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(54) Title: SORTING MINED MATERIAL

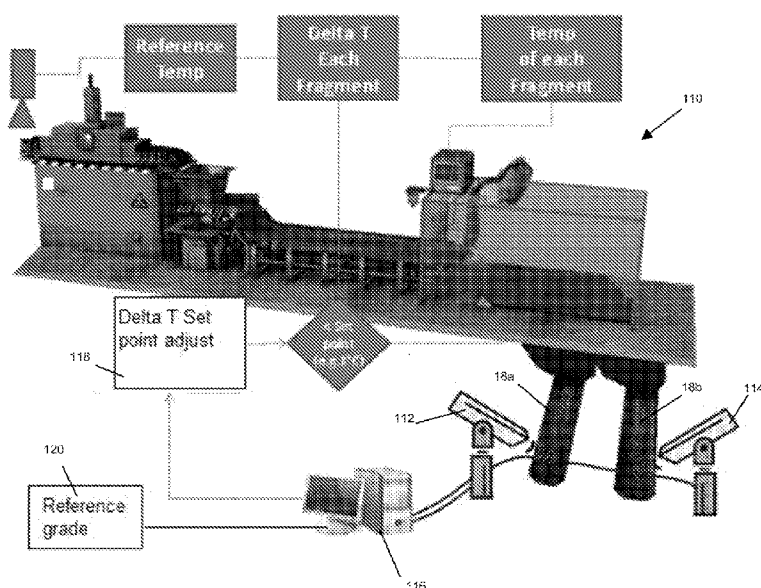


FIGURE 3

(57) Abstract: A method of sorting fragments of mined material is disclosed. The method comprises exposing the fragments to a source of heating to heat the fragments depending on the susceptibility of the material in the different fragments to the source of heating. The heated fragments are thermally analysed using the temperature of each of the fragments as a basis for the analysis and are sorted into two or more streams on a fragment by fragment basis of the temperature of each fragment relative to a set point temperature. The method further comprises monitoring the grade of the ore in one of the ore streams on a bulk basis and changing the set point temperature based on the monitored grade of the ore in the ore stream. Also disclosed is an apparatus for sorting fragments of mined material.



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SORTING MINED MATERIAL

TECHNICAL FIELD

5 The present invention relates to a method and an apparatus for sorting mined material.

 The term “mined” material is understood herein to include, but is not limited to, (a) run-of-mine material and (b) run-of-mine material that has been subjected to at least primary crushing or similar size reduction after the material has been mined and prior to
10 being sorted. The mined material includes mined material that is in stockpiles.

 The present invention relates particularly, although by no means exclusively, to a method and an apparatus for sorting mined material for subsequent processing to recover valuable material, such as valuable metals, from the mined material.

 The present invention also relates to a method and an apparatus for recovering
15 valuable material, such as valuable metals, from a mined material that has been sorted as described above.

 A particular, although not exclusive, area of interest to the applicant is mined material in the form of mined ores that include copper-containing materials such as chalcopyrite, in sulphide forms.

20

BACKGROUND ART

 The applicant is developing an automated sorting method and apparatus for mined material.

25 In general terms, the method of sorting mined material being developed by the applicant includes the following steps:

- (a) exposing particles of mined material to a source of heating such as electromagnetic energy,
- (b) detecting and assessing particles on the basis of composition (including
30 grade) or texture or another characteristic of the particles, and
- (c) physically separating particles based on the assessment in step (b).

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One challenge in implementing an automated sorting method and apparatus successfully is consistency in the grade of materials being accepted and rejected. In other words, considerable effort is being put into ensuring that mined material is appropriately classified according to sorting criteria and is physically separated so the product streams leaving the sorting apparatus have the properties required for the designated downstream processing. For example, it would be uneconomic to operate a smelting plant or a flotation plant where the input stream of mined material from the sorting apparatus contains less of a valuable material than is required to economically run the plant. Similarly, there is a great economic downside when material which could have been economically processed is rejected.

The above references to the background art do not constitute an admission that the art forms a part of the common general knowledge of a person of ordinary skill in the art. The above references are also not intended to limit the application of the apparatus and method as disclosed herein.

15

SUMMARY OF THE DISCLOSURE

According to one aspect there is provided a method of sorting fragments of mined material, the method comprising the steps of:

- (a) exposing the fragments to a source of heating to heat the fragments depending on the susceptibility of the material in the different fragments to the source of heating;
- (b) thermally analysing the fragments using the temperature of each of the fragments as a basis for the analysis;
- (c) sorting the fragments into two or more streams on a fragment by fragment basis of the temperature of each fragment relative to a set point temperature;
- (d) monitoring the grade of the ore in one of the ore streams on a bulk basis; and
- (e) changing the set point temperature based on the monitored grade of the ore in the ore stream.

