

(54) Title: SYSTEM AND METHOD FOR GENERATION OF ELECTRICITY FROM SOLID MUNICIPAL WASTE

System and method for generation of electricity from solid municipal waste**Field of Invention**

This invention relates to a system and novel method for generation of electricity from solid waste, more particularly an integrated system for preparing combustible fuel from Municipal solid waste and utilizing the said fuel to generate electricity.

Background information:

Municipal solid waste is a pollutant posing Public health hazard. The process of extraction of energy from waste also ensures de-polluting of waste and thus eliminates the health hazard posed by waste.

Municipal solid waste has dormant energy in it. It also contains pollutants. Energy recovery from waste involves combustion of waste to release heat energy, absorption of heat energy in water to form steam, and to use steam to drive turbo-generator set to generate electricity.

Since the waste comprises of many things, separating the unwanted and other things, which cause pollution is a laborious and difficult process. Combustion process releases pollutants in the waste gas stream, which pollutes the atmosphere posing a great public health hazard. Therefore the gas needs to be cleaned of all pollutants before releasing to the atmosphere. The prepared fuel for combustion should be free from pollution during combustion.

Therefore it is an object of the present invention is to provide a system and method for generation of electricity from solid municipal waste.

Another object of the present invention is to provide a safe system dispensed with pollution.

Still another object of the present invention is to provide a method for preparing the combustible fuel for generating electricity from municipal waste.

Yet another object of the present invention is to provide a safe and efficient process for generation of electricity.

Summary of the invention:

Accordingly, first embodiment of the present invention provides a system for generation of electricity from solid municipal waste.

Another embodiment of the present invention is to provide a method for generation of electricity from solid municipal waste.

Yet another embodiment of the present invention is to provide a safe system substantially dispensed with pollution.

Still another embodiment of the present invention is to provide a method for preparing the combustible fuel for generating electricity from municipal waste.

Further embodiment of the present invention is to provide a safe process substantially dispensed with pollution.

Another embodiment of the present invention is converting waste into an useful energy resource.

Still another embodiment of the present invention is to provide an efficient method for generating electricity from waste that solves the problem of disposing waste.

Yet another embodiment of the present invention is to provide a system and method for generating electricity and the energy generated in the form of electricity is energy from renewable source and thereby does not contribute to greenhouse effect.

Further embodiment of the present invention is to provide a welcome substitute for energy from fossil fuels, which is a depleting resource.

Another embodiment of the present invention is to provide a method of disposal of Waste is achieved in an environment friendly manner with resource recovery.

Still another embodiment of the present invention is to provide the technology that produces three kinds of successive/concurrent effects such as energy production from non-depleting resource, contributes to maintaining Ecological balance, and environment friendly.

BRIEF DESCRIPTION OF DRAWINGS

The accompanying drawings are intended to provide further understanding of invention and are incorporated in and constitute a part of invention. The drawings illustrate an embodiment of invention and together with the description illustrate principle of invention. The drawings should not be taken as implying any necessary limitation on the essential scope of invention. The drawings are given by way of non-limitative example to explain the nature of the invention. For a more complete understanding of the instant invention reference is now made to the following description taken in conjunction with accompanying drawings.

The various feature of novelty, which characterizes the invention are pointed out specifically in the claims which are part of description. For a better understanding of the invention, its operating advantage, specific objects obtained by its use,

reference should be made to the drawings and descriptive matter in which there are illustrated and described preferred embodiments of invention.

Referring now to drawings, where like numerals designate identical or corresponding parts throughout the referred views.

Fig.1: of the drawing illustrates the various steps involved and their sequence in the process of power generation from Municipal waste.

Fig.2: of the drawing illustrates the bag splitter for slitting the bags and open up the waste.

Fig.3: of the drawing illustrates the various methods involved in segregating and removing different substances from the waste.

Fig.4: of the drawing illustrates the method adopted for removal of ferrous metals from the waste.

Fig.5: of the drawing illustrates the method adopted for moisture reduction of the waste by hot air drying.

Fig.6: of the drawing illustrates shredder for size reduction of the waste

Fig.7: of the drawing illustrates the air classification system for removal of PVC and other non-combustibles.

Fig.8: of the drawing illustrates the power generation system from combustibles as fed in to the boiler and the use of extraction steam for waste drying adopting the principle of co-generation and thereby increasing the overall thermal efficiency of the system of power generation from waste.

Fig.9: of the drawing illustrates the furnace configuration and control of operating parameters for achieving Dioxin free and low NO_x gas stream.

Fig.10: of the drawing illustrates the removal of acid gases, heavy metal vapours, dust etc from the gas stream in the post combustion phase and enable release of clean gas in to the atmosphere through the chimney.

The foregoing description is outlined rather broadly preferred and alternative feature of the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features of the invention will be described hereinafter that form the subject of claims of the invention. Those skilled in the art should appreciate that they can readily use the disclosed conception and specific embodiment as a basis for designing and modifying other structures for carrying out the same purposes of the present invention. Those skilled in the art should realize such equivalent conception do not depart from the spirit and scope of the invention in its broadest form.

Detailed description:

Fig., 8, & 10, of the drawing illustrating various steps and the means involved in the process of power generation from municipal waste.

- a. Isolation of combustibles wherein the combustibles are isolated from the municipal solid waste,
- b. Elimination of pollutants, pollutions are eliminated in this invention
- c. Preparation of feed stock wherein the feed stock is a combustible fuel.
- d. Feeding the feed stock into a combustion chamber of a boiler
- e. Combustion is a controlled combustion
- f. Dust is removed using filter
- g. Acid is removed by neutralizing with alkali.

- h. Heavy metals are removed by absorption in activated carbon
- i. Denox
- j. Final polishing, Removal of remnant pollutants by activated carbon
- k. Discharge of Clean gas
- l. Steam generation utilizing the heat generated in the boiler
- m. Power generation in Co-generation mode.

Fig. 3,4,7 illustrates segregation process used in the manufacture of combustibles are as follows:

From the waste input initially Organics are removed by screening and sent for bio-gas generation. Large size plastics and paper are removed for recycling. Ferrous metals are removed by using magnetic separators. subsequently fine particles are separated by filtration. Subsequently PVC and other non combustible solids are separated by differential density in the air classification system. Hot air drying reduces the moisture content of the waste.

Fig. 5,6 of the drawing illustrates preparation of feedstock consisting of the following steps. Blowing hot air into the waste in rotary driers reduces the moisture content of the waste input. Dried wastes are subjected to a process of size reduction by shredding, leading to form feedstock for combustion.

Figure 7 shows the air classification system, wherein the principle of differential density is used to segregate and drop down solid non combustibles and lift up lighter combustible matter and pneumatically convey and collect separately.

Figure 8 shows the power generation system using waste as the raw material.

This consists of various steps

- a. Combustible fuel is fed into the boiler for combustion.
- b. Hi-pressure steam generated in the boiler is fed into the turbine, which drives generator leading to power generation.

- c. Another end of the turbine is connected to a condenser, which in turn is connected to a cooling tower, with cooling water circulation and vacuum is maintained in the condenser.
- d. In another end of the condenser, the condensate is collected and recycled to the boiler through a hot well, and de-aerator and a feed water pump.
- Part of the steam is extracted from the turbine at low pressure and fed into air heater to generate hot air for waste drying. This is the principle of co-generation and it increases the overall thermal efficiency of the power generation cycle.
- The invention broadly relates to preparation of combustible fuel from Municipal waste and energy recovery through steam and power generation.

Figure 9 of the drawing shows the combustion process in a special furnace with combustibles as input. The combustibles are spread on a travelling grate. The preheated air at 100 C approximately is supplied to the grate from below. The ash content is collected at the other end of the grate. The combustion chamber has a secondary combustion zone wherein a complete combustion takes place. The secondary zone is kept at a temperature above 1000 C for the purpose of complete combustion. Dioxin & Furon formed in the combustion zone are destroyed and neutralized, by giving sufficient time for gas to go up in the chamber at about 950 C temperature. At the superheater the gas temperature is maintained at less than 630 C to avert corrosion of Superheater tubes due to the chance presence of chlorine in the gas.

Figure 10 of the drawing shows the gas cleaning system. The flue gas from boiler is subjected initially to lime injection and further by activated carbon injection and the output gas is allowed to pass through a bag filter.

The output of the bag filter is the clean gas, which is discharged to the atmosphere. Clean gas means the gas that is generated during combustion is subjected to lime, charcoal treatment and filter to obtain the gas substantially free

from acidic gases and heavy metals. The residue of the bag filter is collected at one end for disposal.

The gas cleaning system comprising lime injecting means to remove the acidic gas informed during combustion; activated carbon injecting means is provided to remove heavy metals; and bag filter to filter the dust from the treated gas received after lime and activated carbon treatment and before discharging the said treated gas to the atmosphere wherein the output from the bag filter is substantially clean gas, the residue of the bag filter is collected at one end for disposal.

Preparation of Combustible Fuel:

Municipal solid waste is treated in a series of processes as described below to produce the combustible fuel for combustion in a steam boiler to generate steam. The waste that comes in bags and in loose form is first subjected to a bag splitting operation wherein the bags are opened and the waste is loosened. Then the opened up waste is subjected to the process of screening in a multi-segmented screen wherein the wet organics are separated, the middle size material is passed on to the next process of metal separation and the oversize material is diverted for recovery of recyclables. The wet organics are sent for anaerobic digestion for recovery of methane rich biogas to be used as fuel for energy recovery and the slurry residue for treatment to produce compost. The oversize material mainly consists of large size plastics, paper, cardboard and textile and are recycled to recover economic value.

The middle size material passes on to the next process of metal recovery. Ferrous material is separated by magnetic separation and non-ferrous metals like aluminium, copper etc. are separated by eddy current separators at a later stage.

