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PROVISIONAL SPECIFICATION

IMPROVEMENTS IN AND RELATING TO COMBINATION PRODUCTS

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do hereby declare this invention to be described in the following statement:

IMPROVEMENTS IN AND RELATING TO COMBINED PRODUCTS

TECHNICAL FIELD

The present invention relates to improvements in and relating to combination products.

In particular, the present invention relates to apparatus for converting a solid material to a combined fluid product, and to the product produced by the apparatus.

BACKGROUND ART

The present invention is particularly suited for mixing solid fertiliser with a quantity of water, though this should not be seen to be limiting as the principles of the present invention may have application to other solid material fluidisation systems.

For ease of reference only, the present invention will now be described with reference to fertiliser mixing systems and in particular, pre-wetting systems.

Fertiliser is generally applied in either

a) a solid form, e.g. granules, crystals or powder, principally for ease of handling and application and to assist in controlling the rate of release, and/or

b) as a liquid, for rapid uptake and/or to assist in providing even distribution.

The rate of solid fertiliser release may be controlled by the choice of fertiliser type, varying the size of the particles/granules and or coating with polymers or release inhibitors. In the case of liquid fertilisers, rate of release may be controlled by the choice of fertiliser and/or by the amount of fluid co-applied.

There are however a number of known problems in applying solid fertiliser, including:

- risk of pollution to waterways from run-off if solid fertiliser application is followed by rain or irrigation;

- fertiliser dust during transport and application may pose a health risk to humans and animals, pollute the air and may be too widely distributed in windy conditions to be effective;

- urea fertiliser may in some conditions undergo excessively rapid hydrolysis, leading to substantial losses of ammonia gas to the atmosphere. This volatilisation of ammonia may be inhibited by coating the fertiliser with a urease inhibitor before application.

Furthermore, products such as lime and direct-application soft phosphate rock (called reactive phosphate rock or RPR in New Zealand and Australia), need to be applied in a finely ground form to be agronomically effective. Lime is usually crushed into fine particles in the quarry where it is mined, while RPR is usually crushed prior to beneficiation to improve the grade, at or near the mining site. Both may require limited additional grinding/crushing prior to application. These crushed products can be extremely dusty, creating dust drift and associated problems.

Solid fertiliser may thus be mixed with inhibitors and/or water to alleviate many of these problems. This processing also helps in minimising dust and controlling the distribution of powdered fertilisers which would otherwise be too light and blown about by wind.

There are a number of major disadvantages of applying fertilisers as liquids, whether in solution (e.g. urea or urea ammonium nitrate (UAN)) or as a suspension, and include:

(i) the cost of transportation of the typically required 40-60% weight content of water;

(ii) the requirement for centrally located grinding equipment for grinding of solid fertiliser into the required particle-size range, and the associated mixing and storage equipment;

(iii) the necessity to use high quality and therefore high cost ingredients, and in addition in the case of suspensions, the incorporation of additives such as bentonite clay to keep products in suspension.

Solid fertiliser may be applied by aircraft via aerial 'top-dressing' over large areas, or alternatively by ground-spreader devices. A ground-spreader typically comprises a container or hopper attached to a vehicle or trailer and has an outlet positioned above (usually) one or two spinning discs with vertical bars thereon which strike the fertiliser and propel it away from the ground-spreader, thus distributing the fertiliser. The spread of the fertiliser may be varied by varying the speed of rotation of the spinning disc(s), the disc and bar shape and configuration and the particular placement of the fertiliser onto the disc(s).

While such ground-spreaders are effective in distributing relatively dry and granular fertiliser they may prove ineffective in distributing 'pre-wetted' fertiliser, as the fertiliser particles may bind together and clog the applicator outlet, thus requiring user intervention to unblock.

Furthermore, dry fertiliser ground-spreaders do not include any mixing apparatus for the precise mixing of water with the fertiliser and thus require additional manual labour and/or equipment. Moreover, manually mixing the water can cause further problems in uneven water distribution.

It would thus be advantageous to provide an apparatus which is at least capable of one or more of the following:

- reducing the size of fertiliser particles if required;

- converting a non-powdered fertiliser into a powdered fertiliser;
- crushing fertiliser into smaller particles;
- if necessary, the treating of the fertiliser particles with release inhibitors or the addition of trace elements;
- crushing fertiliser and combining with a particulate material;
- wetting/fluidising fertiliser (whether powdered or not) without clogging;
- adjusting the level of wetting/fluidisation as required;
- accurate spreading of wetted fertiliser.

It would also be advantageous to provide an apparatus capable of reducing one or more of:

- dust pollution to air and waterways
- fertiliser run- off into waterways ;
- transport costs;
- applied fertiliser cost;
- labour requirements.

It is acknowledged that the term ‘comprise’ may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term ‘comprise’ shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term ‘comprised’ or 'comprising' is used in relation to one or more steps in a method or process.

It is an object of the present inventions to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

As used herein the term “CFP” refers to a Combined Fluid Product comprising a crushed product, mixed with a fluid and includes any one or more of:

- a crushed material dissolved in liquid solution;
- an aerated crushed material;
- a crushed material suspended in fluid, and/or
- a wetted crushed material e.g. slurry, sludge, a liquid coated crushed material or wetted powder.

However, this list should not be seen to be limiting as the present invention may be capable of producing any other combination product comprising a crushed or partially crushed product, mixed with a fluid.

According to a first aspect of the present invention there is provided a vehicle which is adapted to:

- convert a solid material to a CFP, and
- dispense a CFP to a surface;

the vehicle including:

- a solid material supply and an associated solid material transfer mechanism, and
- a fluid supply and an associated fluid transfer mechanism,

characterised in that the vehicle includes a converter apparatus for converting the solid material to a CFP, the converter apparatus including:

- a crushing assembly for crushing the solid material, the crushing assembly having a material inlet adapted to receive solid material from the solid material transfer mechanism, and
- a mixing assembly adapted to receive:
    - o fluid from the fluid supply, and
    - o crushed material from the crushing assembly,

  the mixing assembly capable of mixing the fluid from the fluid supply with the crushed material to produce a combined fluid product;

the vehicle further including a dispensing assembly for dispensing the CFP from the mixing assembly onto the surface.

According to a second aspect of the present invention there is provided a vehicle which is adapted to:

- convert a solid material to a CFP, and
- dispense a CFP to a surface;

the vehicle including:

- a solid material supply and an associated solid material transfer mechanism, and
- a liquid supply and an associated liquid transfer mechanism,

characterised in that the vehicle includes a converter apparatus for converting the solid material to a CFP, the converter apparatus including:

- a crushing assembly for crushing the solid material, the crushing assembly having a material inlet adapted to receive solid material from the solid material transfer mechanism, and
- a mixing and treating assembly adapted to receive:
  - liquid from the liquid supply, and
  - crushed material from the crushing assembly of a predetermined size range,

  the mixing assembly capable of mixing the liquid from the liquid supply with the crushed material to produce a combined wetted product;

the vehicle further including a dispensing assembly for dispensing the combined wetted product from the mixing assembly onto the surface.

In one embodiment, one or more liquid supplies may be provided for supplying additive substances such as inhibitors and/or trace elements to the mixing assembly.

According to another aspect of the present invention there is provided a converter apparatus for converting a solid material to a CFP, said converter apparatus including:

- a crushing assembly for crushing the solid material, and

- a mixing assembly adapted to receive the crushed product from the crushing assembly and mix with fluid from the fluid supply to produce a CFP.

A converter apparatus, substantially as hereinbefore described, said apparatus further including a dispensing assembly for dispensing the combined fluid product from the mixing assembly.

For ease of reference only, and unless context dictates otherwise, the present invention will now generally be described in relation to an application where the solid material is a fertiliser to be mixed with a liquid such as water and/or an additive.

As aforementioned and used herein, the term “fluid” refers to any gas, liquid or flowable particulate to be mixed with the crushed material. In preferred embodiments the fluid is a liquid and more preferably may be a quantity of water. Other fluids may also be used, e.g. liquid inhibitor coatings, liquid fertilisers, minerals and trace elements or the like.

As aforementioned and used herein the term “solid material” refers to any solid material which it is desired to break into smaller particles before mixing with a fluid. In general the term “solid material” may include chunks, lumps, crystals and/or granules of material whose size needs to be reduced.

In preferred embodiments the solid material may be a fertiliser and more preferably is a urea-based fertiliser. However, this should not be seen to be limiting as the present invention may be suitable for other fertilisers or solid material.

The solid material is preferably crushed by the crushing assembly to generally reduce in size the majority of the constituent parts of the solid material. It will be appreciated that reference to “crush” in the foregoing description and as used herein should be understood to include any one or more of the following: collisions; breaking; pounding;

compression; of the solid material to break into smaller fragments, or particles, and includes the propulsion of the solid material onto another object.

