

FIELD

5 [001] The present invention relates to an automated tray return system.

BACKGROUND

10 [002] To address labour shortage for cleaners in food centres or cafeterias, several governments have mandated the compulsory return of used trays and crockery by patrons onto racks located at tray return points. However, this causes racks to become cluttered, especially during meal peak hours.

[003] One practice is to have cleaners stationed to clear tray and crockery from these racks when full onto trolleys and push the trolleys to a washing bay. However, these cleaners are then unable to clean tables.

15 [004] To address the above issues, several food centres deploy automated tray return systems. Patrons return their trays to these systems instead of racks. However, current automated tray return systems suffer from several shortcomings. They are bulky. Those that do not perform sorting use a common bin to store trays, cutlery, crockery and food waste. If a tray is returned misaligned, the automated tray return system may jam and thereafter be unable to receive trays until the jam is
20 rectified.

[005] There is thus a need to address the above shortcomings.

SUMMARY OF THE INVENTION

25 [006] According to a first aspect of the present invention, there is provided an automated tray return system comprising a tray receptacle having an entrance to receive a tray; a motor coupled to the tray receptacle, wherein during operation, the motor rotates the tray receptacle to clear content from the tray, followed by a further rotation to eject the tray from the entrance, a speed at which the motor rotates the tray receptacle being adjustable; a sorter arrangement resting on an incline and positioned
30 to catch the content from the tray, the sorter arrangement having openings sized to allow some of the content to pass but prevent others from passing; and a bin assembly to receive the tray from the tray receptacle and the sorted content from the sorter arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

[007] Representative embodiments of the present invention are herein described, by way of example only, with reference to the accompanying drawings, wherein:

5 [008] Figure 1 shows an automated tray return system, in accordance with a first implementation, with its removable assemblies separated

[009] Figure 2A shows a top view while Figure 2B shows a side view of the automated tray return of Figure 1 when fully assembled.

[010] Figures 3A to 3C illustrate the operation of a tray receptacle of the automated tray return of
10 Figure 1.

[011] Figure 4 shows a cross sectional view of a sorter arrangement and a bin assembly of the automated tray return of Figure 1.

[012] Figure 5 shows a top view of a housing for the sorter arrangement.

[013] Figure 6 shows a top view and a cross sectional view for each of the housing for the sorter
15 arrangement, a crockery sorter and a cutlery sorter

[014] Figure 7A shows a front view of the tray receptacle and its driving motor, while Figure 7B shows a top view of the tray receptacle and its driving motor.

[015] Figures 8A to 8D show a tray being received in different orientations by the tray receptacle.

[016] Figures 9A and 9B respectively show a perspective view and a side view of a front deck
20 module of the automated tray return of Figure 1.

[017] Figure 10 shows a side cross sectional view of the bin assembly of the automated tray return of Figure 1.

[018] Figures 11A to 11E show one or more of sieves and a waste water holder.

[019] Figure 12 shows an automated tray return system, in accordance with a second
25 implementation, with its removable assemblies separated.

[020] Figure 13A shows a top view while Figure 13B shows a side view of the automated tray return system of Figure 12 when fully assembled.

[021] Figures 14A to 14C illustrate the operation of the tray receptacle 1306A, 1306B of the automated tray return system of Figure 12.

30 [022] Figure 15 shows a cross sectional view of a sorter arrangement and a bin assembly of the automated tray return system of Figure 12.

[023] Figure 16A shows a top view of a housing for the sorter arrangement. Figure 16B shows the same top view, but with each of the housing and its sorter arrangement shown separately.

[024] Figures 17A, 17B and 17C respectively show a front view, a top view, and a perspective view
35 of the tray receptacle of the automated tray return system of Figure 12.

[025] Figures 18A and 18B show a tray being received in different orientations by the tray receptacle.

[026] Figures 19A and 19B respectively show a perspective view and a side view of a front deck module of the automated tray return system of Figure 12.

5 [027] Figure 20 shows a side cross sectional view of the bin assembly of the automated tray return system of Figure 12.

[028] Figure 21A shows a side view and a perspective view of a cutlery sieve of the automated tray return system of Figure 12. Figure 21B shows a side view and a perspective view of the food waste sieve of the automated tray return system of Figure 12.

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DETAILED DESCRIPTION

[029] In the following description, various embodiments are described with reference to the drawings, where like reference characters generally refer to the same parts throughout the different views.

15 [030] The present application relates to an automated tray return system that allows the return of a tray into an automated station. Such trays are typically returned with content, such as food waste, cutlery and crockery. The food waste may be present on the tray, the cutlery, the crockery or all of them. In one or more implementations, the tray has a rectangular design (see reference numerals 704 and 702 in Figures 7A and 7B) with a length that is longer than its breadth.

[031] The automated capabilities refer to a programmed sequence of steps that when executed causes all services provided by the tray return system to operate independently, such as a standby mode where it awaits receipt of a tray; a clearing stage where the content on the tray is removed; a tray ejection stage where the tray is diverted into storage; and a completion stage to revert the tray return station to the standby mode.

[032] The automated tray return system includes the following components: a receptacle to receive a returned tray; a motor that rotates the receptacle to first clear content from the tray, followed by another rotation to eject the tray from the receptacle; a sorter arrangement on which cleared content from the tray lands, whereby the sorter arrangement has openings of different sizes that sort the content by allowing some to pass, but not others; and a bin assembly to store the ejected tray and the sorted content from the sorter arrangement.

30 [033] The operating speed of the motor is configurable (for example by way of command signals received from by a programmable logic controller, PLC), so that the speed at which the tray receptacle rotates when clearing content from the tray is adjustable. Controlling the speed at which the tray receptacle rotates to clear content from the tray results in making variable the location of the

sorter arrangement relative to the rotation path of the tray receptacle, while also ensuring that items like crockery face downward when impacting the sorter arrangement. By increasing the rotation speed, the sorter arrangement can be disposed further away from this rotation path of the tray receptacle, for example more forward downstream of the flight trajectory path of content after leaving the tray. A slower rotation speed requires for the sorter arrangement to be closer to this rotation path of the tray receptacle, for example being below a stationary position where the tray receptacle receives the tray. The location of the sorter arrangement impacts a ground area that the automated tray return system occupies. Therefore, through appropriate calibration of the motor rotation speed, design control over a floor area that the automated tray return system occupies can be achieved.

10 [034] With the motor providing a full range of rotation that includes a full revolution, this allows the realisation of a configuration where the motor is coupled to a pair of tray receptacles through a connector. As one of the two tray receptacles is being rotated as part of the process of clearing and ejecting a received tray, the same rotation brings the other tray receptacle into a position to receive a new tray. The coupling of such a pair of tray receptacles to the motor allows for trays to be returned to the automated tray return system at a faster speed compared to the use of a single tray receptacle. In contrast, use of an actuator arm that extends and retracts only provides a tray receptacle with a limited angular rotation range that is less than a full revolution, and therefore cannot be used to achieve the above mentioned rotation of a pair of tray receptacles. Alternatively, the motor can use a simpler configuration where it is directly coupled to a single tray receptacle.

15 [035] The tray receptacle is also designed to accommodate should a tray be returned in a longitudinal orientation (where a breadth of the tray faces the entrance of the tray receptacle, i.e. the tray enters breadthwise); a horizontal orientation (where a length of the tray faces the entrance of the tray receptacle, i.e. the tray enters lengthwise); or misaligned. A misaligned tray is when the tray has an angular slant relative to the longitudinal orientation or the horizontal orientation. The tray receptacle has fixtures that adjust the tray into either a longitudinal orientation or a horizontal orientation as the tray is received into the tray receptacle, the adjustment being to correct the tray into a longitudinal orientation or a horizontal orientation.

20 [036] In one implementation, these fixtures include structures such as compartments, where one compartment keeps the tray in the longitudinal orientation and the other compartment keeps the tray in the horizontal orientation, totalling at least two compartments. The selection of a compartment, i.e. into which of these two compartments the tray enters, depends on an angle in which the tray is received into the tray receptacle. If the tray is angled in a substantially longitudinal orientation, it will enter the compartment for longitudinal orientation, which in one implementation, has a sloping section beginning with a width that is less than the length of the tray. This accommodates a tray entering in the longitudinal orientation which presents a dimension that is less than the opening width of the sloping section. However, a tray entering in the horizontal orientation will not fit because it

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presents a dimension that is larger than the opening width of the sloping section. If the tray is angled in a substantially horizontal orientation, it will enter the compartment for horizontal orientation, which in one implementation, has a pair of sections which are flat relative to the sloping section, the flat sections beginning apart by a distance which is more than the breadth of the tray. This accommodates a tray entering in the horizontal orientation which presents a dimension that is wider than the distance the flat sections are apart at the start, allowing the tray to be received by the flat sections. However, a tray entering in the longitudinal orientation will not be receivable by the flat sections because the tray presents a dimension that is less than the distance the flat sections are apart at the start. In one implementation, the sloping section and the flat sections are joined to provide one continuous surface, while in another implementation the sloping section is separated from the flat sections.

