

(19) World Intellectual Property
Organization
International Bureau

(43) International Publication Date
30 November 2017 (30.11.2017)



(10) International Publication Number
WO 2017/202983 A9



(51) International Patent Classification:

C11B 1/02 (2006.01) C11B 1/04 (2006.01)

(21) International Application Number:

PCT/EP2017/062659

(22) International Filing Date:

24 May 2017 (24.05.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

PI 2016701870 24 May 2016 (24.05.2016) MY
PI 2016704327 22 November 2016 (22.11.2016) MY

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR,
KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: APPARATUS AND METHOD FOR APPLYING AN ENZYME PREPARATION

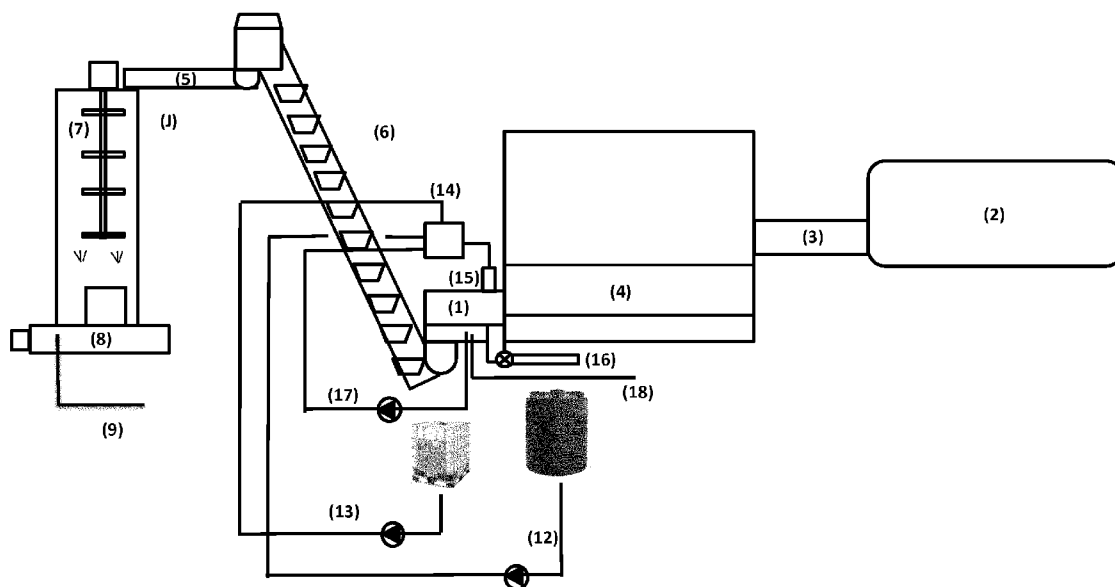


Figure 1

(57) Abstract: The present invention relates to the usage of an apparatus or set up and a method to apply an enzyme preparation on a substrate comprising mainly of sterilised palm fruitlets in the enzyme assisted aqueous extraction process of palm oil.

(48) Date of publication of this corrected version:

04 October 2018 (04.10.2018)

(15) Information about Correction:

see Notice of 04 October 2018 (04.10.2018)

APPARATUS AND METHOD FOR APPLYING AN ENZYME PREPARATION

TECHNICAL FIELD

Disclosed herein is an invention related to the usage of an apparatus or set up and a method to apply an enzymatic aqueous composition on a substrate consisting mainly of sterilised palm fruitlets in preparation for the enzymatic aqueous extraction of palm oil.

BACKGROUND OF THE INVENTION

The United States Department of Agriculture (USADA) estimates that worldwide palm oil production for 2015/2016 will be 61.68 million metric tons. (<https://www.worldpalmoilproduction.com/>). This makes palm oil the world's most important source for vegetable oil.

The process of palm oil production begins in the oil palm plantations. Ripe oil palm fruit bunches, or fresh fruit bunches, (FFB) are harvested from the trees and sent to the mill to be processed, usually within 24 hours to preserve the quality of final product. In the mill, the FFBs are sterilized by steam in pressured vessels to deactivate the natural enzymes in the palm fruits and also to loosen the fruitlets from the stalks, so that they can be further processed. Cooked or sterilized FFBs are sent by conveyors to Thresher – which is a rotating cage – where the fruitlets are detached and separated from the stalks due to the tumbling actions inside the cage. The thresher separates the sterilised FFB into two material streams – one stream which falls through the gaps of the thresher cage and comprising mainly of sterilised palm fruitlets. This stream is called MPD – which stands for Mass Passing to Digester. The other material stream which comprises fruit stalks of mostly depleted palm fruitlets is called EFB – Empty Fruit Bunches. The MPD is transferred through a series of conveyers until it enters the digesters. Fruitlets in the MPD are beaten into pulp or mash in the digester by rotating and static paddles. The resulting mash drops through a chute into a screw press. The screw press separates the digested mash into two streams, a mixed oil/water/fine solids stream, called diluted crude oil – DCO, which passes through the cage of the press and drops into a collection gutter. The other stream which was retained by the cage was fibrous and contained most of the large solid materials, including the mesocarp fibre and palm kernel. This is referred to as pressed cake - PC. The DCO is clarified in a clarifier where the oil portion is separated and harvested. The harvested oil is dried and stored in a storage tank as the main finished product, the crude palm oil, CPO. The remaining portion of the DCO, commonly called the “underflow”, comprising of mainly water, about 5% of small vegetative debris and 0.5% to 2% of free and emulsified oil, is discharged as palm oil mill effluent - POME. The PC may be loosened mechanically so that it can be sorted into mesocarp fibre – MF (a

by-product), palm kernel-PK (a product) and foreign debris – such as stone, plastic and metal pieces (solid wastes).

Mohammad et al. (2015) had disclosed in his publication that an enzymatic treatment is a suitable method for extraction of oil from the palm fruit mesocarp. Further disclosed was that besides the enzyme concentration, the type of enzyme applied was important for cell digestion of palm mesocarp and decreasing the remaining pressed pulp. Further, international publication WO2012011130A2 had disclosed the usage of an enzymatic composition and process for extracting oil from oil palm fruits particularly from mesocarp portion or mesocarp containing oil palm fruits having portion with at least with improved efficiency and/or increased yield of at least 90%. These publications both support the idea that enzymatic application provides a higher yield of palm oil extraction.

There is however no mention of a specific method applying the enzyme onto the substrate to be treated or the use of an applicator to which these enzymes are introduced to the mesocarp of the fruit. The present invention is an apparatus for preparing, conditioning a material train comprises mainly of sterilised whole palm fruitlets, so that the palm fruitlets can be properly imbued with an enzymatic composition prior to the oil extraction processes which occur further downstream; in the digester, the press and other means of oil extraction or recovery.

The present invention refers to an enzymatic composition applicator apparatus and method – EPA - which is generally located between the sterilized FFB threshers and the MPD digesters of a palm oil mill. It does not have a fixed rigid physical design as palm oil mills vary in their designs and process layouts. The proposed EPA could be a purposely designed and constructed apparatus which integrates seamlessly into the production process of a new mill. The proposed EPA could also be an apparatus inserted or integrated into the production process of an existing mill.

In this document, the system, EPA and enzyme applicator are used interchangeably and they referred to the same apparatus. Enzyme solution and enzymatic composition are used interchangeably and they both referred to an aqueous preparation of one enzyme or a combination of several enzymes. Substrate and MPD are used interchangeably and they both referred to the same material to be treated which comprises mainly of sterilised palm fruitlets. Further “*enzyme applicator*” and “*applicator*” are used interchangeably herein.

OBJECT OF THE INVENTION

An object of the present invention is to provide an alternative to the prior art.

In particular, it may be seen as a further object of the present invention to provide an enzymatic treatment that solves the above mentioned problems of the prior art.

It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art.

SUMMARY OF THE INVENTION

The invention relates in a first aspect to an apparatus for use in treating palm fruitlets, preferably being sterilized palm fruitlets, wherein the palm fruitlets are treated at least by being exposed to an enzymatic composition preferably being a water based solution of one or several enzymes, wherein said apparatus comprising

- an applicator comprising:
 - a device configured for stirring and/or flipping palm fruitlets, and
 - a device configured for applying the enzymatic composition onto said palm fruitlets.

The present invention provides inter alia a method and apparatus to provide a mechanical preparatory treatment to condition a substrate, consisting of the sterilised palm fruitlets in the MPD by treating it with an enzymatic composition prior to the commencement of the digestion and subsequent oil extraction processes.

Terms which are used interchangeably in this document include:

1. Enzyme applicator which could refer to Enzymatic composition applicator. Both these terms refer to the apparatus and it's attached or linked components which altogether form a complete system of treatment which includes applying an enzymatic composition unto the MPD which comprises mainly of sterilized whole palm fruitlets. The treatment process includes application (i.e. spraying) of an aqueous enzymatic composition of one or several enzymes on the MPD, physical means of stirring the MPD, means of inflicting cuts and bruises on the palm fruit epicarp and mesocarp to enhance the penetration of the enzymatic composition into the substrate to be treated as well as management and engineering measures to reduce the risk of environmental contamination via proper disposal methods. Further "*enzyme applicator*" and "*applicator*" are used interchangeably herein.
2. MPD Train and substrate is used to refer to a dynamic material stream which comprises of mainly sterilized palm fruitlets upon leaving the thresher till the time they enter the digester. The flow includes movement from thresher along conveyers, in and out of the enzyme applicator till entry into the digester.

3. Enzyme solution and enzymatic composition refers to the aqueous preparation comprising of one or several enzymes which is applied unto the MPD as it passes through the enzyme applicator.

5 4. Conditioned MPD and treated MPD refers to the status of MPD that has passed through all treatment conditions in the enzyme applicator wherein the enzymatic composition has been applied to the substrate.

In this document, substrate and MPD are used interchangeably to describe the material stream exiting the sterilised FFB thresher, where the main component is sterilised palm fruitlet.

10 Mass Passing to Digester(s) (MPD) comprises typically about 70% of palm fruitlets, which is an object of interest to the present invention, containing valuable products such as palm oils and palm kernel. The remaining 30% typically comprised of spikelet, fibre, stones, sand, mud, plastic, wood chips, metal pieces, other low oil content vegetative matters and other foreign objects swept up in the field and during transportation. These 30% of none fruitlet matter can
15 quickly wrap, blunt, damage, break or twist cutting blades and other parts of the palm oil mill machinery.

It has been found, that the present invention provides a method and apparatus capable of providing a (mechanical) preparatory treatment to sufficiently condition a substrate, for example MPD (especially the palm fruitlets in said MPD), by treating the substrate with an
20 enzymatic composition on site prior to the commencement of the digestion or oil extraction process. Hereinafter, this specification will describe some of the preferred embodiments of the present invention. However, it is to be understood that the description of some of the preferred embodiments of the invention does not limit the invention and it is envisioned that those skilled in the art may devise various modification and equivalents without departing from the scope
25 of the appended claims.

It has also been found, that the present invention provides a new method of improving the extraction of palm oil via the introduction of an enzyme solution to the MPD, as the MPD leaves the threshing system before it enters the digesting system. The present invention aims to achieve a greater level of efficiency by sufficiently preparing the sterilised palm fruitlets so that
30 they are conducive and ready for aqueous enzymatic oil extraction by conditioning the palm fruitlets and imbuing them with enzymatic composition prior to the oil extraction processes. This includes but not limited to treating said MPD at an epicarp and mesocarp level to enhance the release of free oils from the MPD. Further, this enzyme composition is introduced along the MPD train line and the substrate does not need to be removed or transported off the MPD

train to be treated. The enzymatic treatment preferably being done on site would show a significant effect.

In a preferred embodiment, the enzyme applicator is designed to operate based on one or more of the following parameters:

- 5 1. The enzyme applicator is to be located to receive and treat the substrate between the point of discharge of the thresher and the point of entry of the substrate into the digester of an oil mill.
2. The enzyme applicator involves means of inflicting damage (such as bruising and cuts) on the epicarp and/or deep cuts into the mesocarp so that the substrate is exposed to the
10 penetration of the enzyme solution or enzymatic preparation.
3. The enzyme applicator involves means of mechanical stirring and flipping actions to the substrate as it moves through the applicator to expose more surface area for enzymatic activity.
4. The enzyme applicator involves the preparation *in-situ* of the dilution water at a suitable
15 activation temperature.
5. The enzyme applicator involves the preparation of an optimum mixture of enzyme and dilution water via an in-line mixing device immediately prior to the point of application and application of the mixed enzyme solution to the substrate according to the substrate loading rate.
- 20 6. The enzyme applicator involves the application of the enzymatic composition in the form of continuous spray of fine droplets by a series of strategically placed spray nozzles.
7. The enzyme applicator involves a containment system which is an enclosed treatment environment which aims to reduce risk of exposure and contamination by enzyme bearing aerosol.
- 25 8. The enzyme applicator involves an air scrubbing and filtration system so that all vapour and aerosol from the treatment enclosure is filtered and removed from the air stream at the point of release out of the system to comply with required clean air standards.
9. The enzyme applicator involves a liquid recovery and recirculation system which allows excess liquid exiting the enzyme applicator to be collected and recycled back to treatment
30 environment within the enzyme applicator via a separate spray system or to be safely neutralised and disposed according to the required discharge standards.

In a preferred embodiment, the enzyme applicator would consist of a single, combination or all of the above mentioned embodiments.

In another embodiment, the enzyme applicator is designed to merge into the substrate process
35 train and commence the treatment nearest to the FFB threshing system.

In a further preferred embodiment, the enzyme applicator is designed to operate based on one or more of the following parameters:

1. The enzyme applicator is located to treat the MPD between the point of discharge of the thresher and the point of entry of the MPD into the digester.
- 5 2. The enzyme applicator involves means of inflicting bruising and cuts on the epicarp or deep cuts into the mesocarp of the fruitlets in the MPD so that they are sufficiently exposed to the enzyme solution.
3. The enzyme applicator involves means of mechanical stirring and flipping actions to the MPD as it moves through the applicator to expose more surface area for enzymatic activity.
- 10 4. The enzyme applicator involves the preparation *in-situ* of the dilution water at a suitable activation temperature.
5. The enzyme applicator involves the preparation of an optimum mixture of enzyme and dilution water via an in-line mixing device immediately prior to the point of application and application of the mixed enzyme solution to the MPD according to the MPD loading rate.
- 15 6. The enzyme applicator involves the application of the enzyme solution in the form of continuous spray of fine droplets by a series of strategically placed spray nozzles.
7. The enzyme applicator involves a containment system which is an enclosed treatment environment which aims to reduce risk of exposure and contamination by enzyme bearing aerosol.
- 20 8. The enzyme applicator involves an air scrubbing and filtration system so that all vapour and aerosol from the treatment enclosure is filtered and removed from the air stream at the point of release to comply with prevailing clean air standards.
9. The enzyme applicator involves a liquid recovery and recirculation system which allows excess liquid exiting the enzyme applicator to be collected and recycled safely back to the
- 25 Enzyme Applicator treatment environment via a separate spray system or to be safely disposed according to the prevailing discharge standards.

In a preferred embodiment, the enzyme applicator is able to complete all the above aqueous enzyme assisted palm oil extraction pre-treatment functions and return the treated MPD back to the regular milling process flow and/or allow the MPD to move on to the downstream oil

30 extraction processes.

In a preferred embodiment, the enzyme applicator is designed to be able to intercept or to be able to be merged into the MPD train in order to treat the MPD after it leaves the threshing system.

35 BRIEF DESCRIPTION OF DRAWINGS

The present invention and in particular preferred embodiments thereof will now be described in more detail with regard to the accompanying figures. The figures show ways of implementing the present invention and are not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim set.

- 5 Figure 1 is a schematic representation of a production line in a commercial palm oil mill from thresher to screw press.

Figure 2 and 3 each illustrate examples of the set-up of an enzyme applicator with described tumbler design

- 10 Figure 4 illustrates the placement of an enzyme applicator incorporated into a bottom ribbon conveyor (thresher conveyor)

Figure 5 illustrates the placement of an enzyme applicator incorporated on top of a cross conveyor.

Figure 6 illustrates the placement of an enzyme applicator incorporated on a ribbon elevator.

Figure 7 illustrates the placement of an enzyme applicator incorporated on a scrapper conveyor.

Figure 8 illustrates a simple depiction of conversion of a section of conveyor to enzyme applicator.

- 15 Figure 9 illustrates a simple depiction of integrating an enzyme applicator into an existing conveyor (as a tumbler unit).

Figure 10a illustrates a typical conveyor set-up (without enzyme applicator)

Figure 10b illustrates a typical conveyor set-up with enzyme applicator.

Figure 11 illustrates possible designs of cutting means.

- 20 Figure 12 illustrates different models of cutting plates installation.

Figure 13 demonstrates the movement of MPD in a ribbon conveyor (without any stirring).