Moisture reduction in the waste is achieved by hot air drying. After drying, the size reduction of waste is achieved by shredding process.

The waste after drying and shredding passes on to the next process of air classification wherein the light combustibles are lifted and dropped in to a bunker as the **combustible fuel** for use in the steam boiler for generation of steam, and the heavy materials like glass, ceramics, stones, etc are dropped on the rejects conveyor for disposal.

Apparatus for making combustible fuel:

Bag splitting unit : The bag splitter is of a unique design having two shafts arranged in parallel with flower shaped cutters on each overlapping in to the space between the cutters of the other shaft. The shafts are run at pre-determined differential speeds. As waste in bags and loose form is dropped on these cutters, the waste in loose form passes down through the cutters and the bags are held on the slow running cutters while the fast running cutters cut through the bags, open them and the loosened waste fall down through the cutters.

Multi-segment screening unit: This is a rotary screen built in sections. The first section has apertures around 100 mm dia . The second section has apertures around 180 mm dia. The third section has apertures 250 mm dia. The rotating screen is placed at 2 deg inclination towards the exit end. Flights are provided in the drum which lift the waste to the top and drop when the drum rotates. At every rotation of the drum the waste when dropped from the top inches forward towards the exit end as the drum is inclined towards the exit end. When waste transits section 1, wet organics are screened through the apertures and conveyed for further processing in anaerobic digesters.

As the waste moves ahead to the section 2, bulk of the waste get screened here and drop on to a conveyor and transported to the next process of metal separation.

In section 3, mini-bags which escaped opening up in the bag splitter get screened drops through the apertures on to a mini- splitter and the opened up waste drops on the conveyor carrying the waste to the metal separators.

The large size plastics, paper etc. which do not get screened moves on to the exit end of the drum and drop on a conveyor which carries the material to recycling area for sorting and recycling.

Metal Separation unit : This is done in two stages by two different devices. The waste drops from the carrying conveyor in a cascade on a drum magnet wherein the drum surface is magnetized and ferrous particles adhere to the surface of the drum and get carried to the bottom of the drum which is de-magnetised and therefore drop down in to a receptacle, while the waste drops down vertically from the drum on to a conveyor and move forward. The second stage magnetic separator is a non-contact type. An over band magnetic conveyor or suspended magnet placed across the transporting conveyor pulls up any ferrous metal from the conveyor and drops it on a receptacle on the side of the transporting conveyor. This double magnetic separation ensures total removal of ferrous metals.

Drying unit: After magnetic separation the transporting conveyor feeds the waste in to a Rotary Drier. This equipment is a long drum with flights inside to carry the waste up and drop from top when rotating. As the drum is also placed inclined towards the exit end, the waste inches forward every rotation towards the exit end. Hot air is blown from the exit end and the dropping waste is exposed to the counter current hot air flow and gets dried. The moisture laden hot air which is at lower temperature at around 70-80 deg. C exits through the entry end of the drum. The waste having transited through the length of the drum

and getting partially dried, drops at the exit end of the drum on a conveyor for carrying to the next process.

The moisture laden hot air is partially exhausted in to the atmosphere through a bag filter to arrest any carry over waste material. The balance air joins the fresh air stream of a blower and gets recycled in to the hot air system. The blower blows the air through a heat exchanger to get the hot air temperature to the required level of 180 Deg. C.. before passing on to the drum for drying the waste. Hot air flow is controlled by damper control depending on the wetness of the incoming waste. By partial recycling of hot air, energy used for drying the waste is minimized.

Steam is used as the heating medium for generating the hot air. The heat exchanger is of composite construction consisting two heaters placed in tandem. The first one uses Low Pressure extraction steam drawn from the turbine and heats the air to around 115 deg C. The second heater further raises the air temperature to 180Deg. C. using High Pressure steam drawn from the boiler. By utilizing the extraction steam from the turbine after it has generated power, the residual heat in the steam is used for drying waste. In this co-gen mode of operation of the power plant the entire heat energy in the steam is utilized for power generation and drying of waste, thus increasing the overall thermal efficiency of the system resulting in minimizing operating cost.

Shredding unit : In the drying process the waste gets sterilized by exposure to high temperature and becomes Bio-Inert. Handling waste at this stage is not hazardous to human health. The waste coming out of the Drier is subjected to manual picking of unwanted items like Shoes, broken toys, small electronic items, etc. before it is fed in to shredders for size reduction.

The shredder consists of single or twin shaft mounted with flail cutters. The cutter blades have an arm with a hammer head with sharpened edges. These blades are mounted on 4 cutter shafts. The blades are free to swing within an arc of 60 deg. Enabling the blades to swing back when some hard material comes in and thus avert damage. The incoming waste after getting cut drops

through a grid with pre-determined spaces to meet the required size reduction of the waste. The speed of the shredder could also be varied as required by the waste composition.

The waste from here is transported to the second stage drying and shredding system. This system is exactly similar to the first stage system described above. By providing two stage system final product moisture content and size are precisely controlled as desired.

Air Classification unit : This system consists of a suction chamber, Tangential separator, suction fan and bag filter. The shredded material is dropped in to a vertical column of suction air created by the suction fan. Here the heavy items like stones, glass pieces, ceramics PVC, non-ferrous metal pieces wet organics, etc. drop down on the rejects conveyor and the light weight material like polyethylene, paper, textile pieces, dried organics, etc. are lifted up by the upward stream of air and enter the tangential separator at a pre-determined velocity. This is a round shaped equipment with suction pipe from the fan connected to one side. As the air stream carrying the material enters this equipment tangentially, the material moves along the round surface down. At the bottom of this equipment is an opening and the material stream when it reaches this point, the solid material drops down into a rotary valve and the air is sucked through the suction pipe connected to the suction fan. The rotary valve seals this equipment which is under suction from the atmosphere and delivers the material to the bunker for holding this

Combustible fuel:

The suction fan passes the air to the atmosphere through a bag filter to trap any carry over material.

The heavies that drop on the rejects conveyor cascades down on an eddy current separator drum. This device induces a repelling magnetic force on the non-ferrous metals and jerks them out of the cascade in to a receptacle for disposal as by-product.

The balance material on the rejects conveyor is sent to landfill.

Energy Recovery through Steam and power generation

Power generation from waste involves the following steps in order to prevent environment degradation by discharge of pollutants.

Pollution control is effected in three phases, pre-combustion phase, combustion phase and post combustion phase.

Pre-combustion phase

In the pre-combustion phase, waste is prepared for combustion in the form of combustible fuel. In the fuel preparation stage, excess moisture in the waste is reduced to the required level by hot air treatment to ensure high efficiency of steam generation. Substances like PVC which are potential pollutants during Combustion and cause Dioxine formation are taken out in the air classifier. Batteries with Heavy metals which cause heavy metal vapor Presence in the waste gas are also taken out in the air classifier. Wet organics which contain heavy metals are also removed and delivered for anaerobic digestion process. Metals are removed. Waste is shredded to proper size to facilitate good combustion. Waste is thus prepared as feedstock to the furnace for combustion.

Combustion phase

Here, the furnace configuration and operating parameters are designed to meet the specific requirement of combustion control.

The combustibles are spread on a traveling grate and move forward. Primary air which is preheated is supplied from under the grate in separate compartments with individual controls to enable air supply control in various zones as the fuel

moves forward. In the first zone volatiles are released and the second zone solids burn and maintain the heat for volatilization. In the third zone solids burning completes and the fourth zone ash formation completes and it discharges in to bottom ash hopper. The primary combustion zone just above the grate is kept as a reducing zone and at temperatures less than 650° C. in order to minimize formation of (Nitrous Oxide) Nox, which is a pollutant. In order to maintain the temperature at this level, provision is made for mixing flue gas from the chimney at 140 degree C and bring down the temperature. As the volatiles go up secondary air which is also pre-heated is injected across to create turbulence, mix with volatiles and burn creating temperature above 1000 ° C. Here Combustion gets completed.

As a precautionary step, the design of the furnace provides for minimum 2 seconds residence time for gas at temperatures above 950 deg C. This will enable destruction of Dioxin in case it is formed due to chance presence of organic chlorine in the feedstock, although care has been taken to remove PVC, the main source of organic chlorine during the fuel preparation stage.

Any excess formation of NOx during combustion will be neutralized by injection of ammonia in the flue gas after combustion.

Thus furnace design and controlled operating parameters ensure combustion of waste without releasing pollutants like NOx and Dioxin in the waste gas.

However, Any chance presence of heavy metals like mercury, cadmium lead etc in the feedstock will lead to presence of heavy metal vapor in the gas stream. In addition acid gases like Sox (Sulphurous acid) and HCL (Hydrochloric acid) are also likely to be present in the gas stream due to the presence of sulphur, chlorides etc in the feedstock. These pollutants will be removed in the post combustion phase.

Membrane wall with steaming tubes form the four walls of the furnace. As the flue gas moves up the furnace, it loses heat by radiation to the membrane wall for steam generation and in this process its temperature is reduced.

By maintaining gas temperature less than 630 Deg C. at the super heater zone, tube corrosion due to presence of chlorine in the gas is minimized and life of Super heater tube increased greatly.

Post Combustion phase.

Acid vapours, heavy metal vapours and dust are the pollutants that are to be removed in this phase.

The dust is first partially removed in a cyclone separator and finally the remainder is arrested in the fabric bag filter for disposal.

Alkali injection in the gas stream is adopted to neutralize the acid vapours like SO_x, HCL etc. Heavy metals are adsorbed in the activated carbon injected in to the gas stream. All these substances of reaction are arrested in a fabric bag filter and removed for disposal and letting out only the clean gas through the chimney to the atmosphere.

