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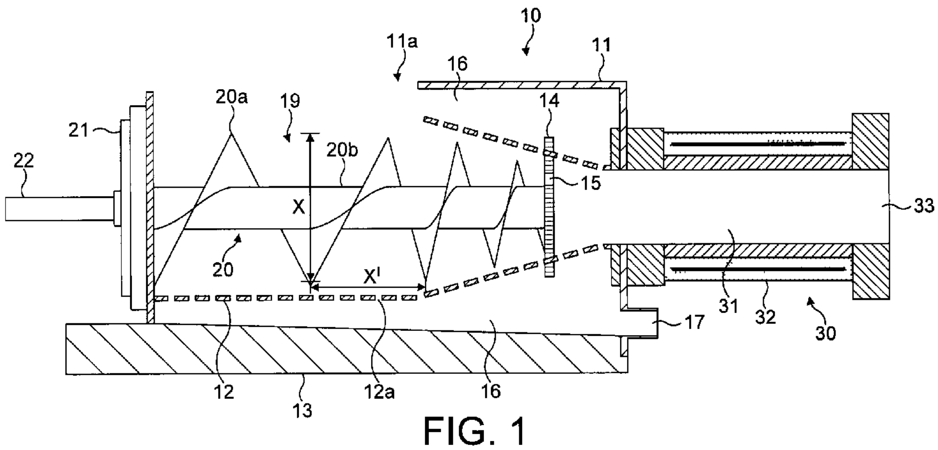

FIG. 1

(57) Abstract: An apparatus (10) suitable for processing a heterogeneous stream of waste material comprising: a housing (11) having a compaction compartment (19); a screw vane (20), located in the compaction compartment, for processing and transporting the waste material through the compaction compartment. The screw vane having a shaft (20b) about which is located a flight (20a) which extends radially outwardly in the form of a helical thread along the length of the shaft. The apparatus further comprises a heating zone (31) having a heating source (32), which is located adjacent to the housing and receives processed waste that has exited the compaction zone; and an extrusion nozzle which allows for processed waste to exit the heating zone. The diameter of the flight of the screw vane decreases along the length of the shaft towards a forward end of the shaft in cooperation with tapering of the diameter of the compaction compartment. A method for processing waste material is also provided. The apparatus and method advantageously provide output waste material which retains its compacted form and does not re-expand to its pre-compressed state.

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WASTE PROCESSING APPARATUS AND METHODS

FIELD OF THE INVENTION

The present invention relates to apparatus and methods for processing and treatment of waste and in particular processing involving a volumetric reduction of waste material.

BACKGROUND

As the world becomes increasingly industrialised and a greater number of nations switch from pastoral towards more developed economies, the amount of raw material consumption is growing rapidly. An unfortunate problem associated with increasing consumption is the associated increase in waste production. Consumerist societies are driven by choice and material gain. With so many products available to choose from product manufacturers often rely on elaborate packaging, get up, and design to entice the individual consumer to make a purchase. Further, as technology progresses at a rapid rate many new products are made with in-built obsolescence or are quickly superseded by the next model. When these factors are combined with poor utilisation of a low cost food supply, it is apparent that the amount of industrial, commercial and domestic waste produced by developing and developed economies is reaching levels that are unsustainable. Whilst efforts continue to reduce the amount of unnecessary waste that is produced, or to recycle higher value components within the waste stream, there is always going to be a proportion of the waste that cannot be effectively re-used.

A problem with varied forms of waste materials is that they can be bulky and take up a great amount of space if left unprocessed. This is especially true for thermoplastic foamed resins such as styrene foam or polyethylene foam which are widely used as packaging materials, heat insulating materials and sound insulating materials. There are several known methods for treating waste materials. Plastics such as the aforementioned thermoplastic foamed resins can be burnt in incinerators. In effect, incineration of waste materials converts the waste into heat, gaseous emissions, and residual solid ash. A problem with this method is that the incinerators tend to become damaged by the high heat generated when burning the plastics and harmful gases such as dioxin and chlorine are produced, as well as other pollutants. The emission of harmful gases into the atmosphere often makes it difficult for developers to obtain planning permission to build the incinerators as invariably there is strong opposition from the local resident population in the vicinity of a proposed incinerator. Further downsides of incineration include the high cost of the technology involved and the requirement for the incinerators to be staffed full-time by skilled management.

Consigning waste to landfill is one of the most traditional methods of waste disposal, and it remains a common practice in most countries. A well-managed and properly designed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials in a way that minimises their impact on the local environment. However, older, poorly-managed landfills can create a number of adverse environmental impacts such as wind-blown waste and litter, attraction of vermin, generation of a toxic waste known as leachate which can pollute groundwater and surface water, and generation of landfill gas, mainly composed of carbon dioxide and methane, which is produced as organic waste breaks down anaerobically. To overcome these problems, many landfills are covered with earth to prevent attracting vermin and to reduce the amount of wind-blown litter. In developed countries many landfills also have a gas extraction system to extract the landfill gas generated by the decomposing waste materials.

It is disadvantageous to dispose of untreated waste material in a landfill because the waste materials are bulky and therefore the cost of transporting them to the landfill is high. Furthermore, if the waste materials are not buried effectively or are not covered, the waste can be scattered by wind and vermin attracted to the decaying waste causing environmental pollution.

In Europe in particular, measures to prevent or reduce the negative effects of landfilling waste on the environment and on human health have been effected by the European Union Landfill Directive 1999/31/EC of 26 April 1999. It bans the landfill of liquids and certain solid wastes, provides for the classification of landfills as sites for inert, hazardous or non-hazardous waste, prohibits co-disposal and introduces requirements for the treatment of wastes prior to landfill. Treatment is defined according to "the three point test":

1. A physical/thermal/chemical or biological process including sorting, that
2. Changes the characteristics of the waste; and
3. Does so in order to:
    (a) reduce its mass, or
    (b) reduce its hazardous nature, or

(c) facilitate its handling, or
(d) enhance its recovery.

Compacting devices can be used to reduce the volume occupied by waste materials. A known type of compactor, typically referred to as a hydraulic compactor, comprises a rotating shaft having a screw vane located in a cylinder, wherein the waste material is driven through the cylinder by the rotating shaft and is deformed and compressed before finally being discharged through a nozzle. Conventional hydraulic compactors are generally slow in operation and the compacted material can create dust and other airborne or surface litter pollution. A particular problem with this type of device is that waste materials with elastic properties often return to their pre-compressed state or at least an expanded state once they have passed through the nozzle. This elastic 'memory' can induce blockages within the device, particularly if the waste material is wet. Furthermore, simple mechanical compaction alone does not meet the "treatment" criteria of the European Union Landfill Directive if the characteristics of the waste is not changed. It is therefore desirable to provide a waste processing apparatus where the waste output from the apparatus is retained in a substantially compacted state post-processing.