Figure 14 illustrates the movement of MPD in a ribbon conveyor with properly angled stirring plate or cutting plates which dig or scoop up the MPD from the bottom of a conveyor with rotary motion.

- 25 Figure 15 illustrates the applicator/application area configured with dosing equipment.

Figure 16 illustrates an air cleaning system/means to filter and remove vapour from an enclosed treatment area.

Figure 17 illustrates an example of cutter design and deployment (sectional view).

Figure 18 is a schematic drawing of a present Palm Oil mill, which includes the usage of an enzyme applicator in the Palm Oil mill set-up.

Figure 19 is an illustration showing schematically a plan view of under thresher conveyor showing layout of spray system.

- 5 Figure 20 is an illustration showing a cross section of conveyor further showing nozzle deployment.

Figure 21 is an illustration showing a cross section of conveyor further showing tumbling effect created by flip plates

- 10 Figure 22 is a photograph illustrating three embodiments of flip plates according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS THE INVENTION

- Reference is made to fig. 1 schematically illustrating an embodiment of a plant for palm oil extraction. As illustrated, the plant comprising a sterilizer 2 receiving FFB (fresh fruit bunches) and sterilizing those by use of e.g. steam. The sterilized FFB are conveyed by use of a
15 conveyor 3 to the thresher 4 in which the fruitlets are separated out and enter into the applicator 1 applying enzymes to the fruitlets.

- After applying of enzymes, the fruitlets are conveyed by an elevator 6, which elevates to the fruitlets to a higher vertical position. This elevation is carried out, since the fruitlets are to be
20 introduced into a digester 7 having an inlet arranged above the outlet of the applicator 1. It is noted that it is not essential to the invention that the fruitlets are conveyed to a higher vertical position before entering the digester 7. In the embodiment shown in fig. 1, the elevator 6 delivers the fruitlets to a conveyer 5 which conveys the fruitlets to from the elevator to the digester 7.

- 25 At the bottom of the digester 6, a press 8 is arranged which receive digested fruitlets and press out palm oil from the fruitless as a stream of dilute crude oil exit 9.

- Fig. 1 also illustrates a tank holding pre-heated fluids and a pump (referenced in common by numeral 12) for feeding this fluid into a device 14 for dosing enzyme(s) and fluid(s). The device
14 for dosing enzyme(s) and fluid(s) also receives enzyme(s) from a tank storing enzyme(s)
30 by use of a pump (tank for storing enzyme(s) and pump are referenced in common by numeral 13).

Fig. 1 also illustrates a preferred, optional feature namely recycling of a stream of enzymes which is expelled from the applicator 1 – typically at the lower end thereof. As illustrated this stream of enzymes is recirculated to the device 14 for dosing enzymes and fluid inside which all the input streams are mixed and dosed.

- 5 If excess enzyme are expelled from the applicator, such a stream 18 can be collected for disposal.

During processing, vapour may be produced which vapour may have a composition making it unsuited for being released to the surrounding without being filtered. Accordingly, an apparatus according preferred embodiments of the invention may include means 16 to filter
10 and remove vapour from an apparatus at the position of the applicator 1.

ON PLACEMENT OF ENZYME APPLICATOR

It has been found in connection with the present invention that an enzyme applicator that the screw conveyors (or ribbon conveyors) that transfer threshed fruitlets to the palm oil mill digesters are ideal for being used in connection with applying an enzyme composition. Some
15 of the findings are:

- a) The palm fruitlets are passing through the conveyor and there are in general no need for costly modifications such as mass flow diversions to take the fruitlets out for applying the enzyme composition;
- b) A screw conveyor (or ribbon conveyors) is already 75% enclosed whereby if
20 considered expedient, only little material and work are need to close up the other 25% open area at the top of the conveyor;
- c) Most if not any section of the screw conveyor (or ribbon conveyor) can be easily modified to serve the mechanical requirements of a functional enzyme applicator, including flipping and stirring the palm fruitlets.
- d) In most palm oil mills, it is not difficult to find e.g. a three (3) meters section of the
25 MPD conveyors which are suitably located for conversion into an enzyme application zone being the zone of the conveyor in which the enzyme composition is applied to the MPD.

Similar principles may also be applied in situations where horizontal screw conveyors do not
30 form at least part of the delivery system of the MPD in some mills.

It is also considered with the scope of the present invention to have a section of the lower cross conveyor of the threshers in a mill be converted to a "Pre-Digesters" so that pre-digestion could start at this point while enzymatic solution is being added.

ON DESIGN OF AN ENZYME SOLUTION SPRAY SYSTEM

5 As illustrated in e.g. fig. 10b, the enzyme spray nozzles (902) are preferably installed in multiple units in a straight array lining one side (see fig. 20) of the conveyor for the following reasons:

10 a) A partial filled screw conveyor has substrate pile to one side of the conveyor channel (indicated by the dotted, straight line in fig. 20) as it is being pushed forward due to the nature of screw design and action of the force of gravity. The spray nozzles array are preferably positioned between 1/3 to 1/4 across the width of the conveyor on the "high flow" side to spray on the exposed surface with maximum mass flow at any one time. The nozzles are arranged in a straight line along the conveyor to create an uninterrupted curtain of enzymatic spray for effective treatment as the MPD is being
15 flipped and turned through the enzymatic treatment zone;

b) If flip plates (or blades in general) are used (see e.g. figure 22 showing preferred embodiments of such plates), such flip plates may advantageously be installed on the conveyor create or increase rotation and tumbling effects of the MPD as it passes in the conveyor. These activities may also rupture the epicarps of the palm fruitlets and
20 expose the mesocarps to enzymatic spray as it commutes through the conveyor;

c) In a conveyor of 600mm wide and screw pitch of 400mm, rotating at 50 rpm, this would allow any MPD surface to expose to the enzymatic spray approximately 7.5 times in the span of 9 seconds, as it is roughed up when it tumbled across a three (3) m long "Enzymatic Treatment Zone" of the Enzyme Applicator in the conveyor.

25 ON DESIGN OF FLIP AND CUT PLATES ATTACHED TO RIBBON OR SCREW CONVEYOR
FLIP PLATES (also referred to as blades herein)

A screw conveyor is typically designed to scoop forward at an angle of about 30 degrees to the vertical plain of the turning axis. This angle minimize energy dissipated due to lifting and frictional losses. A palm oil mill MPD screw conveyor is typically designed to push any material
30 through the conveyor channel efficiently with minimal disturbance. The angle and pitch of the conveyor are designed for its intended purpose. Flipping plates are installed may be seen as increasing the angle of the "plain design" with no such plates so that they can be used to at

least increase flipping, turning and tumbling the MPD to expose it more efficiently to the enzyme composition applied, e.g. by spraying.

FLIP PLATES WITH BRISTLES

5 The flip plates may also be designed with stiff bristles, spikes and/or cutting edges at the rear ends. Such features may help to inflict deep cuts and/or bruises on the oil palm fruitlets, as they are being flipped and tossed about in the Enzyme Applicator treatment zone. All bristles, spikes and/or cutting edges on the plates are design to tilt rearward so that fibrous debris do not get hooked by the bristles and accumulate.

10 ON RELATIONSHIP OF OIL PALM MPD LOADING IN CONVEYOR AND EXPOSURE OF MPD TO ENZYMATIC APPLICATION

A screw conveyor as used in connection with the present invention may be seen as ideally operated at 30% filled. This ensures that the content does not spill out of the conveyor as the mass flow in a screw conveyor is typically tilted to one side. Typically, a screw conveyor used in connection with the present invention has less material on the scoop side and more material
15 piled on the throw side.

A screw conveyor modified for Enzyme Application is typically designed and used to operate not more than 35% filled. This is to preferably applied to ensure a good exposure to enzymatic composition and retain the desirable scoop, tumbler and fall characteristics of the MPD as it is treated by the flip plates (if used).

20 It has been found that an overfilled conveyor may decrease the MPD tumbling effect which often are an importance features to enhance the enzyme penetration into the palm fruitlet mesocarps.

ON STERILIZATION

In most industrial scale palm oil processing which uses wet oil extraction processes,
25 pressurized steam is used to sterilize the palm fruits. The purpose of sterilisation is to inactivate natural enzymes present in palm fruits, enables the separation of the fruit from bunches and, according to the present invention, also to make them softer and therefore to process in the digester and press. The steam cooking vessel which has various design parameters is pressurized to improve penetration of steam and heat energy into the palm fruit
30 bunches to improve rate of complete sterilization of the palm fruits. This form of sterilization is done in a batch process.

Another form of sterilization is the continuous sterilization technology which involves sterilization of palm fruitlets as it is conveyed through a steam train to achieve complete sterilization by the time it exits the steam tunnel. To achieve satisfactory sterilization, the palm fruit bunches are usually split into smaller pieces so that the inner core of the palm fruits could be reached by steam, thus producing proper sterilization.

Sterilized palm fruits or sterilized MPD refer to the palm fruits or substrate or MPD which has been sterilized by any one or all of the discussed sterilization technologies or any other form of sterilization techniques which are available and will be available in the future.

ON THRESHING

- 10 The thresher is usually a rotary drum of about 2 meters in diameter. The drum rotates and bunches get lifted up and dropped when they reach the top of the drum. This action helps the detachment of fruits from the bunches and the separated fruit lets fall through the slots of the drum to a conveyor below.

ON LOCATION

- 15 In a preferred embodiment, depending of the process layout of a palm oil mill, the enzyme applicator could cover the complete process flow or processing path between the thresher and the digester systems in its entirety or it could be integrated in parts within the existing production process.

- 20 Ideally and according to the present invention, the more upstream the applicator treatment area (50) is located within the processing path, the more extended and effective will be the exposure time of fruitlets to the applied enzyme(s).

ON SIZING

- 25 In a preferred embodiment, the enzyme applicator would have a working time of between 5 seconds to 60 seconds such as between 20 and 60 seconds, between 30 and 60 seconds, between 5 and 40 second or such as between 5 and 30 seconds .

In another preferred embodiment, the enzyme applicator would have a length of 3m to 6m and a diameter of 0.35m to 1.2m.

ON SHAPE

- 30 In a preferred embodiment, the enzyme applicator could consist but not limited to several designs. These include:

1. Tilted tumbler design with a top side in-feed and a lower side exit.

2. Horizontal cylindrical chamber with paddle cutter-stirrers.
3. A tilted, horizontal or vertical lifting ribbon conveyor with cutting plates added.
4. A proprietary enzymatic pre-treatment vessel design.

In an embodiment, the EPA could be designed as a tumbler. The tumbler design allows for advantages in terms of volume and system flexibility. These advantages include:

1. Cutting edges can be installed to cover a larger area in the internal face of the tumbling drum to improve the speed of cutting
2. Cuts and bruises are inflicted due to falling MPD on the cutting edges. This reduces the risk of breaking the shells.
3. Tumbler can be tilted and rotation speeds can be adjusted to control the rate of treatment.

In preferred embodiments according to the invention, the enzyme applicator has a tumbler design essentially as described in Figure 2 and 3.

In another embodiment, the enzyme applicator can be an adaptation of an existing mill process set-up whereby the enzyme applicator is integrated and incorporated into an existing conveyer set-up where about 3m to 6m in length of the conveyor is modified to be used as a treatment vessel suitable for enzymatic treatment application.

Among common process set-ups which can incorporate the enzyme applicator system is but not limited to:

1. Ribbon conveyers located below threshers, at a cross linkage between threshers or at elevator ribbon conveyers.
2. Elevators (mainly vertical ribbon elevators (with or without shaft), or tilted ribbon elevators (with or without shaft) among others)
3. Top and bottom distribution ribbon conveyers which distribute MPD to elevators and digesters.

In another embodiment, the enzyme applicator may be design and constructed to fit into a section of an existing MPD conveyor line.

In another embodiment, a section of an existing MPD conveyor may be upgraded, re-fitted and converted to serve the functions of an enzyme applicator. The ideal design would be to incorporate the enzyme applicator into a ribbon conveyer.

In another embodiment, the enzyme applicator can be an adaptation of a section of an existing horizontal ribbon or auger MPD conveyor. Any section of any of the MPD conveyors located between the thresher and the digester can be adapted and converted to be used as an enzyme applicator.

5

In preferred embodiments of the invention the enzyme applicator is incorporated into a bottom ribbon conveyor (thresher conveyer), such as illustrated in Figure 4.

10

In other embodiments the enzyme applicator is incorporated on top of a cross conveyer, such as illustrated in Figure 5.

In other embodiments the enzyme applicator incorporated on a ribbon elevator, such as illustrated in Figure 6.

15

In still other embodiments the enzyme applicator is incorporated on a scrapper conveyer, such as illustrated in Figure 7.

In further embodiments of the invention the enzyme applicator is a converted section of a conveyor, such as illustrated in Figure 8 .

20

In still further embodiments the enzyme applicator is integrated into an existing conveyer (as a tumbler unit), such as illustrated in Figure 9.

25

In currently preferred embodiments, the enzyme applicator is integrated into a conveyor set-up essentially as shown in Figure 10 (without enzyme applicator) and in Figure 10b (with enzyme applicator).

ON CUTTING

30

The size of a single palm fruitlet averages typically from about 15mm by 25mm. It is protected by a waxy epicarp and is therefore not conducive or permeable for enzymatic treatment. Therefore, it is critical that cutting means are used to inflict cuts or damages on the epicarp surfaces and deep into the mesocarp surface around up to 15mm in depth.

35

In another embodiment, palm fruitlets in MPD are inflicted with bruises and cuts in the thresher from the tumbling action which occurs in the vessel. Steel cutters and spikes or any other cutting or slicing apparatus or means is preferred to be fixed in the enzyme applicator to introduce cuts and bruises on the fruitlets to improve enzyme penetration during treatment.

Among considerations for cutting means would include but not limited to:

1. A cutting edge which could be a spike or stiff wire or blade or any suitable cutting mean.
2. A cutting edge or blade could be an extrusion from a sheet of metal, or an extrusion on
5 any material;
3. A cutting edge or blade should have a height of about 5mm to 15mm in length;
4. A cutting edge should be placed at an incline/with an angle of about 30° to 60° from the
surface to prevent entanglement and accumulation of fibrous material on cutting edge;
5. A cutting edge or blade should have a cutting depth in the range of between 3mm to 15mm
10 deep;
6. A cutting edge could be a die casted durable material, or a hard material shaped by tool
and/or machine;
7. A cutting edge can be made from durable material such as steel, hard composite material,
ceramic or any other durable materials;
- 15 8. A cutting edge or blade could be held in place on a plate of hard material by epoxy,
fasteners, welding techniques, or other bonding technology;
9. A cutting mean which consists of multiple cutting edges in order to inflict cuts on a larger
number of fruitlets;
10. Cutting means which can be easily replaceable when damaged by hard objects such as
20 stone and steel pieces, or worn out due to usage;
11. Cutting means which are tangle free to avoid accumulation of slit and fibres;
12. Cutting means which are standardized and can therefore be easily replaced;
13. Cutting means may consist of any hard or sharp object which can inflict a cut on sterilized
palm fruitlets. However, suitable materials are preferred to be slightly elastic, mildly
25 malleable, durable to withstand long usage hours and abrasion as well as affordable.

The cutting means used may be selected from having one or more of the following features:

1. Multiple units of cutting elements or cutting edges are assembled on a cutting plate. A
cutting plate sheet is made out of a durable and malleable material, for example mild steel.
30 A cutting plate can be of any suitable shape or size. Preferably, the cutting plate is a square
or rectangular shaped plate sized 1/8 to 1/4 the diameter of the screw, auger or ribbon
conveyer. The cutting plate is mounted on the conveyer near its perimeter, at a position
which allows the cutting plate to plow through the MPD train as it is being pushed forward
by the conveyer.

2. Curved cutting plates may be installed on the channel of the conveyer, in such manner so its cutting elements could inflict cuts on the fruitlets as they are being pushed through the conveyer channel.

5 Number of cutting plates, how they are installed and cutting elements required are determined by the expected volume and flow rate of MPD as well as the size of the conveyer.

10 An enzyme applicator of 3m in length built into a 0.5m diameter conveyer requires about 50 cutting plates deployed about 200mm apart, with each plate bearing 20 pieces of cutting edges or cutting elements.

According to some embodiments of the invention, the design of the cutting means or plates is essentially as shown in Figure 11.

According to other embodiments the cutting means or plates are installed as shown in Figure 12.

15 ON FLIPPING AND STIRRING

In another embodiment, a stirring and flipping mechanism is required to shift the fruitlets to enhance the surface area of fruitlets to be bruised and cut.

20 A possible flipping/stirring mechanism or flipping and stirring means is that of an auger conveyer designed to tilt at an angle of between 25 to 35 degrees from the plane of its turning axis. This design that the material is pushed along its turning axis while allowing energy conservation while the material flips.