When fragments that are at or colder than the set point temperature are sorted into a rejects stream, and if the monitored grade in the rejects stream is below a reference grade, the set point temperature may be increased.

When fragments that are at or colder than the set point temperature are sorted into a rejects stream, and if the monitored grade in the rejects stream is above a reference grade, the set point temperature may be decreased.

When fragments that are at or hotter than the set point temperature are sorted
5 into an accepts stream, and if the monitored grade in the accepts stream is below a reference grade, the set point temperature may be increased.

When fragments that are at or hotter than the set point temperature are sorted into an accepts stream, and if the monitored grade in the accepts stream is above a reference grade, the set point temperature may be decreased.

10 The grade monitoring data of the ore stream may be integrated over time to provide the bulk grade.

The grade monitoring data of the ore stream may be integrated over a time period to provide the average bulk grade over the time period. The time period may be a period between 1 minute and 5 minutes.

15 The grade of the ore in the stream may be provided by a bulk analyzer having an x-ray fluorescence sensor.

The grade of the ore in the stream may be provided by a bulk analyzer having an x-ray diffraction sensor.

According to another aspect there is also provided an apparatus for sorting
20 mined material, the apparatus comprising:

- (a) a heating station having an energy source, the heating station being configured to expose fragments of the mined material to the energy source which is selected to heat the fragments depending on the susceptibility of material in the different fragments to energy produced by the energy source;
- 25 (b) a thermal analysis assembly that is configured to assess the temperature of fragments for analysing the thermal response of fragments to the electromagnetic radiation;
- (c) a sorting assembly that is configured to sort the fragments into two or more streams on a fragment-by-fragment basis of the temperature of each fragment
30 relative to a set point temperature; and

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(d) a grade monitoring assembly that is configured to monitor the grade of fragments in one or more streams and is configured to adjust the set point temperature in response to the monitored grade.

The heating station may include a thermal imager that records the temperature of fragments entering the heating station. The heating station may further include a source of microwave energy.

The thermal analysis assembly may include a fragment size sensor that is configured to feed data to a computer and wherein the computer is configured to determine the extent of heating of each fragment from a comparison of data obtained from the thermal imager of the heating station and the temperature determined by the thermal analysis assembly.

The grade monitoring assembly may include a computer that generates a mean grade for fragments passing the grade monitoring assembly.

The computer of the grade monitoring assembly may be configured with logic that controls the set-point temperature based on a differential between the generated mean grade and a predetermined mean grade.

The mean may be generated from fragment data obtained over a period in the range of 30 seconds to 30 minutes.

The grade monitoring assembly may include one or more sensors that operate on the basis of X-ray fluorescence (XRF), X-Ray Diffraction (XRD), Nuclear Magnetic Resonance (NMR), neutron activation analysis (NAA) or its variants prompt gamma NAA (PGNAA) and delayed gamma NAA (DGNAA).

The thermal analysis assembly may include a conveyor that is configured to spread fragments relatively evenly over the conveyor in preparation for thermal analysis.

BRIEF DESCRIPTION OF THE DRAWINGS

Notwithstanding any other forms which may fall within the scope of the apparatus and method as set forth in the Summary, specific embodiments will now be described, by way of example only, with reference to the accompanying drawings in which:

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Figure 1 is a flow chart of an embodiment of a method according to the present invention;

Figure 2 is a diagram of an embodiment of an apparatus for sorting mined material according to the present invention; and

5 Figure 3 is a diagram of the embodiment in Figure 2 showing grade analyzers on the output streams which dynamically control the set point temperature of the sorting apparatus.

DESCRIPTION OF EMBODIMENTS

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The embodiment is described in the context of a method of recovering a valuable metal in the form of copper from low grade copper-containing ores in which the copper is present in copper-containing minerals such as chalcopyrite and the ores also contain non-valuable gangue. The objective of the method in the embodiment is to
15 identify particles of mined material containing amounts of copper-containing minerals above a certain grade and to sort these particles from the other particles and to process the copper-containing particles using the most effective and viable option to recover copper from the particles.

It is noted that, whilst the following description does not focus on the
20 downstream processing options, these options include any suitable options ranging from smelting to leaching.

