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(19) **United States**(12) **Patent Application Publication**
ENGEL-HALL et al.(10) **Pub. No.: US 2021/0260784 A1**(43) **Pub. Date: Aug. 26, 2021**(54) **SYSTEMS AND METHODS FOR SLICING
AND DISPENSING BREAD****B26D 3/30** (2006.01)**B26D 5/20** (2006.01)**B26D 7/06** (2006.01)(71) Applicant: **Creator, Inc.**, San Francisco, CA (US)(52) **U.S. Cl.**(72) Inventors: **Aaron ENGEL-HALL**, San Francisco,
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3/30 (2013.01); **B26D 5/20** (2013.01); **A21C**
15/04 (2013.01)(21) Appl. No.: **17/254,797**

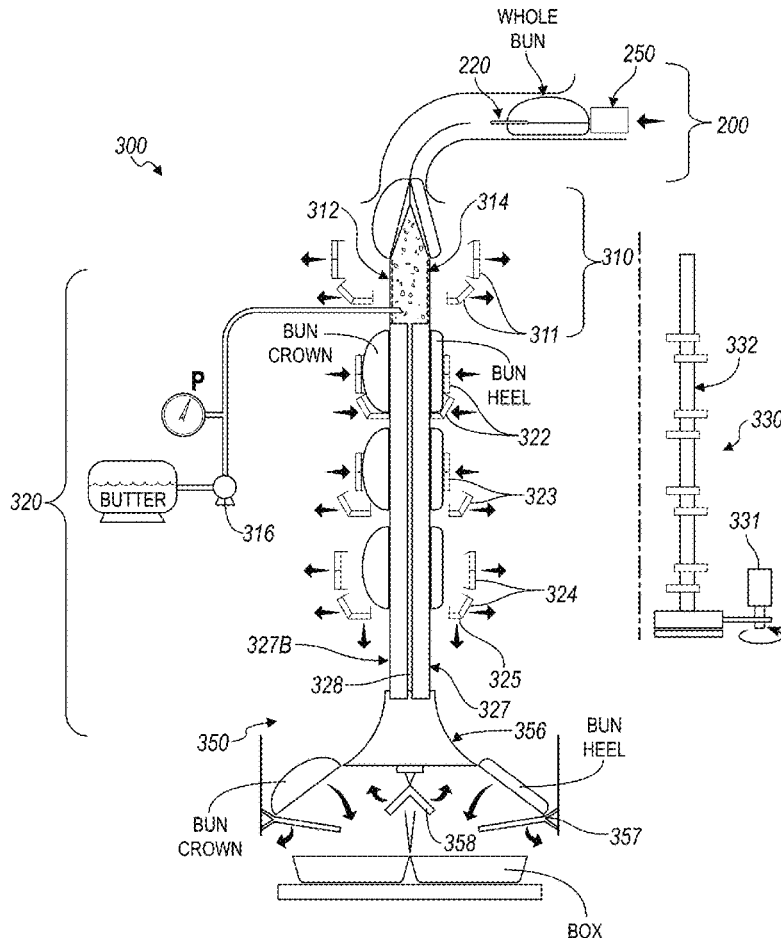
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ABSTRACT(22) PCT Filed: **Jun. 20, 2019**(86) PCT No.: **PCT/US2019/038341**

§ 371 (c)(1),

(2) Date: **Dec. 21, 2020****Related U.S. Application Data**(60) Provisional application No. 62/687,786, filed on Jun.
20, 2018.**Publication Classification**(51) **Int. Cl.****B26D 7/34** (2006.01)**A21C 15/00** (2006.01)**A21C 15/04** (2006.01)

A system may include a chute, a plurality of hoppers, a bun-advancing system, a blade, and a bun-stopper system. The plurality of hoppers are attached to the chute and include outlets in communication with a channel of the chute. The bun-advancing system is configured to move a food product from one of the hoppers to the channel of the chute. The blade may be disposed in the channel and may be configured to reciprocate relative to the chute. The bun-stopper system may include an actuator and a stopper. The stopper may be disposed vertically above the blade. The actuator may be configured to move the stopper between an extended position where the stopper extends into the channel to prevent the food product from contacting the blade and a retracted position where the stopper is retracted from the channel to allow the food product to move into contact with the blade.



