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(54) Apparatus and method for the drying of particulate material

(57) The application provides an apparatus for drying particulate materials comprising:
(i) a dryer (7) in which the particulate materials can be dried and heated, the dryer comprising a heating device (20); a drying chamber having an inlet (5) through which particulate material can be loaded into the drying chamber; an outlet (10) for dried and heated particulate material, and an exhaust gas outlet (6);
(ii) means (30) for moving a stream of heated gas from the heating device (20) through the drying chamber, thereby to dry and heat the particulate material, and then out through the exhaust gas outlet (6) as exhaust gas;
(iii) means defining a primary gas flow path extending from the exhaust gas outlet (6) to a discharge vent (32) through which exhaust gas can be discharged to atmosphere; a filtering device (27) being disposed between the exhaust gas outlet (6) and the discharge vent (32) for removing particulate matter from the exhaust gas prior to discharge through the discharge vent;
(iv) means (37, 38) defining a secondary gas flow path linked to a source of additional heated gas, whereby a downstream end of the secondary gas flow path communicates with the primary gas flow path at a location upstream of the filtering device;
(v) a flow control device (38) associated with the secondary gas flow path, the flow control device (38) being operable to control flow of the additional heated gas along the secondary gas flow path and into the primary gas flow path thereby to regulate the temperature of the exhaust gas in the primary gas flow path so that it is higher than a dew point of the exhaust gas when the exhaust gas enters the filtering device (27).

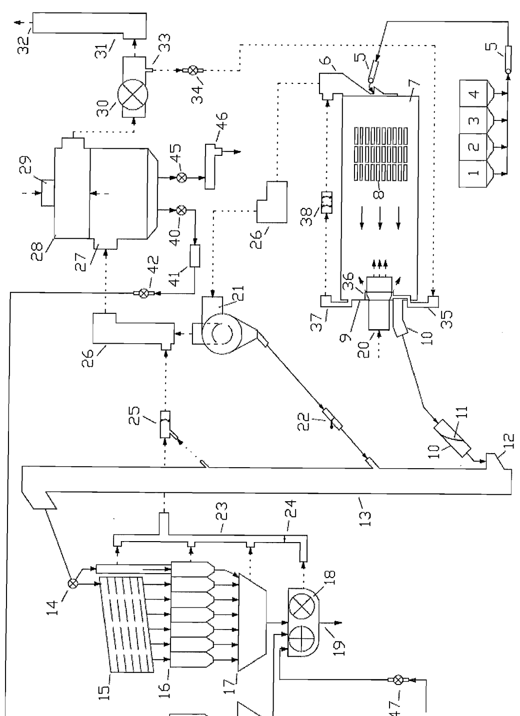

Figure 1

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Description

[0001] This invention relates to an apparatus and method for the drying of particulate material and in particular aggregates such as the aggregates used in the manufacture of asphalt.

Background of the Invention

[0002] Asphalt is the name used in the UK and Europe to denote the material, used in road building and other civil engineering applications, which comprises aggregates (e.g. crushed rock, gravel, shingle, sand and recycled broken up asphaltic road surface material) coated in bitumen. In the USA, this material is generally known as asphalt concrete.

[0003] The aggregates used in making asphalt typically contain substantial quantities of water, either because of the wet nature of the medium from which they have been extracted, or because they have been left out in the open and have therefore been exposed to atmospheric moisture. Consequently, the aggregates need to be dried before use. Moreover, in order to ensure efficient mixing of the aggregates and bitumen and maximise the binding of the bitumen to the aggregates, it is desirable that the aggregates should be heated prior to mixing with the bitumen. For these reasons, the aggregates used in making asphalt tend to be heated to temperatures in the range from 150 to 190 °C or higher. In some asphalt mixes such as hot rolled asphalt (HRA), temperatures as high as 220 °C to 230 °C are used.

[0004] A typical asphalt plant will therefore comprise a dryer for drying and heating the aggregates. A common form of dryer used in asphalt plants is a rotating drum dryer in which the heat for the drying process is provided by one or more combustion burners at one end of the drum. Air is drawn through the combustion burners and the heated gases from the burner pass along the interior of the rotating drum and out through a gas exhaust outlet at the far end of the drum. The stream of hot gases from the burner passing through the drum serves to dry the aggregates. In order to facilitate the drying and heating process, the internal side wall of the drying zone of the drum is provided with a series of scoops or blades which scoop up the aggregates from the floor of the drum, lift them to the high point of revolution of the drum and then drop them so that they fall back as a curtain of aggregates through the stream of hot gases to the floor of the drum. In most known types of drum dryer, a contra-flow arrangement is used in which the drum is inclined so that the drying aggregates gradually migrate from an inlet at the end of the drum opposite the combustion burner towards the end at which the burner is located. Once they have reached the burner end, the dried hot aggregates are discharged into a conveyor device, such as a bucket lift, which carries them to hot aggregate storage containers which, in more modern plants, are typically insulated. Prior to being discharged into the hot aggregate storage containers, they may be separated according to size by a size classifying device such as a vibrating screen device. However, in some plants, the size classifying device may be by-passed and all of the aggregates transferred into a single container. When this is done, the aggregates delivered from the feeders to the dryer are typically pregraded and the delivery of the aggregates into the dryer is controlled in a very accurate manner. This type of operation is useful for the preparation of asphalt mixes with a high proportion of a single size of stones.

[0005] From the hot aggregate storage containers, quantities of aggregates of a particular required size are weighed out into a weighing hopper and then discharged into a mixer. Quantities of recycled fines and other mix components such as lime filler or reclaimed dust may also be added at this stage. Hot bitumen is also introduced into the mixer to complete the final mix which is agitated and circulated in the mixer until the aggregates are thoroughly coated by and mixed with the bitumen. The resulting asphalt is then conveyed to insulated storage vessels (silos), ready for discharge into vehicles to be transported to the point of use. Alternatively, the hot asphalt may be discharged directly into vehicles for transport to the point of use.

[0006] The process of making asphalt generates considerable quantities of dry airborne fine particulate material and it is therefore conventional (and in most cases mandatory) practice to pass the exhaust gases from the dryers through one or more separating devices to remove the particulate materials before venting the exhaust gases to atmosphere. The most common form of separating device is a bag filter. Bag filters are prone to clogging and typically, therefore, means are employed for cleaning the filter to maintain a continual airflow through the filter. Cleaning of the bag filter is normally accomplished by inducing a reverse air flow through a section of the bag filter fabric on a timed basis. Alternatively, if the differential pressure across the fabric increases over a preset level, the cleaning cycle is started automatically until the lower preset pressure level is attained.

[0007] In order for the bag filter to work properly, it is important to ensure that the exhaust gas stream carrying the water vapour away from the dryer is maintained at a sufficiently high temperature that condensation of the vapour in the exhaust gases does not form on the filter material of the bag filter. For this reason, the heat output of the combustion burner in the dryer is set at a level whereby the temperature of the exhaust gas, by the time it reaches the bag filter, is above the dew point. If the temperature of the exhaust gas is not maintained above the dew point, and water does condense in the filter housing, this can lead to blockage of the filter as well as corrosion of the filter housing. The dew point of the exhaust gas will vary widely depending on the level of humidity of the exhaust gas.