The vehicle may be almost any vehicle capable of being adapted to deliver fertiliser. However, in general the vehicle may be a land vehicle.

Preferably, the vehicle of the present invention may be self-propelled.

Although it will be appreciated that the vehicle may also include non-powered vehicles such as trailers, carriages or other mobile supports.

It will be appreciated that the vehicle may include one or more power sources and or drive mechanisms to propel the vehicle and to drive the:

- solid material transfer mechanism;
- fluid transfer mechanism;
- crushing assembly;
- mixing assembly;
- dispensing assembly; or
- a combination of the above.

In one preferred embodiment the spreader includes an engine for self-propulsion. Preferably said engine is configured to power the converter apparatus, solid material transfer mechanism, and/or fluid transfer mechanism via one or more hydraulic drives.

It will be appreciated that one or more other known drive mechanisms may be suitably configured to drive the converter apparatus, solid material/fluid transfer mechanisms, mixing assembly and/or dispensing assembly. For example, Power Take Off (PTO) units, electric engines, pneumatic drives, mechanical drive systems or the like.

Preferably, the solid material and fluid may be stored separately on the vehicle in respective vehicle containers, tanks, hoppers or the like, though it will be appreciated that other storage devices may also be utilised. The solid material may be a single product (e.g. urea) or a mix of two or more products.

In some embodiments the solid material and/or fluid supply may be provided in containers or the like external to the vehicle and connected to the vehicle via one or more conduits. For example, the fluid supply may be a water tank on another vehicle connected via a flexible hose extending to the vehicle and converter apparatus or alternatively from a stationary water tank connected via the flexible hose.

In one preferred embodiment a further fluid supply is provided in the form of an additive supply to be mixed with the solid and/or crushed material. The additive may be any known product such as polymer coatings, release inhibitors, acids or other reactive materials, trace elements, minerals or additional fertiliser types, oils, or any other product which is required to be mixed with the solid and/or crushed material.

Preferably the additive supply is provided in a container, tank or the like separate to the fluid supply to inhibit any premature mixing. The additive supply may also be operatively associated with an additive transfer mechanism similar tot eh fluid transfer mechanism.

Preferably, the solid material and fluid transfer mechanisms may be powered devices to thus provide means for controlling the flow rate of solid material and fluid to the converter apparatus. For example, the solid material transfer mechanism may include an adjustable speed conveyer-belt or the like and the fluid transfer mechanism may include a pump and/or valve arrangement in a pipe connecting the fluid supply to the converter apparatus.

In alternative embodiments the solid material and fluid transfer mechanisms may not be active devices and may include conduits or apertures coupled to corresponding inlets of the crushing and mixing assemblies, the solid material and fluid being transferred under gravity.

The crushing assembly is preferably adapted to produce substantially crushed material e.g. powder, crystals and small granules, or fragments and the like generally comprising smaller constituent particles than that of the solid material.

It will be appreciated by one skilled in the art that numerous crushing assembly types may be utilised in the present invention, such as jaw, gyratory, cone, grinder, mincer, or impact crushers. However, in preferred embodiments the crushing assembly is a grinder-type crusher adapted to crush the solid material between two surfaces, at least one of the surfaces movable relative to the other.

In one preferred embodiment, the crushing assembly may include one or more movable crushing members in an enclosure with a material inlet therein, the crushing assembly configured to crush the solid material between the crushing member(s) and an inner wall (crushing wall) of the enclosure and/or via collision of the material against the crushing wall.

Preferably, the, or each, crushing member may be substantially disc-shaped and rotatable within the enclosure, the enclosure having a substantially cylindrical crushing wall.

Preferably the crushing wall of the enclosure has one or more protrusions to provide improved crushing i.e. by providing more crushing points than a comparative smooth wall.

Preferably the rotatable disc includes at least one opening for permitting passage of crushed material therethrough. This opening thus allows for crushed material to pass to the mixing assembly. In a further embodiment the crushing assembly is configured such that the majority of crushed material may pass to the mixing assembly from between the crushing disc and crushing wall.

It will be appreciated that numerous mixing assemblies may be utilised in the present invention and may include active mixing blades, discs, ball-bearings, jets of fluid, spray nozzles, screw-drives, vortex chambers, fluid baths, and the like or any device capable of mixing a crushed material with a fluid.

Preferably, the mixing assembly is adapted to receive crushed material from the crushing assembly through an aperture or other opening. Preferably, the crushed material falls through the aperture under gravity though it will be appreciated that active transport mechanisms may be utilised such as conveyors or the like.

In an alternative embodiment, the mixing assembly may be adapted to receive crushed material from the crushing assembly via a passage, conduit, or the like, communicatively coupled to the crushing assembly.

Preferably, the mixing assembly is adapted to receive fluid from the fluid supply via at least one fluid inlet. The fluid may be supplied to the inlet by one or more conduits with associated pumps or alternatively the fluid may be supplied under gravity.

In one preferred embodiment, the mixing assembly includes at least one movable mixing member in an enclosure with a fluid inlet therein and a CFP outlet.

Preferably, the mixing member includes one or more blades or the like, rotatable within the enclosure, the enclosure having a substantially cylindrical inner wall (mixing wall).

Preferably the fluid inlet is provided as a passage through the enclosure for passing fluid from the fluid supply. It will be appreciated that multiple fluid inlets may be provided, each connected to one or more fluid supplies.

It will be appreciated that the dispensing assembly may take any form of fluid product dispenser. For example, the dispensing assembly may include pumps, pipe, spray and/or nozzle systems, irrigation systems, spinning discs, propellers, blowers, booms and the like.

In preferred embodiments the dispensing assembly includes at least one rotatable impeller adapted to receive the CFP from the converter apparatus and to impel the product onto a surface.

The force imparted to the combined fluid product, and therefore the distance it may travel, may thus be varied by changing the speed of rotation of the impeller or by increasing the number of impellers from one, to two or more.

While it will be understood by one skilled in the art that the crushing and mixing assemblies may be provided as separate devices connected to each other, in preferred embodiments, the crushing and mixing assemblies are formed as a combined device, the mixing and crushing members provided in a single enclosure.

Preferably the dispensing assembly is also located within the enclosure with the mixing and crushing members, the enclosure including a CFP outlet and the dispensing assembly adapted to receive the CFP from the mixing assembly and eject the CFP out of the combined fluid product outlet.

In general, the solid material is likely to be most easily crushed in a substantially dry state as a wetted solid material may stick to the crushing wall between the protrusions and create a ‘smooth’ surface. Thus, in a preferred embodiment, the crushing member is located proximate the solid material inlet of the enclosure, and the mixing member located distal to said solid material inlet, the crushing and mixing members configured such that the solid material must first pass through the crushing assembly before passing to the mixing assembly. However, it will be appreciated that a combined crushing and mixing assembly that is capable of both crushing the solid material and mixing the crushed product with fluid in a single process is also considered within the scope of the present invention.

Preferably, the crushing and mixing assemblies are configured in use to rotate about substantially vertical axes within the enclosure. Thus, solid material may fall under gravity from the solid material inlet to the crushing assembly to be crushed, or bypass the crushing assembly thus enabling the solid product to be wetted in its original form and then to the mixing assembly to be mixed with the fluid. Preferably, the crushing and mixing assembly rotation axes are substantially coaxial.

Preferably, the, or each dispensing impeller, crushing and mixing members are all connected to a common axle or the like to rotate simultaneously. It will also be appreciated that in alternative embodiments the, or each dispensing impeller, crushing and mixing members may be configured to rotate independently. Moreover, it will be appreciated that one skilled in the art may be capable of adapting the converter apparatus and dispensing assembly such that at least one of the impeller, crushing member and mixing member are contra-rotating with respect to the others.

Preferably, the crushing and mixing assemblies are configured to inhibit the passage of fluid from the mixing assembly to the crushing assembly. Inhibiting fluid entry into the crushing assembly may thus assist in ensuring effective crushing may continue, as the solid material may become more difficult to crush if mixed with the fluid.

For example, in one preferred embodiment, the cylindrical crushing wall may have a smaller diameter than the cylindrical mixing wall, providing a step therebetween, a separation plate may also be provided between the crushing and mixing members, the plate having a larger diameter than the crushing wall. Thus, when in use, the majority of fluid in the mixing assembly will be forced against the mixing wall through centrifugal effects of the rotating mixing member(s) and any fluid passing toward the crushing member is stopped either by the separation plate, or by the step between the mixing and crushing walls.

In an alternative embodiment, a shutter or valve assembly may be provided between the crushing and mixing assemblies to permit passage of solid material to the mixing assembly and/or inhibit return of fluid to the crushing assembly.

The converter apparatus, substantially as aforementioned and further characterised by the inclusion of a control system for controlling the respective flow-rate of the solid material fluid and/or additive from the solid material, fluid and additive supplies via the solid material and fluid transfer mechanisms, to the crushing and mixing assemblies.

