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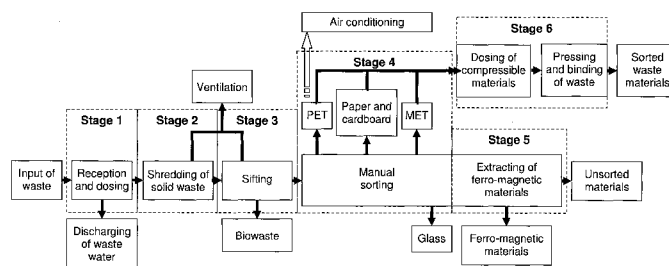


Figure 1

(57) **Abstract:** A procedure and a plant for sorting of municipal solid waste according to the types of material of which certain waste components are made consists of a sequence of mechanical procedures in combination with a manual procedure. Figure 1 shows the scheme of the procedure which consists of the following stages: 1. Reception and dosing of municipal solid waste through a chamber for reception and dosage; 2. Shredding of larger waste in a device for shredding; 3. Sifting of waste in a device for sifting; 4. Manual sorting of unsifted waste on a line for manual sorting; 5. Separation of ferromagnetic metals through a device for magnetic separation of ferromagnetic metals; and 6. Pressing and binding of sorted compressible waste components in a device for pressing and binding. The process and the plant according to the invention solve the technical problem of economical sorting of large amounts of mixed municipal solid waste. The result of sorting is a large number of high quality and consistently sorted components, appropriately packaged for the transportation thereof to the facilities for recycling, incineration or landfills.

PROCEDURE AND PLANT FOR SORTING OF MUNICIPAL SOLID WASTE

DESCRIPTION OF THE INVENTION

TECHNICAL FIELD

The subject matter of the invention is a procedure and a plant for sorting of municipal mixed solid waste. The sorting procedure consists of a series of cold, mechanical, machine processes, combined with a manual procedure. The sorting procedure is carried out in the plant that consists of a device for receiving and dosing, shredding of large waste, sieving, manual sorting, magnetic separation and packaging of sorted waste components. Transport of waste between individual devices is carried out through conveyor belts.

According to the seventh edition of the International Patent Classification, the invention belongs to the following technical fields:

- B03B9/06 - General arrangement of separating plant, e.g. flow sheets specially adapted for refuse,
- B07B - Separating solids from solids by sieving, screening or sifting or by using gas currents; other separating by dry methods applicable to bulk material, e.g. loose articles fit to be handled like bulk material,
- B07C - Postal sorting, sorting individual articles or bulk material fit to be sorted piece-meal, e.g. by picking,
- B09B3/00 - Destroying solid waste or transforming solid waste into something useful or harmless.

TECHNICAL PROBLEM

The climate changes on Earth caused by human influence, gives rise to the question of further sustainable development. One of the problems which have to be solved in order to facilitate sustainable development is the proper management of municipal mixed solid waste, generated by households. Municipal solid waste is basically a mixture of various organic and inorganic substances that may be generally classified into the following groups:

- Biodegradable waste,
- Paper and cardboard,
- Plastic waste,
- Metal waste,

- Glass waste,
- Textile waste and waste footwear,
- Various mixed waste.

Most of these groups of substances can be reused as an energy source or as raw material in the manufacture of new products and recycling, respectively. A precondition for the proper reuse of waste components is proper and economical classification of the municipal solid waste mixture.

The sorting of solid waste in households, as places where the waste is generated, has a relatively weak performance, because it is impossible to discipline all the people in the household to sort the waste properly. The degree of resolution of certain types of waste classified in households is low and uneven. The costs of collecting and transporting of sorted waste in households significantly increase the costs of municipal waste management. Therefore, it is necessary to sort unsorted municipal waste and municipal waste sorted in households prior to the transportation thereof for further use.

The procedure and plant for sorting of municipal solid waste according to the invention, solve the technical problem of economical sorting of large amounts of municipal mixed solid waste by mechanical processes and manual procedures. The result of sorting is a large number of high quality and consistently sorted components appropriately packed for the transportation thereof to the facilities for recycling, incineration or landfills.

