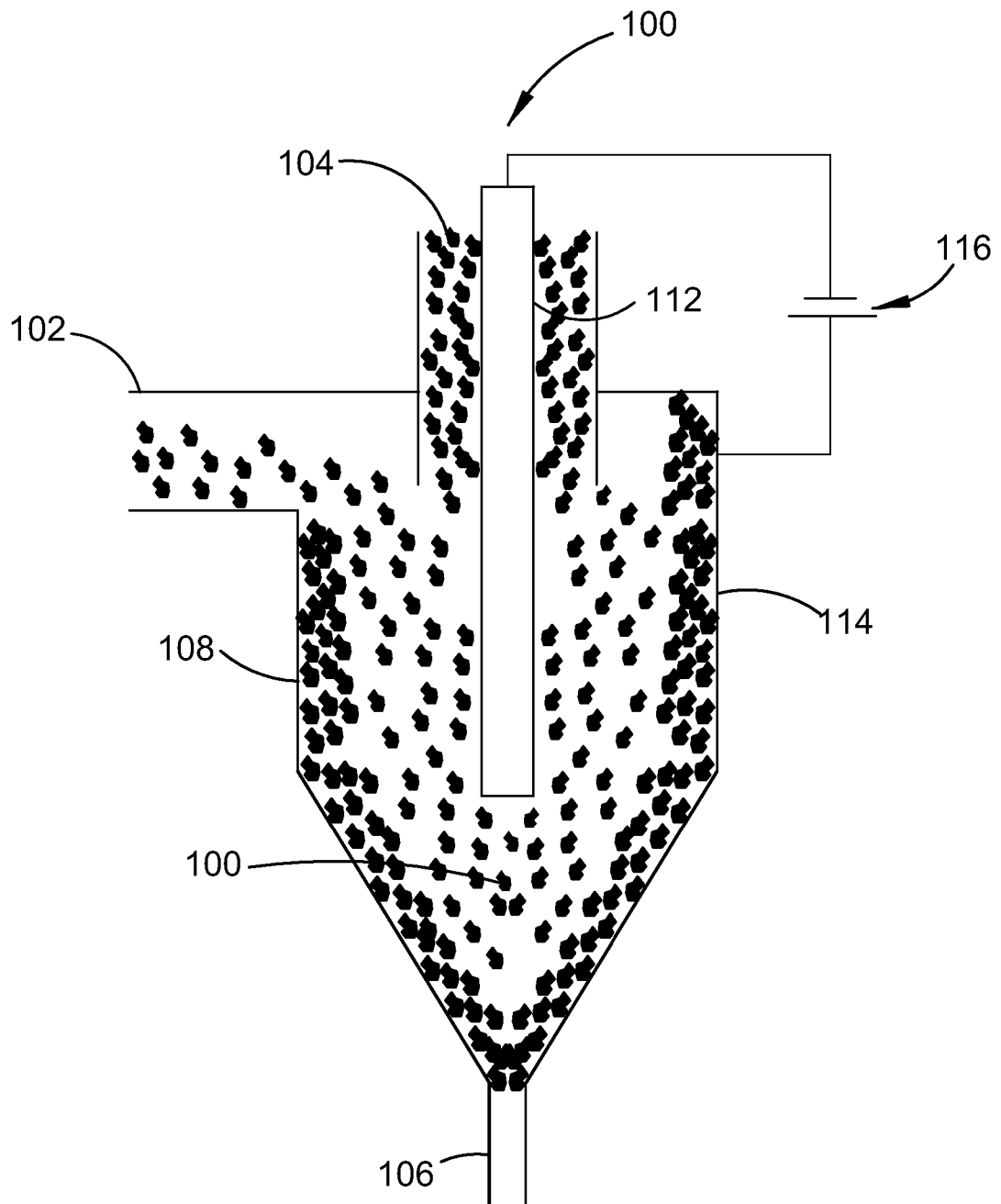


Fig. 1