It is also noted that the present invention is not confined to copper-containing ores and to copper as the valuable material to be recovered. In general terms, the present invention provides a method of dynamically controlling a set point temperature
25 in a sorting system where the change in temperature of an ore fragment is indicative of the valuable material content of the ore fragment. The mined materials may be metalliferous materials and non-metalliferous materials. Iron-containing and copper-containing ores are examples of metalliferous materials. Coal is an example of a non-metalliferous material.

30 Referring firstly to Figure 1, a process for processing mined ore is shown. Specifically, large rocks and boulders of ore are reduced in size in a primary crusher 10 and then sent to a comminution station 12 to reduce the ore further to fragments, i.e.

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particles, of size less than 100mm. The ore particles are then sorted to obtain a stream of ore particles that contains a high content of a valuable material ("accepts stream") and a stream of ore particles that contains a low content of a valuable material ("rejects stream").

5 Generally speaking, a bulk quantity of ore particles is exposed 14 to an excitation energy that is selected to heat the valuable mineral. Ore particles that have a high valuable-material content are heated. For convenience, these particles are termed "hot" particles although their temperature may increase only slightly during heating. Ore particles with a low content of the valuable-material are not heated to the same
10 extent and, for convenience, are termed "cold" particles. The result is that a thermal differential is produced between high and low valuable-material content ore particles. This thermal difference enables the ore particles to be sorted.

 In one form, the excitation energy is electromagnetic radiation such as microwave energy. However, it will be appreciated that, amongst other factors, the
15 excitation energy is selected on the basis of the ore being processed and on the basis of establishing a thermal differential sufficient for sorting. In regard to the latter, the thermal differential is sufficient for a thermal detector to discriminate between "hot" and "cold" particles. Accordingly, the excitation radiation may be x-radiation or other suitable electromagnetic energy.

20 The bulk quantity of ore particles is then subjected to a distributor apparatus, in the form of a distributor station 16, which spatially distributes the particles in preparation for sorting. The distributed particles then pass to a sorting apparatus 18 that identifies and separates "hot" particles from "cold" particles, thereby producing a "cold" stream 18a and a "hot" stream 18b of particles. It will be appreciated, however,
25 that the particles may be sorted into more than two streams depending on the suitability and availability of downstream processing operations to process particles of different ore grades.

 An example of a sorting apparatus is shown in Figure 2. Specifically, a feed material in the form of ore particles that have been crushed by a primary crusher (not
30 shown) to a particle size of 10-75 mm are supplied via a feed assembly 20 onto a conveyor belt 22 and the belt 22 transports the particles through an exposure 14 stage in

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the form of a microwave radiation treatment assembly 24 that includes an exposure chamber 26.

The particles on the belt 22 are exposed to microwave radiation on a particle by particle basis as they move through the exposure chamber 26 of the microwave radiation treatment assembly 24. The microwave radiation may be either in the form of continuous or pulsed radiation.

The particles leave the exposure chamber 26 and are delivered by the conveyor 22 into a chute 28 which directs the particles onto a dispersion plate 30. Particles are spread relatively evenly by action of the dispersion plate 30. The dispersion plate is operated as a vibrating plate that causes the particles to spread apart from each other and that causes the particles to travel from an outlet of the chute to a drop-off edge 32 of the plate 30 opposite the outlet.

The evenly dispersed particles fall from the dispersion plate 30 onto a further conveyor 34 which delivers the particles to the thermal analyzer stage 18 of the sorting apparatus 100.

While travelling on the conveyor 34, the particles are subjected to thermal analysis. In this embodiment, radiation from the particles is detected by high resolution, high speed infrared imagers 66 which capture thermal images of the particles. While one thermal imager is sufficient, two or more thermal imagers may be used for full coverage of the particle surface.

In addition, a laser system (not shown) is operable to determine the size of the individual particle sizes. From the number of detected hot spots (pixels), temperature, pattern of their distribution and their cumulative area, relative to the size of the particle, an estimation of the grade of observed rock particles can be made. This estimation may be supported and/or more mineral content may be quantified by comparison of the data with previously established relationships between microwave induced thermal properties of specifically graded and sized rock particles.

Images collected by the thermal imagers 66 and the visible light sensors (and any other sensors) are processed, for example, using a computer 70 equipped with image processing software. The software is designed to process the sensed data to classify the individual particles for sorting and/or downstream processing options. In

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any given situation, the software may be designed to weight different data depending on the relative importance of the properties associated with the data.

The computer 70 compares the temperature readings from the thermal imagers 66 to a set point temperature to determine whether a given particle is “hot” or “cold”.

