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(54) **Method for processing furnace-bottom residue produced in gasification and slagging combustion furnace**

(57) A gasification and slagging combustion furnace comprises a fluidized-bed gasification furnace (1) as a preceding stage and a slagging combustion furnace (2) as a succeeding stage. The recovered fluidized medium (d) is transferred to the fluidized-bed gasification furnace where the fluidized medium is reused. A metal component (a,b,c) is separated and recovered from the furnace-bottom residue. A nonmetal component is utilized after matter comprising the nonmetal component is rubbed with one another to remove contaminants from the surface of the matter, or after removing by a screen a powder component contained inherently in the nonmetal component and a powder component produced upon crushing of the nonmetal component. Alternatively, a nonmetal component is crushed to produce powder (e), the produced powder is transferred to the fluidized-bed gasification furnace, and then to the slagging combustion furnace where slagging is performed.

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**Description****BACKGROUND OF THE INVENTION**

5 Field of the Invention:

[0001] The present invention relates to a method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace comprising a fluidized-bed gasification furnace provided in a preceding stage and a slagging combustion furnace provided in a succeeding stage, and more particularly to a method for processing a furnace-bottom residue produced in the fluidized-bed gasification furnace provided in the preceding stage.

**Description of the Related Art:**

[0002] There has been known a gasification and slagging combustion furnace comprising a combination of a fluidized-bed gasification furnace and a slagging combustion furnace in which wastes can be combusted without generating dioxins and ash content contained in the wastes can be recovered as molten slag. Incombustible materials produced in the incineration of wastes in the gasification and slagging combustion furnace are classified into a furnace-bottom residue produced in the fluidized-bed gasification furnace, and molten slag and molten fly ash produced in the slagging combustion furnace. The furnace-bottom residue will be described by taking a furnace-bottom residue produced in a fluidized-bed incinerator for example.

[0003] Iron and nonferrous metals are separated from the residue produced in the fluidized-bed incinerator, and fine particles having a diameter of not more than 0.3 mm, which have been highly contaminated with salts or heavy metals and are mostly adhered to and carried with large-diameter matter, are collected by a fine particle separator, and then stored in a hopper.

[0004] The product is separated by means of a crusher and a screen into a product having a diameter of 5 to 12 mm, a product having a diameter of 2 to 5 mm, and a product having a diameter of 0.3 to 2 mm. The product having a diameter of 0.3 to 2 mm is subjected to washing with an alkali or other treatment to dissolve heavy metals. Thus, the product is brought into a harmless condition.

[0005] In this case, the product can be effectively utilized as an aggregate. However, problems associated with the complexity of the system and the treatment of wastewater produced in the washing remain unsolved.

[0006] The furnace-bottom residue is sometimes magnetically separated. In most cases, however, the furnace-bottom residue is carried to a final disposal site as it is. Since the remaining disposal capacity in final disposal sites is currently being reduced, it is necessary to utilize resources effectively and prolong the life of the final disposal site.

**SUMMARY OF THE INVENTION**

[0007] The present invention has been made in view of the above problems in the prior art. It is therefore an object of the present invention to provide a method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace which can convert the furnace-bottom residue produced in a fluidized-bed gasification furnace into resources in a safe manner and in a simplified system.

[0008] In order to achieve the above object, according to a first aspect of the present invention, there is provided a method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace comprising a fluidized-bed gasification furnace and a slagging combustion furnace provided downstream of the fluidized-bed gasification furnace, comprising: recovering a fluidized medium by screening a furnace-bottom residue produced in the fluidized-bed gasification furnace and transferring the recovered fluidized medium to the fluidized-bed gasification furnace where the fluidized medium is reused; separating and recovering a metal component from the furnace-bottom residue; and utilizing a nonmetal component after matter comprising the nonmetal component is rubbed with one another to remove contaminants from the surface of the matter.

[0009] According to a second aspect of the present invention, there is provided a method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace comprising a fluidized-bed gasification furnace and a slagging combustion furnace provided downstream of the fluidized-bed gasification furnace, comprising: recovering a fluidized medium by screening a furnace-bottom residue produced in the fluidized-bed gasification furnace and transferring the recovered fluidized medium to the fluidized-bed gasification furnace where the fluidized medium is reused; and separating and recovering a metal component from the furnace-bottom residue; and utilizing a nonmetal component after removing by a screen a powder component contained inherently in the nonmetal component and a powder component produced upon crushing of the nonmetal component.

[0010] According to a third aspect of the present invention, there is provided a method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace comprising a fluidized-bed gasification fur-

nace and a slagging combustion furnace provided downstream of the fluidized-bed gasification furnace, comprising: recovering a fluidized medium by screening a furnace-bottom residue produced in the fluidized-bed gasification furnace and transferring the recovered fluidized medium to the fluidized-bed gasification furnace where the fluidized medium is reused; separating and recovering a metal component from the furnace-bottom residue; and crushing a nonmetal component in the furnace-bottom residue to produce powder, transferring the produced powder to the fluidized-bed gasification furnace, and then transferring the powder, together with fly ash, with the aid of a gas stream in the fluidized-bed gasification furnace, to the slagging combustion furnace where slagging is performed.

**[0011]** In the fluidized-bed gasification furnace, the fluidized bed is kept at a relatively low temperature ranging from 500 to 600°C. Therefore, unlike the conventional incinerator wherein aluminum (melting point 660°C) is melted and scattered, the fluidized-bed gasification furnace permits aluminum to remain on the bottom of the furnace. Further, since the furnace is in a reducing atmosphere, metals such as iron, copper and aluminum from which adhered combustibles are removed, can be recovered in an unoxidized state.

**[0012]** The furnace-bottom residue produced in the fluidized-bed gasification furnace is discharged together with a fluidized medium from the furnace. The fluidized medium may be separated by means of a screen such as a vibrating screen before or after being processed in a magnetic separator and a nonferrous metal separator, or after being processed in either one of the magnetic separator and the nonferrous metal separator. The opening size of the screen is suitably about 4 mm. The undersize matter is reutilized as a fluidized medium, and the oversize matter is utilized as resources.

**[0013]** In screening the furnace-bottom residue, it is desirable that screening on large-diameter side is carried out separately from screening on small-diameter side from the viewpoint of the efficiency of metal separation. For example, the furnace-bottom residue may be screened, as a basis for separation, using a diameter of 15 mm by a trommel.

**[0014]** In this case, the screening on the large-diameter side and the screening on the small-diameter side may be carried out in the same separator by staggering processing time.

**[0015]** The process on the large-diameter side is carried out by removing large-size iron with a primary magnetic separator (for example, a suspension type magnetic separator), and then by precisely separating iron with a secondary magnetic separator, for thereby improving the separation efficiency in the nonferrous metal separators and preventing the nonferrous metal separator from being damaged due to iron inclusion.

**[0016]** In general, the nonferrous metal separator is of a rotary drum type in which magnets are disposed on a rotary drum. In the rotary drum type separator, nonferrous metals such as aluminum, brass and copper are allowed to fly away by eddy current generated upon crossing of nonferrous metals across magnetic field and force generated by magnetic line of force, thereby separating nonmetals such as stone, glass and earthenware.

**[0017]** Matter on the large-diameter side has a broad size distribution. Therefore, separation by means of the nonferrous metal separator at a time results in deteriorated separation efficiency. Preferably, matter on the large-diameter side is further classified by a screen into two groups different from each other in size (for example, a group having a diameter of not more than 30 mm and a group having a diameter of more than 30 mm). The separation of nonferrous metals in the respective groups is preferably carried out separately from each other.

**[0018]** The furnace-bottom residue on the small-diameter side is also separated by primary magnetic separation, secondary magnetic separation, and nonferrous metal separation in that order.

**[0019]** The first, second, and third aspects of the present invention will be described in sequence in more detail.

**[0020]** First, the first aspect of the present invention will be described.

**[0021]** In the furnace-bottom residue after the separation and removal of the metal component by the above-mentioned manner, fine matter having a diameter of not more than about 0.3 mm is highly contaminated with salts or heavy metals. This fine matter also adheres to the surface of matter having a larger diameter.

**[0022]** According to one embodiment of the present invention, rubbing of the matter with one another in a grinding mill is conducted to remove fine particles adhering to the surface of the large-diameter matter, rather than washing with an alkali, as a means for removing the surface contaminants.

**[0023]** One example of a grinding mill has such a structure that a chamber for giving a residence time to the matter is provided therein and the matter is moved vertically and transversely while pressing the matter against the side wall of the residence chamber and, in addition, diffusing the matter, whereby the matter can be rubbed with one another to remove fine particles therefrom as a contamination source adhered onto the surface of the matter.

**[0024]** The second aspect of the present invention will be described.

**[0025]** In the furnace-bottom residue after the removal of the metal component, the level of contamination of the residue with salts and heavy metals upon the production thereof depends greatly on the surface area of the residue. Therefore, the smaller the diameter of the matter is, the larger mass of the contaminant per unit mass is. For this reason, in order to recover nonmetals as valuables such as construction materials, it is necessary to remove fine particles produced upon crushing of the nonmetal component.

**[0026]** Fine particles have a diameter of not more than about 0.3 mm and include an inherent powder component (which is adhered onto matter having a large diameter and is causative of the contamination of the large-diameter mat-

ter) and a powder component which has been newly produced upon crushing of the nonmetal component.

**[0027]** Surface contamination of matter having a diameter of not less than 0.3 mm, particularly matter having a diameter of about 0.3 to 2 mm, is also not negligible. Therefore, according to the present invention, matter having this diameter range is considerably powdered by means of a crusher (preferably a crusher having such a structure as to grind the surface of matter, or a crusher in which the number of collision of matter against one another or against the wall surface thereof at the time of crushing is large). The provision of a 0.3-mm swirling screen or vibrating screen downstream of the crusher permits the nonmetal component to be safely and effectively utilized as an aggregate.

**[0028]** In the vibrating screen, screening is carried out by vertical motion. On the other hand, the swirling screen has such a structure that screening is carried out by horizontal reciprocation of the screen face and the screen face may be beaten by a rubber ball or the like to prevent openings from clogging.

**[0029]** Thus, in the furnace-bottom residue, the highly contaminated nonmetal component having a diameter of not more than 0.3 mm and the nonmetal component having a diameter slightly larger than 0.3 mm can be removed. This can contribute to the removal of contaminants of the whole nonmetal component. The separated fine particles, together with fly ash discharged from the fluidized-bed gasification furnace, are melted in the slagging combustion furnace as the second-stage furnace to produce molten slag.