[0008] The temperature of the exhaust gases is dependent upon a number of factors, of which the principal factors are:

(a) the heat output of the combustion burner;

(b) the moisture content of the aggregates introduced into the dryer;

(c) the required discharge temperature of the dried aggregates leaving the dryer;

(d) the flow velocity of the gases passing through the dryer;

(e) the efficiency and number of the scoops or lifters in the dryer; and

(f) the extent to which leakage of cold air from the exterior into the interior of the dryer can be prevented.

[0009] Of the above factors, only factor (e) is reasonably constant although a reduction in efficiency of the lifters may be observed as they are subjected to wear.

[0010] When an asphalt production plant is installed by a manufacturer, it is customary to set the plant up using the operating parameters suitable for the production of a relatively low temperature asphalt such as a 20 mm aggregate base course asphalt. With a 20 mm base course asphalt, the operating parameters of the plant are adjusted so that the discharge temperature of the dried aggregates is of the order of 150 °C and the temperature of the exhaust gases exiting the dryer is around 90-95 °C. The plant is set up by processing a trial batch of say 20 tons of aggregate and adjusting the burner output so that the dried aggregate is discharged at the correct temperature. If the temperature of the exhaust gases is too low, one or more of the lifters are removed from the dryer thereby reducing the amount of aggregate scooped up in any one revolution of the drum. This lowers the density of the curtain of aggregate falling through the stream of hot gases passing along the drum and thereby reduces the amount of heat taken out of the gas stream prior to the gases exiting the drum. Conversely, if the exhaust gas temperature is too high, one or more additional lifters may be installed to increase the amount of heat taken out of the hot gas stream by the aggregates. Typically, several trial runs may be conducted, the burner output and number of lifters being varied until an optimal or near optimal (for the 20 mm base course aggregate) combination of burner output and number of lifters has been found that will give the required discharge temperature and exhaust gas temperature.

[0011] A problem with setting up the plant using the operating parameters for one temperature grade of asphalt is that the plant may not operate efficiently for other temperature grades of asphalt.

[0012] Different types of asphalt mix require the aggregates to be dried and heated to different temperatures prior to mixing with bitumen. For example, in the production of hot rolled asphalts (HRA) of the type typically used for the final surface courses of roads and airport runways, the aggregates generally need to be dried and heated to temperatures in excess of 170 °C. As a particular example, a hot mix wearing surface asphalt containing 30-40% of sand of 8-9% moisture content may typically be heated to a temperature of 190 °C. If a plant which has initially been set up for a 20 mm base course asphalt (as described above) is used to produce the hot mix wearing surface asphalt, at the same vacuum pressure used for the base course asphalt, the burner output would probably be 30-40% higher and the temperature of the exhaust gas would typically be 140 °C and could be higher. Under such conditions, the energy wastage caused by discharging the hot exhaust gases into the atmosphere is very substantial.

[0013] If the aggregates used in the production of the asphalt contain recycled broken up asphaltic road materials, the temperatures used during the production are typically reduced so as to avoid the loss of light oil components of the bitumen coating on the particles of recycled road material. For example, for an asphalt mix containing up to about 30% reclaimed asphaltic road surface material, 3% bitumen, 3% reclaimed filler and 64% virgin aggregate, the production temperature can be as low as 140 °C and the exhaust gas temperature would be commensurately lower.

[0014] There are several problems associated with the use of the higher temperature (hot mix) asphalts. Firstly, they are exceedingly wasteful of energy. Secondly, the hotter the asphalt mix, the longer it will take to cool to a temperature at which a further coat can be applied or the asphalt surface has hardened sufficiently to be load bearing. In order to overcome these problems, lower temperature methods of producing asphalts have been developed.

[0015] For example, it is now permissible to produce base course asphalt using 30% recycled asphaltic road material along with virgin aggregate and bitumen where the aggregate is dried and heated in the dryer drum to a discharge temperature of only 95 °C. Whilst this considerably reduces cooling and overcoating times and potentially reduces energy wastage, a substantial problem is that the exhaust gas temperatures typically generated (in the region of 50 °C) tend to be lower than the dew point of the exhaust gas thereby giving rise to condensation in the bag filter as described above.

[0016] At the present time therefore, there remains a need for a process and apparatus for producing low temperature asphalt mixes that avoids the aforementioned problems.

Summary of the Invention

[0017] The present invention provides a number of improvements in the drying and processing of particulate materials and in particular materials commonly referred to as aggregates and which are used in civil engineering applications such as the manufacture of asphalt.

[0018] More particularly, the present invention sets out to provide an improved apparatus for drying aggregate materials of the type used in asphalt manufacture and which provides substantial energy savings over the drying apparatuses used in many existing asphalt manufacturing plants.

[0019] Accordingly, in a first aspect, the invention provides an apparatus for drying particulate materials comprising:

(i) a dryer in which the particulate materials can be dried and heated, the dryer comprising a heating device; a drying chamber having an inlet through which particulate material can be loaded into the drying chamber; an outlet for dried and heated particulate material, and an exhaust gas outlet;

(ii) means for moving a stream of heated gas from the heating device through the drying chamber, thereby to dry and heat the particulate material, and then out through the exhaust gas outlet as exhaust gas;

(iii) means defining a primary gas flow path extending from the exhaust gas outlet to a discharge vent through which exhaust gas can be discharged to atmosphere; a filtering device being disposed between the exhaust gas outlet and the discharge vent for removing particulate matter from the exhaust gas prior to discharge through the discharge vent;

(iv) means defining a secondary gas flow path linked to a source of additional heated gas, whereby a downstream end of the secondary gas flow path communicates with the primary gas flow path at a location upstream of the filtering device;

(v) a flow control device associated with the secondary gas flow path, the flow control device being operable to control flow of the additional heated gas along the secondary gas flow path and into the primary gas flow path thereby to regulate the temperature of the exhaust gas in the primary gas flow path so that it is higher than a dew point of the exhaust gas when the exhaust gas enters the filtering device.

[0020] Particular and preferred aspects and embodiments of the invention are as set out below or as defined in the claims appended hereto.

[0021] The heating device preferably comprises one or more combustion burners, and in particular oil or gas burners.

[0022] In one embodiment, the heating device comprises a combustion burner.

[0023] The stream of heated gas from the heating device therefore typically comprises combustion products and heated gases emanating from the oil or gas burners.

[0024] The filter device preferably comprises a bag filter.

[0025] In order to ensure that condensation does not take place in the filtering device and does not cause blockages of the filtering device, the exhaust gas entering the filtering device must be at a temperature exceeding the dew point of the heated gas. Therefore, means are provided for introducing into the primary gas flow path upstream of the filtering device a supplementary stream of additional heated gas having a higher temperature than the heated gas leaving the drying chamber through the gas outlet.

[0026] The temperature of the heated gas stream passing from the heating device through the drying chamber and out through the gas outlet will typically be lower in the region of the gas outlet, and higher in an upstream heating zone of the chamber closer to the heating device. The aforementioned supplementary stream of additional heated gas may therefore be drawn from an upstream region of the drying chamber which is hotter than a region of the drying chamber immediately adjacent the gas outlet. When the heating device comprises a combustion burner, the supplementary stream of heated gas may advantageously be gas that has been extracted from a region of the drying chamber adjacent the combustion burner.

