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(54) Conveying method and apparatus

(57) A machine includes a single power source 18 for asynchronously operating dual indexing conveyors 12 and 14. The single power source 18 is part of a drive system 16 for the conveyors 12 and 14 and may be a reversible servo unit 18 operatively connected to gear sets 80 and 82 and one-way clutches 38 to drive the conveyors 12 and 14. Alternatively, the power source may be a uni-directional rotating driver with a linkage to reciprocate a rack operatively connected to gear sets with one-way clutches. Each of the conveyors 12 and 14 advances liquid-filled open-topped containers C and is configured to engage the containers C releasably. The drive system 16 schedules conveyor motion according to a predetermined motion profile. The motion profile comprises sequential indexing periods, each indexing period comprising a move portion and a dwell portion. Each move portion comprises a generally discontinuous acceleration profile that includes generally instantaneous acceleration changes of a finite value.

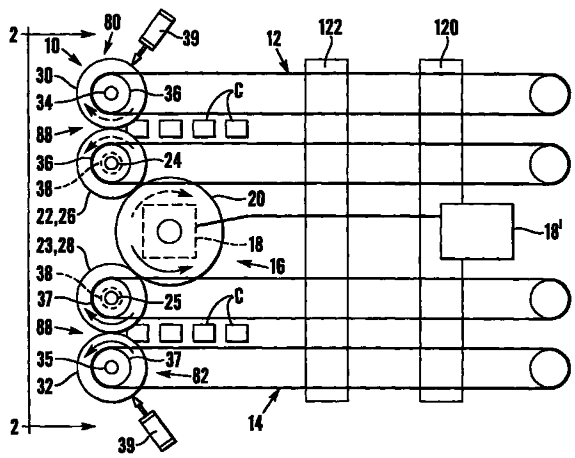

Fig. 1

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Description

[0001] This invention relates generally to an indexing conveying method and apparatus.

[0002] The invention relates more particularly to conveying apparatus including a single power source arrangement for asynchronously operating dual indexing conveyors of the apparatus.

[0003] The invention also relates more particularly to a conveying method and apparatus for moving open-topped liquid-filled containers through a series of processing steps while minimizing liquid slosh in the containers - both during conveyor indexing period dwell portions at processing positions where the processing steps are carried out and during indexing period move portions between processing positions.

[0004] Machines for filling a plurality of containers with liquid products often include conveying apparatus configured to support and successively move containers through various stages of a filling and sealing operation. Typically, a conveying apparatus of this type includes a drive system that indexes, i.e., intermittently moves, a conveyor to advance or successively move the containers first to a filling station where they are filled with the liquid, and then to other stations including top-forming, -heating and -sealing stations where open tops of the containers are closed and sealed. The conveying apparatus then transports the filled, closed and sealed containers to a location where they are off-loaded for shipping or storage.

[0005] US-A-2,628,010 discloses a machine for alternately moving a pair of conveyors, including an air cylinder for alternately actuating a pair of ratchets adapted to rotate respective shafts each carrying a gear operatively connected to a series of gears and further shafts carrying end sprockets for engagement with chains of the pair of conveyors.

[0006] US-A-2,857,787 discloses a common drive mechanism for a pair of asynchronously intermittent, rotating turrets, wherein a portion of the kinetic energy of one turret undergoing deceleration is transferred to the other turret undergoing acceleration. A drive shaft is connected to the two turrets by a pair of cams. A motor is connected to a first speed reduction unit which, in turn, is connected to a second worm gear speed reduction unit, the output of which is connected by a chain to the drive shaft.

[0007] US-A-4,354,086 discloses a drive motor driving two separate cam drive gears for driving first and second transport devices via respective sprocket wheels.

[0008] US-A-4,790,123 discloses a method and machine for driving a pair of conveyors asynchronously. The machine includes a motor, an indexing gear box operatively connected to the motor to convert the continuous rotation of the motor to an indexing movement and to transfer the movement to a driving shaft located centrally in the machine and which, in turn, drives two parallel conveyors.

[0009] A typical conveying apparatus of the kind which includes a drive system that indexes a conveyor to advance containers stepwise may employ either a mechanical cam system or an electronically controlled servo drive motor to schedule conveyor motion and dwell according to a predetermined motion profile. A motion profile is a sequence of accelerations, velocities and/or positions that the drive system imparts to the conveyor and containers. Motion profiles for such systems are cyclical, with each operating cycle or indexing period comprising both a move portion and a dwell portion. Consequently, the motion of the conveyor alternates between dwell portions and motion portions. During the move portion of each indexing period, the conveyor moves the containers between stations. During the dwell portion of each indexing period the conveyor holds the containers stationary at the stations so that operations may be performed on them. Motion profiles also include a predetermined indexing pitch value, which is the distance the conveyor travels during the move portion of each indexing period. Conveyor positioning relative to the stations may also be included in a motion profile.

[0010] In a cam-scheduled conveyor apparatus, a constant speed drive motor is operatively connected to a cam having cam profile characteristics that cause the conveyor to advance intermittently according to a predetermined motion profile. A conveyor apparatus of this type is disclosed in US-A-3,486,423.

[0011] In an electronically scheduled conveying apparatus, an electronic control is programmed to cause the conveyor to move according to the predetermined motion profile. The electronic control accomplishes this by controlling a servo drive motor that is operatively connected to the conveyor. Examples of such systems are disclosed in US-A-5,419,099, US-A-5,385,003 and US-A-5,826,406.

[0012] Increasing production requirements have increased the demands placed on conveyor apparatus of this type. Increased throughput has been achieved by using more aggressive motion profiles that accelerate and move containers more rapidly between stations, by shortening dwell periods, and/or by increasing indexing frequency, i.e., the number of indexing cycles per second. Problematically, aggressive motion profiles tend to have high maximum acceleration values, which are known to increase liquid surface tilt, or slosh. High indexing frequencies are also known to cause excessive liquid slosh in the containers being transported. Increased slosh can result in spillage during movement and can hamper operations such as closing and sealing that occur during the dwell portion of each indexing period.

[0013] As is shown in Figure 5 of the present drawings, during the move portion of each indexing period each container C and the liquid 112 inside each container C move in direction 113 and experiences accelerations Ax in a direction normal to that of gravity g. A liquid surface 114 of the liquid 112 will be tilted at a tilt angle θ such that the liquid surface 114 will be perpendicular to the vector sum of the accelerations Ax and g acting on the liquid 112. This is undesirable with respect to the packaging effort because it brings the liquid 112 closer to a container sealing area 116 of the container C. Therefore, it is desirable to minimize the tilt angle θ of the liquid 112 during an indexing period.

[0014] There exists a static relationship between the liquid surface tilt angle θ and the accelerations on the liquid, such that:

$$\tan(\theta)=Ax/g,$$

where

Ax=the acceleration acting normally to gravity; and
g=the acceleration due to gravity.