25 Another possible mechanism is the installation of flip plates. A flip plate acts to increase the angle of tilt so that stirring and flipping of the MPD can take place. This flip plate is installed at an angle of 30 to 45 degrees which allows it to dig into the MPD train and flip it about to expose the MPD to drops of enzymatic composition from spray nozzles.

The flip plates may be installed with cutting edges or sharp elements to function as cutting plates.

30 Figure 13 demonstrates the movement of MPD in a ribbon conveyer (without any stirring). A ribbon conveyer is designed at an angle of 30° measured from the line of flow. Under regular circumstances, the MPD would move in the direction of the conveyer without any stirring (fruitlets which are at the bottom stay at the bottom and fruitlets on the top stay on the top). In a preferred embodiment, installation of an additional flip plate at 45° to the ribbon conveyer surface will improve the stirring of MPD which in turn improves enzyme reach.

Figure 14 illustrates the movement of MPD in a ribbon conveyer with properly angled stirring plate or cutting plates which dig or scoop up the MPD from the bottom of a conveyer with rotary motion.

Figure 17 illustrates the installation of cutting plates and flip plates on conveyor surface.

- 5 In an embodiment of the invention the enzyme applicator comprises means for stirring, cutting and bruising the substrate, said means being as shown in Figure 17 (sectional view).

ON DILUTION WATER

- 10 In another embodiment, dilution water is used as a carrier to bring the enzymes to MPD wherein the dilution water is preheated to an optimum temperature before it is mixed with the enzyme. The dilution water could be pre-heated with a steam supply pipe, adding hot water or installing a heating element in the water holding tank.

- 15 The enzyme mixture is mixed and delivered near the point of application in a concentrated form. The required dosage is delivered by metering pump. Dilution water on the other hand is pre-heated to a suitable application temperature which would act as an enzyme activation temperature. The dilution water is delivered by the metering pump at about 100 to 200 parts water to 1 part of concentrated enzymatic preparation. The concentrated enzymatic composition and the preheated water is combined at the point of entry into a static mixing device, piped through a pressure gauge, a screen filter, a flow regulator, and flow distribution pipe work before being discharged through spray nozzles to be applied unto the MPD.

- 20 A preferred temperature for the enzymatic composition to be introduced at is at about between 45°C to 75°C. Preferably between 50°C to 70°C, 50°C to 65°C or 55°C to 65°C.

ON DOSAGE

- 25 In another embodiment, the dosage of enzyme used is determined by laboratory tests results whereby the ratio of water to enzyme mixture is dependent on the requirements of the process and operating conditions. Preferably, the water-enzyme mixture is prepared immediately *in situ* prior to application.

- 30 In another embodiment, a metering pump is used to feed dilution water to the mixing device and at the same time, another metering pump is used to feed the enzyme to the mixing device. The mixing device ensures that the dilution water and enzyme are properly mixed before the resulted enzyme water solution is sent to the applicator to be applied on the MPD train via a spray or multiple spray nozzles.

A preferred dosage of enzymatic composition is between the range of 20 mg enzyme protein/kg palm fruitlet and 1000 mg enzyme protein/kg palm fruitlet relative to the amount of palm fruitlet being treated. Another preferred dosage of the enzymatic composition corresponds to 10-100 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches, such as 20-50 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches or such as 30-40 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches.

Another embodiment of the dosage preferred is between 350 ppm and 1000 ppm relative to the amount of palm fruitlet treated.

ON APPLICATION OF ENZYMATIC PREPARATION

10 Prepared enzyme composition (solution) is dispersed across the application zone by means of liquid distribution pipe work and properly spaced spray nozzles;

Further, a supply of compressed air may be introduced into the spray nozzles to act as a propellant for the spraying process, especially when the volume of delivery is low.

The spray nozzles are sized to deliver 1 litre to 5 litres of liquid per minute.

15 The spray nozzles are selected from one or more of the following:

1. Capable of producing wide angle projections of droplets
2. Capable to work under settings of limited headroom
3. Are incorporated with deflectors to prevent or suppress undirected sprayings

20 In an embodiment of the invention the enzyme solution application system is as illustrated in Figure 15.

ON ENCLOSED TREATMENT ZONE

25 In another embodiment, an enclosed zone or treatment vessel is incorporated to ensure that spray droplets and vapour is securely contained to reduce the risk of contamination of ambient air by enzyme bearing aerosol, in compliance with prevailing air safety standards. It is preferred that a casing or a cover is used to enclose the enzyme applicator treatment zone.

The enclosed treatment zone covers the entry point of the MPD all the way till the outlet point of the MPD to the digester. The enzyme applicator may be designed to have an enclosed zone shaped similar to a tunnel.

The enclosed treatment zone may have one or more of the following features:

1. Enclosure to prevent release of enzymes to the air. As the sprayed enzymatic composition comprises protein, some individuals may exhibit adverse reactions upon exposure to the preparation. Therefore to reduce the risk of this, an enclosure is preferred.
2. Allows for more vigorous flipping and stirring. The enclosed zone will prevent materials
5 from flying out of the treatment area during stirring, mixing and application of enzymes.
3. Allows for more intense spraying of liquid which ensures aerosols and fine liquid droplets are securely contained.

Preferably, the treatment zone is within a closed compartment that is air-tight or essentially or substantially air tight in the sense that there is only one outlet for air to exit the treatment zone,
10 that outlet being via scrubbing and/or filtering device as set forth below. Preferably, the treatment zone is air-tight to the extent that the number of aerosols which escapes the treatment zone is limited to the extent that the amount of enzyme protein in samples of air taken in the close vicinity of the treatment zone, such as within a distance of 1 meter from the application zone, are less than 60 ng/m³ air, such as less than 40 ng/m³, or less than 40 ng/m³
15 air.

In specific embodiments of the invention, wherein the treatment zone is a closed compartment equipped means for inspection of the application of enzyme; e.g. a lid or a door, it is to be foreseen that the above limits on the amount of enzyme protein in air samples, may be exceeded when the door or lid is briefly opened for inspection. In a preferred embodiment, the
20 door or lid is opened by use of a sliding mechanism: Compared with a hinged door or lid, the use of a sliding door or lid minimizes the escape of aerosols when opened.

ON FILTERING OF ENZYME CONTAMINATED AIR

The apparatus provided according to the invention may comprise means for filtering air out of
25 the applicator (1), said means for filtering being preferably a water scrubbing device and/or means for mechanical filtering by a penetrable filter material or dry physical filtrations, said means preferably being selected from High Efficiency Air Filters, such as Efficiency Particulate Air Filters (EPA), High Efficiency Particulate Air Filters (HEPA) and Ultra Low Penetration Air Filters (ULPA). As the skilled person will understand, the apparatus may be designed to
30 include several means for filtration, which may be coupled in series, such as a scrubbing device followed coupled to one or more mechanical or physical filtration means.

Preferably, the means for filtering air out of the applicator (1) comprise a scrubbing device, preferably a water scrubbing device, and a High Efficiency Air Filter, preferably a High Efficiency Particulate Air Filters (HEPA). The means for filtering are preferably selected from
35 Efficiency Particulate Air Filters EPA 10 - EPA 12, High Efficiency Particulate Air (HEPA)

Filters HEPA 13 - HEPA 14, and Ultra Low Penetration Air Filters ULPA 15 - ULPA 17, when classified according to the specifications set forth in European Norm EN 1822:2009.

The High Efficiency Air Filter may be positioned to receive air flowing from the scrubbing device.

- 5 In preferred embodiments according to the invention, the means for filtering air out of the applicator (1) are configured to reduce the amount of enzyme protein in the air discharged from the applicator (1) to 50 ng enzyme protein/m³ air or less, such as to 20 ng enzyme protein/m³ air or less, 10 ng enzyme protein/m³ air or less, 5 ng enzyme protein/m³ air or less, or such as 1 ng enzyme protein/m³ air or less. Preferably, this reduction in the amount of
10 enzyme protein in the air discharged from the applicator is achieved when the enzymatic composition is dosed in amounts corresponding to 10-100 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches, such as in amounts corresponding to 20-50 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches or such as in amounts corresponding to 30-40 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches.
- 15 In another embodiment, a slight negative air pressure is maintained in the enclosed treatment chamber to prevent escape of aerosol from the treatment zone. One example is by means of an air suction apparatus connected to a water based air washing system, an air filtration system and a motor driven extraction fan. This embodiment ensures that all air or aerosol discharged from the applicator treatment zone is treated and filtered clean in compliant with
20 prevailing safety regulations.

A suction fan may be used to draw the air stream exiting the discharge end of the enzyme applicator and is discharged after undergoing a series of cleaning and filtering processes:

1. Water scrubbing: Contaminated air is drawn into a confined zone where it is drowsed with water sprays applied via a high throughput sprayer, to trap and suppress aerosol and
25 particulates.
2. The water clean air is then passed through a moisture trap to retain the moisture in the air.

The water scrubbed air is guided through a series of physical filters which are capable of retaining the smallest molecules of protein (which the enzymes in the enzymatic composition is made of). In a preferred embodiment the enzyme applicator comprises an air cleaning
30 system/means to filter and remove vapour from the enclosed treatment area essentially as illustrated in Figure 16.

ON HANDLING OF EXCESS LIQUID

In another embodiment, a solution recovery and recirculation system is incorporated to collect excess unutilized liquids for reuse or for discharge according to prevailing industrial discharge standards.

Excess enzyme solutions or oil is expected to converge at the lowest point of the enzyme applicator due to gravitational force. The preferred embodiment incorporates a stainless steel screen and a collection tank to screen and collect the filtrate. Since the liquid contains active enzyme, it can be reintroduced into the MPD train passing the applicator treatment zone by a set of pump and spray nozzles, such as a separate set of pump and spray nozzles to sustain its effectiveness.

10 ON RESIDENCE TIME AND TREATMENT TIME IN ENZYME APPLICATOR

In an embodiment, the enzyme applicator has an operation time within the range of 10 seconds to 180 seconds on the MPD train in the enzyme applicator.

An average conveyer in a palm oil mill progresses at 15 m to 30 m per minute. This means that the MPD train progresses at 0.25m to 0.5m per second.

15 A 3m long enzyme applicator integrated into a typical conveyer would have a MPD residence time of between 6 seconds to 12 seconds starting from the point of entry until the point of exit.

In a preferred embodiment, the enzyme applicator has a length of between 3m to 6m. Therefore, the enzyme applicator preferably has a treatment time of between 6 seconds to 24 seconds.

20 ON PRESSING

After leaving the treatment area (50) the fruits are conveyed to a digester which mashes them up so that when the mash is pressed in a screw press, the oil is extracted efficiently. The output from the screw press is pressed palm oil and press cake. The extracted oil is mixed with fruit particles, water, sand and dirt.

25 The crude oil is first screened with a vibrating screen to remove the course fibres and other dirt and it is then pumped to the clarification station for further processing.

SPECIFIC EMBODIMENTS OF THE INVENTION

Specific embodiments of the invention include embodiments as defined in the following items:

1. Applicator (1) for enzymatic extraction of palm oil located between a thresher (4) and a digester (6) comprising:
 - (a) Means (10) for bruising and/or cutting fruitlets;

- (b) Means (11) for stirring and flipping fruitlets;
- (c) Means (12) for feeding pre-heated fluid(s);
- (d) Means (13) for feeding enzyme(s);
- (e) Means (14) for dosing said enzyme(s) and fluid(s);
- 5 (f) Means (15) for applying said enzyme(s) and fluid(s) to fruitlets;
- (g) Means (16) to filter and remove vapour from a treatment area (50);
- (h) Means (17) for collecting enzyme solution for reuse; and
- (i) Means (18) for collecting excess enzyme solution for discard,

wherein said means (10, 11, 12, 13, 14, 15, 16, 17, 18) are comprised within a treatment area
 10 (50), fruitlets exiting a thresher (5) and being conducted into said area (50) and through the applicator (1) where they are exposed to a mixture of said enzyme(s) and fluid(s), and then exit said applicator (1), into the digester (6) , wherein excess enzyme solution and oil accumulated in the lowest point of the applicator (1) are collected (17, 18) for reuse and/or disposal.

- 15 2. Applicator (1) according to item 1 wherein said applicator is adjacent to, connected to and/or integrated with all process flow units between the thresher (4) and the digester (6).
- 3. Applicator (1) according to item 1 wherein said applicator is connected to at least one
 20 process flow unit between the thresher (4) and the digester (6).
- 4. Applicator (1) according to item 3, wherein said applicator is connected to a conveyor (3,5).
- 5. Applicator (1) according to item 3, wherein said applicator is connected to a thresher (4).
- 25 6. Applicator (1) according to item 3 wherein said applicator is connected to an elevator (6).
- 7. Applicator (1) according to item 6 wherein said applicator is connected to a scrapper elevator (6).
- 30 8. Applicator (1) according to item 1 wherein means (10) for bruising and/or cutting fruitlets comprise sharp materials with at least one cutting edge suitable to inflict a cut on a sterilised palm fruitlet.
- 35 9. Applicator (1) according to item 8 wherein multiple units of cutting edges are assembled on a plate and wherein said plate is flat or curve, square or rectangular and sized 1/8 to 1/4 of the diameter of the conveyer (3,5).

10. Applicator (1) according to items 8 or 9 wherein a cutting plate is mounted on the conveyer (3,5) near its perimeter, at a position which allows the cutting plate to plow through the process flow as it is being pushed forward by said conveyer (3,5).
- 5 11. Applicator (1) according to item 10, wherein the, at least one, cutting edge tilts backward.
12. Applicator (1) according to items 10 or 11 wherein means (10) for bruising and/or cutting fruitlets comprise spikes, blades, wires or thin plates.
- 10 13. Applicator (1) according to any of items 10-12 wherein means (10) for bruising and/or cutting fruitlets are easily replaceable and/or detachable.
14. Applicator (1) according to any of items 10-13 wherein means (10) for bruising and/or cutting fruitlets comprise hard, resistant materials slightly elastic and mildly malleable.
- 15 15. Applicator (1) according to any of items 10-14 wherein means (10) for bruising and/or cutting fruitlets comprise glass, porcelain, plastic, metal, wood and wood-like materials.
16. Applicator (1) according to any of items 12-15, wherein means (10) for bruising and/or cutting fruitlets comprise an anti-abrasive coating.
- 20 17. Applicator (1) according to item 1 wherein means (11) for stirring and flipping fruitlets comprise a conveyor with an angle of 30° towards the process flow of fruitlets.
- 25 18. Applicator (1) according to item 17, wherein the means (11) for stirring and flipping fruitlets comprise a ribbon conveyor (3,5).
19. Applicator (1) according to any of items 17-18, wherein means (11) for stirring and flipping fruitlets comprise an additional plate with an angle of 45° towards the conveyor.
- 30 20. Applicator (1) according to any of items 17-19, wherein means (11) for stirring and flipping fruitlets comprise an additional plate with an angle of 60° towards the conveyor.
21. Applicator (1) according to item 1 wherein means (12) for feeding pre-heated fluid supply said fluid to the enzyme(s).
- 35 22. Applicator (1) according to item 21 wherein means (12) for feeding pre-heated fluid is a steam supply pipe.

23. Applicator (1) according to any of items 21-22 wherein means (12) for feeding pre-heated fluid is a means suitable to deliver hot water.
24. Applicator (1) according to item 1 wherein means (13) for feeding enzyme comprising means for supplying enzyme to treatment area (50).
25. Applicator (1) according to item 1 wherein means (14) for dosing enzyme comprises means for measuring and adjusting the amount of enzyme supplied to treatment area (50).
26. Applicator (1) according to item 25 wherein means (14) for dosing enzyme is a metering pump.
27. Applicator (1) according to item 1 wherein means (14) for dosing fluid comprises means for measuring and adjusting the amount of fluid supplied to treatment area (50).
28. Applicator (1) according to item 27 wherein means (14) for dosing fluid is a metering pump.
29. Applicator (1) according to item 1 wherein means (15) for applying enzyme(s) and fluid(s) to fruitlets comprises at least one spray nozzle.
30. Applicator (1) according to item 29 wherein means (15) for applying enzyme(s) and fluid(s) to fruitlets comprises at least one spray nozzle and a supply of compressed air introduced in said spray nozzle(s).
31. Applicator (1) according to item 1 wherein the treatment area (50) is a vessel.
32. Applicator (1) according to item 31 comprising cutting edges covering part of the internal surface of the treatment area (50).
33. Applicator (1) according to items 31 or 32, wherein the treatment area (50) is a tumbler.
34. Applicator (1) according to any of items 31-33 wherein the treatment area (50) is a tilted tumbler with top side in-feed and lower side exit.
35. Applicator (1) according to any of items 31-33, wherein the treatment area (50) is a horizontal cylindrical chamber comprising paddle cutter-stirrers.
36. Applicator (1) according to any of items 31-33, wherein the treatment area (50) is a tilted or vertical lifting ribbon conveyor comprising cutting blades.