THE STATE OF THE ART

Patent document No. CN10176586 describes a modular device for sorting of household waste. The device consists of an input section, a section for bags opening, a magnetic separator, a section for water separation and a section for separation of organic substances. Waste transport inside the plant is carried out through conveyor belts.

Patent document No. WO2005120729 describes a complex system and a procedure of municipal waste sorting according to the types of material. Municipal waste is in the beginning sorted according to the size in 3 groups, after that these groups and/or their combinations are sorted according to the types of material by manual separation, separation according to the density, metal separation and additional separation according to the size.

Patent document No. RU2282507 describes a station for waste sorting with mechanisms for handling containers. Separation begins with the reception of unsorted waste on a conveyor belt which is moving periodically and is done on the conveyor belt by manual separation and magnetic separation of ferromagnetic metals.

ESSENCE OF THE INVENTION

A procedure of municipal solid waste sorting according to the invention consists of a series of cold, mechanical, machine shredding processes, sifting and separating in combination with a manual procedure. The sorting procedure is carried out in a plant which consists of a device for reception and dosing, a device for shredding of bulky waste, a device for sifting of biological waste, a line for manual sorting according to the types of material of which an individual waste component is made, a device for magnetic separation of ferromagnetic metals, a device for pressing of compressible sorted waste components and a device for packing and disposal of sorted waste components. Waste transport inside the plant is carried out through conveyor belts.

The essence of the invention is contained in a precisely defined sequence of operations and machine operations where waste is treated before manual sorting and after it.

Stages of the waste treatment prior to manual waste sorting bring the waste in loose condition, from which water present in the collected mixed waste is separated in the device for reception and dosing, and biological waste is separated in the device for sifting. The waste that is relatively dry, loose and without biological waste components is brought to the belt for manual sorting, which greatly facilitates its manual sorting according to the types of material of which waste components are made. Incompressible components of the waste, such as glass waste and metal waste, are disposed in containers suitable for the transportation thereof to recycling.

Compressible components, such as waste paper and plastic waste, are pressed and packed into bundles suitable for the transportation thereof to recycling.

The plant according to the invention differs from the modular device described in patent document No. CN10176586 in that the described modular device does not contain a line for manual sorting, a device for pressing of compressible sorted

waste components and a device for packing of sorted waste components. The process of machine waste sorting described in patent document No. CN10176586 is not carried out in a specific order as the process according to the invention. Due to the lack of manual sorting and to the undefined sequence of machine procedures, the quality of sorting described in patent document No. CN10176586 is significantly lower.

The system and the procedure for waste sorting as described in patent document No. WO2005120729 are mainly based on the sorting according to the size. The process is very complex, making it significantly more expensive than the procedure according to the invention.

The procedure of municipal waste sorting described in patent document No. RU2282507 consists just of two operations: a manual sorting and a magnetic separation of ferromagnetic metals so the quality and the degree of waste resolution are very low. The system of internal transportation of sorted and unsorted waste is based on the usage of a large number of containers and transportation devices which makes it unpractical. The procedure according to the invention in relation to the described procedures and devices includes a relatively small number of machine operations which are strongly interdependent and combined with the manual procedure. The plant according to the invention presents a linear series of the devices for waste sorting between which the waste transportation is carried out through conveyor belts. The number of the types of sorted waste materials is higher than the number in the described solutions and their purity is of significantly higher degree and of more consistent quality. The process and plant according to the invention represent an environmentally clean and cost-effective solution for sorting of large quantities of municipal mixed solid waste, the largest part of which is recycled, after the sorting.

DESCRIPTION OF FIGURES

Figure 1 shows the scheme of the procedure of municipal solid waste sorting.

Figure 2 shows the layout of the plant for sorting of municipal solid waste.

Figure 3 shows a partial longitudinal section A-A of the plant for sorting of municipal solid waste from Figure 2.

DESCRIPTION OF THE PROCEDURE

The procedure for sorting of municipal solid waste shown in Figure 1 is carried out through stages according to the following order and description of certain procedure stages:

5 **Stage 1**

Municipal solid waste is transported at the start position of the procedure to the chamber in which the reception and dosing of municipal solid waste as well as discharging of waste waters from wet waste are carried out. All types of dry or wet municipal mixed solid waste of various sizes, containing the following substances,
10 may be accepted:

- Biodegradable waste from households and towns,
- Paper and cardboard,
- Tetra pack packaging,
- PET – various plastics, bottles, various plastic products and toys,
- 15 • MET – smaller metal parts, metal packaging, aluminum packaging,
- Glass, glass packaging and glass products,
- Textile waste, various clothes, footwear, textile rests,
- Various wastes of different materials.