5 The temperature of a particle is generally related to the amount of copper minerals in the particle. The set point temperature may be a threshold temperature that is set by an operator. The set point temperature may be the sum of a reference base temperature of the input stream and a predetermined Delta T temperature rise. The reference base
10 temperature is a mean temperature (or approximation of mean temperature) of particles entering the microwave treatment assembly 24 as discussed with reference to Figure 3. The Applicants have found that particles that have a given size range and are heated under given conditions will have a temperature increase (the Delta T) to a temperature above the set point temperature if the particles contain at least “y” wt. % copper. The set point temperature can be selected initially based on economic factors and adjusted
15 as those factors change. Barren particles will generally not be heated on exposure to microwave frequency radiation to temperatures above the set point temperature.

The thermal analysis is based on distinguishing between particles that are above and below the set point temperature so that the particles can then be categorized as “hot” and “cold” particles.

20 With reference to Figure 2, the thermal analysis station 18 determines the temperature rise of particles as a result of exposure to microwave energy in the microwave treatment assembly 24. Specifically, a thermal imaging camera 20 is positioned to scan particles entering the microwave treatment assembly 24. The camera 20 determines the temperature of particles and this temperature is taken as a reference
25 base temperature. This reference base temperature is compared with the particle temperature obtained by the thermal analysis station 18 to determine the temperature rise (“Delta T” in Figure 3) of each particle as a result of exposure to the microwave energy. Sorting criteria is then applied to the temperature rise of each particle to determine how the particles are to be sorted. The sorting criteria in this embodiment
30 comprises a set temperature rise which is selected to be representative of a threshold copper content in particles that are economical to process in downstream operations to recover copper metal. The Delta T temperature rise is 1°C so that a particle having a

temperature rise less than 1°C is relative to the reference base temperature is classified as a “cold” particle and therefore is designated for rejection by a separator assembly 50. A particle having a Delta T temperature rise greater than 1°C relative to the reference base temperature is classified as a “hot” particle and therefore is designated for downstream processing to recover copper. It will be appreciated that Delta T temperature, and hence set point temperature, may be dynamically adjusted in accordance with the present invention.

Although the reference base temperature is determined by the camera 20, the reference base temperature may be determined in other ways. For example the particles may be pre-treated so that the particles achieve a pre-determined reference base temperature. Accordingly, the reference base temperature may be recorded in the computer 70 as a fixed temperature, rather than being actively monitored.

Once the thermal and visual light analysis is completed by the computer 70 and each particle is classified, the particles are separated by the separator assembly 50 that includes an array 68 of air ejectors spaced at intervals over a distance that is approximately the same as the width of the belt 34. The array 68 is fed with compressed air from a compressed air source, such as cylinder 69. The particles are separated by being projected from the end of the conveyor 34 and being deflected selectively by compressed air jets (or other suitable fluid jets, such as water jets) as the particles move in a free-fall trajectory from the conveyor 34. The particles are thereby sorted into two streams that are collected in the chutes 52, 54. The thermal analysis identifies the position of each of the particles on the conveyor 34 and the air jets are activated a pre-set time after a particle is analyzed as a particle to be deflected.

In the present instance, the primary classification criterion is the temperature rise of particles as an indication of the grade of the copper in the particle. Particles below the set point temperature (i.e. having a temperature rise below Delta T) are separated into one collection chute 52 as rejects stream 18a and particles above the set point temperature (i.e. having a temperature rise above Delta T) are separated into the other chute 54 as accepts stream 18b. The valuable particles sent to chute 54 are then processed to recover copper from the particles. For example, the valuable particles in the chute 54 are transferred for downstream processing including milling and flotation to form a concentrate and then processing the concentrate to recover copper.

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In an alternative embodiment, the separator assembly 50 may be calibrated to deflect “hot” particles and to allow “cold” particles to continue on their original trajectory.

5 The particles in accepts stream 18b may become a by-product waste stream and are disposed of in a suitable manner. However, this may not always be the case. The particles have lower concentrations of copper minerals that may be sufficiently valuable for recovery by alternative methods. In that event, the “cold” particles may be transferred to a suitable recovery process, such as leaching.

10 The applicant has found that the grade of particles in the accepts steam 18b and rejects stream 18a drift over time for a variety of reasons, including factors such as the feed grade and mineralogy, environmental factors and sorter efficiency. Accordingly, the applicant recognises that, despite having the set point temperature dynamically adjusted by measuring a reference base temperature, it is also necessary to dynamically adjust Delta T temperature.