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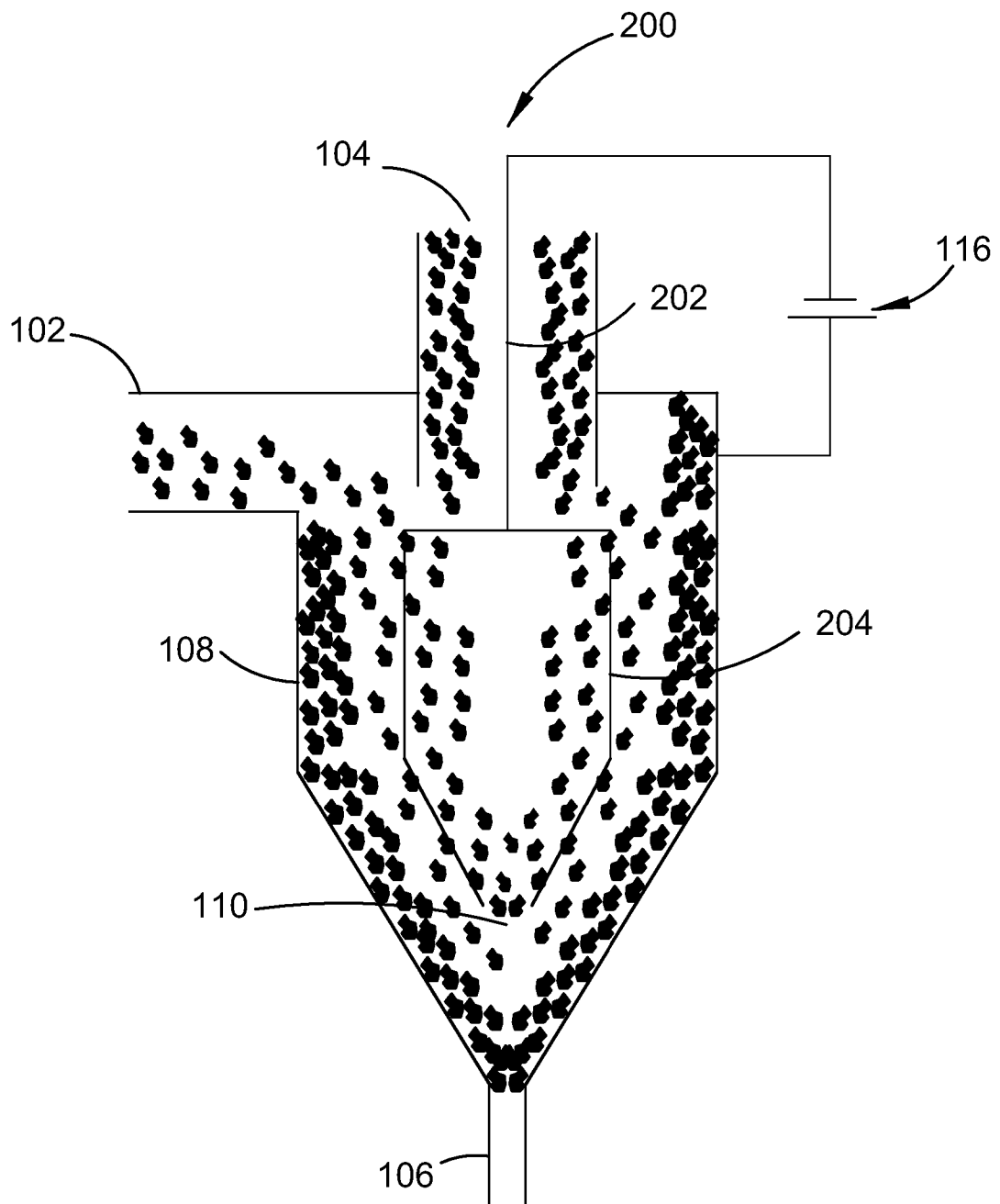


