(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 May 2011 (05.05.2011)

PCT

(10) International Publication Number
WO 2011/053913 A1

(51) International Patent Classification:
B07C 5/344 (2006.01)

(21) International Application Number:
PCT/US2010/054975

(22) International Filing Date:
1 November 2010 (01.11.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/256,648 30 October 2009 (30.10.2009) US
12/848,317 2 August 2010 (02.08.2010) US

(72) Inventor; and
(71) Applicant : **VALERIO, Thomas, A.** [US/US]; 8329 Shallow Creek Court, New Port Richey, FL 34653-7020 (US).

(74) Agent: **MAYBERRY, James, J.**; King & Spalding, 1180 Peachtree Street, 34th Floor, Atlanta, GA 30309 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHOD AND SYSTEM FOR SEPARATING AND RECOVERING WIRE AND OTHER METAL FROM PROCESSED RECYCLED MATERIALS

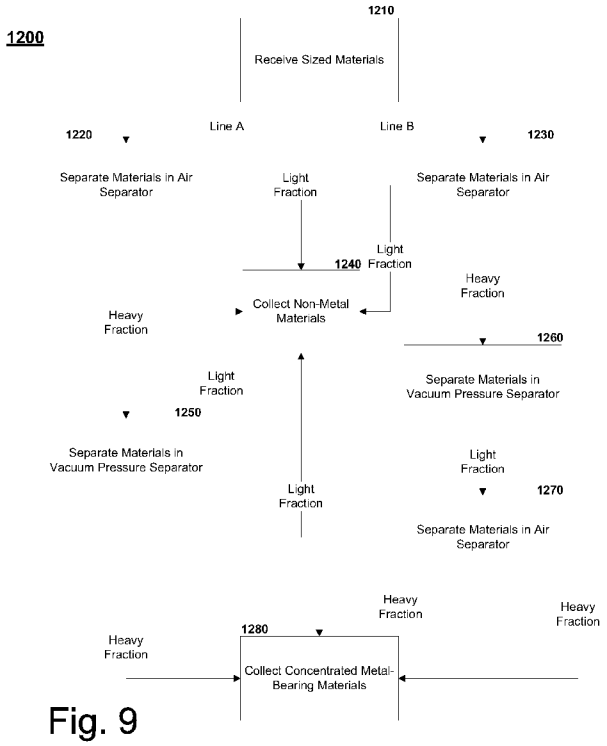


Fig. 9

(57) Abstract: Processing waste materials to recover valuable metals, such as copper, from the materials. The disclosed systems and methods employ processes that further refine the waste materials to concentrate the metallic material after the waste materials are initially processed. Processes include employing air separation and screening. Processes also include employing a dynamic sensor and a vacuum pressure separator to separate metals from other materials. A central processing facility may process metal concentrate from multiple concentration facilities.

WO 2011/053913 A1

Published:

— *with international search report (Art. 21(3))*

METHOD AND SYSTEM FOR SEPARATING AND RECOVERING WIRE AND OTHER METAL FROM PROCESSED RECYCLED MATERIALS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This non-provisional patent application is a continuation-in-part of and claims priority to U.S. Patent Application No. 12/848,317, filed August 2, 2010, titled "Method and System for Separating and Recovering Wire and Other Metal from Processed Recycled Materials," which claims priority under 35 U.S.C. § 119 to U.S. Provisional Patent Application No. 61/230,464, titled "Method and System for Separating and Recovering Wire and Other Metal from Processed Recycled Materials," filed July 31, 2009. This non-provisional patent application further claims priority under 35 U.S.C. § 119 to U.S. Provisional Patent Application No. 61/256,648, titled "Method and System for Separating and Recovering Wire and Other Metal from Processed Recycled Materials," filed October 30, 2009. The complete disclosures of each of the above-identified applications is hereby fully incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates to systems and methods for recovering copper wire and other metals from recycled materials. More particularly, this invention relates to systems and methods for employing primarily dry processes for further recovering metals, typically after employing initial processes to separate materials in a recycle waste recovering operation.

BACKGROUND OF THE INVENTION

[0003] Recycling of waste materials is highly desirable from many viewpoints, not the least of which are financial and ecological. Properly sorted recyclable materials can often be sold for significant revenue. Many of the more valuable recyclable materials do not biodegrade within a short period, and so their recycling significantly reduces the strain on local landfills and ultimately the environment.

[0004] Typically, waste streams are composed of a variety of types of waste materials. One such waste stream is generated from the recovery and recycling of automobiles or other large machinery and appliances. For examples, at the end of its useful life, an automobile is shredded. This shredded material is processed to recover ferrous and non-ferrous metals. The remaining materials, referred to as automobile shredder residue (ASR), which may still include ferrous and non-ferrous metals, including copper wire and other recyclable materials, is typically disposed of in a landfill. Recently, efforts have been made to further recover materials, such as non-ferrous metals including copper from copper wiring and plastics. Similar efforts have been made to recover materials from whitegood shredder residue (WSR), which are the waste materials left over after recovering ferrous metals from shredded machinery or large appliances. Other waste streams that have recoverable materials may include electronic components (also known as "e-waste" or "waste electrical and electronic equipment (WEEE)), building components, retrieved landfill material, or other industrial waste streams. However, in many instances, no cost-effective methods are available to effectively sort waste materials that contain diverse materials. This deficiency has been particularly true for non-ferrous materials, and particularly for non-metallic materials, such as non-ferrous metals, including copper wiring. For example, one approach to recycling wiring has been to station a number of laborers along a sorting line, each of whom manually sorts through shredded waste and manually selects the desired recyclables from the sorting line. This approach is not sustainable in most economics since the labor component is too high.

[0005] While some aspects of ferrous and non-ferrous recycling has been automated for some time, mainly through the use of magnets, eddy current separators, induction sensors and density separators, these techniques are ineffective for sorting some non-ferrous metals, such as copper wire. Again, labor-intensive manual processing has been employed to recover wiring and other non-ferrous metal materials. Because of the cost of labor, many of these manual processes are conducted in other countries and transporting the materials adds to the cost.

[0006] Many processes for identifying and separating materials are know in the art. For example, some processes are disclosed in U.S. Patent Application Publication 2007/0187299, entitled "Dissimilar materials sorting process, system and apparata," and

U.S. Patent Application Publication 2008/0257794, entitled "Method and system for sorting and processing recycled materials." The entire content of these patent application publications are incorporated herein by reference. However, not all processes are efficient for recovering non-ferrous metals and the sequencing of these processes is one factor in developing a cost-effective recovery process. Also, many processes are "wet," that is, they involve using water or other liquid media. Wet processes tend to be less cost effective, in part, because of the extra processing required to manage and dry materials and these processes often produce waste sludge that must be managed. Further, these processes may still provide a waste stream that can be further refined to provide a recovered product that has a high concentration of copper and other valuable metals.

[0007] In view of the foregoing, a need exists for cost-effective, efficient methods and systems for recovering materials from a waste stream, such as materials seen in a recycling process, including non-ferrous metals, in a manner that facilitates revenue recovery while also reducing landfill and, preferably using a dry process, where the process results in a high concentration of recovered metals.

SUMMARY OF THE INVENTION

[0008] The present invention provides cost-effective, efficient methods and systems for recovering materials from a waste stream, such as materials seen in a recycling process, including non-ferrous metals, in a manner that facilitates revenue recovery while also reducing landfill and, using a dry process that results in a high concentration of recovered metals.

[0009] One aspect of the present invention provides a method for processing a waste stream. The method includes the steps of a) receiving the waste stream including non-ferrous metal; b) processing the received waste stream with a closed-loop air separator to separate the waste stream into a light fraction waste stream and a heavy fraction waste stream; c) processing the heavy fraction waste stream in a vacuum pressure separator to increase the concentration of non-ferrous metals in the heavy fraction waste stream as compared to the concentration of non-ferrous metal in the waste stream; and d) separating the heavy fraction stream resulting from step c into a ferrous metal stream fraction and a

non-ferrous metal stream fraction by removing any ferrous metal from the heavy fraction stream resulting from step c.

[0010] Another aspect of the present invention provides a method for processing a waste stream. The method includes the steps of a) receiving the waste stream including non-ferrous metal components; b) processing the received waste stream with an air separator to generate a light fraction waste stream and a heavy fraction waste stream; c) removing ferrous material from the first heavy fraction waste stream to concentrate the fraction of non-ferrous metal in the first heavy fraction; d) separating the first heavy fraction resulting from step c into a first size fraction and a second size fraction, wherein the size of the first size fraction is smaller than the second size fraction; e) mechanically reducing the size of the first size fraction; and f) processing the material resulting from step 3 with a vacuum pressure separator to further concentrate the non-ferrous metal.

[0011] Yet another aspect of the present invention provides a system for processing a waste stream. The system includes: metal concentration facilities, where each concentration facility is located in a geographic location different from each of the other metal concentration facilities and where each metal concentration facility includes: a) a metal waste stream separator using air to separate the waste stream into a light fraction and a heavy fraction, where the heavy fraction includes a concentration of non-ferrous metal as compared to the concentration of non-ferrous metal in the metal waste stream and b) a vacuum pressure separator that further concentrates the non-ferrous metal fraction in the heavy fraction; and a single metal concentrate processing facility operable to process non-ferrous metal concentrate from the plurality of metal concentration facilities to further concentrate the non-ferrous metal concentrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 depicts a process flow diagram for processing recycled materials in accordance with an exemplary embodiment of the present invention.

[0013] Figure 2 depicts a process flow diagram for recovering metals having a specific size range (0 mm - 4 mm) in accordance with an exemplary embodiment of the present invention.

[0014] Figure 3 depicts a process flow diagram for recovering non-ferrous metals having a specific size range (4 mm - 15 mm) in accordance with an exemplary embodiment of the present invention.

[0015] Figure 4 depicts a system for recovering metals having a specific size range (0 mm - 4 mm) in accordance with an exemplary embodiment of the present invention.

[0016] Figure 5 depicts a system for recovering non-ferrous metals having a specific size range (4 mm - 15 mm) in accordance with an exemplary embodiment of the present invention.

[0017] Figure 6 depicts a system for recovering metals in accordance with an exemplary embodiment of the present invention.

[0018] Figure 7 depicts a system for recovering non-ferrous metals in accordance with an exemplary embodiment of the present invention.

[0019] Figure 8 depicts a process flow diagram for separating and recovering wire and other metal from recycled materials in accordance with an exemplary embodiment of the present invention.

[0020] Figure 9 depicts a process flow diagram for concentrating wire and other metals in accordance with an exemplary embodiment of the present invention.

[0021] Figure 10 depicts an overall process for separating and recovering wire and other metals from a concentrate of wire and other metals in accordance with an exemplary embodiment of the present invention.

[0022] Figure 11 depicts an overall system for separating and recovering wire and other metals using a hub-and-spoke system in accordance with an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0023] Exemplary embodiments of the present invention provide systems and methods for recovering non-ferrous metals, such as copper, employing a primarily dry process and in a highly concentrated form.

[0024] Figure 1 depicts a process flow diagram **100** for processing recycled materials in accordance with an exemplary embodiment of the present invention. Referring to Fig. 1, at step **110**, recycled material waste streams, or residues, such as ASR, WSR, and WEEE, are processed to separate and concentrate certain recoverable materials from the residues. Any combination of known or later-developed recycling processes can be used to separate and extract these materials. The results of these processes will be material streams that are concentrated in a particular type of material. One such process stream is concentrated in copper and other metals. This stream will typically have copper wire, other non-ferrous metals, and some (typically 4 to 5 percent) ferrous metals. The typical concentration of non-ferrous materials in this stream is 2 to 6 percent. Other process streams may be concentrated in one or more types of plastics or other recoverable materials.

[0025] One such system that may be used to generate a process stream of copper and other metals is an eddy current system. An eddy current separator typically includes a rotor featuring on cylinder surface rows of permanent magnet blocks of alternate polarities. The permanent magnet blocks can either be standard ferrite ceramic or the more powerful rare earth magnets. The rotor spins at high revolutions, typically between 1800 rpm and 4000 rpm, to produce a variable magnetic field generating “eddy currents” in the metals crossing it. This eddy current reaction on the different non-ferrous metals is different based on their specific mass, shape, and resistivity, creating a repelling force on the charged particles of the non-ferrous metals and causing the materials to be separated.

[0026] Another system that may be used to generate a process stream of copper and other metals is an inductive sensor. An inductive sensor determines the presence of metal based on current produced in an inductive loop. The current from the inductive loop is filtered using two criteria: the amplitude (or magnitude) of the current and the time constant of the current. In other words, for an inductive sensor to indicate that a metallic

object is present, the current generated in the inductive loop must reach a specified minimum level (threshold) and remain above that threshold for a specified time interval, called the debounce, before the digital output from the sensor is turned on. This digital output is an indication of the presence of a metallic object in the monitored material. The digital output is then held on until the inductive loop current drops back below the threshold.