Compacting apparatus should not be confused with extrusion devices, which force a uniform homogeneous feedstock into alignment guides and specifically shaped dies to produce lengths of stock cross-sectional shapes, such as polymer pipes, rods or tracks. Extrusion machines are constructed similarly to the compacting apparatus mentioned above, except that they are only designed to handle throughput of a constant and consistent material, e.g. plastics or metals, and they are not compactors as such.

Various styles of compaction devices are known. By way of example, US 5,1 14,331 describes an apparatus for shrinking volumes of waste foamed resin materials such as styrene foam or polyethylene foam which have been used as packing materials and altering them into chips and discharging them away. The apparatus comprises a hopper into which the waste foamed resin materials are thrown, a crushing room containing a crushing shaft for crushing the waste received in the hopper, a sending cylinder which receives waste from the crushing room and houses a rotatable shaft with a screw vane, a compression cylinder for compressing the waste and which partially houses the rotatable shaft, a heating cylinder for heating the waste to be softened, an extruding nozzle for extruding the waste in an elastic state, a rotating cutting means for cutting the extruded waste into chips and an exhaustion means for air-blowing the chips out of the apparatus.

The apparatus of US 5,114,331 suffers from the disadvantage that it is only capable of compacting and extruding waste foamed resin materials, i.e. a relatively homogenous waste feedstock. The described apparatus would be unsuitable for treating heterogeneous general waste because it is essentially an extrusion machine and has limited crush resistance meaning it would be prone to jamming. Furthermore, it would be unsuitable for treating a mixture of solid and liquid waste.

On the other hand, an extrusion apparatus is described in US 4,091,967 for dealing with the scraps of foamed thermoplastic synthetic resins which are formed during the processing of plastics and synthetic resins. This device suffers from the disadvantage that it is an extrusion machine and is only designed to melt and extrude scraps of foamed thermoplastic synthetic resins, i.e. a relatively homogenous waste feedstock. It would not be suitable for treating a mixture of different waste materials because the melting furnace contains a plurality of fins in which unmelted general waste could become jammed. Furthermore, the extruding screw is not suitable for compaction of general waste.

JP2000246212 and JP2000185317 both describe twin screw-type waste compactors for compressing waste. The devices comprise twin hoppers, whereby general waste is fed into a first hopper and plastic waste is fed into a second hopper. A rotating shaft with a screw vane is associated with each hopper and acts to compress the waste after it is fed into the hopper. General waste fed into one of the hoppers is compressed and tightly covered with the extrusions of plastic waste and the combined extrusions flow through an outlet nozzle. Clearly, the devices of JP2000246212 and JP2000185317 suffer from the disadvantage that the waste requires separation into general waste and plastic waste before being fed into the hoppers. In waste processing a pre-sorting phase is time-consuming and complex, particularly when dealing with a clinical or domestic heterogeneous waste stream.

EP 0790122 describes an apparatus for compacting waste materials comprising a cylinder housing a rotatable shaft having a screw vane for compacting the waste and a flexible output nozzle. A disadvantage of this device is that waste materials with elastic properties will return to their pre-compressed state or at least an expanded state once they have passed through the nozzle, thereby negating the benefit of compacting the waste in the first place.

GB 2,159,093 describes an apparatus for compacting solid waste materials comprising a hopper intoowhich the waste is fed, a cylinder housing a rotatable shaft having a screw vane for compacting the waste, a heating portion that extends along part of the cylinder to heat the waste in the cylinder and an outlet nozzle for compressing the waste coupled to a discharging outlet. A disadvantage of this apparatus is that the screw and the cylinder are of a uniform construction leading to low efficiency of compaction. Furthermore, given that heating takes place over a part of the cylinder, upon cooling after processing, any melted material in the cylinder will solidify and adhere to the screw, making it necessary to continually clean the cylinder and the screw prior to re-use. Also this apparatus is not suitable for treating liquid waste.

It is evident that while attempts have been made to devise waste processing that utilises compaction with further processing of waste materials, there remains a need for apparatus and methods that can accommodate a highly heterogeneous waste stream without the need for pre-treatment or sorting prior to processing.

SUMMARY OF THE INVENTION

In a first aspect; the present invention resides in an apparatus for processing waste material, comprising:

> a housing comprising a barrel, wherein the barrel defines a compaction compartment, and wherein the barrel further comprises an opening for receiving waste material into the compaction compartment at a rearward end of the compaction compartment and a port which allows for compacted waste to exit the compaction compartment at a forward end of the compaction compartment;
>
> a screw vane, located in the compaction compartment, for processing and transporting the waste material through the compaction compartment, said screw vane comprising a shaft about which is located a flight which extends radially outwardly in the form of a helical thread along the length of the shaft from the rearward end of the compaction compartment to the forward end of the compaction compartment;

a heating zone defined by an elongated conduit having a heating source, wherein the heating zone is located adjacent to the housing and receives processed waste that has exited the compaction zone via the port; and

an extrusion nozzle which allows for processed waste to exit the heating zone;

wherein the diameter of the flight of the screw vane decreases along the length of the shaft towards a forward end of the shaft in cooperation with tapering of the diameter of the compaction compartment.

In a second aspect, the present invention resides in an apparatus for processing waste material, comprising:

a housing comprising a barrel, wherein the barrel defines a compaction compartment, and wherein the barrel further comprises an opening for receiving waste material into the compaction compartment at a rearward end of the compaction compartment and a port which allows for compacted waste to exit the compaction compartment at a forward end of the compaction compartment;

a screw vane, located in the compaction compartment, for processing and transporting the waste material through the compaction compartment, said screw vane comprising a shaft about which is located a flight which extends radially outwardly in the form of a helical thread along the length of the shaft from the rearward end of the compaction compartment to the forward end of the compaction compartment; and

an extrusion nozzle which allows for processed waste to exit the heating zone;

wherein the diameter of the flight of the screw vane decreases along the length of the shaft towards a forward end of the shaft in cooperation with tapering of the diameter of the compaction compartment.

In a third aspect, the present invention resides in a screw vane suitable for use in a waste processing apparatus, comprising a shaft about which is located a flight which extends radially outwardly in the form of a helical thread along the length of the shaft, wherein the diameter of the flight and the pitch of the flight diminish along the length of the shaft.

In a fourth aspect, the present invention resides in a method for processing heterogeneous waste material comprising:

feeding heterogeneous waste material into a compaction compartment, wherein the compaction compartment defines a progressively tapering waste processing path that diminishes in diameter as waste proceeds along the processing path;

transporting and compacting the waste material through the compaction compartment towards a port which allows for compacted waste to exit the compaction compartment;

heating the compacted waste, which has exited the compaction compartment, in a heating zone to a temperature that facilitates melting of low molecular weight polymeric materials located within the waste but which is below the carbonisation temperature of either the polymeric materials or the organic matter within the waste; and

extruding the compacted and heated waste from the heating zone through an extrusion nozzle to produce compacted and sterilised waste which is encapsulated within the melted polymeric materials comprised within the waste.