[037] In the case of misalignment, the tray either enters the compartment for horizontal orientation or the compartment for longitudinal orientation, depending on the angular slant relative to the longitudinal orientation or the horizontal orientation. Accordingly, the presence of the two compartments in the tray receptacle relaxes constraints imposed on orientation when the tray is introduced into the automated tray return system. This allows the automated tray return system to accept trays returned in longitudinal or horizontal orientations, and not jam even when the tray is returned misaligned relative to these two orientations.

[038] The sorter arrangement is disposed along a flight trajectory for content after being cleared from the tray after rotation of the tray receptacle. The sorter arrangement thus provides a landing zone for this cleared content. As the cleared content is a mixture of food waste, cutlery and crockery, the mixture requires sorting for each item to be directed into a corresponding bin of the bin assembly. The sorter arrangement performs this sorting by having openings sized to allow some content to pass but prevent others from passing. When the sorter arrangement is realised as a collection of sorters, each sorter may have openings that are similarly sized, but have a different size compared to openings provided in another sorter. The openings in one sorter may also be orientated differently from the openings in another sorter. The size of the openings for each sorter is designed to target separation of an item from the content, e.g. one sorter separates crockery (i.e. removes crockery, allowing cutlery and food waste to pass), while another sorter separates cutlery (i.e. removes cutlery, allows food waste to pass).

[039] The bin assembly is disposed downstream of the tray receptacle and the sorter arrangement. The bin assembly provides storage for the ejected tray from the tray receptacle and the sorted content from the sorter arrangement in one or more bins.

[040] The automated tray return system is described in greater detail below in conjunction with the accompanying Figures.

[041] Figure 1 shows one implementation of an automated tray return system 100 with its removable assemblies 104, 106, 108 separated from its automated station 102.

[042] The automated station 102 has a front deck module 110 for a tray to be returned; a front panel 112 to show operation status and to change operation settings of the automated station 102; LED indicators 130 that light up when the automated station 102 is in operation; and a power switch 114. The removable assemblies 104, 106, 108 ease clearing, cleaning and maintenance of the automated tray return system 100.

[043] The removable assemblies 104, 106, 108 include a bin assembly 104, a sorter arrangement 106 and a water tank 108. These removable assemblies 104, 106, 108 are provided on trolleys with rollers or wheels to facilitate their removal. The water tank 108 provides a portable reservoir for a water jet 202 (refer Figure 2B) that is used clean the sorter arrangement 106 to flush food remnants and keep crockery and cutlery moist. The water tank 108 is not used when the water jet is connected directly to a water source.

[044] Figure 2A shows a top view while Figure 2B shows a side view of the automated tray return system 100 when fully assembled. Both views show the internal components of the automated tray return system 100. The views in Figures 2A and 2B show the automated tray return system 100 in a standby state and ready for a tray to be returned.

[045] The automated station 102 has a water jet 202 disposed proximate to the sorter arrangement 106. The water jet 202 is operable to clean the sorter arrangement 106 by spraying water onto it, the water jet 202 programmed to operate periodically or each time after content is cleared from the tray. An odor control fan 204 is disposed on the top and serves to ventilate the automated station 102 by sucking air out from within.

[046] The automated tray return system 100 has a tray receptacle 206 to receive the tray returned to the automated station 102. The tray receptacle 206 is coupled to a motor 208 which drives the tray receptacle 206 to rotate. The tray receptacle 206 receives the tray from a conveying surface 250 disposed in the front deck module 110, the tray being placed on the conveying surface 250 when it is returned to the automated station 102. However, in another implementation (not shown), the conveying surface and the front deck module are omitted, whereby a tray is returned directly into the tray receptacle. The conveying surface 250 may be, but are not limited to, a conveyor belt or a set of rollers.

[047] Figures 3A to 3C illustrate the operation of the tray receptacle 206. The tray receptacle 206 and its driving motor 208 are part of a flipper module of the automated station 102.

[048] Figure 3A shows the automated tray return system 100 in a standby state. A tray 302 is returned to the automated station 102 via its front deck module 110. Content 304 such as crockery and cutlery may be on the tray 302, although Figure 3A only shows a bowl. In one approach, sensors 908 (refer Figure 9B) detect whether the tray 302 placed on the conveying surface 250 or crockery on the tray 302 has a correct colour. If the colour is correct, the conveying surface 250 will activate to lead the tray 302 into the tray receptacle 206. If the colour is incorrect, the front panel 112 will

display an appropriate alert and the conveying surface 250 remains stationary. In another approach, the sensors 908 detect whether the tray 302 is of a dimension to which the automated station 102 is configured to accept. If the tray 302 is of incorrect dimensions, the front panel 112 will display an appropriate alert and the conveying surface 250 remains stationary. If the tray 302 has acceptable dimensions, the conveying surface 250 is activated to bring the tray 302 into the tray receptacle 206. The tray 302 slides into the tray receptacle 206 as it is in alignment with the conveying surface 250 in the standby state of Figure 3A.

[049] After a timing sequence allocated for the conveying surface 250 to bring the tray 302 into the tray receptacle 206 has lapsed, the automated station 102 stops the conveying surface 250. This prevents other trays which may be on the conveying surface 250 from being fed into the automated station 102. Figure 3B shows the tray 302 having entered the tray receptacle 206 in a horizontal orientation 704 (refer Figure 8A), where a mechanical stop 726 prevents the tray 302 from overshooting. The motor 208 is activated to rotate the tray receptacle 206 to clear the content 304 from the tray 302, as shown in Figure 3B, with the mechanical stop 726 preventing the tray 302 from falling out. The speed at which the motor 208 rotates is adjustable and programmed to be at a magnitude where the content 304 is cleared with sufficient speed to reach the sorter arrangement 106. For the present implementation, the motor 208 may rotate up to a speed where the content 304 is flung off the tray 302, as opposed to a slower speed where the content 304 slides down the tray 302. The sorter arrangement 106 is positioned to catch the content 304 from the tray 302. The sorter arrangement 106 is also inclined so that the content 304 will slide down while it is being sorted into its various components. The sorting performed by the sorter arrangement 106 on the content 304 is described later with reference to Figure 4.

[050] The forward flip which the tray receptacle 206 performs to clear the content 304 is a clockwise rotation of around 90°. To eject the tray 302, the motor 208 performs a further rotation on the tray receptacle 206. This further rotation is a reverse flip of counter clockwise direction ending with the tray receptacle 206 at an angle of around -40° relative to its standby state of Figure 3A. The orientation of the tray receptacle 206 when it ejects the tray 302 is shown in Figure 3C. The tray 302 ejects from the entrance of the tray receptacle 206 towards a tray storage bin of the bin assembly 104. The tray 302 will land on top of other trays that may be present in the tray storage bin. The motor 208 then reverses direction again, to rotate the tray receptacle 206 clockwise to return to its standby state of Figure 3A, where the tray receptacle 206 is in alignment with the front deck module 110.

[051] Figure 4 shows a cross sectional view of the sorter arrangement 106 and the bin assembly 104. The cross sectional view shows how the sorter arrangement 106 separates content 304 that is cleared from the tray receptacle 206 as described above against Figure 3B.

[052] From Figure 3B, the speed at which the tray receptacle 206 is rotated to clear the tray 302 provides the content 304 with a trajectory to land on the sorter arrangement 106. The impact

dislodges food waste on crockery such as plates or bowls, and cutlery such as forks, spoons, knives and chopsticks.

[053] The sorting is such that the content 304 is separated into its various constituents through openings of different sizes, since the openings of one size will allow certain content from passing through but prevent other content from passing through, for the objective of directing the content 304 into an appropriate bin in the bin assembly 104. Thus, the content 304 may pass through different sized openings as it goes through the sorter arrangement 106, before reaching an appropriate bin in the bin assembly 104.

[054] The sorter arrangement 106 may have a series of sorters, with each having an array of openings, where the array in one sorter is sized differently from the array in another sorter. The content that the array of openings on one sorter allows to pass through goes to another sorter, while the content that does not pass through is guided from the sorter arrangement 106 being inclined into an appropriate bin in the bin assembly 104. As for the content that passes through, it gets similarly sorted by the next sorter, i.e. the array of openings on the next sorter allows some content to pass. The content that does not pass through is guided from the sorter arrangement 106 being inclined into an appropriate bin in the bin assembly 104. The sorter arrangement 106 may be pivotally coupled to its housing to facilitate maintenance, such as cleaning of each of the sorters and the housing.