**[0030]** The nonmetallic furnace-bottom residue contains glass, potteries (or ceramics), rubble and the like. Rubble is fragile and is likely to be finely crushed. When the nonmetallic furnace-bottom residue contains a large amount of rubble and the size of the screen opening is 0.3 mm, in some cases, not less than 40% of the nonmetallic furnace-bottom residue cannot be utilized as resources. In this case, it is desirable that the screen opening size of 0.15 mm is employed.

**[0031]** When the opening size of the screen provided downstream of the crusher is large (for example, 0.5 mm), the contamination level of the nonmetal component as the aggregate is reduced. This large opening size, however, is disadvantageous in that since the content of fine particles in the resultant aggregate is low, the aggregate is less likely to meet the requirement for fine aggregates and, in addition, the recovery of nonmetals is reduced.

**[0032]** In the case of not only the trommel but also the vibrating screen, the efficiency of screening should be taken into consideration. That is, since the sharpness of separation is limited and large-size metals such as cans tend to hold sand, even if classification is performed by a screen, a part of small-diameter matter is included in oversize material. This phenomenon is unavoidable.

**[0033]** Further, although the powdering of nonmetals is accelerated by crushing, nonferrous metals (particularly aluminum) are ductile and are likely to be rounded. Therefore, the crushed product may be screened through a screen having an opening size of about 4 mm to recover oversize material, remaining unpowdered, as the nonferrous metal component.

**[0034]** In this method, however, since an excessive load is applied to the crusher, prior to crushing, only the large-diameter matter (for example, matter having a diameter of not less than 30 mm) is processed to recover nonferrous metals by a nonferrous metal separator, the remainder and the matter other than the large-diameter matter after the magnetic separation are crushed by a crusher, and the crushed product is screened through a screen having an opening size of about 4 mm to recover oversize material unpowdered as a nonferrous metal component.

**[0035]** In this method in which a screen is provided downstream of the crusher to recover the nonferrous metal component in accordance with the diameter difference, the inclusion of the nonmetal component is unavoidable. Therefore, the problem of the purity of the nonferrous metal component remains unsolved. For this reason, it is desirable to provide a nonferrous metal separator for screening of the large-diameter matter which has been separated by a trommel.

**[0036]** Next, the third aspect of the present invention will be described.

**[0037]** The furnace-bottom residue after the removal of the metal component is crushed in a vertical mill, a continuous type vibrating mill, or the like. Although the particle size, to which the furnace-bottom residue is to be crushed, varies depending on the ascending flow velocity within the fluidized-bed gasification furnace, the maximum diameter is in the range of about 200 to 300  $\mu\text{m}$ . The maximum diameter may be in the range of 100 to 300  $\mu\text{m}$ . When the continuous vibrating mill is used, it is desirable that a two-stage structure is employed, and rods in the preceding stage and balls in the succeeding stage are used as the vibrating medium. This is because rods are suitable for coarse size reduction while balls are suitable for fine size reduction.

**[0038]** The powdery material thus obtained is returned to the fluidized-bed gasification furnace, carried with a gas stream to the slagging combustion furnace, and melted in the slagging combustion furnace and discharged therefrom as molten slag which is then utilized as a roadbed material or the like. The recovered metal is recycled as valuables.

**[0039]** In the above system, separators are used for the removal of iron and nonferrous metals. When the furnace-bottom residue after the secondary magnetic separation is subjected to size reduction by a device such as a vibrating mill operated based on such a principle that size reduction is carried out by impact crushing, ductile metals such as aluminum tend to become a spherical shape without being crushed. Therefore, size reduction by the vibrating mill followed by screening of the size-reduced product through a vibrating screen having an opening size of about 4 mm allows the

metal component and the nonmetal component to be separated from each other.

**[0040]** In this case, the use of a batch vibrating mill is preferred because, in a continuous vibrating mill, the presence of a dam for providing a residence time is likely to be an obstacle to the passage of the formed spherical metals.

**[0041]** Any device other than the vibrating mill may also be used so far as the device can reduce the size of the non-metal component by fine crushing and can utilize the property of metals such that the shape of metals is rounded due to the ductility of the metal.

**[0042]** According to the present invention, the metal component contained in the furnace-bottom residue produced in the fluidized-bed gasification furnace is recovered, and the nonmetal component is melted in the slagging combustion furnace and recovered as molten slag which is then utilized effectively.

**[0043]** The reason why, when the powdered slag is returned to the fluidized-bed gasification furnace, the metal component is removed is that the metal component is utilized again as resources and, in addition, scattering of aluminum or the like towards the slagging combustion furnace often has an adverse effect on the operating conditions of the slagging combustion furnace depending on the amount of aluminum or other metal scattered.

**[0044]** The above and other objects, features, and advantages of the present invention will be apparent from the following description when taken in conjunction with the accompanying drawings which illustrates preferred embodiments of the present invention by way of example.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0045]**

FIG. 1 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a first embodiment of the present invention;

FIG. 2 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a second embodiment of the present invention;

FIG. 3 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a third embodiment of the present invention;

FIG. 4 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a fourth embodiment of the present invention;

FIG. 5 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a fifth embodiment of the present invention;

FIG. 6 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a sixth embodiment of the present invention;

FIG. 7 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a seventh embodiment of the present invention;

FIG. 8 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to an eighth embodiment of the present invention; and

FIG. 9 is a diagram showing a typical configuration of a gasification and slagging combustion furnace used in the systems shown in FIGS. 1 through 8.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0046]** A method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace according to embodiments of the present invention will be described below with reference to the accompanying drawings.

**[0047]** FIG. 1 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a first embodiment of the present invention.

**[0048]** A gasification and slagging combustion furnace comprises a fluidized-bed gasification furnace 1 provided at the preceding stage, and a slagging combustion furnace 2 provided at the succeeding stage. A furnace-bottom residue containing a fluidized medium "d" produced in the fluidized-bed gasification furnace 1 is separated through a trommel 4 into over-15 mm matter (matter having a diameter of not less than 15 mm) and under-15 mm matter (matter having a diameter of less than 15 mm).

**[0049]** The over-15 mm matter is fed into a suspension-type magnetic separator 5 where large-size iron "a" is separated. The iron "a" separated by the magnetic separator 5 has a high purity.

**[0050]** Further, magnetic separation is more precisely carried out in a secondary magnetic separator 6 such as a drum-type magnetic separator where low-quality iron "b", in which a nonmetal component is included, is recovered from the furnace-bottom residue. At this stage, since iron has been already removed, a nonferrous metal separator such as a rotary drum-type nonferrous metal separator may be used in the next stage.

**[0051]** Nonferrous metals, which have been discharged from the secondary magnetic separator 6, have a broad dimension distribution. In order to enhance the separation efficiency of the nonferrous metal component, a vibrating screen 7 (for separation into under-30 mm matter and over-30 mm matter) and a vibrating screen 8 (for separation into under-4 mm matter and over-4 mm matter) are provided. After screening through the vibrating screen 7, the over-30 mm matter (matter having a diameter of not less than 30 mm) obtained in the vibrating screen 7 are fed into a nonferrous metal separator 9 where a nonferrous metal "c" is separated. On the other hand, the under-30 mm matter (matter having a diameter of less than 30 mm) obtained in the vibrating screen 7 are further separated through the vibrating screen 8 into over-4 mm matter (matter having a diameter of not less than 4 mm) and under-4 mm matter (matter having a diameter of less than 4 mm). The over-15 mm matter separated in the trommel 4 is in a condition such that small-diameter rubble or the like resides in cans or in holes or gaps of metals. That is, under-15 mm matter is also present in the over-15 mm matter. For this reason, the vibrating screen 8 is required to be provided.

**[0052]** The over-4 mm matter obtained in the vibrating screen 8 is fed into a nonferrous metal separator 13 where a nonferrous metal "c" is separated. On the other hand, the under-4 mm matter is returned to the fluidized-bed gasification furnace 1.

**[0053]** The under-15 mm matter separated by the trommel 4 is fed into a primary magnetic separator 10 such as a drum magnetic separator where low-quality iron "b" is separated. Next, the under-15 mm matter from which the low-quality iron "b" is removed is separated through a vibrating screen 11 into over-4 mm matter and under-4 mm matter. The under-4 mm matter is returned as a fluidized medium "d" to the fluidized-bed gasification furnace 1. On the other hand, the over-4 mm matter is fed into a secondary magnetic separator 12 such as a drum magnetic separator where low-quality iron "b" is separated, and followed by separation of a nonferrous metal "c" by means of a nonferrous metal separator 13.

**[0054]** After the removal of the nonferrous metal "c" by the nonferrous metal separator 13, the furnace-bottom residue consisting of nonmetals only is fed into a grinding mill 14 where weak parts of matter are crushed or removed and, at the same time, the surfaces of matter are rubbed with one another to remove adhered fine particles. The matter from which the adhered fine particles are removed is fed into a vibrating screen 15 (for separation into over-0.3 mm matter and under-0.3 mm matter) where highly contaminated fine particles (particle having a diameter of less than 0.3 mm) "e" are removed. These fine particles "e" are returned to the fluidized-bed gasification furnace 1, and then contained into molten slag "f" and effectively utilized. On the other hand, the over-0.3 mm matter may be utilized for a coarse aggregate as it is. The over-0.3 mm matter, however, contains a large quantity of flat materials such as glass pieces and earthenware pieces, and thus has a poor solidifying property. For this reason, in the embodiment shown in FIG. 1, the over-0.3 mm matter, together with slag "f" discharged from a slag formation apparatus 3 for cooling molten slag with water to form granulated slag, is crushed by a crusher 16 to a size of not more than about 2.5 mm, thus producing a fine aggregate "g". In the fine aggregate "g", when the presence of matter having a diameter of not less than 2.5 mm is undesirable, the matter having a diameter of not less than 2.5 mm should be separated through a vibrating screen 17, and returned to the crusher 16 again. Screening for removing fine particles is not required in the fine aggregate "g".

**[0055]** A large amount of matter having a large diameter of not less than 30 mm and having irregular shapes such as earthenware pieces is contained in the furnace-bottom residue from which the metal component has been removed in the nonferrous metal separator 9. This matter is likely to be an obstacle to an enhancement in the effect of the grinding mill 14. Therefore, the contamination level of matter having a large diameter of not less than 30 mm is inherently relatively low, and hence this matter can be fed directly into the crusher 16.