In order that the invention may be more readily understood, reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a cut away side view of the compaction and heat treatment components comprised within an apparatus of the present invention;

Figure 2 is a schematic side view of an apparatus of the present invention incorporating additional features;

Figure 3 is a rearward schematic view of an apparatus of the invention along line A-A as shown in Figure 2.

Figure 4 is a plan (top) schematic view of an apparatus of the invention along line B-B as shown in Figure 2.

Figure 5 (a) shows a representation of a top view of the apparatus with the shredding arrangement visible within the hopper assembly, (b) shows a side view representation of an apparatus of the invention in use.

DETAILED DESCRIPTION

A specific embodiment of the invention is shown in Figure 1. The apparatus 10 comprises a housing 11, which is typically of metal or metal alloy - e.g. steel. The housing 11 encloses a compaction compartment 19. The compaction compartment 19 is substantially cylindrical in cross section and, as such, defines a barrel 12 that extends longitudinally along the length of the housing 11. The barrel 12 substantially encloses the compartment 19 with the exception of an opening 11a that is located in the uppermost portion of the barrel 12 and which allows for the introduction of waste material that is to be processed into the compartment 19. The barrel 12 is suitably formed of case hardened bimetallic steel, although other types of abrasion resistant material are also suitable.

For the purposes of clarity the terms "forward" and "rearward" will be used to define the longitudinal termini of the apparatus 10 and reflect the movement of waste along an axis running from the entry point (rearward) to the exit point (forward) within the apparatus. Located within the compartment 19 is a screw vane 20, adapted to be suitable for cutting and breaking up the waste material and transporting and compacting it through the compartment 19. The screw vane 20 comprises a shaft 20b, about which is located a flight 20a which extends radially outwardly in the form of a helical ridge/thread that extends around the shaft 20b from the rearward portion of the compartment 19 to the forward portion of the compartment 19. The shaft 20b is substantially cylindrical and rotates about a bearing 21 located at the rearward end of the housing and a bearing located in the forward base plate 14 located at the forward end of the housing 11.

The flight 20a of the screw vane 20 varies in diameter along the length of the shaft 20b. The diameter of the flight 20a and the shaft 20b are defined with respect to the central axis of rotation of the screw vane 20. Towards the rearward end of the shaft 20b the flight 20a may have a diameter that is up to 4 times greater than the diameter of the shaft 20b. The diameter of the flight 20a diminishes along the length of the shaft to a diameter that is substantially as little as 1.5 times the diameter of the shaft 20b. In the specific embodiment of the invention shown in Figure 1, the diameter of the flight 20a diminishes along the length of the shaft 20b from the rearward to the forward end of the shaft 20b. In this specific embodiment, the diameter of the flight 20a relative to the diameter of the shaft 20b diminishes from a factor of about 3.5:1 at the rearward end to 2:1 at the forward end. The diameter of the flight 20a diminishes in cooperation with tapering of the compartment 19 as defined by the barrel 12. Simultaneous tapering of the compartment 19 and the screw vane 20 causes increasing compaction of the waste material along the length of the compartment 19 towards the forward end of the apparatus 10. With the exception of the opening 11a, the outer edge of the flight 20a is maintained at a substantially constant distance from the interior surface of the barrel 12 along the entire length of the compartment 19. Typically, the clearance between the outer edge of the flight 20a and the surface of the barrel 12 is between 5mm and 15mm, more typically between 8.5mm and 12.5mm, suitably around 10mm.

In a further specific embodiment (as shown in Figure 1) the pitch of the flight 20a along the shaft 20 varies from a value that is around the same as that of the diameter of the flight 20a to about half of the diameter of the flight 20a. This is shown in Figure 1 as the diameter of the flight (see arrow X) compared to the horizontal distance (pitch) between adjacent points on the flight (as shown by arrow X'). In embodiments of the invention the ratio between X and X' can vary between 1:1 to substantially 2:1 or less, as required.

The effect of combined reduction in the diameter of the flight 20a and the pitch along the length of the shaft 20b effectively results in the progressive tapering of the path along which the waste travels from the rearward to forward direction. The variation of flight 20a diameter and pitch can be used in combination or separately in order to define the waste compaction path within the compartment 19. Variation of the diameter of the flight 20a and/or the pitch can be altered along the shaft 20b, dependent upon the nature of the waste that is likely to be handled by the apparatus of the invention. It is a significant advantage of the invention that the diameter of the flight 20a compared to that of the shaft 20b is substantially greater than that utilised in screw compactors of the art. The inventors have determined that a screw vane 20 comprising a flight 20a of significantly increased diameter results in highly efficient compaction of an unprocessed heterogeneous waste stream (e.g. domestic, clinical or laboratory waste) with a minimum blockage risk. Typically, the compaction rate of the apparatus of the invention is up to five times greater than that of a conventional hydraulic compactor, with the apparatus being able to process up to 500 kg of waste per hour.

At the forward end of the compartment 19 there is located a base plate 14. A port 15 in the base plate 14 allows for compacted waste to exit the compartment 19, towards the nozzle 33.

In a specific embodiment of the invention the barrel 12 comprises a plurality of apertures 12a that enable fluid communication between the compartment 19 and an adjacent drainage compartment 16. The apertures 12a allow for liquid contained within the compacted waste stream to exit the compartment 19 into the drainage compartment 16. The drainage compartment 16 may extend the full length of the housing, or occupy only a portion of the housing. Liquid that accumulates within a sump located in the drainage compartment 16 is able to drain out of the apparatus via a drainage port 17 for further processing. Optionally, liquid may be forcibly expelled from the apparatus by a pump (not shown). The pump may be located within or adjacent to the drainage port 17 and can be used to generate a negative pressure within the drainage compartment. In a preferred embodiment of the invention the lower surface of the drainage compartment 16 slopes towards the drainage port 17. The lower surface of the drainage compartment 16 is defined by the base of the apparatus 13. The apertures 12a may be arrayed with an even spacing within the barrel 12. Alternatively, the density of aperture 12a spacing can vary along the barrel so as to control the drainage of liquids at various positions along the waste compaction path. Typically the apertures 12a are in the form of substantially circular apertures or elongated slots. The circular apertures may range from about 5mm to about 125mm in diameter, more preferably from about 15mm to about 75mm and most preferably from about 25mm to about 50mm. The elongated slots may range from about 25mm width x 125mm length to about 25mm width x 1500mm length or any suitable diameter in between. It will be appreciated that a combination of slots and/or circular apertures of differing sizes can be used in order to control fluid drainage from the compaction compartment 19. The inner surface of the barrel 12 that defines the compaction compartment 19 may also comprise channels or grooves that direct liquid released from the waste stream towards the plurality of apertures 12a.

Following compaction of the waste stream and extrusion of the compacted material through the port 15 in the base plate 14, the compacted waste stream is urged into a heating zone 31 that is defined by an elongated conduit 30. The conduit is suitably manufactured from an abrasion resistant material such as case hardened bimetallic steel.