[055] The sorter arrangement 106 in the present implementation has two such sorters: a crockery sorter 402; and a cutlery sorter 404. The crockery sorter 402 and the cutlery sorter 404 are each pivotally connected to a housing 408 which provides an inclined waste catchment surface 406. The crockery sorter 402 provides the landing surface for the content 304 cleared from the tray 302, while the cutlery sorter 404 is disposed between the crockery sorter 402 and the inclined waste catchment surface 406.

[056] The crockery sorter 402 has openings 502 (refer Figure 5) sized to allow food waste and cutlery to pass but prevent crockery from passing through. As the crockery is prevented from passing through these openings 502, they tumble 414 along the crockery sorter 402 to fall into a crockery bin 420 of the bin assembly 104.

[057] The cutlery sorter 404 has slits 504 (refer Figure 5) that run substantially transverse to the openings 502 in the crockery sorter 402, the slits 504 preventing cutlery from passing but allowing food waste to pass. As the cutlery is prevented from passing through these slits 504, they are guided 410 along the cutlery sorter 404 to fall into a cutlery sieve 422 that is disposed in the crockery bin 420 of the bin assembly 104.

[058] The food waste that passes through the slits 504 of the cutlery sorter 404 lands on the inclined waste catchment surface 406. The inclined waste catchment surface 406 has no openings. A water spray from the water jet 202 (refer Figure 2B) helps to wash down 412 food waste that may stick to the inclined waste catchment surface 406 into a food waste sieve 416 that is disposed in the crockery

bin 420 of the bin assembly 104. This water spray also washes down food waste that may have stuck to the crockery sorter 402 and the cutlery sorter 404 onto the inclined waste catchment surface 406, from which the food waste then gets washed into the food waste sieve 416. Water that is within the food waste sieve 416 is drained into a waste water holder 424 located below the food waste sieve 416.

5 [059] The bin assembly 104 therefore stores sorted content from the sorter arrangement 106. In addition, the bin assembly 104 has a tray storage bin 426 to receive and store the tray 302 ejected from the tray receptacle 206. The tray storage bin 426 has a plate 428 to receive the tray 302; and at least one spring 430 biasing the plate 428 towards an opening of the tray storage bin 426. In the implementation shown in Figure 4, up to four springs 430 are used.

10 [060] Figure 5 shows a top view of the housing 408 for the sorter arrangement 106. While Figure 5 shows that a grille is used for the crockery sorter 402, it is possible to use other structures having openings 502 that are sized to prevent crockery from passing through. Similarly, while a stepped ridge structure (refer Figure 6) is used for the cutlery sorter 404, it is possible to use other structures having slits 504 that are sized to prevent cutlery from passing through. Figure 5 also show that the

15 slits 504 in the cutlery sorter 404 run transverse to the openings 502 of the crockery sorter 402.

[061] The crockery sorter 402 does not extend the full length 514 of the housing 408 for the sorter arrangement 106, but only up to a portion. This is to allow a gap 510 for crockery to pass through the housing 408 into the bin assembly 104 (refer Figure 4). The crockery sorter 402 extends further than the cutlery sorter 404 (i.e. the crockery sorter 402 is longer than the cutlery sorter 404), with the

20 cutlery sorter 404 ending before or slightly covering an opening 512 provided in the inclined waste catchment surface 406. This opening 512 is for cutlery to pass through the housing 408 (refer Figure 4) into the cutlery sieve 422 of the crockery bin 420. Since the cutlery sorter 404 does not extend the full length of the crockery sorter 402, the speed at which the tray receptacle 206 rotates to clear content is adjusted so that the content 304 lands around zone 506 where there is overlap between the

25 crockery sorter 402 and the cutlery sorter 404. This allows food waste, dislodged from the crockery impacting against the parallel bars 508 of the crockery sorter 402, to land on the cutlery sorter 404.

[062] Following impact on the crockery sorter 402, its parallel bars assist to adjust the cutlery in an orientation where they can pass through the openings 502 of the crockery sorter 402. The orientation of the cutlery is then generally transverse to the slits 504 of the cutlery sorter 404, which facilitates the

30 cutlery to impact against the plates of the cutlery sorter 404 and dislodges food from the cutlery onto these plates. While the slits 504 of the cutlery sorter 404 are generally perpendicular to the openings 502 of the crockery sorter 402, other implementations (not shown) are possible, where the slits on the cutlery sorter are misaligned relative to the openings of the crockery sorter. As mentioned above, water from the water jet 202 (refer Figure 2B) then washes down food waste stuck on the crockery

35 sorter 402 and the cutlery sorter 404 onto the inclined waste catchment surface 406. This water then

continues to flush the food waste on the inclined waste catchment surface 406 into the food waste sieve 416 (refer Figure 4).

[063] Figure 6 shows a top view and a cross sectional view for the housing 408, the crockery sorter 402 and the cutlery sorter 404. Each of these components is shown separately in Figure 6.

5 [064] Figure 6 shows that the crockery sorter 402, the cutlery sorter 404 and the waste catchment surface 406 is each inclined at different angles, 30o, 45o and 50o respectively. A pivot point 602 is provided at an end of the crockery sorter 402, while a pivot point 604 of the cutlery sorter 404 is located at an opposite end.

[065] Figure 7A shows a front view of the tray receptacle 206 and its driving motor 208, while

10 Figure 7B shows a top view of the tray receptacle 206 and its driving motor 208.

[066] The tray receptacle 206 is designed to accept trays returned in a longitudinal orientation 702 or a horizontal orientation 704, and not jam even when the tray is returned misaligned relative to these two orientations 702 and 704. A tray is returned in a longitudinal orientation 702 when its breadth 706 faces an entrance 710 of the tray receptacle 206, while the tray is returned in a horizontal orientation 704 when its length 708 faces the entrance 710 of the tray receptacle 206.

15 [067] To accept trays being returned regardless of its orientation, the tray receptacle 206 is configured to have compartments, where one compartment keeps the tray in the longitudinal orientation 702 and the other compartment keeps the tray in the horizontal orientation 704. The choice of which of these two compartments is selected depends on an angle in which the tray is received into the tray receptacle 206, wherein each of these compartments have structural features that align the tray into either the longitudinal orientation 702 or the horizontal orientation 704 as the tray progresses further into the tray receptacle 206. The compartment 712 for the horizontal orientation and the compartment 714 for the longitudinal orientation is more clearly seen in Figure 7B.

20 [068] The compartment 714 for the longitudinal orientation has a sloping section 716 (also refer Figure 8B) beginning with a width 720 that is widest at the entrance 710 and tapers to narrow towards the end of the tray receptacle 206. The sloping section 716 tapers to ensure that a tray that enters in the longitudinal orientation 702, but slanted, get straightened as it slides down and rests at the centre. At the entrance 710, the width 720 of the sloping section 716 is more than the breadth 706 of the tray, so that a tray entering in the longitudinal orientation 702 can fit with some clearance. The tray fits because in the longitudinal orientation 702, the presented dimension is its breadth 706, which is then less than the opening width 720 of the sloping section 716. However, the beginning width 720 of the sloping section 716 should be less than the length 708 of the tray to prevent a tray in a horizontal orientation 702 from entering. Prevention occurs because in the horizontal orientation 704, the presented dimension is its length 708, which is then larger than the opening width 720 and the tray cannot fit into the sloping section 716. Accordingly, the width 720 at the beginning of the sloping

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section 716 is chosen to be more than the breadth 706 of the tray and less than the length 708 of the tray.

[069] The compartment 712 for the horizontal orientation has a pair of sections 718 which are flat relative to the sloping section 716. Like the sloping section 716 of the compartment 714, the flat sections 718 also start at the entrance 710 of the tray receptacle 206. The distance that the flat sections 718 begin apart refers to the distance between facing edges 804 (refer Figure of the flat sections 718 at their start. Since the sloping section 716 is disposed between and connected to the flat sections 718, the distance that the flat sections 718 are apart 720 depends on the beginning width 720 of the sloping section 716. For example, if the beginning width 720 of the sloping section 716 is greater than the breadth 706 of the tray, the flat sections 718 also begin apart 720 by a distance that is greater than the breadth 706 of the tray. This distance apart 720 is more than the breadth 706 of the tray, so that a tray entering in the longitudinal orientation 702 will pass between the flat sections 718 and be prevented from sliding onto the flat sections 718. The tray passes between because in the longitudinal orientation 702, the presented dimension to the flat sections 718 is the breadth 706 of the tray, which is less than the distance that the flat sections 718 is apart and therefore not long enough to reach across the flat sections 718. However, this distance apart 720 should be less than the length 708 of the tray to allow a tray entering in the horizontal orientation 704 to slide onto the flat sections 718. Allowance occurs because in the horizontal orientation 704, the presented dimension is its length 708, which is larger than the distance that the flat sections 718 is apart 720. Accordingly, the distance that the flat sections 718 begin apart 720 is designed to be more than the breadth 706 of the tray but less than the length 708 of the tray.

