

METHODS OF AND SYSTEMS FOR TREATING INCINERATED WASTE

BACKGROUND

1. Field

The invention relates generally to waste treatment, and more particularly to methods
5 of and systems for treating incinerated waste.

2. Related Art

Incineration of waste, such as municipal solid waste for example, may alleviate
demands for landfills and for other ways of disposing of such waste. Incineration of
waste in an incinerator generally produces: (1) flue gases such as carbon dioxide
10 and water vapor for example; (2) fly ash, which escapes up a chimney of the
incinerator; and (3) bottom ash, which collects on an incineration grate of the
incinerator. Some or all of the bottom ash may be disposed of in a landfill, but doing
so increases demands for landfills, which may be restricted in some areas, and
metal from bottom ash disposed of in a landfill may pollute nearby water sources for
15 example. Also, some or all of the bottom ash may be treated for use in various
applications such as manufacture of concrete products for example. However, metal
from bottom ash in concrete products may oxidize over time, causing gaseous
hydrogen to be produced in the concrete products and potentially damaging the
concrete products.

20 SUMMARY

According to one illustrative embodiment, there is provided a method of treating
incinerated waste, the method comprising: size separating at least some of the
incinerated waste, according to a first separation size, into a first undersize fraction
comprising particles smaller than the first separation size and into a first oversize
25 fraction comprising particles larger than the first separation size; size reducing at

least some of the first oversize fraction into a size-reduced first oversize fraction; size separating at least some of the size-reduced first oversize fraction, according to a second separation size, into a second undersize fraction comprising particles smaller than the second separation size and into a second oversize fraction
5 comprising particles larger than the second separation size; combining at least some of the first undersize fraction and at least some of the second undersize fraction into a fine fraction; and extracting metal from at least some of the fine fraction.

According to another illustrative embodiment, there is provided a method of treating incinerated waste, the method comprising extracting metal by froth flotation from at
10 least some of the incinerated waste.

According to another illustrative embodiment, there is provided a system for treating incinerated waste, the system comprising: a means for size separating at least some of the incinerated waste, according to a first separation size, into a first undersize fraction comprising particles smaller than the first separation size and into a first
15 oversize fraction comprising particles larger than the first separation size; a means for size reducing at least some of the first oversize fraction into a size-reduced first oversize fraction; a means for size separating at least some of the size-reduced first oversize fraction, according to a second separation size, into a second undersize fraction comprising particles smaller than the second separation size and into a
20 second oversize fraction comprising particles larger than the second separation size; and a means for extracting metal from at least some of a fine fraction comprising at least some of the first undersize fraction and at least some of the second undersize fraction.

According to another illustrative embodiment, there is provided a system for treating
25 incinerated waste, the system comprising a means for extracting metal by froth flotation from at least some of the incinerated waste.

According to another illustrative embodiment, there is provided a system for treating incinerated waste, the system comprising: a first size separator configured for size separating at least some of the incinerated waste, according to a first separation size, into a first undersize fraction comprising particles smaller than the first separation size and into a first oversize fraction comprising particles larger than the first separation size; at least one size reduction apparatus configured for size reducing at least some of the first oversize fraction into a size-reduced first oversize fraction; a second size separator configured for size separating at least some of the size-reduced first oversize fraction, according to a second separation size, into a second undersize fraction comprising particles smaller than the second separation size and into a second oversize fraction comprising particles larger than the second separation size; and a first at least one metal extraction apparatus configured to extract metal from at least some of a fine fraction comprising at least some of the first undersize fraction and at least some of the second undersize fraction.

According to another illustrative embodiment, there is provided a system for treating incinerated waste, the system comprising a first at least one metal extraction apparatus configured for extracting metal by froth flotation from at least some of the incinerated waste.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of illustrative embodiments in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 is a schematic illustration of an initial washing and size separation portion of a system for treating incinerated waste according to one illustrative embodiment;

- Figure 2 is a schematic illustration of a size reduction portion of the system of Figure 1;
- Figure 3 is a schematic illustration of a fine fraction processing portion of the system of Figure 1; and
- 5 Figure 4 is a schematic illustration of a slime (or ultrafine) fraction processing portion of the system of Figure 1.

DETAILED DESCRIPTION

Referring to Figure 1, a system for treating incinerated waste according to one illustrative embodiment includes a feed bin 1 for receiving the incinerated waste. In
10 the embodiment shown, the incinerated waste includes raw bottom ash (which may also be referred to as grate ash, clinker, or slag) from municipal solid waste that was incinerated in a waste-to-energy facility (not shown). However, in alternative
embodiments, the incinerated waste may include other incinerated waste, which may be from other mixed-waste incinerators or waste-to-energy facilities. In various
15 embodiments, the incinerated waste may include segregated ash such as bottom ash where the combustion products are segregated, or a mixed ash product that may include one or more of fly ash, flue dust, grate siftings, bag house solids, and
pozzolanic ash solids in combination with the bottom ash.

From the feed bin 1, a mechanical feeder 2 (such as a pan or belt feeder for
20 example) in the embodiment shown feeds the incinerated waste onto a conveyor 3, and in some embodiments the mechanical feeder 2 may feed the incinerated waste onto the conveyor 3 at a generally constant rate. In the embodiment shown, the
conveyor 3 transports the incinerated waste to a feed chute 4, through which the incinerated waste enters a washing and size separation device 5, which includes a
25 cylindrical trommel screen that may cause minor attrition of the incinerated waste received at the feed chute 4.

In various embodiments, the feed bin **1** may be configured to receive incinerated waste, such as raw ash that may include bottom ash or more particularly bottom ash from incinerated municipal solid waste for example, by positioning the feed bin **1** to receive the incinerated waste from a stockpile, directly from an operating waste-to-energy facility, or from a combination of both. For example, the feed bin **1** may receive the incinerated waste from mobile equipment such as a front-end loader or dump truck, or from a conveyor directly from an incinerator (not shown). Also, in various embodiments, the system may be in a stand-alone facility in which the feed bin **1** receives the incinerated waste from one or more remote waste-to-energy facilities, or the system may be integrated directly into the operation of a single facility whereby the feed bin **1** receives the incinerated waste from one or more incinerators in the single facility. In such embodiments, the size separation device **5** may be configured to receive incinerated waste through the feed bin **1**, the mechanical feeder **2**, the conveyor **3**, and the feed chute **4**, and the size separation device **5** may be configured to size separate such incinerated waste as described below.

The cylindrical trommel screen of the embodiment shown has an inlet on a first end **56** of the cylindrical trommel screen to receive the incinerated waste from the feed chute **4**, an outlet on a second end **57** of the cylindrical trommel screen opposite and downstream from the first end **56**, a blind section **58** near the first end **56**, a first screening section **59** including a cylindrical screen downstream from the blind section **58**, and a second screening section **60** including a cylindrical screen downstream from the first screening section **59** and near the second end **57**. In the embodiment shown, the first end **56** is higher than the second end **57** so that gravity facilitates movement of material downstream in the cylindrical trommel screen from the first end **56** through the blind section **58**, through the first screening section **59**, through the second screening section **60**, and out the outlet at the second end **57**.

In various embodiments, one or both of the feed chute **4** and the blind section **58** may include wash water sprayers (not shown) to wash the incinerated waste

entering the inlet on the first end **56** of the cylindrical trommel screen with water. Also, in some embodiments, one or both of the first screening section **59** and the second screening section **60** may include cleaning sprayers (not shown) to clean one or both of the respective cylindrical screens of the first screening section **59** and
5 of the second screening section **60** with water.

The blind section **58** may, in some embodiments, include water sprayers (not shown) for spraying a constant spray of water on the incinerated waste received from the feed chute **4** to urge the incinerated waste downstream in the cylindrical trommel screen towards the second end **57**. Also, in some embodiments, the blind
10 section **58** may include a delumper or a similar attritioning device (such as lifters to raise the incinerated waste and drop it from a height, for example) to break up loose lumps and aggregates in the incinerated waste before the incinerated waste reaches one or both of the first screening section **59** and the second screening section **60** downstream from the blind section **58**.

15 The cylindrical screen of the first screening section **59** has openings of a first separation size, which in some embodiments may be between about 1.4 millimeters and about 6.5 millimeters, and which in some embodiments may be about 3 millimeters. A slurry including particles smaller than the first separation size passes through the openings of the cylindrical screen of the first screening section **59**, and
20 particles larger than the first separation size move downstream in the cylindrical trommel screen to the second screening section **60**. Therefore, in the embodiment shown, the first screening section **59** functions generally as a first size separator for size separating at least some of the incinerated waste received from the feed chute **4**, according to the first separation size, into a first undersize fraction including
25 particles smaller than the first separation size and into a first oversize fraction including particles larger than the first separation size. The first undersize fraction may more generally be referred to as a fine fraction, and the first separation size may also be referred to as a fine separation size. In the embodiment shown, a slurry pump **6** receives the first undersize fraction and pumps the first undersize fraction to

a slurry pump **28** that carries the first undersize fraction to a first at least one metal extraction apparatus shown in Figures **3** and **4** and described further below.

In the embodiment shown, the first oversize fraction from the first screening section **59** moves downstream in the cylindrical trommel screen to the second screening section **60**. Also, in some embodiments, the particles in the first oversize fraction may be dewatered in the first screening section **59** sufficiently to allow conveyor transport. The cylindrical screen of the second screening section **60** has openings of a separation size (which may also be referred to as a maximum separation size) larger than the first separation size, and the second screening section **60** may thus be referred to as a maximum size separator. In some embodiments, the maximum separation size may be between about 7.5 centimeters and about 50 centimeters, and may be about 30 centimeters in some embodiments.

Therefore, in the embodiment shown, a main coarse fraction including particles of the incinerated waste larger than the first separation size and smaller than the maximum separation size (and thus including at least some of the first oversize fraction from the first screening section **59**) passes through the openings of the cylindrical screen of the second screening section **60** to a conveyor **8**, and an oversize reject fraction, which includes particles of the incinerated waste received from the feed chute **4** that are larger than the maximum separation size, passes through the second screening section **60**, out the outlet at the second end **57**, and onto a conveyor **7**. The second screening section **60** thus removes, from the main coarse fraction, at least some particles larger than the maximum separation size before size reducing of the main coarse fraction as described below. On or after the conveyor **7**, the oversize reject fraction in some embodiments may be sorted manually to remove coarse metals for recovery and to remove unburned combustible material that may be returned to an incinerator for further incineration, leaving crushable rock and slag that may be recombined with the main coarse fraction (on the conveyor **8**, for example) for further processing as described below.

Although the size separation device **5** in the embodiment shown includes a cylindrical trommel screen, alternative embodiments may include one or more other size separators such as vibrating deck screens for example.

Referring to Figure **2**, the main coarse fraction is conveyed to one or more
5 comminution devices selected to fragment coarse material while generating a minimum of very fine material. For example, in some embodiments, the target size of particles produced by the one or more comminution devices may be between about 0.2 millimeters and about 6.5 millimeters. Metal extraction from finer material may be more difficult than metal extraction from coarser material, and therefore reducing
10 production of very fine material in comminution devices may facilitate extraction of metal from the incinerated waste subjected to such comminution devices.

In the embodiment shown, the conveyor **8** conveys the main coarse fraction to a size separator **9**, which in the embodiment shown includes a screen deck with openings having a separation size of 25 millimeters. In other embodiments, the separation
15 size of the size separator **9** may range from about 1 centimeter to about 10 centimeters. The size separator **9** separates the main coarse fraction (which, as indicated above, includes at least some of the first oversize fraction from the first screening section **59**), according to the separation size of the size separator **9**, into an undersize fraction including particles smaller than the separation size of the size
20 separator **9** and into an oversize fraction including particles larger than the separation size of the size separator **9**.

The oversize fraction from the size separator **9** enters a feed chute for a kinetic impact device **10**, which in the embodiment shown is a hammer mill but could in alternative embodiments be another crusher such as an impact crusher or a
25 compression device such as a roll crusher for example, and which may more generally be referred to as a size reduction apparatus. In the embodiment shown, the kinetic impact device **10** reduces sizes of particles of the oversize fraction from the size separator **9** in a single pass into a size-reduced oversize fraction from the

size separator **9**. The system further includes a size separator **11** for receiving and size separating the size-reduced oversize fraction from the kinetic impact device **10**. In the embodiment shown, the size separator **11** includes a screen having openings of a separation size of about 25 millimeters to separate the size-reduced oversize
5 fraction from the kinetic impact device **10** into an undersize fraction including particles smaller than the separation size of the size separator **11** and into an oversize fraction including particles larger than the separation size of the size separator **11**.

In some embodiments, the kinetic impact device **10** may size reduce at least some
10 brittle material of the oversize fraction from the size separator **9** (to less than about 4 millimeters, for example, and more generally to sizes less than the separation size of the size separator **11** in some embodiments) and may deform at least some malleable material of the oversize fraction from the size separator **9**. In such
15 embodiments, the size separator **11** may separate such brittle material from such malleable material because the size-reduced brittle material may generally be smaller than the separation size of the size separator **11** whereas the deformed malleable material may generally be larger than the separation size of the size separator **11**. Therefore, in some embodiments, the oversize fraction from the size
20 separator **11** may include material that is relatively resistant to grinding due to its hardness, toughness, or malleability for example. Therefore, in some embodiments, the particles in the oversize fraction from the size separator **11** will be primarily metal, but may also include ceramic, rock, and unburned wood or plastic for example.

In general, magnetic separation and eddy current separation may effectively extract
25 metal from among relatively large particles, for example from among particles larger than the separation size of the size separator **11** in the embodiment shown. Therefore, the oversize fraction from the size separator **11** passes onto a conveyor belt including a magnetic separator **12**, which in the embodiment shown is a magnetic head pulley for producing a clean magnetic metal product, and the non-

magnetic portion of the oversize fraction from size separator **11** passes to an eddy current separator **13**, where clean non-magnetic metals may be removed into one or more final products, leaving oversized trash for return to the incinerator. The magnetic separator **12** and the eddy current separator **13** thus extract metal from the oversize fraction from the size separator **11**, and thus may be referred to as a second at least one metal extraction apparatus. The undersize fraction from the size separator **11** is discharged onto a conveyor **14**, which returns the undersize fraction to the feed chute **4**. Therefore, in the embodiment shown, the first screening section **59** also receives and size separates the undersize fraction from the size separator **11**.

The undersize fraction from the size separator **9** enters a feed chute **15** and passes to a comminution device **16**, which may be a mill, a further crushing device, an attrition vessel, or a grinding device in various embodiments, but which is a rod mill in the embodiment shown and which may more generally be referred to as a size reduction apparatus. As indicated above, the particles in the first oversize fraction may be dewatered in the first screening section **59**, and therefore in some embodiments the undersize fraction from the size separator **9** may be re-slurried (for example by adding water until the solids are between about 50% and about 70% by weight of the resulting slurry) for wet grinding in the rod mill of the embodiment shown. The comminution device **16** in the embodiment shown therefore produces a slurry including a size-reduced undersize fraction from the size separator **9**. As indicated above, the undersize fraction from the size separator **9** includes at least some of the first oversize fraction from the first screening section **59**, and therefore the comminution device **16** in the embodiment shown functions as a size reducer to size reduce at least some of the first oversize fraction into a size-reduced first oversize fraction.