37. Applicator (1) according to any of items 31-33 wherein the treatment area (50) comprises a stainless steel (e.g. Sus304) casing or cover, enclosing said treatment area (50).
- 5 38. Applicator (1) according to any of items 31-37 wherein the treatment area (50) comprises a negative air pressure within the vessel.
39. Applicator (1) according to any of items 31-38 wherein the treatment area (50) comprises a negative air pressure within the vessel by means of an air suction pipe connected to a
10 water air washing system, an air filtration system and a suitably sized motor extraction fan.
40. Applicator (1) according to any of items 1-39 wherein said applicator has about 3m in length and it is built into a 0.5m diameter conveyer (3,5) comprising about 50 cutting plates deployed about 200mm apart, with each plate bearing 20 units of cutting edges.
15
41. Method for enzymatically extracting palm oil comprising:
- (a) sterilizing (2) palm fruit;
 - (b) transferring (3) palm fruit into a thresher (4), where fruitlets are separated from fruit bunches;
 - 20 (c) conducting fruitlets exiting a thresher (4) into treatment area (50) through the applicator (1) where they are exposed to at least one of means (10, 11, 12, 13, 14, 15, 16, 17, 18) enclosed in said treatment area (50) and to a dosed mixture of enzyme(s) and fluid(s), absorbing such mixture during a time period ranging from 5 to 60 seconds, and being maintained within an optimum range of temperature (e.g. 50-80°C) for
25 activation of such enzyme(s),
 - (d) digestion of palm fruit mesocarp and in digester (7); and
 - (e) collecting palm oil
wherein excess fluid exiting the applicator (1) is returned back to the process flow by collecting means (17) and/or collected by collecting means (18), thereby improving the
30 oil extraction rate by.;
42. Method according to item 41 wherein means (10) for bruising and cutting fruitlets inflict cuts on the fruitlets as they are being pushed through the conveyer (3,5) channel.
- 35 43. Method according to any of items 41-42 wherein enzyme is mixed with fluid and delivered immediately prior to application in applicator (1) in a concentrated form.

44. Method according to any of items 41-43, wherein dilution water is delivered by a metering pump at about 100 to 200 parts of water to 1 part of enzyme.
- 5 45. Method according to item 44 wherein dilution water is pre-heated prior to being mixed with the enzyme.
46. Method according to any of items 41-45 wherein the dosage of the enzymatic mixture is varied as a function of the substrate load.
- 10 47. Method according to any of items 41-46 wherein the dosing of enzyme is from about 20 mg enzyme protein/kg palm fruitlet and about 1000 mg enzyme protein/kg palm fruitlet, relative to the amount of palm fruitlet being treated.
48. Method according to item 47 wherein the enzyme dose is from about 350 ppm to about 15 1000 ppm, relative to the amount of palm fruitlet being treated.
49. Method according to any of items 41-48 wherein means (15) for applying enzyme(s) and fluid(s) to fruitlets deliver from about 1 litre to about 5 litres of fluid per minute
- 20 50. Method according to any of items 41-49, wherein the enzymatic mixture, comprising enzyme(s) and fluid(s), is applied at about 45°C to about 75°C.
51. Method according to item 41 wherein the step for digesting palm fruit mesocarp in the digester (6) is gradual and takes place from 55 to 85°C, such as from 65 to 85°C.
- 25 52. Method according to any of items 38-39 wherein between 300-600 kg of palm fruitlets are cut per minute.
53. Method according to any of items 38-40 wherein the mixture of enzyme(s) and fluid(s) is 30 pre-heated within the activation temperature range of said enzyme(s).
54. Method according to any of items 38-41 wherein the enzyme(s) and fluid(s) are adjustably dosed (manually or automatically) and mixed through their respective metering pump(s) immediately before application through applicator (1).
- 35 55. Use of applicator (1) according to any of items 1-40 for enzymatic extraction of palm oil by adapting said applicator (1) to a palm oil mill process flow.

EXAMPLE(S)Example 1

As can be seen from typical conveyer set-up with enzyme applicator in figure 9b, the MPD feed from the thresher will pass along the conveyer (906) which is installed with flip plates comprising cutting elements (904). The flip plates (904) provide a bruising and cutting mechanism to enable exposure of the MPD to the enzyme solution. The conveyer (906) is covered with a covering attachment (900) with in-built spray nozzles (902) to continuously spray fine droplets of enzyme solution unto the MPD feed. The spray of enzyme solution from the spray nozzles (902) is prepared *in situ* via the enzyme solution preparation and delivery system (912). Before passing to the digester, the enzymatically treated MPD will pass through an enzyme recovery and management system (910) which allows the excess liquid to be collected and recycled safely to the substrate train or to be safely disposed according to prevailing safety standards. The contaminated air on the other hand is filtered out via an air scrubbing and filtration mechanism (908) to treat air or aerosol leaving the system to be safely discharged according to prevailing safety standards.

Example 2

Figure 18 refers to the placement and industrial application of an enzyme applicator in a palm oil mill wherein a section of the conveyer is converted into an enzyme applicator.

Example 3

20 Filtering process of contaminated air (1):

In an example of treating contaminated air upon application of enzymatic composition in the enclosed treatment area, the sequence may be outlaid as follows:

Wet contaminated air from enzyme applicator → water scrubbing → moisture trap → air filter (HEPA Filter)

25 Filtering process of contaminated air (2):

In an example of treating contaminated air upon application of enzymatic composition in the enclosed treatment area, the sequence may be outlaid as follows:

Wet contaminated air from enzyme applicator → water scrubbing → moisture trap → air filter 1 (water resistant high performance filter) → air filter 2 (R7 synthetic fibre air filter) → air filter 3 (HEPA Filter)

Example 4

Spray nozzle selection:

In an example of selection of spray nozzles, the Spraying System Co, K-Series Flood Jet nozzles or any similar spray nozzle is preferred. The spray nozzles have a range of 3.175mm (1/8 inch) to 9.525 (3/8 inch) in a single block design. These nozzles are able to deliver at a rate of 0.04 litres to 20 litres per minute. The nozzles are able to operate in the range of 7.25 psi (0.5 bars) to 58.01 psi (4 bars). Multiple units of spray nozzles are deployed to provide thorough coverage in the short time that the MPD passes through the enzyme applicator.

Example 5

Figure 18 is a schematic drawing of a present Palm Oil mill, which includes the usage of an enzyme applicator in its Palm Oil mill set-up.

ON FURTHER EMBODIMENTS AND ASPECTS OF THE INVENTION

In the following, at list of items are provided disclosing various preferred aspects, embodiments and features of the present invention:

1. An apparatus for use in treating a substrate comprising of mainly sterilised palm fruitlets wherein the substrate is conditioned and treated using an enzymatic composition which could be a water based solution of one or several enzymes
2. An apparatus for use in treating a substrate comprising of mainly sterilised palm fruitlets wherein the substrate is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means for stirring, bruising and cutting the substrate.
3. An apparatus for use in treating a substrate comprising of mainly sterilised palm fruitlets wherein the substrate is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means to toss and stir the substrate.
4. An apparatus for use in treating a substrate comprising of mainly sterilised palm fruitlets wherein the substrate is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means to prepare a preheated dilution water to mix enzymes to be applied on the substrate.
5. An apparatus for use in treating a substrate comprising of mainly sterilised palm fruitlets wherein the substrate is conditioned using an enzymatic solution wherein the apparatus

utilizes means to mix the enzymatic composition by in situ mixing prior to the point of application on substrate.

- 5 6. An apparatus for use in treating a substrate comprising of mainly sterilised palm fruitlets wherein the substrate is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes one or several means of adjusting the dosage of enzymatic composition applied to approximately match the substrate loading rate.
- 10 7. An apparatus for use in treating a substrate comprising of mainly sterilised palm fruitlets wherein the substrate is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means to apply and spread the enzymatic solution on the substrate.
- 15 8. An apparatus for use in treating a substrate comprising mainly of sterilised palm fruitlets wherein the substrate is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means to treat the substrate in an enclosed area.
- 20 9. An apparatus for use in treating a substrate wherein the substrate comprising mainly of sterilised palm fruitlets is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means to filter and remove vapour from the enclosed treatment area.
- 25 10. An apparatus for use in treating a substrate wherein the substrate comprising mainly of sterilised palm fruitlets is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means to recover excess liquid exiting the enclosed treatment area.
- 30 11. An apparatus for use in treating a substrate wherein the substrate comprising mainly of sterilised palm fruitlets is conditioned using an enzymatic composition which could be a water based solution of one or several enzymes wherein the apparatus utilizes means to recycle excess liquid exiting the enclosed treatment area.
- 35 12. An apparatus for use according to any of items 1-11 wherein the substrate is Mass Passing to Digester(s) (MPD);

13. An apparatus for use according to any of items 1-12 wherein the substrate contains around 60% - 90% palm fruitlets.
14. An apparatus for use according to any of items 1-13 wherein the substrate comprises:
5 fruitlets from palm fresh fruit bunches which have been sterilized;
 said fruitlets are stripped for oil extraction.
15. An apparatus for use according to item 14 wherein the substrate is sterilized by batch sterilization, continuous sterilization or any other sterilization method.
10
16. An apparatus for use according to any of items 1-14 wherein the apparatus is preferred to be used between the threshing process and the digesting process in palm oil extraction.
17. An apparatus for use according to any of items 1-14 wherein the apparatus utilizes means
15 for damaging the protective skin to expose the mesocarp of the MPD.
18. An apparatus for use according to any of items 1-14 wherein the apparatus utilizes means for damaging the epicarp of the substrate.
- 20 19. An apparatus for use according to any one of items 1-18 wherein the damaging means include cutting and bruising.
20. An apparatus for use according to any one of items 1-19 wherein the damaging means are selected from blades, spikes or any other cutting apparatus.
25
21. An apparatus for use according to item 20 wherein the blades, spikes or damaging means are selected from means which are 5 mm to 15 mm in height.
22. An apparatus for use according to any of items 20-21 wherein the blades, spikes or
30 damaging means are sloped at 30° to 45°.
23. An apparatus for use according to any of items 1-14 wherein means of tossing are used to enhance the contact opportunity between the enzymatic composition and the substrate.
- 35 24. An apparatus for use according to any of items 1-14 and item 23 wherein means of tossing include stirring and flipping.

25. An apparatus for use according to any one of items 1-14 or items 23-24 wherein tossing is occurs along a conveyer.
26. An apparatus for use according to any one of items 1-14 or items 20-22 wherein the means
5 of tossing is a flip plate installed on the conveyer surface.
27. An apparatus for use according to item 25 wherein the means of stirring is a flip plate installed at a 30° to 45°.
- 10 28. An apparatus for use according to any of items 1-14 wherein the enzymatic composition is introduced at a predetermined optimum activation temperature.
29. An apparatus for use according to any of items 1-14 and item 24 wherein the enzymatic composition is prepared using water which is pre-heated prior to being mixed with the
15 enzyme.
30. An apparatus for use according to any one of items 1-14 or items 24-25 wherein the enzymatic composition is prepared *in situ*.
- 20 31. An apparatus for use according to any one of items 1-14 or items 24-26 wherein the enzymatic composition is prepared by mixing water and concentrate of enzyme immediately prior to the point of application on substrate.
32. An apparatus for use according to any one of items 1-14 or items 24-27 wherein the
25 apparatus utilizes means to provide a variable dosage of the enzymatic composition during application.
33. An apparatus for use according to any of items 1-14 wherein the apparatus utilizes means to apply the enzyme solution on the substrate.
30
34. An apparatus for use according to any one of items 1-14 or 29 wherein the means to apply the enzyme solution includes an air propellant assisted liquid delivery system.
35. An apparatus for use according to any one of items 1-14 or items 29-30 wherein the air
35 propellant assisted liquid delivery system comprises the use of one or an array of spray nozzles.

36. An apparatus for use according to any of items 1-14 and item 24 wherein the enzymatic composition is introduced at a temperature of between 50°C and 70°C.
- 5 37. An apparatus for use according to item 32 wherein the enzymatic composition is preferred to be introduced at 50°C and 70°C.
38. An apparatus for use according to item 32 wherein the enzymatic composition is preferred to be introduced at 50°C and 65°C.
- 10 39. An apparatus for use according to item 32 wherein the enzymatic composition is preferred to be introduced at 55°C and 65°C.
40. An apparatus for use according to any of items 1-14 and item 24 wherein the dosage of the enzymatic composition used is between 20 mg enzyme protein/kg palm fruitlet and 1000 mg enzyme protein/kg palm fruitlet relative to the amount of palm fruitlet treated.
- 15 41. An apparatus for use according to any of items 36 wherein the dosage of the enzymatic composition used is preferred to be used between 350 ppm and 1000 ppm relative to the amount of palm fruitlet treated.
- 20 42. An apparatus for use according to any of items 1-14 wherein the means of treatment is carried out in an enclosed area.
43. An apparatus for use according to any of items 1-14 wherein the apparatus utilizes means of filtering air out of the enzyme applicator.
- 25 44. An apparatus for use according to any one of items 1-14 or item 39 wherein the apparatus utilizes means of filtering air and removal of excess vapour and aerosol from the enzyme applicator.
- 30 45. An apparatus for use according to any one of items 1-14 or item 39 wherein the preferred filtering means include physical filtration means, water scrubbing means or a combination of physical filtration means and water scrubbing means together.
- 35 46. An apparatus for use according to any of items 1-14 wherein the apparatus utilizes means to collect excess liquid.

47. An apparatus for use according to any one of items 1-14 or items 42 wherein the liquid collected is recycled back into the MPD train in the enzyme applicator.
48. An apparatus for use according to any one of items 1-14 or items 42 wherein the liquid collected is recycled to be introduced for downstream processes.
49. An apparatus for use according to any one of items 1-14 or items 42 wherein the liquid collected is conditioned and discharged.
50. An apparatus for use according to any one of items 1-45 wherein the enzyme applicator has an operation time within the range of 10 seconds to 180 seconds on the MPD train in the enzyme applicator.
51. An apparatus for use according to any one of items 1-45 wherein the enzyme applicator is not fixed to one configuration.
52. An apparatus for use according to any one of items 1-45 wherein the enzyme applicator may be configured to fit in existing mill set-up.
53. An apparatus according to any one of items 1-48 wherein the apparatus is able to complete all pre-treatment functions without the treated substance leaving the MPD train in the enzyme applicator.
- the apparatus utilizes means for damaging the MPD;
- the apparatus utilizes means to toss the MPD;
- the apparatus utilizes means to prepare a preheated dilution water to mix enzymes to be applied on the MPD;
- the apparatus utilizes means to mix the enzymatic composition immediately prior to the point of application on MPD;
- the apparatus utilizes means of adjusting the dosage of enzymatic composition applied to match the MPD load;
- the apparatus utilizes means to apply the enzymatic composition on the MPD;
- the apparatus utilizes means to treat the MPD in an enclosed area;
- the apparatus utilizes means to filter and remove vapour from the enclosed area;
- the apparatus utilizes means to recover excess liquid exiting the enclosed treatment area;
- the apparatus utilizes means to recycle excess liquid exiting the enclosed treatment area.

54. An apparatus for use in treating a substrate wherein the substrate is conditioned using a specific enzymatic composition wherein;
the apparatus utilizes means for damaging the substrate;
the apparatus utilizes means to toss the substrate;
5 the apparatus utilizes means to prepare a preheated dilution water to mix enzymes to be applied on the substrate;
the apparatus utilizes means to mix the enzymatic composition immediately prior to the point of application on substrate;
the apparatus utilizes means of adjusting the dosage of enzymatic composition applied to
10 match the substrate load;
the apparatus utilizes means to apply the enzymatic composition on the substrate;
the apparatus utilizes means to treat the substrate in an enclosed area;
the apparatus utilizes means to filter and remove vapour from the enclosed area;
the apparatus utilizes means to recover excess liquid exiting the enclosed treatment area;
15 the apparatus utilizes means to recycle excess liquid exiting the enclosed treatment area.
55. A process according to any of items 1-54 wherein the enzyme applicator is used in a palm oil mill set-up wherein the enzyme applicator operates between the thresher and the digester utilizing conveyers to move MPD through the enzyme applicator.
20
56. A method of treating palm fruitlets utilizing the apparatus as defined according to any of items 1-51 wherein the method of treatment uses a specific enzymatic composition.
57. A method of treating palm fruitlets according to any of items 1-51 wherein the method of
25 treatment involves treating a substrate which is sterilized and threshed before it is digested.
58. A method of treating palm fruitlets according to any of items 1-51 wherein the method of treatment involves a method of damaging a substrate.
30
59. A method of treating palm fruitlets according to any of items 1-51 wherein the method of treatment involves a method of tossing a substrate.
60. A method of treating palm fruitlets according to any of items 1-51 wherein the method of
35 treatment involves a treatment with a preheated and premixed enzymatic composition which is mixed immediately prior to the point of application on a substrate.