[070] While the sloping section 716 tapers, the separation between facing edges 804 (refer Figure 8B) of the flat sections 718 remains constant along the length 806 of the tray receptacle 206. The width 814 for each of the flat sections 718 is such that when summed with their distance apart 720 provide an overall distance that is at least the length 708 of the tray. The tapering portion of the sloping section 716 is joined to the flat sections 718 of the compartment 712 by an inclined surface 802 that extends from each of the tapering edges.

[071] Although the sloping section 716 (along with its inclined surfaces 802) and the flat sections 718 belong to different compartments, they form a continuous surface. Accordingly, the sloping section 716, the inclined surfaces 802 and the flat sections 718 may be fabricated from a single sheet of metal, although it is possible to have them separately manufactured then welded together.

[072] With the sloping section 716 and the flat sections 718 forming a continuous surface, each of the flat sections 718 flank the sloping section 716 by extending from opposite side edges of the sloping section 716. Each of the flat sections 718 has a side wall 808 (refer Figure 8A), so that the flat sections 718 has opposing side walls 808, each disposed along a corresponding flat section. A ridge 810 extends from each of the side walls 808, so that the ridges 810 extend towards each other.

Each ridge 810 extends to be over at least a portion of a corresponding flat section 718, up to over a portion of the sloping section 716. A gap 816 between the ridges 810 allow contents on the tray, such as crockery, to pass through without obstruction as the tray progresses further into the tray receptacle 206 in either of the two compartments 712 and 714. Accordingly, the combination of the pair of side walls 808 and the pair of ridges 810 provide the tray receptacle 206 with a bracket structure. With reference to Figure 3B, the ridges 810 serve to prevent the tray 302 from falling out when the tray receptacle 206 is rotated to clear the content 304 on the tray 302.

[073] Returning to Figures 7A and 7B, a mechanical stop 724, 726 is disposed at an end of each of the sloping section 716 and the flat sections 718, so that the compartment 712 for the horizontal orientation and the compartment 714 for the longitudinal orientation each has its own mechanism to stop the tray when it reaches the end of the respective compartment 712 and 714.

[074] The mechanical stop 724 at the end of the sloping section 716 (i.e. the mechanical stop 724 for the compartment 714) has a pair of protruding brackets. Each bracket is coupled at one end to the sloping section 716 and at another end to a corresponding ridge 810. The brackets, in conjunction with the portion of the pair of ridges 810 that partially covers the sloping section 716 prevents the tray from falling out when the tray receptacle 206 is rotated to clear content (see Figure 3B). The mechanical stop 726 at the end of the flat sections 718 (i.e. the mechanical stop 726 for the compartment 712) has a pair of bars, each bar being coupled at one end to one of the flat sections 718 and at another end to the corresponding ridge 810.

[075] A rod 722 is located at each of the flat sections 718, along its respective edge. The tray slides on the rod 722 as it enters the compartment 712 for the horizontal orientation which reduces friction since the rod 722 provides a smaller surface area of contact compared to the flat sections 718.

[076] Figures 8A to 8D show a tray being received in different orientations by the tray receptacle 206. These Figures show that the tray either enters the compartment 712 for horizontal orientation or the compartment 714 for longitudinal orientation, depending on an angle in which the tray enters the tray receptacle 206 relative to the longitudinal orientation 702 or the horizontal orientation 704.

[077] In Figure 8A, the tray is received angled in a substantially horizontal orientation 704 on the conveying surface 250 (refer Figure 2A). As the conveying surface 250 moves the tray towards the tray receptacle 206, the compartment 712 for the horizontal orientation will be selected since it is natural for the tray (i.e. the tray has a tendency) to slide along the flat sections 718 of the compartment 712 as the tray moves further into the tray receptacle 206. Either breadth 706 of the tray may contact an inner surface of a corresponding wall 808 as the tray moves further into the tray receptacle 206, which adjusts the tray into the horizontal orientation 704. Accordingly, the compartment 712 aligns the tray into the horizontal orientation 704 even if the tray is misaligned relative to the horizontal orientation 704 before it enters the tray receptacle 206. The compartment 714 for the longitudinal orientation will not be selected because of a mismatch between the opening width 720 of the sloping

section 716 and the length 708 of the tray, with the length 708 of the tray exceeding the width 720 of the sloping section 716.

[078] In Figure 8B, the tray is received angled in a substantially longitudinal orientation 702 on the conveying surface 250 (refer Figure 2A). As the conveying surface 250 moves the tray towards the tray receptacle 206, the compartment 714 for the longitudinal orientation will be selected since the tray will naturally (i.e. has the tendency to) slide down the sloping section 716 as the tray moves further into the tray receptacle 206. Even if the tray enters with a portion sliding on one of the flat sections 718, it would be a small portion. Most of the tray will slide on the sloping section 716. The tray will eventually slide entirely onto the sloping section 716 as the tray is pushed further into the tray receptacle 206 by the conveying surface 250, since the width 814 of that flat section 718 is not sufficient wide to support the small portion of the tray thereon. Accordingly, the compartment 714 aligns the tray into the longitudinal orientation 702 even if the tray is misaligned relative to the longitudinal orientation 702 before it enters the tray receptacle 206. The compartment 712 for the horizontal orientation will not be selected because of a mismatch between the distance the flat sections 718 are apart 720 and the width 706 of the tray, with the distance the flat sections 718 are apart 720 exceeding the width 706 of the tray.

[079] In Figure 8C, the tray is received on the conveying surface 250 (refer Figure 2A), misaligned 820 relative to the longitudinal orientation. The compartment 714 for the longitudinal orientation is selected as follows. As the conveying surface 250 moves the misaligned tray into the tray receptacle 206, the tray will first contact the sloping section 716. As the misaligned tray is pushed further into the tray receptacle 206 by the conveying surface 250, the tray will adjust into the longitudinal orientation due to the inclination of the sloping section 716.

[080] In Figure 8D, the tray is received on the conveying surface 250 (refer Figure 2A), misaligned 822 relative to the horizontal orientation. The compartment 712 for the horizontal orientation is selected as follows. As the conveying surface 250 moves the misaligned tray into the tray receptacle 206, the tray will first contact either or both of the flat sections 718. As the misaligned tray is pushed further into the tray receptacle 206 by the conveying surface 250, a vertice of the tray will contact an inner surface of a corresponding wall 808 as the tray moves further into the tray receptacle 206, which adjusts the tray into the horizontal orientation.

[081] Figure 9A shows a perspective view of the front deck module 110, while Figure 9B shows a side view of the front deck module 110. The conveyor belt 902 of the front deck module 110 has a series of protruding strips 904 that are spaced apart. The tray for returning into the automated station 102 is placed on the conveyor belt 902 forward of the protrusion 904. As the conveyor belt 902 rolls to push the tray into the tray receptacle 206, slippage may occur. The tray may continue to slip until it engages with the protrusion 904, whereby the slippage stops. The protrusion 904 then provides traction by pushing against the tray to ensure that the tray enters the tray receptacle 206 fully and

straightens the tray if it is slanted. If the tray is placed directly on one or more protrusions 904, then the likelihood of the tray slipping while the conveyor belt 902 moves is reduced. Suitable material for the protrusions 904 include rubber strips.

[082] The housing 906 of the front deck module 110 has sensors 908 including one or more of photo-sensor(s), color sensor(s), or reflective sensor(s). These sensors 908 detect whether a correct tray is placed onto the conveyor belt 902, such as through a colour check, as described above with respect to Figure 3A.

[083] Figure 10 shows a side cross sectional view of the bin assembly 104. The bin assembly 104 has one or more bins 426, 420. The tray storage bin 426 is for storing the tray after ejection from the tray receptacle 206. The crockery bin 420 is for storing the crockery from the crockery sorter 402 (refer Figure 4) and the cutlery from the cutlery sorter 404. A plurality of sieves 422, 408 is disposed in one or more of the bins 426, 420. The cutlery sieve 422 and the food waste sieve 416 are disposed in the crockery bin 420, whereby the cutlery sieve 422 is positioned downstream of the cutlery sorter 404 to catch the cutlery, while the food waste sieve 416 is positioned downstream of the inclined waste catchment surface 406 to catch the food waste. The waste water holder 424 is located below the food waste sieve 416.

[084] Figures 11A to 11E show one or more of the sieves 422, 408 and the waste water holder 424. Figure 11A shows these components after assembly. Figure 11B shows the assembled components being disposed in the crockery bin 420. Figure 11C shows the cutlery sieve 422. Figure 11D shows the waste water holder 424. Figure 11E shows the food waste sieve 416.

[085] Figure 12 shows another implementation of an automated tray return system 1200 with its removable assemblies 1204, 1206, 1208 separated from its automated station 1202.