[0027] Accordingly, in one embodiment, the source of additional heated gas is a region of the dryer which is hotter than a region of the drying chamber immediately adjacent the exhaust gas outlet.

[0028] In another embodiment, the source of additional heated gas is a region of the dryer adjacent the combustion burner.

[0029] In a further embodiment, the source of additional heated gas comprises a shroud in close proximity to a heated outer surface of the combustion burner, the shroud having an inlet through which gas can enter the shroud and an outlet leading into the secondary gas flow path. The shroud typically at least partially surrounds the combustion burner and more preferably fully encircles the burner.

[0030] The shroud, which may be of substantially cylindrical form, is typically arranged so that it encircles a section of the burner's combustion chamber. A channel is formed between the shroud and the outer surface of the combustion chamber so that gas passing through the channel is heated by contact with the hot outer surface of the burner.

[0031] Gas entering the shroud may be clean air drawn in from outside the apparatus or it may comprise warm air which has been recycled from another part of the asphalt manufacturing plant, for example warm air recycled from a location downstream of the outlet for the dried and heated particulate material. After the dried and heated particulate materials have left the drying chamber, they may be subjected to one or more further processing stages. At any one or more further processing stages, gas (e.g. air) that has been heated by virtue of proximity to the heated aggregates may be drawn off and recycled back to the shroud.

[0032] In one general embodiment, the apparatus does not include a diverter device of the type described in our earlier UK patent application number 1018834.0.

More particularly, in one general embodiment, the apparatus of the invention is other than one having a diverter device disposed between the filtering device and the discharge vent, wherein the diverter device is controllable to allow heated gas to discharge through the discharge vent or to divert all or a portion of the exhaust gas along a recycling gas flow path back into the drying chamber through or past the heating device.

[0033] The means defining the secondary gas flow path can comprise a duct having a downstream end which forms a junction with the primary gas flow path. The flow control device can comprise one or more flow control elements disposed in the duct. The one or more flow control elements can, for example, comprise one or more variable position doors disposed in the duct.

[0034] An upstream end of the duct can be connected to an outlet at a hotter region of the combustion chamber, e.g. in a region adjacent the heating device (e.g. burner). When the apparatus comprises a shroud, the outlet of the shroud can direct heated gas into a duct leading to the junction with the primary gas flow path. Alternatively, it can direct heated gas into the drying chamber, preferably with at least some of the gas heated in the shroud subsequently being extracted into a duct leading to the junction with the primary gas flow path.

[0035] The means for moving a stream of heated gas from the heating device through the drying chamber and out through the exhaust gas outlet typically comprises one or more extraction fans. The (or each) extraction fan is typically located downstream of the drying chamber and serves to draw the heated gas through the drying chamber. Typically, there is at least one extraction fan or pump located downstream of the filtering device to provide the necessary drawing power to draw the heated gas from the heating device through the drying chamber and along the primary gas flow path.

[0036] The heated gas leaving the drying chamber will contain a mixture of air, gases produced by the burner, water vapour and particulate material. The particulate material will typically vary in size from relatively coarse particles (up to about 1.5 mm) to relatively fine particles (less than 75 μM in diameter).

[0037] Preferably, a coarse particulate separating device for removing separating gas- entrained coarse particulate matter from the exhaust gas is disposed between the drying chamber and the filtering device.

[0038] The dryer typically comprises a rotating drum, the interior of which, together with associated end walls of the dryer, define the drying chamber. The heating device (e.g. combustion burner) is typically located at an upstream end of the drying chamber and the exhaust gas outlet is typically located at a downstream end of the drying chamber, the terms "upstream" and "downstream" in this context referring to the direction of flow of gas through the drying chamber. Thus, in one preferred embodiment, the drying chamber has one or more combustion burners at one end (the upstream end) and the gas outlet is at an end (the downstream end) remote from the combustion burner(s).

[0039] The rotating drum is preferably provided with one or more blades or scoops (collectively referred to herein as "lifters") on an inner surface thereof for collecting, lifting and releasing the particulate material so that it falls back through a stream of heated gas flowing from the heating means through the drying chamber. The shape, number and configuration of the lifters can be varied considerably and the skilled person would be well aware of suitable lifter arrangements for particular dryer drums.

[0040] As stated above, the filtering device is preferably a bag filter. The bag filter is mounted in or on a filter housing. Preferably the filter housing is provided with means for reducing clogging of the bag filter and/or unclogging the bag filter. For example, the filter housing may be provided with a fan or other device for directing air onto the filter in a reverse (upstream) direction to displace fine particulate material from the filter. The bag filter may be of conventional construction.

[0041] The apparatus of the invention typically, but not exclusively, may form part of an asphalt manufacturing plant. Therefore, after drying, the particulate materials will typically be conveyed to one or more storage containers for storing prior to mixing with bitumen to form the asphalt. The term "container" as used herein may refer to an individual container or to a compartment of a larger container.

[0042] Accordingly, the drying chamber typically has an inlet and outlet for the particulate materials and the outlet is linked to a conveyer device for conveying dried particulate materials away from the dryer, for example to one or more storage containers. Although one opening may in principle serve as both the inlet and the outlet for the particulate matter, it is preferred that there are separate inlet and outlet openings.

[0043] A duct or chute may be provided between the outlet for the particulate materials and the conveyer device. The duct or chute preferably is provided with a variable position door for controlling airflow between the drying chamber and the conveyor device.

[0044] The drying chamber may be arranged so that there is a contra-flow movement of particulates in the chamber, i.e. the dryer is constructed so that during the drying process, the particulates move from an inlet at the downstream end of the chamber to an outlet at the upstream end of the chamber. The contra-flow movement may be brought about by inclining the dryer such that its axis is at an angle of 2 to 5 degrees, for example approximately 3.5 degrees, to the horizontal.

[0045] The conveyer device for conveying the dried particulate materials away from the dryer may be a bucket lift. The conveyer device is preferably enclosed so as to prevent or reduce the escape therefrom of dust from the dried particulate materials. In a preferred embodiment, the interior of the conveyer device is linked by one or more ducts to a junction on the primary gas flow path so that gas-entrained particulate material in the conveyer device can be directed to the filtering device and separated. The interior of the conveyer device is preferably linked to the primary gas flow path by means of a duct containing a gas-flow controlling device. For example, the gas-flow controlling device may comprise one or more variable position doors.

[0046] Alternatively, hot gases (e.g. air) from the interior of the conveyer device may be recycled back to the inlet of the shroud.

[0047] A size classifying device for sorting the dried particulates into size ranges may be disposed between the conveyer device and the storage containers. An example of a suitable size classifying device is a vibrating screen size classifier.

[0048] The storage containers are arranged so that they can discharge controlled amounts of particulate materials into a first weighing hopper, the quantities of each of the size range being selected according to the desired properties of the asphalt product. The first weighing hopper is typically positioned beneath the storage containers so that the discharge of the particulate materials is by gravity feed.

[0049] Once the particulate materials have been weighed into the weighing hopper, they are discharged into a mixer which is typically positioned beneath the first weighing hopper. Other materials such as dust or fines recycled from the filtering device (e.g. bag filter) may also be added to the mixer which is typically connected to a source of heated bitumen.