The system further includes a size separator **17** for receiving and size separating the slurry from the comminution device **16**. The size separator **17** in the embodiment shown is capable of separating the slurry from the comminution device **16** into three

size fractions. More particularly, the size separator **17** in the embodiment shown includes a screening device including an upper screen **61** and a lower screen **62** such that the upper screen **61** receives the slurry from the comminution device **16** and the lower screen **62** receives an undersize fraction from the upper screen **61**.

5 The upper screen **61** has openings having a separation size that may be between about 7.5 millimeters and about 5 centimeters in some embodiments, and that may be about 19 millimeters in some embodiments. The upper screen **61** thus functions as a size separator to separate at least some of the slurry from the comminution device **16**, according to the separation size of the upper screen **61**, into the
10 aforementioned undersize fraction including particles smaller than the separation size of the upper screen **61**, and into an oversize fraction including particles larger than the separation size of the upper screen **61**.

The lower screen **62** has openings having a separation size that may be between about 1.5 millimeters and about 25 millimeters in some embodiments, and that may
15 be about 6 millimeters in some embodiments. In some embodiments, the comminution device **16** may size reduce at least some brittle material of the undersize fraction from the size separator **9** (to less than about 4 millimeters, for example, and more generally to sizes less than the separation size of the lower screen **62** in some embodiments, to sizes less than the separation size of the upper
20 screen **61** but greater than the separation size of the lower screen **62** in some embodiments, or to both in some embodiments) and may deform at least some malleable material of the undersize fraction from the size separator **9**. In such embodiments, one or both of the upper screen **61** and the lower screen **62** may separate such brittle material from such malleable material because the size-
25 reduced brittle material may generally be smaller than the separation size of one or both of the upper screen **61** and the lower screen **62** whereas the deformed malleable material may generally be larger than the separation size of one or both of the upper screen **61** and the lower screen **62**.

Further, as indicated above, the slurry from the comminution device **16** includes at least some of the first oversize fraction from the first screening section **59**, and therefore the lower screen **62** may be referred to as a second size separator that generally size separates at least some of the size-reduced first oversize fraction (more particularly the size-reduced undersize fraction from the size separator **9** in the embodiment shown), according to a second separation size (namely the separation size of the lower screen **62** in the embodiment shown), into a second undersize fraction including particles smaller than the second separation size and into a second oversize fraction including particles larger than the second separation size. The second separation size may more generally be referred to as a fine separation size, and the second undersize fraction may more generally be referred to as a fine fraction. A slurry pump **18** receives the second undersize fraction and pumps the second undersize fraction to the aforementioned slurry pump **28**.

In various embodiments including the embodiment shown, the second separation size may be larger than the first separation size. In such embodiments, a particle of incinerated waste that has not been size reduced (such as incinerated waste received at the feed chute **4** in the embodiment shown) and that has a size between the first separation size and the second separation size (for example, between about 3 millimeters and about 6 millimeters in some embodiments) will be size reduced at least once (in one or both of the kinetic impact device **10** and the comminution device **16** rather than entering a fine fraction at the first screening section **59** in the embodiment shown), whereas a particle of incinerated waste that has been size reduced (in the comminution device **16** in the embodiment shown) and that has a size between the first separation size and the second separation size (for example, between about 3 millimeters and about 6 millimeters in some embodiments) will avoid further such size reduction and instead enter a fine fraction (from the lower screen **62** in the embodiment shown). Therefore, embodiments where the second separation size is larger than the first separation size may avoid some further size

reduction and may thereby avoid producing unnecessarily fine incinerated waste from which metal extraction may be more difficult.

In summary, in the embodiment shown, the main coarse fraction from the second screening section **60** (which, as indicated above, includes at least some of the first
5 oversize fraction from the first screening section **59**) is size reduced, and size reducing the main coarse fraction size involves:

1. size separating the main coarse fraction at a third size separator (the size separator **9**), according a third separation size (the separation size of the size separator **9**), into a third undersize fraction including particles smaller than the
10 third separation size and into a third oversize fraction including particles larger than the third separation size;
2. size reducing the third oversize fraction in the kinetic impact device **10** into a size-reduced third oversize fraction; and
3. size reducing the third undersize fraction in the comminution device **16**,
15 independently from size reducing the third oversize fraction in the kinetic impact device **10**, into a size-reduced third undersize fraction.

Further, the embodiment shown includes a fourth size separator (the size separator **11**) for size separating the size-reduced third oversize fraction, according to a fourth separation size (the separation size of the size separator **11**), into a fourth undersize
20 fraction including particles smaller than the fourth separation size and into a fourth oversize fraction including particles larger than the fourth separation size.

Still further, the embodiment shown includes a fifth size separator (the upper screen **61**) for size separating the size-reduced third undersize fraction, according to a fifth separation size (the separation size of the upper screen **61**), into a fifth undersize
25 fraction including particles smaller than the fifth separation size and into a fifth oversize fraction including particles larger than the fifth separation size.

In some embodiments, the upper screen **61** will substantially dewater the particles in the oversize fraction from the upper screen **61**, and in general the particles in the oversize fraction from the upper screen **61** may include material that is relatively resistant to grinding due to its hardness, toughness, or malleability for example.

5 Therefore, in some embodiments the particles in the oversize fraction from the upper screen **61** will be primarily metal, but may also include ceramic, rock, and unburned wood or plastic for example. Also, as indicated above, magnetic separation and eddy current separation are generally effective for extracting metal from among relatively large particles, for example from among particles larger than the fifth
10 separation size of the upper screen **61** in the embodiment shown. Therefore, the fifth oversize fraction from the upper screen **61** in the embodiment shown is conveyed by a conveyor **19** to the magnetic separator **12** and then to the eddy current separator **13** described above.

Also, in some embodiments, the lower screen **62** will substantially dewater the
15 particles in the oversize fraction from the lower screen **62**. The second oversize fraction (namely the oversize fraction from the lower screen **62** in the embodiment shown, which includes at least some of the fifth undersize fraction from the upper screen **61**) passes over a magnetic separator **20**, which in the embodiment shown is a short conveyor belt with a magnetic drum at the discharge end. Material removed
20 by the magnetic separator **20** passes into an iron bin as a part of the magnetic product while the non-magnetic material of the oversize fraction from the lower screen **62** is fed to a washing device **21** to separate substantially all material having a specific gravity of about 1 or less. The washing device **21** thus removes lighter material from at least a portion of the second oversize fraction (from the lower
25 screen **62**) that is not removed by the magnetic separator **20** before metal is extracted from that at least a portion of the second oversize fraction as described below. The washing device **21** in various embodiments may be a jig or cyclone for example, or in the embodiment shown an elutriation column with a countercurrent up-flow of water to carry light material to an overflow.

In the embodiment shown, overflow material from the washing device **21** passes over a dewatering screen to a trash bin for return to the incinerator, while underflow material from the washing device **21** flows by gravity into a gravity separator **22**, which in various embodiments may include a mineral jig, a spiral concentrator, a centrifugal concentrator, or a heavy media concentrator, but in the embodiment shown is a spiral concentrator that separates the underflow material from the washing device **21** into a heavier fraction and a lighter fraction. In one embodiment, the heavier fraction includes particles having a specific gravity greater than about 2.8 and the lighter fraction includes particles having a specific gravity less than about 2.8. In some embodiments, the heavier fraction from the gravity separator **22** includes metal concentrates that pass over a dewatering screen **23** to a concentrate bin, and the gravity separator **22** in cooperation with the dewatering screen **23** thus extract metal from at least some of the heavier fraction. The dewatered metal from the heavier fraction from the gravity separator **22** could constitute a final mixed metal product including one or more of copper, brass, lead, tin, and stainless steel for sale to scrap metal dealers for example, or which could be fed to a separate process for additional cleaning and separation in some embodiments. The dewatered metal from the heavier fraction from the gravity separator **22** may also contain precious metals, and further processing could include one or more of hand sorting, optical sorting, thermal processing, and hydrometallurgical processing to generate separate high value metal products, depending for example on the application, local scrap markets, and metal prices.

The lighter fraction from the gravity separator **22** is dewatered with a screening device **24** and further comminuted or size reduced, in the embodiment shown by crushing the dewatered lighter fraction from the gravity separator **22** in a roll crusher **25**, which may more generally be referred to as a size reduction apparatus. The size-reduced dewatered lighter fraction from the gravity separator **22** is then size separated at a sixth size separator **26**, which in various embodiments may include a screen with openings having a sixth separation size between about 3 millimeters and

about 16 millimeters, or about 6 millimeters in some embodiments. The sixth size separator **26** thus size separates the crushed dewatered lighter fraction from the gravity separator **22** according to the sixth separation size into a sixth undersize fraction including particles smaller than the sixth separation size and into a sixth
5 oversize fraction including particles larger than the sixth separation size. In some embodiments, the roll crusher **25** may size reduce at least some brittle material of the size-reduced dewatered lighter fraction from the gravity separator **22** (to less than about 4 millimeters, for example, and more generally to sizes less than the sixth separation size in some embodiments) and may deform at least some malleable
10 material of the lighter fraction from the gravity separator **22**. In such embodiments, the sixth size separator **26** may separate such brittle material from such malleable material because the size-reduced brittle material may generally be smaller than the sixth separation size whereas the deformed malleable material may generally be
larger than the sixth separation size.

15 The sixth oversize fraction is deposited in a fine aluminum bin, and the sixth size separator **26** thus extracts metal from at least some of the sixth oversize fraction. The magnetic separator **20**, the gravity separator **22**, the roll crusher **25**, and the sixth size separator **26** may thus in the embodiment shown extract metal from the
20 second oversize fraction (from the lower screen **62**, which includes at least some of the fifth undersize fraction from the upper screen **61**) independently from the extraction of metal from the fifth oversize fraction (from the upper screen **61**) at the magnetic separator **12** and at the eddy current separator **13** as described above.

In summary, one or more of the magnetic separator **20**, the washing device **21**, the gravity separator **22**, the dewatering screen **23**, the screening device **24**, the roll
25 crusher **25**, and the sixth size separator **26** in various embodiments may extract metal from at least some of the second oversize fraction, and may be referred to as a third at least one metal extraction apparatus.

The sixth undersize fraction (from the sixth size separator **26**) is combined with wash water in a slurry pump **27**, which pumps the sixth undersize fraction from the sixth size separator **26** to the aforementioned slurry pump **28**. Therefore, in the embodiment shown, the sixth separation size may also be referred to as a fine separation size, and the sixth undersize fraction may also be referred to as a fine fraction. Also, in the embodiment shown, at least some of the first undersize fraction (from the first screening section **59** shown in Figure **1**), at least some of the second undersize fraction (from the second screen **62**), and at least some of the sixth undersize fraction (from the sixth size separator **26**) are combined into a combined fine fraction received at the slurry pump **28**.

Further, as described below, metal may be extracted from the combined fine fraction independently of the extraction of metal from the second oversize fraction (from the lower screen **62**, which includes at least some of the fifth undersize fraction from the upper screen **61** in the embodiment shown) at the magnetic separator **20**, the gravity separator **22**, the roll crusher **25**, and the sixth size separator **26**, and independently from the extraction of metal from the fifth oversize fraction (from the upper screen **61** in the embodiment shown) at the magnetic separator **12** and at the eddy current separator **13** as described above. Therefore, in summary, the size separator **17** size separates the slurry from the comminution device **16** into three size fractions, and metal may be extracted from the three size fractions independently.

In various embodiments, metal may be extracted from each of the three size fractions of the size separator **17** because different methods of metal extraction may be appropriate for each of the size fractions. For example, in the embodiment shown, the magnetic separator **12** and the eddy current separator **13** described above may extract metal from the largest of the three size fractions of the size separator **17** (namely the fifth oversize fraction from the upper screen **61**), the magnetic separator **20**, the gravity separator **22**, the roll crusher **25**, and the sixth size separator **26** described above may extract metal from the middle of the three size fractions of the size separator **17** (namely the second oversize fraction from the

lower screen **62**, which includes the fifth undersize fraction from the upper screen **61**), and the slurry pump **28** receives the combined fine fraction from first undersize fraction (from the first screening section **59** shown in Figure **1**), from the second undersize fraction (from the second screen **62**), and from the sixth undersize fraction (from the sixth size separator **26**) to facilitate extraction of metal from the combined fine fraction as described below.

The embodiment shown may extract metal from the combined fine fraction because of common properties of the first undersize fraction (from the first screening section **59** shown in Figure **1**), the second undersize fraction (from the second screen **62**), and the sixth undersize fraction (from the sixth size separator **26**) that may arise in some embodiments. By extracting metal from the combined fine fraction, embodiments such as those described herein may extract metal from incinerated waste more effectively than some other methods of and systems for treating incinerated waste because many such other methods and systems may not exploit any common properties of sources for such fine fractions, and because many such other methods and systems often discard such fine fractions as waste rather than extracting metal from any such fine fractions.

Referring to Figure **3**, the slurry pump **28** in the embodiment shown transfers the combined fine fraction to a slime size separator **29** for separating the combined fine fraction into at least two size fractions including at least one slime (or ultrafine) fraction and at least one deslimed fraction. The at least one deslimed fraction may also be referred to as at least one sand fraction. The slime size separator **29** in some embodiments may employ established desliming methods, and for example may include one or more hydrocyclones at a low pulp density, a low-speed sand auger with suitable wash water addition, or an elutriation column in which a separation size may be controlled by a water upflow rate. In the embodiment shown, the slime size separator **29** includes one or more low-density hydrocyclones to produce an overflow slime fraction and an underflow deslimed fraction (or sand fraction). In some embodiments, the nominal separation size will be in the range of

about 2 microns to about 50 microns, depending for example on the nature of the raw ash and the intended uses of the final products. In one embodiment, about 80% by weight of the particles of the slime fraction will be smaller than about 35 microns.

The deslimed fraction from the slime size separator **29** flows to a gravity separator **30** that gravity separates the deslimed fraction into a gravity concentrate and into gravity tailings. In various embodiments, the gravity separator **30** may include a mineral jig, a spiral concentrator, a centrifugal concentrator, a heavy media separation device, or any similar gravity separation device to produce a bulk gravity concentrate and relatively heavy-metal-reduced gravity tailings sand. In the embodiment shown, the gravity separator **30** is a mineral jig.