Generation of power from waste involves the key process of combustion of waste. Uncontrolled combustion of waste leads to environment degradation due to release of pollutants in the environment. Controlled combustion as described above enables steam generation in an environment friendly manner.

Power generation

With the successful combustion of waste in an environment friendly manner as described above, the heat released by combustion is then absorbed in water to form High-pressure steam in the boiler system. The High-pressure steam is then fed to steam turbine driving a Generator to generate electricity.

The TG set is operated in the co-generation mode with Part of the steam extracted at low pressure. This steam is used in heat exchangers to generate the hot air required for drying the waste in the waste preparation phase for

combustion. In this manner higher thermal efficiency is achieved in the process of generating power from waste by utilizing the residual heat in the extraction steam after generating power, for drying waste resulting in reduced operating cost.

The inventor has made great effort to provide a system, which meets the requirement of the industry and overcome the problem associated in the prior art.

To achieve the above object according to first aspect and feature of the present invention there is provided a system to improve efficiency.

According to second aspect and feature of the invention in addition to the first feature the invention comprises a system, which is unique, rugged, efficient and economical.

At the outset of the description which follows it is to be understood that ensuing description only illustrates a particular form of this invention. However, such particular form is only an exemplary embodiment without intending to imply and limitation on the scope of this invention. Accordingly, the description is to be understood as an exemplary embodiment and reading of the invention is not intended to be taken restrictively.

The above and other objects features and disadvantages will be clear from the following description of preferred embodiments taken in conjunction with accompanying drawings.

Accordingly a system for generating electricity from solid waste comprising:

- (a) means for preparing combustible fuel;
- (b) boiler is provided with four inner membrane walls with steaming tubes and having plurality of zones therein;
- (c) feeder to feed the said combustible fuel into the boiler for combustion and the said combustible fuel is spread on a traveling grate;

- (d) means to feed primary air from the bottom of the grate in plurality of compartments with controlling means to control air supply to said boiler
- (e) volatiles in the said combustible fuel are released in the first zone wherein the temperature in the said first zone is between 500 degree and 650 degree C of the said plurality zones in the said boiler; flue gas from the chimney having temperature about 140 degree C is mixed to reduce the said substantially high temperature and formation of oxides of nitrogen in the said first zone; the residual combustible solid in the said combustible fuel burn and maintain the heat for volatilization in the second zone of the said plurality zones in the said boiler; combustion completes in the third zone and ash formed during the process discharged into ash hopper in the fourth zone of the said plurality zones in the said boiler;
- (f) injecting means to inject preheated secondary air having temperature about 120 degree C to create turbulence thereby said volatiles are thoroughly mixed to produce temperature above 1000 degree C wherein the said membrane wall with steaming tubes provided in the said boiler absorbs the heat released during combustion and produces high pressure steam;
- (g) feeding means to feed high pressure steam generated in the boiler into the turbine which drives generator leading to power generation; wherein the said turbine is coupled to the input side of the said condenser;
- (h) condenser is connected to a cooling tower with cooling water system, and vacuum is maintained in the said condenser; the condensate obtained is collected and recycled to the boiler through a hot well, and de-aerator and a feed water pump;
- (i) means to draw part of the steam from the turbine at low pressure and feed into air heater to generate hot air for waste drying, by

using principle of co-generation and it increases the over all thermal efficiency of the power generation cycle, and

- (j) a gas cleaning system provided therein to clean the gas that formed during combustion

The means for preparing combustible fuel comprising;

- (a) a bag splitting unit having two shafts with plurality of cutters to cut the wastes packed in bags;
- (b) a multi-segment screening unit includes three sections with different size of apertures between 80mm to 400mm size wherein the first section provided with rotary drum and means to screen wet organics; the second section screen the bulk waste; the third section screens the wastes packed in small bags which escaped from step (a);
- (c) metal separation unit having a drum magnet and over band magnetic conveyer to separate the ferrous metal articles and particles and materials of waste received from step (b);
- (d) drying unit containing a rotary drier wherein hot air is blown from the blower through the heat exchanger onto the exit end; hot air flow is controlled by damper control unit; the waste dropped is exposed to the counter current hot air flow having temperature at about 180 degree C and the waste gets dried; the moisture laden hot air is partially exhausted into the atmosphere through a bag filter and the remaining air joins with the fresh air stream of the blower and get recycled into the hot air system;
- (e) shredding unit having single and/or twin shaft mounted with flail cutters wherein the cutter blades have an arm with a hammer head with sharpened edges and mounted on the four cutter shafts to cut the incoming waste and drop through a grid with predetermined spaces;
- (f) air classification system comprising a suction chamber, tangential separator, suction fan and bag filter wherein the shredded material from step (e) is dropped into a vertical column of suction air created by a suction fan, where light weight materials are lifted and enter the tangential

separator at a predetermined velocity, wherefrom solid materials drop down into a rotary valve and the air is sucked through the suction fan; the said rotary valve seal the said tangential separator from the atmospheric pressure and delivers the said solid materials to the bunker for holding the combustible fuel.

The system wherein gas cleaning system comprising lime injecting means to remove the acidic gas formed during combustion; activated carbon injecting means is provided to remove heavy metals; and bag filter to filter the dust from the treated gas received after lime and activated carbon treatment and before discharging the said treated gas to the atmosphere wherein the output from the bag filter is substantially clean gas, the residue of the bag filter is collected at one end for disposal.

The system wherein the solid waste input is subjected to remove initially organics by screening, metals are removed by magnetic and eddy current separators subsequently fine particles are separated by filtration, subsequently PVC and other non combustibles solids are separated by air classification.

A process for generating electricity from solid waste comprising:

- i. means for preparing combustible fuel;
- ii. boiler is provided with four inner membrane walls with steaming tubes and having plurality of zones therein;
- iii. feeder to feed the said combustible fuel into the boiler for combustion and the said combustible fuel is spread on a traveling grate;
- iv. means to feed primary air from the bottom of the grate in plurality of compartments with controlling means to control air supply to said boiler
- v. volatiles in the said combustible fuel are released in the first zone wherein the temperature in the said first zone is between 500 degree and 650 degree C of the said plurality zones in the said boiler; flue gas from the chimney having temperature about 140 degree C is mixed to reduce the said substantially high temperature and

- formation of oxides of nitrogen in the said first zone; the residual combustible solid in the said combustible fuel burn and maintain the heat for volatilization in the second zone of the said plurality zones in the said boiler; combustion completes in the third zone and ash formed during the process discharged into ash hopper in the fourth zone of the said plurality zones in the said boiler;;
- vi. injecting means to inject preheated secondary air having temperature about 120 degree C to create turbulence thereby said volatiles are thoroughly mixed to produce temperature above 1000 degree C wherein the said membrane wall with steaming tubes provided in the said boiler absorbs the heat released during combustion and produces high pressure steam;
 - vii. feeding means to feed high pressure steam that generated in the boiler into the turbine which drives generator leading to power generation; wherein the said turbine is coupled to the input side of the said condenser;
 - viii. condenser is connected to a cooling tower with cooling water system, and vacuum is maintained in the said condenser; the condensate obtained is collected and recycled to the boiler through a hot well, and de-aerator and a feed water pump;
 - ix. means to draw part of the steam from the turbine at low pressure and fed into air heater to generate hot air for waste drying, by using principle of co-generation and it increases the over all thermal efficiency of the power generation cycle, and
 - x. a gas cleaning system provided therein to clean the gas that formed during combustion

The process for generating electricity from solid waste wherein the means for preparing combustible fuel comprising;

- (1) a bag splitting unit having two shafts with plurality of cutters to cut the wastes packed in bags;

- (2) a multi-segment screening unit including three sections with different size of apertures between 80mm to 400mm size wherein the first section is provided with rotary drum and means to screen wet organics; the second section screens the bulk waste; the third section screens the wastes are packed in small bags which escaped from step (a);
- (3) metal separation unit having a drum magnet and over band magnetic conveyer to separate the ferrous metal articles and particles and materials of waste received from step (b);
- (4) drying unit containing a rotary drier wherein hot air is blown from the blower through the heat exchanger onto the exit end; hot air flow is controlled by damper control unit; the waste dropped is exposed to the counter current hot air flow having temperature at about 180 degree C and the waste gets dried; the moisture laden hot air is partially exhausted into the atmosphere through a bag filter and the remaining air joins with the fresh air stream of the blower and get recycled into the hot air system;
- (5) shredding unit having single and/or twin shaft mounted with flail cutters wherein the cutter blades have an arm with a hammer head with sharpened edges and mounted on the four cutter shafts to cut the incoming waste and drop through a grid with predetermined spaces;
- (6) air classification system comprising a suction chamber, tangential separator, suction fan and bag filter wherein the shredded material from step (e) is dropped into a vertical column of suction air created by a suction fan, where light weight materials are lifted and enter the tangential separator at a predetermined velocity, wherefrom solid materials drop down into a rotary valve and the air is sucked through the suction fan; the said rotary valve seals the said tangential separator from the atmospheric pressure and delivers the said solid materials to the bunker for holding the combustible fuel.

The solid waste input is subjected to removal of organics by screening, ferrous metals by magnetic separator, non-ferrous metals by eddy current separator,

dust particles by filtration and non-combustible heavies & PVC by air classification system, Moisture reduction is achieved by hot air drying. Blowing hot air into the solid waste for the preparation of combustible fuel in rotary driers to remove the moisture content and the moisture free substantially dried waste are subjected to shredding to obtain properly sized feed stock for combustion.