Preferably, the control system includes a CPU or computer system suitably programmed to control:

- the respective rate of crushing and/or mixing by the crushing and mixing assemblies,
- the respective rate of dispensing by the dispensing assembly, and/or
- the speed of the vehicle.

The control system may thus allow an operator or computer system to monitor the vehicle and converter apparatus and set the amount of solid material and fluid being mixed together to provide a defined fluid level of the CFP. The control system may also allow the quantity, spread and concentration of the combined fluid product applied to a surface to be monitored and precisely controlled.

Furthermore, the control system may ensure optimum spreading performance by dictating the speed at which the vehicle operates in regard to the change in the contour of the surface to which CFP is being applied.

In some applications it may be necessary to apply a partially crushed material, and/or a material without being combined with a fluid, to the surface. Thus in one embodiment, the control system may be adapted to control the rate of crushing by the crushing assembly to permit passage of the solid material to pass to the mixing and/or dispensing assemblies without undergoing substantial crushing. This may be achieved for example by reducing the rate of crushing to such an extent that the crushing assembly performs only minimal, if any, crushing to the solid material. In another embodiment the control system may be adapted to prevent the supply of fluid to the mixing assembly thereby preventing mixing of the solid and/or crushed material and allowing a non-CFP to be applied to the surface.

The control system preferably comprises one or more CPUs or computer systems, sensors and/or actuators linked to the vehicle and converter apparatus to control same.

Preferably at least one sensor is linked to the control system and capable of measuring one or more factors of operation. By way of example, the factors of operation may include:

- vehicle speed;
- rate of crushing and/or mixing;
- rate of dispensing;
- temperature of one or more components of the spreader and/or converter apparatus;

- volume flow rate of fluid and/or solid material to the converter apparatus;
- pressure of the fluid in the fluid supply, transfer mechanism and/or converter apparatus;
- concentration of additives e.g. of trace elements or inhibitors;
- hydraulic drive pressure and/or flow-rate;
- any other factor of spreader and/or converter apparatus operation.

Preferably, the control system is adapted to receive signals from the, or each, sensor indicative of a factor of operation and configured to change said factor to within predetermined limits if the, or each, sensor indicates the factor is outside said predetermined limits.

According to another aspect of the present invention there is provided a CFP produced by the converter apparatus, substantially as aforementioned, the CFP including at least one component of crushed material and at least one component of fluid.

Preferably said crushed material is a crushed fertiliser and said fluid is water, though this should not be seen to be limiting as the fluid may also be a coating of polymers, release inhibitors or the like.

According to one aspect of the present invention there is provided a method of converting a solid material to a CFP and dispensing the CFP to a surface; said method including the steps of:

a) supplying solid material to a crushing assembly to crush said solid material,

b) mixing the crushed material with a fluid to produce a CFP,

c) dispensing the CFP.

According to another aspect of the present invention there is provided a method of converting a solid material using a “converter apparatus substantially as aforementioned, said method including the processes of:

- supplying solid material to the crushing assembly,
- operating the crushing assembly to crush the solid material,
- passing the crushed material to said mixing assembly,
- operating said mixing assembly to mix fluid with the crushed solid material to produce a CFP.

Preferably the processes of the above-described method are performed continuously and/or simultaneously.

In a further embodiment the method may include the further step of supplying an additive to the mixing assembly to mix with the crushed material.

Washing cycle

In one preferred embodiment, the method of converting a solid material as described above, further includes the processes of:

- stopping the supply of solid material,
- supplying fluid to the mixing assembly to flush from the mixing assembly at least a portion of any remaining crushed material, and
- restarting the supply of solid material.

This flushing operation ensures that there is minimal build-up of solid material in the mixing assembly which may reduce the mixing effectiveness and/or block the combined fluid product outlet.

Spreader method

According to another aspect of the present invention there is provided a method of operating a vehicle substantially as aforementioned, said method including the steps of:

a) moving a vehicle to the surface to apply a CFP;

b) crushing the solid material;

c) passing the crushed material to said mixing assembly;

d) operating said mixing assembly to mix fluid with the crushed material to produce a CFP ;

e) dispensing the combined fluid product to the surface;

f) moving the vehicle to another part of the surface, or a separate surface ;

Preferably, steps b) to f) are performed simultaneously to thus distribute the combined fluid product whilst moving over the surface.

In a further embodiment, step d) of the method substantially as described above may include the further step of treating the crushed material with an additive fluid.

Urea fertiliser can give increased agronomic effectiveness if applied as a slurry of fine particles of urea in water, and more so if a urease inhibitor and/or nitrification inhibitor is included in the fertiliser.

This increased effectiveness results from reduced volatilisation of ammonia gas from the urea (due to the urease inhibitor), increased total plant uptake of nitrogen from the urea, increased uptake of nitrogen in the ammonium and urea forms, and an increased proportion of nitrogen absorbed directly through the leaves, particularly in the form of urea and ammonium.

The application of urea fertiliser by the present invention may thus be highly effective, as the crushing assembly may be used to crush the urea granules or ‘prills’ (incorporating an inhibitor) and pass the crushed material to the mixing assembly to mix with water (in one preferred embodiment, a water content of 10-20% of total weight) and apply the CFP, in what is essentially a slurry form, to the crop or pasture. At this water percentage, some of the CFP will remain on the leaves to be available for direct absorption, while the remainder may fall through the leaf canopy to the soil, to be available for uptake through the roots. Typical application rates for dispensing this fertiliser-type may be in the range 40-200 kg urea/ha.

If it is desired to achieve a high proportion of foliar uptake, in one preferred embodiment, the proportion of water mixed in via the mixing assembly may be varied by the control system to provide a water content of 50-70% of total weight. Preferably, the rate of application of this fertiliser is 10-50 kg urea/ha.

Fertiliser products such as lime and direct-application soft phosphate rock (called reactive phosphate rock or RPR in New Zealand and Australia), typically need to be applied in a finely ground form to be agronomically effective. Lime is usually crushed into fine particles in the quarry where it is mined, while RPR is usually crushed prior to beneficiation to improve the grade, at or near the mining site. These ground products can be extremely dusty, creating dust drift and associated problems. Furthermore, both types may require additional grinding/crushing prior to application. The present invention may thus be capable of being configured to crush solid material to the required size, as well as wetting the fertiliser by mixing with water to produce a CFP with a water content of 5-10% of total weight to minimise dust during application. Application rates of this wetted product (on a dry-material basis) would typically be in the range of 100-300 kg RPR/ha, and 250-1000 kg lime/ha though this should not be seen to be limiting.

Poorly granulated fertilisers, and bulk blends of granulated and fine-particle fertilisers are also prone to problems with both dust and unevenness of application. Thus the present invention may minimise these problems of mixed blends of fertilisers by crushing the solid fertiliser into a narrower range of particle sizes to avoid segregation of the constituent fertiliser-types, and then mix the crushed material with 5-10% of water to produce a well-mixed, dust-free CFP for spreading. Application rates of this fluid product type would typically be in the range of 200-800 kg fertiliser/ha though this should not be seen to be limiting.

If surface application of granulated fertiliser is followed by rainfall/irrigation-induced run-off, considerable losses of fertiliser nutrients can occur in the run-off, resulting in both economic loss and eutrophication of waterways. This nutrient loss occurs if the fertiliser granules are either physically carried off in the run-off water, or more typically, dissolved by the run-off water before they have had the opportunity to dissolve into the soil.

The present invention may minimise these losses by partial grinding of the fertiliser and mixing it with 10-20% water, before applying the product, essentially in a slurry form, thereby enabling the fertiliser to dissolve into the soil much more rapidly. Application rates of this fluid product type would typically be in the range of 50-500 kg fertiliser/ha though this should not be seen to be limiting.

Thus preferred embodiments of the present invention may provide significant advantages over prior art, including providing a converter apparatus capable of one or more of:

- reducing the size of solid material;
- treating the solid material and/or adding additives to it
- converting the solid material to a wetted product and dispensing same without clogging;
- adjusting the level of fluid content in the CFP;
- spreading solid, dry, wetted and/or fluid material.

Preferred embodiments of the present invention may also provide a converter apparatus capable of reducing one or more of:

- dust pollution;
- ‘run-off’ of fertiliser into waterways,
- transport costs,
- labour requirements.
- -the effective applied cost of fertiliser

Brief Description of Drawings

Further aspects and advantages of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a plan view of a vehicle according to one preferred embodiment of the present invention;

Figure 2 shows a side view of the vehicle shown in figure 1;

Figure 3 shows a rear view of the vehicle shown in figures 1 and 2;

Figure 4 shows a partial-section side elevation of a converter apparatus according to one preferred embodiment of the present invention;

Figure 5 shows a side elevation of the converter apparatus shown in figure 4;

Figure 6 shows a plan elevation of the converter apparatus shown in figure 4;

Figures 7a-b respectively show a plan view and a partial-section side view of an upper crushing disc according to one preferred embodiment;

Figures 8a-b respectively show a plan view and a partial-section side view of a crushing disc according to one preferred embodiment;

Figures 9a-b respectively show a plan view and a partial-section side view of a separation plate according to one preferred embodiment;

Figures 10a-b respectively show a plan view and a partial-section side view of mixing blades according to one preferred embodiment;

Figures 11a-b respectively show plan and side views of an impeller according to one preferred embodiment;

Figure 12 shows a pictorial diagram of the rear of a vehicle according to another preferred embodiment;

Figures 13a-b respectively show perspective and side pictorial elevations of the water tank shown in figure 12;

Figure 14 shows a transverse cross-section of the water tank of figures 12 and 13.