61. A method of treating palm fruitlets according to item 56 wherein the dosage of the enzymatic composition used is varied based on substrate load.
62. A method of treating palm fruitlets according to any of items 1-51 wherein the method of
 5 treatment involves a method of treating a substrate in an enclosed area comprising:
 a method to filter and remove vapour from the enclosed area;
 a method to recover excess liquid exiting the enclosed treatment area;
 a method to recycle excess liquid exiting the enclosed treatment area.
- 10 63. A method of treating palm fruitlets according to anyone of items 1-51 comprising:
 a method of treating substrate using an enzymatic preparation;
 a method of treating sterilized and threshed substrate before it is digested;
 a method of inflicting damages on the substrate;
 a method of tossing substrate;
 15 a method of treating substrate using an enzymatic composition wherein:
 an enzymatic composition is prepared by mixing preheated water with enzyme;
 an enzymatic composition is mixed immediately prior to the point of application on
 substrate;
 an enzymatic composition dosage varies based on substrate load;
 20 an enzymatic composition is applied by spraying through multiple units of spray nozzles,
 with or without air propellant assisted, through and within a liquid delivery system;
 a method of treating substrate in an enclosed area comprising:
 a method to filter and remove vapour from the enclosed area;
 a method to recover excess liquid exiting the enclosed treatment area;
 25 a method to recycle excess liquid exiting the enclosed treatment area.

List of reference numbers:

- | | |
|------|--|
| 1 | Applicator |
| 2 | Steriliser |
| 3 | Conveyor |
| 30 4 | Thresher |
| 5 | Conveyor |
| 6 | Elevator |
| 7 | Digester |
| 8 | Press |
| 35 9 | Dilute crude oil exit |
| 10 | Means for bruising and cutting fruitlets |

- 11 Means/device for stirring and/or flipping fruitlets
- 12 Means for feeding pre-heated fluid(s)
- 13 Means for feeding enzyme(s)
- 14 Means / device for dosing enzymatic composition preferably being a water based
- 5 solution of one or several enzyme(s) and fluid(s) preferably being water
- 15 Means for applying said enzyme(s) and fluid(s) to fruitlets
- 16 Means to filter and remove vapour from a treatment area (50)
- 17 Means for collecting enzyme solution for reuse
- 18 Means for collecting excess enzyme solution for disposal
- 10 19 Conditioning device
- 50 Treatment Area
- 902 Spray nozzles

REFERENCES

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- 15 (2015) Enhanced Oil Extraction From Palm Fruit Mesocarp Using Technical Enzymes,
International Journal of Advances in Science Engineering and Technology, ISSN: 2321-9009
Volume- 3, Issue-1, Jan.2015
- Sambasivarao Javvadi, Saylee Pradhan, Chandrakant Laxminarayan Rathi, Ahila Wani
- (2012) An enzyme composition and process for extracting oil from oil palm fruits, WO
- 20 2012011130 A2

CLAIMS

1. An apparatus for use in treating palm fruitlets, preferably being sterilized palm fruitlets, wherein the palm fruitlets are treated at least by being exposed to an enzymatic composition preferably being a water based solution of one or several enzymes, wherein said apparatus comprising
- 5 - an applicator (1) comprising:
- a device configured for stirring and/or flipping palm fruitlets (11), and
- a device configured for applying the enzymatic composition (15) onto said palm fruitlets.
- 10 2. An apparatus according to claim 1, wherein the apparatus further comprising a digester (7) being arranged so as to receive palm fruitlets from the applicator (1) after being exposed to an enzymatic composition in said applicator (1).
3. An apparatus according to claim 1 or 2, wherein the device for stirring and/or flipping fruitlets
- 15 (11) further is configured for bruising and cutting the palm fruitlets while the fruitlets are being stirred and/or flipped.
4. An apparatus according to any of the preceding claims, wherein the apparatus comprises means to prepare preheated water (12) to mix with enzymes to produced the enzymatic composition.
- 20 5. An apparatus according to any of the preceding claims, wherein the device for applying the enzymatic composition (15) is configured to apply and spread the enzymatic solution on the palm fruitlets.
- 25 6. An apparatus according to any of the preceding claims, wherein the apparatus comprises means (16) to filter and/or remove vapour from the applicator (1).
7. An apparatus according to any of the preceding claims, wherein the apparatus comprises means (17) to recover excess liquid, such means to collect enzyme solution, such as excess
- 30 enzyme solution, from the applicator (1) and recycle the recovered liquid to the applicator (1).
8. An apparatus according to any of the preceding claims, wherein the applicator (1) defines enclosed volume.
- 35 9. An apparatus according to any of the preceding claims, the apparatus further comprising a sterilizer (2) for sterilizing fruit bunches, the sterilizer (2) is preferably a batch sterilizer or a continuously sterilizer.

10. An apparatus according to any of the preceding claims, wherein the apparatus further comprising a thresher (4) configured to separate the fruitlets from the fruit branches and the applicator (1) is arranged to receive the fruitlets from the thresher (4).
- 5 11. An apparatus according to any of the preceding claims, wherein the device configured for stirring and/or flipping palm fruitlets (11) comprises or is a screw, auger or ribbon conveyer comprising a rotatable conveying part, such as a screw.
12. An apparatus according to any of the preceding claims, wherein device configured for stirring
10 and/or flipping the palm fruitlets (11) comprises or is a rotatable tumbler.
13. An apparatus according to any of preceding claims, wherein the applicator (1) further comprising means for damaging the protective skin (epicarp, exocarp) to expose the mesocarp of the palm fruitlets (MPD), such as means for cutting into and preferably through and/or bruising
15 the protective skin to expose the mesocarp of the palm fruitlets (MPD).
14. An apparatus according to claim 13, wherein the means for damaging are selected from blades, spikes or any other cutting apparatus, preferably said blades, spikes has a length and a height, wherein said height is between 5 and 15 mm.
- 20 15. An apparatus according to any of the claims 11-14, wherein the means for damaging the protective skin are arranged on the rotatable tumbler.
16. An apparatus according to any of the claims 11-14, wherein the means for damaging the
25 protective skin are arranged on the rotatable conveying part.
17. An apparatus according to any of the claims 16, when dependant on claim 11, wherein the blades, spikes or damaging means are sloped at 30° to 45° forwardly relatively to a pitch angle of the rotatable conveying part.
- 30 18. An apparatus according to any of the preceding claims, wherein the apparatus further comprising a heater and/or cooler device arranged to control the temperature of the enzymatic composition (15) to be at a predetermined optimum activation temperature prior to being applied onto the palm fruitlets.
19. An apparatus according to claim 18, the enzymatic composition is prepared using water which
35 is pre-heated by use of said heater prior to being mixed with the enzyme.
20. An apparatus according to any one of the preceding claims, wherein the apparatus comprises means (14) to provide a variable dosage of the enzymatic composition during application.

21. An apparatus according to any one of preceding claims, wherein the device configured for applying the enzymatic composition comprises one or more spray nozzles (902) arranged to spray the enzymatic composition onto the palm fruitlets.

5

22. An apparatus according to any one of the preceding claims, wherein the device configured for applying the enzymatic composition comprises an air propellant assisted liquid delivery system.

23. An apparatus according claim 22, wherein the air propellant assisted liquid delivery system comprises the use of one or an array of spray nozzles (902).

10

24. An apparatus according to any of one claims 21-23, wherein the enzyme spray nozzles (902) are installed in multiple units in a straight array lining one side of the conveyor.

25. An apparatus according to any one of claims 21-24, wherein the nozzles (902) are arranged in a straight line along the conveyor to create an uninterrupted curtain of enzymatic spray for effective treatment as the MPD is being flipped and turned through the enzymatic treatment zone;

15

26. An apparatus according to any of the preceding claims, wherein the device configured for applying the enzymatic composition is configured for applying dosage of the enzymatic composition corresponding to 10-100 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches, such as in amounts corresponding to 20-50 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches or such as in amounts corresponding to 30-40 mg Enzyme Protein(EP)/metric tonne fresh fruit bunches.

20

25

27. An apparatus according to any of the preceding claims, wherein the applicator (1) comprising an enclosed area, such as a chamber, inside which chamber

- the application of enzymatic composition, and
- the stirring and/or flipping

30 takes place.

30

28. An apparatus according to any of the preceding claims, wherein the apparatus comprises means for filtering air out of the applicator (1), said means for filtering being preferably a water scrubbing device and/or means for mechanical filtering by a penetrable filter material, said means preferably being selected from High Efficiency Air Filters, such as Efficiency Particulate Air Filters (EPA), High Efficiency Particulate Air Filters (HEPA) and Ultra Low Penetration Air Filters (ULPA).

35

29. An apparatus according to claim 28, wherein the means for filtering air out of the applicator (1) comprise a scrubbing device, preferably a water scrubbing device, and a High Efficiency Air Filter.

30. An apparatus according to claim 28 or 29, wherein High Efficiency Air Filter is positioned to receive air flowing from the scrubbing device.

31. An apparatus according to any of claims 28 and 29, wherein the means for filtering air out of the applicator (1) are configured to reduce the amount of enzyme protein in the air discharged from the applicator (1) to 50 ng enzyme protein/m³ air or less, such as to 20 ng enzyme protein/m³ air or less, 10 ng enzyme protein/m³ air or less, 5 ng enzyme protein/m³ air or less, or such as 1 ng enzyme protein/m³ air or less.

32. An apparatus according to any of the preceding claims, wherein the apparatus comprises means for removal of excess vapour and aerosol from the applicator (1).

33. An apparatus according to any of the preceding claims, wherein the apparatus comprises means to collect excess liquid comprising said enzyme composition, preferably from the applicator, and recycling the excess liquid to applicator and/or to a downstream process.

34. An apparatus according to any of claims 27-33, wherein said enclosed area, such as said chamber, comprises means allowing the application of enzymatic composition to be inspected, said means preferably being a lid or a door, such as a sliding door.

35. An apparatus according to any of the preceding claims, wherein the applicator is configured for providing a retention/operation time, being the time elapsed between application of enzyme composition onto said palm fruitlets and the palm fruitlets leaves the applicator, within the range of 10 seconds to 180 seconds.

36. An apparatus according to any one of preceding claims, wherein the applicator is retro-fitted into an existing mill set-up.

37. An apparatus according to any of the preceding claims, wherein the apparatus further comprising a digester, and wherein the applicator is arranged between the thresher and the digester and the apparatus further comprising conveyers arranged convey palm fruitlets through the applicator.

38. An apparatus according to any of the preceding claims, wherein the application is arranged gravitational below the thresher (4), the thresher (4) having a lower opening arranged an opening

of the applicator (1) so that fruitlets provided in the thresher (4) falls under the action of the gravity into the applicator (1).

39. A method of treating palm fruitlets, said method utilizing the apparatus as defined according to any of claims 1-38, the method comprising apply said enzymatic composition onto said palm
5 fruitlets while the palm fruitlets are stirred and/or flipped.

40. A method according to claim 39, wherein the method further comprising threshing fruit bunches to provide palm fruitlets.

10 41. A method of treating palm fruitlets according to claim 39 or 40, wherein the method of treatment further comprising sterilizing the fruit bunches prior to being threshed.

42. A method of treating palm fruitlets according to any of claims 39-41, wherein the method of treatment further comprises damaging the protective skin (epicarp, exocarp) of the fruitlets while being stirred and/of flipped.