In the chamber, draining of wet waste and drainage of extracted waste water into
20 the system for waste water treatment are carried out. Dosing of drained waste is carried out using built-in worm screws and a thrust hydraulic system as built into the chamber. A constantly dosed amount of waste is directed to an inclined ribbed conveyor belt by which it is delivered to the second stage of the procedure.

Stage 2

25 In the second stage of the procedure shredding of municipal solid waste, such as bags and boxes in which small waste is packed is carried out. Shredding in a shredding device which cuts the bags and boxes with small waste as well as larger pieces of waste is carried out continuously. In this way, the small waste packed in the bags and boxes, becomes available. Through this procedure, municipal mixed
30 waste of different sizes is shredded to sizes appropriate for sifting and manual sorting in further stages of the procedure. Shredded and loose waste is transported by inclined ribbed conveyor belt to the third stage of the procedure.

Stage 3

In the third stage of the procedure, sifting of waste is carried out in a sifting device with a rotating inclined screen. The size of the screen perforation is such as to allow the passing of mostly the smallest biowaste that falls into containers placed under the screen and suitable for the transport of biological waste over long distances. Unsifted bulky waste that comes from the screen is lifted up by inclined ribbed conveyor belt to the fourth stage of the procedure. In the second and third stages of the treatment, dust is generated and is, by using of a unique ventilation system with filters, removed from the device for shredding and the device for sifting of waste.

Stage 4

In the fourth stage of the procedure, manual sorting of the unsifted waste is carried out according to the types of material of which certain substances are made. A line for manual sorting is placed in a closed prefabricated building object on a platform with a horizontal conveyor belt, on which unsifted waste is brought from the sifting device. On both sides of the conveyor belt there are containers with funnels in which sorted waste is put. Under the platform there are containers and boxes for the reception of certain types of sorted waste. The workers placed on both sides of the conveyor belt sort the waste which is transported by the belt in front of them, in order that they can select certain types of waste from the belt and put them in containers with funnels intended for certain types of waste, through which selected waste falls in the container or the box under the platform. To facilitate the pressing of plastic bottles and other closed plastic packaging, this type of waste should be perforated. Because of that, this type of packaging is punched in a perforating device prior to its disposal in the corresponding container with a funnel. Incompressible components of solid waste made of glass and compressible components of solid waste made of various types of plastics, paper and cardboard and compressible products made of stained metal are sorted manually. By disposing the incompressible components of waste in containers suitable for transport over longer distances, the process of their sorting is terminated. Compressible components of the waste are disposed in boxes from which the appropriately dosed quantities are pressed on the horizontal conveyor belt, that

carries them to the inclined ribbed conveyor belt, which lifts them to a device for pressing and binding in the sixth stage of the procedure.

Unsorted part of waste remains on the conveyor belt that brings it out from the closed area for the purpose of manual sorting in the fifth stage of the procedure.

- 5 In order to achieve the conditions for presence and work of people who sort the waste manually, the area in which manual sorting is done is designed as a closed space that is air conditioned to regulate the temperature and air cleanliness, due to the presence of various vapors and dust.

Stage 5

- 10 In the fifth stage of the procedure, by using a device for magnetic separation of ferromagnetic metals, we are separating ferromagnetic metals from the unsorted part of the waste that remains on the conveyor belt after manual sorting of waste. Separated ferromagnetic metal waste is disposed in the containers suitable for long distance transportation. The remaining unsorted waste material is deposited
15 in containers suitable for transporting of unsorted waste to landfills.

Stage 6

- In the sixth stage of the procedure, pressing and binding of sorted compressible components of waste are carried out in a device for pressing and binding. Bales of bound components of compressible waste are temporarily deposited at the landfill
20 near the plant to collect them for transportation to a recycling factory. The sixth stage of the procedure is functionally independent from the previous stages of the procedure. Therefore, phases 1-5 of the procedure are related to one management system and the sixth stage of the procedure is related to a separate management system.