Fig. 2

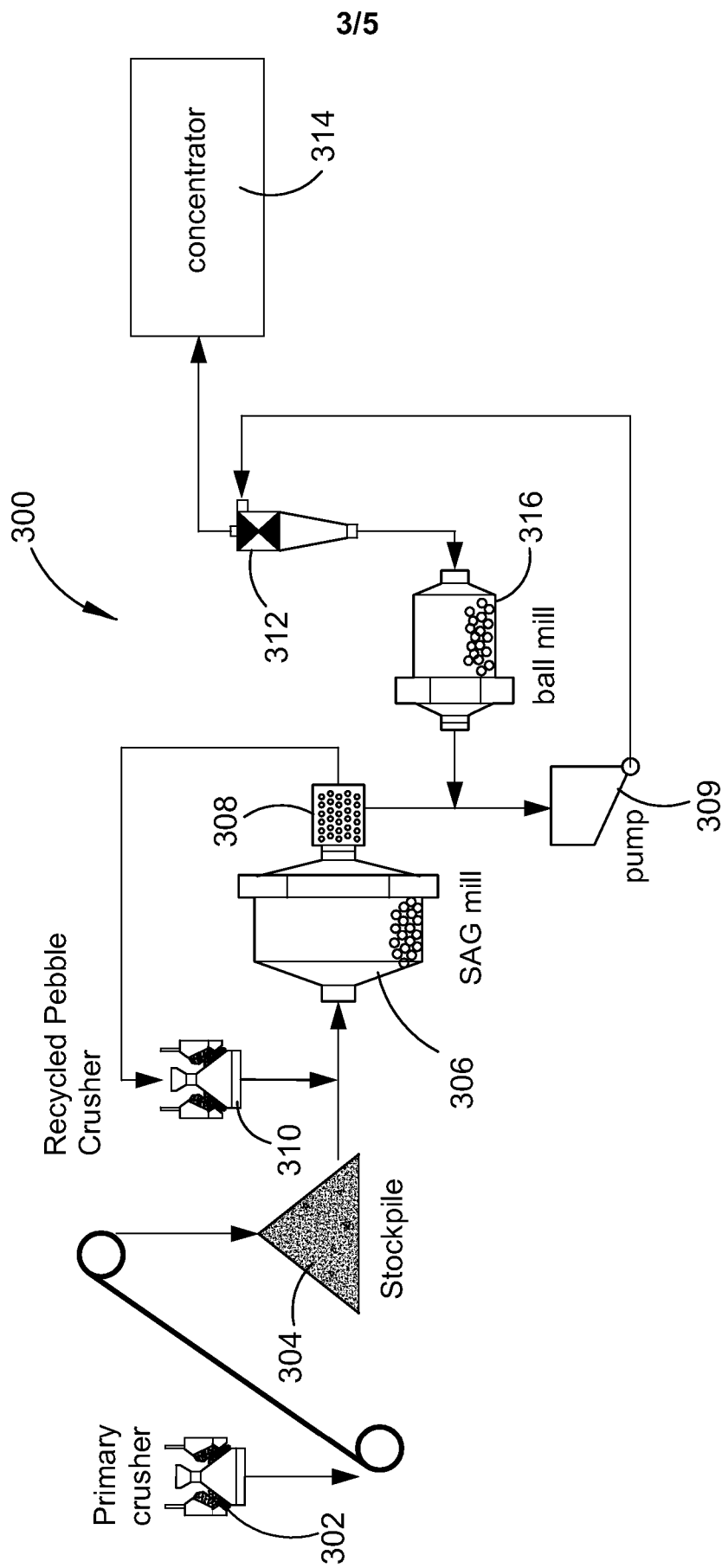


Fig. 3

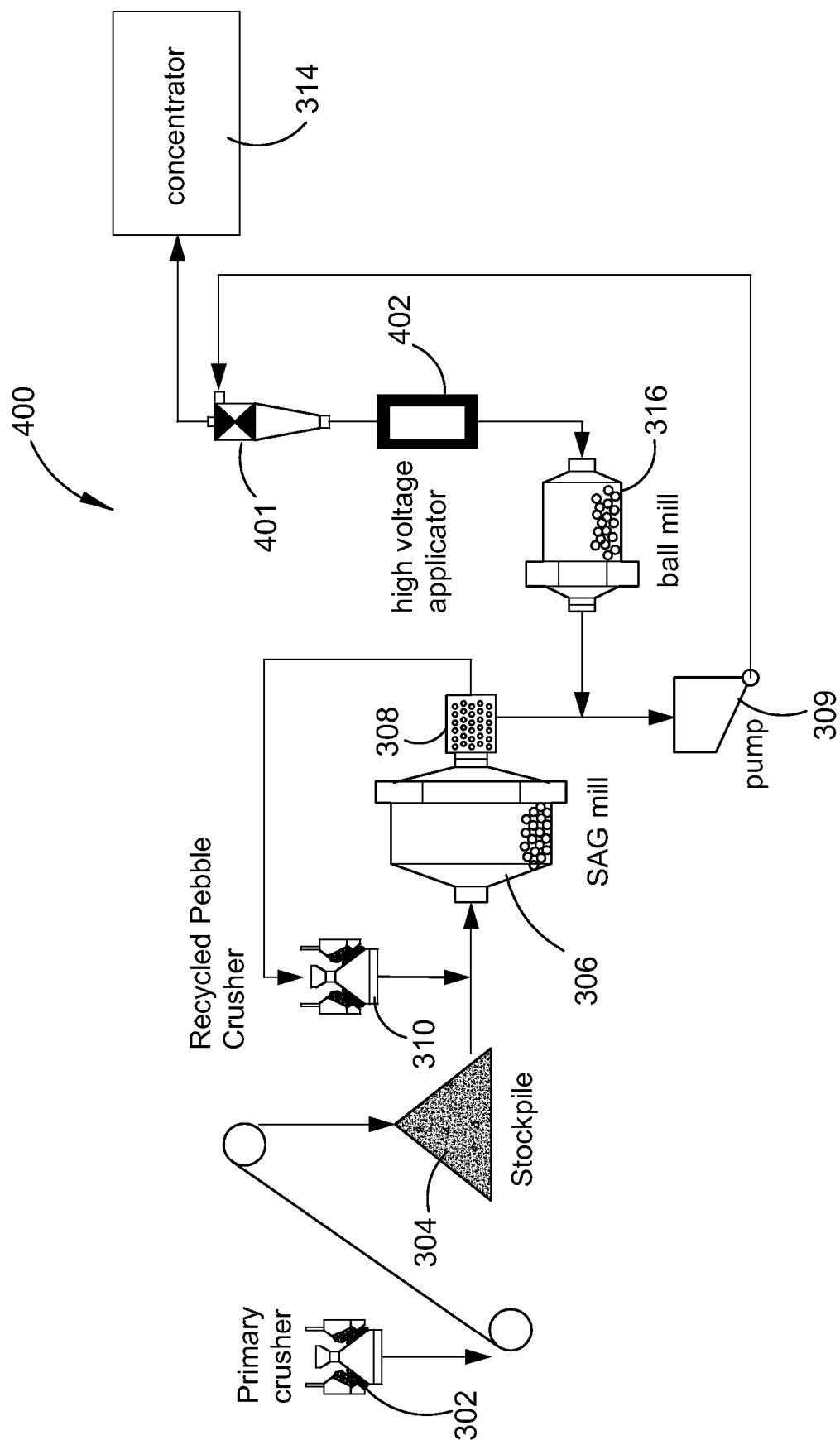