Best Modes for Carrying out the Invention

Figures 1-3 show a vehicle according to one preferred embodiment of the present invention in the form of a truck (1). The truck (1) has an engine and cab unit (2) and a solid material supply in the form of fertiliser container (3). The truck (1) also has a fluid supply in the form of water tank (25) (shown in figures 12-14) for supplying water to two converter apparatus (4) attached to the rear of the truck (1).

Each converter apparatus (4) converts solid or granular fertiliser (not shown) from the container (3) to a CFP which is then dispensed onto the ground behind the truck (1). Figure 1 also shows a typical required fertiliser spread of 180°. Thus the vehicle (1) may drive over an area to be fertilised and continuously supply a CFP in the form of a combined fluid fertiliser.

Figures 4-11 show one of the converter apparatus (4). The converter apparatus (4) has an enclosure in the form of cylindrical steel housing (5) enclosing a crushing assembly (6) for crushing the fertiliser, and a mixing assembly (7) for mixing the fertiliser from the crushing assembly (6) with water from a pair of fluid inlets (8). The inlets (8) are connected to the water tank (25) via a pipe and pump arrangement (not shown).

The housing (5) also has a dispensing assembly in the form of rotatable impeller (9) which spins and ejects the combined fluid fertiliser out of a fertiliser outlet in the form of slit aperture (10). The slit aperture (10) extends about the lower part of the housing (5) in a 70° arc. As can be seen in figure 1, the converter apparatus (4) are arranged behind the truck (1) to achieve the desired spread of 180°.

The housing (5) has a fertiliser inlet (11) which receives fertiliser from the fertiliser container (3) via a conveyor (26) (shown in figure 12). This fertiliser then falls onto an upper crushing disc (12a) (more clearly shown in figure 7a, b) of a set of three crushing discs (12a-c) (shown more clearly in figures 8a, b).

The crushing discs (12a-c) are attached to a rotatable axle (13) that spins about a vertical axis (14) such that the fertiliser falling into the crushing assembly (6) is spun out under centrifugal effects into a cylindrical crushing wall (15).

While some of the fertiliser may break into smaller particles on impact with the crushing wall (15) the majority of fertiliser is crushed on the crushing wall (15) and/or between the wall (15) and radially extending fins (16) which are angled non-parallel and non-coplanar with the plane of the disc (12a-c). The fins (16) are orientated to extend in the direction of rotation at an angle to the discs (12a-c) thus forcing any fertiliser impinging on the fins (16) radially outward and downward.

These fins (16) also provide apertures (17) through which the crushed fertiliser may fall to the next disc (12b-c) or to the mixing (7) and dispensing (9) assemblies.

The upper crushing disc (12a) has flanges (22) extending perpendicular to the disc on every second fin (16). As the fertiliser inlet (11) only introduces fertiliser to a small portion of the circumference of the upper disc (12a), where a crushing disc such as (12a) or (12b) is provided, there is a risk that more fertiliser will travel through the crushing (6) and mixing (7) assemblies below the fertiliser inlet (11) and therefore create an uneven crushing and/or mixing. Thus, upwardly extending flanges (22) on the upper disc (12a) ensure that fertiliser entering the crushing assembly (6) is collected against a flange (22) on entry and distributed evenly over the crushing disc (12a).

A number of protrusions (18) are welded to the crushing wall (15) to provide an uneven surface and therefore an improved crushing surface over a comparative smooth wall.

After being crushed by the crushing assembly (6) the fertiliser falls onto a separation plate (19) (shown in figures 9a and 9b) that separates the mixing assembly (7) from the crushing assembly (6) to inhibit the passage of water from the mixing assembly (7) to the crushing assembly (6). Inhibiting water entry into the crushing assembly (6) ensures effective crushing may continue, as the fertiliser may become more difficult to crush if damp.

The crushing wall (15) has a smaller diameter than the mixing wall (20) to provide a step (21) therebetween. The separation plate (19) is generally similar in shape, but has a larger diameter, to crushing plates (12b, c). The separation plate (19) is also of a slightly smaller diameter than the mixing wall (20). Thus, the separation plate (19) may spin freely but, in combination with the step (21), may inhibit water passing up into the crushing discs (12a-c) of the crushing assembly (6).

The mixing assembly (7) includes two sets (23) of three mixing blades (24) (shown more clearly in figures 10a and 10b), each blade (24) has a planar blade portion (24a). The mixing blades (24) may thus rotate about the axle (13) and mix the crushed fertiliser falling from the separation plate (19) with water from the fluid inlets (8).

The rotatable impeller (9) is shown more clearly in figure 11 and includes a planar disc (9a) with three curved perpendicular flanges (9b) that may thus strike the combined fluid fertiliser from the mixing blades (24) and eject the wetted fertiliser from outlet (10). The impeller (9) also has three flanges (9c) underneath to disperse any excess water or CFP that may interfere with the rotation of the impeller (9).

The crushing discs (12), separation plate (19), mixing blade-sets (23) and rotatable impeller (9) are all connected to the central axle (13) and configured to rotate in unison about the central axis (14) in a clockwise direction with respect to a plan elevation of the converter apparatus (4).

Figure 12 shows the container (3) in more detail which has two storage portions (3a, b) located above the water tank (25). The storage portions each have a conveyor (26) for transferring fertiliser from the container (3) to the fertiliser inlet (11) of the converter apparatus (4). A hydraulic valve block (27) and associated hydraulic lines (not shown) are provided for driving the conveyors and converter apparatus (4).

The water tank (25) is substantially triangular in cross-section and aligned along the center of the truck (1) to reduce movement of water within the tank when the truck is moving. The water tank (25) also has a filling and breathing pipe (28) to allow the tank to be filled and to permit entry of air when the tank is being drained. Four outlets (29) (only one shown) are provided on the bottom of the tank (25) and are connected to respective water pumps (30) (only one shown) via pipes (not shown). The water pumps (30) each supply a fluid inlet (8) of the converter apparatus (4) via pipes (not shown). Figure 13b shows a series of baffles (31) for preventing water surges in the tank (25). As shown in figure 14, each baffle (31) has transfer apertures (32) for passage of water between compartments and are collectively connected together via a steel rod (33) which helps to increase the rigidity and prevent any deformation of the baffles (31).

The vehicle (1) also includes a control system (not shown) that consists of a computer processor, associated hardware and software. The control system is manually operable and is also linked to sensors (not shown) for measuring the vehicle speed, rate of rotation of the converter apparatus (4) and the volume flow-rate of fertiliser and water to the converter apparatus (4).

The control system (not shown) which has a suitably programmed CPU (not shown) can adjust the respective flow-rates of the fertiliser and water to the crushing (6) and mixing (7) assemblies and therefore control the ratio of water to fertiliser of the final product. For example,

- if the fertiliser is only required to be wetted (the process of which may induce some dissolution of the fertiliser), the water pump and fertiliser conveyor may be controlled via the CPU to supply water at a typical water content percentage of 5-25% of total weight;

- if the solid material is required to be in a ‘true’ suspension in the water (e.g. for a pesticide application), the water pump and fertiliser conveyor may be controlled via the CPU to supply water at a typical water content percentage of 30-50% of total weight;

- if the fertiliser is required to be completely dissolved in the water (e.g. for foliar application), the water pump and fertiliser conveyor may be controlled via the CPU to supply water at a typical water content percentage of 50-90% of total weight .

The control system can also control via the CPU the distance and amount of wetted product to be spread by controlling the speed of rotation of the impeller (9).

The CPU is programmed to control the CFP ratios and impeller (9) rotation rate within predetermined limits to ensure the desired fertiliser application is achieved. The CPU is also capable of determining vehicle speed and other variables from the sensor signals and set the water and fertiliser levels in the CFP and impeller (9) rotation rate accordingly to maintain the desired application rate.

The CPU also includes a programmed wash-cycle that can be activated via the control system which will then continue to supply water to the converter apparatus (4) but stop supply of the fertiliser for a short period of time or predetermined number of revolutions. This wash-cycle flushes the mixing assembly (7) and impeller (9) with water and thus ensures that there is minimal build-up of fertiliser which would otherwise reduce the converting effectiveness and/or block the fertiliser outlet (10).