The gravity tailings from the gravity separator **30** are conditioned in a first conditioning tank **31** with a first at least one chemical reagent, which in various embodiments may include one or more of at least one xanthate, at least one dithiophosphate, at least one thiocarbamate, at least one thionocarbamate, at least one mercaptobenzothiozole, at least one hydroxamate, at least one fatty acid, at least one amine, at least one soluble base metal salt, at least one soluble sulphide compound, at least one alkali, at least one alkali earth, and at least one frothing agent, into a first conditioned slurry. In various embodiments, the first at least one chemical reagent may be added manually or automatically in the first conditioning tank **31**. In some embodiments, the gravity tailings from the gravity separator **30** may be conditioned in the first conditioning tank **31** for about 5 minutes with about 50 grams of potassium amyl xanthate per tonne of the gravity tailings from the gravity separator **30**, about 10 grams of sodium ethyl, sec-butyl dithiophosphate per tonne of the gravity tailings from the gravity separator **30**, and about 20 grams of methyl isobutyl carbinol per tonne of the gravity tailings from the gravity separator **30**.

The first conditioned slurry is then subjected to froth flotation, which in some embodiments may involve using commercially available multi-stage flotation cells to produce one or more cleaned metal concentrates and final cleaned sand tailings. In

the embodiment shown, the first conditioned slurry from the first conditioning tank **31** is subjected to froth flotation in a first froth flotation cell **32** to produce a first concentrate and first tailings. In some embodiments, the first conditioned slurry may be about 30% solids by weight and may be subjected to about 10 minutes of froth
5 flotation in the first froth flotation cell **32**. In the embodiment shown, the first concentrate is further upgraded or cleaned in a first concentrate cleaning flotation cell **33**, at a lower pulp density than the first conditioned slurry, into a first cleaned first concentrate, and first cleaner tailings from the first concentrate cleaning flotation cell **33** are returned to the first conditioning tank **31** such that the first froth flotation
10 cell **32** receives the first cleaner tailings and also separates at least some of the first cleaner tailings into the first concentrate and into the first tailings.

In some embodiments, multiple cleaning stages may be included to obtain a higher metal content in a resulting final first cleaned flotation concentrate. In embodiments with multiple cleaning stages, the tailings from a given cleaning stage may be
15 returned to the start of a previous cleaning stage, and the cleaned concentrate may be passed to a subsequent cleaning stage, except that the final first cleaned concentrate from the final cleaning stage may be dewatered. In the embodiment shown, the first cleaned concentrate from the first concentrate cleaning flotation cell **33** is the final first cleaned flotation concentrate, and is dewatered in a first thickener
20 **34** into a first cleaned and dewatered flotation concentrate. In some embodiments, the first thickener **34** may separate water from the first cleaned concentrate by allowing the first cleaned concentrate to settle over time.

In the embodiment shown, the first tailings from the first froth flotation cell **32** are conditioned in a second conditioning tank **35** with a second at least one chemical
25 reagent, such as about 100 grams of copper sulphate per tonne of the first tailings from the first froth flotation cell **32**, to produce a second conditioned slurry. In various embodiments, the second at least one chemical reagent may include one or more of: at least one activator such as copper sulphate for example; at least one sulphidizing agent such as sodium hydrosulphide for example; at least one metal sulphide

collector such as potassium amyl xanthate for example; and at least one frother such as methyl isobutyl carbinol for example. Also, in various embodiments, the second at least one chemical reagent may be added manually or automatically in the second conditioning tank **35**. The second conditioned slurry is re-floated for about 10
5 minutes in a second froth flotation cell **36** (which may also be referred to as a scavenger flotation cell) to produce a second concentrate and second tailings. The second concentrate in the embodiment shown is cleaned in a second concentrate cleaning flotation cell **37** into a cleaned second concentrate, and second cleaner tailings from the second concentrate cleaning flotation cell **37** are returned to the
10 second conditioning tank **35** such that in the embodiment shown, the second froth flotation cell **36** receives the second cleaner tailings and also separates at least some of the second cleaner tailings into the second concentrate and into the second tailings.

In some embodiments, multiple cleaning stages may be included to obtain a higher
15 metal content in a resulting final second cleaned flotation concentrate. In embodiments with multiple cleaning stages, the tailings from a given cleaning stage may be returned to the start of a previous cleaning stage, and the cleaned concentrate may be passed to a subsequent cleaning stage, except that the final second cleaned concentrate from the final cleaning stage may be dewatered. In
20 other embodiments, the second concentrate from the second froth flotation cell **36** may be combined with the first concentrate from the first froth flotation cell **32** and subjected to cleaning flotation as a combined product. In the embodiment shown, the second cleaned concentrate from the second concentrate cleaning flotation cell
37 is the final second cleaned flotation concentrate, and is dewatered in a second
25 thickener **38** into a second cleaned and dewatered flotation concentrate. Again, in some embodiments, the second thickener **38** may separate water from the second cleaned concentrate by allowing the second cleaned concentrate to settle over time.

In the embodiment shown, the second tailings from the second froth flotation cell **36** are dewatered in a thickener or a sand auger **39**, and the resulting final cleaned

sand tailings may be a stackable sand product that may be used in producing concrete products for example.

The embodiment shown includes two-stage froth flotation and accordingly may produce the first cleaned and dewatered flotation concentrate from the first thickener
5 **34** in the first froth flotation stage, the second cleaned and dewatered flotation concentrate from the second thickener **38** in the second froth flotation stage, and the final cleaned sand tailings from the thickener or sand auger **39**. However, as indicated above, various embodiments may include different numbers of stages, each of which may include a respective conditioning tank, a respective froth flotation
10 cell, a respective concentrate cleaning flotation cell or series of concentrate cleaning flotation cells, and a respective thickener similar to those described above to produce a respective cleaned and dewatered flotation concentrate generally as described above, and such embodiments may also produce final cleaned sand tailings from the last one of the froth flotation states as described above. Depending
15 on quantities and grades, such cleaned and dewatered flotation concentrates may constitute separate saleable products, or may be combined with products (such as those described below) from the gravity concentrate from the gravity separator **30** for sale or further processing. In general, the various froth flotation stages may extract metal from at least some of the combined fine fraction received at the slurry pump
20 **28**.

The gravity concentrate from the gravity separator **30** in the embodiment shown is further processed by wet magnetic separation at a wet magnetic separator **40** into a magnetic fraction and into a non-magnetic fraction. The magnetic fraction from the wet magnetic separator **40** in various embodiments may be either re-combined with
25 the products such as those described above from the gravity tailings from the gravity separator **30** or sold as an iron concentrate, depending for example on available markets and requirements for the makeup of the final cleaned sand tailings.

The non-magnetic fraction of the gravity concentrate from the gravity separator **30** in the embodiment shown is further upgraded and separated using a secondary gravity separator **41**, which in various embodiments may be a cleaning jig or a shaking table for example. The secondary gravity separator **41** may produce a separate saleable
5 precious metals concentrate and a mixed heavy metal product (including one or more of copper, lead, zinc, and tin for example) that may be directly saleable, or that may be further upgraded along with coarse metal concentrates using thermal or hydrometallurgical methods, for example, to produce higher-value metal products. The wet magnetic separator **40** and the secondary gravity separator **41** in the
10 embodiment shown may therefore extract metal from the gravity concentrate from the gravity separator **30**. Reject material from the secondary gravity separator **41** in the embodiment shown is collected in a launder **42** and returned to the slurry pump **28**.

Referring to Figure 4, the slime fraction from the slime size separator **29** may be
15 handled in a number of different ways depending on the market potential for possible saleable products. In some embodiments, the slime fraction from the slime size separator **29** may not be processed into a useable product, but may instead be dewatered by flocculation, thickening, and filtration for transportation and disposal. In such embodiments, the leachability of any residual heavy metals in the slime fraction
20 may be controlled by adding phosphate-based reagents or other stabilizers to ensure metal stability in the disposal environment.

However, the embodiment shown may process the slime fraction from the slime size separator **29** into useable products. In the embodiment shown, the slime fraction from the slime size separator **29** is partially dewatered in a primary thickener **43**
25 (which may, in some embodiments, separate water from the slime fraction by allowing the slime fraction to settle over time, and which may be referred to as a third thickener for dewatering the slime fraction into a thickened slurry) to reduce salt content and increase pulp density to above 30% solids by weight of the slime fraction. The thickened slime fraction in the embodiment shown is then pumped to a

conditioning tank **44** where the thickened slime fraction is diluted with clean water to a slurry having less than 25% solids by weight. Also, if necessary in some embodiments, an alkaline reagent such as calcium hydroxide or sodium carbonate may be added manually or automatically to the conditioning tank **44** to increase the pH of the slurry to above about 11. More generally, the pH of the slurry may be increased to oxidize aluminum in the slurry to prevent later oxidation of aluminum that may produce hydrogen in a finished concrete product for example. In some embodiments, the slurry may be mixed in the conditioning tank **44** at low speed for up to 1 hour.

10 In the embodiment shown, the conditioning tank **44** overflows into a secondary thickener **45** (which may, in some embodiments, separate water from the overflow of the conditioning tank **44** by allowing the overflow of the conditioning tank **44** to settle over time) for additional salt removal and to increase the pulp density of the overflow slurry from the conditioning tank **44** to more than 30% solids by weight, or to
15 increase the pulp density of the overflow slurry from the conditioning tank **44** to about 40% solids by weight in some embodiments. The thickened slurry from the secondary thickener **45** is then pumped to a third conditioning tank **46** where a third at least one chemical reagent may be added. In various embodiments, the third at least one chemical reagent may include standard flotation reagents such as one or
20 more of at least one xanthate, at least one dithiophosphate, at least one thiocarbamate, at least one thionocarbamate, at least one mercaptobenzothiozole, at least one hydroxamate, at least one fatty acid, at least one amine, at least one soluble base metal salt, at least one soluble sulphide compound, at least one alkali, at least one alkali earth, and at least one frothing agent. In various embodiments, the
25 third at least one chemical reagent may be added manually or automatically in the third conditioning tank **46**. In some embodiments, the thickened slurry from the secondary thickener **45** may be conditioned with about 50 grams of potassium amyl xanthate and about 10 grams of sodium ethyl, sec-butyl dithiophosphate per tonne

of the thickened slurry from the secondary thickener **45** in the third conditioning tank **46** for about 5 minutes to about 10 minutes.

Overflow from the third conditioning tank **46** (which may be referred to as a third conditioned slurry) flows, in the embodiment shown, to a fourth conditioning tank including a high-shear mixer **47** where a fourth at least one chemical reagent may be added. The fourth at least one chemical reagent may include one or more of diesel fuel, kerosene, fuel oil, and at least one fatty acid. In various embodiments, the fourth at least one chemical reagent may be added manually or automatically in the high-shear mixer **47**. In some embodiments, the fourth at least one chemical reagent includes about 500 grams of diesel fuel per tonne of overflow from the third conditioning tank **46**. The slurry formed by combining the overflow from the third conditioning tank **46** with the fourth at least one chemical reagent (if any) may be mixed (with a mixing impeller in some embodiments) in the high-shear mixer **47** at high speed (about 800 rpm or from about 200 rpm to about 1,000 rpm, for example) for about 15 minutes or for up to about 30 minutes before overflowing to a third froth flotation cell **48** (which may also be referred to as a rougher flotation cell) where the slurry may separate into a third concentrate and into third tailings. In some embodiments, the overflow from the high-shear mixer **47** in the third froth flotation cell **48** may be diluted with clean water to 30% solids by weight, and about 20 grams of methyl isobutyl carbinol per tonne of overflow from the high-shear mixer **47** may be added to the overflow from the high-shear mixer **47**. Also, in some embodiments, flotation in the third froth flotation cell **48** may last about 10 minutes.

Tailings from the third froth flotation cell **48** in the embodiment shown flow into a fourth conditioning tank **49** where a fifth at least one chemical reagent may be added. In various embodiments, the fifth at least one chemical reagent may be added manually or automatically in the fourth conditioning tank **49**. In some embodiments, the fifth at least one chemical reagent may include about 100 grams of copper sulphate and about 10 grams of methyl isobutyl carbinol per tonne of tailings from the third froth flotation cell **48**. In various embodiments, the fifth at least

one chemical reagent may include one or more of: at least one activator such as copper sulphate for example; at least one sulphidizing agent such as sodium hydrosulphide for example; at least one metal sulphide collector such as potassium amyl xanthate for example; at least one frother such as methyl isobutyl carbinol for example; and at least one agglomerating agent such as kerosene for example. The conditioned tailings from the fourth conditioning tank **49** in the embodiment shown then overflow into a fourth froth flotation cell **50** (which may also be referred to as a final scavenger flotation unit) where, in some embodiments, the pulp density may be further diluted to about 20% solids by weight. In the fourth froth flotation cell **50** in the embodiment shown, the conditioned tailings from the fourth conditioning tank **49** may separate into a fourth concentrate and into fourth tailings.

In the embodiment shown, the third concentrate from the third froth flotation cell **48** and the fourth concentrate from the fourth froth flotation cell **50** are combined and cleaned in at least two stages. In other embodiments, the third concentrate from the third froth flotation cell **48** and the fourth concentrate from the fourth froth flotation cell **50** may be cleaned separately, and each such concentrate may be cleaned in one or more cleaner stages. More particularly, in the embodiment shown, the third concentrate from the third froth flotation cell **48** and the fourth concentrate from the fourth froth flotation cell **50** are cleaned in a first cleaner **51**, and the cleaned concentrate from the first cleaner **51** is cleaned in a second cleaner **52**. In some embodiments, the slurries cleaned in the first and second cleaners **51** and **52** may be diluted to about 10% solids by weight. Also, in some embodiments, small amounts of methyl isobutyl carbinol may be added if needed to maintain a suitable froth. In the embodiment shown, tailings from the first cleaner **51** flow back to the third froth flotation cell **48**, tailings from the second cleaner **52** flow back to the first cleaner **51**, and the cleaned concentrate from the second cleaner **52** is dewatered in a thickener **53**, which may produce a dewatered cleaned concentrate in some embodiments by allowing the cleaned concentrate from the second cleaner **52** to settle over time. The dewatered cleaned concentrate from the thickener **53** may in

some embodiments be combined with sand flotation concentrates (such as the first cleaned and dewatered flotation concentrate from the first thickener **34** and the second cleaned and dewatered flotation concentrate from the second thickener **38** described above, for example) for sale or for further upgrading.

5 In summary, the primary thickener **43**, the conditioning tank **44**, the secondary thickener **45**, the third conditioning tank **46**, the high-shear mixer **47**, the third froth flotation cell **48**, the fourth conditioning tank **49**, the fourth froth flotation cell **50**, the first cleaner **51**, and the second cleaner **52** extract metal from at least some of the
10 slime fraction from the slime size separator **29**. Also, in summary, one or more of the slime size separator **29**, the gravity separator **30**, the first conditioning tank **31**, the first froth flotation cell **32**, the first concentrate cleaning flotation cell **33**, the first thickener **34**, the second conditioning tank **35**, the second froth flotation cell **36**, the second concentrate cleaning flotation cell **37**, the second thickener **38**, the wet magnetic separator **40**, the secondary gravity separator **41**, the primary thickener **43**,
15 the conditioning tank **44**, the secondary thickener **45**, the third conditioning tank **46**, the high-shear mixer **47**, the third froth flotation cell **48**, the fourth conditioning tank **49**, the fourth froth flotation cell **50**, the first cleaner **51**, and the second cleaner **52** in various embodiments may extract metal from one or more of the fine fractions mentioned above, and may be referred to as the first at least one metal extraction
20 apparatus mentioned above.