15 In this regard, each stream 18a, 18b is transferred on the respective conveyors 42, 44 through a bulk grade analysis station 19 (Figure 1), which comprises two online grade analyzers 112, 114. The online grade analyzers 112, 114 may have any number or type of sensor technologies which determines grade on a bulk basis. Known online sensor technologies for copper grade determination include: X-ray fluorescence (XRF),
20 X-Ray Diffraction (XRD), Nuclear Magnetic Resonance (NMR), neutron activation analysis (NAA) and its variants prompt gamma NAA (PGNAA) and delayed gamma NAA (DGNAA). Each grade analyzer 112, 114 is linked to a processor, for example, to a computer 90 that collects data obtained by the cameras grade analyzers 112, 114.

25 The online analyzers 112, 114 are able to monitor average grade (copper grade) of the fragments in respective streams 18a and 18b on a bulk basis. The grade is integrated over time to give the average grade over a time period, such as 30 seconds or 30 minutes. The monitored grades by the online analyzers 112, 114 are an input to the control of the sorting process. More specifically, the Delta T temperature (and hence set point temperature) is adjusted 118 depending on the grade measurements of the
30 online analyzers. The monitored grades on the streams 18a and 18b are compared to reference grades for the streams. The online analyzers 112, 114 are connected to computer system 116. A reference grade for each stream 18a, 18b is input into the

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computer system 116. The reference grade may be the same for each stream 18a, 18b. The computer system 116 is operable to dynamically change the Delta T temperature. The computer system 116 includes a logic program to make adjustments to the Delta T temperature (and thus dynamically control the set point temperature) as per the logic in the table below:

Stream	Analyzer reading relative to reference grade	Delta T control
Rejects stream (18a)	above reference grade (120)	Decrease Delta T set point
Rejects stream (18a)	below reference grade (120)	Increase Delta T set point
Accepts stream (18b)	above reference grade (120)	Decrease Delta T set point
Accepts stream (18b)	below reference grade (120)	Increase Delta T set point

Looking at the first example in the table, if the rejects stream is found to have a monitored grade which is above the reference grade 120, the Delta T set point is decreased. This has the effect that fragments do not need to heat as much in order to be diverted to the accepts stream 18b. As a consequence the highest grade of particles in the rejects streams will be lowered and the analyzed grade on the rejects stream will decrease until it is at or below the reference grade.

Only one of the rejects stream 18a or accepts stream 18b need to be monitored for Delta T control, or both streams may be monitored. The reference grades are determined by economics and desired upgrading of the stream entering the feed assembly. It is preferable that the rejects stream 18a is monitored to dynamically control the set point temperature. In mineral recovery it is generally more important that the grade of the rejects stream be controlled to not be too high a grade than controlling the accepts stream to not be too low a grade. For this reason the Applicant believes that a system wherein the monitored grade of the rejects stream drives the set point temperature is preferable.

Whilst a number of specific apparatus and method embodiments have been described, it should be appreciated that the apparatus and method may be embodied in many other forms. For example, although the description above relates to varying of a set point temperature, the Applicant envisages that the grade of fragments may also be

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inferred by other means such as XRF, XRD, NMR or PGNAA analyzers to drive the sorting step relative to a set point grade. In this instance the online bulk analyzers 112, 114 will be used to dynamically control the set point grade in the same manner as described for dynamically controlling the set point temperature. In another embodiment
5 both temperature analysis and grade analysis by XRF, XRD, NMR or PGNAA may be combined to determine sorting criteria of the fragments and the online bulk analyzers 112, 114 will dynamically inform the sorting criteria

By way of example, whilst the embodiments include exposing the particles to be sorted to microwave radiation, the present invention is not so limited and extends to the
10 use of any other suitable electromagnetic energy.

In the claims which follow, and in the preceding description, except where the context requires otherwise due to express language or necessary implication, the word “comprise” and variations such as “comprises” or “comprising” are used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence
15 or addition of further features in various embodiments of the apparatus and method as disclosed herein.

CLAIMS

1. A method of sorting fragments of mined material, the method comprising the steps of:
 - 5 (a) exposing the fragments to a source of heating to heat the fragments depending on the susceptibility of the material in the different fragments to the source of heating;
 - (b) thermally analysing the fragments using the temperature of each of the fragments as a basis for the analysis;
 - 10 (c) sorting the fragments into two or more streams on a fragment by fragment basis of the temperature of each fragment relative to a set point temperature;
 - (d) monitoring the grade of the ore in one of the ore streams on a bulk basis; and
 - 15 (e) changing the set point temperature based on the monitored grade of the ore in the ore stream.
2. The method of claim 1, wherein fragments that are at or colder than the set point temperature are sorted into a rejects stream, and if the monitored grade in the rejects
20 stream is below a reference grade, the set point temperature is increased.
3. The method of claim 1 or claim 2, wherein fragments that are at or colder than the set point temperature are sorted into a rejects stream, and if the monitored grade in the rejects stream is above a reference grade, the set point temperature is decreased.
25
4. The method of claim 1, wherein fragments that are at or hotter than the set point temperature are sorted into an accepts stream, and if the monitored grade in the accepts stream is below a reference grade, the set point temperature is increased.
- 30 5. The method of claim 1 or claim 4, wherein fragments that are at or hotter than the set point temperature is sorted into an accepts stream, and if the monitored grade in the accepts stream is above a reference grade, the set point temperature is decreased.