The combustion in the said boiler with combustibles as feedstock wherein the combustibles are spread on a traveling grate, the pre heated air at 100° C approximately is supplied to the grate from below, the ash content is collected at the other end of the grate, the combustion chamber has secondary combustion zone wherein a complete combustion takes place, the secondary zone is kept at temperature above 1000° C for the purpose of complete combustion, dioxin formed in the combustion zone is destroyed and neutralized, by giving sufficient time to go up in the chamber, at the super heater the temperature is maintained at less than 630° C which enables mitigating corrosion to the super heater tube by chlorine.

The gas cleaning system comprising lime injecting means to remove the acidic gas formed during combustion; activated carbon injecting means is provided to remove heavy metals; and bag filter to filter the dust from the treated gas received after lime and activated carbon treatment and before discharging the said treated gas to the atmosphere wherein the output from the bag filter is substantially clean gas , the residue of the bag filter is collected at one end for disposal.

SALIENT FEATURES OF THE INVENTION

The basic feature of the invention is in the system and a method for extracting energy from municipal waste.

The another feature of the invention is the power generation from waste which is a substitute for fossil fuels which are a depleting resource.

The power generation is very eco-friendly which does not contribute to green house effect.

As the invention achieving the dual objective of disposal of waste in an environment friendly manner and generation of power from a non-depleting resource, this invention is unique and has ramifications through out the entire world for the purpose of maintaining economically viable alternative to the problem of power generation and to the problem of waste disposal. Further, as the combustibles in the waste are predominantly current bio-mass, there is no net addition of greenhouse gases in to the atmosphere. In effect this technology has three fold concurrent advantages:

- (1) Environment Friendly.
- (2) Energy production from non-depleting resource
- (3) Contributes to maintaining Ecological balance.

The invention has been explained in relation to specific embodiment. It is inferred that the foregoing description is only illustrative of the present invention and it is not intended that the invention be limited or restrictive thereto. Many other specific embodiments of the present invention will be apparent to one skilled in the art from the foregoing disclosure. All substitution, alterations and modification of the present invention, which come within the scope of the following claims, are to which the present invention is readily susceptible without departing from the spirit of the invention.

The scope of the invention should therefore be determined not with reference to the above description but should be determined with reference to appended claims along with full scope of equivalents to which such claims are entitled.

I CLAIM

1. A system for generating electricity from solid waste comprising:
 - (k) means for preparing combustible fuel;
 - (l) boiler is provided with four inner membrane walls with steaming tubes and having plurality of zones therein;
 - (m) feeder to feed the said combustible fuel into the boiler for combustion and the said combustible fuel is spread on a travelling grate;
 - (n) means to feed primary air from the bottom of the grate in plurality of compartments with controlling means to control air supply to said boiler
 - (o) volatiles in the said combustible fuel are released in the first zone wherein the temperature in the said first zone is between 500 degree and 650 degree C of the said plurality zones in the said boiler; flue gas from the chimney having temperature about 140 degree C is mixed to reduce the said substantially high temperature and formation of oxides of nitrogen in the said first zone; the residual combustible solid in the said combustible fuel burn and maintain the heat for volatilization in the second zone of the said plurality zones in the said boiler; combustion completes in the third zone and ash formed during the process discharged into ash hopper in the fourth zone of the said plurality zones in the said boiler;;
 - (p) injecting means to inject preheated secondary air having temperature about 120 degree C to create turbulence thereby said volatiles are thoroughly mixed to produce temperature above 1000 degree C wherein the said membrane wall with steaming tubes provided in the said boiler absorbs the heat released during combustion and produces high pressure steam;

- (q) feeding means to feed high pressure steam that generated in the boiler into the turbine which drives generator leading to power generation; wherein the said turbine is coupled to the input side of the said condenser;
 - (r) condenser is connected to a cooling tower with cooling water system, and vacuum is maintained in the said condenser; the condensate obtained is collected and recycled to the boiler through a hot well, and de-aerator and a feed water pump;
 - (s) means to draw part of the steam from the turbine at low pressure and fed into air heater to generate hot air for waste drying, by using principle of co-generation and it increases the over all thermal efficiency of the power generation cycle, and
 - (t) a gas cleaning system provided therein to clean the gas that formed during combustion
2. The system as claimed in the claim 1, wherein the means for preparing combustible fuel comprising;
- i. a bag splitting unit having two shafts with plurality of cutters to cut the wastes packed in bags;
 - ii. a multi-segment screening unit includes three sections with different size of apertures between 80mm to 400mm size wherein the first section provided with rotary drum and means to screen wet organics; the second section screens the bulk waste; the third section screens the wastes are packed in small bags which escaped from step (a);
 - iii. metal separation unit having a drum magnet and over band magnetic conveyer to separate the ferrous metal articles and particles and materials of waste received from step (b);
 - iv. drying unit containing a rotary drier wherein hot air is blown from the blower through the heat exchanger onto the exit end; hot air flow is controlled by damper control unit; the waste dropped is exposed to the counter current hot air flow having temperature at about 180 degree C and the waste gets dried; the moisture laden hot air is

partially exhausted into the atmosphere through a bag filter and the remaining air joins with the fresh air stream of the blower and get recycled into the hot air system;

- v. shredding unit having single and/or twin shaft mounted with flail cutters wherein the cutter blades have an arm with a hammer head with sharpened edges and mounted on the four cutter shafts to cut the incoming waste and drops through a grid with predetermined spaces;
 - vi. air classification system comprising a suction chamber, tangential separator, suction fan and bag filter wherein the shredded material from step (e) is dropped into a vertical column of suction air created by a suction fan, where light weight materials are lifted and enter the tangential separator at a predetermined velocity, wherefrom solid materials drops down into a rotary valve and the air is sucked through the suction fan; the said rotary valve seals the said tangential separator from the atmospheric pressure and delivers the said solid materials to the bunker for holding the combustible fuel.
3. The system as claimed in the claim 1, wherein gas cleaning system comprising lime injecting means to remove the acidic gas formed during combustion; activated carbon injecting means is provided to remove heavy metals; and bag filter to filter the dust from the treated gas received after lime and activated carbon treatment and before discharging the said treated gas to the atmosphere wherein the output from the bag filter is substantially clean gas, the residue of the bag filter is collected at one end for disposal.
4. The system as claimed in the claim 2, wherein the solid waste input is subjected to remove initially organics by screening, metals are removed by magnetic and eddy current separators subsequently fine particles are separated by filtration, subsequently PVC and other non combustible solids are separated by air classification.

5. A process for generating electricity from solid waste comprising:
- (a) means for preparing combustible fuel;
 - (b) boiler is provided with four inner membrane walls with steaming tubes and having plurality of zones therein;
 - (c) feeder to feed the said combustible fuel into the boiler for combustion and the said combustible fuel is spread on a traveling grate;
 - (d) means to feed primary air from the bottom of the grate in plurality of compartments with controlling means to control air supply to said boiler
 - (e) volatiles in the said combustible fuel are released in the first zone wherein the temperature in the said first zone is between 500 degree and 650 degree C of the said plurality zones in the said boiler; flue gas from the chimney having temperature about 140 degree C is mixed to reduce the said substantially high temperature and formation of oxides of nitrogen in the said first zone; the residual combustible solids in the said combustible fuel burn and maintain the heat for volatilization in the second zone of the said plurality zones in the said boiler; combustion completes in the third zone and ash formed during the process discharged into ash hopper in the fourth zone of the said plurality zones in the said boiler;;
 - (f) injecting means to inject preheated secondary air having temperature about 120 degree C to create turbulence thereby said volatiles are thoroughly mixed to produce temperature above 1000 degree C wherein the said membrane wall with steaming tubes provided in the said boiler absorbs the heat released during combustion and produces high pressure steam;
 - (g) feeding means to feed high pressure steam that generated in the boiler into the turbine which drives generator leading to power

generation; wherein the said turbine is coupled to the input side of the said condenser;

- (h) condenser is connected to a cooling tower with cooling water system, and vacuum is maintained in the said condenser; the condensate obtained is collected and recycled to the boiler through a hot well, and de-aerator and a feed water pump;
- (i) means to draw part of the steam from the turbine at low pressure and fed into air heater to generate hot air for waste drying, by using principle of co-generation and it increases the over all thermal efficiency of the power generation cycle, and
- (j) a gas cleaning system provided therein to clean the gas that formed during combustion