[0027] Eddy current and inductive sensor systems are two exemplary systems that can be employed, perhaps in conjunction with other processes, to generate a process stream of copper and other metals. Other systems and processes may also be employed to generate a process stream of copper and other metals without deviating from the present invention. That is, the starting point for the present invention is a process stream of copper and other metals.

[0028] At step **120**, other process streams, including but not limited to a process stream concentrated in recoverable plastic materials, is further processed. This further processing provides additional separation and concentration of the recoverable materials, such as plastics. Although the materials at step **120** do not include concentrates of copper and other metals, these materials still may include copper and other metals in them, as step **110** would not typically concentrate all metallic material into the copper and other metals process stream. For example, some insulated copper wire might be included in a plastics process stream. The further processing of the streams at step **120** may separate additional copper and other metals from these streams. As such, this copper and other metals may be added to the material processed at step **130**.

[0029] At step **130**, the process stream of copper and other metals that results from step **110**, plus any copper and other metals resulting from step **120**, is further processed. As an initial step, the process stream of copper and other metals is separated into two size categories, typically 0 to 4 millimeters (mm) and 4 mm to 15 mm. For example, a screen with a 4 mm mesh or other method for separating the resulting material into two size ranges can be employed. The further processing of these separated materials is discussed below, in connection with Figures 2 and 3. The separation into two size categories, such as 0 to 4 millimeters (mm) and 4 mm to 15 mm, described here is exemplary and other

size categories may be used. Also, more than two size categories may be produced. Further, materials that are processed are three dimensional. Typically, the sizes cited herein, *e.g.*, "4 mm" represents the size of a screen mesh that a component of the waste stream can fit through or the width of a slotted screen. Accordingly, one of the dimensions of the component may be larger than 4 mm.

[0030] Figure 2 depicts a process flow diagram **130a** for recovering metals having a specific size range (0 mm - 4 mm) in accordance with an exemplary embodiment of the present invention. Figure 4 depicts a system for recovering metals having a specific size range (0 mm - 4 mm) in accordance with an exemplary embodiment of the present invention. Referring to Figures 2 and 4, at step **210**, the process **130a** receives material with a size range of typically 0 to 4 mm. This material may be received on a material conveyor **410**. The material conveyor **410** may be one or more of the following: conveyor belts, slides, chutes, screw conveyors, augers, and the like. The received material primarily includes non-ferrous metals but may also include some ferrous metals and other materials.

[0031] At step **220**, the received material is further separated using an air separator **420**. One possible air separator that may be used is a Zig-a-Flo Aspirator, manufactured by Forsberg, Inc. Another such air separator is described in U.S. Patent Application No. 12/769,525, entitled "Apparatus and Method for Separating Materials Using Air, which is hereby incorporated by reference herein in its entirety. Other air separators may be used. This air separation step results in two separated process streams. The light fraction stream will have dust and other materials that are not of value to recover. As such, the light fraction is not further processed, but is instead collected at step **260**. This collected material is likely discarded.

[0032] The heavy fraction stream contains metals to be recovered. At step **230**, the heavy fraction from the air separation step **220** is screened, such as by a screen **430** with a 4 mm mesh. The screening process separates the heavy fraction by size. Typically, material that is smaller than 4 mm passes through the screen **430** while larger material is captured in the screen **430**. The fraction retained in the screen **430**, that is, the fraction larger that 4 mm, is not further processed in process **130a**, but is instead collected at step

260. This collected material may be further processed (for example, this collected material may be processed in accordance with process **130b**, discussed below in conjunction with Figure 3). Step **230** is optional and may be omitted, as the material received at step **210** is already segregated into the 0 to 4 mm size range. However, this step **230** may be necessary if the initial segregation process, that is, the segregation prior to step **210**, allowed materials greater than 4 mm to enter the process stream.

[0033] The fraction from the screening step **230** that passes through the screen **430**, or, if step **230** is omitted, the heavy fraction from the air separation step **220**, is then processed in a destoner **440**, also referred to as a vacuum pressure separator (VPS) at step **240**. The terms "destoner" and "vacuum pressure separator" or "VPS" are used interchangeably in this disclosure. A destoner separates dry, granular materials into two specific weight fractions - a heavy fraction and a light fraction. Typically, a destoner includes a screen on a deck. Material is vibrated on the deck as air moves up through the screen. The light fraction is entrained in the air stream while the heavy fraction is not. A typical destoner is the Forsberg P-Series Destoner, made by Forsberg, Inc.

[0034] The light fraction separated by the destoner **440** would typically include dirt, rocks, glass, plastic, rubber, and other materials with a density of less than approximately 2.8 grams per cubic centimeter. These materials are not worth recovering and, as such, this light fraction is not further processed, but is instead collected at step **260**. The heavy fraction separated by the destoner **440** contains concentrated copper in the form of fine copper wire. This material is collected at step **250** and the process **130a** ends.

[0035] Figure 3 depicts a process flow **130b** for recovering metals having a specific size range (4 mm - 15 mm) in accordance with an exemplary embodiment of the present invention. Figure 5 depicts a system for recovering non-ferrous metals having a specific size range (4 mm - 15 mm) in accordance with an exemplary embodiment of the present invention. Referring to Figures 3 and 5, at step **305**, the process **130b** receives a process stream of copper and other metals with a size range of typically 4 mm to 15 mm, such as by a material conveyor **505**. This material primarily includes non-ferrous metals but may also include ferrous metals and other materials. Although this stream has been segregated to include primarily materials in the size range of 4 mm to 15 mm, smaller

and larger sized materials may be present in the waste stream. The material conveyor **505** may be one or more of the following: conveyor belts, slides, chutes, screw conveyors, augers, and the like.

[0036] At step **310**, the process stream of copper and other metals is separated using an air separator **510**. One possible air separator that may be used is a Zig-a-Flo Aspirator, manufactured by Forsberg, Inc. Another such air separator is described in U.S. Patent Application No. 12/769,525, entitled "Apparatus and Method for Separating Materials Using Air, which is hereby incorporated by reference herein in its entirety. Other air separators may be used. This air separation step results in two separated waste streams. The light fraction will have materials that are not of value to recover. As such, the light fraction is not further processed with process **130b**, but is instead collected. This collected material is likely discarded but may be further processed to recover valuable material (further processing steps not shown).

[0037] At step **315**, the heavy fraction from the air separation step **320** is screened, using a 15 mm mesh screen **515**. Material greater than 15 mm in size is captured in the screen **515**. The captured material is not further processed with process **130b**, but is instead collected. This collected material may be further processed (further processing steps not shown). Step **315** is optional and may be omitted, as the material received at step **210** is already segregated into a 4 mm to 15 mm size range, that is, the material is less than or equal to 15 mm. However, this step **315** may be necessary if the initial segregation process, that is, the segregation prior to step **305**, allowed materials greater than 15 mm to enter the process stream.

[0038] The material in the 4 mm to 15 mm size range, that is, the material that passed through the screen **515**, is further processed at step **320**. At step **320**, the material is separated into a light fraction and heavy fraction using a destoner **520**, also referred to as a vacuum pressure separator. The light fraction from the destoner **520** will typically include non-metals but may include some insulated wire. The further processing of this light fraction is discussed below, in connection with steps **360** and **365**.

[0039] The heavy fraction from step **320** is further processed at step **325**. At step **325**, the heavy fraction stream is screened to separate the material according to size. For

example, a screen **525** with a 2 mm mesh size is used. Accordingly, material less than 2 mm in size passes through the screen **525** and is recovered, such as in collector **598** at step **398**. This material is primarily fine copper wire that was entrained with the 4 mm to 15 mm material prior to receiving the material at step **305**.

[0040] The material captured in the screen **525**, that is, material 2 mm in size and greater, is further processed at step **330**. At step **330**, the material is crushed, such as in a crusher **530**. A typical crusher that may be used is a vertical shaft impact (VSI) crusher. An exemplary crusher is the Turbo 54 VSI Crusher, manufactured by Cemco, Inc.

[0041] The crushed material is screened at step **335**, using a 2 mm mesh screen **535**. Material that is caught in the screen **535**, which would typically be material greater than or equal to 2 mm in size, contains copper and other metals. This material is recycled back to the crusher **530** at step **330**. This recycling process may be performed at least two times. That is, after the material is recycled through step **330**, it is again screened at step **335**. Material captured in the screen **535** at step **335** is again sent to the crusher **530** at step **330**. Material that is captured a third time in the screen **535** at step **335** may not be further recycled but instead processed at step **340**, described below. Given this recycling process through the crusher **530**, the process **130b** is conducted batch-wise, at least for step **330** and subsequent steps. In an alternative embodiment, this recycling process may be omitted. By omitting this recycling process, the process **130b** may be more continuous.

[0042] Material that passes through the screen **535** at step **335**, that is, material typically smaller than 2 mm in size, is further processed at step **345**, discussed below.

[0043] At step **340**, the material that is greater than or equal to 2 mm in size is size reduced to a size of at least 5 mm through a chopping or grinding process in a size reducer **540**. Any known type of size reducer, such as a grinder, ring mill, hammermill, and the like, may be used. The material is then separated using a destoner **542**. The destoner **542** may be identical to the destoner **520**. The light fraction from the destoner **542** will have materials that are not of value to recover, typically non-metallic materials. As such, the light fraction is not further processed with process **130b**, but is instead

collected. This collected material is likely discarded. The heavy fraction from the destoner **542** is collected in a collector **599** at step **399**.

[0044] At step **345**, the material that passes through the screen at step **335** is further processed by an additional screen **545** with a 0.7 mm mesh. At step **350**, the material that was captured by the screen **545** at step **345**, that is, material greater than or equal to 0.7 mm in size, is further processed by a destoner **550**. The destoner **550** may be identical to the destoner **520** and/or the destoner **542**. The light fraction from the destoner **550** will have materials that are not of value to recover, typically non-metallic materials. As such, the light fraction is not further processed with process **130b**, but is instead collected. This collected material is likely discarded. The heavy fraction from the destoner **550** would include copper and other metals and would be collected at step **399**.

[0045] At step **355**, the material that passed through the screen **545** at step **345**, that is, material less than 0.7 mm in size, is further processed by a electrostatic separator (not shown) or water separation table **555**. An electrostatic separator uses charged electrodes to separate materials of differing electrostatic charges. Any metals in the material processed at step **355** would be separated from other, non-metallic materials. The metals would be collected at step **399**.

[0046] Similarly, a water separation table is a flowing film concentrator. Flowing film concentrators have a thin layer of water flowing across them, where these layers of water include entrained solid materials, materials with different densities. A pattern of raised ridges (riffles) across the length of the table causes the higher density particles to stay behind the ridge, since they are closest to the bottom of the flowing water film. These particles, which would include the copper wire pieces and other metal, follow the ridge down the slope to the metal discharge point. Since the water is flowing perpendicular to the ridges or riffles of the table, the low specific gravity material will be washed over the top of the ridges and off the tailings discharge side of the table. In this way, the copper or other metal is separated from non-metal materials. The metals would be collected at step **399**.

[0047] The metal collected at either step **398** or step **399** would contain high concentrations of copper and other metals. That is, the resulting product would have low

concentrations of debris and other materials of non-value. The metal collection aspect of process **130b** has been illustrated as two separate steps, step **398** and step **399**, for convenience of illustrating the process. As can be recognized from Figure 3 and the description above, metal material is collected at a number of points in the process **130b** following specific process steps, such as process steps **340**, **350**, **355**, and **365** and the process does not actual have two discrete metal collection steps.

[0048] As discussed above, the light fraction generated from the destoner **520** at step **320** is further processed at step **360**. At step **360**, this light fraction of material is separated using an air separator **560**. The air separator **560** may be identical to the air separator **510**. The heavy fraction from the air separator step **360** is processed by a dynamic sensor **565** at step **365**. A dynamic sensor differs from an inductive sensor. A dynamic sensor measures the rate of change of the amount of current produced in an inductive loop and detects the presence of metallic objects based on this rate of change. A key difference between a dynamic sensor and a standard inductive sensor is the way the detector filters and interprets the analog current level generated in the inductive loop. In an alternative embodiment, an inductive sensor (not shown) can be used instead of the dynamic sensor. Certain exemplary dynamic sensors are described in more detail in U.S. Patent No. 7,732,726, entitled "System and Method for Sorting Dissimilar Materials Using a Dynamic Sensor," issued June 8, 2010, the entire content of which is hereby fully incorporated herein by reference. The metal objects identified by the dynamic sensor would be collected at step **398**. This collection step may include the dynamic sensor actuating an air jet to direct the copper wire material into the collector **598** based on the dynamic sensor **565** identifying the copper wire material. For example, the copper wire material may be moving along a conveyor belt past the detectors that make up the dynamic sensor **565**. Upon the dynamic sensor **565** identifying a location on the conveyor belt of copper wire material, the copper wire is directed, such as by an air jet, to the collector **598** when the material reaches the end of the conveyor belt.