**[0056]** The nonmetal component after crushing by the crusher 16 is not required to be screened for the separation of fine particles, and the whole crushed nonmetal component may be effectively utilized. Dry classification, especially a gravitational classifier (a horizontal stream type or a vertical stream type) suitable for the separation of matter having a diameter of about 100 to 300  $\mu\text{m}$ , may be substituted for the vibrating screen 15.

**[0057]** FIG. 2 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a second embodiment of the present invention.

**[0058]** The second embodiment shown in FIG. 2 is basically the same as the first embodiment, except that the secondary magnetic separator 12 and the nonferrous metal separator 13 are omitted and the secondary magnetic separator 6 and the nonferrous metal separator 9 serve respectively also as the secondary magnetic separator 12 and the nonferrous metal separator 13 by staggering processing time. Specifically, the under-15 mm matter separated in the trommel 4 is separated by the vibrating screen 11 into over-4 mm matter and under-4 mm matter. The under-4 mm matter is returned as a fluidized medium "d" to the fluidized-bed gasification furnace 1. On the other hand, the over-4 mm matter is transferred to the secondary magnetic separator 6, and after separating low-quality iron "b" in the secondary magnetic separator 6, the over-4 mm matter is transferred to the nonferrous metal separator 9 while by-passing the vibrating screen 7. The over-15 mm matter obtained in the trommel 4 is transferred through the magnetic separator 5 to the secondary magnetic separator 6, and after separating low-quality iron "b" in the secondary magnetic separator 6, the over-15 mm matter is fed into the vibrating screen 7 where the over-15 mm matter is separated into over-30 mm matter and under-30 mm matter. The over-30 mm matter is fed into the nonferrous metal separator 9. The under-30 mm

matter is separated through the vibrating screen 8 into over-4 mm matter and under-4 mm matter. The under-4 mm matter is returned as a fluidized medium "d" to the fluidized-bed gasification furnace 1, while the over-4 mm matter is transferred to the nonferrous metal separator 9.

**[0059]** FIG. 3 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a third embodiment of the present invention.

**[0060]** In the third embodiment shown in FIG. 3, the metal separation procedure is the same as that in the first embodiment shown in FIG. 1, and hence the description thereof will be omitted.

**[0061]** The furnace-bottom residue after the separation of the metal component is crushed by a crusher 16.

**[0062]** The objects processed in the crusher 16 are as follows:

1 A furnace-bottom residue after the separation of nonferrous metals in the nonferrous metal separator 13

2 A furnace-bottom residue after the separation of nonferrous metals in the nonferrous metal separator 9

3 A furnace-bottom residue containing nonferrous metals which is under-4 mm matter obtained in the vibrating screen 8

4 Slag "f" discharged from the slag formation device 3

5 Returned matter (matter to be recrushed) which is the over-2.5 mm matter (matter having a diameter of not less than 2.5 mm) obtained in the vibrating screen 17

**[0063]** In the crusher 16, the furnace-bottom residue is crushed to matter having a diameter of not more than about 2.5 mm. The vibrating screen 17 is provided downstream of the crusher 16. The crushed product obtained in the crusher 16 is screened through the vibrating screen 17, and the matter having a diameter of not less than 2.5 mm is again returned to the crusher 16. Thus, the size of the fine aggregate "g" as a product can be rendered uniform. In general, the fine aggregate has a diameter of not more than about 5 mm. The fine aggregate for asphalt mixtures has a diameter of not more than about 2.5 mm, and hence the diameter of the fine aggregate may be selected according to applications.

**[0064]** The nonferrous metal contained in the furnace-bottom residue 3 is ductile and retained as oversize material on the vibrating screen 17 without being crushed. Therefore, the nonferrous metal is unfavorably circulated between the vibrating screen 17 and the crusher 16. For this reason, in the final stage of the processing step, the nonferrous metal "c" is withdrawn from the circulating line.

**[0065]** Only about 10% of the large-diameter matter obtained in the trommel 4 is accounted for by the furnace-bottom residue 3, and, in addition, the content of the nonmetal component in the furnace-bottom residue 3 is not high. Therefore, the furnace-bottom residue 3 may be returned to the fluidized-bed gasification furnace 1.

**[0066]** Highly contaminated fine particles as under-0.3 mm matter (matter having a diameter of less than 0.3 mm) contained in the nonmetal component as the under-2.5 mm matter (matter having a diameter of less than 2.5 mm) are removed through the vibrating screen 15, and again returned to the fluidized-bed gasification furnace 1, from which these fine particles are carried by a gas stream to the slagging combustion furnace 2 where they are mixed with molten slag "f" which is then effectively utilized.

**[0067]** The vibrating screen 15 is provided for removing under-0.3 mm matter which has been highly contaminated with salts or heavy metals. The slag "f" does not cause any problem of contamination, irrespective of a size of the slag. Therefore, there is no particular need to screen the slag "f" through the vibrating screen 15. In this case, the slag "f" may also be used to produce a fine aggregate "g" without the use of the vibrating screen 15 shown in FIG. 3.

**[0068]** In the vibrating screen 15, screening is conducted by vertical motion. In general, a swirling screen is preferably used for screening matter having a diameter of not more than 0.5 mm from the viewpoint of efficiency.

**[0069]** If the furnace-bottom residue contains a large amount of fragile rubble, and thus, as a result of the removal of the under-0.3 mm matter, a large proportion of the furnace-bottom residue is returned to the fluidized-bed gasification furnace 1, then the opening size of the screen may be reduced, so as to remove under-0.15 mm matter.

**[0070]** Actual measurements will be described below.

**[0071]** The properties of a sample after the separation of a metal component in over-15 mm matter and under-15 mm matter separated through the trommel 4 shown in FIG. 3 are summarized in Table 1.

Table 1

| Properties of sample after metal separation |        |                                            |                                           |                    |
|---------------------------------------------|--------|--------------------------------------------|-------------------------------------------|--------------------|
| Item                                        | Unit   | Under-15 mm matter:<br>Small-diameter side | Over-15 mm matter:<br>Large-diameter side | Observation method |
| Metal                                       | Mass % | 0.5                                        | 0.2                                       | Magnet and visual  |

Table 1 (continued)

| Properties of sample after metal separation |        |                                            |                                           |                    |
|---------------------------------------------|--------|--------------------------------------------|-------------------------------------------|--------------------|
| Item                                        | Unit   | Under-15 mm matter:<br>Small-diameter side | Over-15 mm matter:<br>Large-diameter side | Observation method |
| Glass                                       | Mass % | 27.0                                       | 63.4                                      | Magnet and visual  |
| Non-metals other than glass                 | Mass % | 72.5                                       | 36.4                                      | Magnet and visual  |

**[0072]** The nonmetal sample after the separation of the metal was crushed by the crusher 16 (impact sand production machine) to a size of not more than about 2.5 mm.

**[0073]** The crushed product was separated through the swirling screen 15 into an undersize material, and an oversize material as a product.

**[0074]** In the case of an opening size of 0.3 mm and an opening size of 0.15 mm in the swirling screen 15, the yield of aggregate (percentage of the nonmetal recovered as the aggregate in the nonmetal processed in the crusher 16) is shown in Table 2.

**[0075]** When a relatively large amount of fragile rubble is contained as in the case of the sample used in this experiment, the use of an opening size of 0.15 mm in the swirling screen 15 can improve the yield of aggregate.

**[0076]** The results of an elution test on the oversize material (over-0.15 mm matter) as the product and the undersize material (under-0.15 mm matter) separated by the swirling screen are shown in Table 3. As is apparent from Table 3, even when the opening size is 0.15 mm, the levels of six toxic substances, as measured according to the method specified in Notification No. 46 of 1991 of the Environment Agency, could meet the environmental quality standards for soil pollutants.

Table 2

| Yield of aggregate              |                       |
|---------------------------------|-----------------------|
| Opening size of swirling screen | Yield of aggregate(%) |
| 0.3 mm                          | 58.5                  |
| 0.15 mm                         | 74.7                  |

Table 3

| Results of elution test on product and fine particles having a diameter of less than 0.15 mm |          |                                    |                                           |                                                     |
|----------------------------------------------------------------------------------------------|----------|------------------------------------|-------------------------------------------|-----------------------------------------------------|
| Item for analysis                                                                            | Unit     | Concentration in eluate of product | Concentration in eluate of fine particles | Environmental quality standards for soil pollutants |
| Lead                                                                                         | mg/liter | < 0.005                            | < 0.005                                   | Not more than 0.01                                  |
| Chromium (VI)                                                                                | mg/liter | 0.006                              | 0.60                                      | Not more than 0.05                                  |
| Cadmium                                                                                      | mg/liter | < 0.001                            | < 0.001                                   | Not more than 0.01                                  |
| Arsenic                                                                                      | mg/liter | < 0.001                            | < 0.001                                   | Not more than 0.01                                  |
| Selenium                                                                                     | mg/liter | 0.002                              | 0.003                                     | Not more than 0.01                                  |
| Total mercury                                                                                | mg/liter | < 0.0005                           | < 0.0005                                  | Not more than 0.0005                                |
| Note) The test was carried out according to Notification No. 46 of the Environment Agency.   |          |                                    |                                           |                                                     |

**[0077]** Dry classification, especially a gravitational classifier (such as a horizontal type or a vertical type) suitable for the classification of particles having a diameter of about 100 to 300  $\mu\text{m}$ , may be substituted for the swirling screen

or the vibrating screen 15.

**[0078]** FIG. 4 is a block diagram showing the fourth embodiment of the method according to the present invention. The fourth embodiment shown in FIG. 4 is basically the same as the third embodiment, except that the vibrating screen 8 and the nonferrous metal separator 13 are omitted. Specifically, the under-30 mm matter obtained in the vibrating screen 7 is transferred to the crusher 16. The material discharged from the secondary magnetic separator 12 is also transferred through the vibrating screen 19 into over-4 mm matter and under-4 mm matter. Thus, only for the furnace-bottom residue having a diameter of not less than 30 mm, nonferrous metal "c" is previously removed by the nonferrous metal separator 9. For the remaining nonferrous metal, the property of nonferrous metal "c" such that, upon crushing, the nonferrous metal is rounded without being powdered, is utilized for separation. Specifically, the remaining nonferrous metal is processed in the crusher 16, and the crushed product is then fed into the vibrating screen 19 to separate the over-4 mm matter as the nonferrous metal "c". In this case, the under-4 mm matter is transferred to the vibrating screen 17.

**[0079]** In this connection, it should be noted that this method is based on the assumption that most of the nonmetal component is crushed by means of the crusher 16 to a size of not more than 4 mm. If it is difficult to meet this condition, a nonferrous metal separator should be separately provided.