[0015] Using this equation, it is possible to predict the amount that the liquid 112 will creep up a wall 118 of the container C relative to its position with zero Ax. That is to say, if a constant acceleration Ax were to be applied to the carton, and the liquid surface 114 "magically" positioned to tilt at the angle θ calculated from the above equation, the liquid surface 114 would remain at that angle for as long as Ax was applied. However, for any practical indexing situation this equation loses its usefulness because it does not capture the dynamic aspects of the indexing motion. Typically, the acceleration Ax during index varies continuously, going from zero to some maximum positive value, then through zero to some maximum negative value, and finally back to zero again at the end of the indexing period. Even if a container containing liquid were to be accelerated with a constant Ax, the above equation would not predict the maximum slosh height because of the limitations mentioned above.

[0016] Approaches that have been taken to reduce slosh include the intuitively obvious approaches of using less aggressive motion profiles, for example, slowing the indexing frequency of the conveyor, although the latter measure would also reduce throughput.

[0017] Up until the time of conception of the present invention, conveyor motion profiles had been controlled by cams configured to execute generally continuous or "jerk-limited" acceleration profiles. In other words, the acceleration profiles included gradual changes in acceleration rather than instantaneous or near-instantaneous acceleration changes of a finite value. The differential of such an acceleration profile with respect to time results in a finite jerk value along the entire profile. Continuous acceleration curves were an obvious choice for indexing liquid-filled containers because such profiles were known to reduce machine wear and vibration in high-speed motion-inducing machine applications. Commonly employed motion profiles included those having continuous cycloidal, modified sine or modified trapezoidal acceleration curves. Polynomial position profiles that exhibit continuous acceleration were also known.

[0018] Although motion profiles having continuous acceleration curves are and have been known to reduce machine wear and vibration in motion-producing machine applications, in other machine applications, it is not unknown to employ motion profiles having discontinuous, i.e. "non-jerk limited", acceleration curves that include instantaneous or near-instantaneous acceleration changes of a finite value. The differential of such an acceleration curve with respect to time results in an infinite jerk value at one or more points in the profile. Commonly used motion profiles of this type have discontinuous acceleration profiles that produce parabolic motion profiles, simple harmonic motion profiles, and polynomial position profiles that correspond to discontinuous acceleration.

[0019] According to one aspect of the present invention, there is provided apparatus for asynchronously driving a pair of indexing conveyors, said apparatus comprising an actuating source operatively connected to two gear means mounted on respective shaft means for asynchronously driving the pair of conveyors, and one-way clutch means operatively connected to each gear means, characterized in that control means is operatively connected to said actuating source for controlling the acceleration and deceleration of each of the conveyors from and towards each of its dwell positions.

[0020] According to a second aspect of the present invention, there is provided apparatus comprising first and second indexing conveyors, a continually reversing drive member, and first and second connecting means connecting said drive member to the respective conveyors in a manner which does not drive the conveyors backwards, characterized in that the apparatus further includes control means arranged to control the speed of said drive member in one sense and an opposite sense throughout substantially the whole of each decelerating movement and each accelerating movement of said drive member into and out of each dwell position of said drive member.

[0021] According to a third aspect of the present invention, there is provided apparatus comprising first and second indexing conveyors, a continually reversing drive member, and first and second connecting means connecting said drive member to the respective conveyors in a manner which does not drive the conveyors backwards, characterized in that said first and second connecting means include first and second toothed elements, respectively, and said drive member comprises a third toothed element in driving connection with said first and second toothed elements.

[0022] According to a fourth aspect of the present invention, there is provided a method comprising providing first and second indexing conveyors, a drive member, and first and second connecting means connecting said drive member to the respective conveyors, continually reversing said drive member so as to drive the conveyors alternately through said first and second connecting means in a manner which does not drive the conveyors backwards, characterized by controlling the speed of said drive member in one sense and an opposite sense throughout substantially the whole of each decelerating movement and each accelerating movement of said drive member into and out of each dwell position of the drive member.

[0023] Owing to these aspects of the invention, it is possible to improve apparatus for driving a pair of conveyors asynchronously, in particular from a single power source. It is also possible to provide controlled motions of the conveyors, as is required for moving liquid-filled containers the tops of which are open.

[0024] A preferred embodiment of the invention is a machine including an intermittently actuating single power source operatively connected to two gear devices, which may be respective single gears or respective sets of gears, having one-way clutches connected thereto, and being mounted on shafts which asynchronously drive a pair of indexing conveyors carrying open-topped cartons through filling and top-forming and-sealing stations.

[0025] The power source may be one of (1) a reversible servo unit having a gear thereon for meshing with respective gears of the two gear devices, and (2) a unidirectional rotating driver with linkage means connected from the driver to reciprocate a rack for meshing with respective gears of the gear devices.

[0026] According to a fifth aspect of the present invention, there is provided container conveying apparatus for moving liquid-filled open-topped containers, the apparatus comprising:

a conveyor configured to engage releasably at least one of the containers; and
a drive system operatively connected to the conveyor and configured to schedule conveyor motion according to a predetermined motion profile comprising at least one indexing period, the or each indexing period comprising a move portion and a dwell portion, characterized in that the drive system is configured to accelerate the conveyor discontinuously during the or each indexing period move portion and in that the discontinuous acceleration of the conveyor is describable by an acceleration curve that includes generally instantaneous acceleration changes of a finite value.

[0027] According to a sixth aspect of the present invention, there is provided a method of moving liquid-filled open-topped containers, comprising conveying the containers according to a predetermined motion profile comprising at least one indexing period, the or each indexing period comprising a move portion and a dwell portion, characterized in that the conveying includes discontinuously accelerating the containers during the or each indexing period move portion, and in that the discontinuous acceleration is describable by an acceleration curve that includes generally instantaneous acceleration changes of a finite value, whereby slosh is minimized and greater through-put is obtainable.

[0028] Owing to these aspects of the invention, it is possible to minimize slosh while allowing higher through-put.

[0029] In order that the invention may be clearly and completely disclosed, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a diagrammatic top plan view of a filling and top-sealing machine for containers;
Figure 2 is a diagrammatic end view taken along the plane of the line 2-2 of Figure 1, and looking in the direction of the arrows;
Figure 2A is a fragmentary, diagrammatic, end view of an alternative embodiment of the machine of Figure 2;
Figure 3 is a view similar to Figure 1, but of another version of the machine;
Figure 4 is a view similar to Figure 2, but taken along the plane of the line 4-4 of Figure 3, and looking in the direction of the arrows;
Figure 4A is a view similar to Figure 2A of an alternative embodiment of the machine of Figure 4;
Figure 5 is a schematic vertical sectional view of a liquid-filled open-topped container being laterally accelerated during a move portion of an indexing period of one of the conveyors of the machine;
Figure 6 is a graph showing the velocity curve of a parabolic motion profile of a single indexing period of the one of the conveyors of the machine;
Figure 7 is a graph showing a discontinuous acceleration curve of the single indexing period of Figure 6; and
Figure 8 is a graph representing a continuous modified sine acceleration curve.