[0050] In one embodiment, a flow path extends between the filtering device and the mixer so that fine particulate matter separated from the exhaust gas can be introduced into the mixer. Preferably a storage container for the fine particulate material and preferably also a second weighing hopper are disposed between the filtering device and the mixer. The second weighing hopper is typically positioned beneath the said storage container.

[0051] In order to prevent or reduce the escape of dust into the atmosphere, any one or more of the storage containers, size classifying device, first weighing hopper and mixer may be provided with a dust extractor for collecting gas-entrained fine particulate material and directing it to the filtering device. Where the mixer is provided with a dust extractor, a gas flow path may be provided between the mixer and the filtering device, a valve being disposed in the said gas flow path for controlling the flow of gas-entrained fine particulate material from the mixer to the filtering device. The valve may comprise one or more variable position doors. In one embodiment, warm air collected by the dust extractor may be recycled back to the drying chamber and/or the shroud adjacent the drying chamber.

[0052] The particulate materials to which the present invention relates are preferably aggregates of the type used in civil engineering applications and include materials such as crushed stone, gravel, sand and like materials, as well as reclaimed asphalt materials obtained by the removal of the asphalt surfaces of roads during renovation and resurfacing work.

[0053] The invention will now be described in more detail, but not limited, by reference to the specific embodiments illustrated in the accompanying drawings Figures 1 to 6.

Brief Description of the Drawings

[0054]

Figure 1 is a schematic view of the component parts of an asphalt manufacturing plant incorporating an apparatus according to one embodiment of the present invention.

Figure 2 is an enlarged view showing of part of one end of the drying chamber in the apparatus of Figure 1, and showing the combustion burner and ducting either side of the combustion burner.

Figure 3 is an enlarged view of a flow control device for controlling the introduction of heated gases into the primary gas flow path of the apparatus shown in Figure 1.

Figure 4 is an enlarged view showing the lower end of the bucket lift in Figure 1 and the connecting duct from the drying chamber.

Figure 5 is an enlarged view of a gas-flow controlling device located between the interior of the bucket lift and the filtering device forming part of the apparatus of Figures 1 to 4.

Figure 6 is an enlarged view of a valve-containing portion of duct extending between the mixer in Figure 1 and the gas-flow controlling device of Figure 5.

Figure 7 is a schematic view of the component parts of an asphalt manufacturing plant incorporating an apparatus according to a second embodiment of the present invention

Detailed Description of the Invention

[0055] Referring to the drawings, Figure 1 is a schematic illustration of an asphalt manufacturing plant incorporating an aggregate drying system in accordance with one embodiment of the invention.

[0056] The aggregates used for the manufacture of the asphalt are stored in cold storage bins 1, 2, 3, 4 (there may be more than four - for example some plants have 16 or more) from which controlled amounts of aggregates are conveyed to a rotating drum dryer 7 by means of a conveyor belt 5 and are discharged through an inlet into the downstream end of the drying chamber of the rotating drum dryer. The aggregates can be, for example crushed stone, gravel, small stones or sand, or reclaimed asphalt materials. The aggregates in the cold storage bins will typically contain substantial amounts of moisture and will require drying before they can be mixed with bitumen to form asphalt.

[0057] The rotating drum dryer 7 is provided with a variable speed motor (not shown) which rotates the drum. At the end (upstream end) of the drying chamber remote from the inlet for the aggregates, is an oil-fired or gas-fired burner 20. The output from the burner, a stream of hot gas, passes along the drying chamber from the upstream end to the downstream end. Towards the downstream end is an array of scoops or lifters 8 attached to the wall of the drum. As the drum rotates, the lifters 8 scoop up the aggregates from the floor of the drum and then release them at the top of the drum so that they fall back through the stream of heated air passing along the drying chamber. The lifters can be of conventional shape and configuration. The axis of the drum is set at a slight incline (for example about 3.5 degrees) so that the aggregates gradually make their way along the drying chamber towards the burner 20. By the time they reach the burner end, the aggregates are dry and have been heated to a desired temperature. At the upstream end of the drying chamber, the dried heated aggregates exit via chute 10, the lower end of which is closed by a one way door 11 which prevents air and entrained dust particles from passing back up the chute and into the drying chamber.

[0058] Upon reaching the lower end of the chute, the aggregates pass through the door 11 and into the inlet 12 of a bucket lift 13, as can be seen more clearly in Figure 4. The bucket lift is enclosed to prevent or reduce the escape of fine particulate materials to the atmosphere. The interior of the bucket lift is connected by means of a duct to a gas-flow controlling device 25 shown in enlarged schematic detail in Figure 5. The gas flow device 25 comprises a pair of adjustable position doors, the positions of which can be varied to control the negative pressure within the duct 23 and the associated ductwork leading to the device 25. A pipe 25.1 mounted in the wall of the gas flow device leads to a pressure transducer which is connected to controls (not shown) for controlling the positions of the doors.

[0059] The bucket conveyor 13 lifts the dried heated aggregates and discharges them into a chute 14 which is fitted with a diverter door to enable the aggregates to be channelled either to a vibrating screen assembly 15 or directly to hot storage bins 16. Aggregates passing into the vibrating screen assembly 15 are separated by size before being directed to the hot storage bins 16.

[0060] Arranged below the hot storage bins 16 is a weighing hopper 17 and, below the weighing hopper 17 is a mixer 18. Also arranged to discharge into the mixer 18 are a supply of molten bitumen and a chute or pipe from a hopper 44 which is connected to a silo 43 for recycled dust. The flow of molten bitumen to the mixer is controlled by a valve 47.

[0061] The bucket lift 13, vibrating screen assembly 15, hot storage bins 16, weighing hopper 17 and mixer 18 are each provided with extraction vents connected via ducts 23 and the gas-flow controlling device 25 to the primary exhaust duct 26 downstream of a coarse dust removal apparatus 21. In this way, any fine gas-entrained particulate material is collected and recycled rather than being allowed to escape into the atmosphere. The extraction vent for the mixer 18 is shown in enlarged schematic detail in Figure 6 and contains a rotating gate valve 24 for controlling gas flow.

[0062] The asphalt is prepared by weighing a required amount of aggregate of a desired size range from the hot storage bins 16 into the hopper 17 and then thence into the mixer 18. Where required, an amount of recycled dust material from silo 43 may be weighed into hopper 44 and then discharged into the mixer. Molten bitumen is then added to the aggregates in the mixer and the resulting mixture is stirred to ensure that the aggregates and bitumen are well mixed and the aggregate particles are coated with the bitumen. The hot asphalt mixture is then discharged through gate 19 into a suitable receptacle for transporting to the site of use.

[0063] During the drying of the aggregates in the drying chamber of the rotary drum dryer 7, the hot gases pass along the drying chamber to an exhaust gas outlet which leads into the end box 6 of the dryer and then into the primary exhaust duct 26. A temperature probe (not shown) is located immediately adjacent the exhaust gas outlet and measures the temperature of the exhaust gases. The primary exhaust duct 26 is provided with a coarse dust removal apparatus 21 which removes larger particles entrained in the hot exhaust gases and discharges them down a chute 22. A one-way door in the chute 22 prevents air from entering and travelling up the chute. The chute 22 discharges the coarse dust particles into the bucket lift 13 from where they are conveyed to the hot storage bins 16, either directly or via the vibrating screen assembly 15.