In a specific embodiment of the invention, the conduit 30 is enshrouded with a heating unit 32 that allows for elevation of the temperature in the heating zone 31 to a temperature that facilitates the melting of mixed polymeric materials located within the compacted waste stream but which is below the carbonisation temperature of either the polymers or the organic matter within the waste stream. Low melting point polymers include, for example, film waste and bottles comprising polyethylene terephthalate (PET), high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene and polyvinyl chloride (PVC). The low melting point polymers located within the compacted waste stream melt and mix further with the remainder of the waste material so as to form a semi-liquefied compaction slurry of waste that is urged along the heating zone 31 due to displacement caused via further waste entering the heating zone 31 via the port 15. The waste slurry exits the heating zone 31 via an extrusion nozzle 33.

A variety of mechanisms are available for applying thermal energy to the heating zone 31. In a specific embodiment of the invention shown in Figure 1, an electrical conduction heater 32 is comprised within the conduit 30, allowing for controlled heating along the length of the conduit 30. Electrical resistance heaters are particularly suitable, of ceramic, cast aluminium or bronze construction, comprising an integrated cooling circuit and controlled by a thermocouple to adjust the temperature for precise temperature control. Other types of heating sources are possible, including electromagnetic induction, heat exchanger and microwaves. In a specific embodiment of the invention a temperature gradient can be applied from the rearward end of the heating zone 31 towards the forward end of the heating zone 31. In an alternative embodiment of the invention the gradient of temperature can increase to a maximum within the central region of the heated zone 31 and then diminish towards the extrusion nozzle 33.

The rotatable shaft 20b can be engaged with a drive assembly via the portion of the shaft 22 that extends outwardly from the rearward end of the housing 11. Figure 2 shows a drive motor 50 that provides motive force to drive the rotation of the screw vane 20 in a forward direction. In the event of blockage, so as to prevent damage to the screw vane 20 and motor 50, the drive motor 50 can be adjustable for speed and may further comprise a thrust bearing. Furthermore, the ultimate density of the output processed waste can be altered by varying the speed of rotation of the shaft. Typically, the shaft rotates at a speed in the region of 2 to 8 rpm. In a particular embodiment of the invention, the drive motor 50 includes a reverse gearing arrangement that allows for the screw vane 20 to be driven in a rearward direction so as to further assist in clearance of potential blockages.

The apparatus of the invention is suitable for treatment of a variety of waste streams. For example, the compactor is ideally suited for effecting the secure and safe destruction of confidential waste material and magnetic media such as VHS video tapes which are now obsolete and for compacting pharmaceuticals or foodstuffs that have manufacturing defects such as incorrect packaging or are time expired rendering them impossible for resale. A particular advantage of the apparatus is that it is able to provide treatment of unprocessed waste originating from domestic, clinical, laboratory or mixed industrial sources. In particular the waste does not require pre-treatment prior to introduction into the apparatus of the invention. It is of particular advantage that the waste can include liquid-containing materials which are increasingly prohibited from inclusion in landfill, because the apparatus allows for the extraction of the liquid component from the waste stream. In a particular embodiment of the invention, the apparatus is suitable for separation of liquid waste from solid waste, for example in the treatment of waste which comprises a high liquid component, including tinned food products, packaging containing waste vegetable matter, automotive oil filters, and liquid chemical or biohazardous waste located within metal drums or plastic barrels. When it is envisaged that the waste stream is likely to include a significant liquid component, it is typical that the apparatus of the invention comprises the liquid extraction features of the invention located prior to the heating zone, so as to minimise the risk of a steam explosion.

The heterogeneous waste that is treated by the process of the invention is sterile due to the heating, heavy compaction, and encapsulation within the polymeric component of the waste stream. For a waste stream, such as domestic waste, the extruded material is largely encapsulated within plastics and polymer materials comprised within the waste stream. The apparatus of the invention is particularly useful for processing heavily contaminated waste, such as hospital waste or food packaging containing blood, since the temperature profile and duration of the compaction process can be adjusted to exceed standard sterilisation procedures such as hospital autoclaving. The resultant material can be allowed to cool and is suitable for disposal in landfill in accordance with national regulations. An advantage of sterilised material is that it is virtually odourless and can be safely stored indefinitely.

In a specific embodiment of the invention, the nozzle 33 can be shaped so as to enable the extruded and encapsulated material to be formed into a configuration that is more appropriate for transport. Alternatively, the configuration of the extruded material can be such that it is suitable for alternative uses, such as in the construction industry, e.g. as a building block suitable for the construction of hard standing, or for underground cable conduit covers.

A mould (or die) 70 (as shown in Figure 5) may be located adjacent to the nozzle 33. The mould shapes the partially melted waste material into a desired shape as it cools and expels the waste through a mould outlet. In general use the mould is unheated, although it is possible for the heating unit 32 to be arranged and configured to heat at least a portion of the mould in the event that the apparatus 10 has not been used for a period of time, during which cooling and solidification of waste material may have occurred.

In specific embodiments of the invention the profile of the mould (die) can be altered so that different shaped waste can be output from the apparatus. For example, the mould may be square, triangular or circular, depending on the ultimate use of the waste. The output waste may be used as a building material, in which case square or oblong blocks of waste are preferable. A suitably sized and shaped mould may be used to produce simple products such as railway sleepers or ties in-situ where the waste is generated, thereby removing the need for output waste to be moved for manufacturing into products elsewhere. Heterogeneous output waste may advantageously be formed into briquettes for use as a refuse derived 'green' fuel, whereas homogenous output waste, such as PET beverage bottles or cardboard and paper, may be recycled.

Referring to Figure 2, in an embodiment of the invention the apparatus 10 comprises a hopper 40 having an upper opening into which waste material can be received and a lower opening which can lead directly to the opening 11a in the housing 11 (see Figure 1).

As shown in Figure 3, waste material can be fed into the hopper 40 via a side chute 41 which may be interlocked for safety. The chute 41 is hingedly mounted along the lower surface that engages with the hopper 40, so as to be movable between a vertical closed position, in which the chute 41 substantially covers the side opening in the hopper 40, and an horizontal open position, in which the side opening is at least partially uncovered. Figure 4 is a top view of the apparatus looking down into the hopper.

In an embodiment of the invention a shredding assembly 61 is located between the hopper 40 and the compaction compartment 19. Pre-treatment by mechanical disruption allows the waste to be pre-sized prior to compaction, although in some instances pre-sizing is not necessary, e.g. for small items of starting waste. Shredding helps the low melting point polymers within the waste stream mix with the high melting point polymers and organic matter and encapsulate them during the heating and sterilisation process. Different forms of shredders may be used depending upon the type of waste to be processed. For example, a single shaft rotary grinder shredder may be suitable for use with wood, paper, hard plastics, and other brittle materials, whereas a dual or quad-shaft rotary shear shredder may be suitable for use with metals, soft plastics, tyres, electronic waste, or any diverse and contaminated materials.