**[0080]** FIG. 5 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a fifth embodiment of the present invention. The fifth embodiment shown in FIG. 5 is the same as the fourth embodiment, except that the vibrating screen 7 and the nonferrous metal separator 9 are further omitted. More specifically, the material discharged from the secondary magnetic separator 6 is transferred to the crusher 16, and the material discharged from the secondary magnetic separator 12 is also transferred to the crusher 16. A nonferrous metal separator 18 is provided downstream of the vibrating screen 19. According to this embodiment, all of the nonmetal and the nonferrous metal are processed in the crusher 16. This imposes a large load on the crusher 16.

**[0081]** The property of nonferrous metals such that, upon crushing, the nonferrous metal component is rounded without being powdered, is utilized for separation of the nonferrous metals. Specifically, upon processing in the crusher 16, the crushed product is fed into the vibrating screen 19 where over-4 mm matter is separated. In this stage, this matter contains a considerably large amount of nonmetals. Therefore, the over-4 mm matter is fed into the nonferrous metal separator 18 to separate nonferrous metal "c". The material discharged from the nonferrous metal separator 18 is returned to the crusher 16. The under-4 mm matter obtained in the vibrating screen 19 is transferred to the vibrating screen 17.

**[0082]** In the embodiments shown in FIGS. 4 and 5, the by-pass of the vibrating screen 19 is used in the processing of the slag "f" because there is no need to screen the slag through the vibrating screen 19.

**[0083]** FIG. 6 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a sixth embodiment of the present invention.

**[0084]** A gasification and slagging combustion furnace comprises a fluidized-bed gasification furnace 1 provided at the preceding stage, and a slagging combustion furnace 2 provided at the succeeding stage. A furnace-bottom residue containing a fluidized medium "d" produced in the fluidized-bed gasification furnace 1 is separated through a trommel 4 into over-15 mm matter (matter having a diameter of not less than 15 mm) and under-15 mm matter (matter having a diameter of less than 15 mm).

**[0085]** The over-15 mm matter is fed into a suspension-type magnetic separator 5 where large-size iron "a" is separated. The iron "a" separated by the magnetic separator 5 has a high purity.

**[0086]** Further, magnetic separation is more precisely carried out in a secondary magnetic separator 6 such as a drum-type magnetic separator 6 where low-quality iron "b", in which a nonmetal component is included, is recovered from the furnace-bottom residue. At this stage, since iron has been already removed, a nonferrous metal separator such as a rotary drum-type nonferrous metal separator may be used in the next stage.

**[0087]** Nonferrous metals, which have been discharged from the secondary magnetic separator 6, have a broad dimension distribution. In order to enhance the separation efficiency of the nonferrous metal component, a vibrating screen 7 is provided to separate the material into over-30 mm matter and under-30 mm matter. After screening through the vibrating screen 7, the over-30 mm matter (matter having a diameter of not less than 30 mm) obtained in the vibrating screen 7 is fed into a nonferrous metal separator 9 where nonferrous metals "c" such as aluminum, brass, and copper are separated.

**[0088]** On the other hand, the under-15 mm matter separated by the trommel 4 is fed into a primary magnetic separator 10 such as a drum-type magnetic separator where low-quality iron "b" is separated. Next, the under-15 mm matter from which the low-quality iron "b" is removed is separated through a vibrating screen 11 into over-4 mm matter (matter having a diameter of not less than 4 mm) and under-4 mm matter (matter having a diameter of less than 4 mm). The under-4 mm matter is returned as a fluidized medium "d" to the fluidized-bed gasification furnace 1. On the other hand, the over-4 mm matter is fed into a secondary magnetic separator 12 such as a drum-type magnetic separator

where low-quality iron "b" is separated, followed by separation of a nonferrous metal "c" by a nonferrous metal separator 13.

**[0089]** The material discharged from the secondary magnetic separator 12 and the under-30 mm matter obtained in the vibrating screen 7 are fed into a nonferrous metal separator 13 where nonferrous metal "c" is separated.

**[0090]** The furnace-bottom residue, from which nonferrous metals have been removed through the nonferrous metal separators 9 and 13, composed mainly of the nonmetal component is comminuted by a comminution device 20 to particles having a maximum diameter of about 100 to 300  $\mu\text{m}$ . The powdered particles "e" after comminution are returned to the fluidized-bed gasification furnace 1, from which the particles "e" are carried by a gas stream to the slagging combustion furnace 2. In the slagging combustion furnace 2, the particles are melted at a temperature of about 1,350°C and molten slag is fed into a slag formation apparatus 3, from which the slag "f" having high environmental safety is discharged. The slag "f" is effectively utilized as an aggregate or the like. The slag formation apparatus 3 is generally of a type such that the molten slag is brought into contact with water to form granulated slag. Alternatively, for example, slagging by slow cooling with air or the like may be used.

**[0091]** Examples of the comminution device 20 include vertical mills (size reduction by means of a roller and dry classification is carried out by a single device) and Continuous vibrating mills commonly used in the cement industry and the like.

**[0092]** FIG. 7 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to a seventh embodiment of the present invention. The seventh embodiment shown in FIG. 7 is basically the same as the sixth embodiment, except that the vibrating screen 7, the nonferrous metal separator 9, and the nonferrous metal separator 13 are omitted. Specifically, the material discharged from the secondary magnetic separator 6 is transferred to the comminution device 20. The material discharged from the secondary magnetic separator 12 is also transferred to the comminution device 20. The vibrating screen 19 is provided downstream of the comminution device 20. The comminution product is separated through the vibrating screen 19 into over-4 mm matter and under-4 mm matter. The over-4 mm matter is recovered as nonferrous metal "c", while the powdered particles "e" (finely pulverized) as the under-4 mm matter is returned to the fluidized-bed gasification furnace 1.

**[0093]** FIG. 8 is a block diagram showing a method for processing furnace-bottom residue produced in a gasification and slagging combustion furnace according to an eighth embodiment of the present invention. The eighth embodiment shown in FIG. 8 is the same as the seventh embodiment, except that the secondary magnetic separator 6, the secondary magnetic separator 12, and the vibrating screen 11 are further omitted. Specifically, the material discharged from the magnetic separator 5 is transferred to the comminution device 20. The material discharged from the magnetic separator 10 is returned as a fluidized medium "e" to the fluidized-bed gasification furnace 1. A secondary magnetic separator 21 is provided downstream of the comminution device 20, and a vibrating screen 19 is provided downstream of the secondary magnetic separator 21. After comminution by the comminution device 20, the comminution product is fed into the secondary magnetic separator 21 where low-quality iron "b" is removed. The remainder is separated through the vibrating screen 19 into over-4 mm (nonferrous metal) matter and under-4 mm (finely pulverized nonmetal) matter. The under-4 mm matter (powdered particles "e") is returned to the fluidized-bed gasification furnace 1. In this embodiment, the furnace-bottom residue is separated through the trommel 4 into over-4 mm matter and under-4 mm matter.

**[0094]** As shown in Table 1, it is difficult for the nonmetal sample after the separation of the metal component to be completely free from any metal, and, in particular, elongated metals are likely to be left in the nonmetal sample.

**[0095]** In the case of the first and second aspects of the present invention, these metals are also left in the fine aggregate "g". Since, however, the amount of these metals is so small that they can be removed, for example, by passing the fine aggregate "g" through a simple screen (opening size: about 10 to 20 mm; single-stage or two-stage screening).

**[0096]** In the case of the third aspect of the present invention, even after the sample after the separation of the metal component is comminuted by means of the comminution device 20, a small amount of the metal as an impurity remains uncomminuted and is likely to stay within the comminution device 20 (for both the vertical mill and the continuous vibrating mill). This makes it necessary to periodically remove the metal.

**[0097]** FIG. 9 is a cross-sectional view showing a typical configuration of a gasification and slagging combustion furnace used in the systems shown in FIGS. 1 through 8. The fluidized-bed gasification furnace 1 is a cylindrical fluidized-bed gasification furnace having an internally circulating flow of a fluidized medium therein, and has an enhanced ability of wastes to be diffused within the furnace for thereby realizing stable gasification. An oxygen-free gas is supplied into the central part of the interior of the furnace wherein a fluidized medium settles, while an oxygen-containing gas is supplied into the peripheral part of the furnace. This permits char produced within the gasification furnace to be selectively combusted, contributing to an improvement in conversion of carbon and cold gas efficiency. The slagging combustion furnace 2 is a swirling-type slagging combustion furnace.

**[0098]** The cylindrical fluidized-bed gasification furnace shown in FIG. 9 will be described in more detail. As shown in FIG. 9, a conical distributor plate 106 is disposed at the furnace bottom of the fluidized-bed gasification furnace 1. A

fluidizing gas supplied through the distributor plate 106 comprises a central fluidizing gas 207 which is supplied from a central portion 204 of the furnace bottom to the interior of the furnace as an upward flow, and a peripheral fluidizing gas 208 which is supplied from a peripheral portion 203 of the furnace bottom to the interior of the furnace as an upward flow. The central fluidizing gas 207 comprises an oxygen-free gas, and the peripheral fluidizing gas 208 comprises an oxygen-containing gas. The total amount of oxygen in all of the fluidizing gas is set to be 10% or higher and 30% or lower of the theoretical amount of oxygen required for combustion of materials such as wastes. Thus, the interior of the furnace 1 is kept in a reducing atmosphere.

**[0099]** The mass velocity of the central fluidizing gas 207 is set to be smaller than that of the peripheral fluidizing gas 208. The upward flow of the fluidizing gas in an upper peripheral region of the furnace is deflected toward a central region of the furnace by a deflector 206. Thus, a descending fluidized bed 209 of the fluidized medium (generally silica sand) is formed in the central region of the furnace, and an ascending fluidized bed 210 is formed in the peripheral region of the furnace. As indicated by the arrows 118, the fluidized medium ascends in the ascending fluidized bed 210 in the peripheral region of the furnace, is deflected by the deflector 206 to an upper portion of the descending fluidized bed 209, and descends in the descending fluidized bed 209. Then, as indicated by the arrows 112, the fluidized medium moves along the fluidizing gas distributor plate 106 and moves into a lower portion of the ascending fluidized bed 210. In this manner, the fluidized medium circulates in the ascending fluidized bed 210 and the descending fluidized bed 209 as indicated by the arrows 118, 112.