6. The method defined in any one of claims 1 to 5, wherein grade monitoring data of the ore stream is integrated over time to provide the bulk grade.
- 5 7. The method defined in any one of claims 1 to 5, wherein grade monitoring data of the ore stream is integrated over a time period to provide the average bulk grade over the time period.
8. The method of claim 7, wherein the time period is a period between 1 minute
10 and 5 minutes.
9. The method of any one of the preceding claims, wherein the grade of the ore in the monitored stream is provided by a bulk analyzer having an x-ray fluorescence sensor.
- 15 10. The method of any one of claims 1 to 8, wherein the grade of the ore in the monitored stream is provided by a bulk analyzer having an x-ray diffraction sensor.
11. An apparatus for sorting mined material, the apparatus comprising:
- 20 (a) a heating station having an energy source, the heating station being configured to expose fragments of the mined material to the energy source which is selected to heat the fragments depending on the susceptibility of material in the different fragments to energy produced by the energy source;
- 25 (b) a thermal analysis assembly that is configured to assess the temperature of fragments for analysing the thermal response of fragments to the electromagnetic radiation;
- (c) a sorting assembly that is configured to sort the fragments into two or more streams on a fragment-by-fragment basis of the temperature of each
30 fragment relative to a set point temperature; and

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- (d) a grade monitoring assembly that is configured to monitor the grade of fragments in one or more streams and is configured to adjust the set point temperature in response to the monitored grade.

5 12. The apparatus defined in claim 11, wherein the heating station includes a thermal imager that records the temperature of fragments entering the heating station.

13. The apparatus defined in claim 11, wherein the heating station includes a source of microwave energy.

10

14. The apparatus defined in claim 11, wherein the thermal analysis assembly includes a fragment size sensor that is configured to feed data to a computer and wherein the computer is configured to determine the extent of heating of each fragment from a comparison of data obtained from the thermal imager of the heating station and the temperature determined by the thermal analysis assembly.

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15. The apparatus defined in claim 11, wherein the grade monitoring assembly includes a computer that generates a mean grade for fragments passing the grade monitoring assembly.

20

16. The apparatus defined in claim 15, wherein the computer of the grade monitoring assembly is configured with logic that controls the set-point temperature based on a differential between the generated mean grade and a predetermined mean grade.

25

17. The apparatus defined in claim 16, wherein the mean is generated from fragment data obtained over a period in the range of 30 seconds to 30 minutes.

30

18. The apparatus defined in claim 11, wherein the grade monitoring assembly includes one or more sensors that operate on the basis of X-ray fluorescence (XRF), X-Ray Diffraction (XRD), Nuclear Magnetic Resonance (NMR), neutron activation

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analysis (NAA) or its variants prompt gamma NAA (PGNAA) and delayed gamma NAA (DGNAA).

19. The apparatus defined in claim 11, wherein the thermal analysis assembly
5 includes a conveyor that is configured to spread fragments relatively evenly over the conveyor in preparation for thermal analysis.