[0064] After the initial coarse filtration in the dust removal apparatus 21, the exhaust gases enter a filtering device 27 which removes fine dust particles from the gases. The filtering device typically comprises a bag filter of known construction, the filtering bag being formed from a high temperature resistant fabric such as Nomex®. A second temperature probe (not shown) is positioned in the duct immediately upstream of the filtering device. If the temperature probe senses that the temperature of the heated gas about to enter the filtering device has reached 200 °C, the maximum desirable working temperature of the bag filter, the burner in the dryer is turned off.

[0065] Fine dust particles collected by the bag filter can either be discharged via a valve 40 and conveying apparatus 41, 42 to the storage silo 43 or they can be discharged via valve 45 into a fine particulate conditioner 46 which mixes the dust with water to form a paste or sludge which can then be sent for disposal.

[0066] In order to prevent clogging of the bag filter, a pulsed or reverse flow through the bag filter may be introduced via inlet fan 29 to blow dust out of the filter.

[0067] Once the exhaust gases have been subjected to fine filtration, they pass through an extractor fan 30 and then into a chimney stack and out through discharge vent 32 at the top of the chimney stack 31 into the atmosphere.

[0068] The end box 6, primary exhaust duct 26, filtering device 27, extractor fan 30, and chimney together constitute a primary gas flow path from the exhaust gas outlet in the drying chamber to the discharge vent 32. The extractor fan 30 provides the necessary drawing power to draw the heated gases from the burner through the drying chamber and along the primary gas flow path.

[0069] Located between the filtering device 27 and the chimney stack 31 is a diverter device comprising a length of duct 33 connected to a variable speed fan 34. The variable speed fan 34 is connected to one end of a length of duct 35 which is connected at its other end to the dryer 7. The length of duct 33, variable speed fan 34 and duct 35 together constitute a recycling gas flow path back to the drying chamber.

[0070] The manner in which the duct 35 is connected to the dryer is illustrated in more detail in Figure 2. As can be seen from Figure 2, the combustion burner 20 is set into an end wall 9 of the dryer so that the head of the burner extends into the drying chamber 7. The head of the burner 20 is surrounded by a shroud 36 of generally cylindrical form. The end of duct 35 is connected to an opening in the wall of the shroud. The end wall 9 has a further opening which leads into duct 37. Duct 37 in turn is connected via a flow control device 38 and another length of duct to the dryer end box 6. The duct 37 and flow control device 38 together form a secondary gas flow path leading to a junction with the primary gas flow path at the dryer end box 6.

[0071] The flow control device 38 is shown in more detail in Figure 3. As shown, the flow control device comprises two pairs of opposed variable position doors for controlling gas flow. Located between the two pairs of doors are a temperature probe 38.2 and a pipe 38.3 which connects to a pressure transducer.

[0072] In use, the burner output is set at a level necessary to dry the aggregates and heat them to a desired temperature. The heated gas stream from the burner is drawn along the chamber by the vacuum provided by the extraction fan 30. Before commencing drying and heating a batch of aggregates, the apparatus is first run for a short period to warm the system up to operating temperature. During this warming up phase, hot gases passing through the bag filter housing serve to elevate the temperature of the housing and bag filter above the dew point. During this initial warming up phase, the gas-flow controlling device 25 may be set to the closed position to prevent cold air from being drawn into the system.

[0073] After the initial warming up phase has been completed, moist aggregates are introduced into the drying chamber. As the heated gas stream from the burner passes along the chamber, the gas stream is cooled by contact with the moist aggregates. For lower temperature asphalts, such as base course asphalt containing 30% recycled asphaltic road material, the temperature of the gas leaving the drying chamber through the gas outlet may be as low as 50 °C which is less than its dew point. If the exhaust gas were allowed to travel on to the coarse particle separating device and then into the bag filter at a temperature less than the dew point, the result would be that once the bag filter had cooled after the initial warming up period, a substantial amount of the water vapour present in the gas would condense on the filter leading to caking of the fine particulate matter and blocking of the filter bag. In addition, corrosion of any metallic components of the separating device would be likely to occur.

[0074] If the temperature probe immediately upstream of the filtering device senses that the temperature of the gases about to enter the filter housing is too low, i.e. is below the dew point of the gas, the variable position doors in the flow control device 38 are opened and hot gas from the hotter upstream end of the drying chamber is then drawn along the secondary gas flow path through the outlet in the wall 9 and along the duct 37. The hot gas passes along the duct 37, through the flow control device 38 and along the further length of duct to the dryer end box 6 where it mixes with the cooler exhaust gas from the gas outlet at the downstream end of the chamber. The introduction of the hot gas into the primary gas flow path has the effect of raising the temperature of the exhaust gas above the dew point thereby preventing condensation in the fine particulate separating device 27.

[0075] The advantage of the arrangement described above is that it allows a much lower initial drying temperature to be used when drying the aggregates for low temperature asphalts (and in particular aggregates containing a proportion of reclaimed asphalt road surface material) whilst keeping the temperature of the exhaust gases passing through the fine particulate separating device above the dew point. In so doing, considerable savings in energy can be made.

[0076] In the embodiment shown in Figure 1, a diverter device is provided between the filtering device 27 and the chimney stack 31. The filter device can be used to recycle warm gas emerging from the filtering device back round to the drying chamber by switching a valve in the diverter device to the recycle position and then activating fan 34. Recycled warm air passes though the inlet 35 in the shroud 36 and is heated within the shroud before re-entering the drying chamber. The use of recycled warm gases can help reduce the fuel consumption of the burner.

[0077] In an alternative embodiment shown in Figure 7 the diverter device is omitted and there is no recycling gas flow path between the fan 30 and the inlet 135 of the shroud. In the embodiment of Figure 7, the inlet 135 is linked by pipe 134 and junction 48 to the ducts 13 and 23 so as extract warm air from the ducts which can then be recycled through the shroud. An advantage in recycling warm air from ducts 13 and/or 23 rather than via a diverter arrangement downstream, of the filtering device 27 is that the gases from ducts 13 and/or 23 will contain less moisture.

[0078] In a variation (not shown) of the embodiment shown in Figure 7, the inlet 135 for the shroud can simply take in fresh air from the atmosphere.

Equivalents

[0079] It will readily be apparent that numerous modifications and alterations may be made to the specific embodiments of the invention described above without departing from the principles underlying the invention. All such modifications and alterations are intended to be embraced by this application.

Claims

1. An apparatus for drying particulate materials comprising:

(i) a dryer in which the particulate materials can be dried and heated, the dryer comprising a heating device; a drying chamber having an inlet through which particulate material can be loaded into the drying chamber; an outlet for dried and heated particulate material, and an exhaust gas outlet;
(ii) means for moving a stream of heated gas from the heating device through the drying chamber, thereby to dry and heat the particulate material, and then out through the exhaust gas outlet as exhaust gas;
(iii) means defining a primary gas flow path extending from the exhaust gas outlet to a discharge vent through which exhaust gas can be discharged to atmosphere; a filtering device being disposed between the exhaust gas outlet and the discharge vent for removing particulate matter from the exhaust gas prior to discharge through the discharge vent;
(iv) means defining a secondary gas flow path linked to a source of additional heated gas, whereby a downstream end of the secondary gas flow path communicates with the primary gas flow path at a location upstream of the filtering device;
(v) a flow control device associated with the secondary gas flow path, the flow control device being operable to control flow of the additional heated gas along the secondary gas flow path and into the primary gas flow path thereby to regulate the temperature of the exhaust gas in the primary gas flow path so that it is higher than a dew point of the exhaust gas when the exhaust gas enters the filtering device.