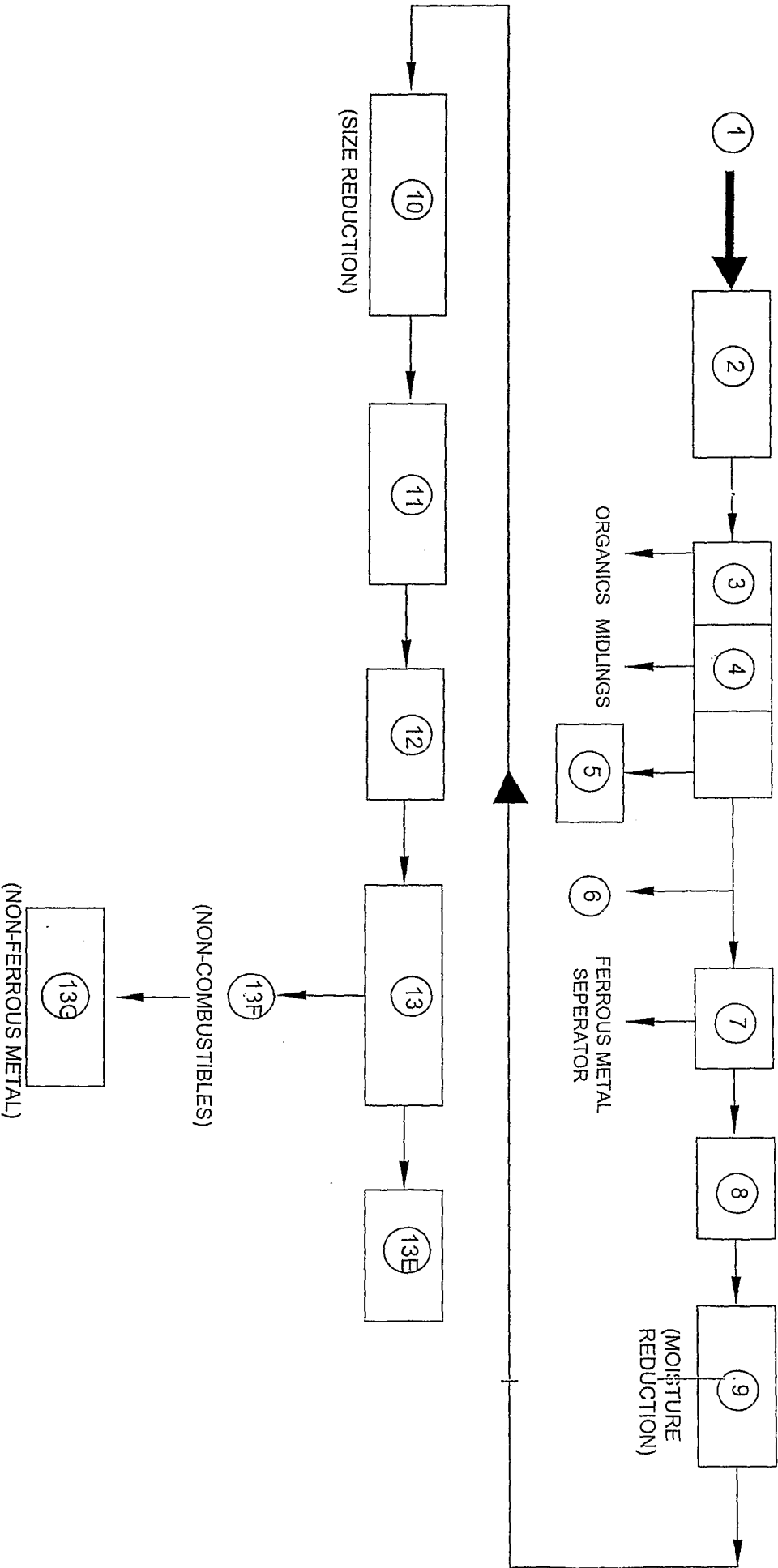
6. The process for generating electricity from solid waste as claimed in claim 5, wherein the means for preparing combustible fuel comprising;
- i. a bag splitting unit having two shafts with plurality of cutters to cut the wastes packed in bags;
 - ii. a multi-segment screening unit includes three sections with different size of apertures between 80mm to 400mm size wherein the first section provided with rotary drum and means to screen wet organics; the second section screens the bulk waste; the third section screens the wastes are packed in small bags which escaped from step (a);
 - iii. metal separation unit having a drum magnet and over band magnetic conveyer to separate the ferrous metal articles and particles and materials of waste received from step (b);
 - iv. drying unit containing a rotary drier wherein hot air is blown from the blower through the heat exchanger onto the exit end; hot air flow is controlled by damper control unit; the waste dropped is exposed to the counter current hot air flow having temperature at about 180 degree C and the waste gets dried; the moisture laden hot air is partially exhausted into the atmosphere through a bag filter and the

- remaining air join with the fresh air stream of the blower and get recycled into the hot air system;
- v. shredding unit having single and/or twin shaft mounted with flail cutters wherein the cutter blades have an arm with a hammer head with sharpened edges and mounted on the four cutter shafts to cut the incoming waste and drops through a grid with predetermined spaces;
 - vi. air classification system comprising a suction chamber, tangential separator, suction fan and bag filter wherein the shredded material from step (e) is dropped into a vertical column of suction air created by a suction fan, where light weight materials are lifted and enter the tangential separator at a predetermined velocity, wherefrom solid materials drop down into a rotary valve and the air is sucked through the suction fan; the said rotary valve seals the said tangential separator from the atmospheric pressure and delivers the said solid materials to the bunker for holding the combustible fuel.
7. The process as claimed in any preceding claim, the solid waste input is subjected to removal of organics by screening, ferrous metals by magnetic separator, non-ferrous metals by eddy current separator, dust particles by filtration, and non-combustible heavies & PVC by air classification system. Moisture reduction is achieved by hot air drying.
8. The process as claimed in any preceding claim, wherein moisture reduction is achieved by hot air drying.
9. The process as claimed in any preceding claim, wherein blowing hot air into the solid waste for the preparation of combustible fuel in rotary driers to remove the moisture content and the moisture free substantially dried waste are subjected to shredding to obtain properly sized feed stock for combustion.
10. The process as claimed in any preceding claim, the combustion in the said boiler with combustibles as feedstock wherein the combustibles are spread on a traveling grate, the pre heated air at 100° C approximately is

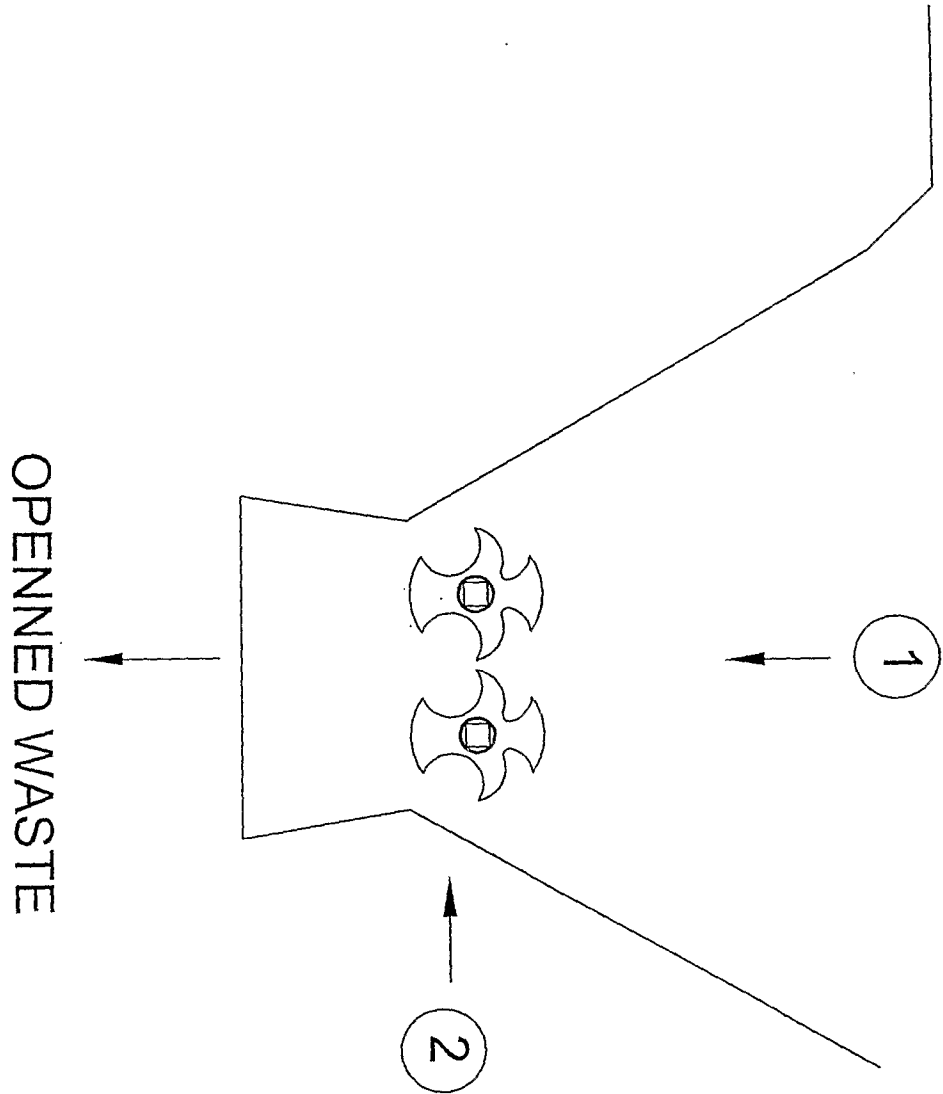
supplied to the grate from below, the ash content is collected at the other end of the grate, the combustion chamber has secondary combustion zone wherein a complete combustion takes place, the secondary zone is kept at temperature above 1000° C for the purpose of complete combustion, dioxin formed in the combustion zone is destroyed and neutralized, by giving sufficient time to go up in the chamber, at the super heater the temperature is maintained at less than 630° C which enables mitigating corrosion to the super heater tube by chlorine.

11. The process as claimed in any preceding claim, wherein gas cleaning system comprising lime injecting means to remove the acidic gas formed during combustion; activated carbon injecting means is provided to remove heavy metals; and bag filter to filter the dust from the treated gas received after lime and activated carbon treatment and before discharging the said treated gas to the atmosphere wherein the output from the bag filter is substantially clean gas, the residue of the bag filter is collected at one end for disposal.
12. A system for generating electricity from solid waste such as herein substantially described and exemplified.
13. A process for generating electricity from solid waste such as herein substantially described and exemplified.