**[0100]** While the materials "A" supplied to the upper portion of the descending fluidized bed 209 by a metering feeder 101 descend together with the fluidized medium in the descending fluidized bed 209, the materials are volatilized with heating by fluidized medium. Because there is no or little oxygen available in the descending fluidized bed 209, volatile matter (generated gas) generated by pyrolysis is not combusted and passes through the descending fluidized bed 209 as indicated by the arrows 116. Consequently, the descending fluidized bed 209 is a gasification zone G. The volatile matter moves into a freeboard 107 as indicated by the arrow 120, and is discharged from a gas outlet 108.

**[0101]** Char (fixed carbon) and tar produced in the descending fluidized bed 209 moves together with the fluidized medium from the lower portion of the descending fluidized bed 209 to the lower portion of the ascending fluidized bed 210 in the peripheral region of the furnace as indicated by the arrows 112, and is partially oxidized by the peripheral fluidizing gas 208 having a relatively large oxygen concentration. Consequently, the ascending fluidized bed 210 forms an oxidization zone S. In the ascending fluidized bed 210, the fluidized medium is heated by the heat produced when char (fixed carbon) is oxidized. The heated fluidized medium is turned over by the deflector 206 as indicated by the arrows 118, and transferred to the descending fluidized bed 209 where it serves as a heat source for volatilization. In this manner, the fluidized bed 209 is kept at a temperature ranging from 400 to 1000°C, preferably from 400 to 600°C. A ring-shaped incombustibles discharge port 205 is formed at the peripheral portion of the furnace bottom of the fluidized-bed gasification furnace 1 for discharging the furnace-bottom residue.

**[0102]** In the fluidized-bed gasification furnace 1 shown in FIG. 9, the gasification zone G and the oxidization zone S are formed in the fluidized bed, and the fluidized medium circulates in both zones. Because the fluidized medium serves as a heat transfer medium, combustible gas having a high heating value is generated in the gasification zone G, and char and tar which are difficult to be gasified is combusted efficiently in the oxidization zone S. Consequently, gasification efficiency of materials can be improved and combustible gas (pyrolysis gas) having a good quality can be generated.

**[0103]** The gas outlet 108 of the fluidized-bed gasification furnace 1 is connected to a gas inlet 131 of a slagging combustion furnace 2 through a duct 109.

**[0104]** Next, the slagging combustion furnace will be described in more detail. The slagging combustion furnace 2 includes a cylindrical primary combustion chamber 115a having a substantially vertical axis, a secondary combustion chamber 115b which is slightly inclined to the horizontal direction, and a tertiary combustion chamber 115c disposed downstream of the secondary combustion chamber 115b and having a substantially vertical axis. A slag discharge port 142 is provided between the secondary combustion chamber 115b and the tertiary combustion chamber 115c. Up to the slag discharge port 142, most of ash is slagged and discharged through the slag discharge port 142. The molten slag discharged from the slag discharge port 142 flows into a slag formation apparatus 3 (see FIG. 1), where the molten slag is brought in contact with water to form granulated slag. The produced gas is supplied into the swirling-type slagging combustion furnace in the tangential direction so that a swirling flow of the gas is created within the primary combustion chamber 115a. The produced gas supplied into the swirling-type slagging combustion furnace forms a swirling flow, and solid matter contained in the gas is trapped on the circumferential inner wall surface under a centrifugal force. Therefore, advantageously, the percentage of slagging and the percentage of slag collection are high, and slag mist is less likely to be scattered.

**[0105]** Oxygen is supplied into the swirling-type slagging combustion furnace through a plurality of nozzles 134 so as to properly maintain the temperature distribution in the furnace. The temperature distribution is regulated so that the decomposition of hydrocarbons and the slagging of ash are completed in the primary combustion chamber 115a and the secondary combustion chamber 115b. When oxygen is solely supplied, for example, there is a fear of a nozzle being

burned. Therefore, oxygen is diluted with steam or the like before supplying, as necessary.

**[0106]** The slag flows down on the lower surface of the secondary combustion chamber 115b, is discharged as molten slag 126 through the slag discharge port 142, and then flows into the slag formation apparatus 3 (see FIG. 1) where the slag is brought in contact with water to form granulated slag. The third combustion chamber 115c serves as a buffer zone which prevents the slag discharge port 142 from being cooled by radiational cooling from a waste heat boiler provided downstream of the tertiary combustion chamber 115c. An exhaust port 144 for discharging exhaust gas is provided at the upper end of the tertiary combustion chamber 115c, and a radiation plate 148 is provided on the lower part of the tertiary combustion chamber 115c. The radiation plate 148 serves to reduce the quantity of heat emitted through the exhaust port 144 by radiation. Reference numeral 132 denotes a start-up burner, and reference numeral 136 denotes a stabilizing burner. Exhaust gas in the slagging combustion furnace 2 is discharged through an exhaust port 144, and then cooled to 650°C or below in a waste heat boiler or the like.

**[0107]** As described above, according to the present invention, a fluidized medium is recovered by screening a furnace-bottom residue produced in a fluidized-bed gasification furnace, and is then returned to and reutilized in the fluidized-bed gasification furnace. Metals, such as iron, aluminum, brass and copper, contained in the furnace-bottom residue are recovered and reutilized as resources.

**[0108]** Nonmetals are processed by three methods whose advantages in respective aspects will be described below.

**[0109]** The first aspect of the present invention offers the following advantages:

**[0110]** Nonmetal matter is rubbed with one another to remove contaminants adhered on the surface thereof, and the nonmetals from which the contaminants are removed are effectively utilized as an aggregate or the like. Since the contaminants are removed by dry process, a problem associated with waste water treatment can be eliminated, and the total system can be simplified.

**[0111]** The nonmetal component is recovered as resources in the following manner: It is desirable that after the removal of the surface contaminants, the nonmetal component is crushed, and the crushed product is utilized as an fine aggregate. In many cases, nonmetals only after removal of the surface contaminants are flat. The use of this material as a coarse aggregate results in low solid volume percentage (percentage of net aggregate in unit volume (one cubic meter)), poor solidification, and poor applications. Examples of applications of nonmetals include fine aggregates for asphalt mixtures, interlocking blocks, and embedding materials.

**[0112]** The second aspect of the present invention offers the following advantages:

**[0113]** Nonmetals are crushed, fine particles are removed from the crushed product, and the crushed product is effectively utilized as aggregates or the like. As with the first aspect of the present invention, in the second aspect of the present invention, since the contaminants are removed by a dry process, a problem associated with waste water treatment can be eliminated, and the total system can be simplified.

**[0114]** The recycling of nonmetals in the first aspect of the present invention holds true for the second aspect of the present invention.

**[0115]** The third aspect of the present invention offers the following advantages:

**[0116]** Nonmetals are powdered, and the powdered nonmetals are carried by a gas stream together with fly ash in the fluidized-bed gasification furnace to the slagging combustion furnace where the nonmetal powder is converted into a molten slag which is then effectively utilized as aggregates or the like.

**[0117]** Thus, a furnace-bottom residue produced in the fluidized-bed gasification furnace can be recycled as resources by a safe and simplified system. Nonmetals are recycled as resources in the following manner: The nonmetal component can be converted into molten slag and effectively utilized, and applications of the slag are the same as those in the first and second aspects of the present invention. In the first and second aspects of the present invention, the nonmetal component is a mixture of stone, glass, earthenware and the like. However, in the third aspect of the present invention, by virtue of its constitution, the nonmetal component is recycled in a homogeneous state.

**[0118]** Although certain preferred embodiments of the present invention have been shown and described in detail, it should be understood that various changes and modifications may be made therein without departing from the scope of the appended claims.

## Claims

1. A method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace comprising a fluidized-bed gasification furnace and a slagging combustion furnace provided downstream of said fluidized-bed gasification furnace, comprising:

recovering a fluidized medium by screening a furnace-bottom residue produced in said fluidized-bed gasification furnace and transferring the recovered fluidized medium to said fluidized-bed gasification furnace where the fluidized medium is reused;

separating and recovering a metal component from the furnace-bottom residue; and  
utilizing a nonmetal component after matter comprising said nonmetal component is rubbed with one another to remove contaminants from the surface of said matter.

- 5    2. A method according to claim 1, wherein said matter comprising said nonmetal component is rubbed with one another in a grinding mill.
- 10    3. A method according to claim 1 or 2, wherein said nonmetal component after the removal of the surface contaminant is screened to separate the nonmetal component into fine particles and nonmetals other than said fine particles, and said fine particles are returned to said fluidized-bed gasification furnace, while said nonmetals other than said fine particles are utilized.
- 15    4. A method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace comprising a fluidized-bed gasification furnace and a slagging combustion furnace provided downstream of said fluidized-bed gasification furnace, comprising:
 

recovering a fluidized medium by screening a furnace-bottom residue produced in said fluidized-bed gasification furnace and transferring the recovered fluidized medium to said fluidized-bed gasification furnace where the fluidized medium is reused;

20    separating and recovering a metal component from the furnace-bottom residue; and  
utilizing a nonmetal component after removing by a screen a powder component contained inherently in said nonmetal component and a powder component produced upon crushing of said nonmetal component.
- 25    5. A method according to claim 4, wherein said powder component removed by said screen is returned to said fluidized-bed gasification furnace.
- 30    6. A method according to claim 4 or 5, wherein the separation of said metal component is carried out by subjecting said furnace-bottom residue to magnetic separation and nonferrous metal separation, and the separated nonmetal component is then crushed.
- 35    7. A method according to claim 4, wherein the separation of said metal component is carried out by subjecting the furnace-bottom residue to magnetic separation, the remainder after the separation of said metal component is then crushed, and nonferrous metals remaining uncrushed and having ductility are recovered by a screen as oversize material while nonmetals are recovered as undersize material.
- 40    8. A method for processing a furnace-bottom residue produced in a gasification and slagging combustion furnace comprising a fluidized-bed gasification furnace and a slagging combustion furnace provided downstream of said fluidized-bed gasification furnace, comprising:
 