[0049] Alternatively, the material identified in step **365**, which will likely include insulated wire, can be mixed with the material captured in the screen **535** at step **335** and further processed at step **340**. In other words, in this alternative embodiment, the

material identified at step **365** would be size reduced and separated with a destoner **542** at step **340**.

[0050] Figure 6 depicts a process flow diagram **130c** for recovering metals in accordance with an alternative exemplary embodiment of the present invention. Figure 7 depicts a system **700** for recovering non-ferrous metals in accordance with this alternative exemplary embodiment of the present invention. As can be seen in these figures, this alternative embodiment does not employ a crusher. The use of a crusher may be undesirable because of the dust generated by the crusher. Referring to Figures 6 and 7, at step **601**, the process **130c** receives a process stream of copper and other metals with a size range of typically 0 mm to 15 mm, such as by a material conveyor **701**. This material primarily includes non-ferrous metals but may also include ferrous metals and other materials. Although this stream has been segregated to include primarily materials in the size range of 0 mm to 15 mm, larger sized materials may be present in the waste stream. The material conveyor **701** may be one or more of the following: conveyor belts, slides, chutes, screw conveyors, augers, and the like.

[0051] At step **605**, the process stream of copper and other metals is separated using an air separator **705**. One possible air separator that may be used is a Zig-a-Flo Aspirator, manufactured by Forsberg, Inc. Another such air separator is described in U.S. Patent Application No. 12/769,525, entitled "Apparatus and Method for Separating Materials Using Air, which is hereby incorporated by reference herein in its entirety. Other air separators may be used. This air separation step results in two separated waste streams. The light fraction will have materials that are not of value to recover. As such, the light fraction is not further processed with process **130c**, but is instead collected. This collected material is likely discarded but may be further processed to recover valuable material (further processing steps not shown).

[0052] At step **610**, the heavy fraction from the air separation step **605** is further processed. The material is separated into a light fraction and heavy fraction using a destoner **710**, also referred to as a vacuum pressure separator. The light fraction from the destoner **710** will typically include non-metals but may include some insulated wire. The

further processing of this light fraction is discussed below, in connection with steps **620** and **630**.

[0053] The heavy fraction from step **610** is further processed at step **615**. The heavy fraction stream is screened to separate the material according to size using screen **715**. The exemplary screen **715** is a slotted screen with slots measuring 3.6 millimeters by 40 millimeters. Material that is caught in the screen **715**, that is, material that did not fall through the 3.6 mm x 40 mm slots, is further processed at step **625**, which is described below.

[0054] At step **635**, the material that passed through the screen **715** is further screened using a screen **735**. The exemplary screen **735** is a slotted screen with slots measuring 2.4 millimeters by 40 millimeters. Material that is caught in the screen **735**, that is, material that did not fall through the 2.4 mm x 40 mm slots, is further processed at step **640**, which is described below.

[0055] At step **645**, the material that passed through the screen **735** is further screened using a screen **745**. The exemplary screen **745** s a slotted screen with slots measuring 1.2 millimeters by 40 millimeters. Material that is caught in the screen **745**, that is, material that did not fall through the 1.2 mm x 40 mm slots, is further processed at step **650**, which is described below.

[0056] At step **655**, the material that passed through the screen **645** is separated into a light fraction and a heavy fraction using a destoner **755**. The light fraction from the destoner **755** typically would not include any material of value to recover. This light fraction would likely be discarded. The heavy fraction from the destoner **755** includes concentrated non-ferrous metals, which are recovered at step **696** in a collector **796**, such as a bin.

[0057] Similarly, at step **640**, the material that failed to pass through the screen **635** is separated into a light fraction and a heavy fraction using a destoner **740**. The light fraction from the destoner **740** typically would not include any material of value to recover. This light fraction would likely be discarded. The heavy fraction from the destoner **740** includes concentrated non-ferrous metals, which are recovered at step **693** in a collector **793**, such as a bin. Similarly, at step **650**, the material that failed to pass

through the screen **645** is separated into a light fraction and a heavy fraction using a destoner **750**. The light fraction from the destoner **750** typically would not include any material of value to recover. This light fraction would likely be discarded. The heavy fraction from the destoner **750** includes concentrated non-ferrous metals, which are recovered at step **694** in a collector **794**, such as a bin.

[0058] Destoners **710**, **740**, **750**, and **755** have been described as separate pieces of equipment in this exemplary embodiment. Alternative embodiments can employ less than four separate destoners to perform the process **130c**. In that alternative, a single destoner may perform more than one of the steps **610**, **640**, **650**, **655**. Similarly, the function of collectors **693**, **694**, and **696** may be performed by less than three collectors.

[0059] At step **620**, the light fraction generated by the destoner **710** at step **610** is further processed in an air separator **720**. One possible air separator that may be used is a Zig-a-Flo Aspirator, manufactured by Forsberg, Inc. Another such air separator is described in U.S. Patent Application No. 12/769,525, entitled "Apparatus and Method for Separating Materials Using Air, which is hereby incorporated by reference herein in its entirety. Other air separators may be used. This air separation step results in two separated waste streams. The light fraction will have materials that are not of value to recover. As such, the light fraction is not further processed with process **130c**, but is instead collected. This collected material is likely discarded but may be further processed to recover valuable material (further processing steps not shown).

[0060] At step **630**, the heavy fraction generated at step **620** is processed using a dynamic sensor **730** to identify copper wire in the heavy fraction. Identified copper wire is collected at step **692** in collector **792**, such as a bin. This collection step may include the dynamic sensor actuating an air jet to direct the copper wire material into the collector **792** based on the dynamic sensor **730** identifying the copper wire material. For example, the copper wire material may be moving along a conveyor belt past the detectors that make up the dynamic sensor **730**. Upon the dynamic sensor **730** identifying a location on the conveyor belt of copper wire material, the copper wire is directed, such as by an air jet, to the collector **792** when the material reaches the end of the conveyor belt.

[0061] Similarly, at step **625**, the material that failed to pass through the screen **615** is processed using a dynamic sensor **725** to identify copper wire in the heavy fraction. Identified copper wire is collected at step **691** in collector **791**, such as a bin. This collection step may include the dynamic sensor actuating an air jet to direct the copper wire material into the collector **791** based on the dynamic sensor **725** identifying the copper wire material. For example, the copper wire material may be moving along a conveyor belt past the detectors that make up the dynamic sensor **725**. Upon the dynamic sensor **725** identifying a location on the conveyor belt of copper wire material, the copper wire is directed, such as by an air jet, to the collector **791** when the material reaches the end of the conveyor belt. In an alternative embodiment, the functions of the dynamic sensor **725** and dynamic sensor **730** could be performed by a single dynamic sensor.

[0062] Figures 8, 9, and 10 describe alternative exemplary methods for recovering non-ferrous metals, such as copper from processed recycled material, such as ASR, WSR, and WEEE. These descriptions include an identification of the primary system components used in the methods.

[0063] Figure 8 depicts a process flow diagram **1100** for separating and recovering wire and other metal from recycled materials in accordance with an exemplary embodiment of the present invention. Referring to Figure 1, at step **1105**, sized waste material is received. This waste material may be ASR, WSR, or WEEE or a combination of these materials. The material may be sized such that most of the waste is typically 15 mm in size or less. The waste material may be further segregated such that one waste stream ranges in size from 0-4 mm and the other waste stream ranges in size from 4 mm to 15 mm.

[0064] Following step **1105**, the waste is sent into one of two processing lines, lines A and B. In one embodiment, a waste stream ranging in size from 0-4 mm is send into Line A to step 110 and a waste stream ranging in size from 4 mm to 15 mm is sent into Line B to step **1115**. Alternatively, Line A could be a primary processing line where all waste is processed with Line B a standby line. This standby line may be used should Line A be down for maintenance or if the amount of material to be processed warrants the operation of two lines.

[0065] At step **1110**, the material is separated in an air separator. The air separator, or classifier, may be a closed-loop, counter-flow system. Air is introduced into an air intake near the bottom of the unit. Waste material to be separated is introduced into the system at the intake feeder near the top of the unit. The intake feeder may include a rotary valve to introduce the material. The air from the air intake moves into and up a plenum area where the air interacts with the waste material as it falls down through the plenum under gravity. The air is pushed through the separator by a fan, for example, a 50 horsepower fan. One possible air separator that may be used is described in U.S. Patent Application No. 12/769,525, entitled "Apparatus and Method for Separating Materials Using Air, which is hereby incorporated by reference herein in its entirety. Other air separators may be used.

[0066] The movement of air through the material causes lighter material to be entrained in the air flow while the heavier material falls through the plenum. Typically in air separation systems, some light material may still remain with the heavy material, as the light material is physically entwined with the heavy material and the force of the air is insufficient to entrain the light material.

[0067] Residence time of the material in the plenum may be optimized in a number of ways. This optimization allows for highly efficient separation of the materials - the residence time is such that the material that falls through the plenum under gravity is mixed with the moving air to maximize the amount of light materials that are entrained in the air as it moves up. This process, in turn, maximizes the amount of heavy material, including the desired copper wire and other metals, that falls out of the plenum. In other words, this increased residence time allows for a more complete separation of the light and heavy fraction of materials. Other known air separators, such as a Z-box, may also be used at this step.

[0068] Similarly, at step **1115**, the waste material is separated using an air separator.

[0069] In an alternative embodiment, the heavy fraction from step **1110** or step **1115** may be further processed using an air screening step (not shown). In the air screen, air is passed through the material as it resides on a screen. In this process, the air entrains additional light materials, which are collected at step **1120**.

[0070] At step **1120**, the light fraction from the air separator, that is, the fraction entrained in the air stream, is collected. Typically, this material, which may be 20% of the waste stream, would be discarded. However, for some waste streams, it may be further processed to recover any remaining metal.

[0071] From step **1110**, the heavy fraction is processed in a vacuum pressure separator (VPS) at step **1125**. The VPS, also referred to as a destoner, includes a 40-200 mesh screen. The screen is angled and vibrates. As it vibrates, air is passed up through the screen. The heavier materials "walk" up the mesh screen while the lighter materials move down the screen. The heavy and light fractions are collected separately. The heavy fraction, which may include 5%-20% of the material fed into the VPS, is collected for further processing. The light fraction is collected at step **1120**.

[0072] Similarly, from step **1115**, the heavy fraction from the air separator is processed at step **1130** in a VPS. The heavy and light fractions are collected. The heavy fraction, which may include 5%-20% of the material fed into the VPS, is collected for further processing. In one embodiment, the light fraction is further separated at step **1135**, using an air separator. In that embodiment, the resulting heavy fraction is collected for further processing and the light fraction is collected at step **1120**.

[0073] At step **1140**, the heavy fractions from steps **1125**, **1130**, and **1135** are introduced into a ferrous metal separator. This separator uses magnets to remove ferrous metals from the waste stream. Typically, the waste stream would have been processed before step **1105** to remove ferrous metals. However, some fraction of the waste would typically still include ferrous metals. At step **1145**, the ferrous metals are collected and combined with other ferrous metals for recycling.

[0074] In an alternative embodiment, the ferrous metal separation step **1140** could be omitted. Alternatively, the step could be performed later in the overall process, as described below in connection with steps **1160**, **1170**, **1175**, **1180**, and **1185**.

[0075] At step **1150**, the non-ferrous materials are introduced into a mechanical screen, typically sized at 3/8 inches. The mechanical screen uses vibration to work the material through the screen. Material that is smaller than the screen opening size (the "undersize" material), 3/8 inches in this exemplary embodiment, passes through the screen and is

collected. Material that is larger than 3/8 inches (the "oversize" material) moves to the outside edge of the screen and is collected.

[0076] At step **1155**, the undersize material is processed in a crusher, such as an impact crusher. In this type of crusher, centrifugal force is used to move the material around the crusher the chamber of the crusher. The material impacts "anvils" as it circulates in the chamber and, as a result of the impact, the material is reduced in size. That is, the waste material is "thrown" against the anvils to achieve the size reduction. These types of crushers work optimally with a specific amount of material in the crusher. More or less material makes the crusher less efficient. As such, the crusher typically includes a hopper, which collects the material from step **1150** until a sufficient amount of material can be introduced into the crusher. These crushers may create dust and often include a baghouse that collects the dust. In this exemplary embodiment, the dust is collected and disposed of. An exemplary crusher is a Cemco Model 54 crusher, with a capacity of approximately 125 tons per hour. Alternatively, known alternative size reducing processes may be employed, preferably processes that do not generate large amounts of dust, can be used instead of a crusher.

[0077] At step **1165**, the material that results from the crusher is processed with a system of two screens, sized at 1 mm and 3 mm in this exemplary embodiment. This processing results in three products: a product that is less than 1 mm in size, a product that is 1 mm - 3 mm in size, and a product that is greater than 3 mm in size. Each of these streams is further processed using a VPS in steps **1170**, **1175**, and **1180**, respectively.