[0030] Referring now to the drawings in greater detail, Figures 1 and 2 illustrate a container-conveying apparatus 10 for supporting and successively moving containers C through a filling station 120 and a top-sealing station 122 in a container-forming and-sealing machine. The apparatus 10 includes (1) a pair of side-by-side indexing conveyors 12 and 14 adapted to receive and convey the containers C; and (2) a drive system 16 adapted to drive the indexing conveyors 12 and 14 asynchronously during container-filling and top-folding and-sealing operations. However, in other embodiments, the apparatus 10 may include only one or more than two indexing conveyors.

[0031] The drive system 16 includes a reversible servo unit 18 driving a gear 20, which drives two gear devices 80 and 82 which drive the respective conveyors 12 and 14. The device 80 comprises gears 22, 26 and

30, whilst the device 82 comprises gears 23, 28 and 32. The gear devices 80 and 82 have respective shaft arrangements 84 and 86, of which the arrangement 84 comprises shafts 24 and 34 and the arrangement 86 comprises shafts 25 and 35. The gears 26 and 30 and the gears 28 and 32 are respective pairs of intermeshing gears 88. The two gears 22 and 23 mesh with the gear 20 and are mounted on the respective shafts 24 and 25. The gears 26 and 28 are also mounted on the respective shafts 24 and 25 (Figure 2). The gears 26 and 28 mesh with the respective further gears 30 and 32 mounted on the respective shafts 34 and 35. The shafts 24/34 and 25/35 rotate respective pulleys or sprockets 36 and 37 for driving two sides of the respective conveyors 12 and 14. A one-way clutch 38 is operatively connected between each of the gears 22 and 23 and its associated shaft 24 or 25, to drive the conveyors 12 and 14 asynchronously via the shafts 24/34 and 25/35 in one direction, depending upon the direction of rotation of the reversible servo unit 18.

[0032] A suitable, optional, holding device 39 may be operatively connected to each of the gears 30 and 32 to maintain the dwell or stop positions of the conveyor 12 or 14.

[0033] As an alternative embodiment, the apparatus 10 may have the gear 20 mesh directly with each of the gears 26 and 28, as shown in Figure 2A, with a clutch 38 operatively connected to each of the gears 26,30,28 and 32 and their respective shafts. In this embodiment, the gear device 80 comprises the pair 88 of intermeshing gears 26 and 30 and the gear device 82 comprises the pair 88 of intermeshing gears 28 and 32.

[0034] A servo unit, such as the reversible servo unit 18, typically may be variably accelerated and decelerated by virtue of an associated reversible servo unit controller, represented as 18' in Figure 1, programmed to use a parabolic curve or cam emulation. As such, the approach toward and departure from each dwell position of each of the conveyors 12 and 14 assumes a controlled motion, serving to minimize "slosh" of the product within the liquid-carrying containers C during the intermittent conveying thereof.

[0035] Referring now to Figures 3 and 4, there is illustrated an alternative embodiment of a container-conveying apparatus 10A. The apparatus 10A includes (1) the pair of side-by-side indexing conveyors 12A and 14A, also adapted to receive and convey containers C; and (2) a drive system 40 adapted to asynchronously drive the indexing conveyors 12A and 14A during the processing of the containers.

[0036] The system 40 includes a uni-directionally rotating driver unit 42, which may be electrical, such as a step motor or a servo motor. A crank arm 44 is connected to the driver unit 42 for rotation therewith. A link 46 is pivotally connected between the distal end of the crank arm 44 and a two-sided toothed rack 48 and is adapted to move the rack 48 longitudinally back and forth. The toothed rack 48 meshes at one side thereof with a gear 50 of the gear device 80 and at the other side thereof with a gear 52 of the gear device 82. A one-way clutch, which may be a ratchet-and-pawl, represented as 54, is operatively connected to each of the gears 50 and 52. The gear device 80 comprises the gear 50 and gears 55 and 56, whilst the gear device 82 comprises the gear 52 and gears 64, 66 and 68. The shaft arrangement 84 comprises the shafts 58 and 60, whilst the shaft arrangement 86 comprises the shafts 62, 67 and 69. The gear device 80 includes the pair 88 of intermeshing gears 55 and 56 and the gear device 82 includes the pair 88 of intermeshing gears 66 and 68.

[0037] Where the apparatus 40 is electrical, with the unit 42 being for example a servo motor or a step motor, a servo controller, represented as 40', is programmed to use a parabolic curve or cam emulation to control acceleration and deceleration, and, thereby, minimize liquid product slosh in the containers as they are being transferred from station to station. Alternatively, the toothed rack 48 may be driven mechanically, such as by a cam, an indexer, or a geneva mechanism, represented as 48', machined to produce the required motion and driven by a constant speed drive motor.

[0038] The gears 50 and 55 are mounted on the same shaft 58. The gear 55 meshes with the gear 56 mounted on the shaft 60. The gears 55 and 56 rotate pulleys or sprockets 61 mounted on the respective shafts 58 and 60 for driving the two sides of the conveyor 12A carrying containers C therebetween on the pull stroke of the rack 48.

[0039] The gear 52 is mounted on the shaft 62. The gear 64 is also mounted on the shaft 62 and meshes with the gear 66. The latter gear 66 is mounted on the shaft 67 and meshes with the gear 68 mounted on the shaft 69. The gears 66 and 68 rotate pulleys or sprockets 70 mounted on the respective shafts 67 and 69 for driving the two sides of the conveyor 14A, also carrying containers C therebetween, on the push stroke of the rack 48. The one-way clutches 54 operatively connected between the gears 50 and 52 and their respective associated shafts 58 and 62 serve to drive the conveyors 12A and 14A asynchronously via the shafts 58/60 and 67/69 in one direction, depending upon the direction of movement of the rack 48.

[0040] As an alternate embodiment, as shown in Figure 4A, the apparatus 10A may have the rack 48 mesh directly with each of the gears 55 and 64, with clutches 54 operatively connected between the gears 55,56,66 and 68 and their respective shafts 48,60,67 and 69. The gear device 80 comprises the pair 88 of intermeshing gears 55 and 56, whilst the gear device 82 comprises the pair 88 of intermeshing gears 66 and 68 and the third gear 64. The shaft arrangement 84 comprises the shafts 58 and 60, whilst the shaft arrangement 86 comprises the shafts 62,67 and 69.

[0041] An optional holding device 72 may be operatively connected to each of the gears 56 and 68 to maintain respective dwell positions of the conveyors 12A and

14A.

[0042] As shown in Figures 1 to 4A, and described above, the container-conveying apparatus 10,10A each comprise two conveyors 12,14; 12A,14A. As is also stated above, other embodiments may include only a single conveyor. Therefore, for the sake of simplicity, the remainder of this description will refer only to conveyor 12 relative to the embodiments of Figures 1,2 and 2A and only to conveyor 12A relative to the embodiments of Figures 3,4 and 4A. Except where stated otherwise, all description relating to elements of the embodiments of Figures 1,2 and 2A is intended to apply equally to corresponding elements of the embodiments of Figures 3,4 and 4A.