The CPU may also be set to shut-off the water supply to the converter units (4) and therefore allow crushed product to be distributed without any water content.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

Quinspread Technologies Limited
by its Attorneys

JAMES & WELLS

Figure 1

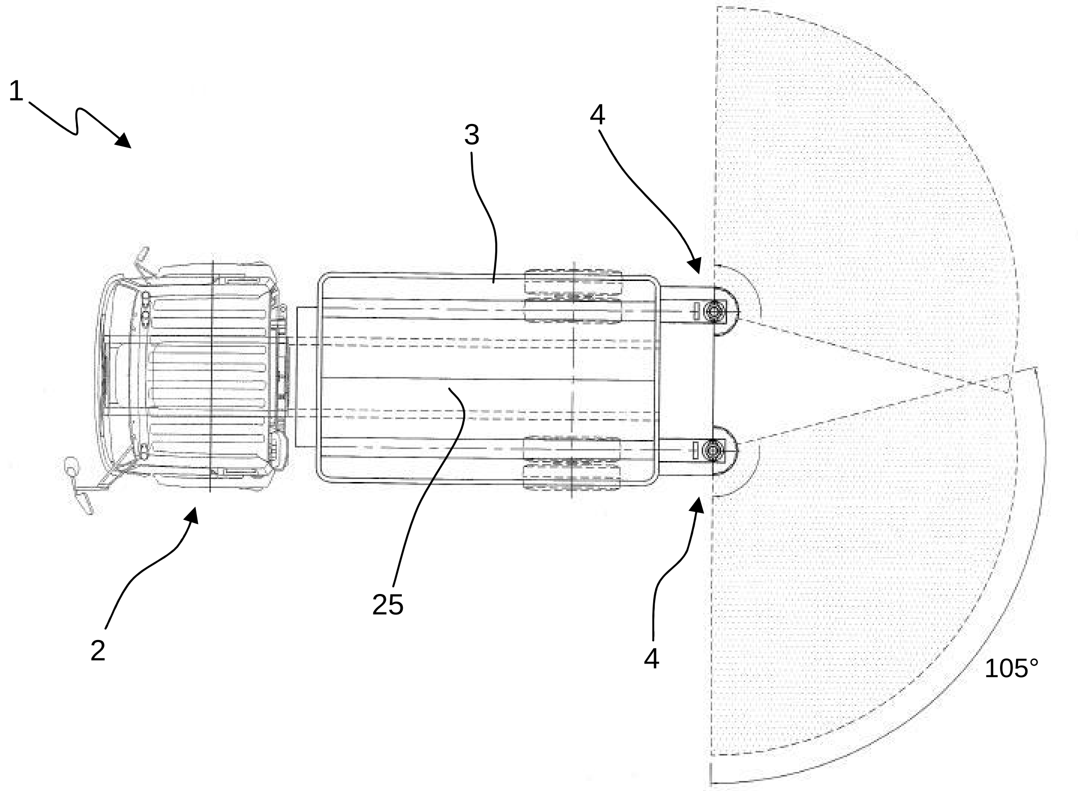


Figure 2

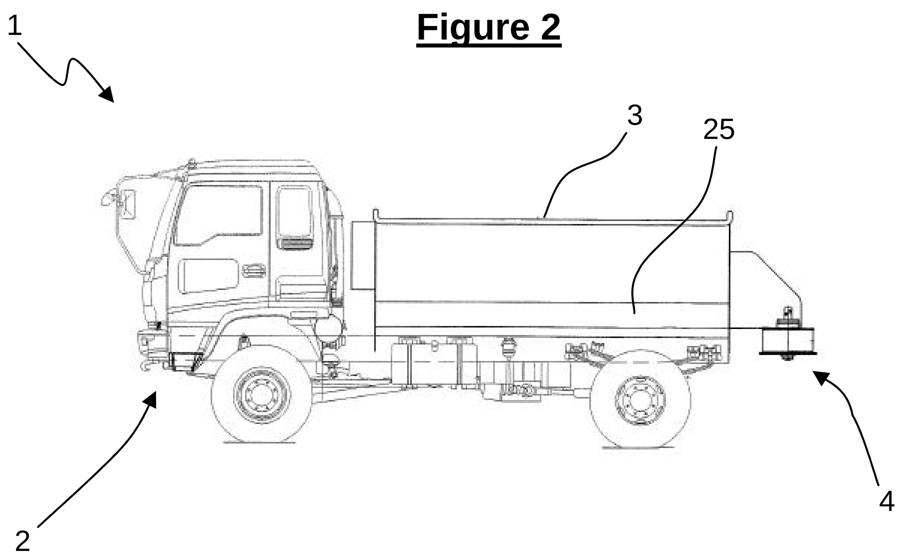


Figure 3

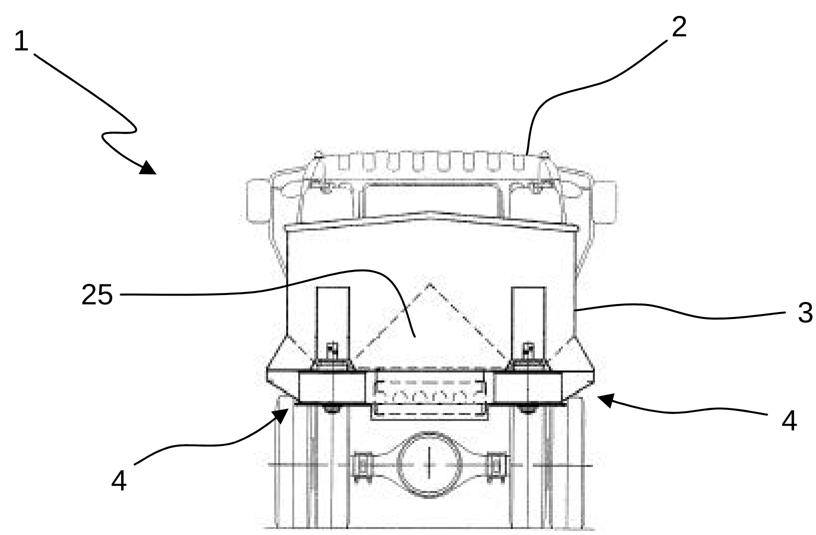


Figure 4

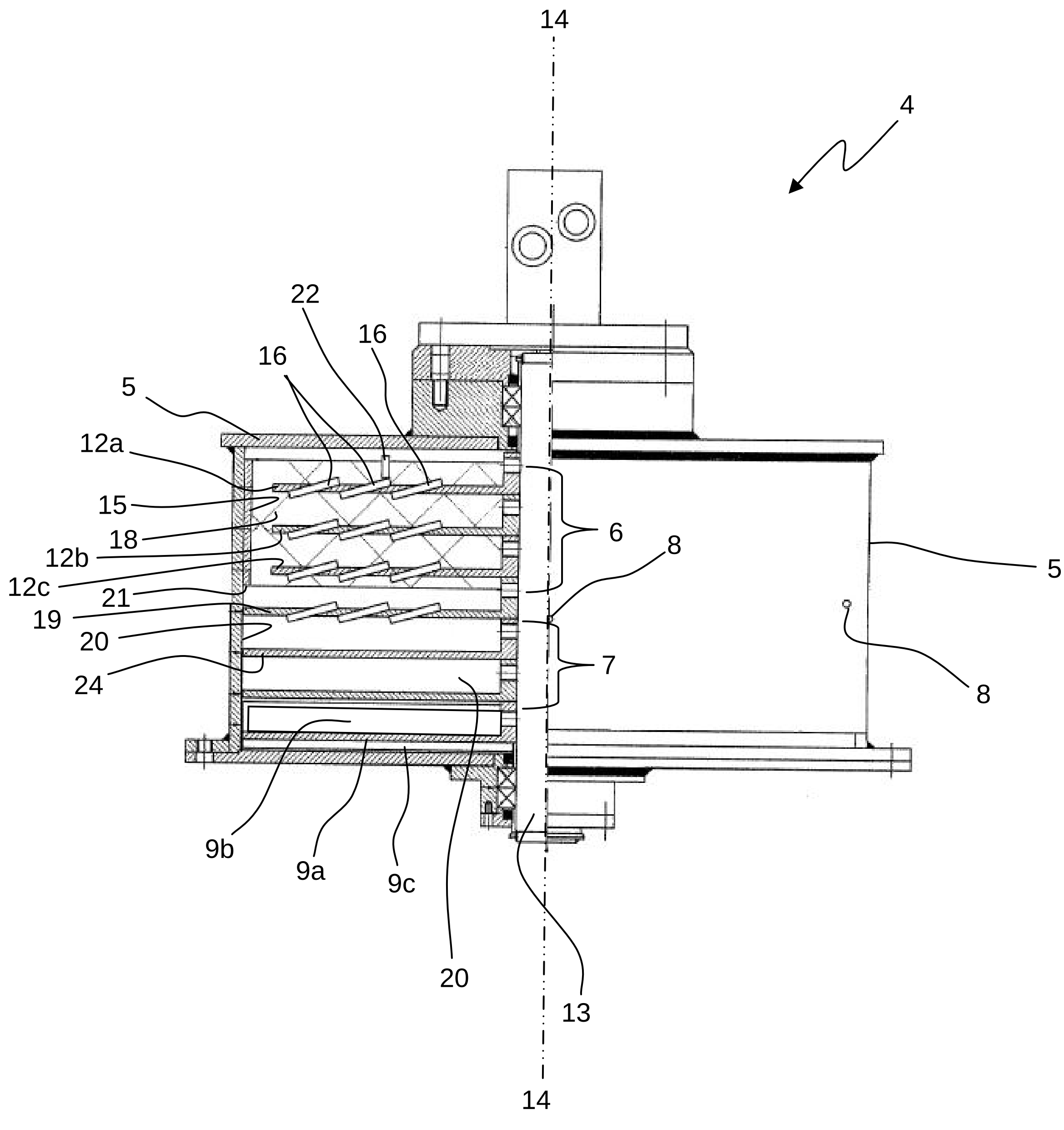


Figure 5

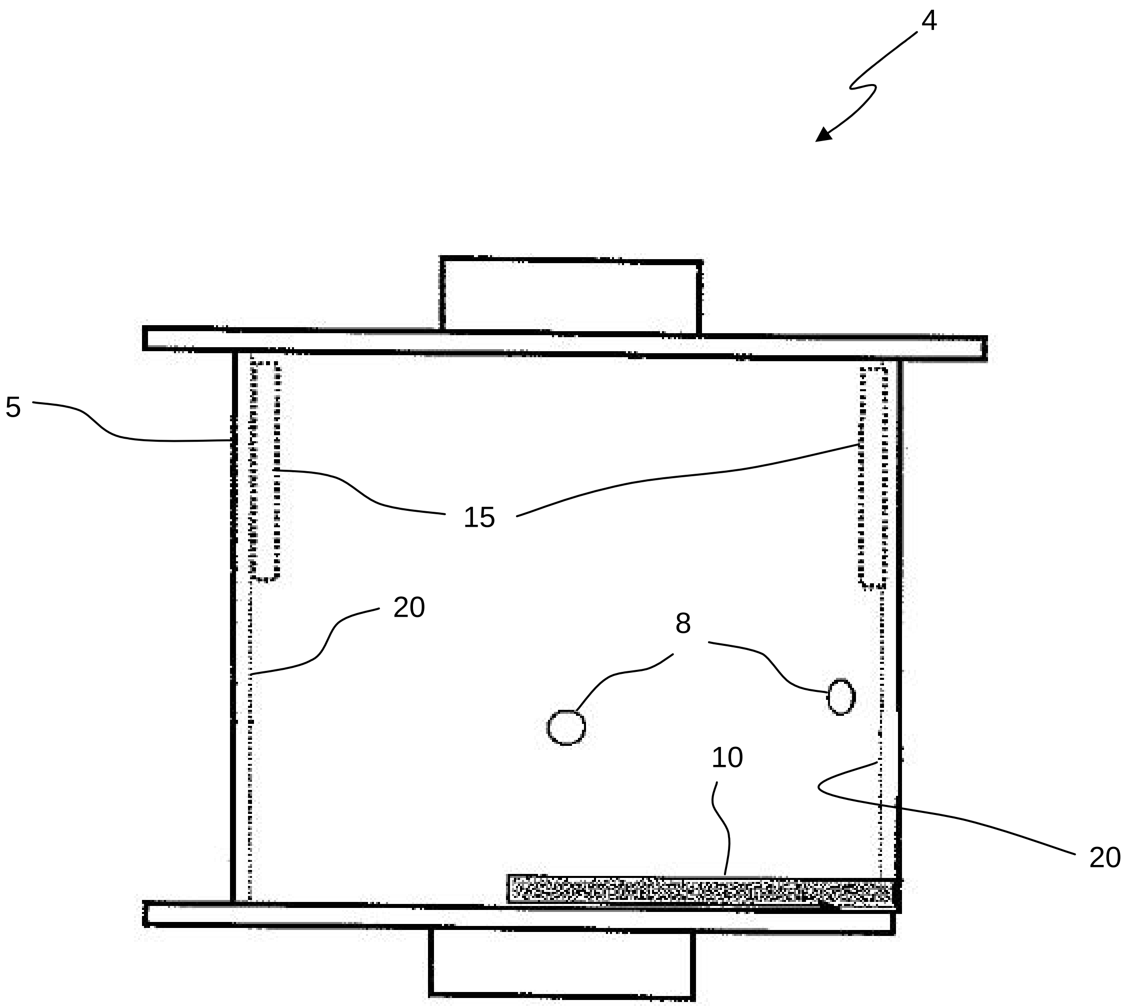


Figure 6

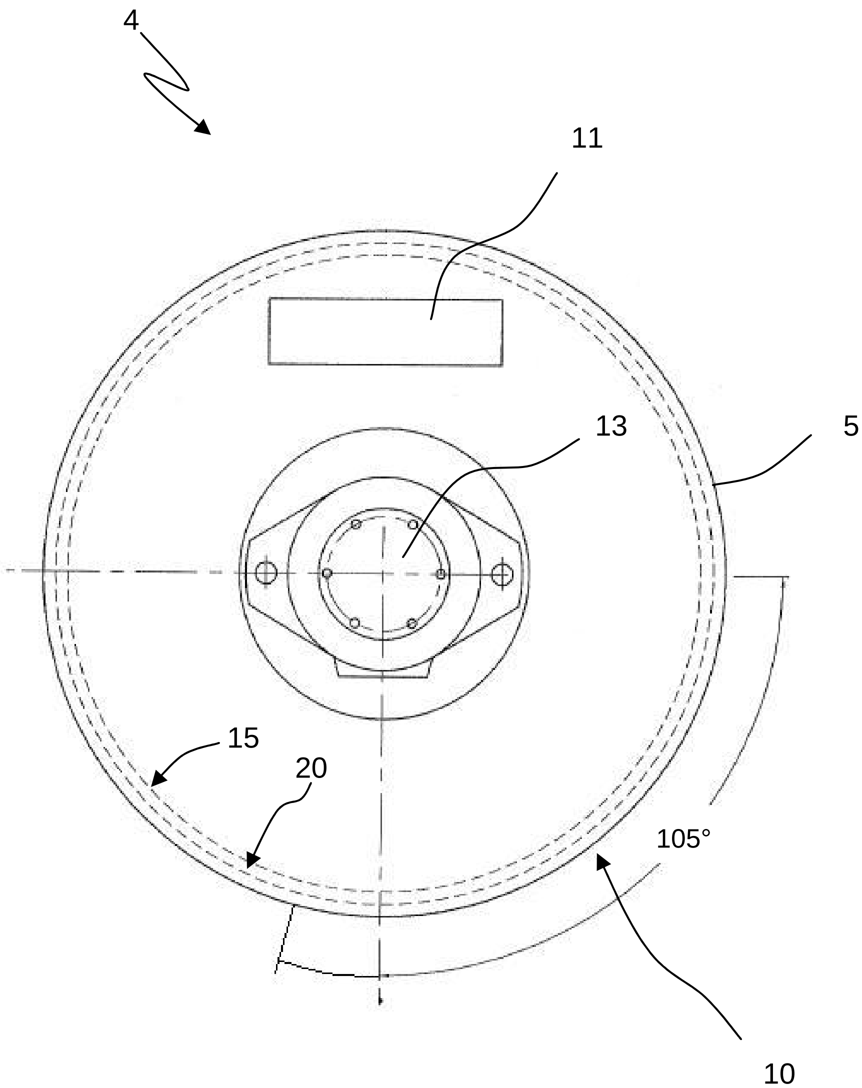