25 DESCRIPTION OF THE PLANT

The plant for sorting of municipal solid waste according to the described procedure is shown in Figures Nos. 2 and 3. Based on the described procedure, the plant consists of the following devices:

- 30 **1. Chamber 1 for reception and dosing** of municipal solid waste and drainage of free waste water from wet waste.

Chamber 1 consists of a metal shell with tight bottom. In order to allow an easier reception of the municipal waste, chamber 1 is located below the ground level. Around chamber 1, above the ground, there is a fence that has in the front side a

door for the access of vehicles with waste, and on the back side an inclined ribbed conveyor belt T_1 . The bottom of the chamber has slope front and back side in the form of letter V for easier supply of waste to the inclined ribbed conveyor belt T_1 . Free waste water is collected on the bottom of chamber 1 and is, by using a submersible sludge pump, drained away in waste water treatment system. From the bottom of the chamber, the waste is directed by two worm screws and a thrust hydraulic system to the inclined ribbed conveyor T_1 .

2. Device 2 for shredding of large waste

Device 2 consists of a drum which on periphery has uniformly placed blades. The drum with blades is rotating in a casing that on the front and back sides has stationary blades between which drum blades for cutting the waste rotate. Axial distance between the rotating and the stationary blades is such that they cut only the biggest waste such as bags and boxes in which small waste is packed. Unchopped waste is brought by the inclined ribbed conveyor belt T_1 to the input hole of device 2 on the upper side of device 2, and the chopped and loose waste is falling from the hole on the lower side of device 2 onto the inclined ribbed conveyor belt T_2 . The dust generated during shredding is removed from device 2 by means of a ventilation system.

3. Device 3 for sifting

Device 3 for sifting consists of a cylindrical rotating screen placed in its casing. Device 3 is placed on a rack for the purpose of insertion of containers for reception of sifted waste from device 3. The axis of the cylindrical screen is inclined under a small angle in relation to the horizontal level in order to facilitate the transit of waste through the screen from the higher input hole to the lower output hole of the screen. The screen on its inner shell has a spiral rib which facilitates the transportation of waste through the screen. Chopped waste from device 2 is brought by an inclined ribbed conveyor belt T_2 to a higher, input hole of the screen that is rotating and sifting small biological waste onto the bottom of the device casing. On the screen, circular and/or rectangular holes are made for sifting the waste which is mostly of biological origin. Sifted waste is directed from the casing bottom to the holes on the bottom of the casing through which it is falling into the containers placed under device 3. Larger unsifted waste exits through a lower, output hole of the screen and falls onto an inclined ribbed conveyor belt T_3 . The

dust generated during sifting, is removed from device 3 by means of a ventilation system.

4. Line 4 for manual sorting

Line 4 for manual sorting consists of a machine and a building part. The machine
5 part of line 4 for manual sorting consists of a horizontal conveyor belt T_4 , a larger
number of containers with funnels which serve for waste sorting and which are
placed on both sides of a horizontal conveyor belt T_4 and a large number of PET
perforating devices. The machine part of line 4 for manual sorting is placed in a
closed, prefabricated, air conditioned object on a platform. The building part is
10 made as a line of connected container units which form a single spatial entirety in
the form of tunnel. Unsifted waste from device 3 for sifting is led by an inclined
ribbed conveyor belt T_3 to the beginning of the horizontal conveyor belt T_4 .
Workers placed on both sides of the conveyor belt T_4 sort the waste which is
transported by the conveyor in front of them in order that they sort a certain type of
15 waste from the belt and put it in a certain container with funnel. The contents of the
loaded containers with funnels pass through the floor of the building object into
containers or boxes under the platform. By disposing the sorted incompressible
waste components into containers under the platform suitable for longer distance
transportations, the procedure of their sorting is terminated. Sorted compressible
20 components of waste are collected in boxes under the platform for the
transportation thereof to a device for pressing and binding. Unsorted waste at the
end of the conveyor belt T_4 which brings it out of the building object is sorted by a
device for magnetic separation of ferromagnetic metals.