[0043] The conveyor 12, 12A is configured to engage releasably a plurality of the containers C and the drive system 16,40 is operatively connected to the conveyor 12,12A. The drive system 16,40 is configured to schedule conveyor motion and the motion of any containers C engaged by the conveyor 12,12A according to a predetermined motion profile shown in Figures 6 and 7. The drive system 16,40 successively moves the containers C in an open-topped condition first to a filling station schematically shown at 120,120A in Figures 1 and 3, respectively, where they are filled with liquid. The drive system 16,40 then moves the containers C to other stations including a top-sealing station schematically shown at 122,122A in Figures 1 and 3, respectively, where the open tops of the containers C are closed and sealed. The motion profile comprises a plurality of sequential indexing periods, one of which is representatively shown at 124 in Figures 6 and 7. Each indexing period 124 comprises a move portion 126 and a dwell portion 128 to produce conveyor motion that alternates between dwell portions 128 and motion portions 126. The conveyor 12 moves the containers C between stations 120,122 during the move portion 126 of each indexing period 124 and holds the containers C stationary during the dwell portion 128 of each indexing period 124. During each indexing period move portion 126 the containers C are accelerated in a generally discontinuous manner as can be described by the generally discontinuous acceleration curve shown in Figure 7. As is also shown in Figure 7, generally instantaneous acceleration changes 130 of a finite value occur at the beginning and the end of the move portion 126 of each indexing period 124 to minimize slosh while allowing a greater number of containers C to be processed in less time.

[0044] The move portion 126 of each indexing period 124 preferably comprises a parabolic motion profile. A parabolic motion profile is preferable, in part, because it is simple to produce. A discontinuous acceleration curve that would be associated with such a parabolic motion profile is shown in Figure 7 and a corresponding velocity curve is shown in Figure 6. Parabolic motion may not be desirable for high operating speed mechanical systems owing to the prospect of excessive wear caused by the acceleration discontinuities at the start and end of the constant acceleration segments of the motion. However, parabolic motion can be used in low operating speed applications without experiencing a significant degree of these deleterious effects.

[0045] Certain discontinuous acceleration curves, such as the constant acceleration curve shown in Figure 7, are preferable to some of the standard continuous acceleration curves such as the modified sine curve shown in Figure 8 because the discontinuous acceleration curves deliver lower maximum slosh angles θ during the dwell and move portions of each indexing period. One explanation for this phenomenon is that, for a given amount of force applied over the move portion of an indexing period, the maximum or peak acceleration of a discontinuous acceleration curve is generally lower than that of a continuous acceleration curve because the maximum acceleration value of the corresponding motion profile is reached almost instantaneously. In the case of a constant acceleration curve such as that shown in Figure 7, acceleration remains constant at the maximum value until the end of the move portion of the indexing period. Alternatively, acceptable results can be obtained with any number of other discontinuous acceleration curves to include those corresponding to position profiles described by one or more 7^{th} order polynomial equations.

[0046] The drive system 16,40 may comprise a unidirectionally rotating driver unit 48' in Figure 3 in the form of a cam operatively connected to a constant speed drive motor, the cam having cam profile characteristics that cause the conveyor 12 to advance intermittently according to a predetermined optimum motion profile. In other embodiments, the cam may be specially machined as part of an otherwise commercially available indexer. The operating speed of the apparatus 10 is the cycle rate at which indexing periods 124 are repeated as can be expressed in cycles per minute, or cam rotations per minute.

[0047] The drive system 16, 40 may, alternatively, comprise a uni-directional rotating driver unit as shown at 42 in Figure 3 in the form of a servo motor operatively connected to the conveyor 12A. An electronic controller 40' is connected to the servo motor 42 and is programmed to command the servo motor to move the conveyor 12A according to the predetermined motion profile.

[0048] It should be apparent that further advantages of the machine described with reference to the drawings are that it includes a compact, efficient, and positively controlled arrangement for asynchronously driving dual indexing conveyors substantially 180 degrees out of phase with one another, for processing, for example, liquid-carrying cartons, thereby reducing the amount of peak power which would be required for a machine having simultaneously operating intermittently driven conveyors.

Claims

1. Apparatus for asynchronously driving a pair of indexing conveyors (12,14; 12A,14A), said apparatus comprising an actuating source (18;42) operatively connected to two gear means (80,82) mounted on respective shaft means (84,86) for asynchronously driving the pair of conveyors (12,14;12A,14A), and one-way clutch means (38;54) operatively connected to each gear means (80,82), characterized in that control means (18';40';48') is operatively connected to said actuating source (18;42) for controlling the acceleration and deceleration of each of the conveyors (12,14;12A,14A) from and towards each of its dwell positions.

2. Apparatus according to claim 1, wherein said actuating source (18;42) drives said first and second gear means (80,82) by way of toothed means (20;48) meshing with respective selected gears (22,23;26,28;50,52;55,64) of the first and second gear means (80,82).

3. Apparatus according to claim 2, wherein said two gear mans (80,82) include respective pairs (88) of intermeshing gears (26,30,28,32) mounted on respective shafts (24,34,25,35) of the respective shaft means (84,86) which drive the respective conveyors (12,14), with respective gears (26,28) of the respective pairs of intermeshing gears (26,30,28,32) being mounted on the shafts (24,25) of said selected gears (22,23).

4. Apparatus according to claim 2, wherein said selected gears (26,28) mesh with respective second gears (30,32) of said gear means (80,82), the selected gear (26,28) and the second gear (30,32) of each gear means (80,82) being mounted on respective shafts (24,34,25,35) of the shaft means (84,86) driving each conveyor (12,14), and said one-way clutch means (38) comprises one-way clutches (38) operatively connected respectively to said selected gears (26,28) and said second gears (30,32).

5. Apparatus according to claim 2, wherein said two gear means (80,82) include respective pairs (88) of intermeshing gears (55,56,66,68) mounted on respective shafts (58,60,67,69) of the respective shaft means (84,86) which drive the respective conveyors (12A,14A), with one (80) of said gear means (80,82) having one gear (55) of its pair (88) mounted on a shaft (58) of its selected gear (50), and the other (82) of said gear means (80,82) having its selected gear (52) and a further gear (64) mounted on a separate shaft (62) of its shaft means (86), and said further gear (64) meshes with one (66) of the pair (88) of intermeshing gears (66,68) of the other gear means (82).

6. Apparatus according to claim 2, wherein the selected gear (55) of one (80) of said gear means (80,82) meshes with a second gear (56) of the one gear means (80), said selected gear (55) and said second gear (56) are mounted on respective shafts (58,60) of one (84) of said shaft means (84,86) driving one (12A) of said pair of conveyors (12A,14A), and the selected gear (64) of the other gear means (82) meshes with one (66) of a pair (88) of intermeshing gears (66,68) mounted on respective shafts (67,69) of the other shaft means (86) for driving the other (14A) of said pair of conveyors (12A,14A), and said one-way clutch means (54) comprises respective one-way clutches (54) operatively connected to the selected gear (55) of said one gear means (80), said second gear (56), and the gears (66,68) of said pair (88).

7. Apparatus according to claim 2, 3, or 5, wherein said one-way clutch means (38;54) comprises respective clutches (38;54) operatively connected to the respective selected gears (22,23;26,28;50,52).