[086] The automated station 1202 has a front deck module 1210 for a tray to be returned; a front panel 1212 to show operation status and to change operation settings of the automated station 1202; LED indicators 1230 that light up when the automated station 1202 is in operation; and a power switch 1214. The removable assemblies 1204, 1206, 1208 ease clearing, cleaning and maintenance of the automated tray return system 1200.

[087] The removable assemblies 1204, 1206, 1208 include a bin assembly 1204, a sorter arrangement 1206 and a water tank 1208. These removable assemblies 1204, 1206, 1208 are provided on trolleys with rollers or wheels to facilitate their removal. The water tank 1208 provides a portable reservoir for a water jet 1302 (refer Figure 13B) that is used clean the sorter arrangement 1206 to flush food remnants and keep crockery and cutlery moist. The water tank 1208 is not used when the water jet is connected directly to a water source.

[088] Figure 13A shows a top view while Figure 13B shows a side view of the automated tray return system 1200 when fully assembled. Both views show the internal components of the

automated tray return system 1200. The views in Figures 13A and 13B show the automated tray return system 1200 in a standby state and ready for a tray to be returned.

[089] The automated station 1202 has a water jet 1302 disposed proximate to the sorter arrangement 1206. The water jet 1302 is operable to clean the sorter arrangement 1206 by spraying water onto it, the water jet 1302 programmed to operate periodically or each time after content is cleared from the tray. An odor control fan 1304 is disposed on the top and serves to ventilate the automated station 1202 by sucking air out from within.

[090] The automated tray return system 1200 has a pair of tray receptacles 1306A, 1306B to receive the tray returned to the automated station 1202. In comparison, the automated tray return system 1100 of Figure 1 uses only a single tray receptacle 206. The pair of tray receptacles 1306A, 1306B is coupled to a motor 1308 through a connector 1322, the motor 1308 driving the pair of tray receptacles 1306A, 1306B to rotate. Each of the tray receptacles 1306A, 1306B is rigidly coupled to the connector 1322 in that their orientation remains fixed as they are rotated by the motor 1308 (refer Figure 14B). The tray receptacle 1306B that is positioned at the entrance of the automated station 1202 in the standby state receives the tray from a conveying surface 1350 disposed in the front deck module 1210, the tray being placed on the conveying surface 1350 when it is returned to the automated station 1202. However, in another implementation (not shown), the conveying surface and the front deck module are omitted, whereby a tray is returned directly into the tray receptacle. The conveying surface 1350 may be, but are not limited to, a conveyor belt or a set of rollers. A tray transfer ramp 1320 guides a tray ejected from the tray receptacle 1306 into a tray storage bin 1526 of the bin assembly 1204.

[091] Figures 14A to 14C illustrate the operation of the pair of tray receptacles 1306A, 1306B. The pair of tray receptacles 1306A, 1306B and its driving motor 1308 are part of a flipper module of the automated station 1202.

[092] Figure 14A shows the automated tray return system 1200 in a standby state. A tray 1402 is returned to the automated station 1202 via its front deck module 1210. Content 1404 such as crockery and cutlery may be on the tray 1402, although Figure 14A only shows a bowl. In one approach, sensors 1908 (refer Figure 19B) detect whether the tray 1402 placed on the conveying surface 1350 or crockery on the tray 1402 has a correct colour. If the colour is correct, the conveying surface 1350 will activate to lead the tray 1402 into the tray receptacle 1306. If the colour is incorrect, the front panel 1212 will display an appropriate alert and the conveying surface 1350 remains stationary. In another approach, the sensors 1908 detect whether the tray 1402 is of a dimension to which the automated station 1202 is configured to accept. If the tray 1402 is of incorrect dimensions, the front panel 1212 will display an appropriate alert and the conveying surface 1350 remains stationary. If the tray 1402 has acceptable dimensions, the conveying surface 1350 is activated to bring the tray 1402 into the tray receptacle 1306B that is positioned at the entrance of the automated station 1202. The

tray 1402 slides into the tray receptacle 1306B as it is in alignment with the conveying surface 1350 in the standby state of Figure 14A.

[093] After a timing sequence allocated for the conveying surface 1350 to bring the tray 1402 into the tray receptacle 1306B has lapsed, the automated station 1202 stops the conveying surface 1350.

5 This prevents other trays which may be on the conveying surface 1350 from being fed into the automated station 1202. Figure 14B shows the tray 1402 having entered the tray receptacle 1306B in a horizontal orientation 1704 (refer Figures 17A and 17B), where a mechanical stop 1726 prevents the tray 1402 from overshooting. The motor 1308 is activated to rotate the tray receptacle 1306B and the other tray receptacle 1306A, to clear the content 1404 from the tray 1402, as shown in Figure 14B.
10 The mechanical stop 1726 prevents the tray 1402 from falling out. The speed at which the motor 1308 rotates is adjustable and programmed to be at a magnitude where the content 1404 is cleared with sufficient speed to reach the sorter arrangement 1206.

[094] For the present implementation, the sorter arrangement 1206 is located below the pair of tray receptacles 1306A, 1306B, so that the sorter arrangement 1206 is close to the rotation path of the tray
15 tray receptacle 1306A, 1306B. Accordingly, the motor 1308 rotates the pair of tray receptacles 1306A, 1306B at a speed which is slower compared to that which the motor 208 rotates the tray receptacle 206 of the automated station 102 (refer Figure 3B). This reduces the noise the cleared content 1404 makes when landing on the sorter arrangement 1206 and reduces breakage of crockery and cutlery. The rotation speed of the tray receptacle 1306B may be adjusted to have the content
20 1404 slide down the tray 1402. The sorter arrangement 1206 is positioned to catch the content 1404 from the tray 1402. The sorter arrangement 1206 is also inclined so that the content 1404 will slide down while it is being sorted into its various components. The sorting performed by the sorter arrangement 1206 on the content 1404 is described later with reference to Figure 15.

[095] The forward flip which the tray receptacle 1306B performs to clear the content 1404 is a
25 clockwise rotation of around 90°. To eject the tray 1402, as shown in Figure 14C, the motor 1308 performs a further rotation on the pair of tray receptacles 1306A, 1306B which is in the same direction as that when clearing the content 1404. That is the pair of tray receptacles 1306A, 1306B rotates in the same direction when clearing content 1404 and when ejecting the tray 1402. This contrasts with the rotation of the tray receptacle 206 of the automated station 102 to eject the tray 302
30 (refer Figure 3C), which is opposite to the rotation when clearing the content 304. Ejection occurs when the tray receptacle 1306B with the tray 1402 rotates to an angle of around 225° relative to its standby state of Figure 14A. The tray 1402 ejects from the entrance of the tray receptacle 1306B towards a tray storage bin 1526 of the bin assembly 1204. The tray 1402 will land on top of other trays that may be present in the tray storage bin 1526. The motor 1308 stops when the tray 1402 is
35 ejected and reverses rotation direction to return the other tray receptacle 1306A to its standby state of Figure 14A, where the tray receptacle 1306A is in alignment with the front deck module 1210.

Accordingly, during operation, the automated station 1202 is configured to have only one of the tray receptacles 1306A, 1306B receive a tray. In addition, following ejection of a tray from one of the tray receptacles 1306A, 1306B, the other tray receptacle is in an alignment to receive a new tray. That is, a new tray is received into a tray receptacle that is other than the one that has ejected its tray.

5 [096] The use of a pair of tray receptacles 1306A, 1306B allows the automated tray return system 1200 to receive and clear trays more quickly compared to the use of a single tray receptacle. By having the tray receptacles 1306A, 1306B alternate receipt of a tray, one of the tray receptacles 1306A, 1306B is almost in position to receive another tray when a previous tray is being deposited into storage by the other tray receptacle 1306A, 1306B. There is less wait time to clear a queue of
10 trays that may be on the front deck module 1210. A clearing speed of 4 seconds per tray is possible.

[097] Figure 15 shows a cross sectional view of the sorter arrangement 1206 and the bin assembly 1204. The cross sectional view shows how the sorter arrangement 1206 separates content 1404 that is cleared from the tray receptacle 1306 as described above against Figure 14B.

[098] From Figure 14B, the speed at which the tray receptacle 1306 is rotated to clear the tray 1402
15 provides the content 1404 with a trajectory to land on the sorter arrangement 1206. The impact dislodges food waste on crockery such as plates or bowls, and cutlery such as forks, spoons, knives and chopsticks.

[099] The sorting is such that the content 1404 is separated into its various constituents through openings of different sizes, since the openings of one size will allow certain content from passing
20 through but prevent other content from passing through, for the objective of directing the content 1404 into an appropriate bin in the bin assembly 1204. Thus, the content 1404 may pass through different sized openings as it goes through the sorter arrangement 1206, before reaching an appropriate bin in the bin assembly 1204.