5. Device 5 for magnetic separation of ferromagnetic metals

25 Above the end of the horizontal conveyor belt T_4 for manual sorting that extends
beyond the building construction there is a device 5 for magnetic separation of
ferromagnetic metals. It consists of a strong electromagnet with associated
equipment for operation and management of the electromagnet. Separated
ferromagnetic metal waste is disposed in containers suitable for transport over
30 long distances. The remaining unsorted waste material is deposited in containers
suitable for transporting of unsorted waste to the landfills.

6. Device 6 for pressing and binding of sorted compressible components of
waste.

Sorted compressible waste components collected in boxes under the platform have to be packed appropriately for the transportation thereof to recycling facilities. Every sorted component has to be packed individually in the manner that a certain amount of the selected component is pushed from the box onto a horizontal conveyor belt T_5 which is placed under the box bottom level and parallel with the line 4 for manual sorting. The horizontal conveyor belt T_5 brings the sorted component to an inclined ribbed conveyor belt T_6 , which lifts it up to the input hatch of device 6 for pressing and binding. Device 6 consists of a reception part, a hydraulic press and a part for binding of sorted compressible components into bales. In the reception part, the amount of waste to be pressed by the hydraulic press is determined and in the part for binding, the pressed waste components are bonded into bales. The bales of bonded components of compressible waste are temporarily deposited in landfills near the plant to be collected for transport to recycling facilities.

Devices 1 to 5 together with transport devices T_1 to T_4 , which connect them, form one technological unit of the plant for waste sorting, on the components according to the materials from which these components are made. All the devices in this part of the plant are connected in a linear series of devices. The plant according to the invention can be manufactured for the sorting of various quantities of municipal mixed solid waste. The capacity of individual plants can range from 5 to 20 tons of waste / hour.

Device 6 for pressing and binding is functionally independent from the devices described in the previous stages of the procedure until the boxes below the platform contain sufficient quantities of sorted compressible components of waste.

CLAIMS**1**

A procedure for sorting of municipal solid waste according to the types of materials, of which certain components are made, **characterized in** that the procedure consists of the following stages:

1. Reception and dosing of municipal solid waste and drainage of free waste water from wet waste through a chamber for reception and dosage;
2. Shredding of larger waste in a device for shredding;
3. Sifting of waste in a device for sifting;
4. Manual sorting of unsifted waste on a line for manual sorting according to the types of material of which certain waste components are made;
5. Separation of ferromagnetic metals from an unsorted part of waste through a device for magnetic separation of ferromagnetic metals; and
6. Pressing and binding of sorted compressible waste components in a device for pressing and binding.

2

The procedure for sorting of municipal solid waste according to claim 1, **characterized in** that waste transportation between some stages of the procedure is done by inclined ribbed conveyor belts and horizontal conveyor belts.

3

The procedure for sorting of municipal solid waste according to claim 1, **characterized in** that in the third stage of the procedure the smallest biological waste is separated by sifting.

4

The procedure for sorting of municipal solid waste according to claim 1, **characterized in** that dedusting, using a unique ventilation system, is carried out during the shredding of larger waste in the second stage of the procedure and during waste sifting in the third stage of the procedure.

5

The procedure for sorting of municipal solid waste according to claim 1, **characterized in** that in the fourth stage of the procedure the manual sorting of unsifted waste is done in the manner that workers select from the belt one type of waste defined by the material of which it is made and deposit it in a container with

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funnel intended for this type of material and that the contents of the loaded containers with funnels are discharged into containers or boxes under the platform on which a line for manual waste sorting is placed.

6

- 5 The procedure for sorting of municipal solid waste according to claim 5, **characterized in** that plastic bottles and other closed plastic packaging should be perforated in a device for perforating before being deposited in the appropriate container with funnel.

7

- 10 The procedure for sorting of municipal solid waste according to claim 5, **characterized in** that in the fourth stage of the procedure incompressible components of solid waste made of glass and compressible components made of different types of plastic materials, paper, cardboard and compressible products made of stained metal are separated by manual sorting.

8

- 15 The procedure for sorting of municipal solid waste according to claim 5, **characterized in** that in the fourth stage of the procedure manual sorting is done in a closed air conditioned space.