[0078] In one embodiment, a single VPS may be used and the material processed batch-wise, based on size. In another embodiment, separate VPS units could be employed. Also, a variation on the VPS may be employed. In this alternative, the VPS includes a mesh platform that is not only slanted, but pitched towards one corner. Also, the mesh screen includes ridges, or riffles. In this configuration, the vibration, pitch of the table, and air cause the material to travel differently over the riffles. The riffles are always taller on the feed side of the table and decreases in height as they progress towards the recovery side of the table. Air tables work similar to wet gravity tables, in that the material is fed perpendicular to the riffles and the high density material remains behind

the riffles. The fluidizing air columns rise through the bed of material. This fluidization causes settling at differential rates, where the light density material flows above and over the riffles, while the high density material stays close to the platform surface and follows the riffles to the concentrate discharge, with the discharge point for more dense materials higher up the table. Typically, the table is arranged to have multiple discharge points, where each discharge point represents a different density range of materials.

[0079] Also, because of the large volume of material that is generated by the crusher at step **1155**, the screens at step **1165** may include a surge hopper to meter the material into the screens.

[0080] At step **1185**, the final metal-bearing material, which is the heavy fraction from the VPS, is collected. As mentioned above, prior to this collection step, the heavy material from the VPS in steps **1170**, **1715**, and **1180** may be processed with a ferrous metal separator, where ferrous metals are separated from the waste stream, instead of at step **1140**.

[0081] At step **1160**, the oversize material from step **1150** is processed with a dynamic sensor. Although similar to an inductive sensor, a dynamic sensor differs from an inductive sensor. The dynamic sensor measures the rate of change of the amount of current produced in an inductive loop and detects the presence of metallic objects based on this rate of change. A key difference between a dynamic sensor and a standard inductive sensor is the way the detector filters and interprets the analog current level generated in the inductive loop. Certain exemplary dynamic sensors are described in more detail in U.S. Patent No. 7,732,726, entitled "System and Method for Sorting Dissimilar Materials Using a Dynamic Sensor," issued June 8, 2010, the entire content of which is hereby fully incorporated herein by reference.

[0082] Figure 2 depicts a process flow **1200** diagram for concentrating wire and other metals in accordance with an exemplary embodiment of the present invention. Referring to Figure 2, at step **1210**, sized waste material is received. This waste material may be ASR, WSR, or WEEE or a combination of these materials. The material may be sized such that most of the waste is typically 15 mm in size or less. The waste material may be

further segregated such that one waste stream ranges in size from 0-4 mm and the other waste stream ranges in size from 4 mm to 15 mm.

[0083] Following step **1210**, the waste is sent into one of two processing lines, lines A and B. In one embodiment, a waste stream ranging in size from 0-4 mm is send into Line A to step **1220** and a waste stream ranging in size from 4 mm to 15 mm is sent into Line B to step **1230**. Alternatively, Line A could be a primary processing line where all waste is processed with Line B a standby line. This standby line may be used should Line A be down for maintenance or if the amount of material to be processed warrants the operation of two lines.

[0084] At step **1220**, the material is separated in an air separator. The air separator, or classifier, may be a closed-loop, counter-flow system. One possible air separator that may be used is described in U.S. Patent Application No. 12/769,525, entitled "Apparatus and Method for Separating Materials Using Air, which is hereby incorporated by reference herein in its entirety. Other air separators may be used. Air is introduced into an air intake neat the bottom of the unit. Waste material to be separated is introduced into the system at the intake feeder near the top of the unit. The intake feeder may include a rotary valve to introduce the material. The air from the air intake moves into and up a plenum area where the air interacts with the waste material as it falls down through the plenum under gravity. The air is pushed through the separator by a fan, for example, a 50 horsepower fan.

[0085] The movement of air through the material causes lighter material to be entrained in the air flow while the heavier material falls through the plenum. Typically in air separation systems, some light material may still remain with the heavy material, as the light material is physically entwined with the heavy material and the force of the air is insufficient to entrain the light material.

[0086] Residence time of the material in the plenum may optimized in a number of ways. This optimization allows for highly efficient separation of the materials - the residence time is such that the material that falls through the plenum under gravity is mixed with the moving air to maximize the amount of light materials that are entrained in the air as it moves up. This process, in turn, maximizes the amount of heavy material, including the

desired copper wire and other metals, that falls out of the plenum. In other words, this increased residence time allows for a more complete separation of the light and heavy fraction of materials. Other known air separators, such as a Z-box, may be used at this step.

[0087] Similarly, at step **1230**, the waste material is separated using an air separator.

[0088] In an alternative embodiment, the heavy fraction from step **1220** or step **1230** may be further processed using an air screening step (not shown). In the air screen, air is passed through the material as it resides on a screen. In this process, the air entrains additional light materials, which are collected at step **1240**.

[0089] At step **1240**, the light fraction from the air separator, that is, the fraction entrained in the air stream, is collected. Typically, this material, which may be 20% of the waste stream, would be discarded. However, for some waste streams, it may be further processed to recover any remaining metal.

[0090] From step **1220**, the heavy fraction is processed in a vacuum pressure separator (VPS) at step **1250**. The VPS includes a 40-200 mesh screen. The screen is angled and vibrates. As it vibrates, air is passed up through the screen. The heavier materials "walk" up the mesh screen while the lighter materials move down the screen. The heavy and light fractions are collected. The heavy fraction, which may include 5%-20% of the material fed into the VPS, is collected for further processing at step **1280**. The light fraction is collected at step **1240**.

[0091] Similarly, from step **1230**, the heavy fraction from the air separator is processed at step **1260** in a VPS. The heavy and light fractions are collected. The heavy fraction, which may include 5%-20% of the material fed into the VPS, is collected at step **1280** for further processing. In one embodiment, the light fraction is further separated at step **1270**, using an air separator. In that embodiment, the resulting heavy fraction is collected for further processing at step **1280** and the light fraction is collected at step **1240**.

[0092] The process **1200** represents a concentration system. The resulting metal concentrate can be further processed to increase the concentration of metal in the waste processing product.

[0093] Figure 3 depicts an overall process **1300** for separating and recovering wire and other metals from a concentrate of wire and other metals in accordance with an exemplary embodiment of the present invention. Referring to Figure 3, at step **1305**, the material collected at step **1280** of process **1200** is received. At step **1310**, this material is introduced into an air screen. The air screen separates the material by size. At step **1315**, materials less than 0.7 mm or greater than three-quarter inches are collected. Material in the size range of 0.7 mm to three-quarter inches is further processed at step **1320**. Material in the 0 to 0.7 mm range may be sold as #2 copper.

[0094] At step **1320**, a ferrous metal separator is used. This separator uses magnets to remove ferrous metals from the waste stream. Typically, the waste stream would have been processed before process **1200** to remove ferrous metals. However, some fraction of the waste would typically still include ferrous metals. At step **1325**, the ferrous metals are collected and combined with other ferrous metals for recycling.

[0095] In an alternative embodiment, the ferrous metal separation step **1320** could be omitted. Alternatively, the step could be performed, later in the overall process, as described below in connection with steps **1340**, **1350**, **1355**, **1360**, and **1365**.

[0096] At step **1330**, the non-ferrous materials are introduced into mechanical screen, typically sized at 3/8 inches. The mechanical screen uses vibration to work the material through the screen. Material that is smaller than the screen opening size (the "undersize" material), 3/8 inches in this exemplary embodiment, passes through the screen and is collected. Material that is larger than 3/8 inches (the "oversize" material) moves to the outside edge of the screen and is collected.

[0097] At step **1335**, the undersize material is processed in a crusher, such as an impact crusher. In this type of crusher, centrifugal force is used to move the material around the crusher the chamber of the crusher. The material impacts "anvils" as it circulates in the chamber and, as a result of the impact, the material is reduced in size. That is, the waste material is "thrown" against the anvils to achieve the size reduction. These types of

crushers work optimally with a specific amount of material in the crusher. More or less material makes the crusher less efficient. As such, the crusher typically includes a hopper, that collects the material from step **1335** until a sufficient amount of material can be introduced into the crusher. These crushers may create dust and often include a baghouse that collects the dust. In this exemplary embodiment, the dust is collected and disposed of.

[0098] At step **1345**, the material that results from the crusher is processed with a system of two screens, sized at 1 mm and 3 mm in this exemplary embodiment. This processing results in three products: a product that is less than 1 mm in size, a product that is 1 mm - 3 mm in size, and a product that is greater than 3 mm in size. Each of these streams are further processed at using a VPS in steps **1350**, **1355**, and **1360**, respectively.

[0099] In one embodiment, a single VPS may be used and the material processed batch-wise, based on size. In another embodiment, separate VPS units could be employed. Also, a variation on the VPS may be employed. In this alternative, the VPS includes a mesh platform that is not only slanted, but pitched towards one corner. Also, the mesh screen includes ridges, or riffles. In this configuration, the vibration, pitch of the table, and air cause the material to travel differently over the riffles. The riffles are always taller on the feed side of the table and decreases in height as they progress towards the recovery side of the table. Air tables work similar to wet gravity tables, in that the material is fed perpendicular to the riffles and the high density material remains behind the riffles. The fluidizing air columns rise through the bed of material. This fluidization causes settling at differential rates, where the light density material flows above and over the riffles, while the high density material stays close to the platform surface and follows the riffles to the concentrate discharge, with the discharge point for more dense materials higher up the table. Typically, the table is arranged to have multiple discharge points, where each discharge point represents a different density range of materials.

[00100] Also, because of the high volume of material that is generated by the crusher at step **1335**, the screens at step **1345** may include a surge hopper to meter the material into the screens.

[00101] At step **1365**, the final metal-bearing material, which is the heavy fraction from the VPS, is collected. As mentioned above, prior to this collection step, the heavy material from the VPS in steps **1350**, **1355**, and **1360** may be processed with a ferrous metal separator, where ferrous metals are separated from the waste stream, instead of at step **1320**.

[00102] At step **1340**, the oversize material from step **1330** is processed with a dynamic sensor. A dynamic sensor differs from an inductive sensor. The dynamic sensor measures the rate of change of the amount of current produced in an inductive loop and detects the presence of metallic objects based on this rate of change. A key difference between a dynamic sensor and a standard inductive sensor is the way the detector filters and interprets the analog current level generated in the inductive loop. Certain exemplary dynamic sensors are described in more detail in U.S. Patent No. 7,732,726, entitled "System and Method for Sorting Dissimilar Materials Using a Dynamic Sensor," issued June 8, 2010, the entire content of which is hereby fully incorporated herein by reference.

[00103] The process **1300** represents a final processing system. The resulting metal product can be recycled into new metal products.

Figure 4 depicts an overall system for separating and recovering wire and other metals using a hub-and-spoke system in accordance with an exemplary embodiment of the present invention. Referring to Figure 4, a Central Concentrate Processing Facility **1410** processes concentrates in accordance with process **1300**. Feed material to the Central Concentrate Processing Facility **1410** comes from multiple Wire and Metal Concentrating Facilities **1420**, **1430**, **1440**, **1450**, **1460**. These Wire and Metal Concentrating Facilities **1420**, **1430**, **1440**, **1450**, **1460** typically are located at a distance from the Central Concentrate Processing Facility **1410** and produce feed material for the Central Concentrate Processing Facility **1410** using process **1200**, that is, a metal concentrate from ASR, WSR, WEEE, or other recycling residue. In this way, the Wire and Metal Concentrating Facilities **1420**, **1430**, **1440**, **1450**, **1460** can be sized to process the amount of shredder residue or other waste produced in the area of the individual facilities. The Central Concentrate Processing Facility **1410** can be sized to process the

concentrate from the multiple facilities, rather than having individual processing facilities at each Wire and Metal Concentrating Facilities **1420**, **1430**, **1440**, **1450**, **1460** facility.

[00104] A Wire and Metal Concentrating Facility **1470** may be co-located with the Central Concentrate Processing Facility **1410** and produce additional concentrate.

[00105] One of ordinary skill in the art would appreciate that the present invention provides systems and methods for processing waste materials to recover valuable metals, such as copper, from the materials. The systems and methods employ processes that further refine the waste materials to concentrate the metallic material after the waste materials are initially processed. Processes include employing air separation and screening. Processes also include employing a dynamic sensor and a vacuum pressure separator to separate metals from other materials.

[00106] Although specific embodiments of the invention have been described above in detail, the description is merely for purposes of illustration. It should be appreciated, therefore, that many aspects of the invention were described above by way of example only and are not intended as required or essential elements of the invention unless explicitly stated otherwise. Modifications of, and equivalent steps corresponding to, the disclosed aspects of the exemplary embodiments, in addition to those described above, can be made by a person of ordinary skill in the art, having the benefit of this disclosure, without departing from the spirit and scope of the invention defined in the following claims, the scope of which is to be accorded the broadest interpretation so as to encompass such modifications and equivalent structures.