Fig. 4

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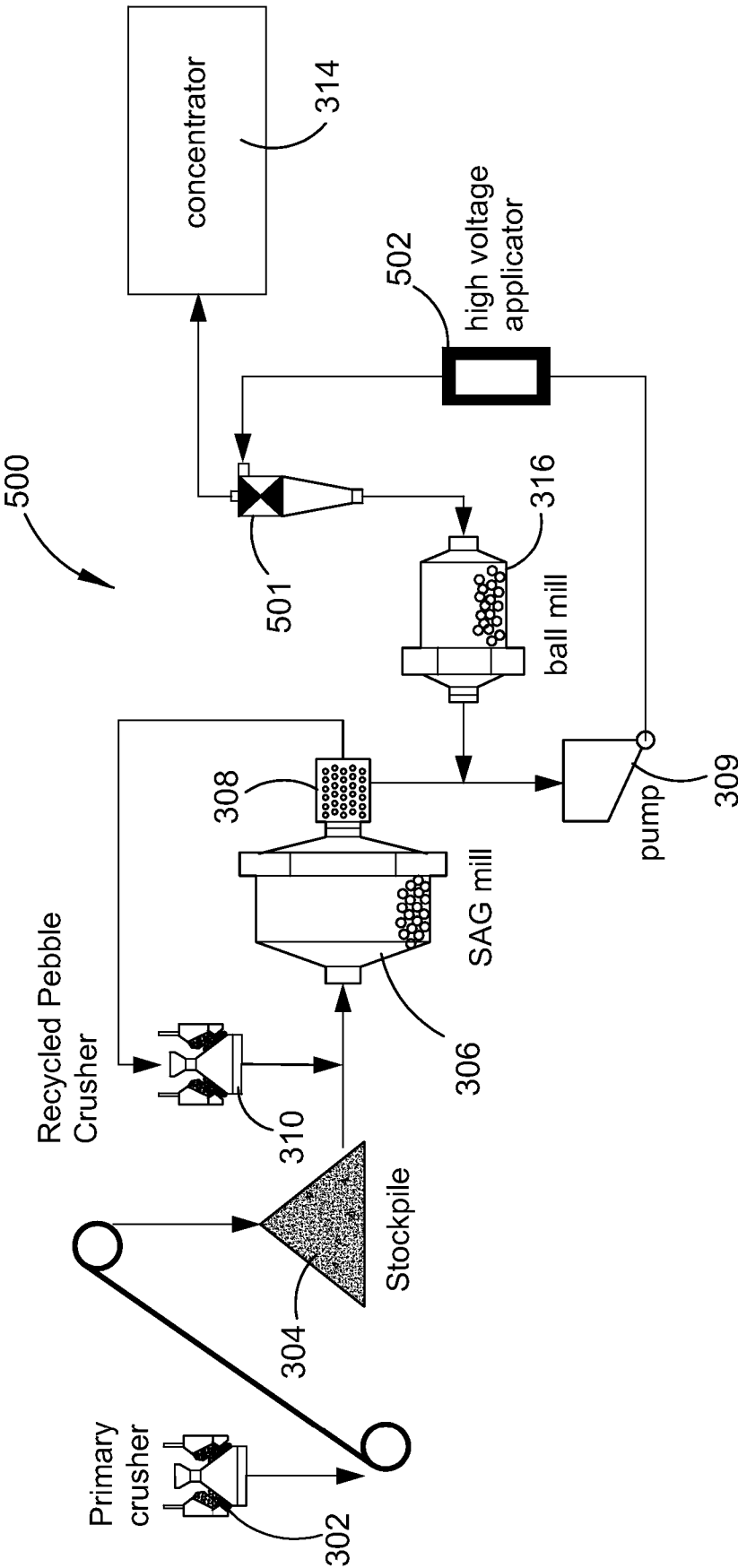