The fourth tailings from the fourth froth flotation cell **50** in the embodiment shown are dewatered by flocculation and settling in a fourth thickener **54** and then filtered in a filter **55** to reduce moisture content as may be required to produce a final slimes product. If necessary in some embodiments, re-pulping with clean water and re-
25 filtering may achieve a level of soluble salt content that may be desired in the dewatered fourth tailings from the fourth froth flotation cell **50**. Further, in embodiments where the pH of the slurry was raised, for example to oxidize at least some elemental aluminum in the slurry, then the pH of the slurry may be reduced,

for example by contacting the slurry with carbon dioxide, before the slurry is thickened in the fourth thickener **54**.

Also, in the embodiment shown, neutral wash water from various washing stages such as from the fourth thickener **54** may be recycled to earlier washing and dilution stages. However, solutions from the primary thickener **43** and from the secondary thickener **45** may have relatively high salt concentrations, and therefore in some embodiments such solutions may be withdrawn from the process as may be required, rather than recycled to earlier washing and dilution stages, to prevent high salt content in recycled process water. Also, where may be required, the solutions from the primary thickener **43** and from the secondary thickener **45** in some embodiments may be treated for discharge or re-use by commercial desalination techniques such as reverse osmosis or ultra-filtration, for example. The solutions from the primary thickener **43** and from the secondary thickener **45** could also be treated in some embodiments by evaporation and precipitation methods to recover useable industrial salts such as calcium chloride, for example.

In general, embodiments such as the system described above may recover or re-use a relatively large proportion of the incinerated waste received at the feed chute **4** when compared to other systems for treating incinerated waste. For example, some embodiments may recover or re-use all of the incinerated waste received at the feed chute **4** except for some dissolved salts.

More particularly, metal extracted by the various methods described above may have well-defined markets for recycling, re-use, or sale, and therefore marketing metal extracted by the various methods described above may be preferable to other methods that do not extract metal as efficiently. For example, the methods of extracting metal from at least some of the incinerated waste from the feed chute **4** (shown in Figure **1**) in the embodiment shown involve extracting metal from the at least some of the incinerated waste independently of further incineration of the at least some of the incinerated waste, which may allow more efficient extraction of

metal when compared to other methods that involve further incineration of incinerated waste.

As indicated above, some embodiments may involve thermal processing of non-magnetic metal concentrates, such as controlled heating and mixing in an inert environment to melt low-melting-point metals such as lead and lead alloys, allowing them to flow freely away from the higher-melting-point metals to separate such low-melting-point metals from such higher-melting-point metals. Such thermal processing can be done at relatively low temperatures, allowing for simple materials of construction and low energy requirements.

Also as indicated above, some embodiments may involve hydrometallurgical processing, which may involve more complex processes and that may be more costly than thermal processing, but which may produce more valuable recovered-metal products. Such hydrometallurgical processing may be done in some embodiments in a separate facility off-site from the system described above, where concentrates may be combined from multiple sources. Also, such hydrometallurgical processing may in some embodiments involve multi-stage leaching and precipitation of copper, lead, tin, and zinc, with precious metals concentrated into a small residue. Such hydrometallurgical processing may be more economically justified if precious metal values are relatively high because precious metals may be more readily recovered in a saleable form by hydrometallurgical processing when compared to thermal processing for example.

Further, final cleaned sand tailings (from the thickener or sand auger **39** in the embodiment described above) may be used as an aggregate in concrete products or as other building or fill material, for example.

Still further, the final slimes product (from the fourth froth flotation cell **50**, the fourth thickener **54**, and the filter **55** in the embodiment shown) may have significant pozzolanic properties and may resemble coal fly ash in some embodiments,

especially in embodiments where waste-to-energy fly ash is included in the raw feed (to the feed chute 4 in the embodiment shown). The final slimes product in some embodiments may be sufficiently washed, through multi-stage thickening and re-pulping, to reduce the salt content of the slimes product to a level that allows the

5 resulting washed slimes product to be employed as an amendment in concrete mixtures as a partial replacement for commercial cement, such as a partial replacement for Portland cement for example. In other embodiments, the final slimes product may be combined with one or more additives to form a cement-free concrete product. Such additives may include one or more of sodium carbonate, sodium

10 hydroxide, calcium hydroxide, potassium hydroxide, and fly ash.

Therefore, in some embodiments, washed and dewatered slimes may be transported to an existing concrete manufacturing facility for addition to commercial mixtures, or in other embodiments a stand-alone concrete product may be produced from a recipe that includes a large component of final cleaned sand tailings and a

15 final slimes product from embodiments such as those described above, together with limited amounts of cement and possibly coarse aggregate. Such concrete products could be marketed based on their properties and recycled content, which may represent a substantially higher end-use value for the bulk of the processed ash residue when compared to other methods and systems.

20 Although specific embodiments have been described and illustrated, such embodiments should be considered illustrative only and not as limiting the invention as construed in accordance with the accompanying claims.

What is claimed is:

1. A method of treating incinerated waste, the method comprising:

5 size separating at least some of the incinerated waste, according to a first separation size, into a first undersize fraction comprising particles smaller than the first separation size and into a first oversize fraction comprising particles larger than the first separation size;

size reducing at least some of the first oversize fraction into a size-reduced first oversize fraction;

10 size separating at least some of the size-reduced first oversize fraction, according to a second separation size, into a second undersize fraction comprising particles smaller than the second separation size and into a second oversize fraction comprising particles larger than the second separation size;

15 combining at least some of the first undersize fraction and at least some of the second undersize fraction into a fine fraction; and

extracting metal from at least some of the fine fraction.

- 20 2. The method of claim 1 wherein size reducing the at least some of the first oversize fraction comprises size reducing at least some brittle material of the first oversize fraction and deforming at least some malleable material of the first oversize fraction.
3. The method of claim 1 or 2 wherein the first separation size is between about 1.4 millimeters and about 6.5 millimeters.
4. The method of claim 1 or 2 wherein the first separation size is about 3 millimeters.

5. The method of claim **1**, **2**, **3**, or **4** wherein the second separation size is between about 1.5 millimeters and about 25 millimeters.
6. The method of claim **1**, **2**, **3**, or **4** wherein the second separation size is about 6 millimeters.
- 5 7. The method of any one of claims **1** to **6** wherein the second separation size is larger than the first separation size.
8. The method of any one of claims **1** to **7** wherein the incinerated waste comprises raw ash.
9. The method of any one of claims **1** to **8** wherein the incinerated waste
10 comprises bottom ash.
10. The method of any one of claims **1** to **8** wherein the incinerated waste comprises bottom ash from incinerated municipal solid waste.
11. The method of any one of claims **1** to **10** further comprising removing from the incinerated waste at least some particles larger than a maximum separation
15 size before size reducing the at least some of the first oversize fraction.
12. The method of claim **11** wherein the maximum separation size is between about 7.5 centimeters and about 50 centimeters.
13. The method of any one of claims **1** to **12** wherein:

size reducing the at least some of the first oversize fraction comprises:

20 size separating the at least some of the first oversize fraction, according to a third separation size, into a third undersize fraction comprising particles smaller than the third separation

size and into a third oversize fraction comprising particles larger than the third separation size; and

size reducing at least some of the third undersize fraction into a size-reduced third undersize fraction; and wherein

5 size separating the at least some of the size-reduced first oversize fraction according to the second separation size comprises size separating at least some of the size-reduced third undersize fraction according to the second separation size.

- 10 **14.** The method of claim **13** wherein the third separation size is between about 1 centimeter and about 10 centimeters.
- 15.** The method of claim **13** wherein the third separation size is about 25 millimeters.
- 15 **16.** The method of claim **13**, **14**, or **15** wherein size reducing the at least some of the third undersize fraction comprises milling the at least some of the third undersize fraction.
- 20 **17.** The method of claim **13**, **14**, **15**, or **16** wherein size reducing the at least some of the first oversize fraction further comprises size reducing the at least some of the third oversize fraction, independently from size reducing the at least some of the third undersize fraction, into a size-reduced third oversize fraction.
- 18.** The method of claim **17** wherein size reducing the at least some of the third oversize fraction comprises crushing the at least some of the third oversize fraction.
- 25 **19.** The method of claim **17** or **18** further comprising size separating at least some of the size-reduced third oversize fraction, according to a fourth

separation size, into a fourth undersize fraction comprising particles smaller than the fourth separation size and into a fourth oversize fraction comprising particles larger than the fourth separation size.

- 5 **20.** The method of claim **19** wherein the fourth separation size is about 25 millimeters.
- 21.** The method of claim **19** or **20** further comprising extracting metal from at least some of the fourth oversize fraction.
- 10 **22.** The method of claim **21** wherein extracting metal from the at least some of the fourth oversize fraction comprises magnetic separation of the at least some of the fourth oversize fraction.
- 23.** The method of claim **21** or **22** wherein extracting metal from the at least some of the fourth oversize fraction comprises eddy current separation of the at least some of the fourth oversize fraction.
- 15 **24.** The method of any one of claims **19** to **23** wherein size separating the at least some of the incinerated waste according to the first separation size comprises size separating at least some of the fourth undersize fraction according to the first separation size.
- 25.** The method of any one of claims **13** to **24** further comprising:
- 20 size separating the at least some of the size-reduced third undersize fraction, according to a fifth separation size larger than the second separation size, into a fifth undersize fraction comprising particles larger than the second separation size and smaller than the fifth separation size, and into a fifth oversize fraction comprising particles larger than the fifth separation size, such that the second oversize
- 25 fraction comprises at least some of the fifth undersize fraction;

extracting metal from at least some of the second oversize fraction independently from extracting metal from the at least some of the fine fraction; and

5 extracting metal from at least some of the fifth oversize fraction independently from extracting metal from the at least some of the fine fraction and independently from extracting metal from the at least some of the second oversize fraction.

26. The method of claim **25** wherein the fifth separation size is between about 7.5 millimeters and about 5 centimeters.
- 10 27. The method of claim **25** wherein the fifth separation size is about 19 millimeters.
28. The method of claim **25**, **26**, or **27** wherein extracting metal from the at least some of the second oversize fraction comprises magnetic separation of the at least some of the second oversize fraction.
- 15 29. The method of claim **25**, **26**, **27**, or **28** further comprising removing lighter material from at least a portion of the second oversize fraction before extracting metal from the at least a portion of the second oversize fraction.
30. The method of any one of claims **25** to **29** wherein extracting metal from the at least some of the second oversize fraction comprises separating at least
20 some particles of the second oversize fraction into a lighter fraction and into a heavier fraction.
31. The method of claim **30** further comprising:

size reducing at least some of the lighter fraction into a size-reduced lighter fraction; and

size separating at least some of the size-reduced lighter fraction, according to a sixth separation size, into a sixth undersize fraction comprising particles smaller than the sixth separation size and into a sixth oversize fraction comprising particles larger than the sixth separation size.

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32. The method of claim **31** wherein the sixth separation size is between about 3 millimeters and about 16 millimeters.

33. The method of claim **31** wherein the sixth separation size is about 6 millimeters.

10 **34.** The method of claim **31**, **32**, or **33** wherein extracting metal from the at least some of the second oversize fraction further comprises extracting metal from at least some of the sixth oversize fraction.

35. The method of claim **31**, **32**, **33**, or **34** wherein extracting metal from the at least some of the fine fraction comprises extracting metal from at least some
15 of the sixth undersize fraction.

36. The method of any one of claims **30** to **35** wherein extracting metal from the at least some of the second oversize fraction further comprises extracting metal from at least some of the heavier fraction.

37. The method of any one of claims **25** to **36** wherein extracting metal from the at least some of the fifth oversize fraction comprises magnetic separation of
20 the at least some of the fifth oversize fraction.

38. The method of any one of claims **25** to **37** wherein extracting metal from the at least some of the fifth oversize fraction comprises eddy current separation of the at least some of the fifth oversize fraction.

39. The method of any one of claims 1 to 38 wherein extracting the metal from the at least some of the fine fraction comprises extracting the metal from the at least some of the fine fraction independently of further incineration of the at least some of the fine fraction.
- 5 40. The method of any one of claims 1 to 39 wherein extracting metal from the at least some of the fine fraction comprises gravity separating the at least some of the fine fraction.
41. The method of any one of claims 1 to 40 wherein extracting metal from the at least some of the fine fraction comprises extracting metal by froth flotation of
10 the at least some of the fine fraction.
42. A method of treating incinerated waste, the method comprising extracting metal by froth flotation from at least some of the incinerated waste.
43. The method of claim 42 further comprising size separating at least some of the incinerated waste, according to a fine separation size, into a fine fraction
15 comprising particles smaller than the fine separation size, wherein extracting metal by froth flotation from the at least some of the incinerated waste comprises extracting metal by froth flotation from at least some of the fine fraction.
44. The method of claim 43 wherein the fine separation size is between about 1
20 millimeter and about 12 millimeters.
45. The method of claim 44 wherein the fine separation size is up to about 8 millimeters.
46. The method of claim 44 wherein the fine separation size is up to about 6.5 millimeters.

47. The method of claim **43**, **44**, **45**, or **46** wherein the fine separation size is at least about 3 millimeters.
48. The method of claim **43** wherein the fine separation size is about 4 millimeters.
- 5 49. The method of any one of claims **41** to **48** further comprising size separating at least some of the incinerated waste, according to a slime separation size, into a slime fraction comprising particles smaller than the slime separation size and into a deslimed fraction comprising particles larger than the slime separation size.
- 10 50. The method of claim **49** wherein the slime separation size is between about 2 microns and about 50 microns.
51. The method of claim **49** or **50** wherein extracting metal by froth flotation comprises extracting metal by froth flotation from at least some of the deslimed fraction.
- 15 52. The method of claim **49**, **50**, or **51** further comprising gravity separating the deslimed fraction of the incinerated waste into a gravity concentrate and into gravity tailings.
53. The method of claim **52** wherein extracting the metal by froth flotation comprises extracting the metal by froth flotation from at least some of the gravity tailings.
- 20 54. The method of claim **52** or **53** further comprising extracting metal from at least some of the gravity concentrate.
55. The method of claim **54** wherein extracting metal from the at least some of the gravity concentrate comprises wet magnetic separation of the at least

some of the gravity concentrate into a magnetic fraction and into a non-magnetic fraction.