What is Claimed:

1. A method for processing a waste stream comprising the steps of:

a) receiving the waste stream comprising non-ferrous metal;

b) processing the received waste stream with a closed-loop air separator to separate the waste stream into a light fraction waste stream and a heavy fraction waste stream;

c) processing the heavy fraction waste stream in a vacuum pressure separator to increase the concentration of non-ferrous metals in the heavy fraction waste stream as compared to the concentration of non-ferrous metal in the waste stream; and

d) separating the heavy fraction stream resulting from step c into a ferrous metal stream fraction and a non-ferrous metal stream fraction by removing any ferrous metal from the heavy fraction stream resulting from step c.

2. The method of claim 1 further comprising the step of screening the non-ferrous metal stream fraction generated at step d to separate the stream into a first size fraction and a second size fraction.

3. The method of claim 2 wherein the first size fraction comprises material that is processed with a dynamic sensor.

4. The method of claim 2 wherein the second size fraction comprises material processed in a second vacuum pressure separator to further concentrate the non-ferrous metal.

5. The method of claim 4 wherein the second size fraction is size reduced prior to processing in the second vacuum pressure separator.

6. The method of claim 5 wherein the second size fraction is size reduced using a crusher.

7. The method of claim 1 wherein the non-ferrous metal comprises copper.

8. The method of claim 1 wherein the waster stream comprises processed automobile shredder residue.

9. A method for processing a waste stream comprising the steps of:

a) receiving the waste stream comprising non-ferrous metal components;

b) processing the received waste stream with an air separator to generate a light fraction waste stream and a heavy fraction waste stream;

c) removing ferrous material from the first heavy fraction waste stream to concentrate the fraction of non-ferrous metal in the first heavy fraction;

d) separating the first heavy fraction resulting from step c into a first size fraction and a second size fraction, wherein the size of the first size fraction is smaller than the second size fraction;

e) mechanically reducing the size of the first size fraction; and

f) processing the material resulting from step 3 with a vacuum pressure separator to further concentrate the non-ferrous metal.

10. The method of claim 9 wherein the light fraction from step b) comprises #2 copper.

11. The method of claim 9 wherein the step of mechanically reducing the size of the first size fraction comprises using a crusher to crush the first size fraction.

12. The method of claim 9 wherein the second size fraction is further processed by a dynamic sensor.

13. A system for processing a waste stream comprising:

a plurality of metal concentration facilities, wherein each concentration facility is located in a geographic location different from each of the other metal concentration facilities in the plurality of metal concentration facilities, wherein each metal concentration facility comprises:

a metal waste stream separator using air to separate the waste stream into a light fraction and a heavy fraction, wherein the heavy fraction comprises a concentration of non-ferrous metal as compared to the concentration of non-ferrous metal in the metal waste stream;

a vacuum pressure separator that further concentrates the non-ferrous metal fraction in the heavy fraction; and

a single metal concentrate processing facility operable to process non-ferrous metal concentrate from the plurality of metal concentration facilities to further concentrate the non-ferrous metal concentrate.

14. The system of claim 13 wherein the single metal concentrate processing facility comprises a dynamic sensor to further concentrate the non-ferrous metal concentrate.

15. The system of claim 13 wherein the single metal concentrate processing facility comprises a vacuum pressure separator to further concentrate the non-ferrous metal concentrate.

16. The system of claim 13 wherein the metal waster stream processed by the metal waste stream separator using air comprises processed automobile shredder residue.

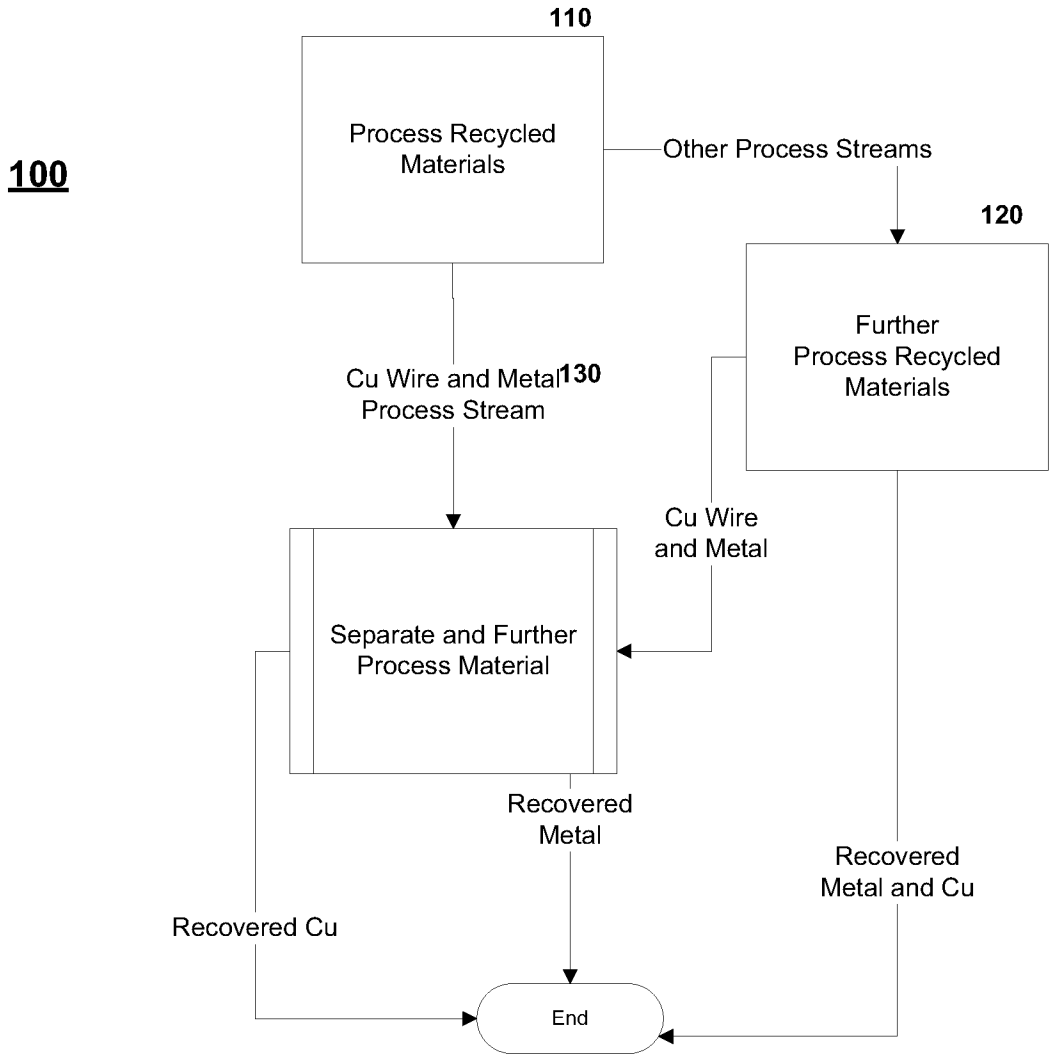

100
110
Process Recycled Materials
Other Process Streams
120
Further Process Recycled Materials
Cu Wire and Metal Process Stream
130
Cu Wire and Metal
Separate and Further Process Material
Recovered Metal
Recovered Metal and Cu
Recovered Cu
End

Fig. 1

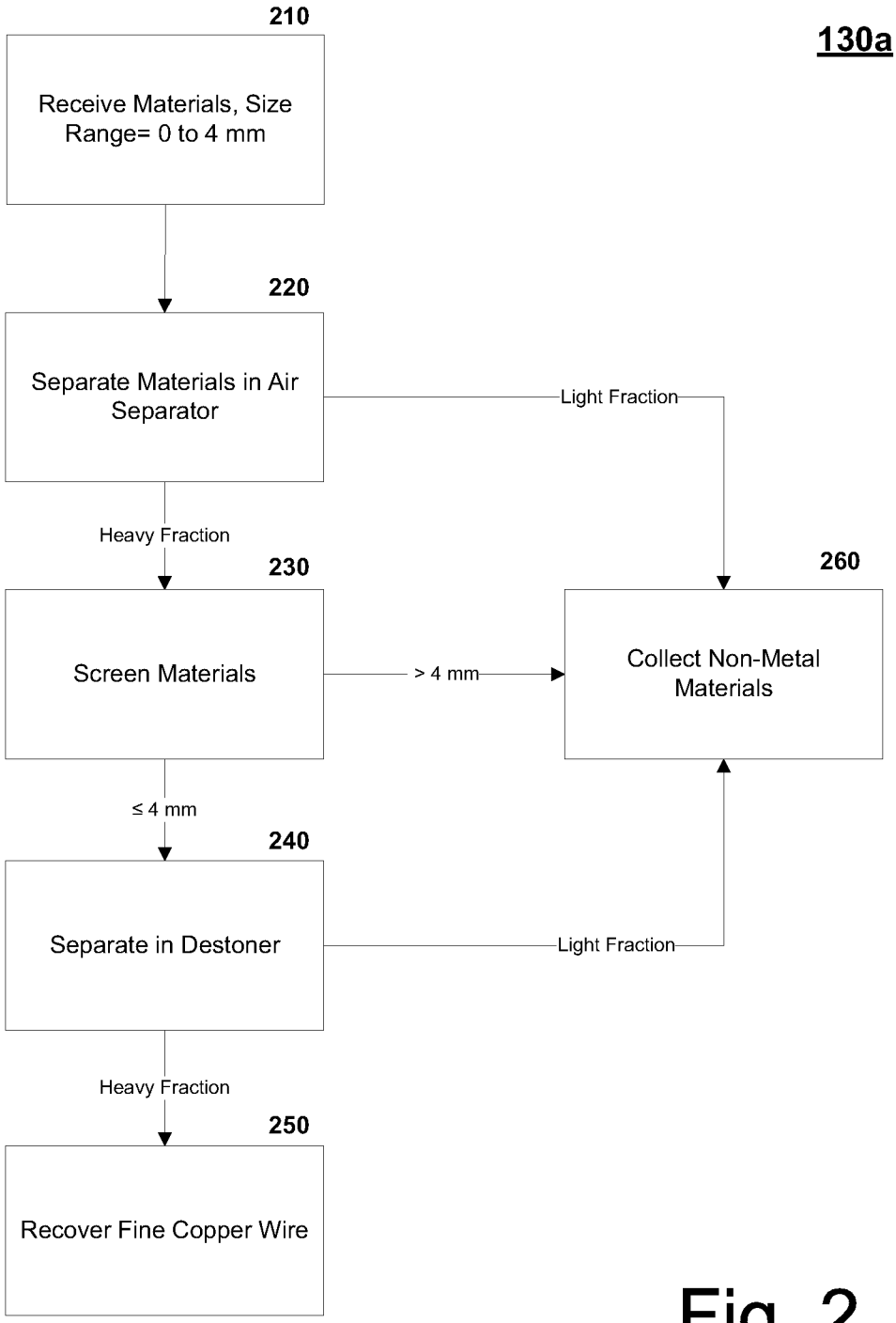

130a
210
Receive Materials, Size Range= 0 to 4 mm
220
Separate Materials in Air Separator
Light Fraction
Heavy Fraction
230
Screen Materials
> 4 mm
260
Collect Non-Metal Materials
≤ 4 mm
240
Separate in Destoner
Light Fraction
Heavy Fraction
250
Recover Fine Copper Wire