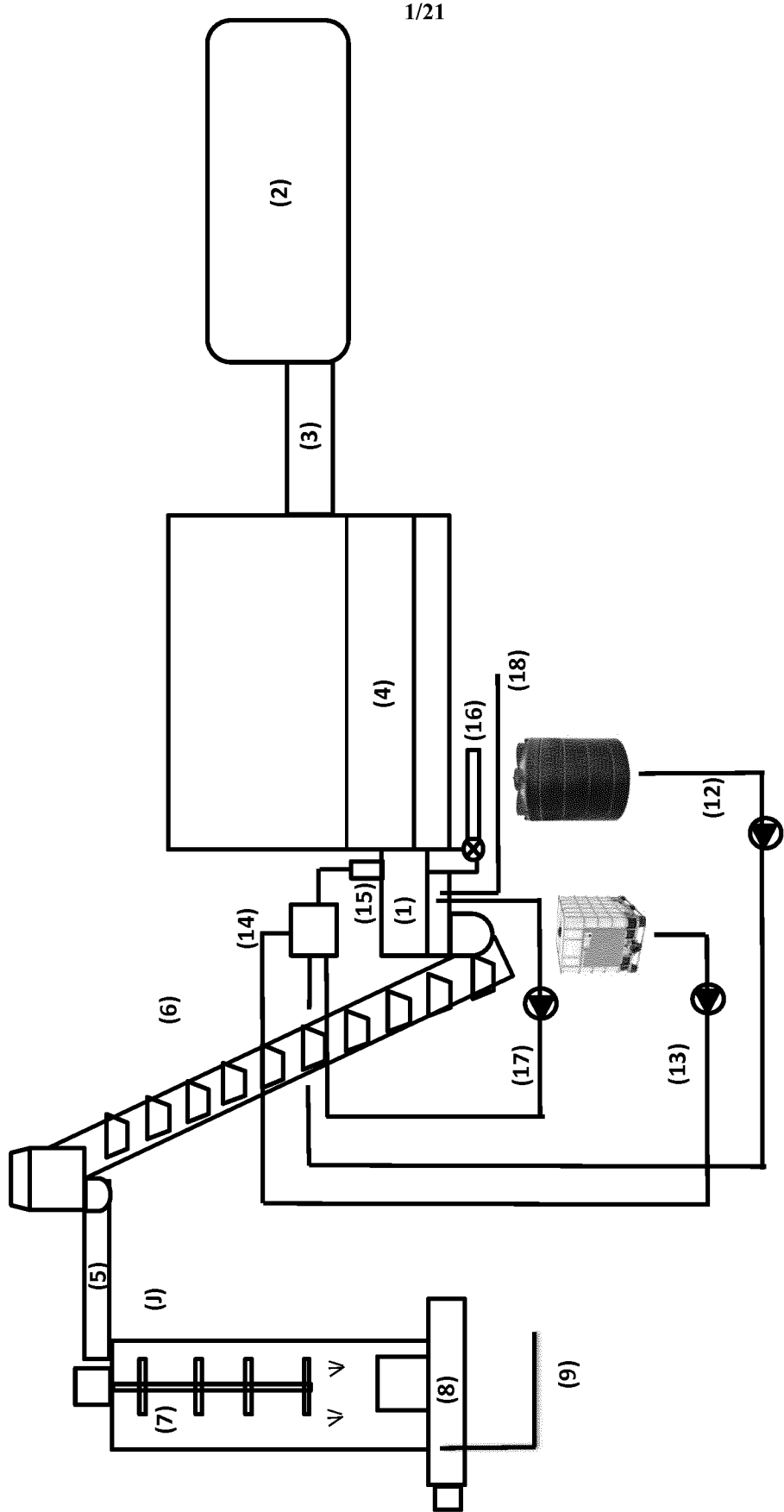


Figure 1

Examples of Applicator with tumbler design

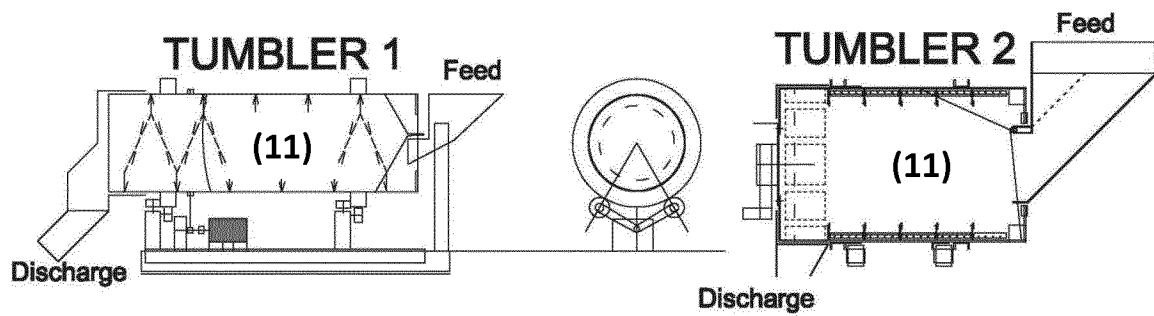


Figure 2

APPLICATOR BASED ON TUMBLER DESIGN

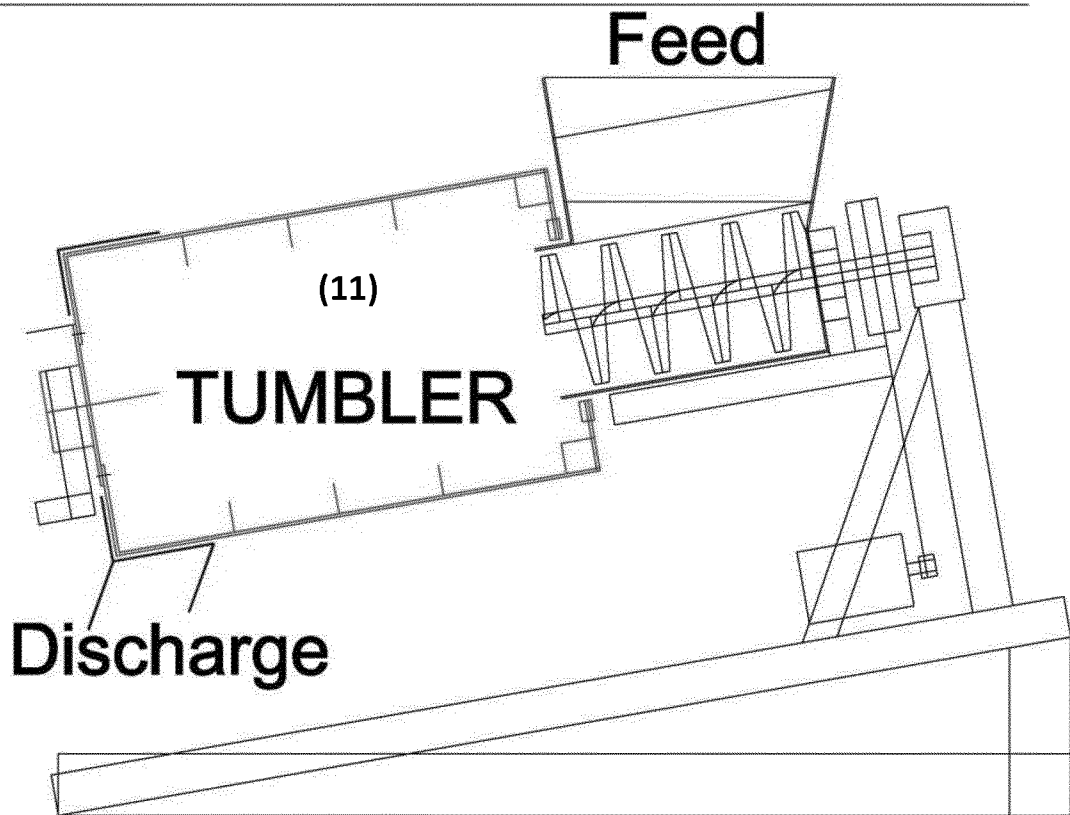


Figure 3

Example of Applicator incorporating into Thresher conveyor

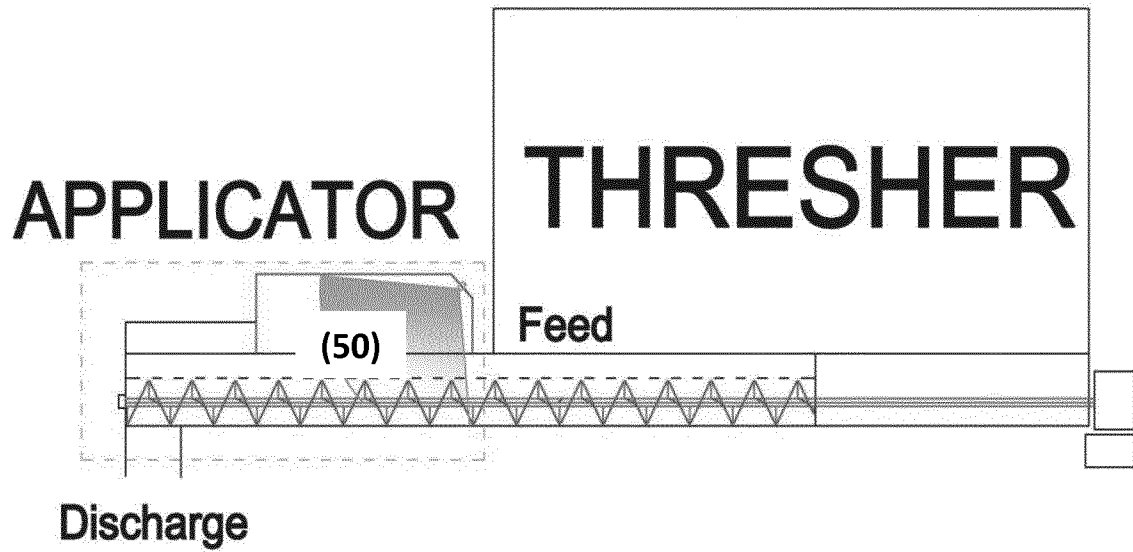


Figure 4

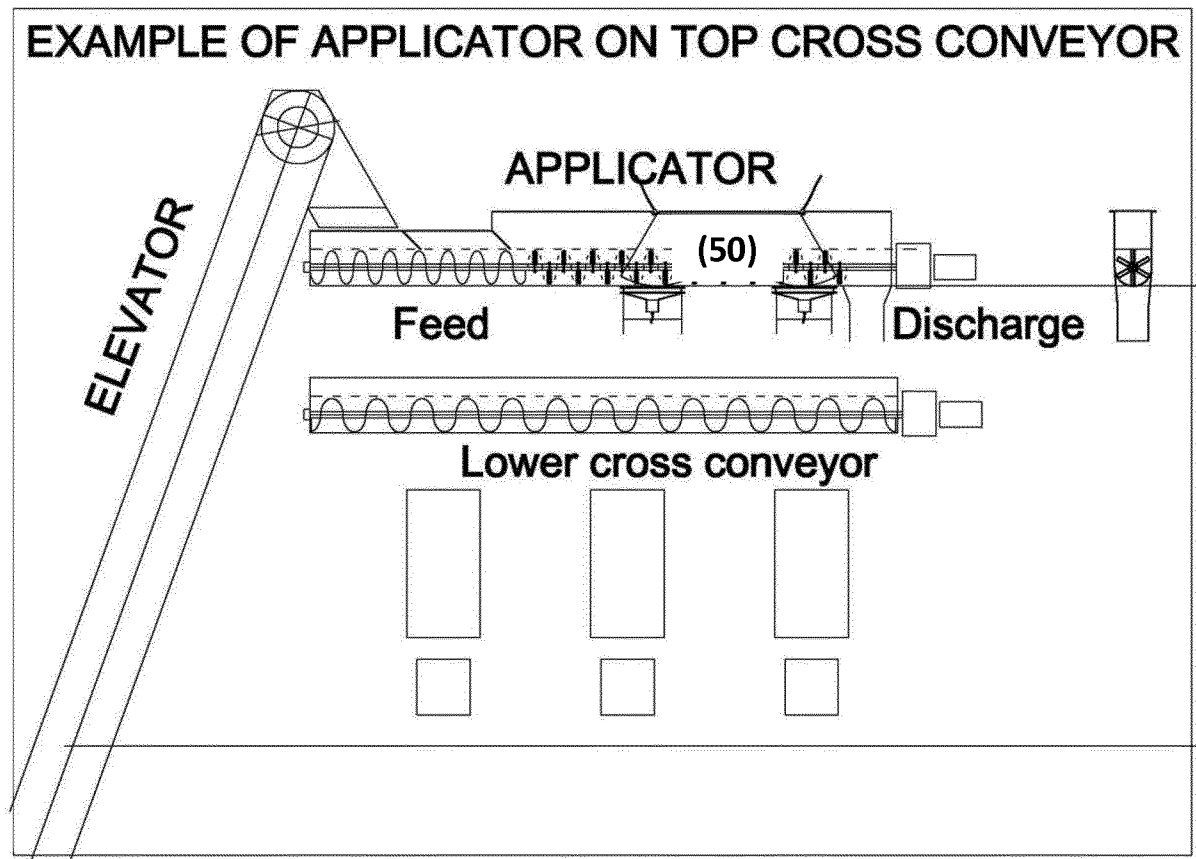


Figure 5

Example of Applicator on Ribbon Elevator

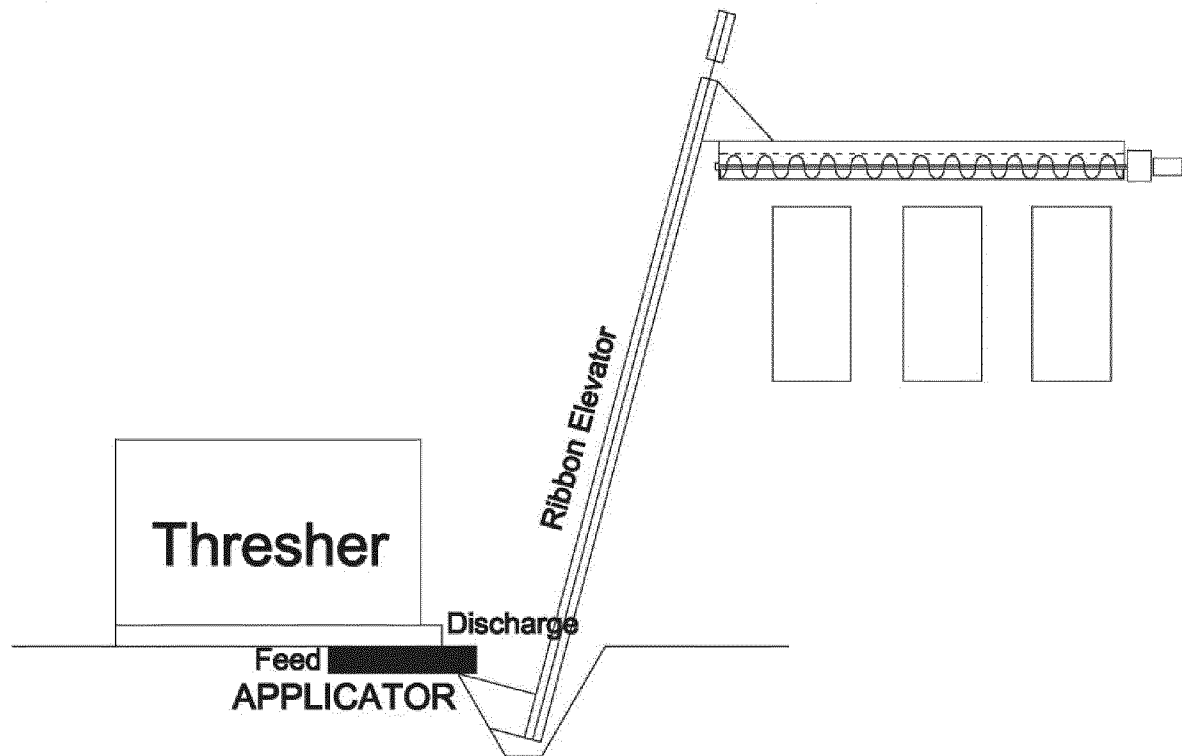


Figure 6

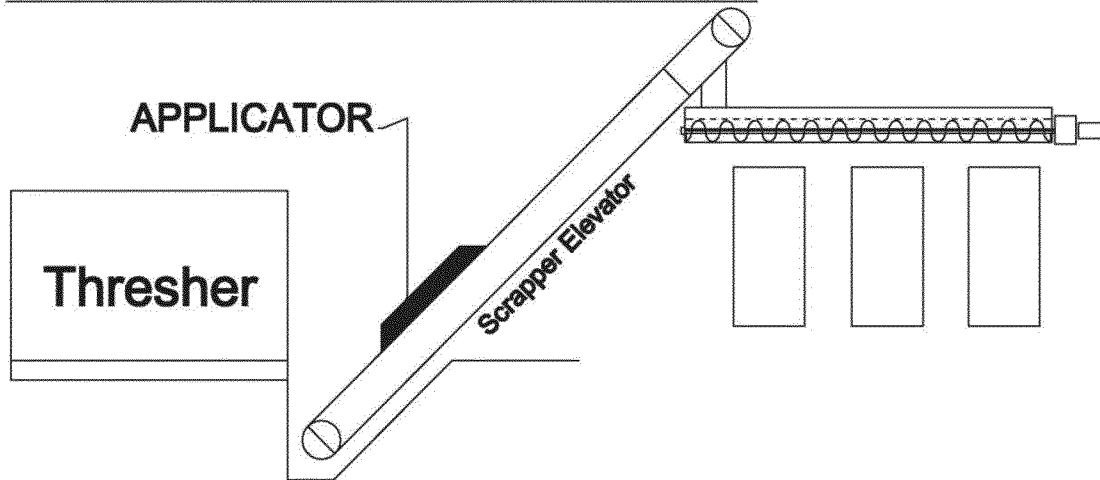
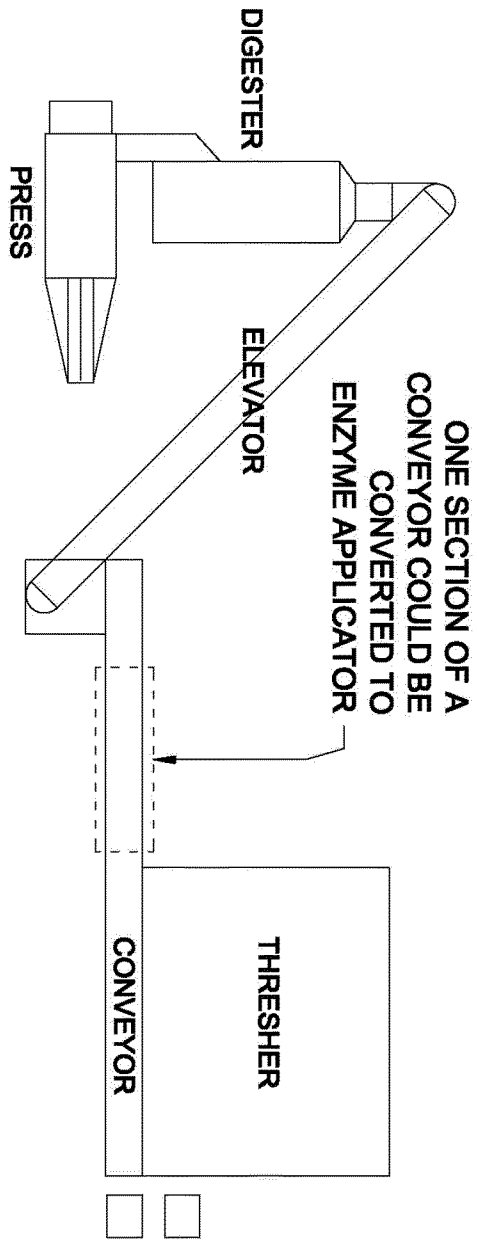
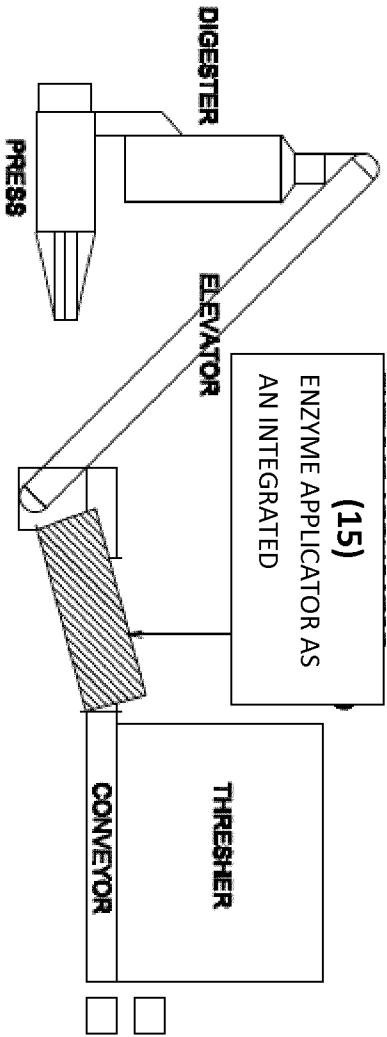
Example of Applicator on Scraper Conveyor