The apparatus 10 may, in certain embodiments, further comprise a ventilation system (not shown) downstream of the compartment 19 for the pressure release of fumes and superheated steam produced during heating of the waste material. The type of ventilation system used will depend on the location of the apparatus 10. For example, if the apparatus is located on a marine vessel the fumes are suitably vented by an electric fan into the ship's stack, or in other locations, the fumes can be directed to a flue that may also comprise an activated carbon filter.

In a specific embodiment of the invention, a guillotine (not shown) comprising a hardened steel blade connected to a hydraulic activator operating on a timer may be located adjacent to the mould outlet to cut the expelled compacted waste material to the desired length. A collector may be provided beneath the guillotine to receive the cut lengths of waste material. The expelled compacted sterile block of waste can then be safely stored, transported, further processed or disposed of.

The apparatus 10 may be provided with a control panel 71 which comprises a microprocessor/programmable logic controller which is programmed prior to installation of the apparatus and is integrated with the drive assembly to control the speed of rotation of the rotatable shaft, temperature of the heating arrangement, and optionally the temperature of the mould and the time period for each cycle of the guillotine. Different programmes can be used for different types of waste material. The control panel enables an unskilled operator to successfully use the apparatus of the invention. Furthermore, the control panel allows safe operation of the apparatus and prevents the apparatus from being damaged if solidified residual waste is present in the heating zone of the apparatus upon start-up by softening the residual waste before the drive is engaged.

It is possible to extract the heat generated during the heating process using a heat exchanger in order to heat a building, or to assist in providing energy to power a combined heat power plant, for example to provide electricity to power refrigeration or air conditioning in a supermarket.

In one embodiment of the invention, the apparatus can be operated in a cold mode, either without a heater present or without the heater turned on. This mode may be chosen if the waste material does not contain plastics or the operator simply wishes to use the apparatus as a compactor, for example to condense cardboard, to de-water general waste or to crush cans, with a volumetric reduction of up to 80:1 on steel or aluminium cans.

Although the apparatus is designed to handle a diverse heterogeneous waste stream, it is of course possible for homogeneous waste material to be processed and compacted. The type of waste to be compacted will largely depend upon the location of the apparatus. For example, a compactor located on a cruise ship may be required to process significant quantities of generally polymeric waste, whereas a compactor situated behind a supermarket or shopping mall may be used to process single use plastic packaging such as carrier bags or shrink wrap film used to wrap pallets of goods.

Although particular embodiments of the invention has been disclosed herein in detail, this has been done by way of example and for the purposes of illustration only. The aforementioned embodiments are not intended to be limiting with respect to the scope of the appended claims. It is contemplated by the inventors that various substitutions, alterations, and modifications may be made to the invention without departing from the spirit and scope of the invention as defined by the claims. The various embodiments of the invention as described may be utilised either alone or in combination.

CLAIMS

1. An apparatus for processing waste material, comprising:

a housing comprising a barrel, wherein the barrel defines a compaction compartment, and wherein the barrel further comprises an opening for receiving waste material into the compaction compartment at a rearward end of the compaction compartment and a port which allows for compacted waste to exit the compaction compartment at a forward end of the compaction compartment;

a screw vane, located in the compaction compartment, for processing and transporting the waste material through the compaction compartment, said screw vane comprising a shaft about which is located a flight which extends radially outwardly in the form of a helical thread along the length of the shaft from the rearward end of the compaction compartment to the forward end of the compaction compartment;

a heating zone defined by an elongated conduit having a heating source, wherein the heating zone is located adjacent to the housing and receives processed waste that has exited the compaction zone via the port; and

an extrusion nozzle which allows for processed waste to exit the heating zone;

wherein the diameter of the flight of the screw vane decreases along the length of the shaft towards a forward end of the shaft in cooperation with tapering of the diameter of the compaction compartment.

2. The apparatus of claim 1, wherein the pitch of the flight diminishes along the length of the shaft.

3. The apparatus of claim 2, wherein the diameter of the flight relative to the pitch of the flight varies between about 1:1 and 2:1 along the length of the shaft.

4. The apparatus of any of claims 1 to 3, wherein the barrel further comprises a plurality of apertures to enable fluid communication between the compaction compartment and an adjacent drainage compartment.

5. The apparatus of claim 4, wherein the drainage compartment extends along the full length of the housing.

6. The apparatus of claim 4, wherein the drainage compartment extends along a portion of the housing.

7. The apparatus of any of claims 4 to 6, wherein the drainage compartment comprises a drainage port.

8. The apparatus of claim 7, wherein a lower surface of the drainage compartment slopes towards the drainage port.

9. The apparatus of any of claims 4 to 8, wherein the apertures are evenly spaced along the length of the barrel.

10. The apparatus of any of claims 4 to 8, wherein the apertures are variably spaced along the length of the barrel.

11. The apparatus of any of claims 4 to 10, wherein the apertures are circular.

12. The apparatus of claim 11, wherein the apertures range from about 5mm to about 125mm in diameter.

13. The apparatus of claim 11, wherein the apertures range from about 15mm to about 75mm in diameter.

14. The apparatus of claim 11, wherein the apertures range from about 25mm to about 50mm in diameter.

15. The apparatus of any of claims 4 to 10, wherein the apertures comprise elongated slots.

16. The apparatus of any of claims 4 to 15, wherein the barrel further comprises channels or grooves which direct fluid towards the apertures.

17. The apparatus of any of claims 1 to 16, wherein the maximum diameter of the flight is 4 times greater than the diameter of the shaft.

18. The apparatus of any of claims 1 to 17, wherein the minimum diameter of the flight is 1.5 times the diameter of the shaft.

19. The apparatus of any of claims 1 to 16, wherein the diameter of the flight relative to the diameter of the shaft tapers from about 3.5:1 at the rearward end of the shaft to 2:1 at the forward end of the shaft.

20. The apparatus of any of claims 1 to 19, wherein an outer edge of the flight is maintained at a constant distance from an interior surface of the barrel along the entire length of the compaction compartment.

21. The apparatus of claim 20, wherein the distance between the outer edge of the flight and the inner surface of the barrel is between 5mm and 15mm.

22. The apparatus of claim 20, wherein the distance between the outer edge of the flight and the inner surface of the barrel is between 8.5mm and 12.5mm.

23. The apparatus of claim 20, wherein the distance between the outer edge of the flight and the inner surface of the barrel is 10mm.

24. The apparatus of any of claims 1 to 23, wherein the heating source includes an electrical conduction heater, electromagnetic induction, a heat exchanger and microwaves.

25. The apparatus of any of claims 1 to 24, wherein a temperature gradient is applied from a rearward end of the heating zone to a forward end of the heating zone.

26. The apparatus of any of claims 1 to 24, wherein a temperature gradient is applied to the heating zone such that the temperature of the heating zone increases from a rearward end of the heating zone towards the centre of the heating zone and decreases from the centre of the heating zone towards a forward end of the heating zone.

27. The apparatus of any of claims 1 to 26, further comprising a hopper having an upper opening into which waste material is received and a lower opening which communicates with the opening of the barrel.