Fig. 2

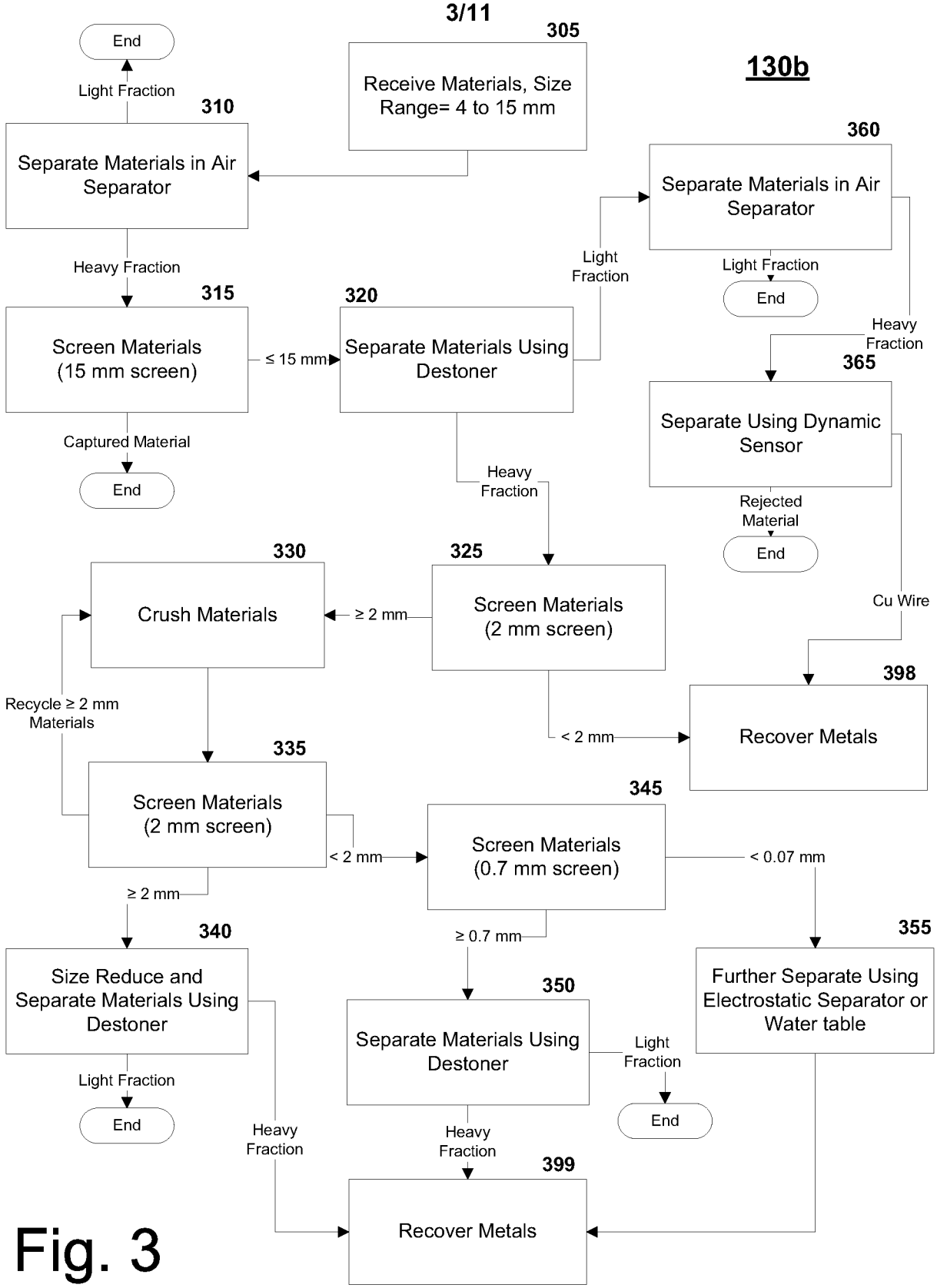

130b
305
Receive Materials, Size Range= 4 to 15 mm
310
Separate Materials in Air Separator
Light Fraction
End
Heavy Fraction
315
Screen Materials (15 mm screen)
≤ 15 mm
320
Separate Materials Using Destoner
Captured Material
End
Light Fraction
360
Separate Materials in Air Separator
Light Fraction
End
Heavy Fraction
365
Separate Using Dynamic Sensor
Rejected Material
End
Heavy Fraction
330
Crush Materials
≥ 2 mm
325
Screen Materials (2 mm screen)
Cu Wire
398
Recover Metals
< 2 mm
Recycle ≥ 2 mm Materials
335
Screen Materials (2 mm screen)
< 2 mm
345
Screen Materials (0.7 mm screen)
< 0.07 mm
≥ 2 mm
≥ 0.7 mm
340
Size Reduce and Separate Materials Using Destoner
350
Separate Materials Using Destoner
Light Fraction
End
355
Further Separate Using Electrostatic Separator or Water table
Light Fraction
End
Heavy Fraction
Heavy Fraction
399
Recover Metals

Fig. 3

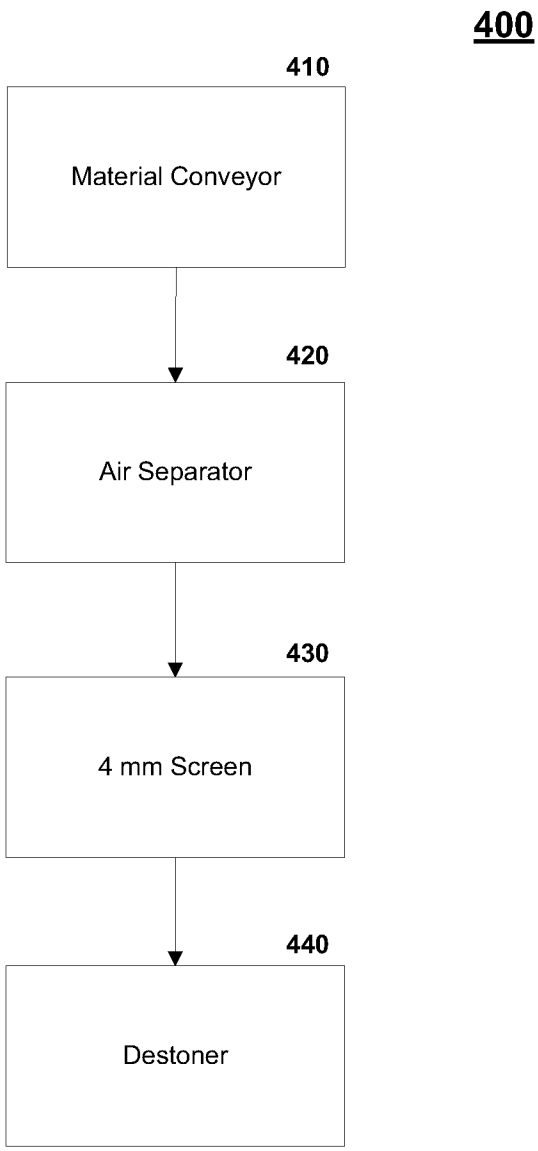

400
410
Material Conveyor
420
Air Separator
430
4 mm Screen
440
Destoner

Fig. 4

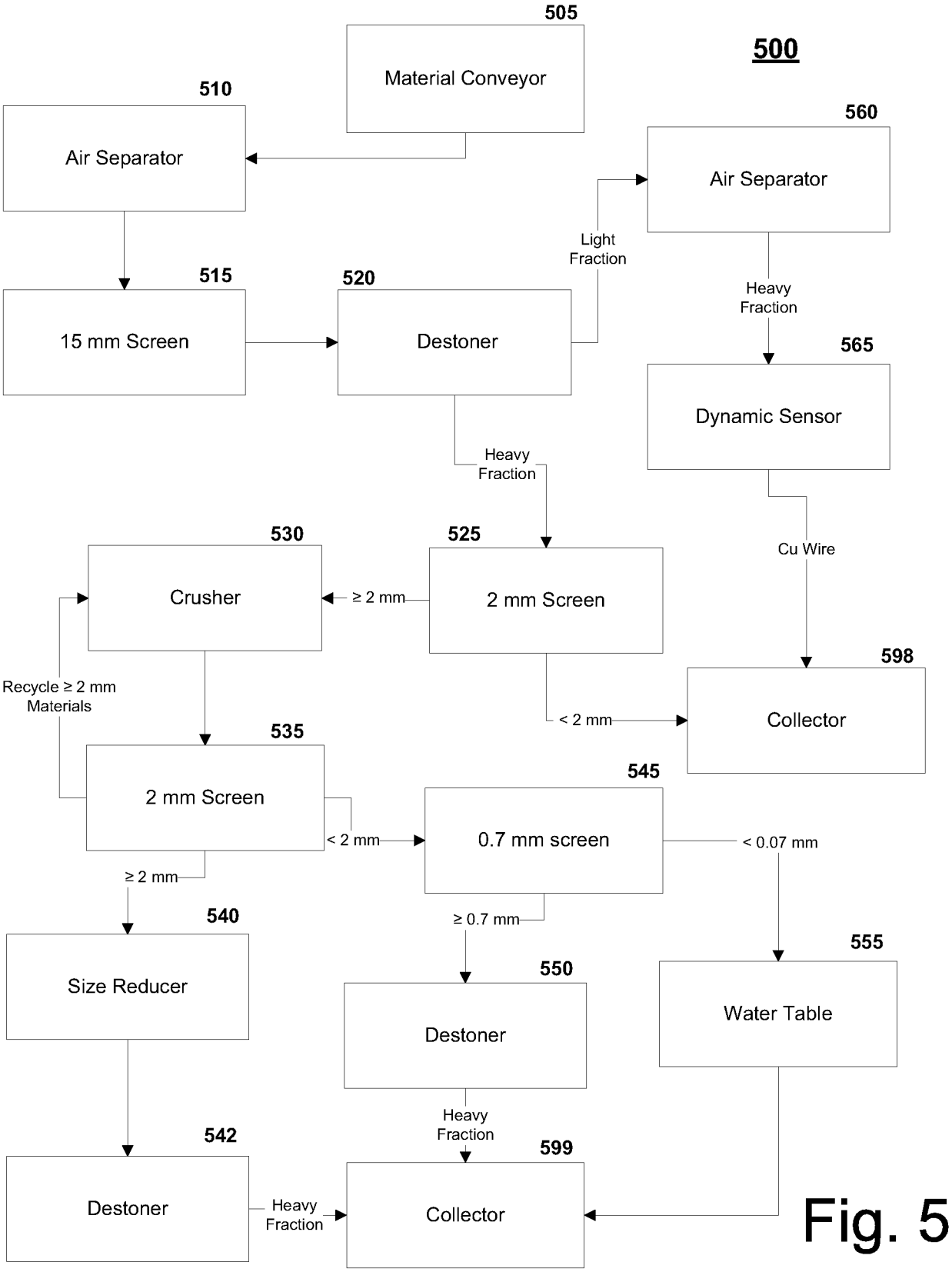

500
505
Material Conveyor
510
Air Separator
560
Air Separator
Light Fraction
Heavy Fraction
515
15 mm Screen
520
Destoner
565
Dynamic Sensor
Heavy Fraction
530
Crusher
≥ 2 mm
525
2 mm Screen
Cu Wire
598
Collector
< 2 mm
Recycle ≥ 2 mm Materials
535
2 mm Screen
545
0.7 mm screen
< 2 mm
< 0.07 mm
≥ 2 mm
≥ 0.7 mm
540
Size Reducer
550
Destoner
555
Water Table
Heavy Fraction
542
Destoner
Heavy Fraction
599
Collector

Fig. 5

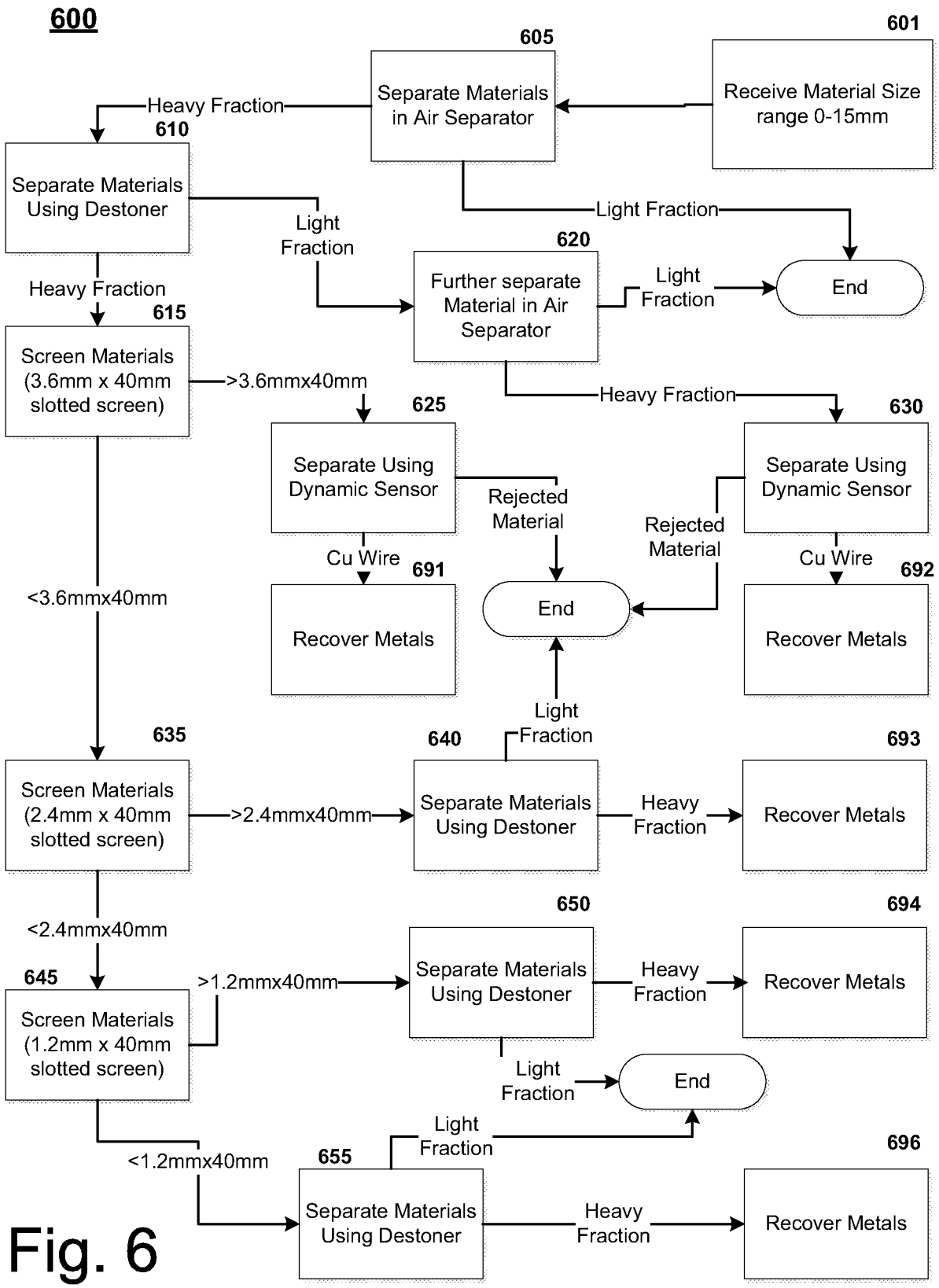

600
601
Receive Material Size range 0-15mm
605
Separate Materials in Air Separator
Heavy Fraction
610
Separate Materials Using Destoner
Light Fraction
Light Fraction
620
Further separate Material in Air Separator
Light Fraction
End
Heavy Fraction
615
Screen Materials (3.6mm x 40mm slotted screen)
>3.6mmx40mm
625
Separate Using Dynamic Sensor
Heavy Fraction
630
Separate Using Dynamic Sensor
Rejected Material
Rejected Material
Cu Wire
691
Recover Metals
End
Cu Wire
692
Recover Metals
<3.6mmx40mm
Light Fraction
635
Screen Materials (2.4mm x 40mm slotted screen)
>2.4mmx40mm
640
Separate Materials Using Destoner
Heavy Fraction
693
Recover Metals
<2.4mmx40mm
650
Separate Materials Using Destoner
Heavy Fraction
694
Recover Metals
645
Screen Materials (1.2mm x 40mm slotted screen)
>1.2mmx40mm
Light Fraction
End
Light Fraction
<1.2mmx40mm
655
Separate Materials Using Destoner
Heavy Fraction
696
Recover Metals