Figure 7



CONVERSION OF A SECTION OF CONVEYOR TO APPLICATOR

Figure 8



ENZYME APPLICATOR WITH THUMBLER DESIGN

Figure 9

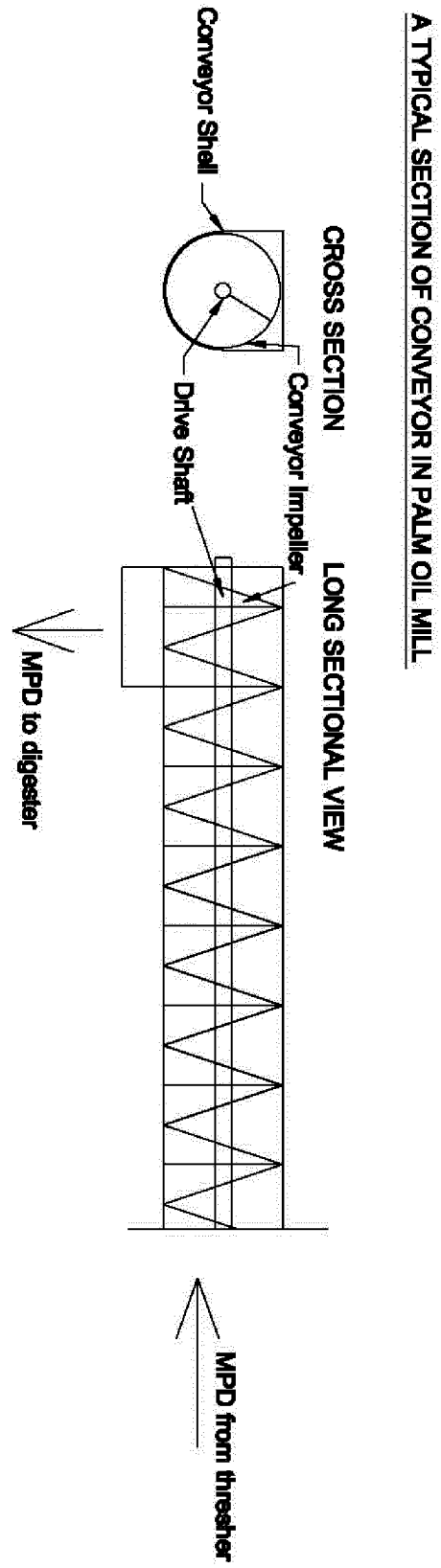


Figure 10a

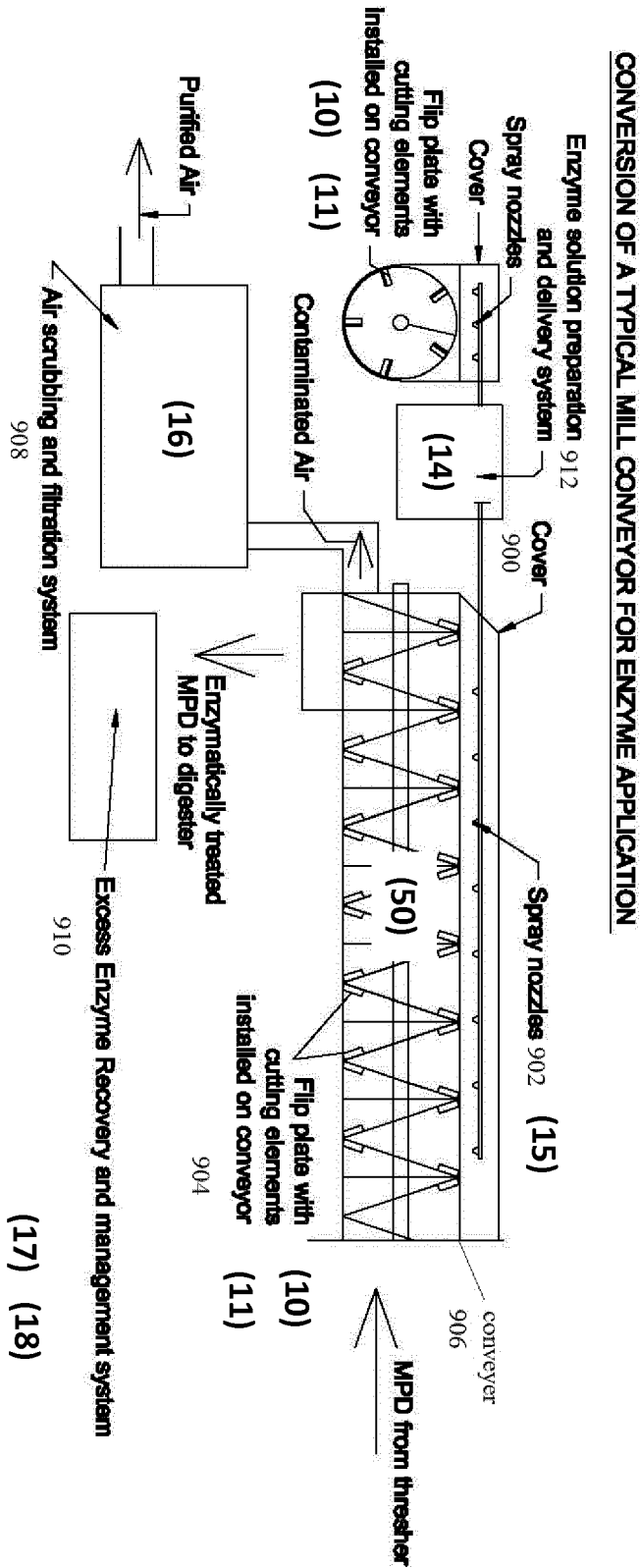


Figure 10b

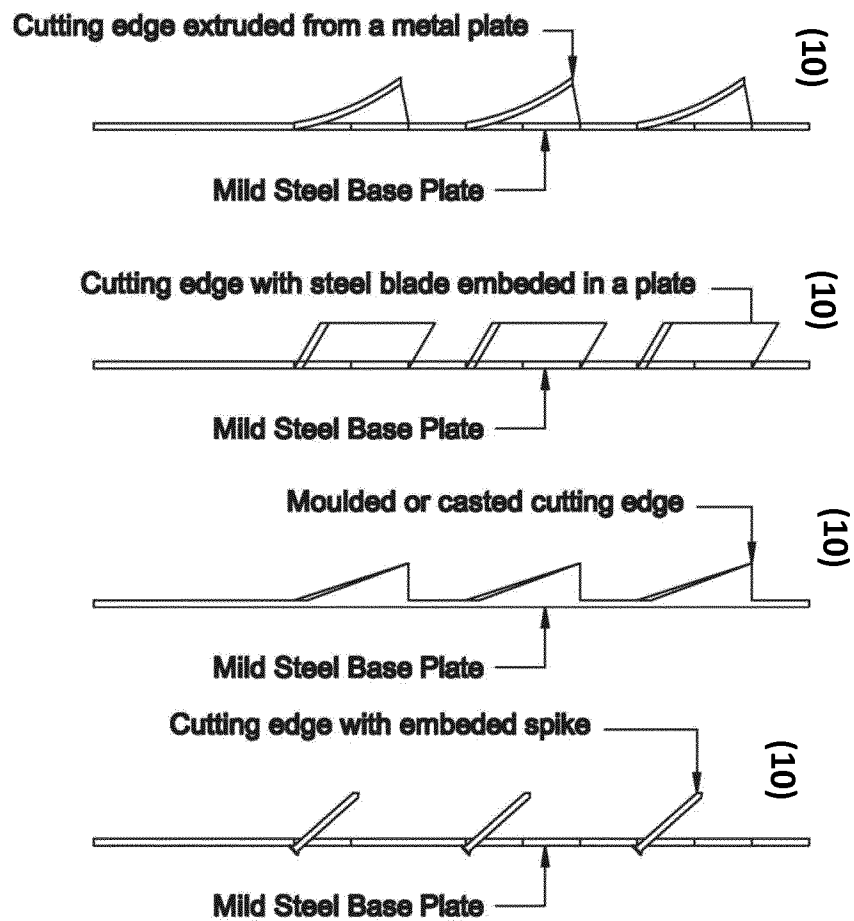
SIDE VIEWS SHOWING DESIGN OF CUTTING EDGES

Figure 11

OIL PALM MPD CUTTING PLATES INSTALLATION EXAMPLES



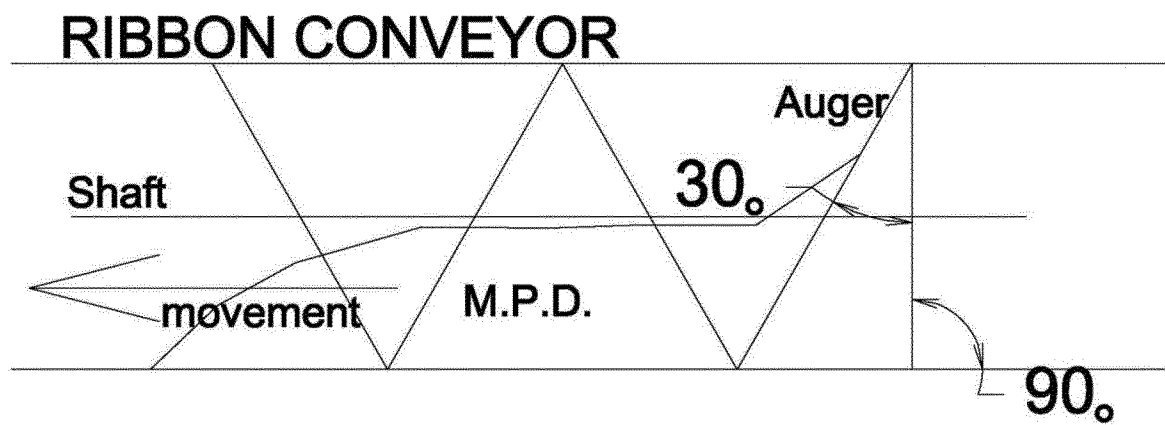


Figure 13

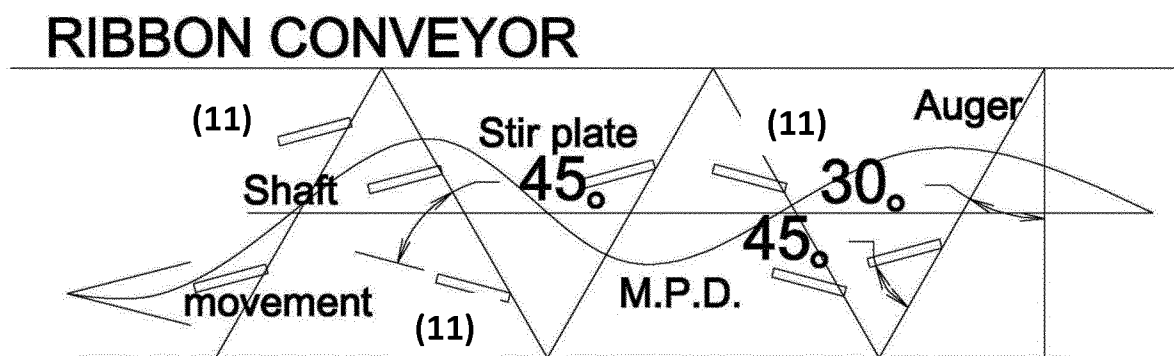


Figure 14

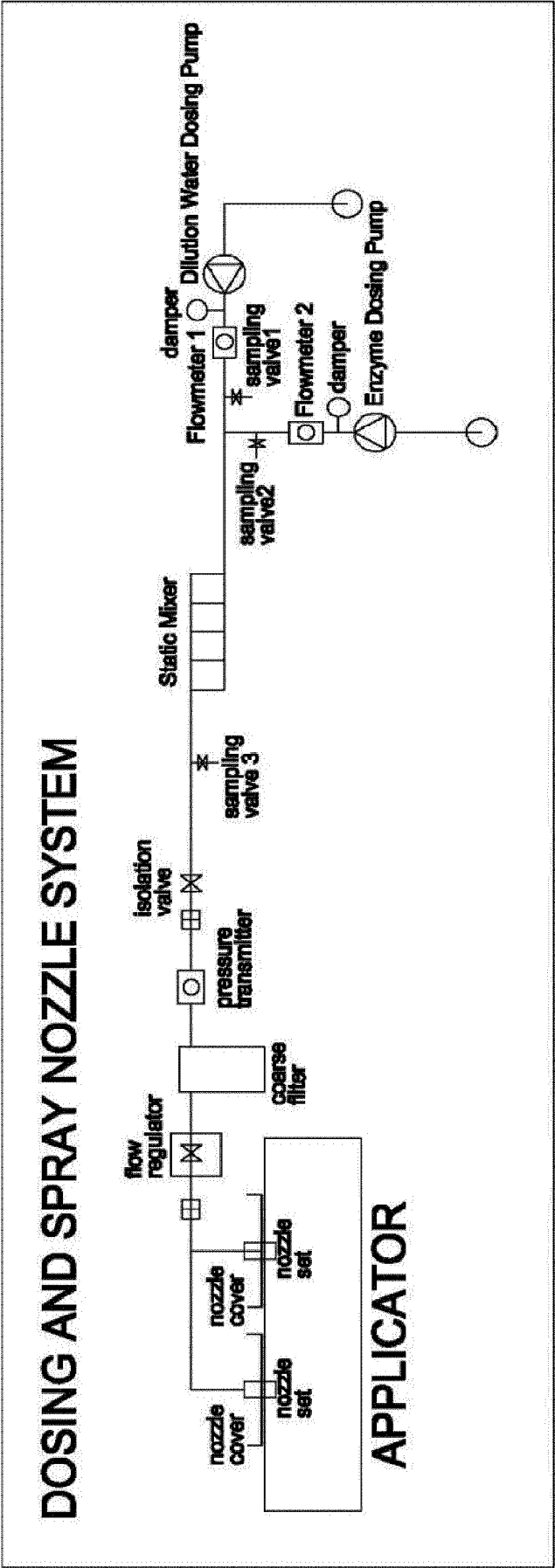


Figure 15

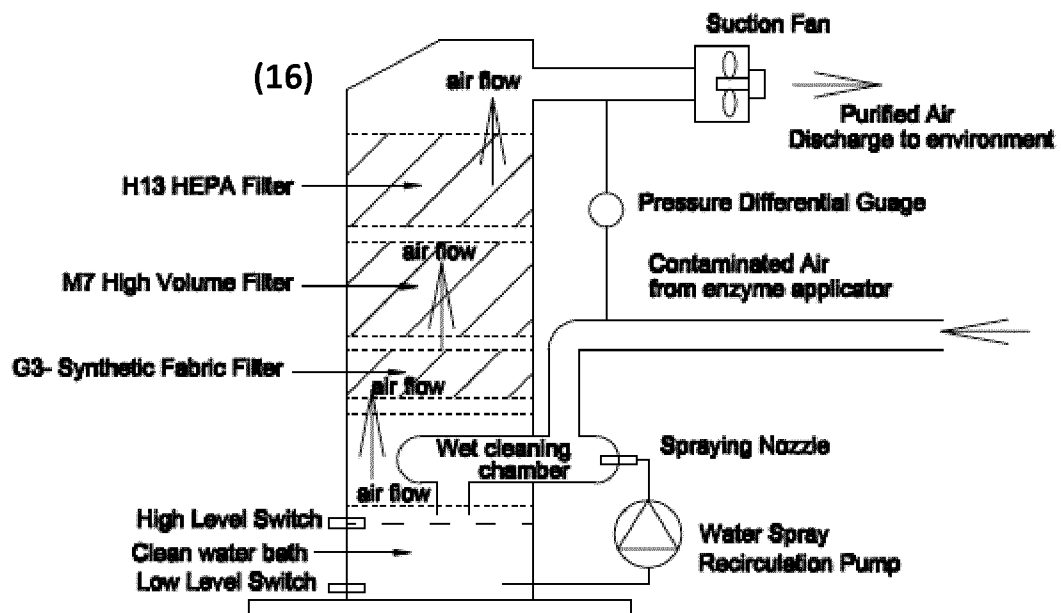
EXAMPLE: CONCEPT OF AN AIR CLEANING SYSTEM FOR ENZYME APPLICATOR