28. The apparatus of claim 27, wherein the hopper further comprises a side chute into which waste material is received.

29. The apparatus of any of claims 1 to 28, further comprising an assembly for mechanical disruption of waste material upstream of compaction.

30. The apparatus of claim 29, wherein the assembly for mechanical disruption is a shredder.

31. The apparatus of any of claims 1 to 30, further comprising a ventilation system downstream of the compaction compartment.

32. The apparatus of any of claims 1 to 31, wherein the configuration of the extrusion nozzle is variable so as to enable different shaped waste to be output from the apparatus.

33. The apparatus of any of claims 1 to 32, further comprising a mould adjacent to the extrusion nozzle to mould the extruded waste material into a desired shape.

34. The apparatus of claim 33, wherein the heating source is arranged to heat at least a portion of the mould.

35. An apparatus for processing waste material, comprising:

a housing comprising a barrel, wherein the barrel defines a compaction compartment, and wherein the barrel further comprises an opening for receiving waste material into the compaction compartment at a rearward end of the compaction compartment and a port which allows for compacted waste to exit the compaction compartment at a forward end of the compaction compartment;

a screw vane, located in the compaction compartment, for processing and transporting the waste material through the compaction compartment, said screw vane comprising a shaft about which is located a flight which extends radially outwardly in the form of a helical thread along the length of the shaft from the rearward end of the compaction compartment to the forward end of the compaction compartment; and

an extrusion nozzle which allows for processed waste to exit the heating zone;

wherein the diameter of the flight of the screw vane decreases along the length of the shaft towards a forward end of the shaft in cooperation with tapering of the diameter of the compaction compartment.

36. A screw vane suitable for use in a waste processing apparatus, comprising a shaft about which is located a flight which extends radially outwardly in the form of a helical thread along the length of the shaft, wherein the diameter of the flight and the pitch of the flight diminish along the length of the shaft.

37. The screw vane of claim 36, wherein the diameter of the flight relative to the pitch of the flight varies between about 1:1 and 2:1 along the length of the shaft.

38. The screw vane of claim 36 or claim 37, wherein the maximum diameter of the flight is 4 times the diameter of the shaft.

39. The screw vane of any of claims 36 to 38, wherein the minimum diameter of the flight is 1.5 times the diameter of the shaft.

40. The screw vane of any of claims 36 to 39, wherein the diameter of the flight relative to the diameter of the shaft is about 3.5:1 at a rearward end of the shaft to 2:1 at a forward end of the shaft.

41. A method for processing heterogeneous waste material comprising:

feeding heterogeneous waste material into a compaction compartment, wherein the compaction compartment defines a progressively tapering waste processing path that diminishes in diameter as waste proceeds along the processing path;

transporting and compacting the waste material through the compaction compartment towards a port which allows for compacted -waste to exit the compaction compartment;

heating the compacted waste, which has exited the compaction compartment, in a heating zone to a temperature that facilitates melting of low molecular weight polymeric materials located within the waste but which is below the carbonisation temperature of either the polymeric materials or the organic matter within the waste; and

extruding the compacted and heated waste from the heating zone through an extrusion nozzle to produce compacted and sterilised waste which is encapsulated within the melted polymeric materials comprised within the waste.

42. The method of claim 41 further comprising mechanical disruption of the heterogeneous waste material prior to the step of feeding the waste material into the compaction compartment.

43. The method of claim 41 or claim 42 further comprising moulding the extruded waste material into a desired shape after the step of extruding the compacted and heated waste material through the extrusion nozzle.