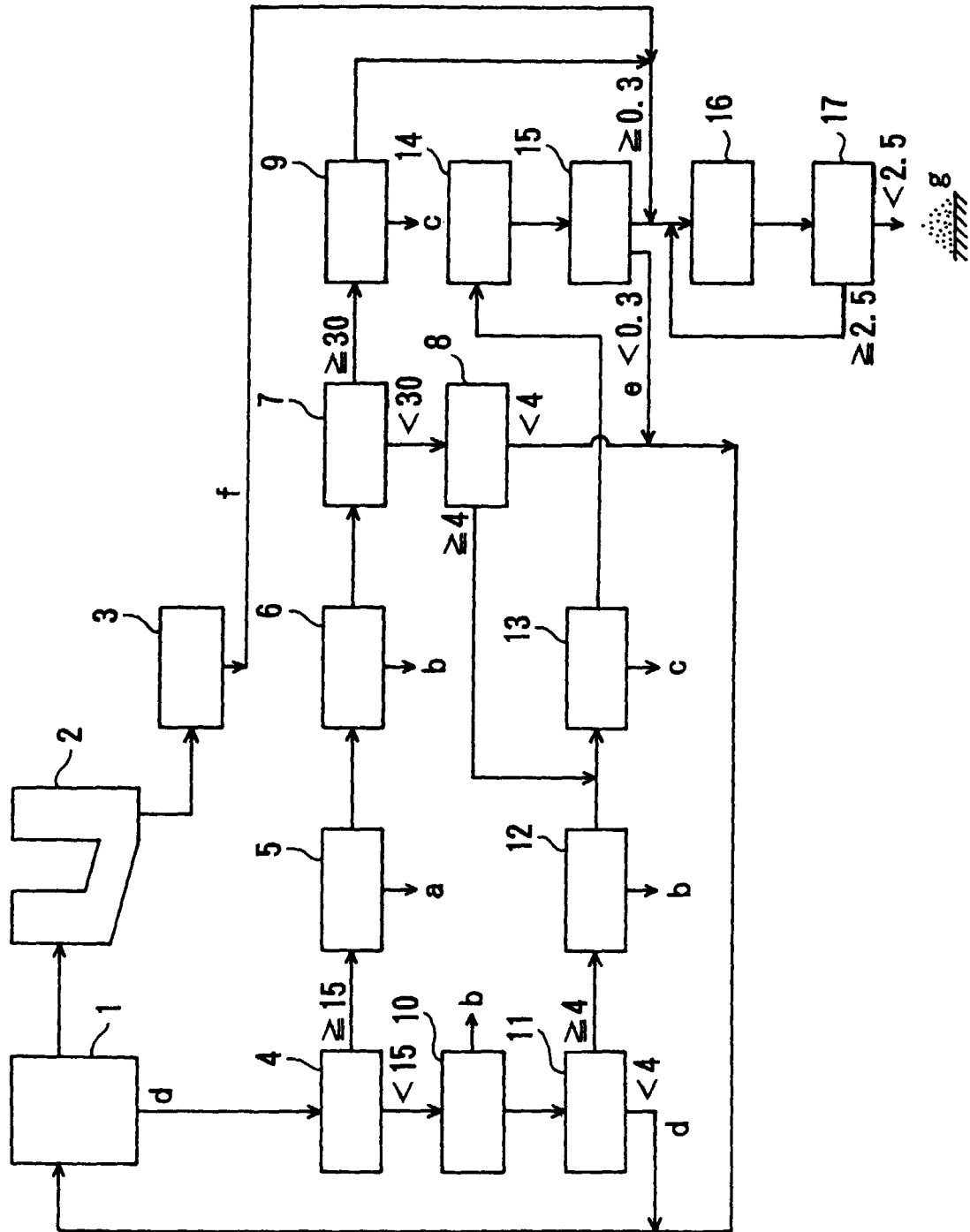
recovering a fluidized medium by screening a furnace-bottom residue produced in said fluidized-bed gasification furnace and transferring the recovered fluidized medium to said fluidized-bed gasification furnace where the fluidized medium is reused;

45    separating and recovering a metal component from the furnace-bottom residue; and  
crushing a nonmetal component in said furnace-bottom residue to produce powder, transferring the produced powder to said fluidized-bed gasification furnace, and then transferring said powder, together with fly ash, with the aid of a gas stream in said fluidized-bed gasification furnace, to said slagging combustion furnace where slagging is performed.

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FIG. 1



**F / G. 2**

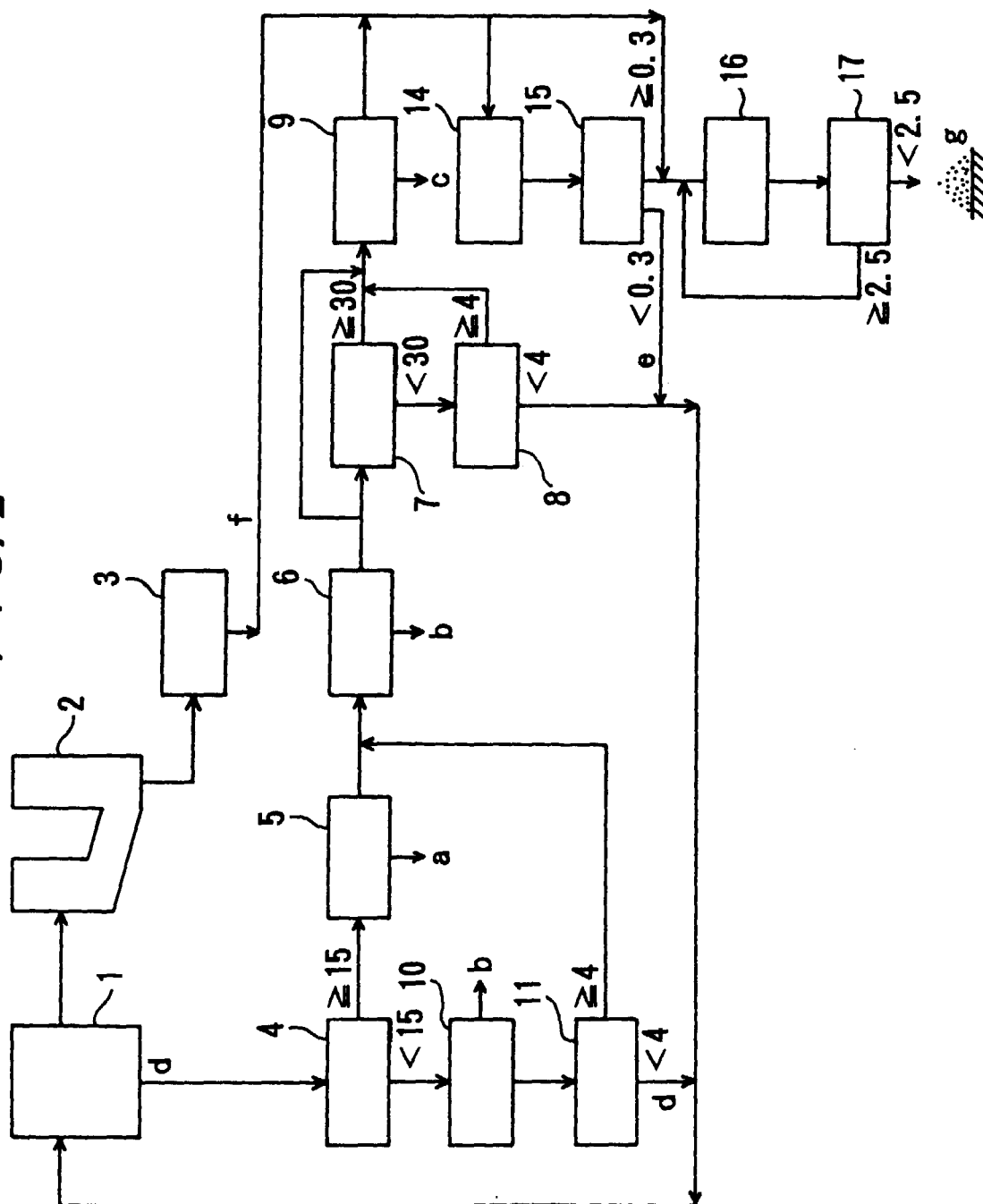
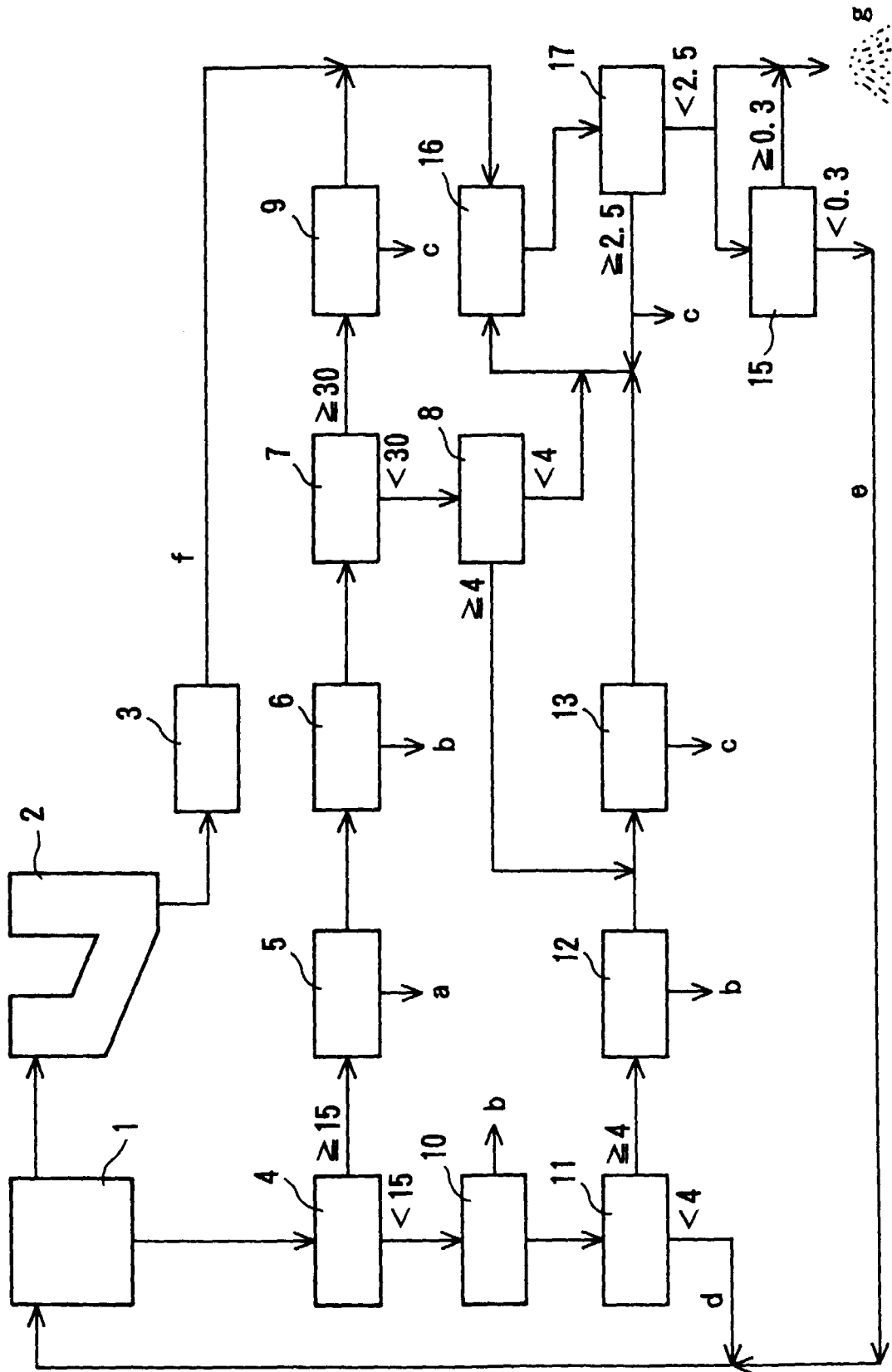