Fig. 6

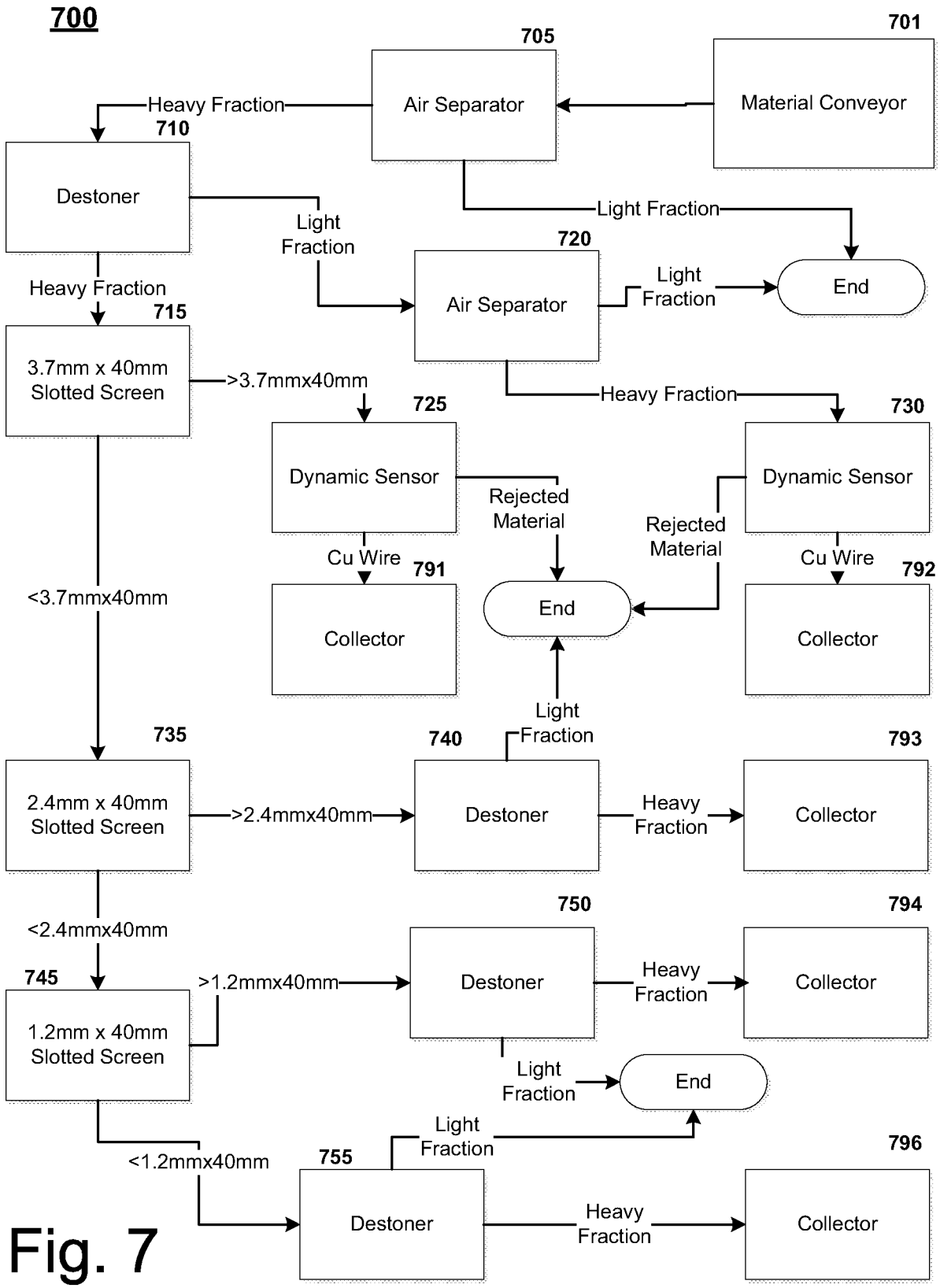

700
701
705
Material Conveyor
Air Separator
Heavy Fraction
710
Destoner
Light Fraction
Light Fraction
720
Air Separator
Light Fraction
End
Heavy Fraction
715
3.7mm x 40mm Slotted Screen
>3.7mmx40mm
Heavy Fraction
725
730
Dynamic Sensor
Dynamic Sensor
Rejected Material
Rejected Material
Cu Wire
791
Cu Wire
792
<3.7mmx40mm
Collector
End
Collector
Light Fraction
735
740
793
2.4mm x 40mm Slotted Screen
>2.4mmx40mm
Destoner
Heavy Fraction
Collector
<2.4mmx40mm
750
794
745
>1.2mmx40mm
Destoner
Heavy Fraction
Collector
1.2mm x 40mm Slotted Screen
Light Fraction
End
Light Fraction
796
<1.2mmx40mm
755
Destoner
Heavy Fraction
Collector

Fig. 7

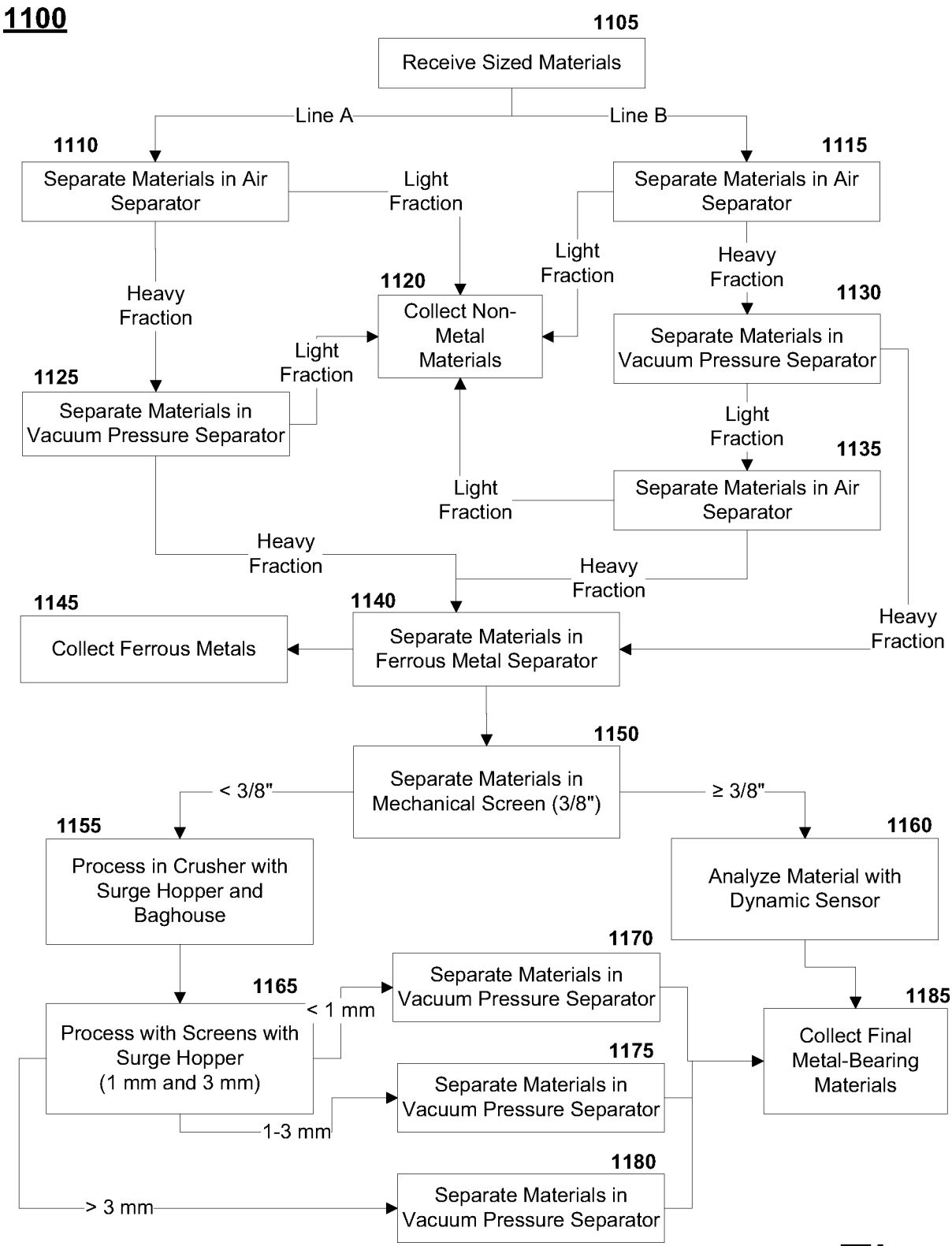

1100
1105
Receive Sized Materials
Line A
Line B
1110
Separate Materials in Air Separator
Light Fraction
1115
Separate Materials in Air Separator
Heavy Fraction
Light Fraction
Heavy Fraction
1120
Collect Non-Metal Materials
1130
Separate Materials in Vacuum Pressure Separator
Light Fraction
1125
Separate Materials in Vacuum Pressure Separator
Light Fraction
Light Fraction
1135
Separate Materials in Air Separator
Heavy Fraction
Heavy Fraction
1145
Collect Ferrous Metals
1140
Separate Materials in Ferrous Metal Separator
Heavy Fraction
1150
Separate Materials in Mechanical Screen (3/8")
< 3/8"
≥ 3/8"
1155
Process in Crusher with Surge Hopper and Baghouse
1160
Analyze Material with Dynamic Sensor
1170
Separate Materials in Vacuum Pressure Separator
1165
< 1 mm
Process with Screens with Surge Hopper (1 mm and 3 mm)
1185
Collect Final Metal-Bearing Materials
1175
Separate Materials in Vacuum Pressure Separator
1-3 mm
1180
> 3 mm
Separate Materials in Vacuum Pressure Separator