Figure 7

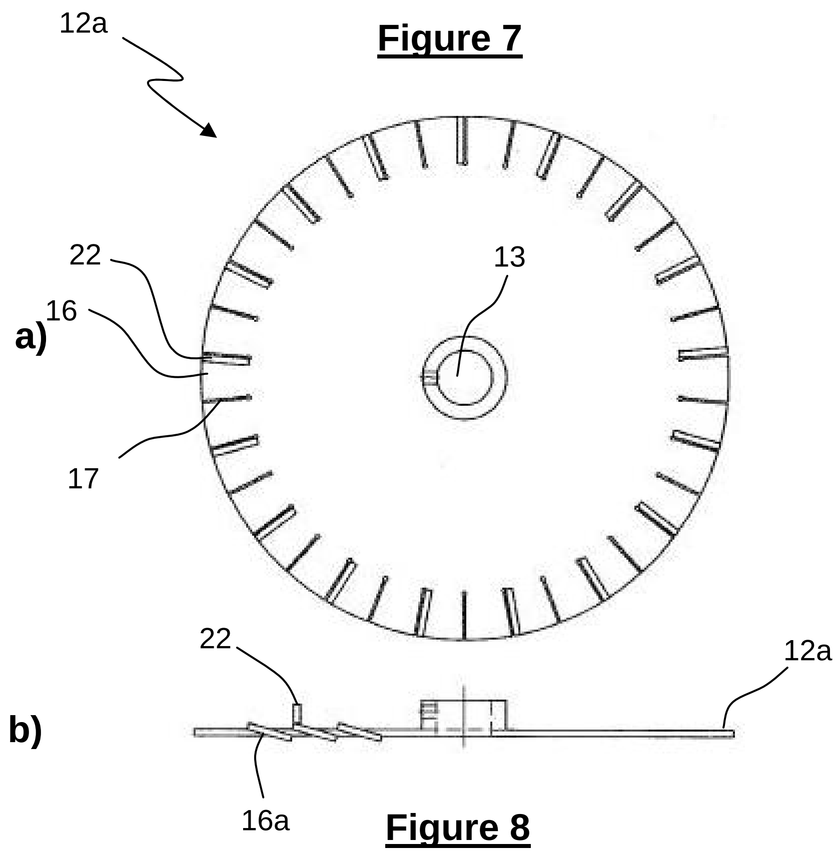


Figure 8

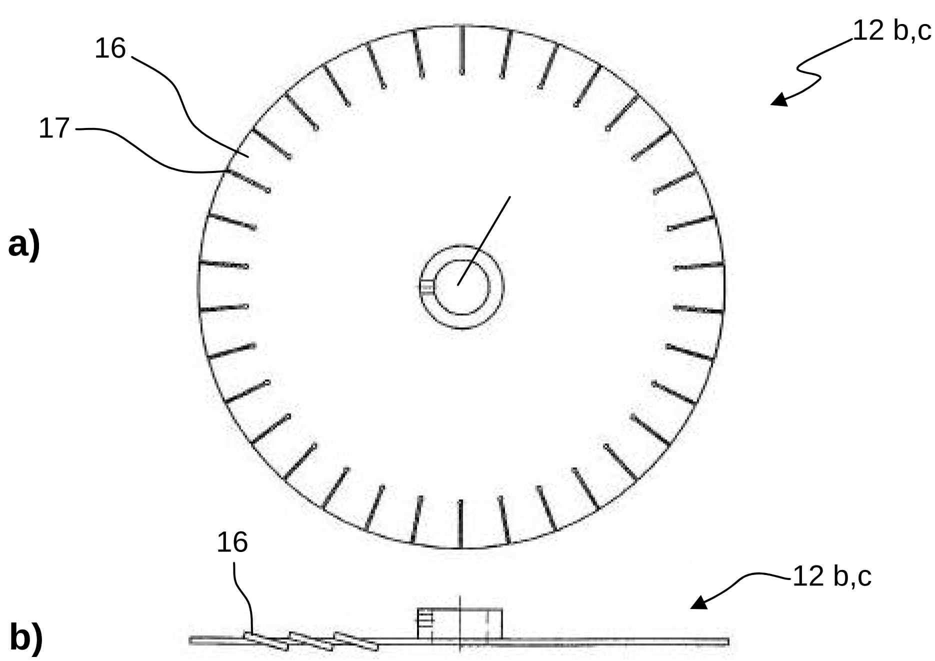


Figure 9

a)

b)

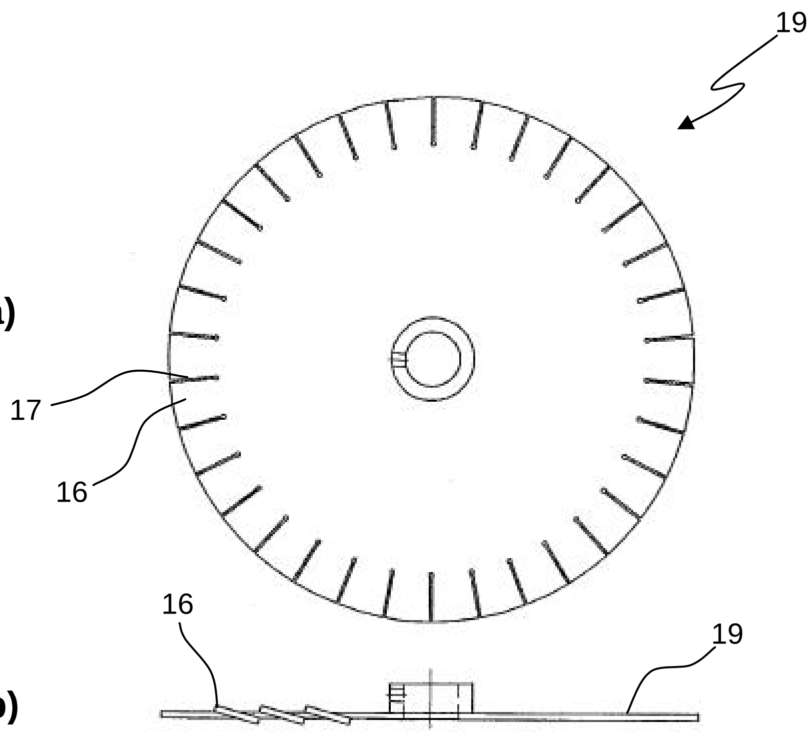


Figure 10

a)

b)

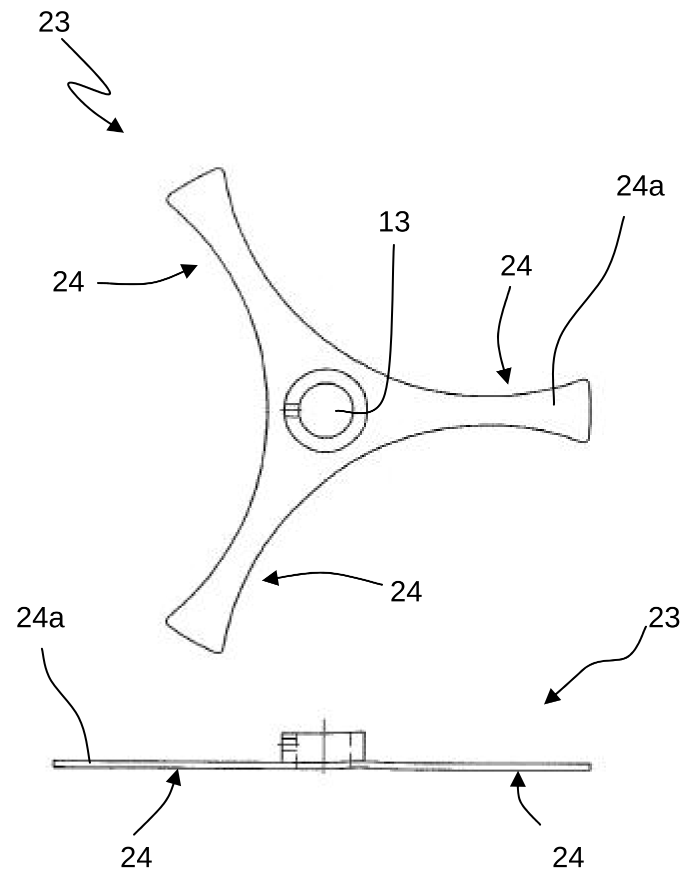
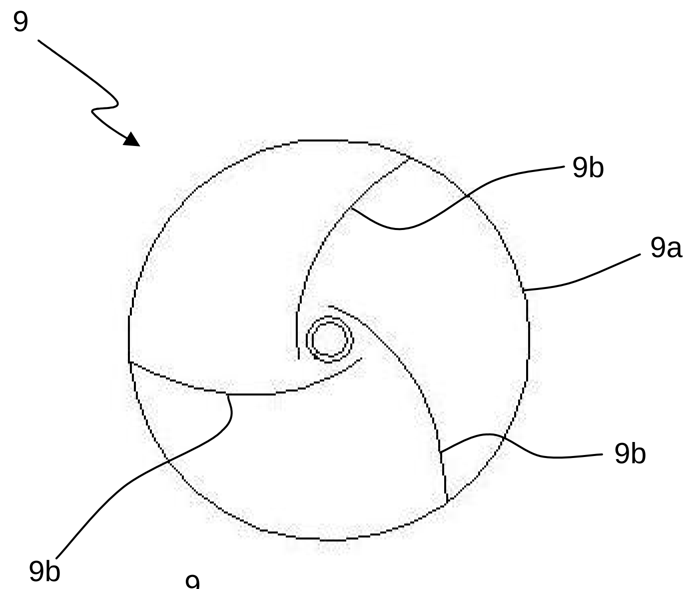