FIG. 3



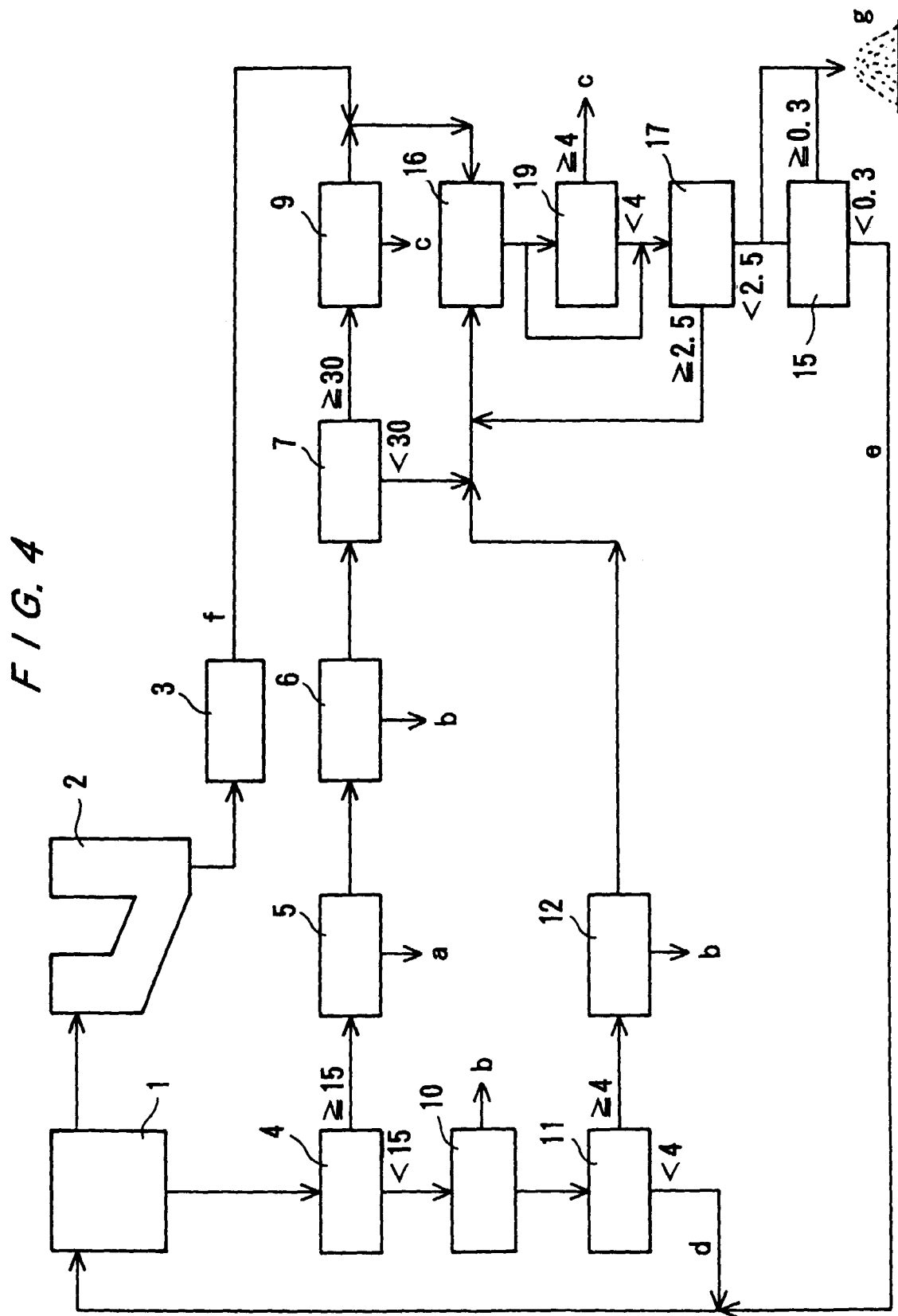
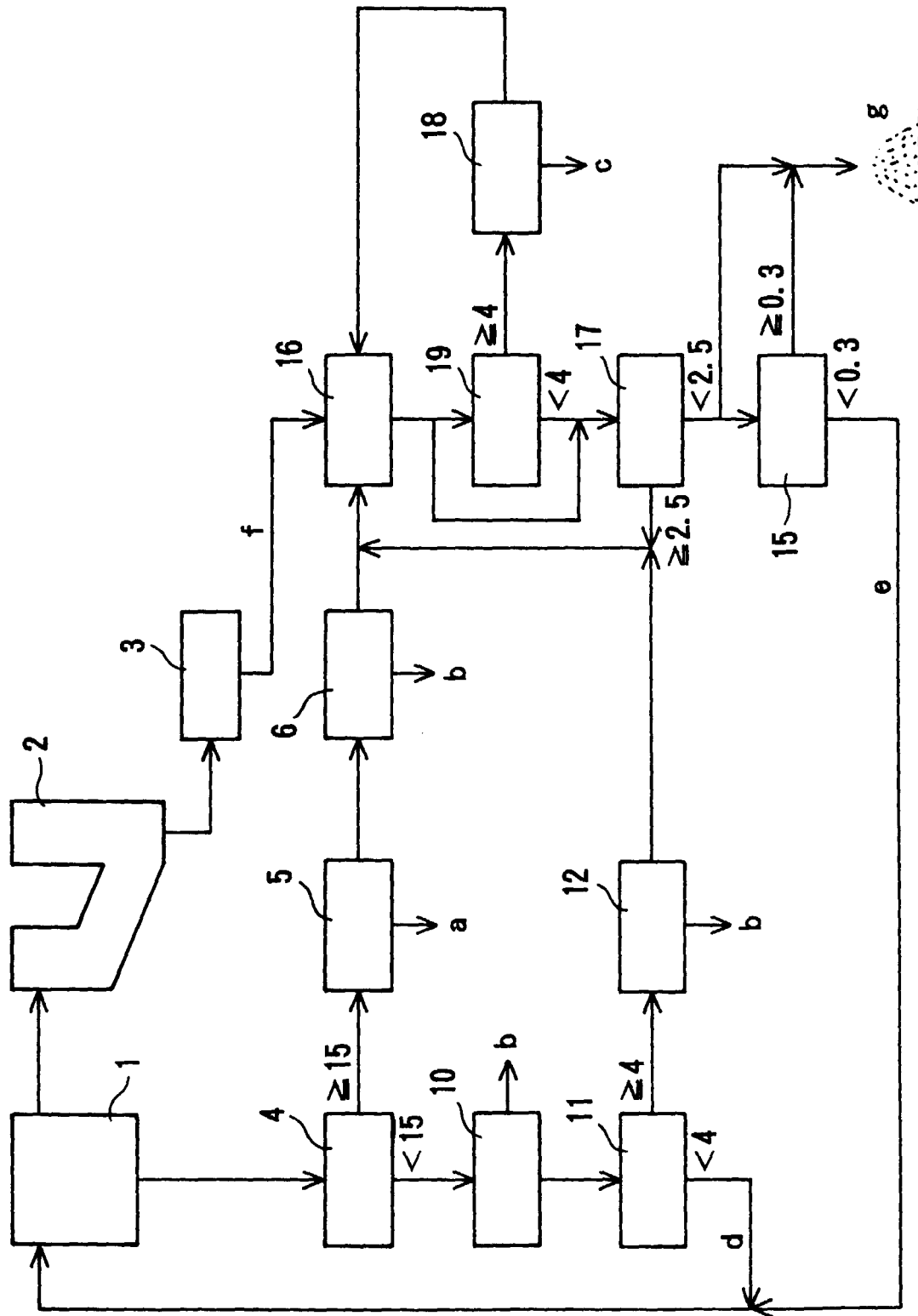