56. The method of claim **55** wherein extracting metal from the at least some of the gravity concentrate further comprises gravity separation of the non-magnetic fraction.
57. The method of any one of claims **41** to **56** wherein extracting the metal by froth flotation comprises conditioning at least some of the incinerated waste with a first at least one chemical reagent into a first conditioned slurry.
58. The method of claim **57** wherein the first at least one chemical reagent comprises one or more of: at least one xanthate; at least one dithiophosphate; at least one thiocarbamate; at least one thionocarbamate; at least one mercaptobenzothiozole; at least one hydroxamate; at least one fatty acid; at least one amine; at least one soluble base metal salt; at least one soluble sulphide compound; at least one alkali; at least one alkali earth; and at least one frothing agent.
59. The method of claim **57** or **58** wherein extracting the metal by froth flotation further comprises separating at least some of the first conditioned slurry by froth flotation into a first concentrate and into first tailings.
60. The method of claim **59** wherein extracting the metal by froth flotation further comprises separating the first concentrate into a cleaned first concentrate and into first cleaner tailings.
61. The method of claim **60** further comprising separating at least some of the first cleaner tailings by froth flotation into the first concentrate and into the first tailings.

62. The method of claim **60** or **61** wherein extracting the metal by froth flotation further comprises dewatering the cleaned first concentrate.
63. The method of claim **59**, **60**, **61**, or **62** wherein extracting the metal by froth flotation further comprises conditioning at least some of the first tailings with a second at least one chemical reagent into a second conditioned slurry.
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64. The method of claim **63** wherein the second at least one chemical reagent comprises one or more of: at least one activator; at least one sulphidizing agent; at least one metal sulphide collector; and at least one frother.
65. The method of claim **63** or **64** wherein extracting the metal by froth flotation further comprises separating at least some of the second conditioned slurry by froth flotation into a second concentrate and into second tailings.
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66. The method of claim **65** wherein extracting the metal by froth flotation further comprises separating the second concentrate into a cleaned second concentrate and into second cleaner tailings.
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67. The method of claim **66** further comprising separating at least some of the second cleaner tailings by froth flotation into the second concentrate and into the second tailings.
68. The method of claim **66** or **67** wherein extracting the metal by froth flotation further comprises dewatering the cleaned second concentrate.
- 20
69. The method of any one of claims **47** to **68** wherein extracting the metal by froth flotation comprises extracting the metal by froth flotation from at least some of the slime fraction.
70. The method of claim **69** wherein extracting the metal by froth flotation from the at least some of the slime fraction comprises conditioning the at least

some of the slime fraction with a third at least one chemical reagent into a third conditioned slurry.

- 5 **71.** The method of claim **70** wherein the third at least one chemical reagent comprises one or more of: at least one xanthate; at least one dithiophosphate; at least one thiocarbamate; at least one thionocarbamate; at least one mercaptobenzothiozole; at least one hydroxamate; at least one fatty acid; at least one amine; at least one soluble base metal salt; at least one soluble sulphide compound; at least one alkali; at least one alkali earth; and at least one frothing agent.
- 10 **72.** The method of claim **70** or **71** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises further conditioning at least some of the third conditioned slurry with a fourth at least one chemical reagent.
- 15 **73.** The method of claim **72** wherein the fourth at least one chemical reagent comprises one or more of: diesel fuel; kerosene; fuel oil; and at least one fatty acid.
- 74.** The method of claim **72** or **73** wherein conditioning the at least some of the third conditioned slurry comprises high-speed mixing the at least some of the third conditioned slurry.
- 20 **75.** The method of claim **72** or **73** wherein conditioning the at least some of the third conditioned slurry comprises mixing the at least some of the third conditioned slurry at a mixing speed between about 200 rpm and about 2000 rpm.
- 25 **76.** The method of claim **72** or **73** wherein conditioning the at least some of the third conditioned slurry comprises mixing the at least some of the third conditioned slurry at a mixing speed of about 800 rpm.

- 5 **77.** The method of any one of claims **70** to **76** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises dewatering the at least some of the slime fraction into a thickened slurry, and wherein conditioning the at least some of the slime fraction comprises conditioning the at least some of the thickened slurry.
- 78.** The method of any one claims **70** to **77** further comprising oxidizing at least some elemental aluminum in the slime fraction.
- 79.** The method of claim **78** wherein oxidizing the at least some elemental aluminum in the slime fraction comprises elevating a pH of the slime fraction.
- 10 **80.** The method of any one claims **70** to **79** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises separating at least some of the third conditioned slurry by froth flotation into a third concentrate and into third tailings.
- 81.** The method of claim **80** wherein extracting the metal by froth flotation from
15 the at least some of the slime fraction further comprises cleaning at least some of the third concentrate into a cleaned third concentrate.
- 82.** The method of claim **81** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises dewatering at least some of the cleaned third concentrate.
- 20 **83.** The method of claim **80**, **81**, or **82** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises conditioning at least some of the third tailings with a fifth at least one chemical reagent into a fourth conditioned slurry.
- 84.** The method of claim **83** wherein the fifth at least one chemical reagent
25 comprises one or more of: at least one activator; at least one sulphidizing

agent; at least one metal sulphide collector; at least one frother; and at least one agglomerating agent.

- 5 **85.** The method of claim **83** or **84** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises separating the fourth conditioned slurry by froth flotation into a fourth concentrate and into fourth tailings.
- 86.** The method of claim **85** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises cleaning at least some of the fourth concentrate into a cleaned fourth concentrate.
- 10 **87.** The method of claim **86** wherein extracting the metal by froth flotation from the at least some of the slime fraction further comprises dewatering at least some of the cleaned fourth concentrate.
- 88.** The method of any one of claims **85**, **86**, or **87** further comprising dewatering at least some of the fourth tailings.
- 15 **89.** A method of producing a concrete product, the method comprising:
 producing the second tailings according to claim **65**, **66**, **67**, or **68**; and
 producing the concrete product with at least some of the second tailings.
- 90.** A method of producing a concrete product, the method comprising:
20 producing the fourth tailings according to claim **85**, **86**, **87**, or **88**; and
 producing the concrete product with at least some of the fourth tailings.

91. The method of claim **90** wherein producing the concrete product with at least some of the fourth tailings comprises combining the at least some of the fourth tailings with Portland cement.
- 5 92. The method of claim **90** wherein producing the concrete product with at least some of the fourth tailings comprises combining the at least some of the fourth tailings with at least one additive to produce the concrete product cement-free.
- 10 93. The method of claim **92** wherein the at least one additive comprises one or more of sodium carbonate, sodium hydroxide, calcium hydroxide, potassium hydroxide, and fly ash.
94. The method of claim **90, 91, 92, or 93** further comprising:
producing the second tailings according to claim **65, 66, 67, or 68**; and
producing the concrete product with at least some of the second tailings.
- 15 95. A system for treating incinerated waste, the system comprising:
a means for size separating at least some of the incinerated waste, according to a first separation size, into a first undersize fraction comprising particles smaller than the first separation size and into a first oversize fraction comprising particles larger than the first
20 separation size;
a means for size reducing at least some of the first oversize fraction into a size-reduced first oversize fraction;
a means for size separating at least some of the size-reduced first oversize fraction, according to a second separation size, into a second

undersize fraction comprising particles smaller than the second separation size and into a second oversize fraction comprising particles larger than the second separation size; and

5 a means for extracting metal from at least some of a fine fraction comprising at least some of the first undersize fraction and at least some of the second undersize fraction.

- 10 **96.** The system of claim **95** wherein the means for size reducing the at least some of the first oversize fraction comprises a means for size reducing at least some brittle material of the first oversize fraction and for deforming at least some malleable material of the first oversize fraction.
- 97.** The system of claim **95** or **96** wherein the first separation size is between about 1.4 millimeters and about 6.5 millimeters.
- 98.** The system of claim **95** or **96** wherein the first separation size is about 3 millimeters.
- 15 **99.** The system of claim **95**, **96**, **97**, or **98** wherein the second separation size is between about 1.5 millimeters and about 25 millimeters.
- 100.** The system of claim **95**, **96**, **97**, or **98** wherein the second separation size is about 6 millimeters.
- 20 **101.** The system of any one of claims **95** to **100** wherein the second separation size is larger than the first separation size.
- 102.** The system of any one of claims **95** to **101** wherein the means for size separating the at least some of the incinerated waste according to the first separation size is configured to size separate raw ash.

103. The system of any one of claims **95** to **102** wherein the means for size separating the at least some of the incinerated waste according to the first separation size is configured to size separate bottom ash.
- 5 104. The system of any one of claims **95** to **102** wherein the means for size separating the at least some of the incinerated waste according to the first separation size is configured to size separate bottom ash from incinerated municipal solid waste.
- 10 105. The system of any one of claims **95** to **104** further comprising a means for removing from the incinerated waste at least some particles larger than a maximum separation size before size reducing the at least some of the first oversize fraction.
106. The system of claim **105** wherein the maximum separation size is between about 7.5 centimeters and about 50 centimeters.
- 15 107. The system of any one of claims **95** to **106** wherein:
the means for size reducing the at least some of the first oversize fraction comprises:
a means for size separating the at least some of the first oversize fraction, according to a third separation size, into a third undersize fraction comprising particles smaller than the third separation size and into a third oversize fraction comprising particles larger than the third separation size; and
a means for size reducing at least some of the third undersize fraction into a size-reduced third undersize fraction; and wherein
25 the means for size separating the at least some of the size-reduced first oversize fraction according to the second separation size is

configured for size separating at least some of the size-reduced third undersize fraction according to the second separation size.

- 108.** The system of claim **107** wherein the third separation size is between about 1 centimeter and about 10 centimeters.
- 5 **109.** The system of claim **107** wherein the third separation size is about 25 millimeters.
- 110.** The system of claim **107**, **108**, or **109** wherein the means for size reducing the at least some of the third undersize fraction comprises a mill for milling the at least some of the third undersize fraction.
- 10 **111.** The system of claim **107**, **108**, **109**, or **110** wherein the means for size reducing the at least some of the first oversize fraction further comprises a means for size reducing the at least some of the third oversize fraction, independently from the means for size reducing the at least some of the third undersize fraction, into a size-reduced third oversize fraction.
- 15 **112.** The system of claim **111** wherein the means for size reducing the at least some of the third oversize fraction comprises a crusher for crushing the at least some of the third oversize fraction.
- 113.** The system of claim **111** or **112** further comprising a means for size separating at least some of the size-reduced third oversize fraction, according
20 to a fourth separation size, into a fourth undersize fraction comprising particles smaller than the fourth separation size and into a fourth oversize fraction comprising particles larger than the fourth separation size.
- 114.** The system of claim **113** wherein the fourth separation size is about 25 millimeters.

115. The system of claim **113** or **114** further comprising a means for extracting metal from at least some of the fourth oversize fraction.
116. The system of claim **115** wherein the means for extracting metal from the at least some of the fourth oversize fraction comprises a means for magnetic separation of the at least some of the fourth oversize fraction.
117. The system of claim **115** or **116** wherein the means for extracting metal from the at least some of the fourth oversize fraction comprises a means for eddy current separation of the at least some of the fourth oversize fraction.
118. The system of any one of claims **113** to **117** wherein the means for size separating the at least some of the incinerated waste according to the first separation size is configured for size separating at least some of the fourth undersize fraction.
119. The system of any one of claims **107** to **118** further comprising:
- a means for size separating the at least some of the size-reduced third undersize fraction, according to a fifth separation size larger than the second separation size, into a fifth undersize fraction comprising particles larger than the second separation size and smaller than the fifth separation size, and into a fifth oversize fraction comprising particles larger than the fifth separation size, such that the second oversize fraction comprises at least some of the fifth undersize fraction;
 - a means for extracting metal from at least some of the second oversize fraction independently from the means for extracting metal from the at least some of the fine fraction; and
 - a means for extracting metal from at least some of the fifth oversize fraction independently from the means for extracting metal from the at

least some of the fine fraction and independently from the means for extracting metal from the at least some of the second oversize fraction.

- 120.** The system of claim **119** wherein the fifth separation size is between about 7.5 millimeters and about 5 centimeters.
- 5 **121.** The system of claim **119** wherein the fifth separation size is about 19 millimeters.
- 122.** The system of claim **119**, **120**, or **121** wherein the means for extracting metal from the at least some of the second oversize fraction comprises a means for magnetic separation of the at least some of the second oversize fraction.
- 10 **123.** The system of claim **119**, **120**, **121**, or **122** further comprising a means for removing lighter material from at least a portion of the second oversize fraction before extracting metal from the at least a portion of the second oversize fraction.
- 124.** The system of any one of claims **119** to **123** wherein the means for extracting metal from the at least some of the second oversize fraction comprises a means for separating at least some particles of the second oversize fraction into a lighter fraction and into a heavier fraction.
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- 125.** The system of claim **124** further comprising:
- 20 a means for size reducing at least some of the lighter fraction into a size-reduced lighter fraction; and
- a means for size separating at least some of the size-reduced lighter fraction, according to a sixth separation size, into a sixth undersize fraction comprising particles smaller than the sixth separation size and into a sixth oversize fraction comprising particles larger than the sixth separation size.
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- 126.** The system of claim **125** wherein the sixth separation size is between about 3 millimeters and about 16 millimeters.
- 127.** The system of claim **125** wherein the sixth separation size is about 6 millimeters.
- 5 **128.** The system of claim **125**, **126**, or **127** wherein the means for extracting metal from the at least some of the second oversize fraction further comprises a means for extracting metal from at least some of the sixth oversize fraction.
- 129.** The system of claim **125**, **126**, **127**, or **128** wherein the means for extracting metal from the at least some of the fine fraction is configured for extracting
10 metal from at least some of the sixth undersize fraction.
- 130.** The system of any one of claims **124** to **129** wherein the means for extracting metal from the at least some of the second oversize fraction further comprises a means for extracting metal from at least some of the heavier fraction.
- 131.** The system of any one of claims **119** to **130** wherein the means for extracting
15 metal from the at least some of the fifth oversize fraction comprises a means for magnetic separation of the at least some of the fifth oversize fraction.
- 132.** The system of any one of claims **119** to **131** wherein the means for extracting metal from the at least some of the fifth oversize fraction comprises a means for eddy current separation of the at least some of the fifth oversize fraction.
- 20 **133.** The system of any one of claims **95** to **132** wherein the means for extracting the metal from the at least some of the fine fraction is configured for extracting the metal from the at least some of the fine fraction independently of further incineration of the at least some of the fine fraction.

134. The system of any one of claims **95** to **133** wherein the means for extracting metal from the at least some of the fine fraction comprises a means for gravity separating the at least some of the fine fraction.
- 5 135. The system of any one of claims **95** to **134** wherein the means for extracting metal from the at least some of the fine fraction comprises a means for extracting metal by froth flotation of the at least some of the fine fraction.
136. A system for treating incinerated waste, the system comprising a means for extracting metal by froth flotation from at least some of the incinerated waste.
- 10 137. The system of claim **136** further comprising a means for size separating at least some of the incinerated waste, according to a fine separation size, into a fine fraction comprising particles smaller than the fine separation size, wherein the means for extracting metal by froth flotation from the at least some of the incinerated waste is configured for extracting metal by froth flotation from at least some of the fine fraction.
- 15 138. The system of claim **137** wherein the fine separation size is between about 1 millimeter and about 12 millimeters.
139. The system of claim **138** wherein the fine separation size is up to about 8 millimeters.
- 20 140. The system of claim **139** wherein the fine separation size is up to about 6.5 millimeters.
141. The system of claim **137**, **138**, **139**, or **140** wherein the fine separation size is at least about 3 millimeters.
142. The system of claim **137** wherein the fine separation size is about 4 millimeters.