8. Apparatus according to any preceding claim, wherein said control means (18';40') is a servo controller (18';40') programmed to use a parabolic curve or a cam emulation to minimize liquid product slosh in containers (C) being transferred by said conveyors (12,14;12A,14A).

9. Apparatus according to any preceding claim, wherein said actuating source (18) is an intermittently actuating single reversible power source (18).

10. Apparatus according to claim 9, wherein said power source (18) is a reversible servo motor (18) and said control means (18') is a servo controller (18') adapted to provide controlled motion for said conveyors (12,14).

11. Apparatus according to any one of claims 2 to 7, or claim 8 as appended to claim 2, wherein said actuating source (40) comprises a uni-directionally rotating driver (42) and linkage means (44,46) whereby said source (40) actuates said toothed means (48) which is in the form of a rack (48).

12. Apparatus according to claim 11, wherein said rack (48) includes teeth formed on opposite sides thereof for meshing with said respective selected gears (50,52;55,64).

13. Apparatus comprising first and second indexing conveyors (12,14;12A,14A), a continually reversing

drive member (20;48), and first and second connecting means (80,82,38;80,82,54) connecting said drive member (20;48) to the respective conveyors (12,14;12A,14A) in a manner which does not drive the conveyors (12,14;12A,14A) backwards, characterized in that the apparatus further includes control means (18';40';48') arranged to control the speed of said drive member (20;48) in one sense and an opposite sense throughout substantially the whole of each decelerating movement and each accelerating movement of said drive member (20;48) into and out of each dwell position of said drive member (20;48).

14. Apparatus according to claim 13, wherein said drive member (20;48) is driven by a servo motor or a step motor (18;42) and said control means (18',40') is a servo controller arranged to control the motor (18;42).

15. Apparatus according to claim 13, wherein said drive member (48) is driven by said control means (48') which is itself driven by a motor, said control means (48') being a mechanical device shaped to produce a desired motion of said drive member (48).

16. Apparatus according to any one of claims 13 to 15, wherein said conveyors are for advancing liquid-filled open-topped containers, and wherein said control means (18';40';48') is configured to schedule conveyor motion according to a predetermined motion profile comprising at least one indexing period (124), the or each indexing period (124) comprising a move portion (126) and a dwell portion (128), and is also configured to accelerate each conveyor (12,14;12A,14A) discontinuously during the or each indexing period move portion (126), the discontinuous acceleration of each conveyor (12;14;12A,14A) being describable by an acceleration curve that includes generally instantaneous acceleration changes of a finite value.

17. Apparatus according to claim 16, wherein the move portion (126) of each indexing period (124) includes a parabolic motion profile.

18. Apparatus according to claim 17, wherein the move portion (126) of each indexing period (124) includes a generally trapezoidal velocity profile.

19. Apparatus according to claim 16, wherein the move portion of each indexing period includes a polynomial motion profile.

20. Apparatus comprising first and second indexing conveyors (12,14;12A,14A), a continually reversing drive member (20;48), and first and second connecting means (80,82,38;80,82,54) connecting said drive member (20;48) to the respective conveyors (12,14;12A,14A) in a manner which does not drive the conveyors (12,14;12A,14A) backwards, characterized in that said first and second connecting means (80,82,38;80,82,54) include first and second toothed elements (22,23;26,28;50,52;55,64), respectively, and said drive member (20;48) comprises a third toothed element (20,48) in driving connection with said first and second toothed elements (22,23;26,28;50,52;55,64).

21. Apparatus according to claim 20, wherein said first and second connecting means (80,82,38) comprise first and second gear means (80,82), respectively, and wherein said first and second toothed elements (22,23;26,28) comprise respective gears (22,23;26,28) of said first and second gear means (80,82) and said third toothed element comprises an oscillatory gear (20) meshed with said gears (22,23;26,28).

22. Apparatus according to claim 20, wherein said first and second connecting means (80,82,54) comprise first and second gear means (80,82), respectively, and wherein said first and second toothed elements (50,52;55,64) comprise respective gears (50,52;55,64) of said first and second gear means (80,82) and said third toothed element comprises a reciprocatory rack (48) meshed with said gears (50,52;55,64).

23. Apparatus according to claim 21 or 22, wherein said first and second connecting means (80,82,38;80,82,54) include one-way clutches (38;54) operatively connected to the respective said gears (22,23;26,28;50,52;55,64) of the first and second gear means (80,82).

24. A method comprising providing first and second indexing conveyors (12,14;12A,14A), a drive member (20;48), and first and second connecting means (80,82,38;80,82,54) connecting said drive member (20;48) to the respective conveyors (12,14;12A,14A), continually reversing said drive member (20;48) so as to drive the conveyors (12,14;12A,14A) alternately through said first and second connecting means (80,82,38;80,82,54) in a manner which does not drive the conveyors (12,14;12A,14A) backwards, characterized by controlling the speed of said drive member (20;48) in one sense and an opposite sense throughout substantially the whole of each decelerating movement and each accelerating movement of said drive member (20;48) into and out of each dwell position of the drive member (20;48).

25. A method according to claim 20, and further comprising controlling the speed of said drive member

(20;48) throughout substantially the whole of each cycle of movement of the drive member (20:48).

26. A method according to claim 24 or 25, and including conveying liquid-filled open-topped containers (C), and wherein the speed of said drive member (20;48) corresponds to a predetermined motion profile which comprises at least one indexing period (124), the or each indexing period (124) comprising a move portion (126) and a dwell portion (128), and which also comprises discontinuous acceleration during the or each indexing period move portion (126), the discontinuous acceleration being describable by an acceleration curve that includes generally instantaneous acceleration changes of a finite value, whereby slosh is minimized and greater through-put is obtainable.

27. A method according to claim 26, wherein the move portion (126) of each indexing period (124) includes a parabolic motion profile.

28. A method according to claim 27, wherein the move portion (126) of each indexing period (124) includes a generally trapezoidal velocity profile.

29. A method according to claim 26, wherein the move portion of each indexing period includes a polynomial motion profile.

30. Container conveying apparatus for moving liquid-filled open-topped containers, the apparatus comprising:

a conveyor (12,14;12A,14A) configured to engage releasably at least one of the containers (C); and
a drive system (16;40) operatively connected to the conveyor (12,14;12A,14A) and configured to schedule conveyor motion according to a predetermined motion profile comprising at least one indexing period (124), the or each indexing period (124) comprising a move portion (126) and a dwell portion (128), characterized in that the drive system (16;40) is configured to accelerate the conveyor (12,14;12A,14A) discontinuously during the or each indexing period move portion (126) and in that the discontinuous acceleration of the conveyor (12,14;12A,14A) is describable by an acceleration curve that includes generally instantaneous acceleration changes of a finite value.

31. Apparatus according to claim 30, wherein the move portion (126) of each indexing period (124) includes a parabolic motion profile.

32. Apparatus according to claim 31, wherein the move portion (126) of each indexing period (124) includes a generally trapezoidal velocity profile.

33. Apparatus according to claim 30, wherein the move portion of each indexing period includes a polynomial motion profile.