FIG. 5





**FIG. 7**

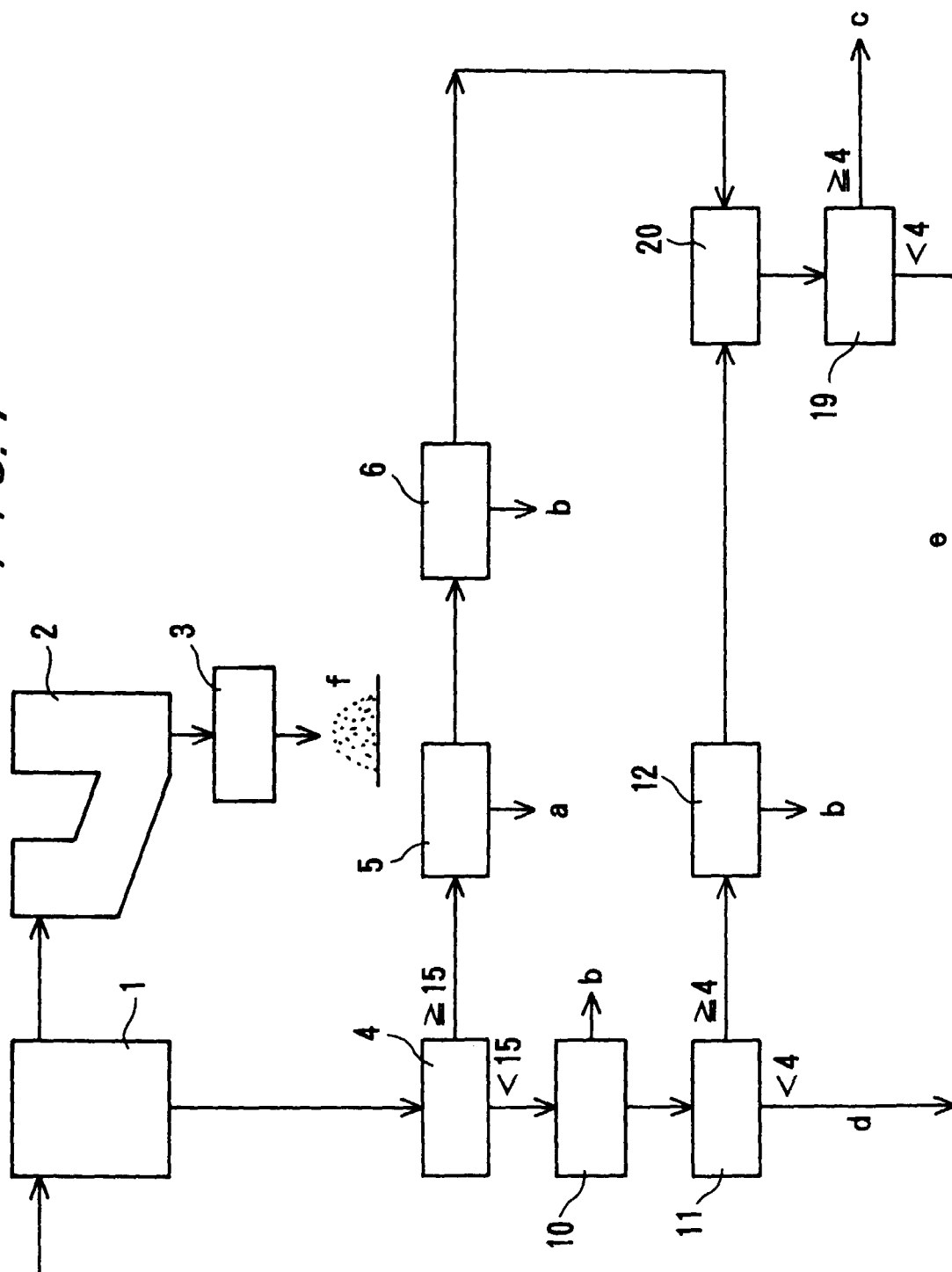


FIG. 8

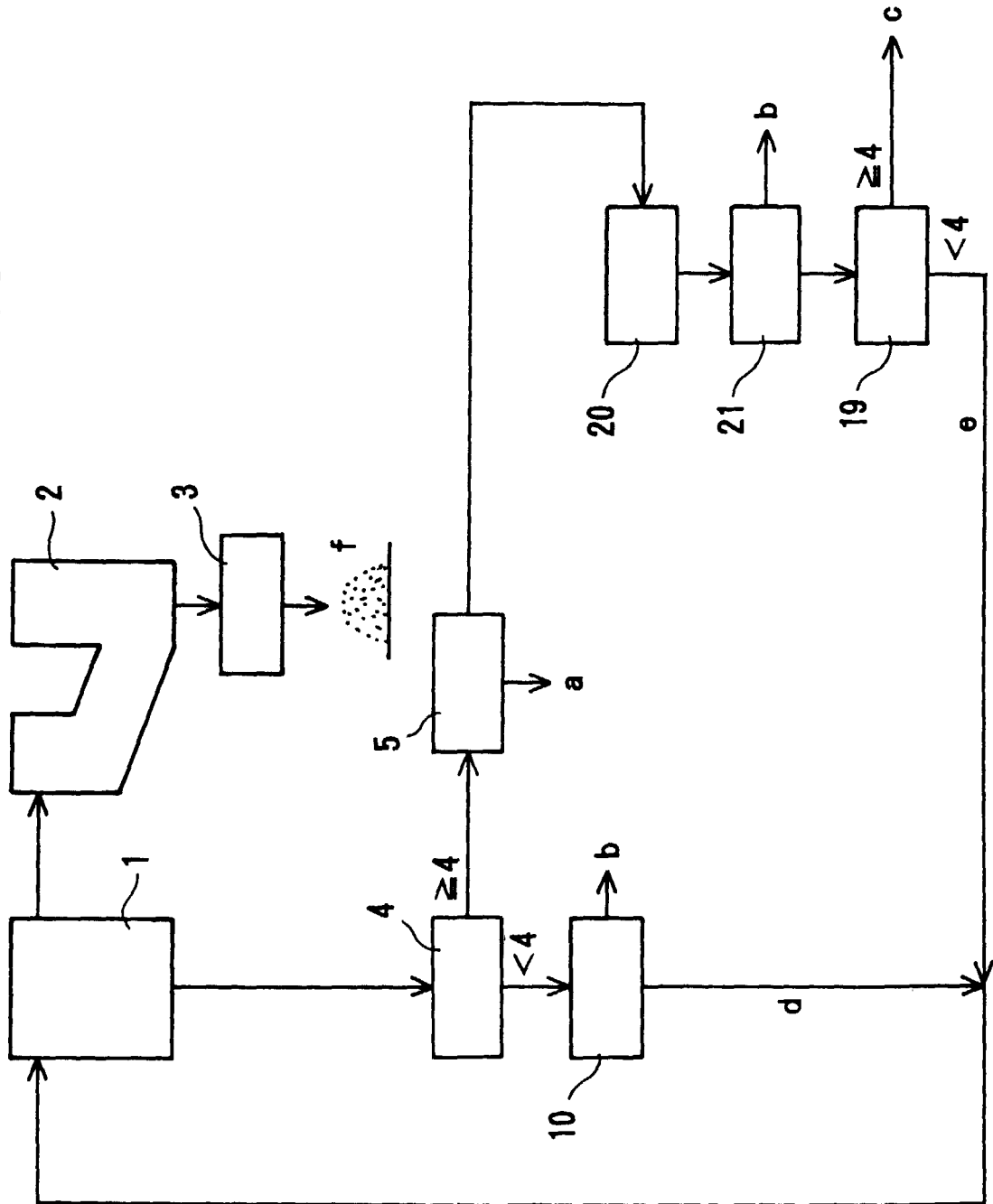
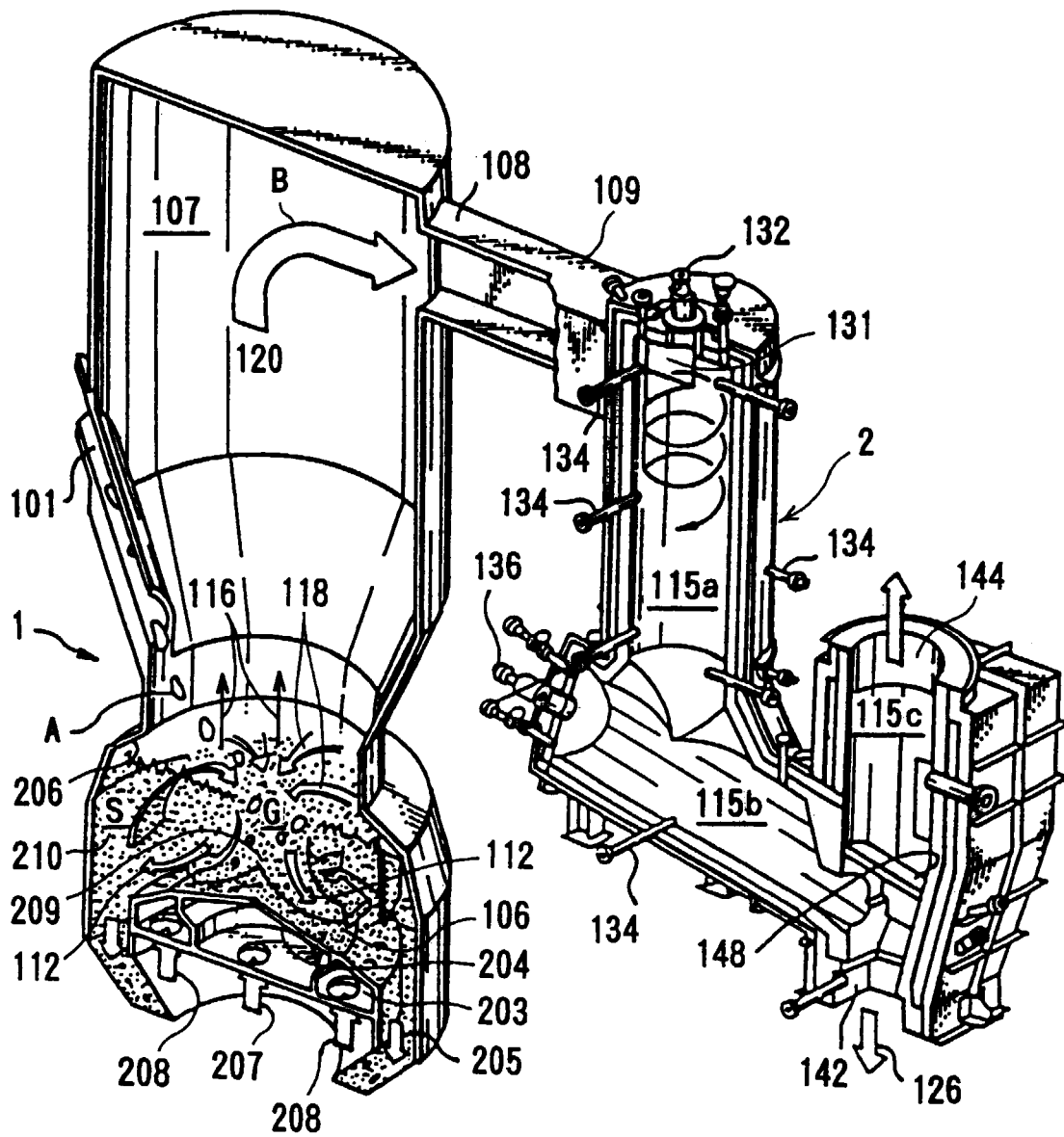


FIG. 9





European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 00 11 7221

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                              |                                                            |                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                                                                | Relevant to claim                                          | CLASSIFICATION OF THE APPLICATION (Int.C1.7)   |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EP 0 676 464 A (EBARA CORP)<br>11 October 1995 (1995-10-11)<br>* page 11, line 21 - line 47 *<br>* page 12, line 26 - line 31 *<br>* figures 5,9 *                                                           | 1,4,5,8                                                    | F23C10/26<br>F23C10/10<br>C10J3/52<br>C10J3/54 |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | GB 2 026 144 A (BABCOCK AG)<br>30 January 1980 (1980-01-30)<br>* page 1, line 22 - line 33 *<br>* page 2, line 74 - line 93 *<br>* figures 1,4 *                                                             | 4-6,8                                                      |                                                |
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Application Number  
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