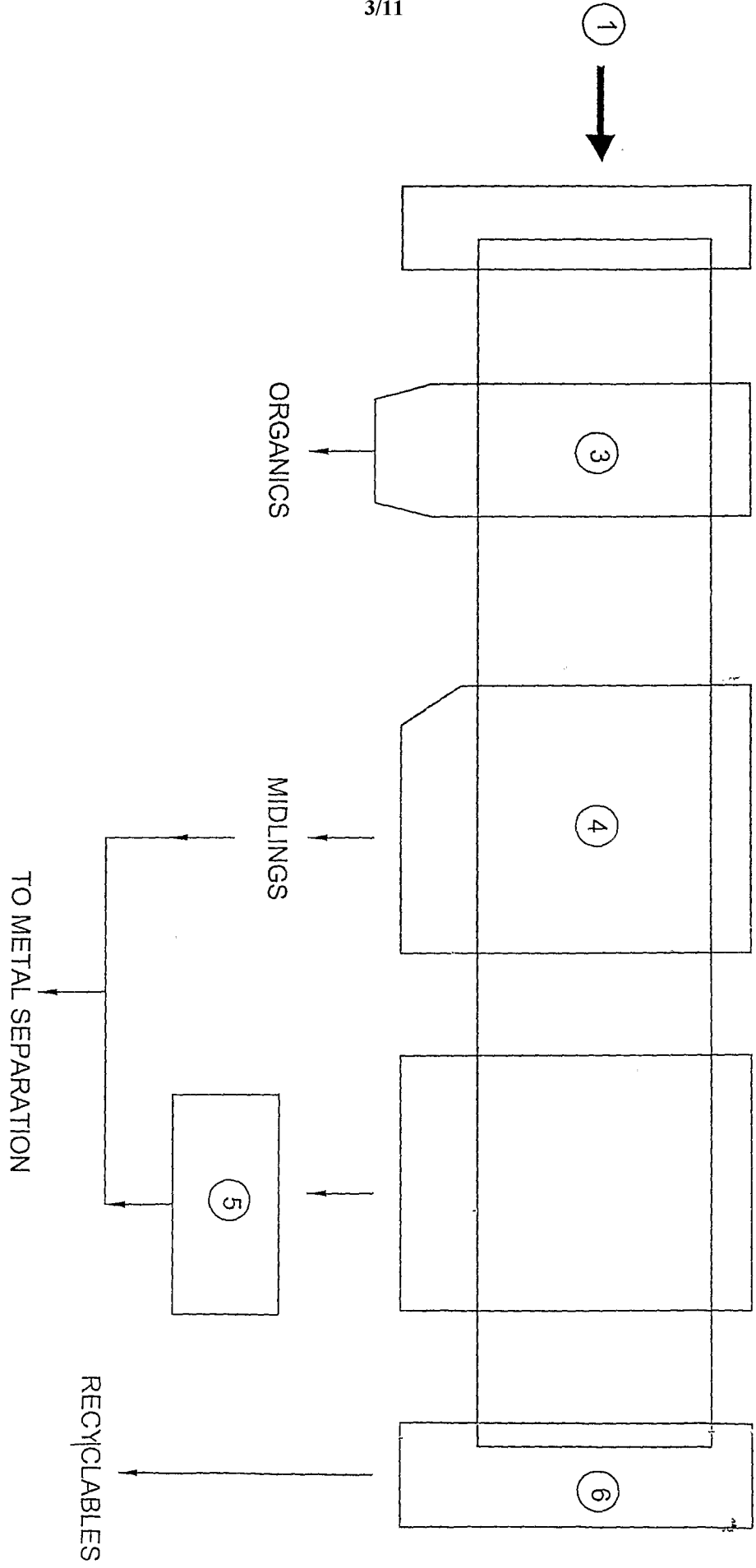
THE PROCESS



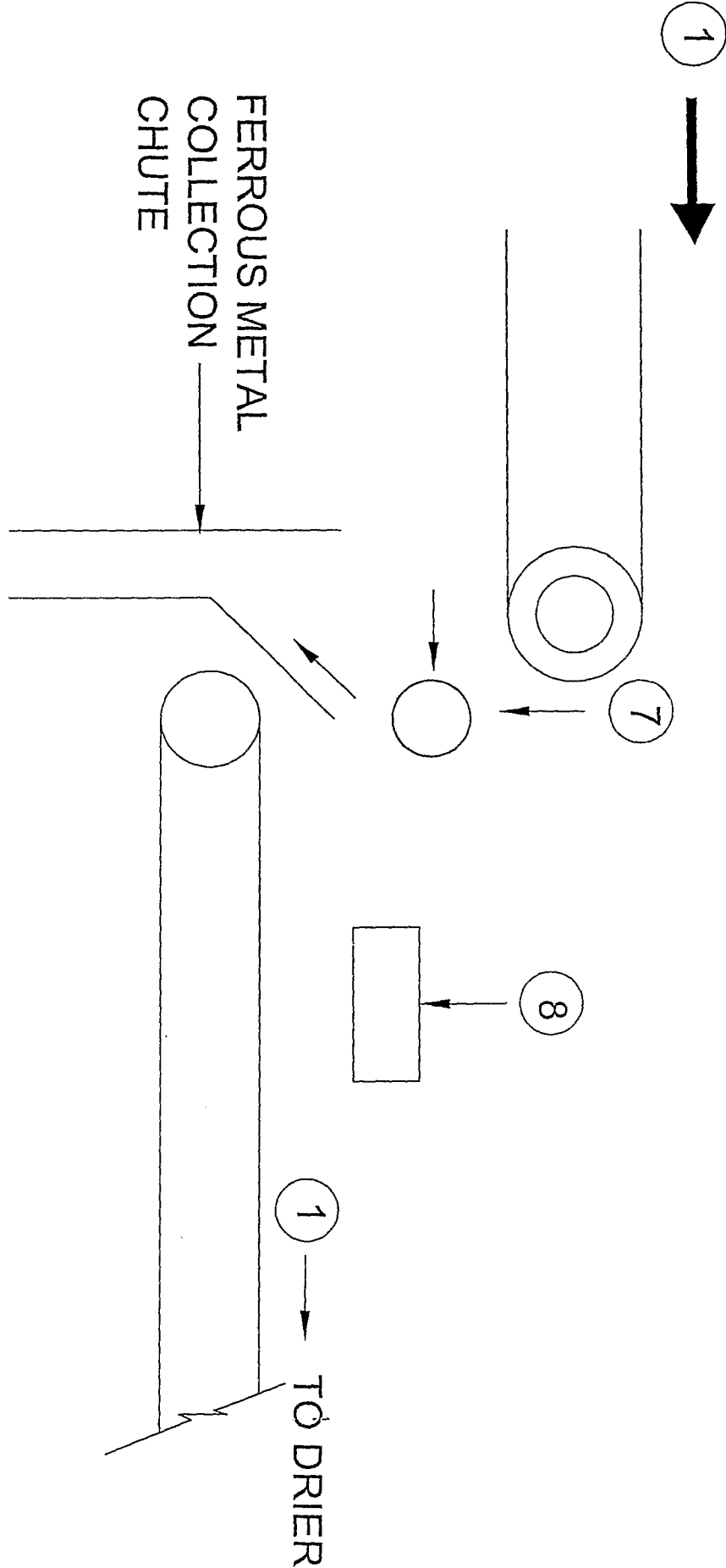
BAG SPLITTING UNIT



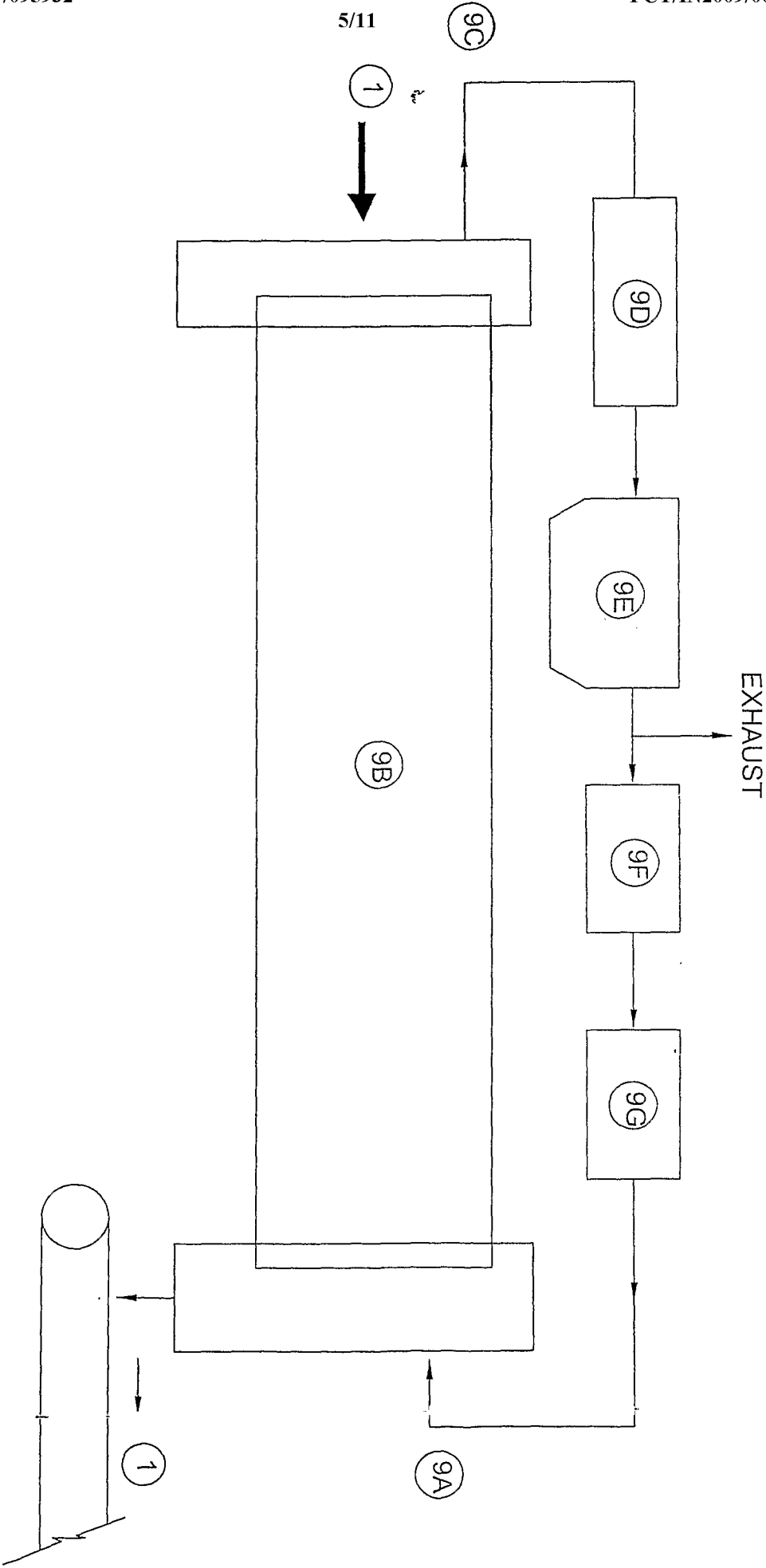