[100] The sorter arrangement 1206 may have a series of sorters, with each having an array of
25 openings, where the array in one sorter is sized differently from the array in another sorter. The content that the array of openings on one sorter allows to pass through goes to another sorter, while the content that does not pass through is guided from the sorter arrangement 1206 being inclined into an appropriate bin in the bin assembly 1204. As for the content that passes through, it gets similarly sorted by the next sorter, i.e. the array of openings on the next sorter allows some content to pass.
30 The content that does not pass through is guided from the sorter arrangement 1206 being inclined into an appropriate bin in the bin assembly 1204. The sorter arrangement 1206 may be pivotally coupled to its housing to facilitate maintenance, such as cleaning of each of the sorters and the housing.

[101] The sorter arrangement 1206 in the present implementation has two such sorters: a crockery
35 sorter 1502; and a cutlery sorter 1504. The crockery sorter 1502 and the cutlery sorter 1504 are each pivotally connected to a housing 1508 which provides an inclined waste catchment surface 1506. The crockery sorter 1502 provides the landing surface for the content 1404 cleared from the tray 1402,

while the cutlery sorter 1504 is disposed between the crockery sorter 1502 and the inclined waste catchment surface 1506.

[102] The crockery sorter 1502 has openings 1602 (refer Figure 16) sized to allow food waste and cutlery to pass but prevent crockery from passing through. As the crockery is prevented from passing through these openings 1602, they tumble 1514 along the crockery sorter 1502 to fall into a crockery bin 1520 of the bin assembly 1204.

[103] The cutlery sorter 1504 has slits 1604 (refer Figure 16) that run substantially transverse to the openings 1602 in the crockery sorter 1502, the slits 1604 preventing cutlery from passing but allowing food waste to pass. As the cutlery is prevented from passing through these slits 1604, they are guided 1510 along the cutlery sorter 1504 to fall into a cutlery sieve 1522 that is disposed in a waste water bin 1550 of the bin assembly 1204.

[104] The food waste that passes through the slits 1604 of the cutlery sorter 1504 lands on the inclined waste catchment surface 1506. The inclined waste catchment surface 1506 has no openings. A water spray from the water jet 1302 washes down 1512 food waste that may stick to the inclined waste catchment surface 1506 into a food waste sieve 1516 that is disposed in the waste water bin 1550 of the bin assembly 1204. This water spray also washes down food waste that may have stuck to the crockery sorter 1502 and the cutlery sorter 1504 onto the inclined waste catchment surface 1506, from which the food waste then gets washed into the food waste sieve 1516. Water that is within the food waste sieve 1516 is drained into the waste water bin 1550 located below the food waste sieve 1516.

[105] The bin assembly 1204 therefore stores sorted content from the sorter arrangement 1206. In addition, the bin assembly 1204 has a tray storage bin 1526 to receive and store the tray 1402 ejected from the tray receptacle 1306A, 1306B. The ejected tray 1402 is guided to the tray storage bin 1526 via the tray transfer ramp 1320. The tray storage bin 1526 has a plate 1528 to receive the tray 1402; and at least one spring 1530 biasing the plate 1528 towards an opening of the tray storage bin 1526. In the implementation shown in Figure 15, up to four springs 430 are used.

[106] Figure 16A shows a top view of the housing 1508 with its sorter arrangement 1206. Figure 16B shows the same top view, but with each of the housing 1508 and its sorter arrangement 1206 shown separately.

[107] While Figures 16A and 16B show that a grille is used for the crockery sorter 1502, it is possible to use other structures having openings 1602 that are sized to prevent crockery from passing through. Similarly, while a stepped ridge structure (refer Figure 15) is used for the cutlery sorter 1504, it is possible to use other structures having slits 1604 that are sized to prevent cutlery from passing through. Figure 16A also show that the slits 1604 in the cutlery sorter 1504 run transverse to the openings 1602 of the crockery sorter 1502.

[108] Since the automated tray return system 1200 is designed to have the crockery bin 1520 (refer Figure 15) located forward of the sorter arrangement 1206, the crockery sorter 1502 extends the full length 1614 of the housing 1508 for the sorter arrangement 1206 to ensure that the crockery does not pass into the waste water bin 1550 below the housing 1508. The crockery sorter 1502 extends further than the cutlery sorter 1504 (i.e. the crockery sorter 1502 is longer than the cutlery sorter 1504), with the cutlery sorter 1504 covering a cutaway 1612 formed in the inclined waste catchment surface 1506. This cutaway 1612 is for food waste to pass through the housing 1508 (refer Figure 15) into the food waste sieve 1516 of the waste water bin 1550. The cutlery sorter 1504 ends before or slightly covers a gap 1630 adjacent to where the inclined waste catchment surface 1506 ends, the gap 1630 allowing cutlery to fall through the housing 1508 into the cutlery sieve 1522 of the waste water bin 1550.

[109] Since the cutlery sorter 1504 does not extend the full length of the crockery sorter 1502, the speed at which the tray receptacle 206 rotates to clear content is adjusted so that the content 1404 lands around zone 1606 where there is overlap between the crockery sorter 1502 and the cutlery sorter 1504. This allows food waste, dislodged from the crockery impacting against the parallel bars 1608 of the crockery sorter 1502, to land on the cutlery sorter 1504.

[110] Following impact on the crockery sorter 1502, its parallel bars 1608 assist to adjust the cutlery in an orientation where they can pass through the openings 1602 of the crockery sorter 1502. The orientation of the cutlery is then generally transverse to the slits 1604 of the cutlery sorter 1504, which facilitates the cutlery to impact against the plates of the cutlery sorter 1504 and dislodges food from the cutlery onto these plates. While the slits 1604 of the cutlery sorter 1504 are generally perpendicular to the openings 1602 of the crockery sorter 1502, other implementations (not shown) are possible, where the slits on the cutlery sorter are misaligned relative to the openings of the crockery sorter. As mentioned above, water from the water jet 1302 (refer Figure 15) then washes down food waste stuck on the crockery sorter 1502 and the cutlery sorter 1504 onto the inclined waste catchment surface 1506. This water then continues to flush the food waste on the inclined waste catchment surface 1506 into the food waste sieve 1516 (refer Figure 15).

[111] Figure 17A shows a front view of the tray receptacle 1306A, 1306B, Figure 17B shows a top view and Figure 17C shows a perspective view.

[112] The tray receptacle 1306A, 1306B is designed to accept trays returned in a longitudinal orientation 1702 or a horizontal orientation 1704, and not jam even when the tray is returned misaligned relative to these two orientations 1702 and 1704. A tray is returned in a longitudinal orientation 1702 when its breadth 1706 faces an entrance 1710 of the tray receptacle 1306A, 1306B, while the tray is returned in a horizontal orientation 1704 when its length 1708 faces the entrance 1710 of the tray receptacle 1306A, 1306B.

[113] To accept trays being returned regardless of its orientation, the tray receptacle 1306A, 1306B is configured to have compartments, where one compartment keeps the tray in the longitudinal

orientation 1702 and the other compartment keeps the tray in the horizontal orientation 1704. The choice of which of these two compartments is selected depends on an angle in which the tray is received into the tray receptacle 1306A, 1306B, wherein each of these compartments have structural features that align the tray into either the longitudinal orientation 1702 or the horizontal orientation 1704 as the tray progresses further into the tray receptacle 1306A, 1306B. The compartment 1712 for the horizontal orientation and the compartment 1714 for the longitudinal orientation is more clearly seen in Figure 17B.

[114] The compartment 1714 for the longitudinal orientation has a sloping section 1716 (also refer Figure 18A) beginning with a width 1720 that is widest at the entrance 1710 and tapers to narrow towards the end of the tray receptacle 1306A, 1306B. The sloping section 1716 tapers to ensure that a tray that enters in the longitudinal orientation 1702, but slanted, get straightened as it slides down and rests at the centre. The compartment 1714 for the longitudinal orientation is designed to receive up to three stacked trays.

[115] At the entrance 1710, the width 1720 of the sloping section 1716 is more than the breadth 1706 of the tray, so that a tray entering in the longitudinal orientation 1702 can fit with some clearance. The tray fits because in the longitudinal orientation 1702, the presented dimension is its breadth 1706, which is then less than the opening width 1720 of the sloping section 1716. However, the beginning width 1720 of the sloping section 1716 should be less than the length 1708 of the tray to prevent a tray in a horizontal orientation 1704 from entering. Prevention occurs because in the horizontal orientation 1704, the presented dimension is its length 1708, which is then larger than the opening width 1720 and the tray cannot fit into the sloping section 1716. Accordingly, the width 1720 at the beginning of the sloping section 1716 is chosen to be more than the breadth 1706 of the tray and less than the length 1708 of the tray.