2. An apparatus according to claim 1 wherein the heating device comprises a combustion burner.

3. An apparatus according to claim 1 wherein the source of additional heated gas is a region of the dryer which is hotter than a region of the drying chamber immediately adjacent the exhaust gas outlet

4. An apparatus according to claim 2 wherein the source of additional heated gas is a region of the dryer adjacent the combustion burner.

5. Apparatus according to claim 2 wherein the source of additional heated gas comprises a shroud in close proximity to a heated outer surface of the combustion burner, the shroud having an inlet through which gas can enter the shroud and an outlet leading into the secondary gas flow path.

6. Apparatus according to claim 5 wherein the shroud at least partially surrounds the combustion burner.

7. Apparatus according to claim 6 or claim 7 wherein the means defining the secondary gas flow path comprises a duct which extends to a junction with the primary gas flow path and wherein the flow control device comprises one or more flow control elements disposed in the said duct.

8. Apparatus according to claim 7 wherein the duct extends from the shroud to the junction with the primary gas flow path.

9. Apparatus according to claim 7 wherein the outlet of the shroud opens into the drying chamber and the duct extends from a region of the drying chamber adjacent the shroud to the junction with the primary gas flow path.

10. An apparatus according to any one of the preceding claims wherein the source of additional heated gas comprises gas that has been recovered from a location downstream of the outlet for dried and heated particulate material.

11. An apparatus according to any one of claims 1 to 10 wherein the drying chamber is a rotating drum.

12. An apparatus according to any of claims 1 to 11 wherein the filtering device comprises a bag filter.

13. An apparatus as defined in any one of the preceding claim but excluding any such apparatus having a diverter device disposed between the filtering device and the discharge vent, wherein the diverter device is controllable to allow heated gas to discharge through the discharge vent or to divert all or a portion of the exhaust gas along a recycling gas flow path back into the drying chamber through or past the heating device.

14. An asphalt manufacturing plant comprising an apparatus as defined in any one of claims 1 to 13.

15. A method of drying and heating particulate materials (such as aggregates used in the production of asphalt) comprising:

(i) introducing the particulate materials into a dryer, the dryer comprising a heating device; a drying chamber having an inlet through which particulate material can be loaded into the drying chamber; an outlet for dried and heated particulate material, and an exhaust gas outlet;
(ii) moving a stream of heated gas from the heating device through the drying chamber, thereby to dry and heat the particulate material, and then out through the exhaust gas outlet as exhaust gas;
(iii) moving the exhaust gas along a primary gas flow path extending from the exhaust gas outlet to a discharge vent through which the exhaust gas can be discharged to atmosphere; a filtering device being disposed between the exhaust gas outlet and the discharge vent for removing particulate matter from the exhaust gas prior to discharge through the discharge vent;
(iv) monitoring the temperature of the exhaust gas prior to it entering the filtering device; and
(v) where necessary introducing additional heated gas into the primary gas flow path at a location upstream of the filtering device thereby to regulate the temperature of the exhaust gas in the primary gas flow path so that it is higher than a dew point of the exhaust gas when the exhaust gas enters the filtering device.

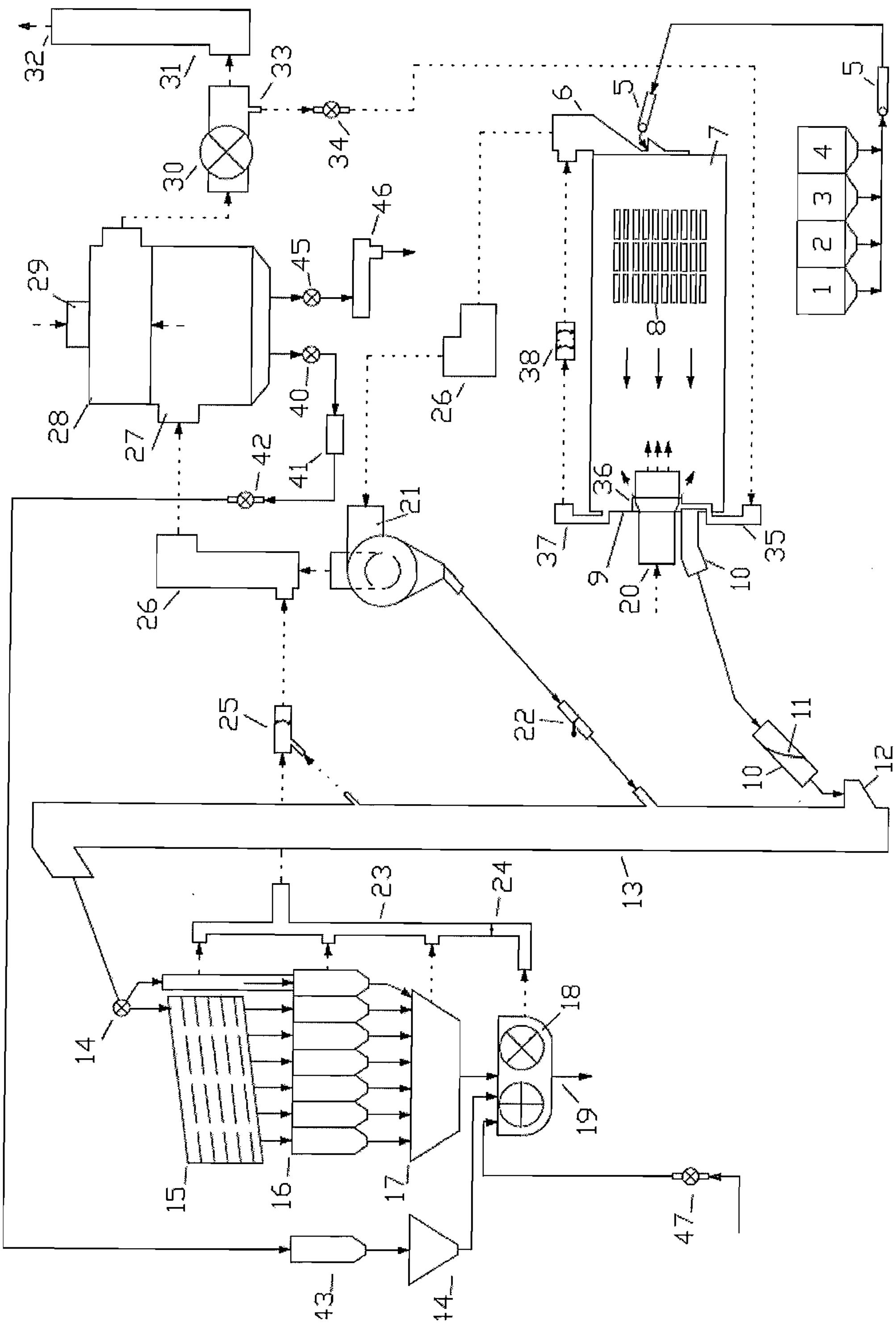
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Figure 1