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- 143.** The system of any one of claims **135** to **142** further comprising a means for size separating at least some of the incinerated waste, according to a slime separation size, into a slime fraction comprising particles smaller than the slime separation size and into a deslimed fraction comprising particles larger than the slime separation size.
- 144.** The system of claim **143** wherein the slime separation size is between about 2 microns and about 50 microns.
- 145.** The system of claim **143** or **144** wherein the means for extracting metal by froth flotation comprises a means for extracting metal by froth flotation from at least some of the deslimed fraction.
- 146.** The system of claim **143**, **144**, or **145** further comprising a means for gravity separating the deslimed fraction of the incinerated waste into a gravity concentrate and into gravity tailings.
- 147.** The system of claim **146** wherein the means for extracting the metal by froth flotation comprises a means for extracting the metal by froth flotation from at least some of the gravity tailings.
- 148.** The system of claim **146** or **147** further comprising a means for extracting metal from at least some of the gravity concentrate.
- 149.** The system of claim **148** wherein the means for extracting metal from the at least some of the gravity concentrate comprises a means for wet magnetic separation of the at least some of the gravity concentrate into a magnetic fraction and into a non-magnetic fraction.
- 150.** The system of claim **149** wherein the means for extracting metal from the at least some of the gravity concentrate further comprises a means for gravity separation of the non-magnetic fraction.

- 151.** The system of any one of claims **135** to **150** wherein the means for extracting the metal by froth flotation comprises a means for conditioning at least some of the incinerated waste with a first at least one chemical reagent into a first conditioned slurry.
- 5 **152.** The system of claim **151** wherein the first at least one chemical reagent comprises one or more of: at least one xanthate; at least one dithiophosphate; at least one thiocarbamate; at least one thionocarbamate; at least one mercaptobenzothiozole; at least one hydroxamate; at least one fatty acid; at least one amine; at least one soluble base metal salt; at least one
10 soluble sulphide compound; at least one alkali; at least one alkali earth; and at least one frothing agent.
- 153.** The system of claim **151** or **152** wherein the means for extracting the metal by froth flotation further comprises a means for separating at least some of the first conditioned slurry by froth flotation into a first concentrate and into first
15 tailings.
- 154.** The system of claim **153** wherein the means for extracting the metal by froth flotation further comprises a means for separating the first concentrate into a cleaned first concentrate and into first cleaner tailings.
- 155.** The system of claim **154** wherein the means for separating the at least some of the first conditioned slurry by froth flotation into the first concentrate and into the first tailings is configured to separate at least some of the first cleaner
20 tailings by froth flotation into the first concentrate and into the first tailings.
- 156.** The system of claim **154** or **155** wherein the means for extracting the metal by froth flotation further comprises a means for dewatering the cleaned first concentrate.
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- 157.** The system of claim **153**, **154**, **155**, or **156** wherein the means for extracting the metal by froth flotation further comprises a means for conditioning at least some of the first tailings with a second at least one chemical reagent into a second conditioned slurry.
- 5 **158.** The system of claim **157** wherein the second at least one chemical reagent comprises one or more of: at least one activator; at least one sulphidizing agent; at least one metal sulphide collector; and at least one frother.
- 159.** The system of claim **157** or **158** wherein the means for extracting the metal by froth flotation further comprises a means for separating at least some of the
10 second conditioned slurry by froth flotation into a second concentrate and into second tailings.
- 160.** The system of claim **159** wherein the means for extracting the metal by froth flotation further comprises a means for separating the second concentrate into a cleaned second concentrate and into second cleaner tailings.
- 15 **161.** The system of claim **160** wherein the means for separating the at least some of the second conditioned slurry by froth flotation into the second concentrate and into the second tailings is configured to separate at least some of the second cleaner tailings by froth flotation into the second concentrate and into the second tailings.
- 20 **162.** The system of claim **160** or **161** wherein the means for extracting the metal by froth flotation further comprises a means for dewatering the cleaned second concentrate.
- 163.** The system of any one of claims **143** to **162** wherein the means for extracting the metal by froth flotation comprises a means for extracting the metal by
25 froth flotation from at least some of the slime fraction.

- 164.** The system of claim **163** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction comprises a means for conditioning the at least some of the slime fraction with a third at least one chemical reagent into a third conditioned slurry.
- 5 **165.** The system of claim **164** wherein the third at least one chemical reagent comprises one or more of: at least one xanthate; at least one dithiophosphate; at least one thiocarbamate; at least one thionocarbamate; at least one mercaptobenzothiozole; at least one hydroxamate; at least one fatty acid; at least one amine; at least one soluble base metal salt; at least one
10 soluble sulphide compound; at least one alkali; at least one alkali earth; and at least one frothing agent.
- 166.** The system of claim **164** or **165** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for further conditioning at least some of the third conditioned slurry
15 with a fourth at least one chemical reagent.
- 167.** The system of claim **166** wherein the fourth at least one chemical reagent comprises one or more of: diesel fuel; kerosene; fuel oil; and at least one fatty acid.
- 168.** The system of claim **166** or **167** wherein the means for conditioning the at least some of the third conditioned slurry comprises a means for high-speed
20 mixing the at least some of the third conditioned slurry.
- 169.** The system of claim **166** or **167** wherein the means for conditioning the at least some of the third conditioned slurry comprises a means for mixing the at least some of the third conditioned slurry at a mixing speed between about
25 200 rpm and about 2000 rpm.

170. The system of claim **166** or **167** wherein the means for conditioning the at least some of the third conditioned slurry comprises a means for mixing the at least some of the third conditioned slurry at a mixing speed of about 800 rpm.
- 5 171. The system of any one of claims **164** to **170** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for dewatering the at least some of the slime fraction into a thickened slurry, and wherein the means for conditioning the at least some of the slime fraction comprises a means for conditioning the at least some of the thickened slurry.
- 10 172. The system of any one claims **164** to **171** further comprising a means for oxidizing at least some elemental aluminum in the slime fraction.
173. The system of claim **172** wherein the means for oxidizing the at least some elemental aluminum in the slime fraction comprises a means for elevating a pH of the slime fraction.
- 15 174. The system of any one claims **164** to **173** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for separating at least some of the third conditioned slurry by froth flotation into a third concentrate and into third tailings.
- 20 175. The system of claim **174** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for cleaning at least some of the third concentrate into a cleaned third concentrate.
- 25 176. The system of claim **175** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for dewatering at least some of the cleaned third concentrate.

- 177.** The system of claim **174**, **175**, or **176** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for conditioning at least some of the third tailings with a fifth at least one chemical reagent into a fourth conditioned slurry.
- 5 **178.** The system of claim **177** wherein the fifth at least one chemical reagent comprises one or more of: at least one activator; at least one sulphidizing agent; at least one metal sulphide collector; at least one frother; and at least one agglomerating agent.
- 10 **179.** The system of claim **177** or **178** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for separating the fourth conditioned slurry by froth flotation into a fourth concentrate and into fourth tailings.
- 15 **180.** The system of claim **179** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for cleaning at least some of the fourth concentrate into a cleaned fourth concentrate.
- 181.** The system of claim **180** wherein the means for extracting the metal by froth flotation from the at least some of the slime fraction further comprises a means for dewatering at least some of the cleaned fourth concentrate.
- 20 **182.** The system of any one of claims **179**, **180**, or **181** further comprising a means for dewatering at least some of the fourth tailings.
- 183.** A system for treating incinerated waste, the system comprising:
- 25 a first size separator configured for size separating at least some of the incinerated waste, according to a first separation size, into a first undersize fraction comprising particles smaller than the first separation

size and into a first oversize fraction comprising particles larger than the first separation size;

at least one size reduction apparatus configured for size reducing at least some of the first oversize fraction into a size-reduced first oversize fraction;

a second size separator configured for size separating at least some of the size-reduced first oversize fraction, according to a second separation size, into a second undersize fraction comprising particles smaller than the second separation size and into a second oversize fraction comprising particles larger than the second separation size; and

a first at least one metal extraction apparatus configured to extract metal from at least some of a fine fraction comprising at least some of the first undersize fraction and at least some of the second undersize fraction.

184. The system of claim **183** wherein the at least one size reduction apparatus is configured for size reducing at least some brittle material of the first oversize fraction and for deforming at least some malleable material of the first oversize fraction.

185. The system of claim **183** or **184** wherein the first separation size is between about 1.4 millimeters and about 6.5 millimeters.

186. The system of claim **183** or **184** wherein the first separation size is about 3 millimeters.

187. The system of claim **183**, **184**, **185**, or **186** wherein the second separation size is between about 1.5 millimeters and about 25 millimeters.

188. The system of claim **183**, **184**, **185**, or **186** wherein the second separation size is about 6 millimeters.
189. The system of any one of claims **183** to **188** wherein the second separation size is larger than the first separation size.
- 5 **190.** The system of any one of claims **183** to **189** wherein the first size separator is configured to size separate raw ash.
- 191.** The system of any one of claims **183** to **190** wherein the first size separator is configured to size separate bottom ash.
- 10 **192.** The system of any one of claims **183** to **190** wherein the first size separator is configured to size separate bottom ash from incinerated municipal solid waste.
- 193.** The system of any one of claims **183** to **192** further comprising a maximum size separator configured for removing from the incinerated waste at least some particles larger than a maximum separation size before size reducing the at least some of the first oversize fraction.
- 15 **194.** The system of claim **193** wherein the maximum separation size is between about 7.5 centimeters and about 50 centimeters.
- 195.** The system of any one of claims **183** to **194**:
- 20 further comprising a third size separator configured for size separating the at least some of the first oversize fraction, according to a third separation size, into a third undersize fraction comprising particles smaller than the third separation size and into a third oversize fraction comprising particles larger than the third separation size;

wherein the at least one size reduction apparatus comprises a first size reduction apparatus configured for size reducing at least some of the third undersize fraction into a size-reduced third undersize fraction; and

wherein the second size separator is configured for size separating at least some of the size-reduced third undersize fraction according to the second separation size.

5
196. The system of claim **195** wherein the third separation size is between about 1 centimeter and about 10 centimeters.

10
197. The system of claim **195** wherein the third separation size is about 25 millimeters.

198. The system of claim **195**, **196**, or **197** wherein the first size reduction apparatus comprises a mill for milling the at least some of the third undersize fraction.

15
199. The system of claim **195**, **196**, **197**, or **198** further comprising a second size reduction apparatus for size reducing the at least some of the third oversize fraction, independently from the first size reduction apparatus, into a size-reduced third oversize fraction.

20
200. The system of claim **199** wherein the second size reduction apparatus comprises a crusher for crushing the at least some of the third oversize fraction.

25
201. The system of claim **199** or **200** further comprising a fourth size separator for size separating at least some of the size-reduced third oversize fraction, according to a fourth separation size, into a fourth undersize fraction comprising particles smaller than the fourth separation size and into a fourth oversize fraction comprising particles larger than the fourth separation size.

202. The system of claim **201** wherein the fourth separation size is about 25 millimeters.
203. The system of claim **201** or **202** further comprising a second at least one metal extraction apparatus configured to extract metal from at least some of the fourth oversize fraction.
204. The system of claim **203** wherein the second at least one metal extraction apparatus is configured for magnetic separation of the at least some of the fourth oversize fraction.
205. The system of claim **203** or **204** wherein the second at least one metal extraction apparatus is configured for eddy current separation of the at least some of the fourth oversize fraction.
206. The system of any one of claims **201** to **205** wherein the first size separator is configured for receiving at least some of the fourth undersize fraction and for size separating the at least some of the fourth undersize fraction.
207. The system of any one of claims **195** to **206** further comprising:
a fifth size separator configured for size separating the at least some of the size-reduced third undersize fraction, according to a fifth separation size larger than the second separation size, into a fifth undersize fraction comprising particles larger than the second separation size and smaller than the fifth separation size, and into a fifth oversize fraction comprising particles larger than the fifth separation size, such that the second oversize fraction comprises at least some of the fifth undersize fraction;

a third at least one metal extraction apparatus for extracting metal from at least some of the second oversize fraction independently from the first at least one metal extraction apparatus; and

5 a fourth at least one metal extraction apparatus for extracting metal from at least some of the fifth oversize fraction independently from the first at least one metal extraction apparatus and independently from the third at least one metal extraction apparatus.

208. The system of claim **207** wherein the fifth separation size is between about 7.5 millimeters and about 5 centimeters.

10 **209.** The system of claim **207** wherein the fifth separation size is about 19 millimeters.

210. The system of claim **207**, **208**, or **209** wherein the third at least one metal extraction apparatus comprises a magnetic separator.

15 **211.** The system of claim **207**, **208**, **209**, or **210** wherein the third at least one metal extraction apparatus comprises a washing device configured for removing lighter material from at least a portion of the second oversize fraction before extracting metal from the at least a portion of the second oversize fraction.

20 **212.** The system of any one of claims **207** to **211** wherein the third at least one metal extraction apparatus comprises a first gravity separator for separating at least some particles of the second oversize fraction into a lighter fraction and into a heavier fraction.

213. The system of claim **212** further comprising:

25 a third size reduction apparatus configured for size reducing at least some of the lighter fraction into a size-reduced lighter fraction; and

a sixth size separator configured for size separating at least some of the size-reduced lighter fraction, according to a sixth separation size, into a sixth undersize fraction comprising particles smaller than the sixth separation size and into a sixth oversize fraction comprising particles larger than the sixth separation size.

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214. The system of claim **213** wherein the sixth separation size is between about 3 millimeters and about 16 millimeters.

215. The system of claim **213** wherein the sixth separation size is about 6 millimeters.

10 **216.** The system of claim **213**, **214**, or **215** wherein the third at least one metal extraction apparatus is configured for extracting metal from at least some of the sixth oversize fraction.

15 **217.** The system of claim **213**, **214**, **215**, or **216** wherein the first at least one metal extraction apparatus is configured for extracting metal from at least some of the sixth undersize fraction.

218. The system of any one of claims **212** to **217** wherein the third at least one metal extraction apparatus is configured for extracting metal from at least some of the heavier fraction.

20 **219.** The system of any one of claims **207** to **218** wherein the fourth at least one metal extraction apparatus is configured for magnetic separation of the at least some of the fifth oversize fraction.

220. The system of any one of claims **207** to **219** wherein the fourth at least one metal extraction apparatus is configured for eddy current separation of the at least some of the fifth oversize fraction.