[116] The compartment 1712 for the horizontal orientation has a pair of sections 1718 which are flat relative to the sloping section 1716. Like the sloping section 1716 of the compartment 1714, the flat sections 1718 also start at the entrance 1710 of the tray receptacle 1306A, 1306B. The sloping section 1716 is disposed between the flat sections 1718 but is not connected to the flat sections 1718. The flat sections 1718 are separated by a gap 1828. This gap 1828 is also the distance the flat sections 1718 begin apart, which is the distance between facing edges 1804 (refer Figure 17C) of the flat sections 1718 at their start. However, like the tray receptacle 206 (refer Figure 7B), the distance that the flat sections is apart 1720 is more than the breadth 1706 of the tray, so that a tray entering in the longitudinal orientation 1702 will pass between the flat sections 1718 and be prevented from sliding onto the flat sections 1718. The tray passes between because in the longitudinal orientation 1702, the presented dimension to the flat sections 1718 is the breadth 1706 of the tray, which is less than the distance that the flat sections 1718 is apart and therefore not long enough to reach across the flat sections 1718. However, this distance apart 1720 should be less than the length 1708 of the tray to

allow a tray entering in the horizontal orientation 1704 to slide onto the flat sections 1718. Allowance occurs because in the horizontal orientation 1704, the presented dimension is its length 1708, which is larger than the distance that the flat sections 1718 is apart 1720. Accordingly, the distance that the flat sections 1718 begin apart 1720 is designed to be more than the breadth 1706 of the tray but less than the length 1708 of the tray.

[117] The sloping section 1716 and the flat sections 1718 are separate fixtures of the tray receptacle 1306A, 1306B. With reference to Figure 17C, the sloping section 1716 is located below the flat sections 1718, so that the compartment 1714 for the longitudinal orientation is provided on a lower deck of the tray receptacle 1306A, 1306B, while the compartment 1712 for the horizontal orientation is provided on an upper deck of compartment 1712 for the horizontal orientation. The width 1814 for each of the flat sections 1718 is narrower near the entrance 1710 and wider 1826 toward the end of the tray receptacle 1306A, 1306B. The wider segment 1826 of the flat sections 1718, in conjunction with a mechanical stop 1724 prevents the tray from falling out when the tray receptacle 1306A, 1306B is rotated to clear content (see Figure 14B). The sloping section 1716 tapers to an opening 1730. The opening 1730 allows loose crockery to fall through. In contrast, the base of the tray receptacle 206 (see Figures 8A and 8B) has no opening. An inclined surface 1802 flanks each of the tapering edges of the sloping section 1716 and the opening 1730. The sloping section 1716, the opening 1730 and the inclined surface 1802 constitute parts of the base 1740 (refer Figure 17A) for the tray receptacle 1306A, 1306B.

[118] With reference to both Figures 17B and 17C, the flat sections 1718 extend over at least a portion of the base 1740 of the tray receptacle 1306A, 1306B, the base 1740 having the sloping section 1716, the opening 1730 and the inclined surface 1802 as mentioned above. On each flat section 1718 extends a side wall 1808, so that there are opposing side walls 1808, with each disposed on a corresponding flat section 1718. A ridge 1810 extends from each of the side walls 1808, so that the ridges 1810 extend towards each other. Each ridge 1810 extends to be over at least a portion of a corresponding flat section 1718. A gap 1816 between the ridges 1810, in addition to the gap 1828 between the flat sections 1718, allow contents on the tray, such as crockery, to pass through without obstruction as the tray progresses further into the tray receptacle 1306A, 1306B in either of the two compartments 1712 and 1714.

[119] A mechanical stop 1724, 1726 is disposed at an end of each of the flat sections 1718 and the base 1740, so that the compartment 1712 for the horizontal orientation and the compartment 1714 for the longitudinal orientation each has its own mechanism to stop the tray when it reaches the end of the respective compartment 1712 and 1714.

[120] The mechanical stop 1724 at the end of the base 1740 (i.e. the mechanical stop 1724 for the compartment 1714) has a pair of bars. Each bar is coupled at one end to the base 1740 and at another end to a corresponding flat portion 1718. The mechanical stop 1724 at the end of the base 1740 (i.e.

the mechanical stop 1724 for the compartment 1712) has a pair of bars, each bar being coupled at one end to the base 1740 and at another end to a corresponding flat portion 1718. The mechanical stop 1726 at the end of the flat sections 1718 (i.e. the mechanical stop 1726 for the compartment 1712) has a pair of bars, each bar being coupled at one end to one of the flat sections 1718 and at another end to the corresponding ridge 1810.

[121] Figures 18A and 18B show a tray being received in different orientations by the tray receptacle 1306A, 1306B. These Figures show that the tray either enters the compartment 1712 for horizontal orientation (refer Figure 17B) or the compartment 1714 for longitudinal orientation, depending on an angle in which the tray enters the tray receptacle 1306A, 1306B relative to the longitudinal orientation 1702 or the horizontal orientation 1704.

[122] In Figure 18A, the tray is received angled in a substantially horizontal orientation 1704 on the conveying surface 1350, which has at least one protruding strip 1904. For example, the conveying surface 1350 may have two protrusions 1904, each located at half a cycle of the conveying surface 1350. As the conveying surface 1350 moves the tray towards the tray receptacle 1306A, 1306B, facilitated by traction from protrusion 1904 pushing against the tray, the compartment 1712 for the horizontal orientation will be selected since it is natural (i.e. the tray has a tendency) for the tray to slide along the flat sections 1718 of the compartment 1712 as the tray moves further into the tray receptacle 1306A, 1306B. Either breadth 1706 of the tray may contact an inner surface of a corresponding wall 1808 as the tray moves further into the tray receptacle 1306A, 1306B, which adjusts the tray into the horizontal orientation 1704. Accordingly, the compartment 1712 aligns the tray into the horizontal orientation 1704 even if the tray is misaligned relative to the horizontal orientation 1704 before it enters the tray receptacle 1306A, 1306B. The compartment 1714 for the longitudinal orientation will not be selected because of a mismatch between the opening width 1720 (refer Figure 17C) of the sloping section 1716 and the length 1708 of the tray, with the length 1708 of the tray exceeding the width 1720 of the sloping section 1716.

[123] In Figure 18B, the tray is received with slight misalignment relative to a longitudinal orientation 1702 on the conveying surface 1350. As the conveying surface 1350 moves the tray towards the tray receptacle 1306A, 1306B, the compartment 1714 for the longitudinal orientation will be selected since the tray will naturally (i.e. has the tendency to) start sliding down the sloping section 1716 as the tray moves further into the tray receptacle 1306A, 1306B. The tray will eventually slide entirely onto the sloping section 1716 as the tray is pushed further into the tray receptacle 1306A, 1306B by the conveying surface 1350. Accordingly, the compartment 1714 aligns the tray into the longitudinal orientation 1702 even if the tray is misaligned relative to the longitudinal orientation 1702 before it enters the tray receptacle 1306A, 1306B. The compartment 1712 for the horizontal orientation will not be selected because of a mismatch between the distance the flat sections 1718 are

apart 1720 (refer Figure 17C) and the width 1706 of the tray, with the distance the flat sections 1718 are apart 1720 exceeding the width 1706 of the tray.

[124] Figure 19A shows a perspective view of the front deck module 1210, while Figure 19B shows a side view of the front deck module 1210. A conveyor belt 1902 of the front deck module 1210 has a series of protruding strips 1904 that are spaced apart. The tray for returning into the automated station 1202 is placed on the conveyor belt 1902 forward of the protrusion 1904. As the conveyor belt 1902 rolls to push the tray into the tray receptacle 1306A, 1306B, slippage may occur. The tray may continue to slip until it engages with the protrusion 1904, whereby the slippage stops. The protruding strip 1904 then provides traction by pushing against the tray to ensure that the tray enters the tray receptacle 1306A, 1306B fully and straightens the tray if it is slanted. If the tray is placed directly on one or more protrusions 904, then the likelihood of the tray slipping while the conveyor belt 902 moves is reduced. Suitable material for the protrusions 904 include rubber strips.

[125] The housing 1906 of the front deck module 1210 has sensors 1908 including one or more of photo-sensor(s), color sensor(s), or reflective sensor(s). These sensors 1908 detect whether a correct tray is placed onto the conveyor belt 1902, such as through a colour check, as described above with respect to Figure 14A.