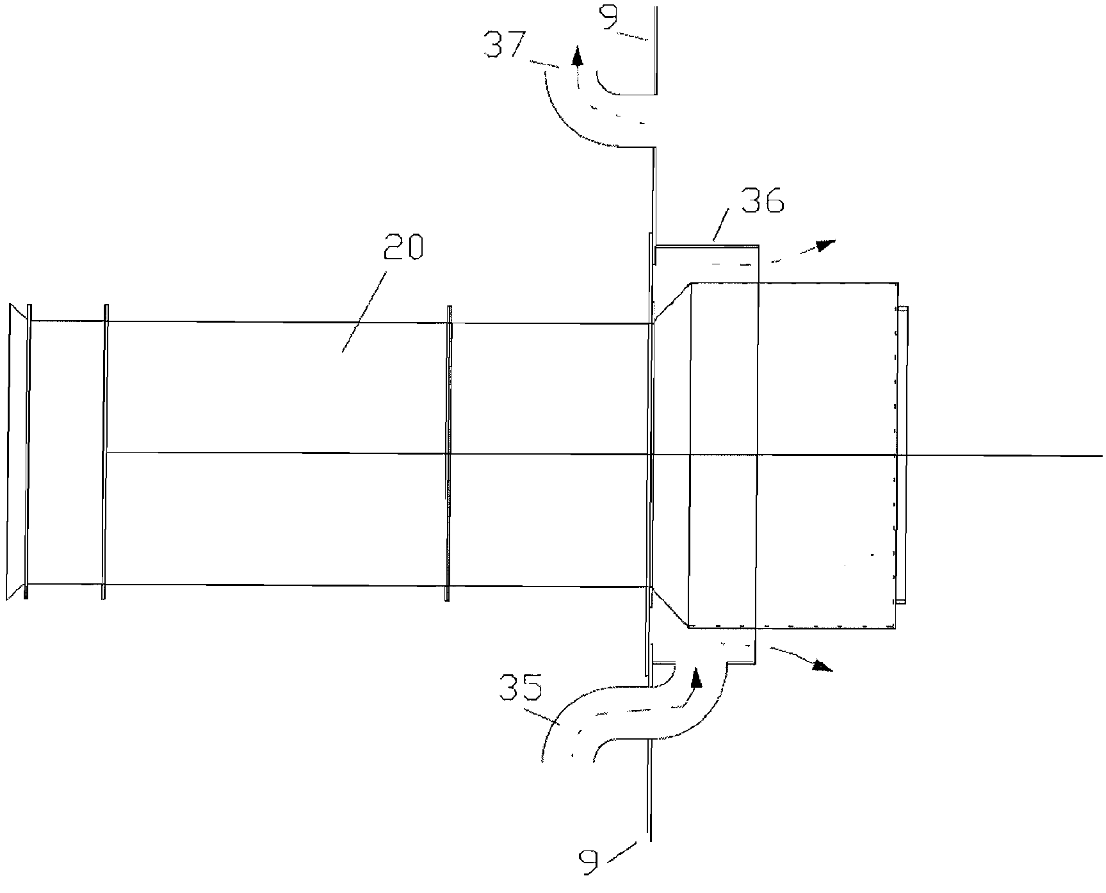

Figure 2

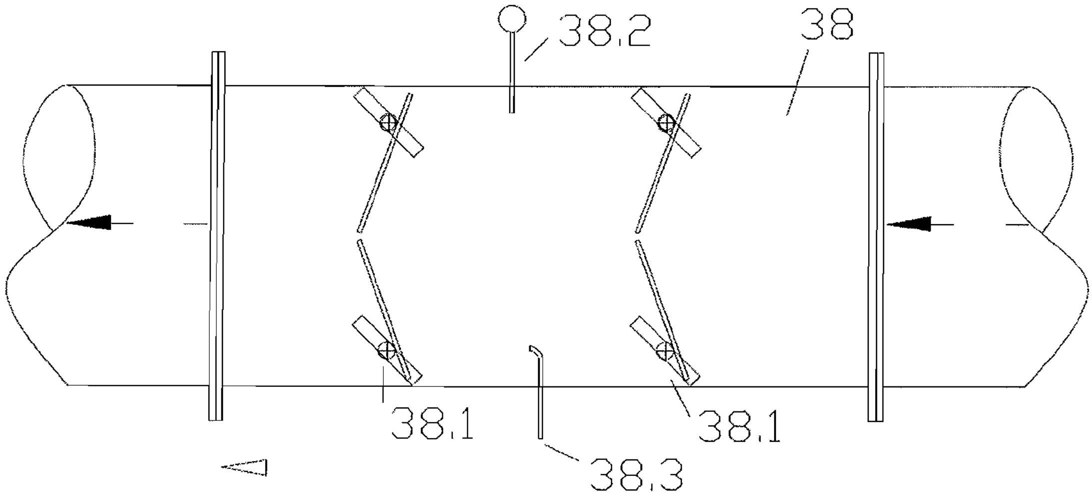

Figure 3

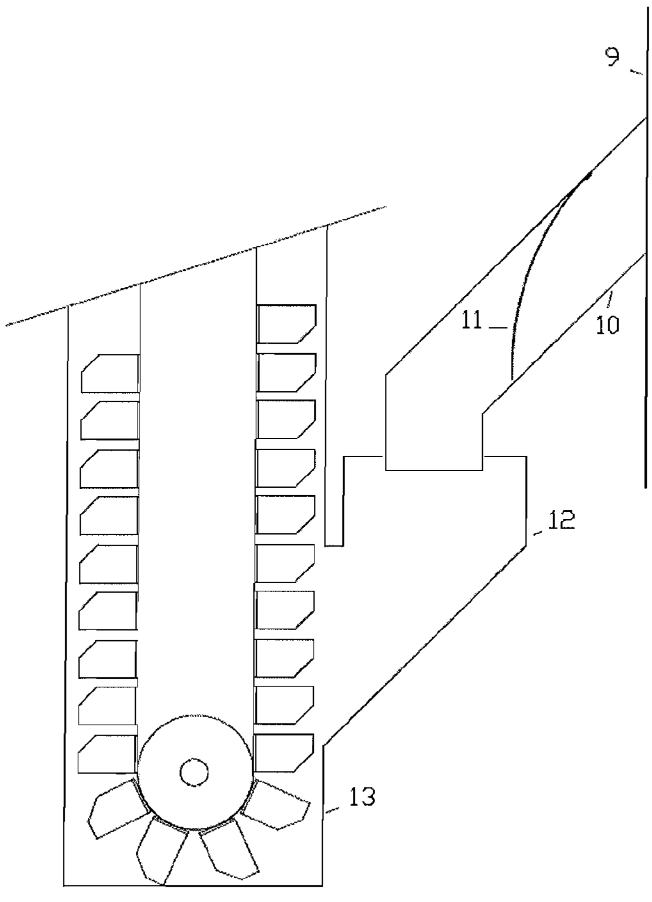

Figure 4

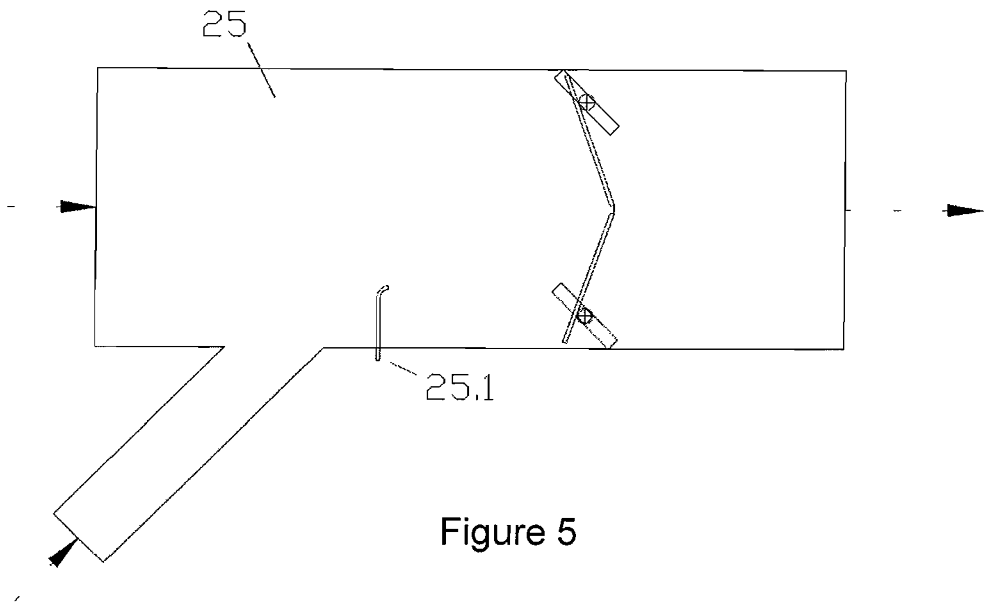

Figure 5