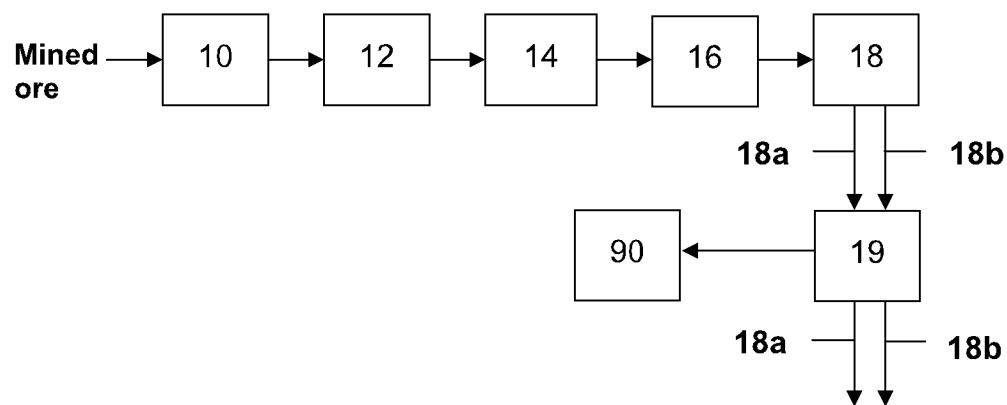


FIGURE 1

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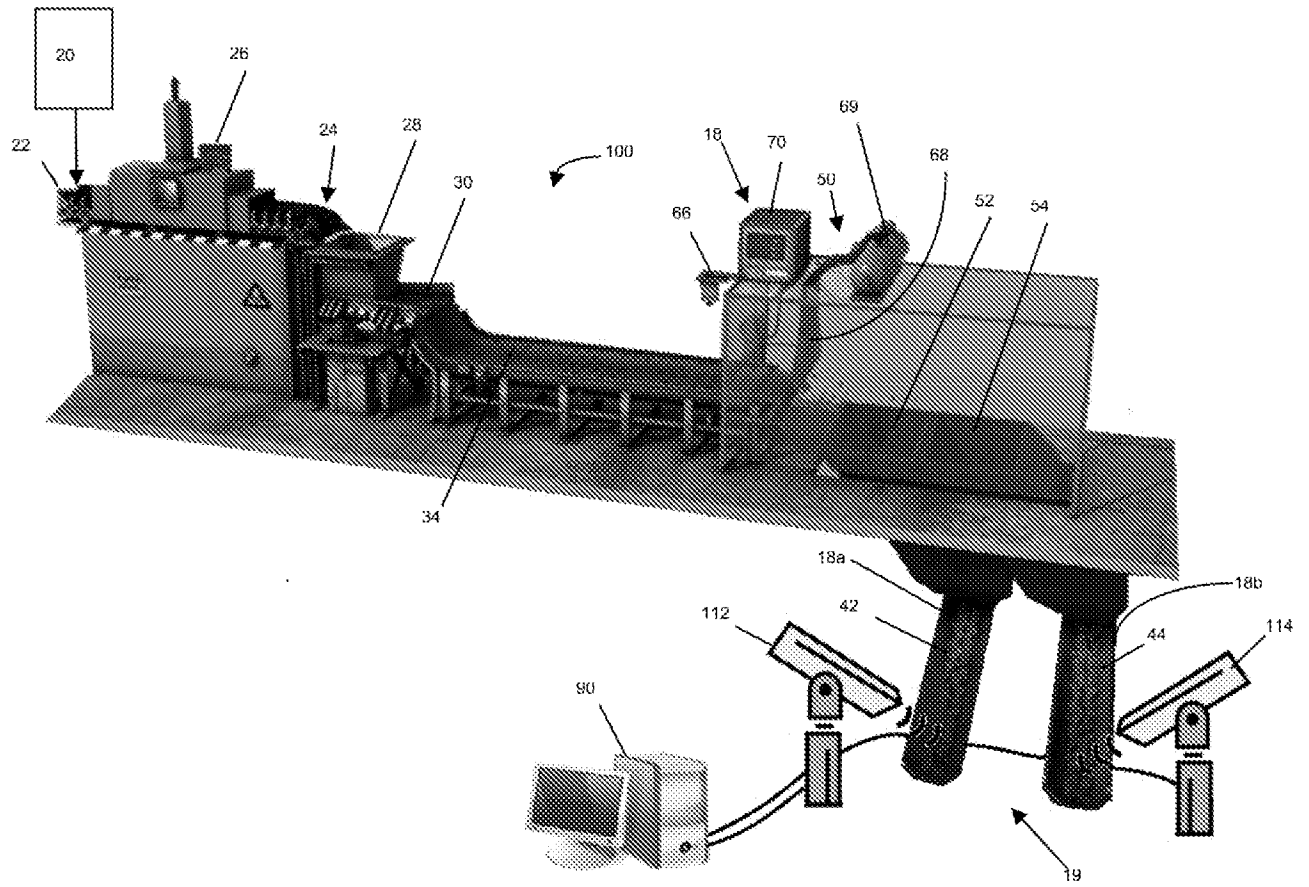