[126] Figure 20 shows a side cross sectional view of the bin assembly 1204. The bin assembly 1204 has one or more bins 1520, 1526, 1550. The crockery bin 1520 is for storing the crockery from the crockery sorter 1502 (refer Figure 15). The tray storage bin 1526 is for storing the tray after ejection from the tray receptacle 1306A, 1306B. The waste water bin 1550 is for storing the cutlery from the cutlery sorter 1504. A plurality of sieves 1522, 1508 is disposed in one or more of the bins 1520, 1526, 1550. The cutlery sieve 1522 and the food waste sieve 1516 are disposed in the waste water bin 1550, whereby the cutlery sieve 1522 is positioned downstream of the cutlery sorter 1504 to catch the cutlery, while the food waste sieve 1516 is positioned downstream of the inclined waste catchment surface 1506 to catch the food waste. The waste water bin 1550 is to store water that is drained from the food waste sieve 1516 and the cutlery sieve 1522. The water that drains from either or both of these sieves 1508 and 1522 includes water from the water jet 1302 that is sprayed to clean the inclined waste catchment surface 1506, the crockery sorter 1502 and the cutlery sorter 1504. The waste water bin 1550 may be replaced with a waste digester, such as a compostor for composting food waste into plant fertilizer.

[127] Figure 21A shows a side view and a perspective view of the cutlery sieve 1522. Figure 21B shows a side view and a perspective view of the food waste sieve 1516.

[128] The tray receptacles 206; 1306A and 1306B are interchangeable. That is, the automated station 102 may use the tray receptacle 1306A, 1306B instead of the tray receptacle 206. This is achieved by having its motor 208 couple to the tray receptacle 1306A, 1306B. Similarly, the automated station 1202 may use a pair of tray receptacles 206, instead of the pair of tray receptacle

1306A, 1306B. This is achieved by having its motor 1308 couple to the connector 1322 with the tray receptacle 206 at each end.

[129] Both automated tray return systems 100, 1200 are configured to detect when one of the bins in their respective bin assemblies 104, 1204 is full, for instance the crockery bin 420, 1520; or the tray storage bin 426, 1526. A designated indicator from the LED indicators 130, 1230 will light up to notify users accordingly and notify cleaners to replace the bins that are full.

[130] The automated tray return systems 100, 1200 are also configured to recognise tray and crockery colours; and programmable to only receive trays and crockery of a pre-set colour. This is useful to prevent cross-mixing of trays, crockery and cutlery for designated dietary restrictions (e.g. vegetarian, non-vegetarian; and religious sensitivities like Halal and Non Halal). For example, when deploying several automated tray return systems 100, 1200, each may be designated to receive a tray designated for use by vegetarian, non-vegetarian, Halal and Non-Halal food stalls. In case of stoppage, the automated tray return systems 100, 1200 can be reboot through the power switch 114, 1214 or an emergency stop button.

[131] In addition to being able to receive a tray in any orientation, the tray receptacles 206; 1306A and 1306B of the automated tray return systems 100, 1200 are designed with sufficient clearance to receive such trays stacked. Their respective entrances 710, 1710 are rounded to facilitate return of these trays.

[132] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

[133] While this invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes can be made and equivalents may be substituted for elements thereof, without departing from the spirit and scope of the invention. In addition, modification may be made to adapt the teachings of the invention to particular situations and materials, without departing from the essential scope of the invention. Thus, the invention is not limited to the particular examples that are disclosed in this specification, but encompasses all embodiments falling within the scope of the appended claims.

CLAIMS

1. An automated tray return system comprising
a tray receptacle having an entrance to receive a tray;
5 a motor coupled to the tray receptacle, wherein during operation, the motor rotates the tray receptacle to clear content from the tray, followed by a further rotation to eject the tray from the entrance, a speed at which the motor rotates the tray receptacle being adjustable;
a sorter arrangement resting on an incline and positioned to catch the content from the tray, the sorter arrangement having openings sized to allow some of the content to pass but prevent others
10 from passing; and
a bin assembly to receive the tray from the tray receptacle and the sorted content from the sorter arrangement.
2. The automated tray return system of claim 1, wherein the tray receptacle comprises at least
15 two compartments, each to align the tray into a longitudinal orientation or a horizontal orientation, the selected compartment depending on an angle in which the tray is received into the tray receptacle, the longitudinal orientation being where a breadth of the tray faces the entrance of the tray receptacle and the horizontal orientation being where a length of the tray faces the entrance of the tray receptacle.
- 20 3. The automated tray return system of claim 2,
wherein the compartment that aligns the tray into the longitudinal orientation comprises a sloping section beginning with a width that is less than the length of the tray, the beginning of the sloping section being disposed at the entrance; and
wherein the compartment that aligns the tray into the horizontal orientation comprises a pair
25 of sections which are flat relative to the sloping section, the flat sections beginning apart by a distance which is more than the breadth of the tray, and the beginning of the flat sections being disposed at the entrance.
4. The automated tray return system of claim 3, wherein each of the flat sections extend from
30 opposite side edges of the sloping section, wherein the tray receptacle further comprises
opposing side walls, each disposed along a corresponding flat section; and
a ridge extending from each of the opposing side walls to be over at least a portion of a corresponding flat section; and
a mechanical stop disposed at an end of each of the sloping section and the flat sections.
- 35 5. The automated tray return system of claim 4,

- wherein the mechanical stop at the end of the sloping section comprises
- a pair of protruding brackets, each bracket being coupled at one end to the sloping section and at another end to a corresponding ridge; and
- wherein the mechanical stop at the end of the flat sections comprises
- 5 a pair of bars, each bar being coupled at one end to one of the flat sections and at another end to the corresponding ridge.
6. The automated tray return system of claim 3, wherein the flat sections extend over at least a portion of a base with the sloped section, wherein the tray receptacle further comprises
- 10 opposing side walls, each disposed along a corresponding flat section;
- a ridge extending from each of the opposing side walls to be over at least a portion of the corresponding flat section; and
- a mechanical stop disposed at an end of each of the base and the flat sections.
- 15 7. The automated tray return system of claim 6,
- wherein the mechanical stop at the end of the base comprises
- a pair of bars, each bar being coupled at one end to the base and at another end to a corresponding flat portion; and
- wherein the mechanical stop at the end of the flat sections comprises
- 20 a pair of bars, each bar coupled at one end to one of the flat sections and at another end to the corresponding ridge.
8. The automated tray return system of any of the preceding claims, wherein the motor is coupled to a pair of the tray receptacles through a connector to which the tray receptacles are rigidly
- 25 coupled, wherein during operation, only one of the tray receptacles is configured to have an inserted tray.
9. The automated tray return system of claim 8, wherein the pair of the tray receptacles rotates in a same direction when clearing the content on the tray and ejecting the tray, the motor being stopped
- 30 when the tray is ejected.
10. The automated tray return system of claim 8 or 9, wherein following ejection of its tray from one of the tray receptacles, the other tray receptacle is in an alignment to receive a new tray.
- 35 11. The automated tray return system of any one of the claims 8 to 10, wherein the sorter arrangement is located below the pair of the tray receptacles.

12. The automated tray return system of any one of the claims 1 to 7, wherein the motor reverses a rotation direction of the tray receptacle, after clearing the content on the tray, to eject the tray.
- 5 13. The automated tray return system of claim 12, wherein the sorter arrangement is located forward of the tray receptacle, wherein during operation, the motor rotates the tray receptacle with sufficient speed to fling the content on the tray towards the sorter arrangement.
- 10 14. The automated tray return system of any one of the preceding claims, further comprising a water jet disposed proximate to the sorter arrangement, the water jet operable to clean the sorter arrangement and moisten the sorted content in the bin assembly.
- 15 15. The automated tray return system of any one of the preceding claims, further comprising an inclined waste catchment surface,
wherein the sorter arrangement comprises:
a crockery sorter having openings sized to allow food waste and cutlery to pass but prevent crockery from passing; and
a cutlery sorter disposed between the crockery sorter and the inclined water waste catchment surface, the cutlery sorter having slits that run substantially transverse to the openings in the crockery sorter, the slits preventing cutlery from passing but allowing food waste to pass and land on the inclined waste catchment surface.
- 20 16. The automated tray return system of claim 15, wherein the sorter arrangement is pivotally connected to a housing providing the inclined waster catchment surface.
- 25 17. The automated tray return system of claim 15 or 16, wherein the bin assembly comprises one or more bins for storing the tray after ejection from the tray receptacle, the crockery from the crockery sorter and the cutlery from the cutlery sorter;
a plurality of sieves disposed in one or more of the bins, each for catching the cutlery or the food waste and positioned downstream of the cutlery sorter or the inclined waste catchment surface respectively.
- 30 18. The automated tray return system of claim 17, wherein the tray storage bin comprises a plate to receive the tray from the tray receptacle; and
at least one spring biasing the plate towards an opening of the tray storage bin.
- 35

19. The automated tray return system of any one of the claims 16 to 18, wherein the housing and the bin assembly rest on rollers to facilitate removal.

20. The automated tray return system of any of the preceding claims, further comprising a
5 conveying surface from which the tray receptacle receives the tray wherein the conveying surface comprises protruding strips to provide traction to a tray placed onto the conveying surface.