34. Apparatus according to any one of claims 30 to 33, wherein the drive system (40) includes a constant speed drive motor that is operatively connected to a cam (48') having cam profile characteristics that cause the conveyor (12A,14A) to advance intermittently according to the predetermined motion profile.

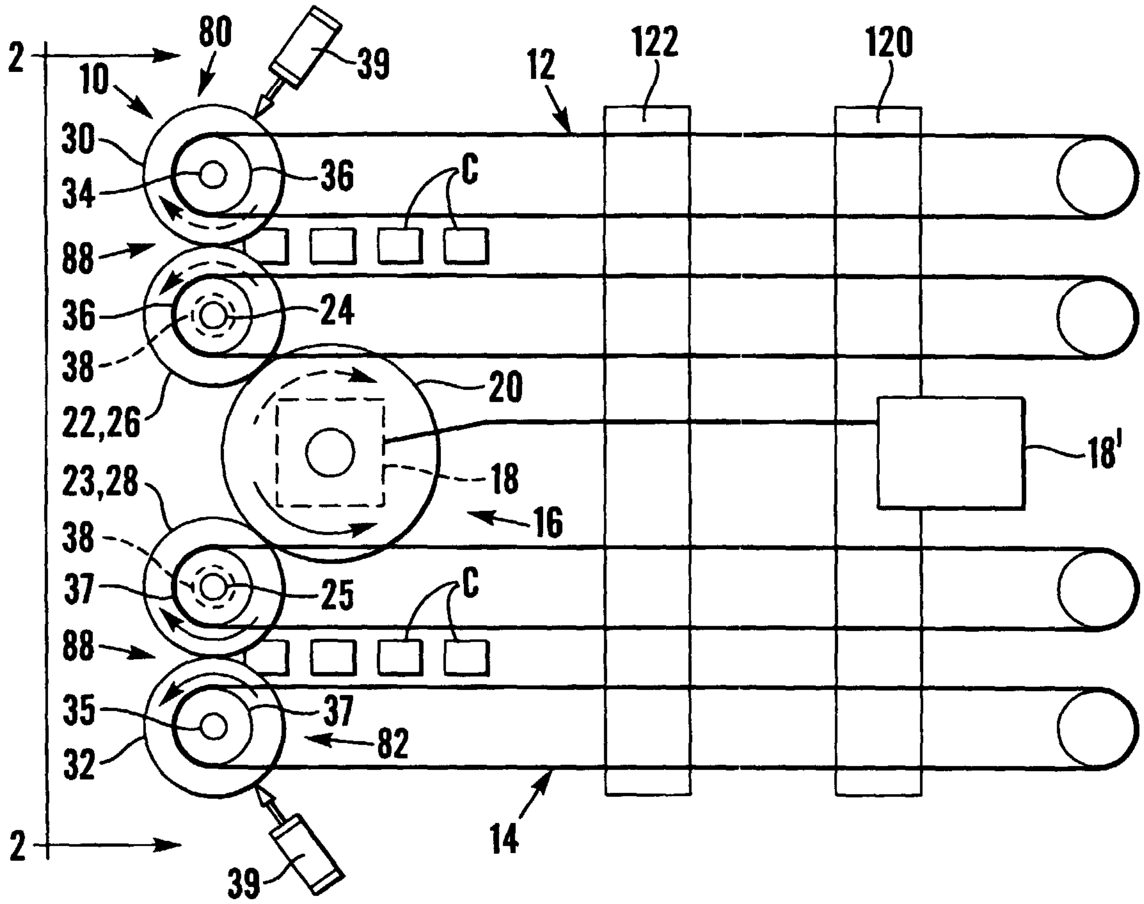
35. Apparatus according to any one of claims 30 to 33, wherein the drive system (16) includes a servo motor (18;42) operatively connected to the conveyor (12,14;12A,14A) and an electronic control (18';40') connected to the servo motor (18;42) and programmed to command the servo motor (18;42) to move the conveyor (12,14;12A,14A) according to the predetermined motion profile.

36. A method of moving liquid-filled open-topped containers (C), comprising conveying the containers (C) according to a predetermined motion profile comprising at least one indexing period (124), the or each indexing period (124) comprising a move portion (126) and a dwell portion (128), characterized in that the conveying includes discontinuously accelerating the containers (C) during the or each indexing period move portion (126), and in that the discontinuous acceleration is describable by an acceleration curve that includes generally instantaneous acceleration changes of a finite value, whereby slosh is minimized and greater throughput is obtainable.

37. A method according to claim 36, wherein the move portion (126) of each indexing period (124) includes a parabolic motion profile.

38. A method according to claim 37, wherein the move portion (126) of each indexing period (124) includes a generally trapezoidal velocity profile.

39. A method according to claim 36, wherein the move portion of each indexing period includes a polynomial motion profile.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39

Fig. 1

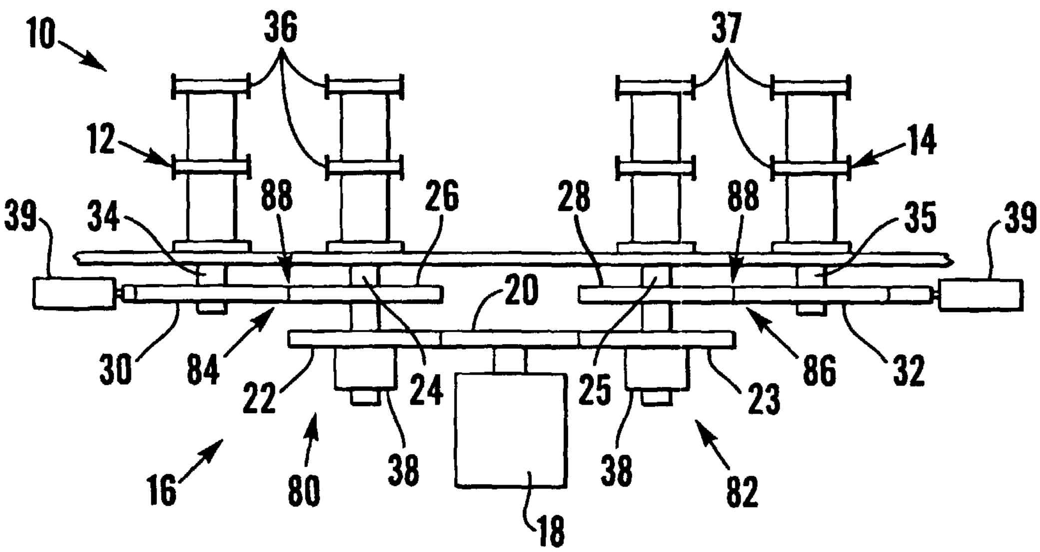
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Fig. 2