Figure 16

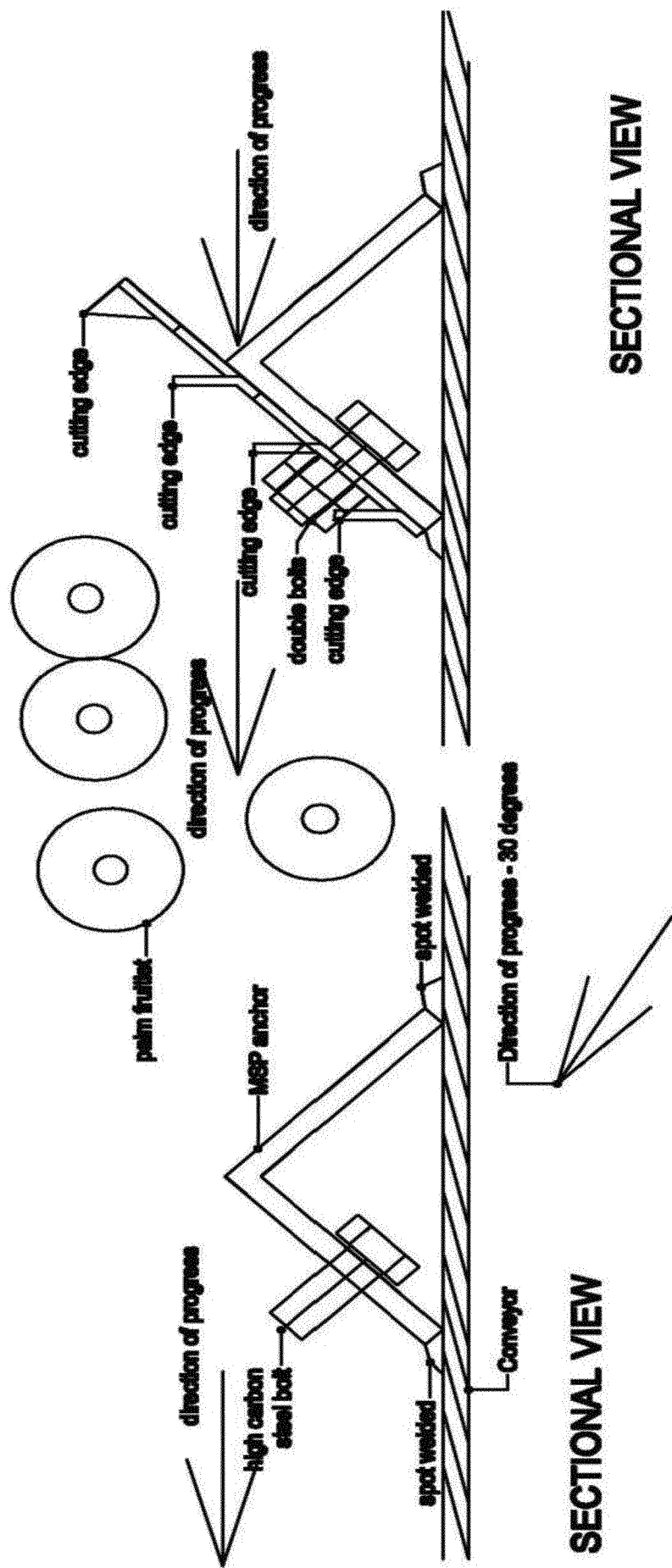


Figure 17

Figure 18

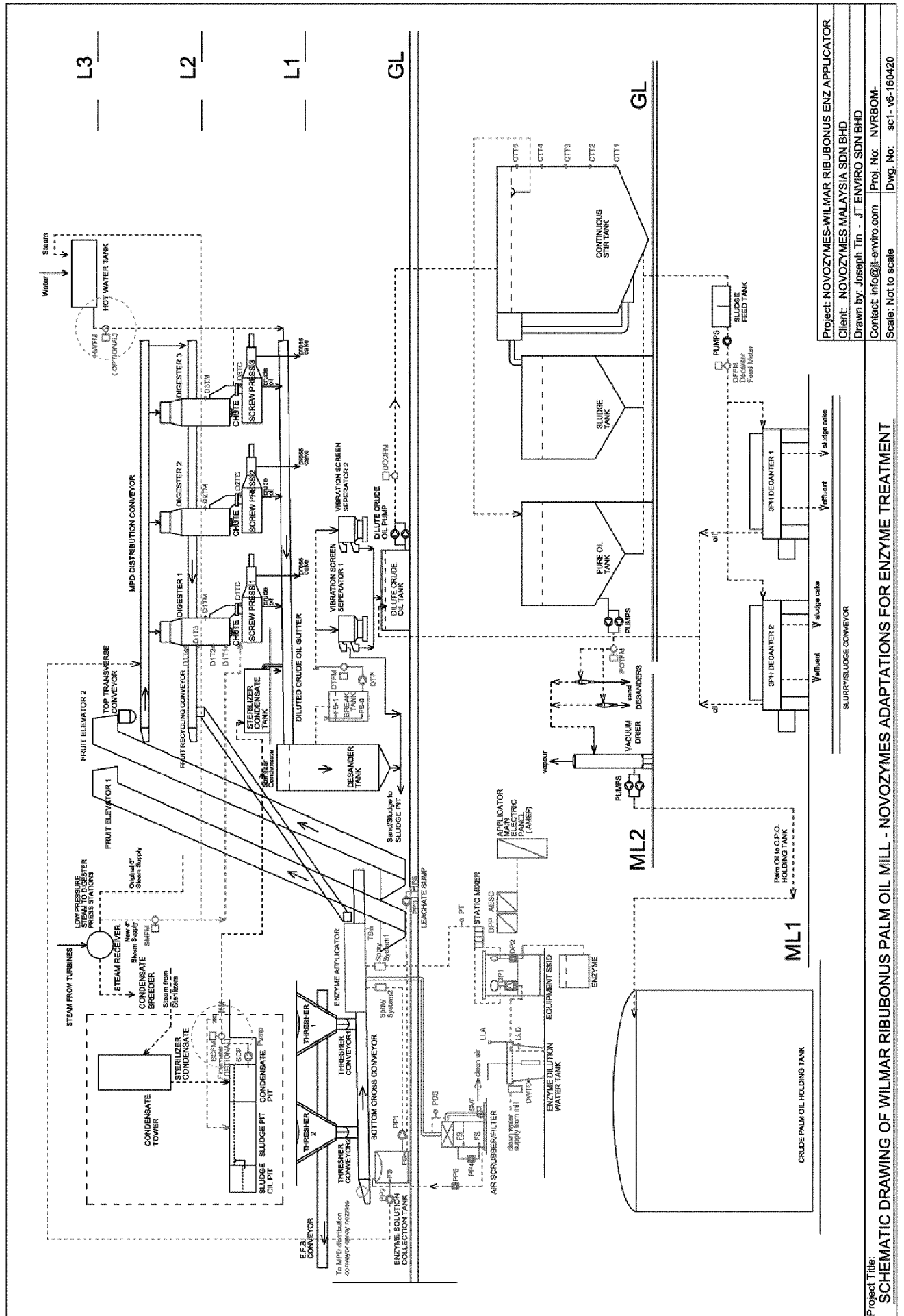
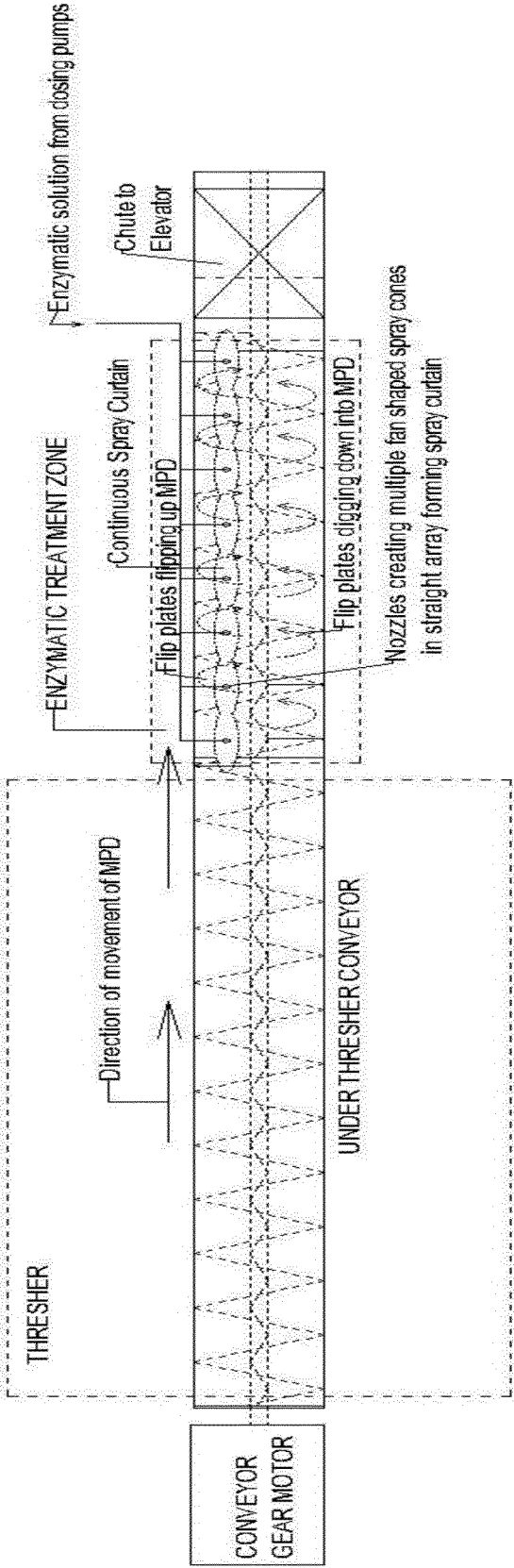


ILLUSTRATION ONE



PLAN VIEW OF UNDER THRESHER CONVEYOR SHOWING LAYOUT OF SPRAY SYSTEM

Figure 19

Illustration Two:

CROSS SECTION OF CONVEYOR SHOWING NOZZLE DEPLOYMENT

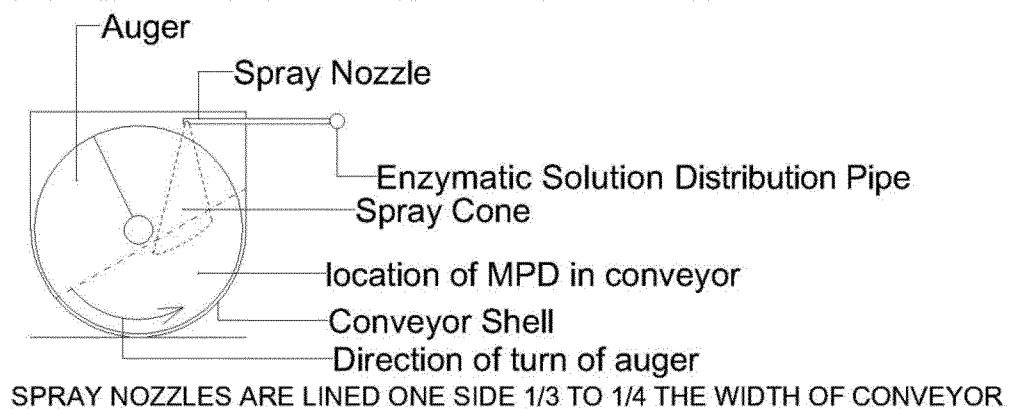


Figure 20

Illustration Three

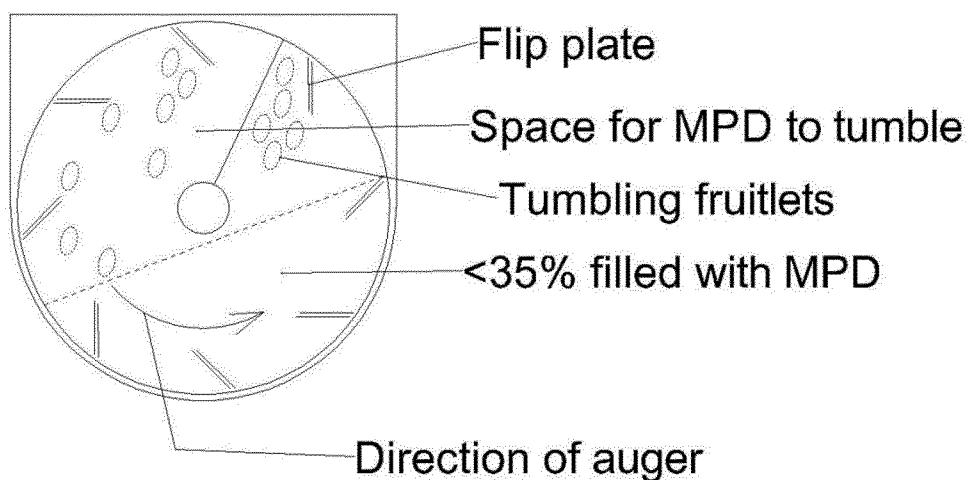
CROSS SECTION OF CONVEYOR SHOWING TUMBLING EFFECT
CREATED BY FLIP PLATES

Figure 21

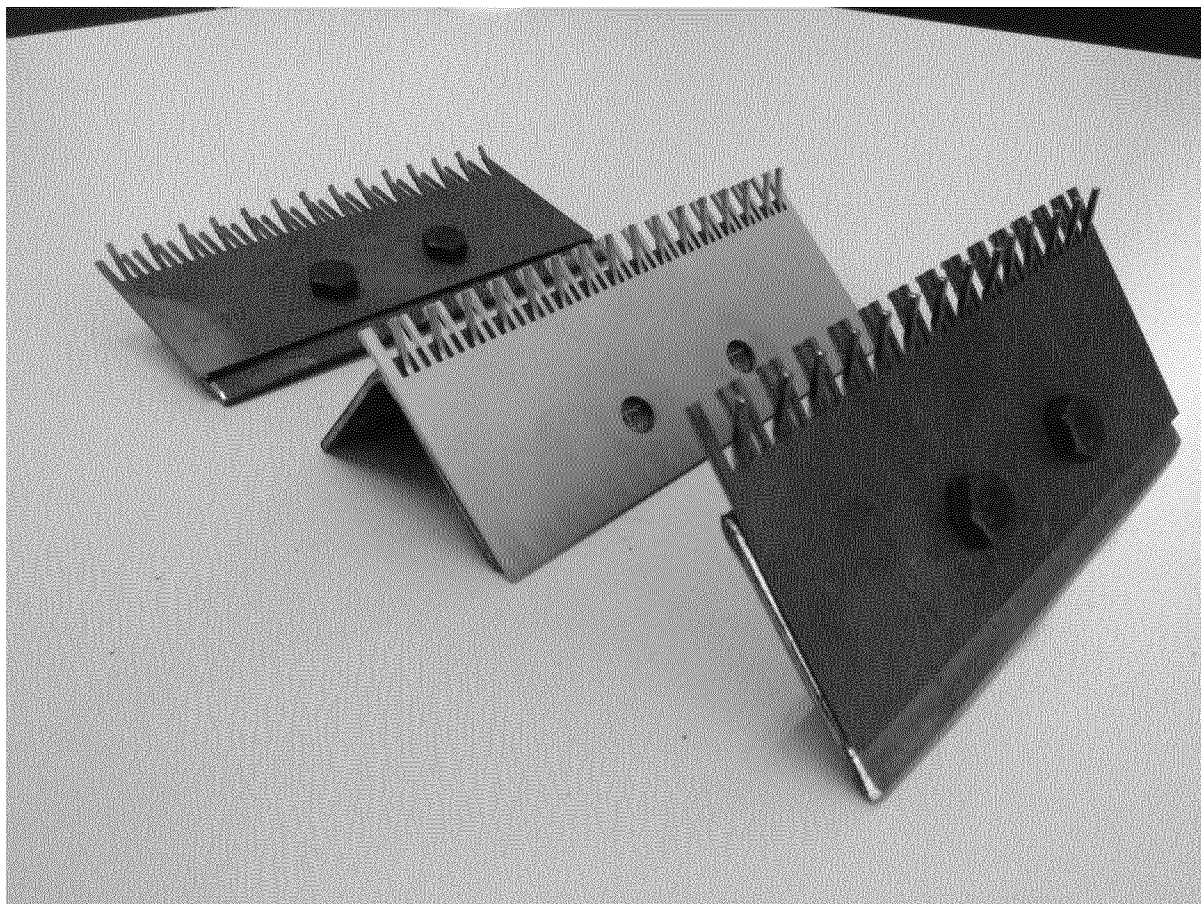


Figure 22

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/062659

A. CLASSIFICATION OF SUBJECT MATTER
INV. C11B1/02 C11B1/04
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C11B

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

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

EPO-Internal, BIOSIS, COMPENDEX, FSTA, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2016/162510 A1 (NOVOZYMES AS [DK]) 13 October 2016 (2016-10-13) page 11, line 34 - page 14, line 10; figure 2	1-42
X	----- AU 2015 101 377 A4 (DUPONT NUTRITION BIOSCI APS) 5 November 2015 (2015-11-05) page 13, lines 13-25 page 12, line 14 - line 28 the whole document	1-42
X	----- EP 0 435 061 A2 (KONE OY [FI]) 3 July 1991 (1991-07-03) page 3, column 1, paragraph 2-3; figures 1-2	1-38
	----- -/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 July 2017

Date of mailing of the international search report

01/08/2017

Name and mailing address of the ISA/

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Authorized officer

Rooney, Kevin

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/062659

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Alistair S. Grandison: "Postharvest Handling and Preparation of Foods for Processing : BRENNAN:FOOD PROC.HANDB. 0-BK" In: "Food Processing Handbook : BRENNAN:FOOD PROC.HANDB. 0-BK", 21 November 2005 (2005-11-21), Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, FRG, XP55392279, ISBN: 978-3-527-30719-7 pages 1-31, DOI: 10.1002/3527607579.ch1, figure 1.5 the whole document -----	1-38
X	GB 866 694 A (DONALD SPENCER CHEESMAN) 26 April 1961 (1961-04-26) the whole document -----	1-38
X	CN 102 845 618 A (HUNAN GLOBAL TECHNOLOGY AGRICULTURAL DEV CO LTD) 2 January 2013 (2013-01-02) abstract; figure 1 -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/062659

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