9

- 20 The procedure for sorting of municipal solid waste according to claim 1, **characterized in** that in the fifth stage of the procedure ferromagnetic metals are separated from the unsorted part of waste which remained on the conveyor belt after manual sorting, and that the rest of the unsorted waste material is deposited in containers suitable for the transportation thereof to landfills of unsorted waste.

10

- 25 The procedure for sorting of municipal solid waste according to claim 1, **characterized in** that in the sixth stage of the procedure compressible waste components are bonded into bales.

11

- 30 A plant for sorting of municipal solid waste according to the types of material, of which certain waste components are made, **characterized in** that the plant consists of:

13

1. A chamber (1) for reception and dosing of municipal solid waste and drainage of free waste water from wet waste;
2. A device (2) for shredding of large waste;
3. A device (3) for sifting;
- 5 4. A line (4) for manual sorting;
5. A device (5) for magnetic separation of ferromagnetic metals; and
6. A device (6) for pressing and binding of sorted compressible waste components.

12

- 10 The plant for sorting of municipal solid waste according to claim 11, **characterized in** that the transportation of waste between certain devices is done using inclined ribbed conveyor belts (T_1), (T_2), (T_3) and (T_6), as well as horizontal conveyor belts (T_4) and (T_5).

13

- 15 The plant for sorting of municipal solid waste according to claim 11, **characterized in** that the chamber (1), placed under the ground level, consists of a metal shell with tight bottom in the form of letter V, that free waste water from the chamber (1) bottom is drained in a system for waste water treatment and that waste from the chamber (1) bottom is directed, using two worm screws and a thrust hydraulic
20 system, to the inclined ribbed conveyor belt (T_1).

14

- The plant for sorting of municipal solid waste according to claim 11, **characterized in** that the device (2) consists of a rotating drum with blades which rotate between stationary blades on a casing and cut the largest waste and that dust from the
25 device (2) is removed using a ventilation system.

15

- The plant for sorting of municipal solid waste according to claim 11, **characterized in** that the device (3), placed on a rack, consists of a cylindrical rotating screen placed in its casing, that the screen axis is inclined under a small angle in the
30 direction of the output hole of the screen, that the screen in its inner shell has a spiral rib, that circular and/or rectangular holes for sifting are made on the screen and that dust from the device (3) is removed using a ventilation system.

14

16

The plant for sorting of municipal solid waste according to claim 11, **characterized in** that the line (4) consists of a machine part which consists of a horizontal conveyor belt (T₄), a larger number of containers with funnels which are used for waste sorting and which are placed on both sides of the horizontal conveyor belt (T₄) and a large number of devices for perforating plastic bottles.

17

The plant for sorting of municipal solid waste according to claim 16, **characterized in** that a machine part of the line (4) is placed in the closed, prefabricated, air conditioned building object on a platform and that a building part is made as a line of connected container units which form a single spatial entirety in the form of tunnel.

18

The plant for sorting of municipal solid waste according to claims 16 and 17, **characterized in** that the contents of the loaded containers with funnels are discharged through the floor of the building object into containers or boxes under the platform.

19

The plant for sorting of municipal solid waste according to claim 11, **characterized in** that the device (5) consists of an electromagnet with the associated equipment for running and management.

20

The plant for sorting of municipal solid waste according to claim 11, **characterized in** that the device (6) consists of a reception part, a hydraulic press and a part for binding of unsorted compressible waste components into bales.

21

The plant for sorting of municipal solid waste according to claims 11 to 20, **characterized in** that the capacity of the plant can range from 5 to 20 tons of waste/hour.