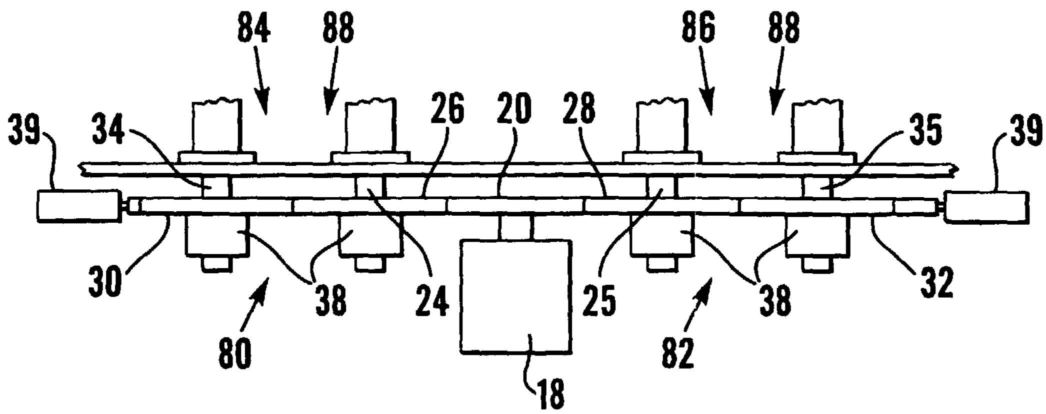
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Fig.2A

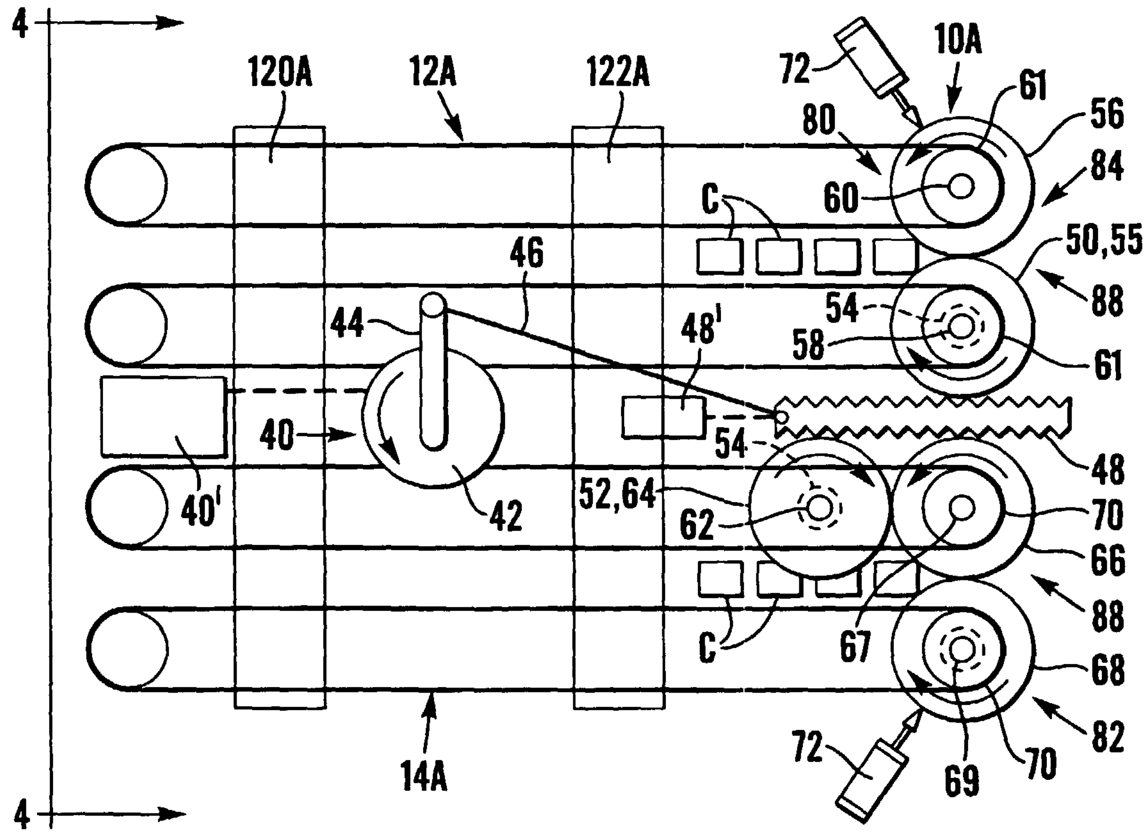
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Fig.3

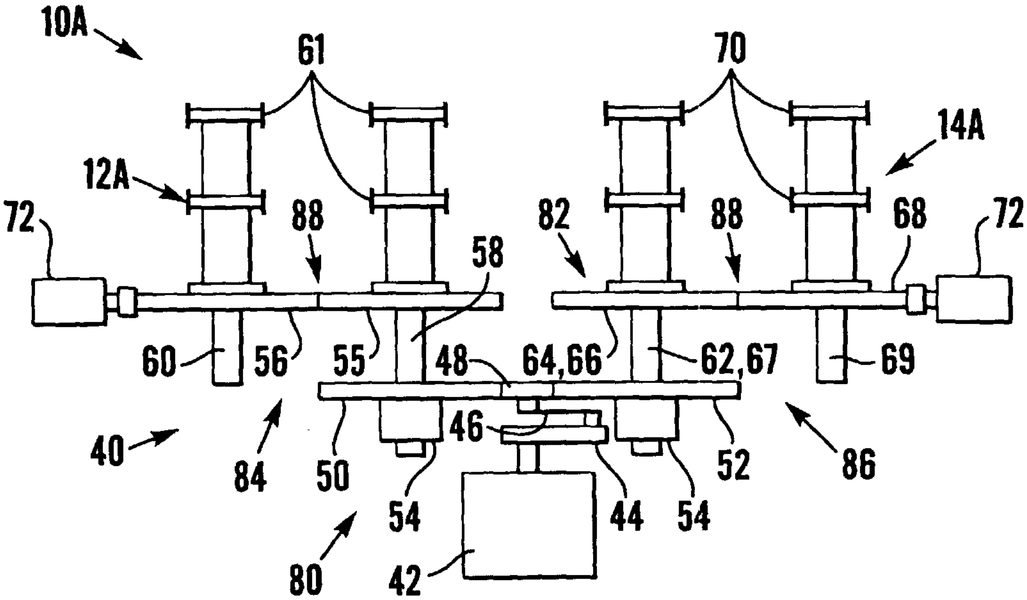
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Fig.4

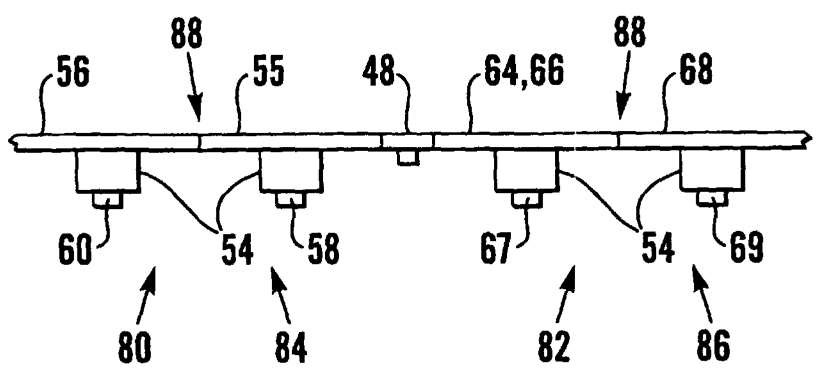
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Fig.4A