FIGURE 2

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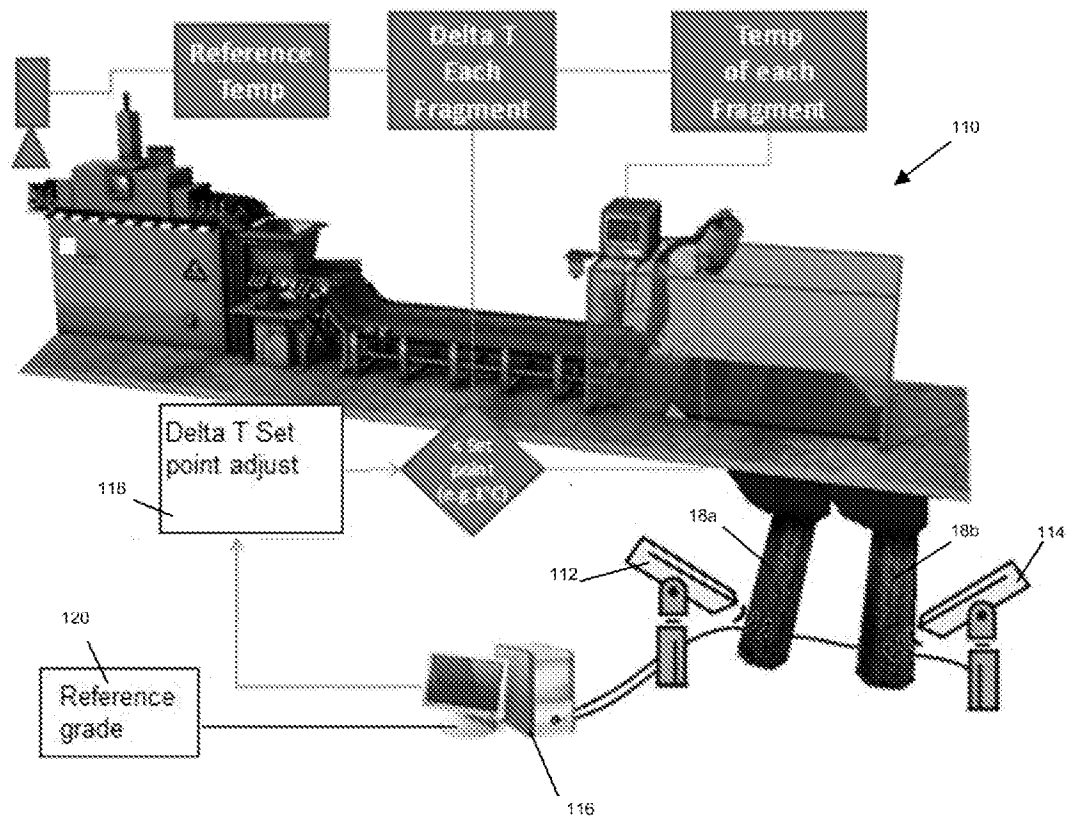


FIGURE 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2014/000500

A. CLASSIFICATION OF SUBJECT MATTER

B01J 19/08 (2006.01) B01J 19/12 (2006.01) H05B 6/64 (2006.01) B03B 1/02 (2006.01) B02C 23/08 (2006.01)
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

EPOQUENET (WPI AND EPODOC DATABASES) SEARCH: B02C23/08/IC/CC OR B07B13/18/IC/CC OR B07B13/14/IC/CC OR B01J19/12/IC/CC OR B01J19/08/IC/CC OR H05B6/00/IC/CC OR H05B6/64/IC/CC; SORT+ OR CLASSIF+ OR GRADE+ OR SEPARAT+; FRAGMENT+ OR MINED+ OR CRUSH+; HEAT+ OR TEMPERATURE+; DIFFER+ OR VARY+ OR MANIP+ OR DYNAMIC+ OR ADJUST+ OR MONITOR+ OR CONTROL+ OR SENS+ OR DETECT+ OR ANALY+ OR (SET 3D POINT+); IMAG+ OR PHOTO+ OR INFRA+ OR CAMERA+ OR RADIAT+ OR MICRO_WAV+ OR ELECTRO_MAGNET+; and similar terms used. **GOOGLE PATENTS; GENERAL INTERNET KEYWORD SEARCH; ESP@CENET; GOOGLE SCHOLAR; AND USPTO DATABASE SEARCH:** Keywords used such as: temperature; difference; thermal; microwave; ore; crushed; mined; mine; grade; sort; classify; separate; dynamic; adjust; monitored; and similar keywords used. **APPLICANT NAME SEARCH UNDERTAKEN:** SEARCH TERMS USED IN ESP@CENET AND GOOGLE PATENT DATABASES- TECHNOLOGICAL RESOURCES: HARDING, THOMAS.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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



Further documents are listed in the continuation of Box C



See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 19 September 2014	Date of mailing of the international search report 19 September 2014
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaaustralia.gov.au	Authorised officer Peter Ellis AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 02 6225 6106

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