Fig. 5

A. CLASSIFICATION OF SUBJECT MATTER

B02C 19/18 (2006.01) B02C 23/08 (2006.01) B03B 13/04 (2006.01) B03B 7/00 (2006.01)

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)

EPODOC, DWPI, INSPEC, GOOGLE, ESPACENET: (or ((or Particle, mineral, ore, slurry, mined) 2d (or separat+, reduc+, liberat+)), (electric+ 2d comminut+), electro_comminut+, disintegrator?); (Or Voltage, (electric+ 2d puls+), electro_fractur+); (Or Micro_crack+, +break+, weak+, pre_weak+, cleav+, fragment+, comminution, fractur+, crack+, dispers+, separat+, split+, fissure, ruptur+); (or Vessel? Contain+, chamber, conduit?, hydro_cyclon+, cylind+, conic+); (or Centrifugal+, divid+, group, tangential+, circulat+, spin+, +cyclon+, separat+, sieve, sort+, remov+, partition+) 5d ((OR light, heav+, small+, big+, large?, massive, coarse, fine) 2d particle?)); applicant field was searched with: Technological Resources Pty and comminut*, selFrag AG and similar terms; Inventor search in Espacenet: WELLWOOD, Grant Ashley.

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	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 5 November 2014	Date of mailing of the international search report 05 November 2014
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au	Authorised officer Firoozeh Rabbani AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832287

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2014/000817
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2421203 A (URI ANDRES) 21 June 2006 Refer to the whole document and in particular to Figs, pg 6 lines 25-27, pg 7 lines 19-26, claims 1-4, 12, & 15, pg 6 lines 15-24, pg 4 lines 10-11, pg 5 lines 17-21, p.g. 7 lines 1-3, pg 7 line 19 to pg 8 line 5-7	1-9, 13-28
X	WO 1999/003588 A1 (IMPERIAL COLLEGE INNOVATIONS LIMITED) 28 January 1999 Refer to the whole document and in particular to Figs., pg 6 lines 1 to end of second paragraph on pg 7	1-3, 5-9, 13, 16-18, 20-22, 27-28
X	US 2006/0163392 A1 (HOPPE et. al.) 27 July 2006 Refer to the whole document and in particular to Figs., claim 1, [0010]-[0019], [0047],[0049]	1-3, 5-13, 16-18, 20-22, 27-28
X A	ERIC WANG et. al.: "Pre-weakening of mineral ores by high voltage pulses", Minerals Engineering, Vol. 24, (2011), pg 455-462. Refer to the whole document and in particular to pg 457 first full paragraph on left hand column As above	23-25 1-22, 27-28
X A	ERIC WANG et. al.: "Factors affecting electrical comminution performance", Minerals Engineering, Vol. 34, (2012), pg 48-54 Refer to the whole document and in particular to Table 6, section 3.1 Effect of feed size and grain size, section 4.2 Effect of incremental breakage, Fig. 4 As above	23-25 1-22, 27-28
A	EP 0029553 A1 (THE UNIVERSITY OF UTAH RESEARCH FOUNDATION) 03 June 1981 Refer to the whole document and in particular to pg 17 and Figures	1-28
A	ERIC WANG et. al.: "Mineral liberation by high voltage pulses and conventional comminution with same specific energy levels", Minerals Engineering, 27-28, (2012), pg 28-36 Refer to the whole document	1-28

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2014/000817	
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.			
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Publication Number	Publication Date	Publication Number	Publication Date
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WO 1999/003588 A1	28 January 1999	AU 8350498 A	10 Feb 1999
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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.			
Form PCT/ISA/210 (Family Annex)(July 2009)			

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/AU2014/000817	
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.			
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Publication Number	Publication Date	Publication Number	Publication Date
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End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			