221. The system of any one of claims **183** to **220** wherein the first at least one metal extraction apparatus is configured for extracting the metal from the at least some of the fine fraction independently of further incineration of the at least some of the fine fraction.
- 5 222. The system of any one of claims **183** to **221** wherein the first at least one metal extraction apparatus is configured for gravity separation of the at least some of the fine fraction.
223. The system of any one of claims **183** to **222** wherein the first at least one metal extraction apparatus is configured for extracting metal by froth flotation
10 of the at least some of the fine fraction.
224. A system for treating incinerated waste, the system comprising a first at least one metal extraction apparatus configured for extracting metal by froth flotation from at least some of the incinerated waste.
225. The system of claim **224** further comprising at least one fine size separator for
15 size separating at least some of the incinerated waste, according to a fine separation size, into a fine fraction comprising particles smaller than the fine separation size, wherein the first at least one metal extraction apparatus is configured for extracting metal by froth flotation from at least some of the fine fraction.
- 20 226. The system of claim **225** wherein the fine separation size is between about 1 millimeter and about 12 millimeters.
227. The system of claim **226** wherein the fine separation size is up to about 8 millimeters.
228. The system of claim **226** wherein the fine separation size is up to about 6.5
25 millimeters.

229. The system of claim **225**, **226**, **227**, or **228** wherein the fine separation size is at least about 3 millimeters.
230. The system of claim **225** wherein the fine separation size is about 4 millimeters.
- 5 231. The system of any one of claims **223** to **230** further comprising at least one slime size separator for size separating at least some of the incinerated waste, according to a slime separation size, into a slime fraction comprising particles smaller than the slime separation size and into a deslimed fraction comprising particles larger than the slime separation size.
- 10 232. The system of claim **231** wherein the slime separation size is between about 2 microns and about 50 microns.
233. The system of claim **231** or **232** wherein the first at least one metal extraction apparatus is configured for extracting metal by froth flotation from at least some of the deslimed fraction.
- 15 234. The system of claim **231**, **232**, or **233** further comprising a second gravity separator for gravity separating the deslimed fraction of the incinerated waste into a gravity concentrate and into gravity tailings.
235. The system of claim **234** wherein the first at least one metal extraction apparatus is configured for extracting the metal by froth flotation from at least
20 some of the gravity tailings.
236. The system of claim **234** or **235** wherein the first at least one metal extraction apparatus is configured for extracting metal from at least some of the gravity concentrate.
237. The system of claim **236** wherein the first at least one metal extraction
25 apparatus comprises a wet magnetic separator for wet magnetic separation of

the at least some of the gravity concentrate into a magnetic fraction and into a non-magnetic fraction.

- 5 **238.** The system of claim **237** wherein the first at least one metal extraction apparatus further comprises a third gravity separator for gravity separation of the non-magnetic fraction.
- 239.** The system of any one of claims **223** to **238** wherein the first at least one metal extraction apparatus comprises a first conditioning tank for conditioning at least some of the incinerated waste with a first at least one chemical reagent into a first conditioned slurry.
- 10 **240.** The system of claim **239** wherein the first at least one chemical reagent comprises one or more of: at least one xanthate; at least one dithiophosphate; at least one thiocarbamate; at least one thionocarbamate; at least one mercaptobenzothiozole; at least one hydroxamate; at least one fatty acid; at least one amine; at least one soluble base metal salt; at least one soluble sulphide compound; at least one alkali; at least one alkali earth; and at least one frothing agent.
- 15
- 241.** The system of claim **239** or **240** wherein the first at least one metal extraction apparatus further comprises a first froth flotation cell for separating at least some of the first conditioned slurry by froth flotation into a first concentrate and into first tailings.
- 20
- 242.** The system of claim **241** wherein the first at least one metal extraction apparatus further comprises a first concentrate cleaning flotation cell for separating the first concentrate into a cleaned first concentrate and into first cleaner tailings.
- 25 **243.** The system of claim **242** wherein the first froth flotation cell is configured to receive at least some of the first cleaner tailings and to separate the at least

some of the first cleaner tailings by froth flotation into the first concentrate and into the first tailings.

- 5 **244.** The system of claim **242** or **243** wherein the first at least one metal extraction apparatus further comprises a first thickener for dewatering the cleaned first concentrate.
- 245.** The system of claim **241**, **242**, **243**, or **244** wherein the first at least one metal extraction apparatus further comprises a second conditioning tank for conditioning at least some of the first tailings with a second at least one chemical reagent into a second conditioned slurry.
- 10 **246.** The system of claim **245** wherein the second at least one chemical reagent comprises one or more of: at least one activator; at least one sulphidizing agent; at least one metal sulphide collector; and at least one frother.
- 247.** The system of claim **245** or **246** wherein the first at least one metal extraction apparatus further comprises a second froth flotation cell for separating at
15 at least some of the second conditioned slurry by froth flotation into a second concentrate and into second tailings.
- 248.** The system of claim **247** wherein the first at least one metal extraction apparatus further comprises a second concentrate cleaning flotation cell for separating the second concentrate into a cleaned second concentrate and
20 into second cleaner tailings.
- 249.** The system of claim **248** wherein the second froth flotation cell is configured to receive at least some of the second cleaner tailings and to separate the at least some of the second cleaner tailings by froth flotation into the second concentrate and into the second tailings.

- 250.** The system of claim **248** or **249** wherein the first at least one metal extraction apparatus further comprises a second thickener for dewatering the cleaned second concentrate.
- 251.** The system of any one of claims **231** to **250** wherein the first at least one metal extraction apparatus is configured for extracting the metal by froth flotation from at least some of the slime fraction.
- 252.** The system of claim **251** wherein the first at least one metal extraction apparatus comprises a third conditioning tank for conditioning the at least some of the slime fraction with a third at least one chemical reagent into a third conditioned slurry.
- 253.** The system of claim **252** wherein the third at least one chemical reagent comprises one or more of: at least one xanthate; at least one dithiophosphate; at least one thiocarbamate; at least one thionocarbamate; at least one mercaptobenzothiozole; at least one hydroxamate; at least one fatty acid; at least one amine; at least one soluble base metal salt; at least one soluble sulphide compound; at least one alkali; at least one alkali earth; and at least one frothing agent.
- 254.** The system of claim **252** or **253** wherein the first at least one metal extraction apparatus further comprises a fourth conditioning tank for further conditioning at least some of the third conditioned slurry with a fourth at least one chemical reagent.
- 255.** The system of claim **254** wherein the fourth at least one chemical reagent comprises one or more of: diesel fuel; kerosene; fuel oil; and at least one fatty acid.
- 256.** The system of claim **254** or **255** wherein the fourth conditioning tank comprises a high-speed mixer configured for high-speed mixing the at least

some of the third conditioned slurry.

- 5 **257.** The system of claim **254** or **255** wherein the fourth conditioning tank comprises a mixer configured for mixing the at least some of the third conditioned slurry at a mixing speed between about 200 rpm and about 2000 rpm.
- 258.** The system of claim **254** or **255** wherein the fourth conditioning tank comprises a mixer configured for mixing the at least some of the third conditioned slurry at a mixing speed of about 800 rpm.
- 10 **259.** The system of any one of claims **252** to **258** wherein the first at least one metal extraction apparatus further comprises a third thickener for dewatering the at least some of the slime fraction into a thickened slurry, and wherein the third conditioning tank is configured for conditioning the at least some of the thickened slurry.
- 260.** The system of any one claims **252** to **259** wherein the first at least one metal extraction apparatus is configured for oxidizing at least some elemental aluminum in the slime fraction.
- 15 **261.** The system of claim **260** wherein the first at least one metal extraction apparatus is configured for oxidizing at least some elemental aluminum in the slime fraction by elevating a pH of the slime fraction.
- 20 **262.** The system of any one claims **252** to **261** wherein the first at least one metal extraction apparatus further comprises a third froth flotation cell for separating at least some of the third conditioned slurry by froth flotation into a third concentrate and into third tailings.
- 263.** The system of claim **262** wherein the first at least one metal extraction apparatus is configured for cleaning at least some of the third concentrate into
- 25

a cleaned third concentrate.

- 264.** The system of claim **263** wherein the first at least one metal extraction apparatus is further configured for dewatering at least some of the cleaned third concentrate.
- 5 **265.** The system of claim **262**, **263**, or **264** wherein the first at least one metal extraction apparatus further comprises a fourth conditioning tank configured for conditioning at least some of the third tailings with a fifth at least one chemical reagent into a fourth conditioned slurry.
- 10 **266.** The system of claim **265** wherein the fifth at least one chemical reagent comprises one or more of: at least one activator; at least one sulphidizing agent; at least one metal sulphide collector; at least one frother; and at least one agglomerating agent.
- 15 **267.** The system of claim **265** or **266** wherein the first at least one metal extraction apparatus further comprises a fourth froth flotation cell configured for separating the fourth conditioned slurry by froth flotation into a fourth concentrate and into fourth tailings.
- 268.** The system of claim **267** wherein the first at least one metal extraction apparatus is configured for cleaning at least some of the fourth concentrate into a cleaned fourth concentrate.
- 20 **269.** The system of claim **268** wherein the first at least one metal extraction apparatus is further configured for dewatering at least some of the cleaned fourth concentrate.
- 270.** The system of any one of claims **267**, **268**, or **268** further comprising a fourth thickener for dewatering at least some of the fourth tailings.