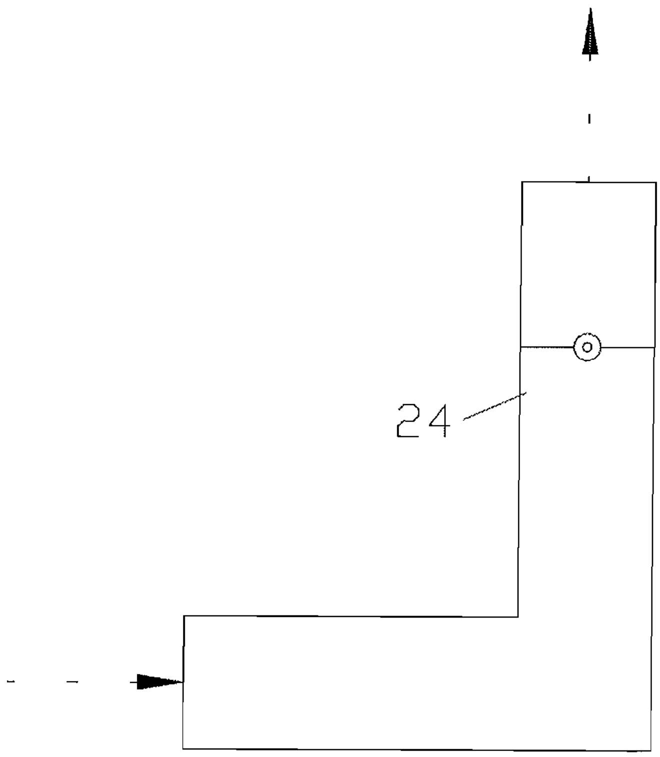

Figure 6

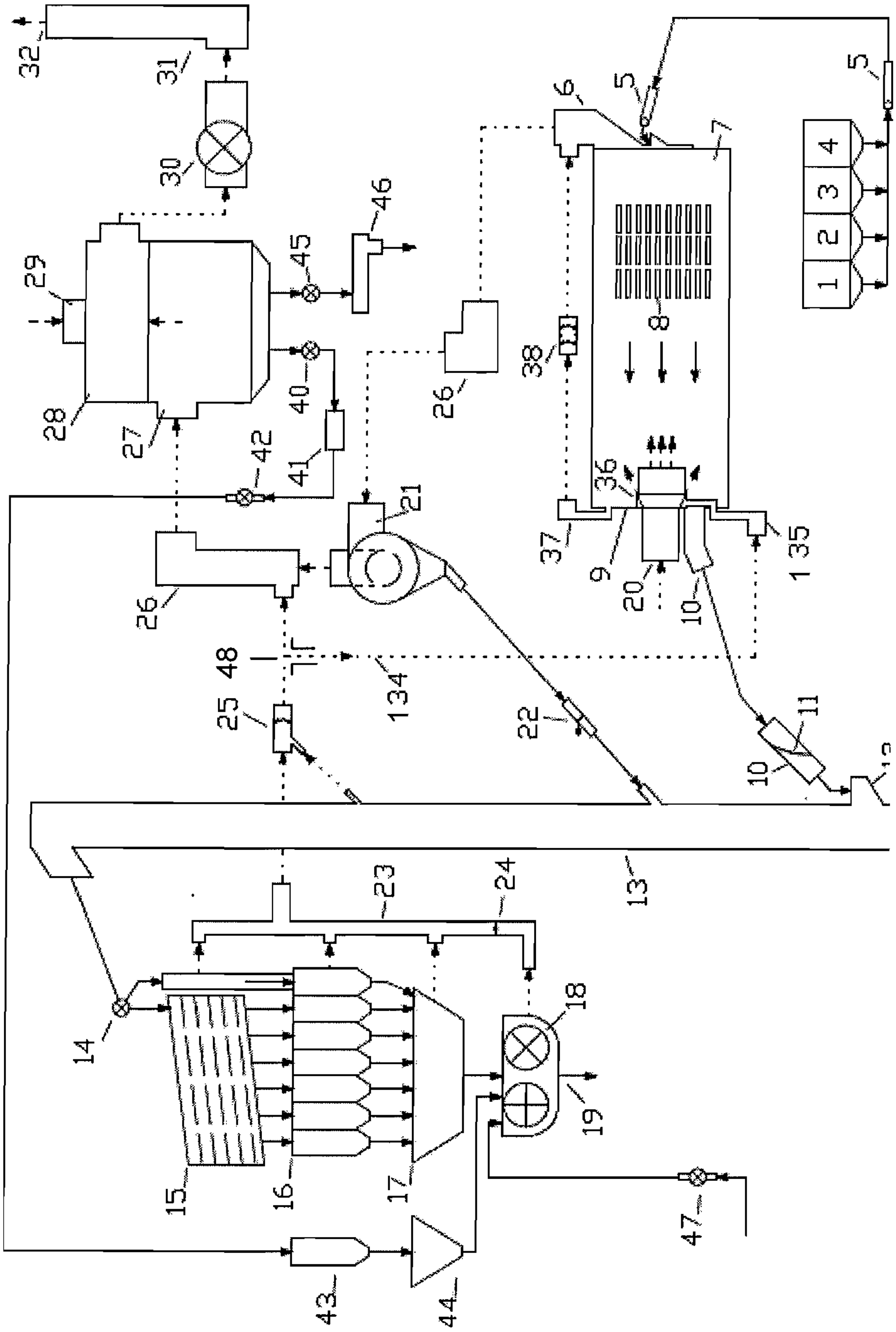
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Figure 7

REFERENCES CITED IN THE DESCRIPTION

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