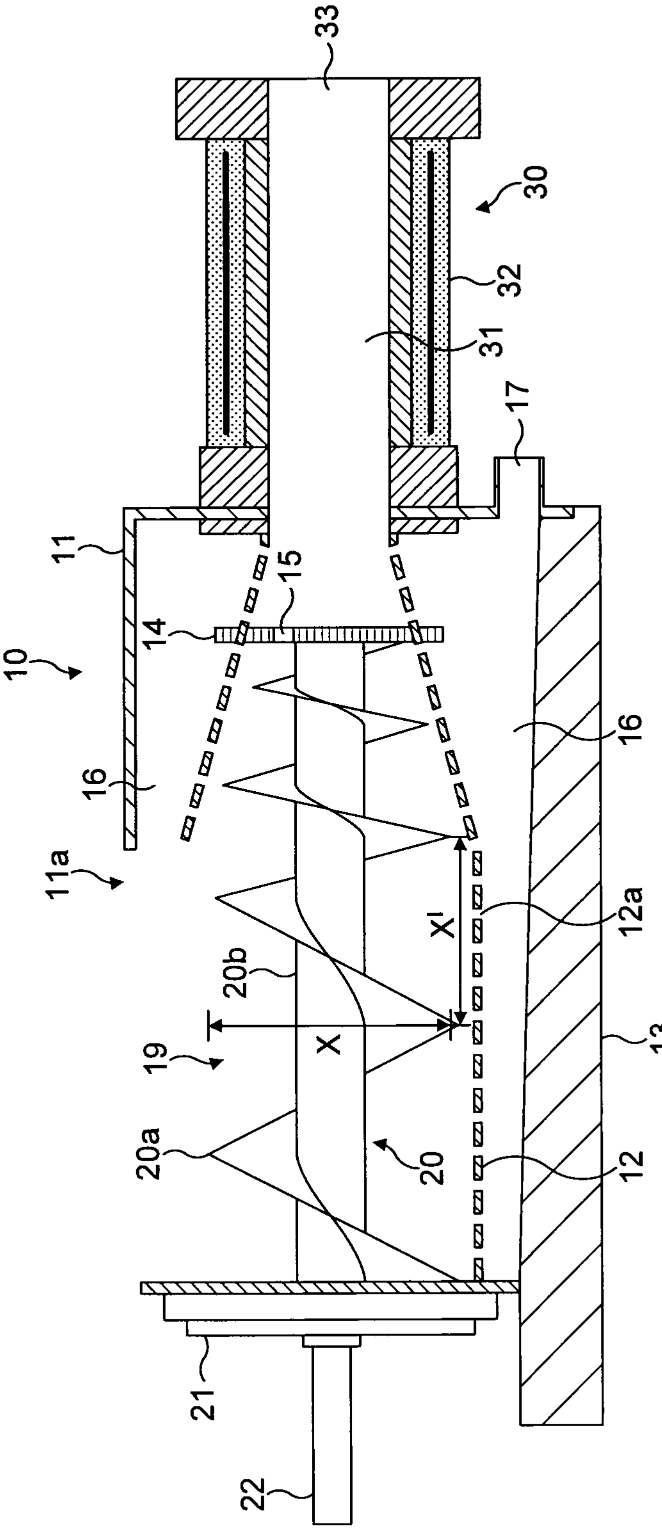

FIG. 1

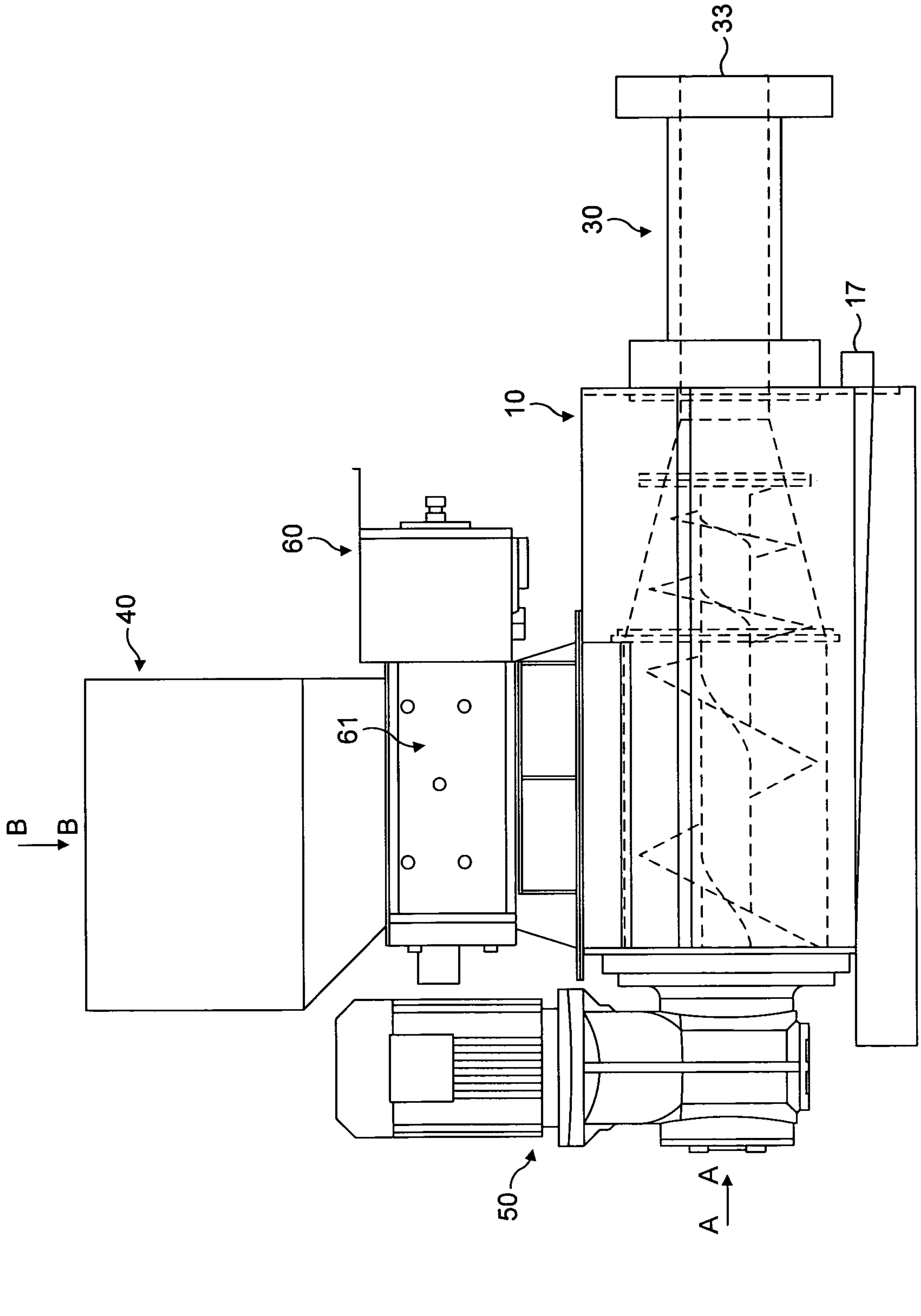

FIG. 2

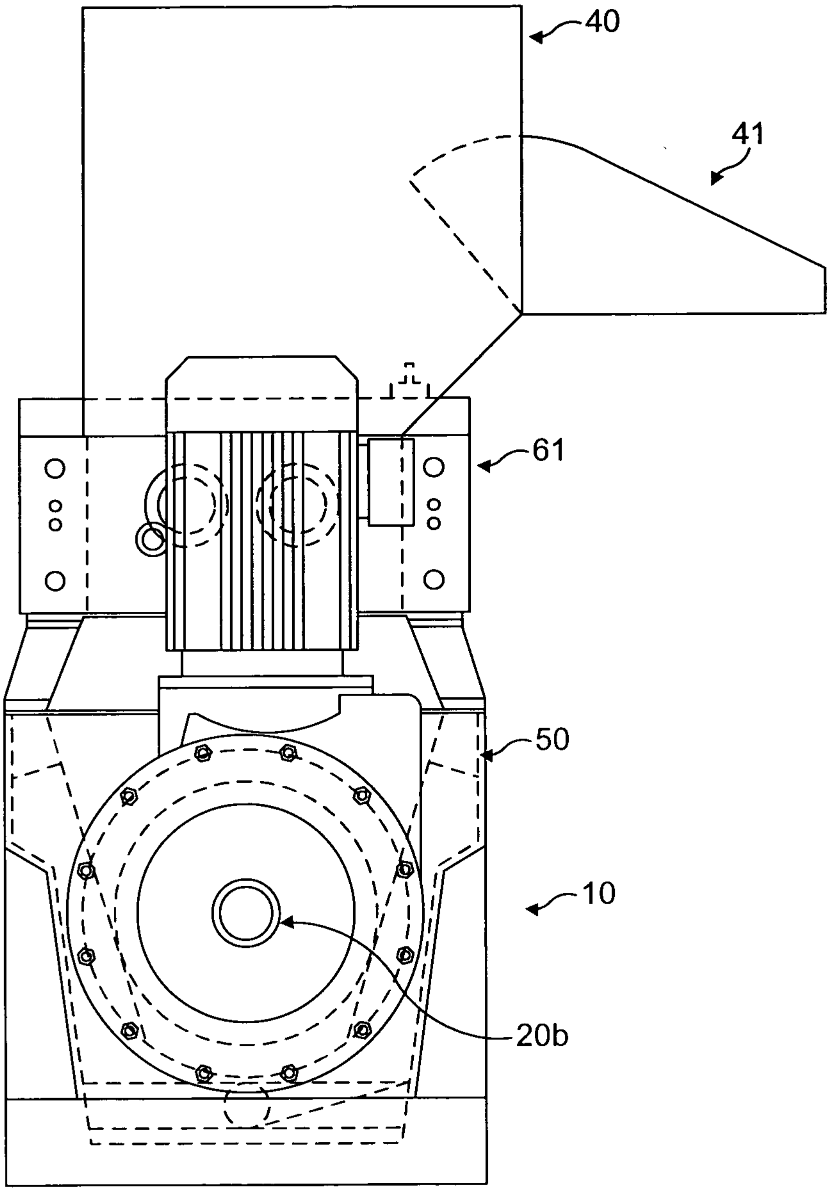

FIG. 3

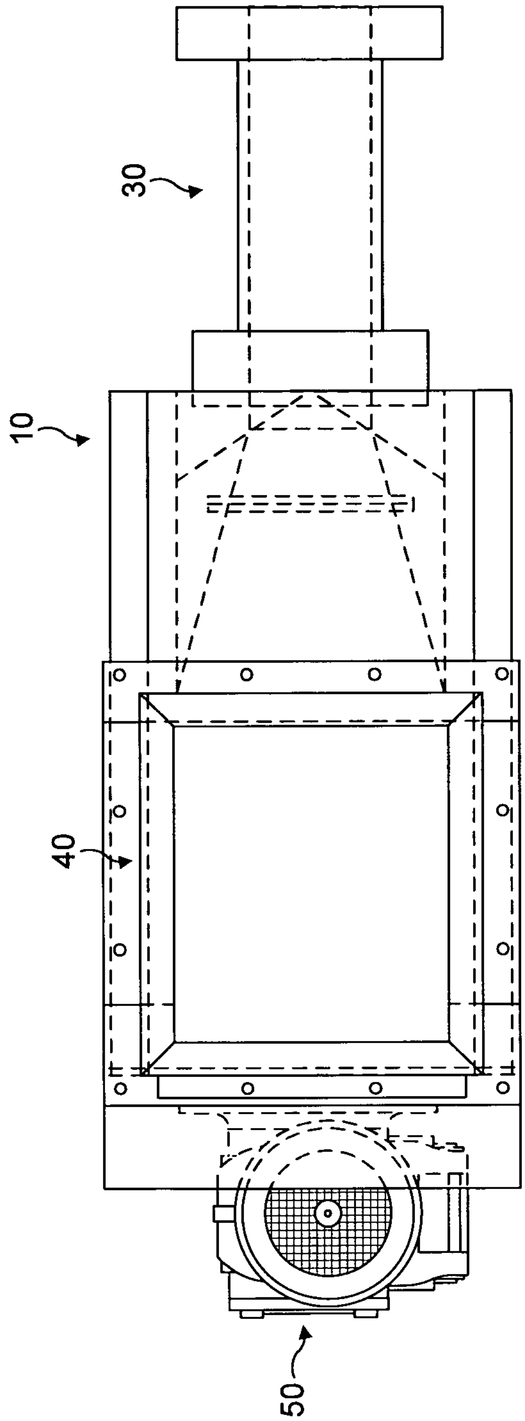

FIG. 4

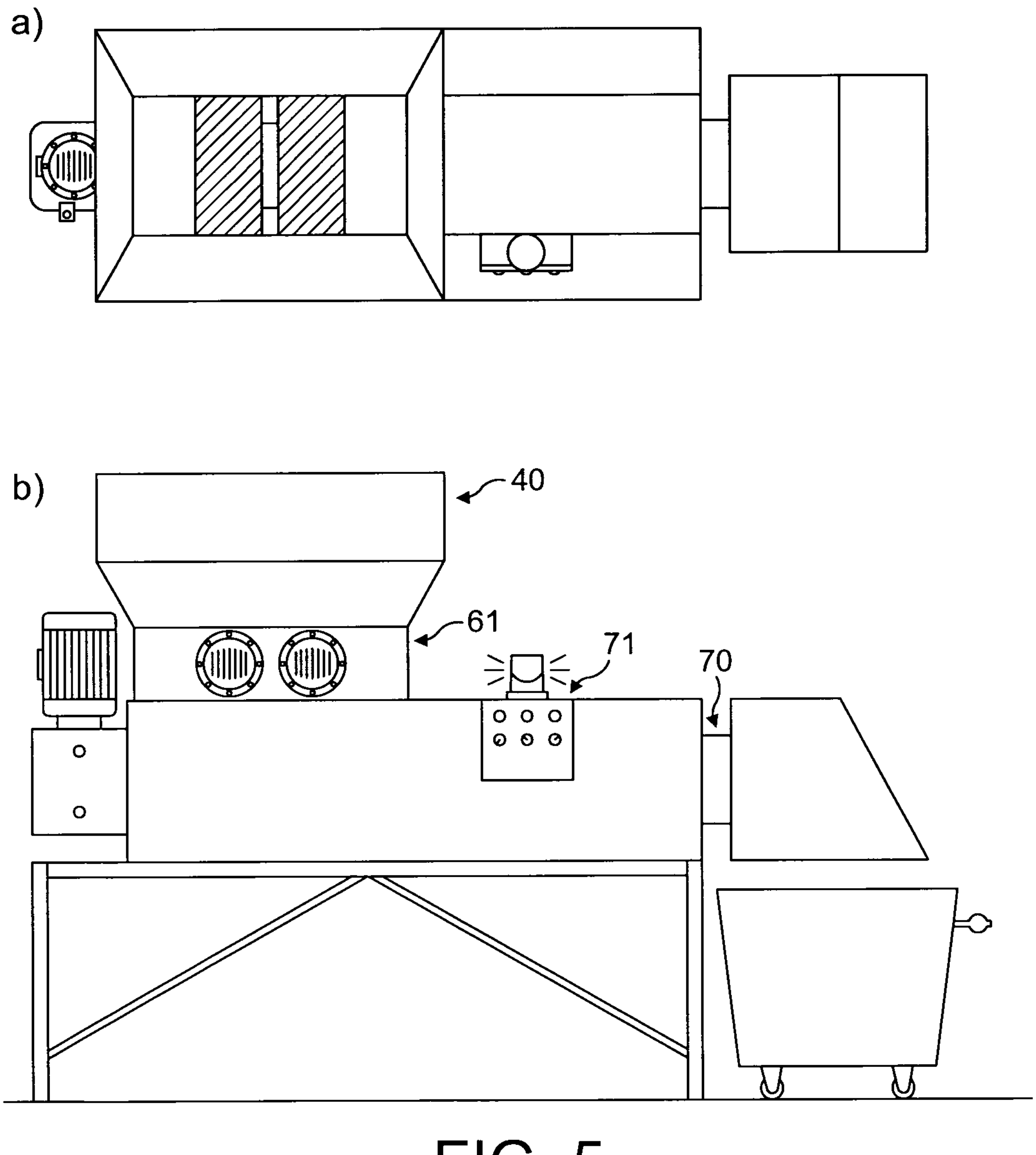

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/001560

A. CLASSIFICATION OF SUBJECT MATTER
INV. B30B9/12 B30B11/24 B29B17/00 B29C47/38 B30B9/30

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B30B B29B B29C

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 practical, search terms used)

EPO-Internal , WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	US 5 114 331 A (UMEHARA TAKESHI [JP] ET AL) 19 May 1992 (1992-05-19) cited in the application	1-3, 17-32, 35-42
Y	column 4, line 32 - line 55; figures 3,7	4-16,33, 34,43
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex

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19 August 2008	28/08/2008

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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