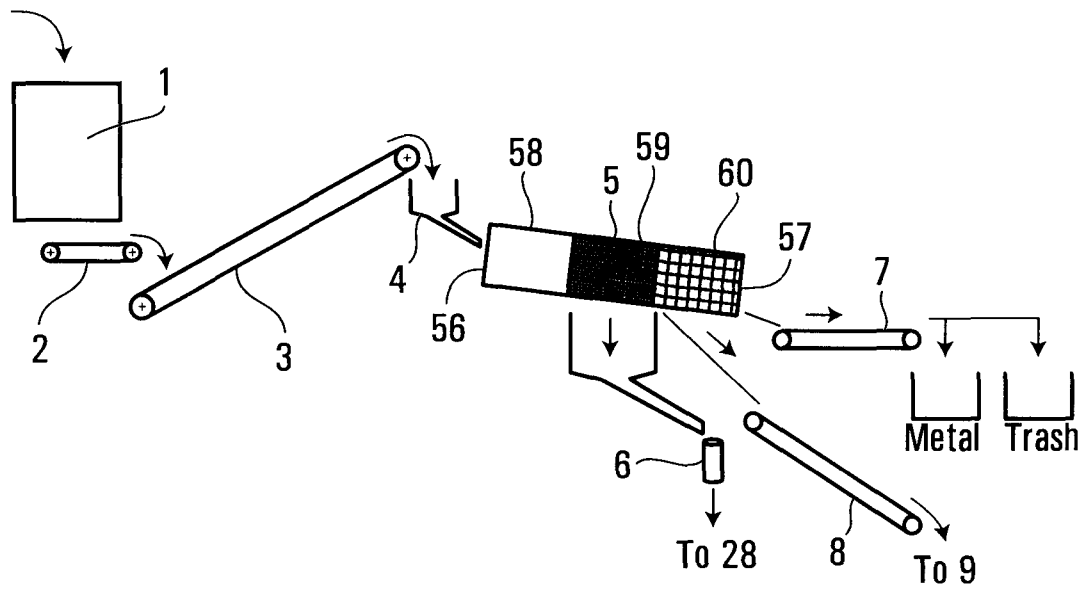


FIG. 1

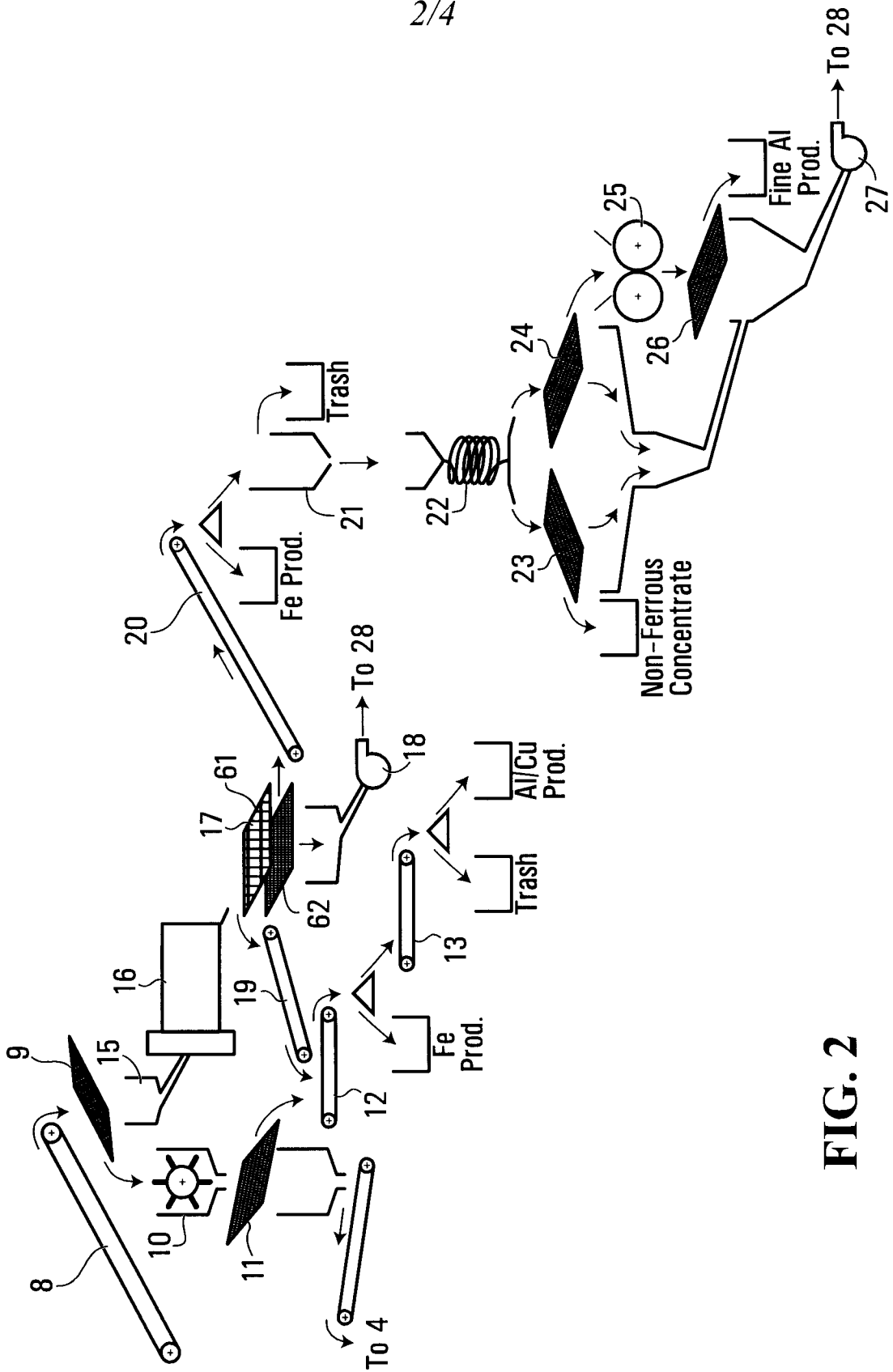
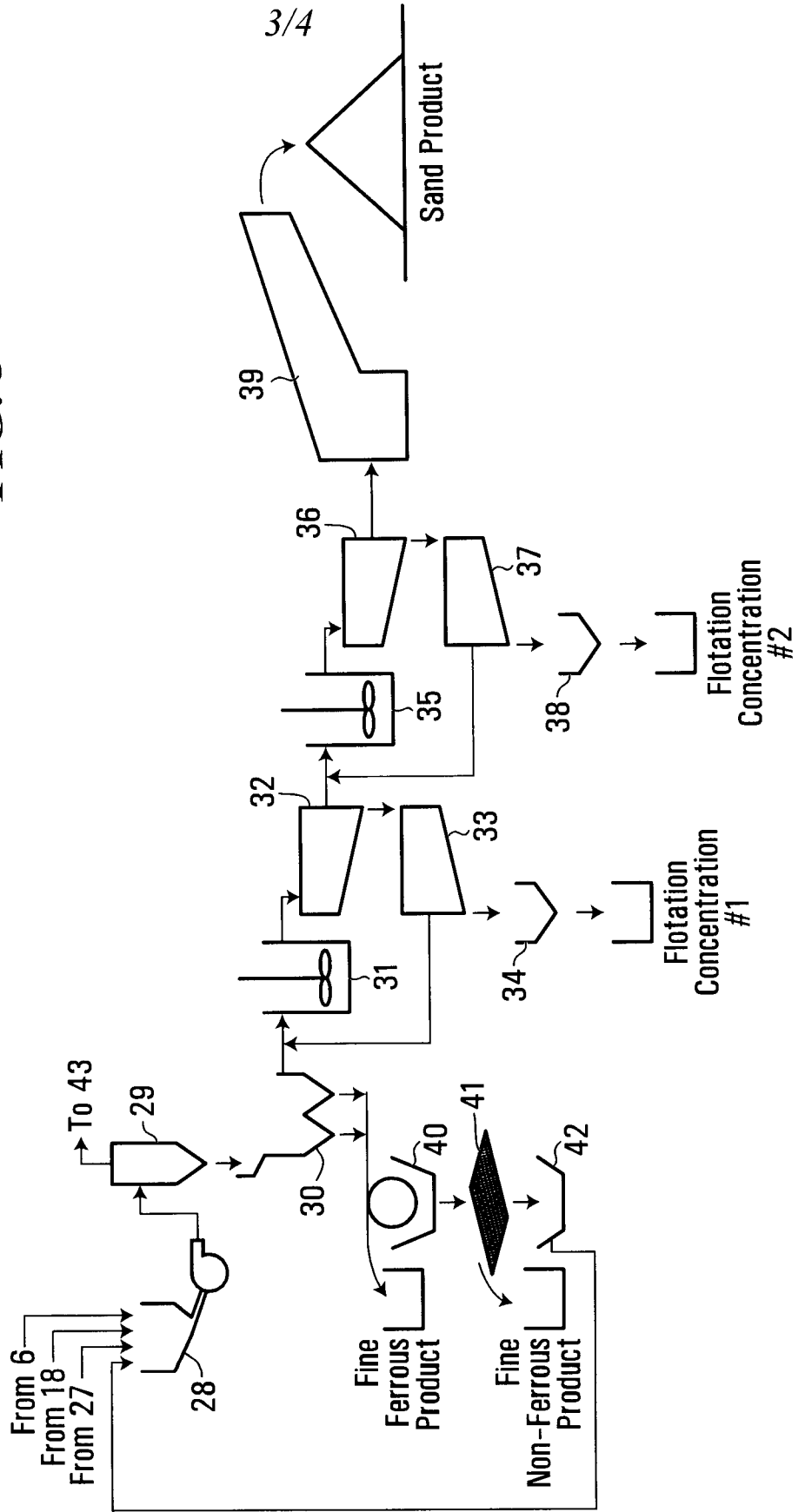


FIG. 2

FIG. 3



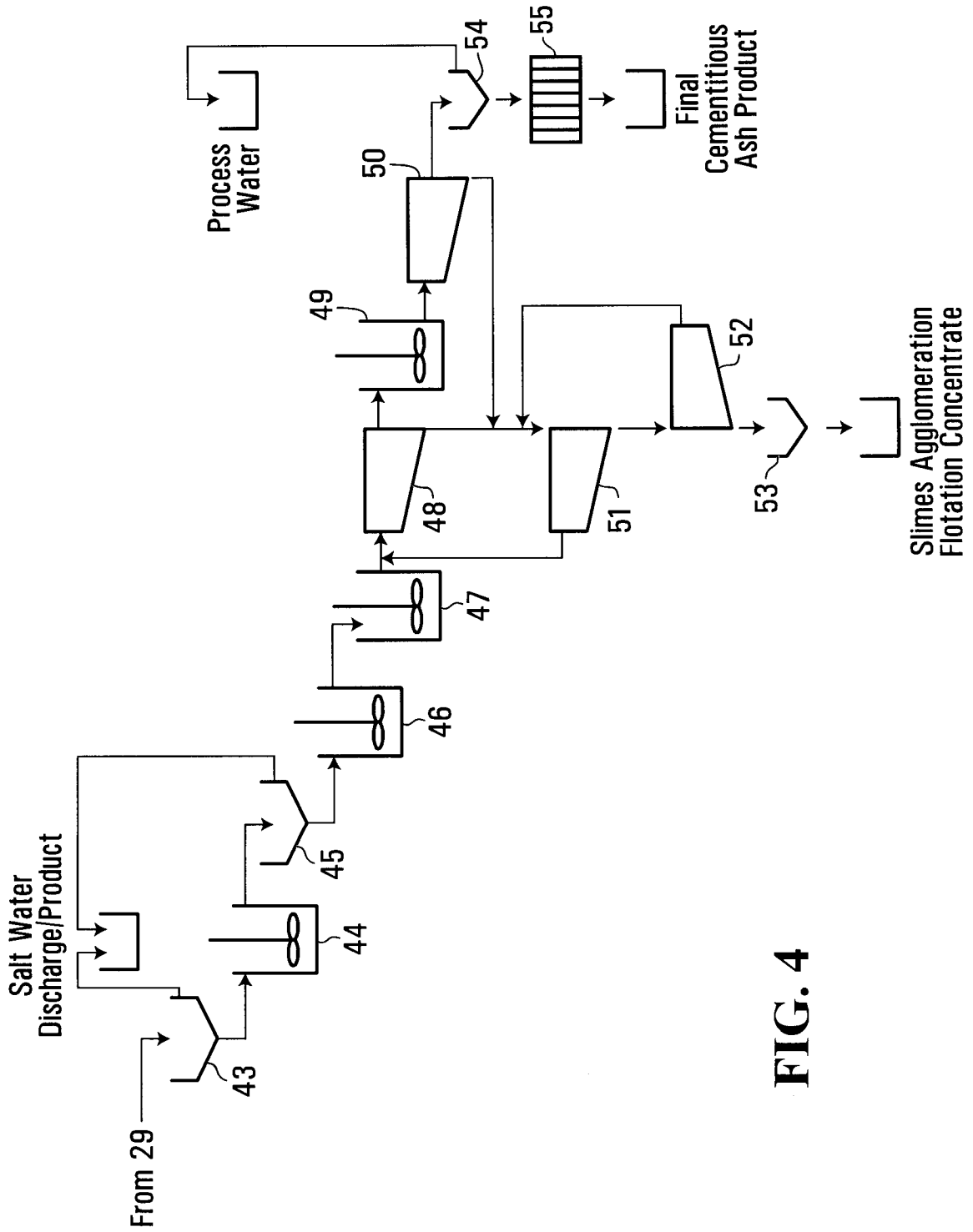


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2012/000945

A. CLASSIFICATION OF SUBJECT MATTER IPC: B07B 15/00 (2006.01) , A62D 3/40 (2007.01) , B01D 11/02 (2006.01) , B03B 7/00 (2006.01) , B03C 1/02 (2006.01) , B03D 1/02 (2006.01) (more IPCs on the last page) 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: B03B 9/04, B03D 1/02/04/06		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) DB : TOTALPATENT KW : METAL		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US2971703A (RATH) 14 February 1961 (14-02-1961)	1-2, 11-12, 39-40, 95-96, 105-106, 133-134, 183-184, 193-194, 221-222 41, 43, 135, 137, 223, 225
X Y	US4044956A (BENEDETTO et al.) 30 August 1977 (30-08-1977)	1-2, 8-11, 39, 95-96, 102-105, 133, 183-184, 190-193, 221 41, 43, 135, 137, 223, 225
X Y	JP2006015190A (SUZUKI et al.) 19 January 2006 (19-01-2006)	42, 136, 224 41, 43, 135, 137, 223, 225
X Y	JP2005272955A (SHIBAYAMA et al.) 06 October 2005 (06-10-2005)	42, 136, 224 41, 43, 135, 137, 223, 225
A	CA2418020A1 (BRODEUR) 04 August 2004 (04-08-2004)	1-270
A	CA1340476C (KELLER) 30 March 1999 (30-03-1999)	1-270
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&"	document member of the same patent family
"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		
Date of the actual completion of the international search 14 June 2013 (14-06-2013)	Date of mailing of the international search report 09 July 2013 (09-07-2013)	
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Authorized officer Alan Jones (819) 934-8531	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2012/000945

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA2390906A1 (MAILVAGANAM et al.) 20 December 2002 (20-12-2002)	1-270
A	US4376043A (HEIJWEGEN et al.) 08 March 1983 (08-03-1983)	1-270
A	US4404022A (GODBEHERE) 13 September 1983 (13-09-1983)	1-270
A	US4804147A (HOOPER) 14 February 1989 (14-02-1989)	1-270
A	US4815667A (KELLER) 28 March 1989 (28-03-1989)	1-270
A	US5174509A (STARKE et al.) 29 December 1992 (29-12-1992)	1-270
A	US5992776A (ARCAINI et al.) 30 November 1999 (30-11-1999)	1-270
A	US4121945A (HURST et al.) 24 October 1978 (24-10-1978)	1-270
A	US5443157A (BAKER et al.) 22 August 1995 (22-08-1995)	1-270
A	US4077847A (CHOI et al.) 07 March 1978 (07-03-1978)	1-270

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of the first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons :

1. Claim Nos. :
because they relate to subject matter not required to be searched by this Authority, namely :

2. Claim Nos. :
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically :

3. Claim Nos. :
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows :

(SEE EXTRA SHEET)

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos. :
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos. :

- Remark on Protest** The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

B07B 13/04 (2006.01) , *C04B 18/06* (2006.01) , *F23G 5/00* (2006.01)

CONTINUATION OF BOX No. III

The claims are directed to a plurality of inventive concepts as follows:

Group A - Claims 1-41, 95-135, 183-223 are directed to a system and method of treating incinerated waste, comprising:

size separating at least some of the incinerated waste, according to a first separation size, into a first undersize fraction comprising particles smaller than the first separation size and into a first oversize fraction comprising particles larger than the first separation size;

size reducing at least some of the first oversize fraction into a size reduced first oversize fraction;

size separating at least some of the size-reduced first oversize fraction, according to a second separation size, into a second undersize fraction comprising particles smaller than the second separation size and into a second oversize fraction comprising particles larger than the second separation size;

combining at least some of the first undersize fraction and at least some of the second undersize fraction into a fine fraction;

and extracting metal from at least some of the fine fraction.

Group B - Claims 42-94, 136-182, 224-270 are directed to a system and method of treating incinerated waste, comprising extracting metal by froth flotation from at least some of the incinerated waste.

It is held that the international application relates to a group of inventions which are not so linked as to form a single general inventive concept.

Where a group of inventions is claimed in one and the same international application, the requirement of unity of invention referred to in Rule 13.1 shall be fulfilled only when there is a technical relationship among those inventions involving one or more of the same or corresponding special technical features.

The expression "special technical features" shall mean those technical features that define a contribution which each of the claimed inventions, considered as a whole, makes over the prior art.

The only technical feature shared by the group of inventions in the application is the provision of extracting metal from incinerated waste, which is well-known in industry, and is therefore not a contribution over the prior art.

The application thus fails to fulfill the requirement of unity of invention.

The claims must be limited to one inventive concept as set out in Rule 13 of the PCT.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2012/000945

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US2971703A	14 February 1961 (14-02-1961)	None	
US4044956A	30 August 1977 (30-08-1977)	BE839501A1 CA1060867A1 CH604901A5 DE2609801A1 FR2303600A1 FR2303600B1 JPS51113368A NL7602561A SE415235B SE415235C SE7603202A	01 July 1976 (01-07-1976) 21 August 1979 (21-08-1979) 15 September 1978 (15-09-1978) 30 September 1976 (30-09-1976) 08 October 1976 (08-10-1976) 04 May 1979 (04-05-1979) 06 October 1976 (06-10-1976) 14 September 1976 (14-09-1976) 22 September 1980 (22-09-1980) 15 January 1981 (15-01-1981) 13 September 1976 (13-09-1976)
JP2006015190A	19 January 2006 (19-01-2006)	None	
JP2005272955A	06 October 2005 (06-10-2005)	JP2005272955A JP4417152B2	06 October 2005 (06-10-2005) 17 February 2010 (17-02-2010)
CA2418020A1	04 August 2004 (04-08-2004)	BE1015890A6 CA2418020C DE102004005535A1	08 November 2005 (08-11-2005) 13 September 2011 (13-09-2011) 05 August 2004 (05-08-2004)
CA1340476C	30 March 1999 (30-03-1999)	CA1269355A1 DE3689440D1 DE3689440T2 EP0220853A2 EP0220853A3 EP0220853B1 JPS62164835A US4815667A	22 May 1990 (22-05-1990) 03 February 1994 (03-02-1994) 11 May 1994 (11-05-1994) 06 May 1987 (06-05-1987) 16 August 1989 (16-08-1989) 22 December 1993 (22-12-1993) 21 July 1987 (21-07-1987) 28 March 1989 (28-03-1989)
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US4376043A	08 March 1983 (08-03-1983)	AT13201T AU538381B2 AU7020181A CA1163382A1 DE40870T1 DE3170374D1 EP0040870A1 EP0040870B1 JPS575826A JPS627254B2 NL8002743A	15 May 1985 (15-05-1985) 09 August 1984 (09-08-1984) 19 November 1981 (19-11-1981) 06 March 1984 (06-03-1984) 28 March 1985 (28-03-1985) 13 June 1985 (13-06-1985) 02 December 1981 (02-12-1981) 08 May 1985 (08-05-1985) 12 January 1982 (12-01-1982) 16 February 1987 (16-02-1987) 16 December 1981 (16-12-1981)
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INTERNATIONAL SEARCH REPORT

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