MULTI - SEGMENT SCREENING UNIT



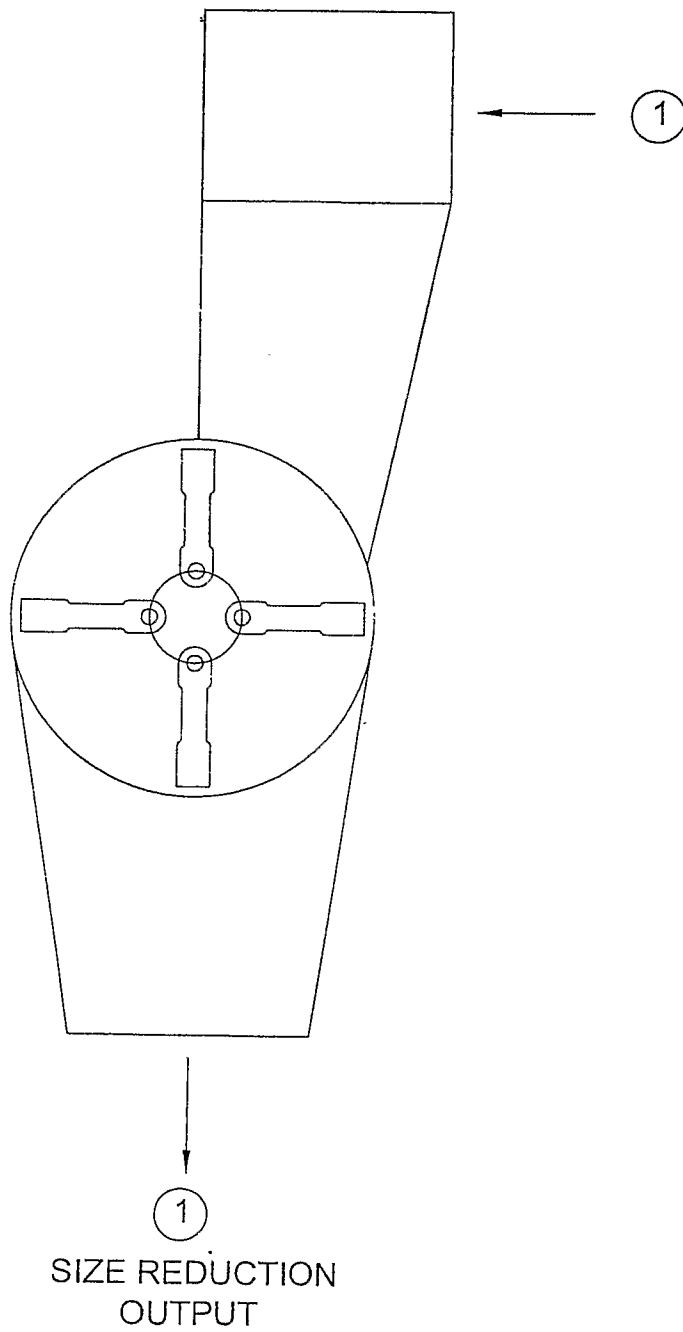
METAL SEPARATION UNIT

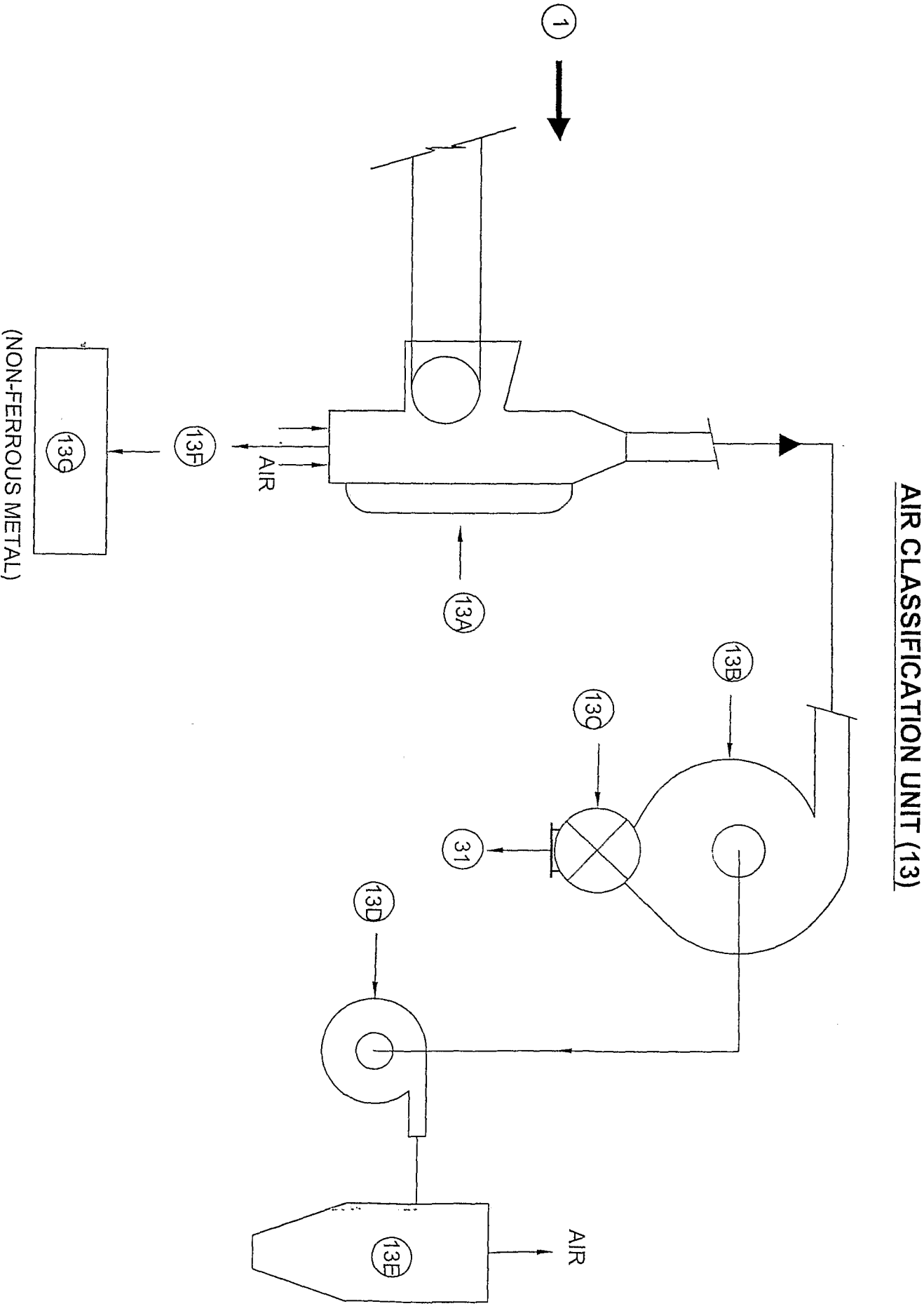


DRYING UNIT (9,11)