Fig. 8

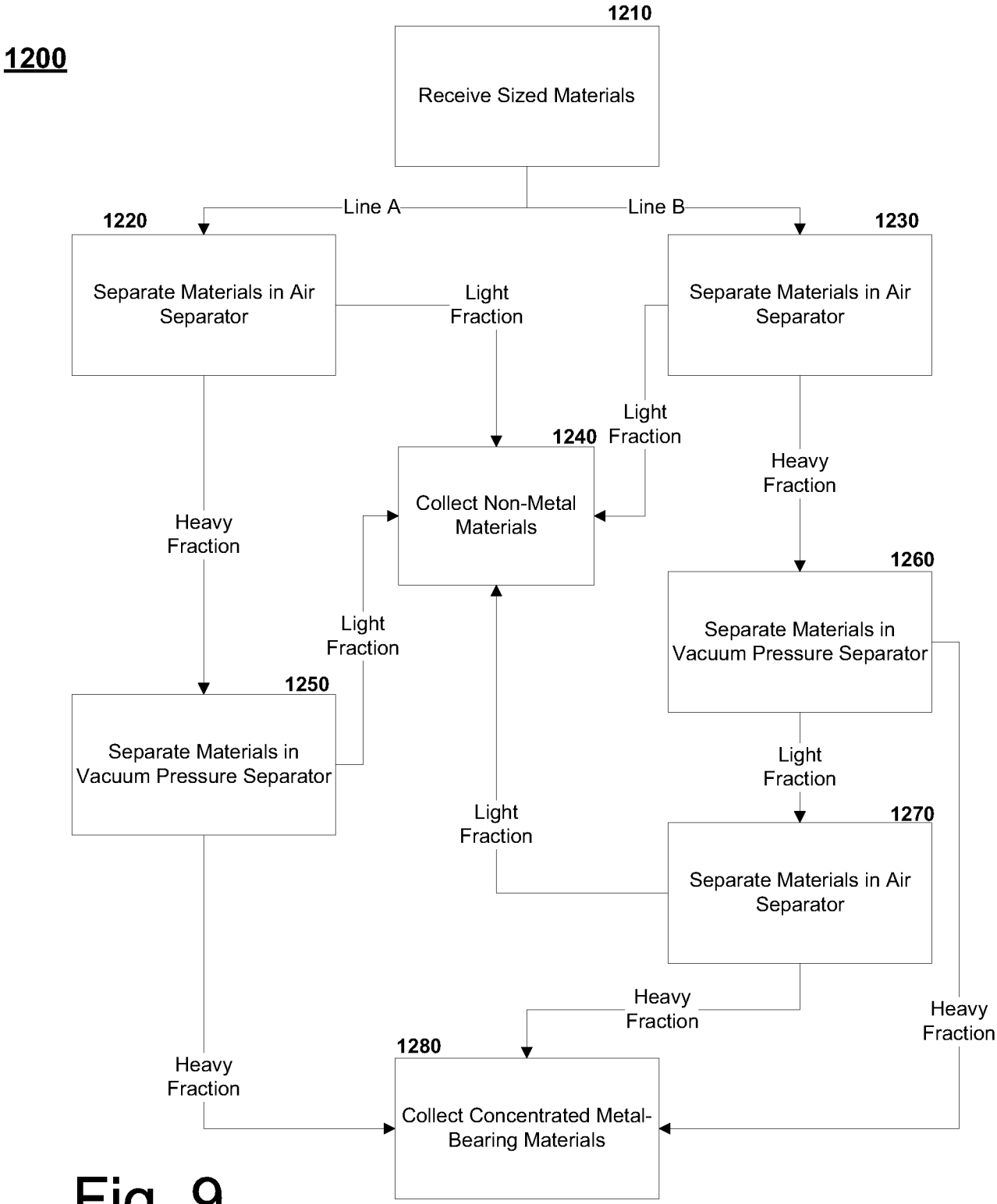

1200
1210
Receive Sized Materials
Line A
Line B
1220
Separate Materials in Air Separator
Light Fraction
1230
Separate Materials in Air Separator
Light Fraction
1240
Collect Non-Metal Materials
Heavy Fraction
Heavy Fraction
1260
Separate Materials in Vacuum Pressure Separator
Light Fraction
1250
Separate Materials in Vacuum Pressure Separator
Light Fraction
Light Fraction
1270
Separate Materials in Air Separator
Heavy Fraction
Heavy Fraction
1280
Heavy Fraction
Collect Concentrated Metal-Bearing Materials

Fig. 9

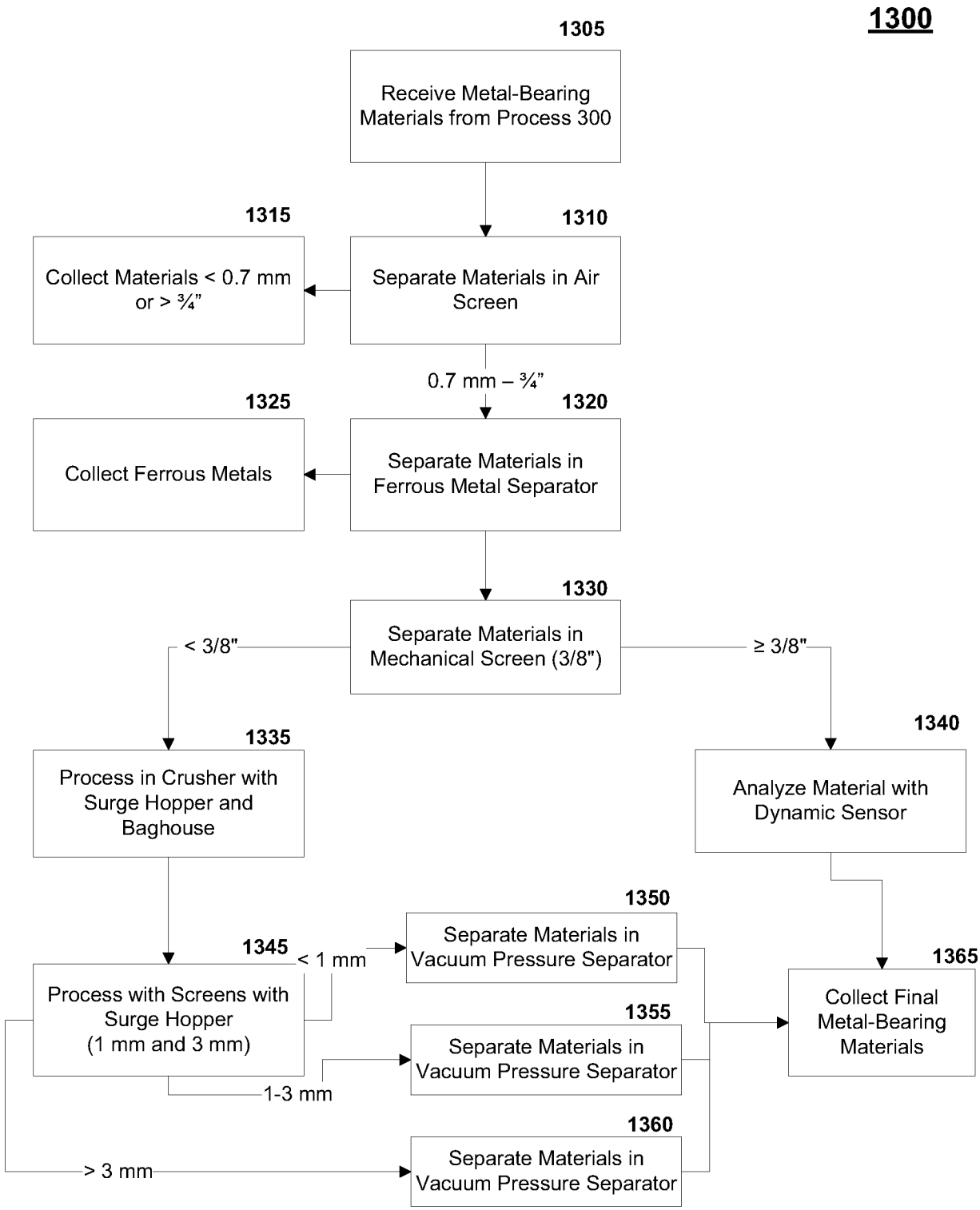

1300
1305
Receive Metal-Bearing Materials from Process 300
1315
Collect Materials < 0.7 mm or > ¾"
1310
Separate Materials in Air Screen
0.7 mm – ¾"
1325
Collect Ferrous Metals
1320
Separate Materials in Ferrous Metal Separator
1330
Separate Materials in Mechanical Screen (3/8")
< 3/8"
≥ 3/8"
1335
Process in Crusher with Surge Hopper and Baghouse
1340
Analyze Material with Dynamic Sensor
1350
Separate Materials in Vacuum Pressure Separator
1345
< 1 mm
Process with Screens with Surge Hopper (1 mm and 3 mm)
1365
Collect Final Metal-Bearing Materials
1355
Separate Materials in Vacuum Pressure Separator
1-3 mm
1360
Separate Materials in Vacuum Pressure Separator
> 3 mm

Fig. 10

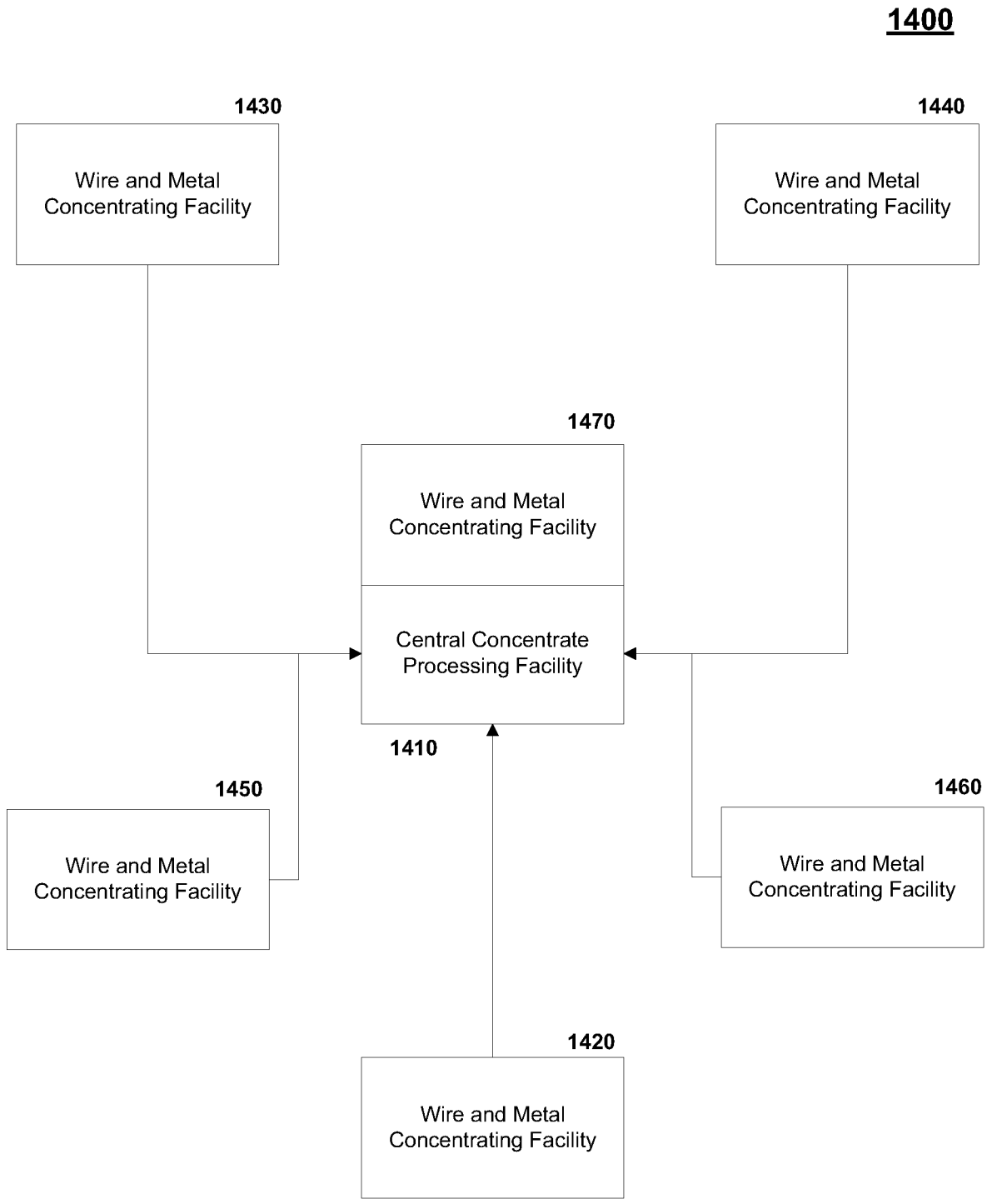

1400
1430
Wire and Metal Concentrating Facility
1440
Wire and Metal Concentrating Facility
1470
Wire and Metal Concentrating Facility
Central Concentrate Processing Facility
1410
1450
Wire and Metal Concentrating Facility
1460
Wire and Metal Concentrating Facility
1420
Wire and Metal Concentrating Facility

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/054975

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B07C 5/344 (2010.01)
USPC - 209/571
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(8) - B07C 5/344 (2010.01)
USPC - 209/44.1, 571, 930; 241/24.14; 264/115; 324/207.15

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)
PatBase, Google Patents, USPTO PAIR

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008/0257794 A1 (VALERIO) 23 October 2008 (23.10.2008) entire document	1-16
Y	US 5,344,025 A (TYLER et al) 06 Sepetember 1994 (06.09.1994) entire document	1-12
Y	US 6,669,839 B2 (TIPTON et al) 30 December 2003 (30.12.2003) entire document	13-16
A	US 5,443,157 A (BAKER et al) 22 August 1995 (22.08.1995) entire document	1-16
A	US 5,535,891 A (KUNIYONE et al) 16 July 1996 (16.07.1996) entire document	1-16
A	US 5,611,493 A (HAYASHI et al) 18 March 1997 (18.03.1997) entire document	1-16
P	US 7,786,401 B2 (VALERIO) 31 August 2010 (31.08.2010) entire document	1-16

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December 2010	28 DEC 2010
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774