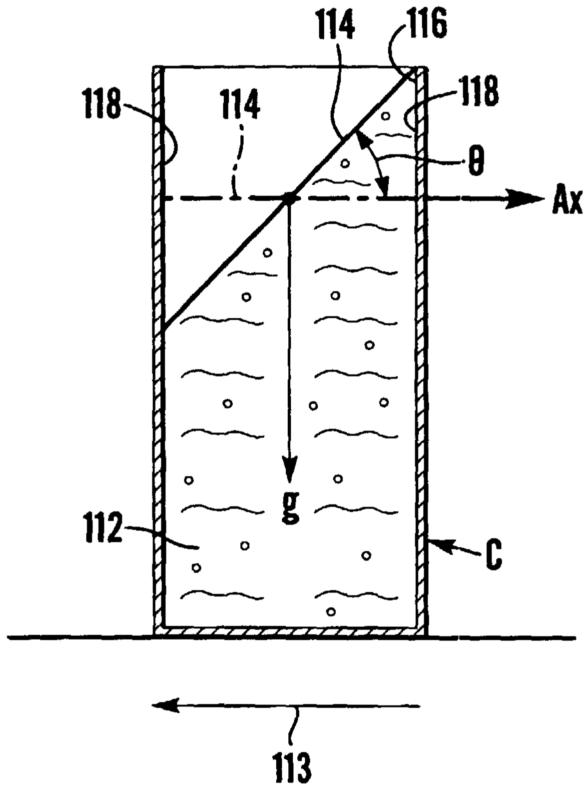

Fig.5

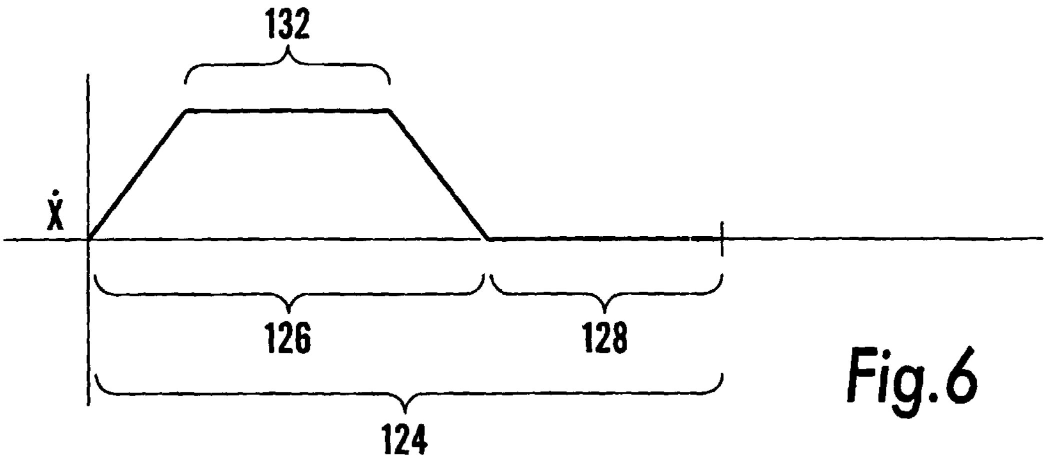

Fig.6

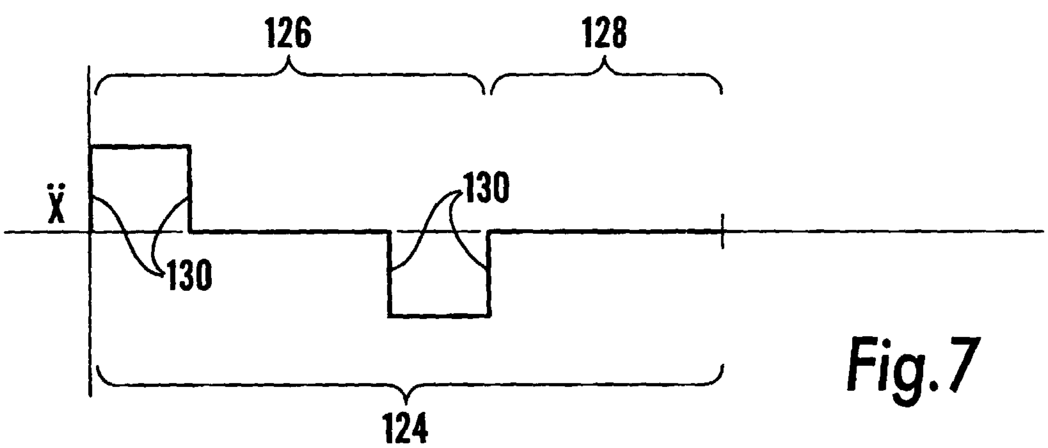

Fig.7

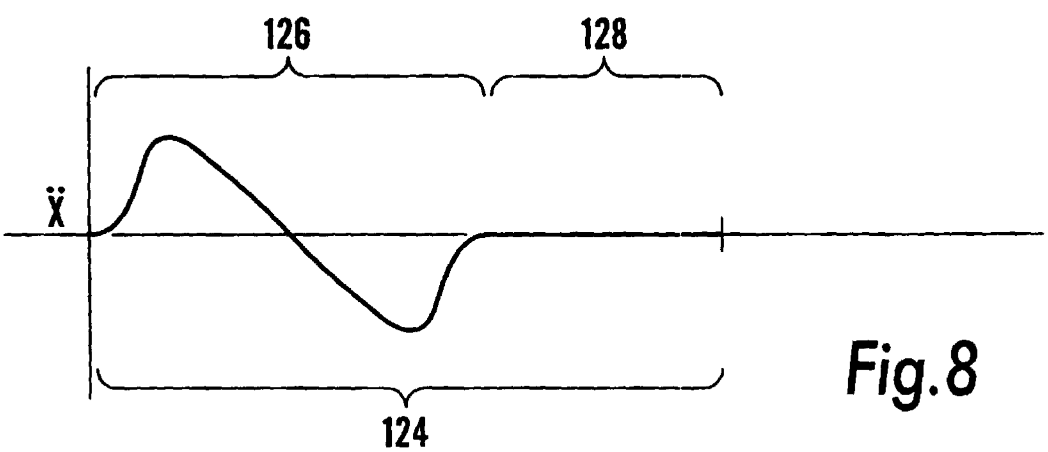

Fig.8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 4923

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,X	US 2 628 010 A (C. RAY) 10 February 1953 (1953-02-10) * column 3, line 33 - column 4, line 24 *	1,7,9, 13,20, 24,25	B65B43/52 B65B65/02
A	* column 7, line 8 - line 47; figures 1-3,5,7 *	8	
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A	US 3 295 664 A (R. HEFFELFINGER) 3 January 1967 (1967-01-03) * column 1, line 16 - line 23; claim 1; figures *	16,26, 30,36	

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B65B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 October 1999	Jagusiak, A

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