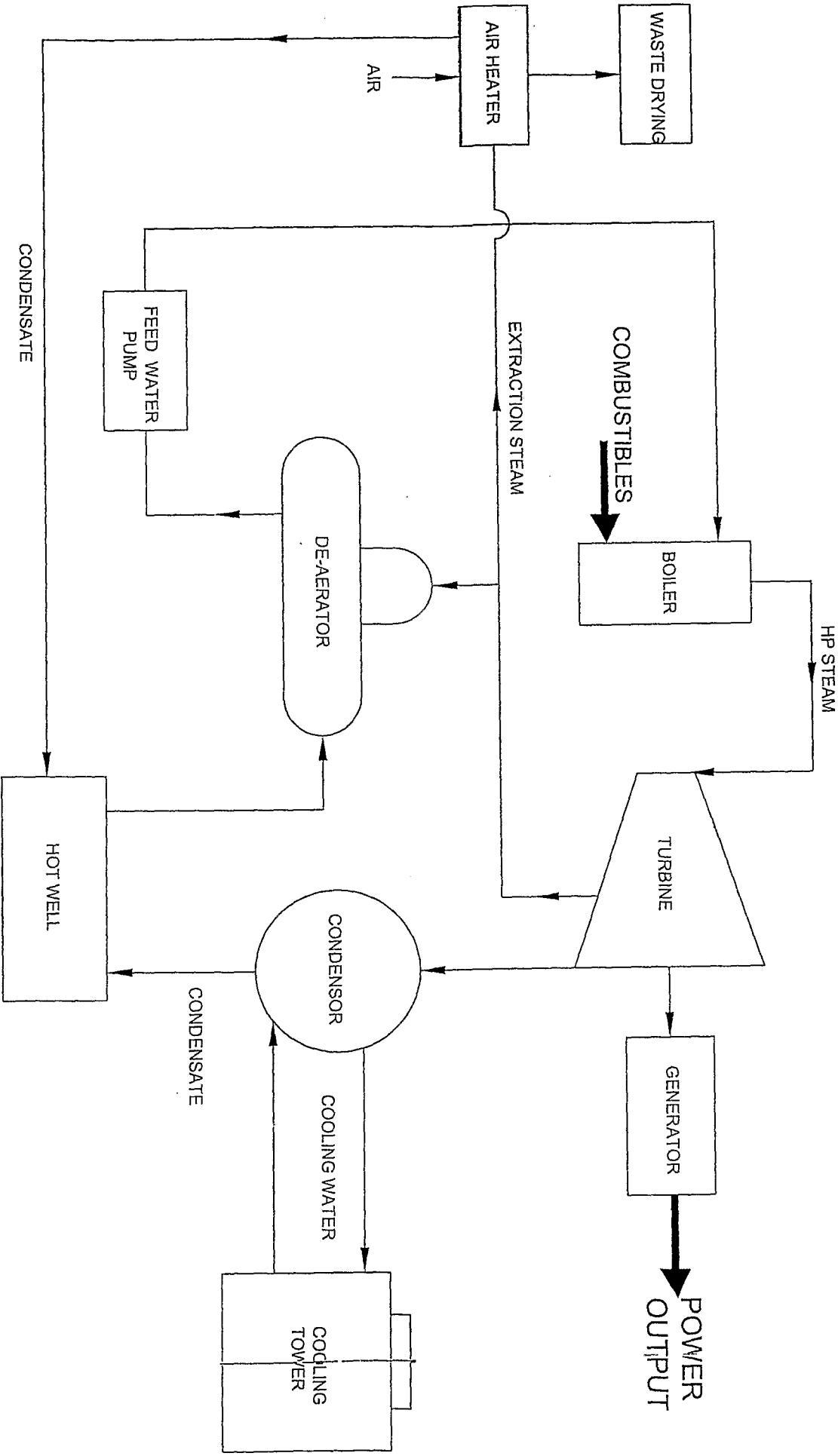


SHREDDING UNIT (10,12)

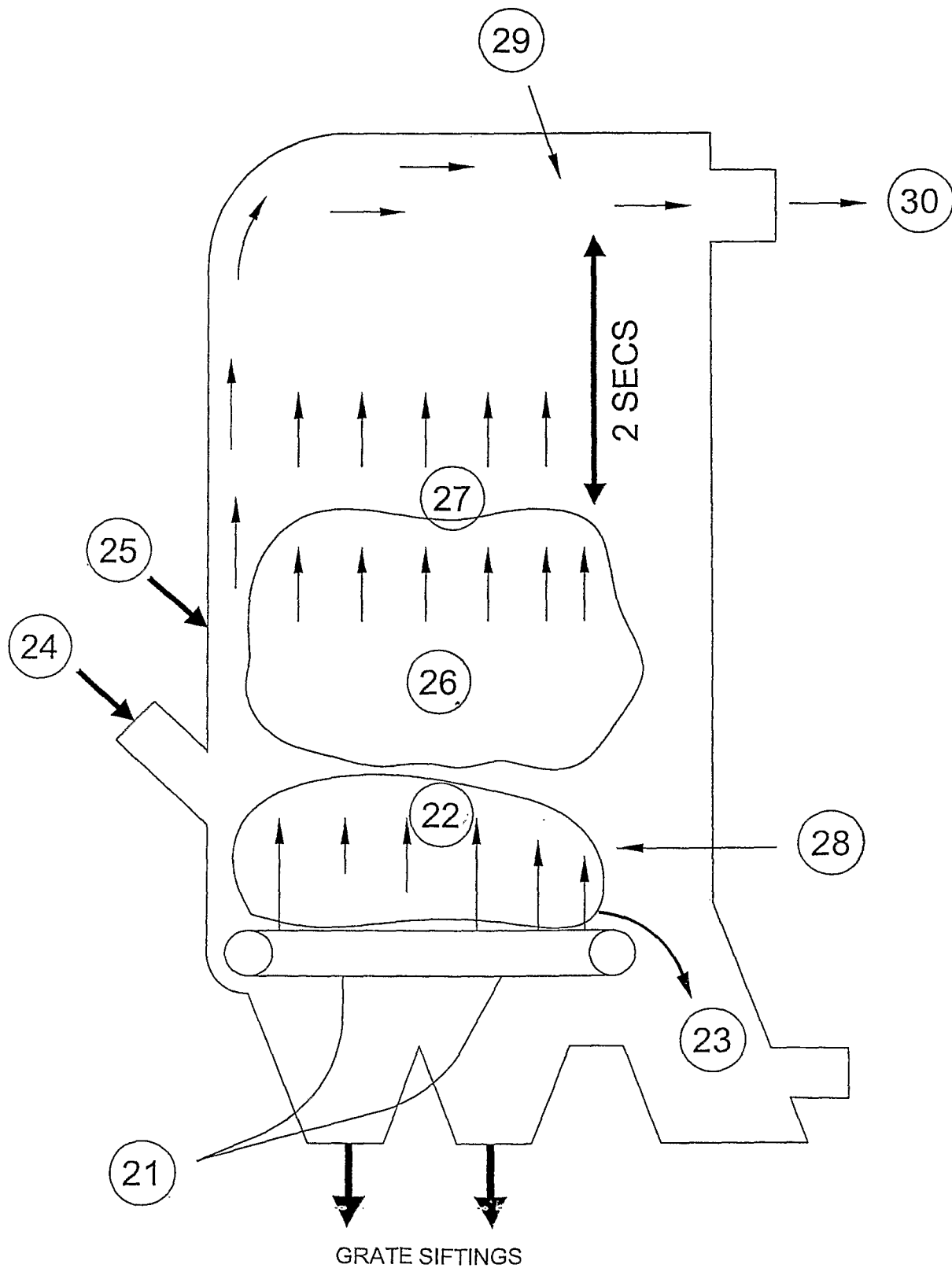




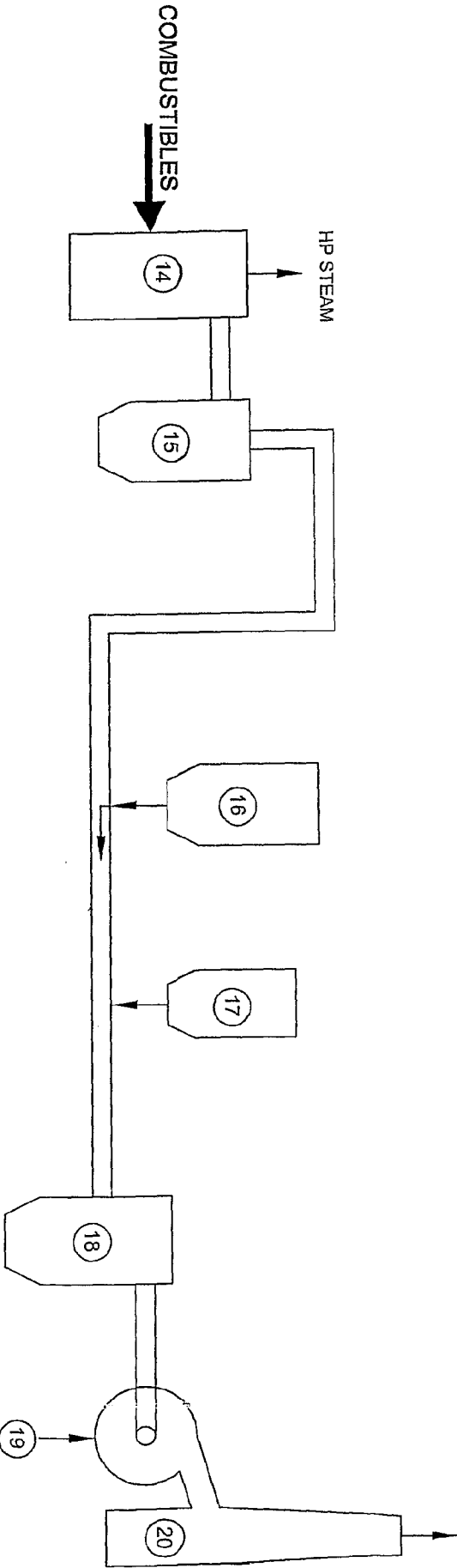
POWER GENERATION FROM WASTE - SCHEMATIC



SPECIAL FURNACE FOR COMBUSTION



FLUE GAS CLEANING UNIT



NOMENCLATURE FOR DRAWINGS

No.	Item	No	Item
1	Waste Input	13e	Bag Filter
2	Bag Splitter	13f	Rejected Solid Waste
3	Organics	13g	Eddy Current Separator
4	Bag Splitting Operation	14	Flue Gas From Boiler
5	Mini Bag Splitter	15	Dust Separation
6	Wastes - Paper and Plastics For Recycling	16	Lime Injection
7	Magnetic Separator	17	Carbon Injection
8	Over Band Magnet	18	Bag Filter
9 & 11	Drying Unit	19	ID Fan
9a & 11a	Hot Air Input	20	Chimney
9b & 11b	Rotary Driers	21	Pre Heat Air
9c & 11c	Hot Air Outlet	22	The Combustibles
9d & 11d	Suction Fan	23	Ash
9e & 11e	Bag Filter	24	Air Inlet
9f & 11f	Blower	25	Secondary Air
9g & 11g	Heater	26	Secondary Combustion Zone
10 & 12	Shredding Unit	27	Complete Combustion
13	Air Classification Unit	28	Re-firing
13a	Suction Chamber	29	Ammonia Injection
13b & 13c	Tangential Separator	30	Flue Gas Outlet Duct
13d	Suction Fan	31	Prepared Fuel