Figure 11

a)



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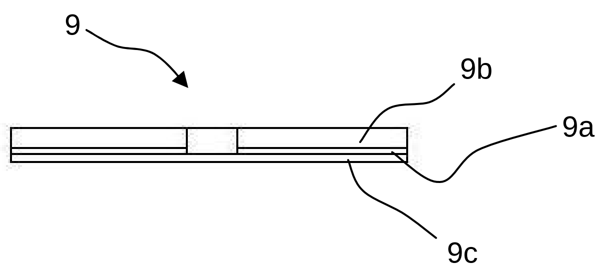


c)

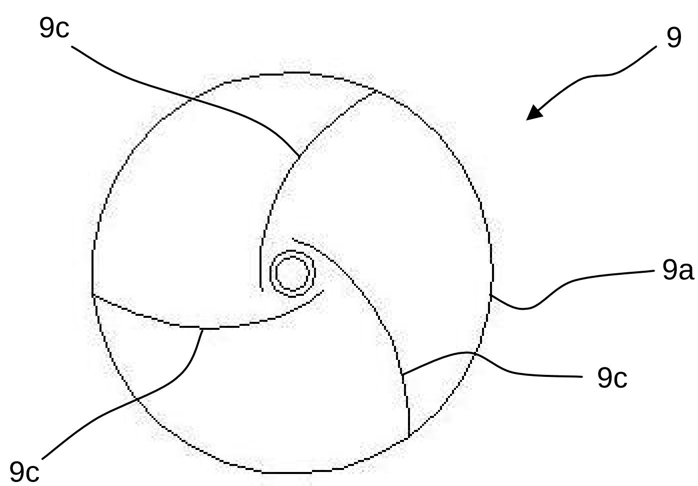


Figure 12

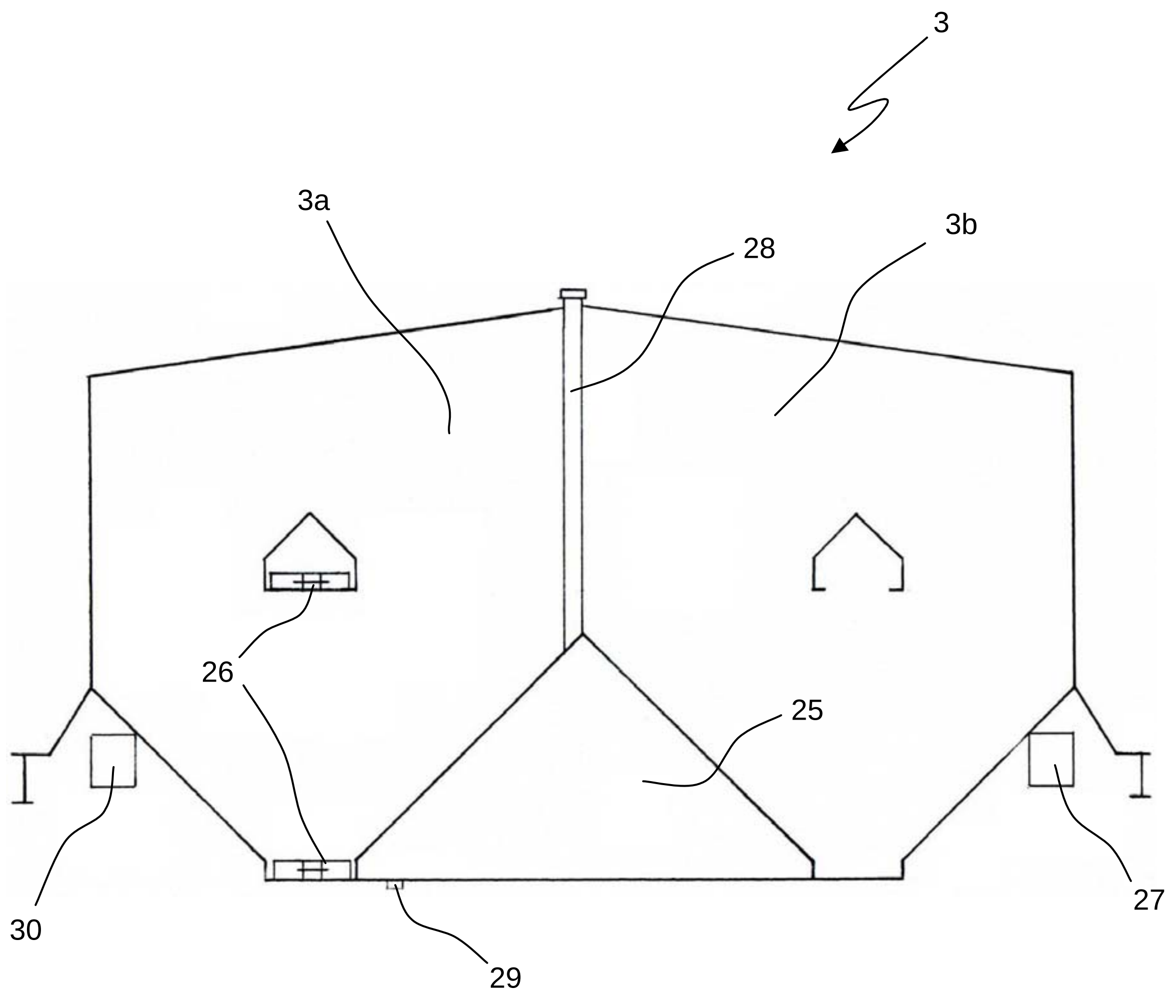
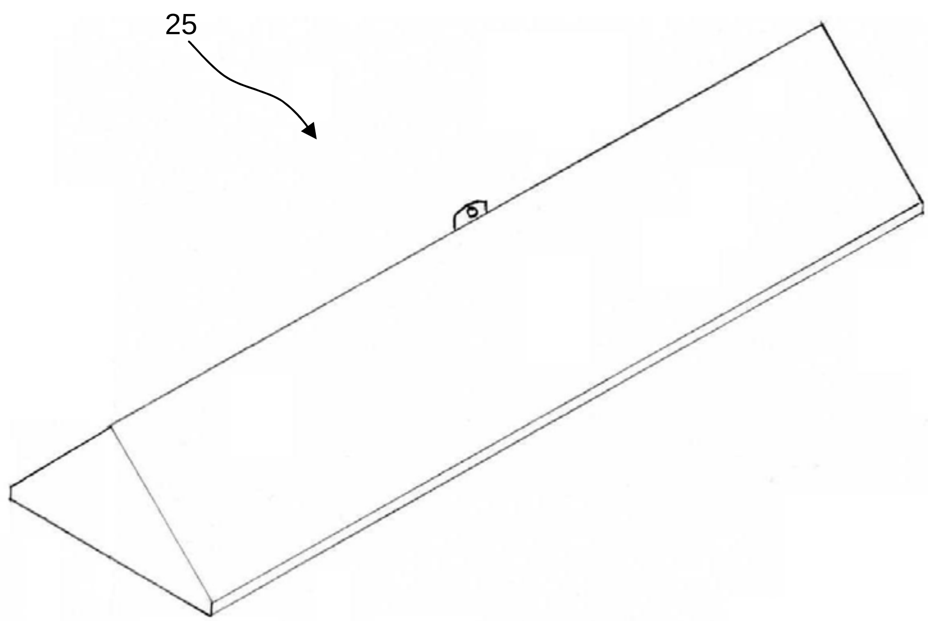
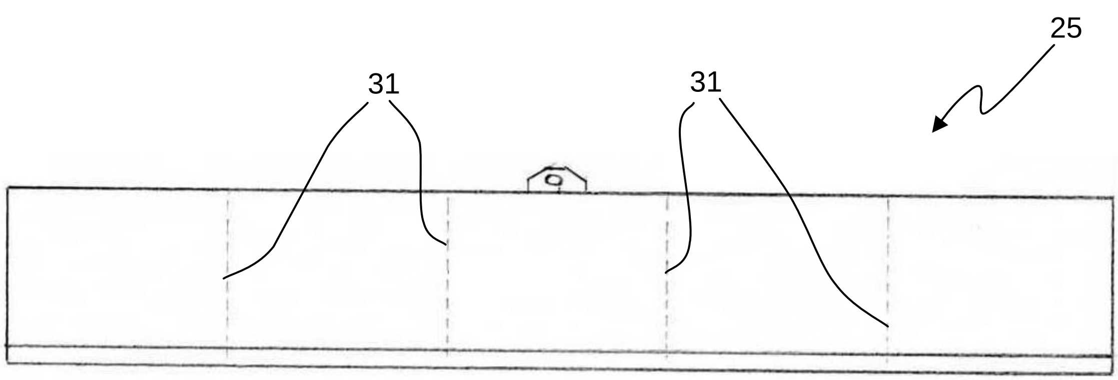


Figure 13



a)



b)

Figure 14