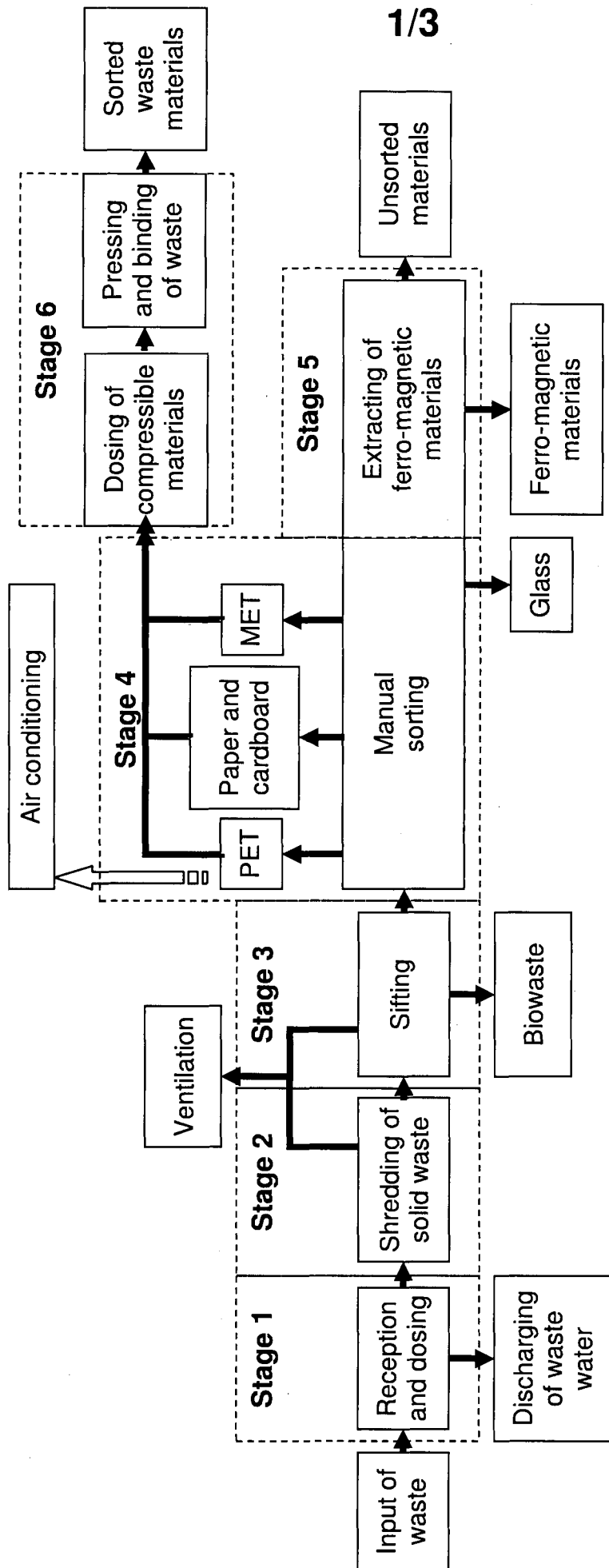


Figure 1

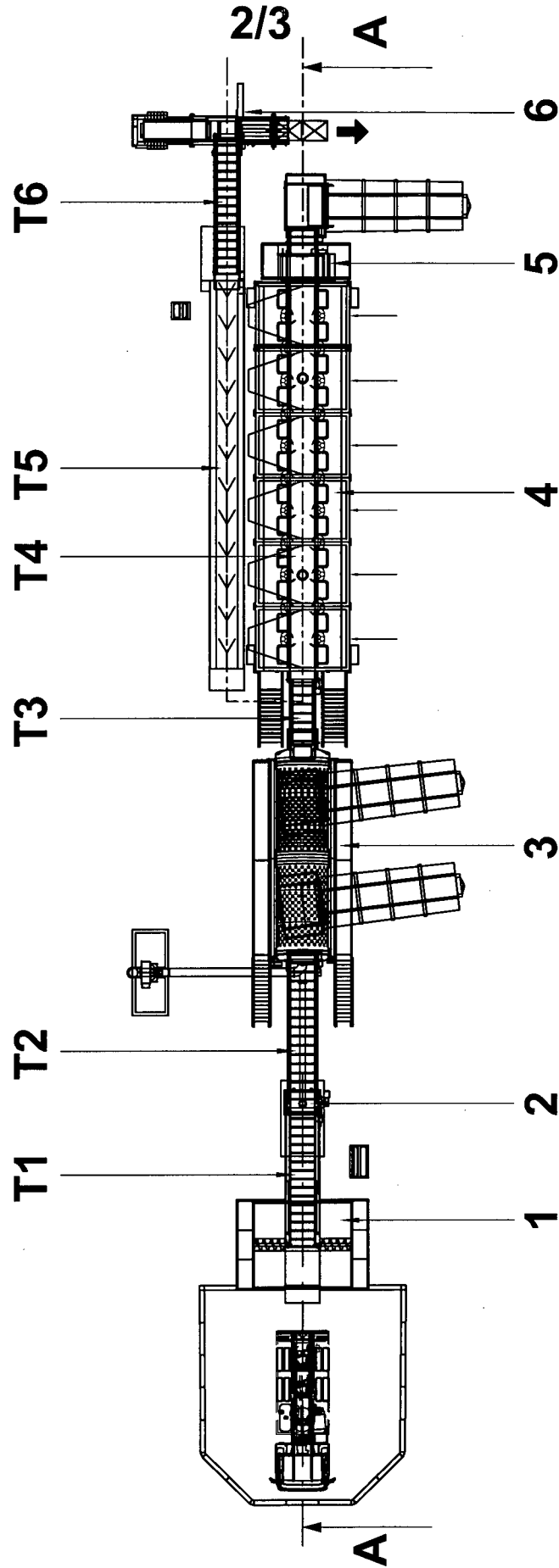


Figure 2

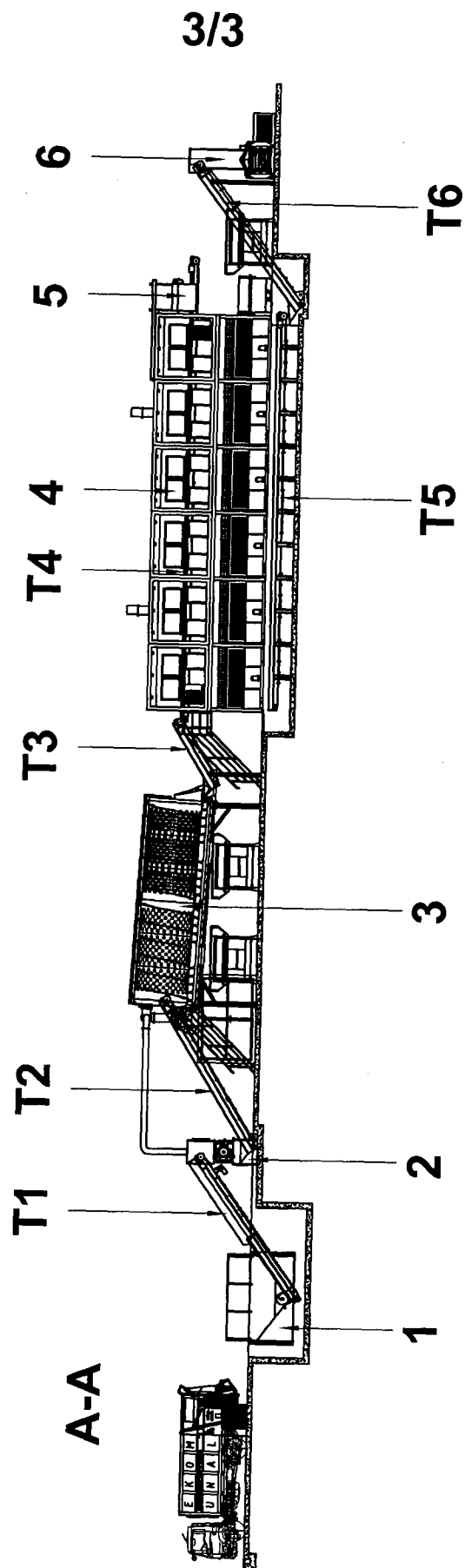


Figure 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/HR2012/000008

A. CLASSIFICATION OF SUBJECT MATTER
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ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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B03B

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

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

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 610 396 A (CARBONELL SERRA ENRIQUE [ES] ET AL) 9 September 1986 (1986-09-09) column 3, line 39 - column 5, line 31; claims; figure 1 -----	1-21
X	US 5 071 075 A (WIENS THOMAS J [US]) 10 December 1991 (1991-12-10) column 3, line 34 - column 6, line 48; claims; figures 1,2 -----	1-21
A	EP 0 443 314 A2 (DOPPSTADT WERNER [DE]) 28 August 1991 (1991-08-28) the whole document -----	1-21



Further documents are listed in the continuation of Box C.



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