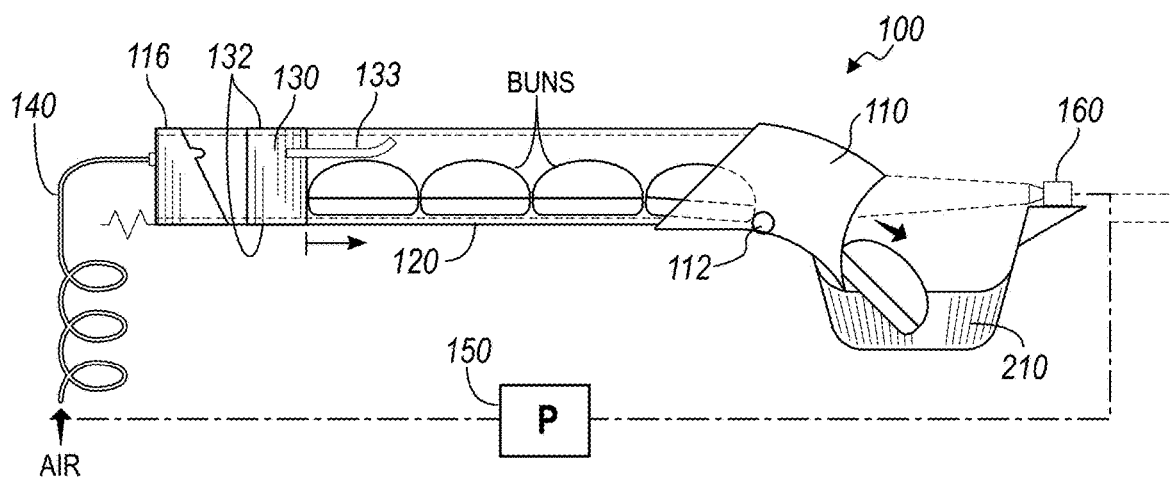


FIG. 1

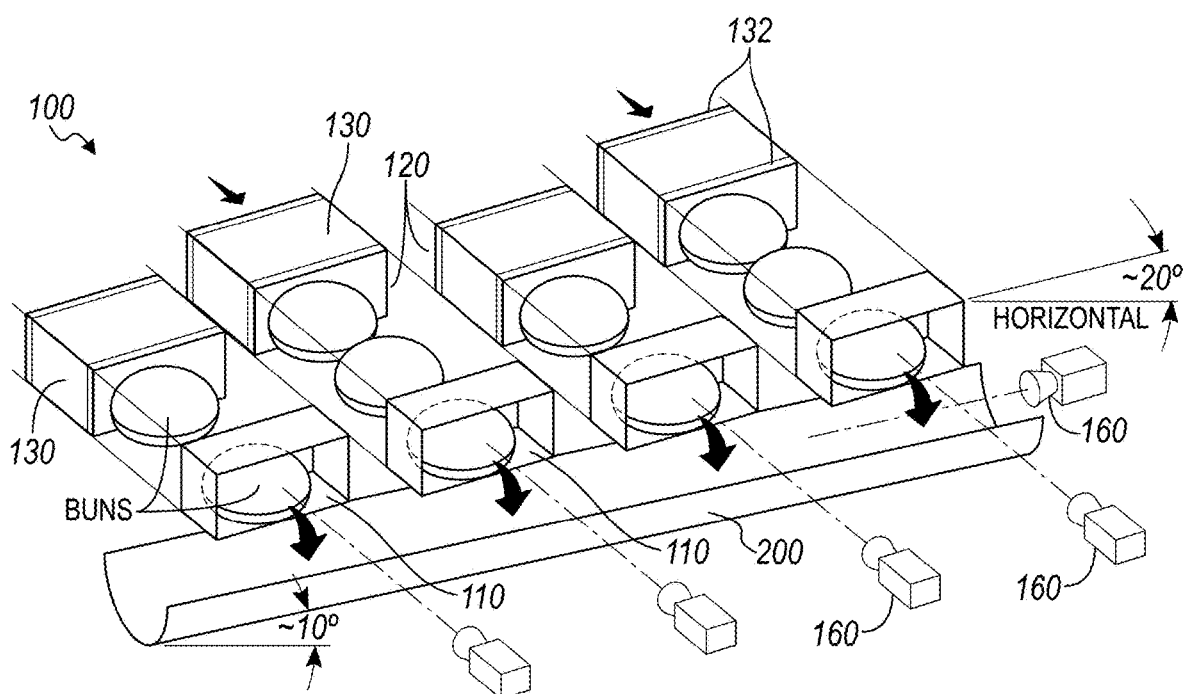
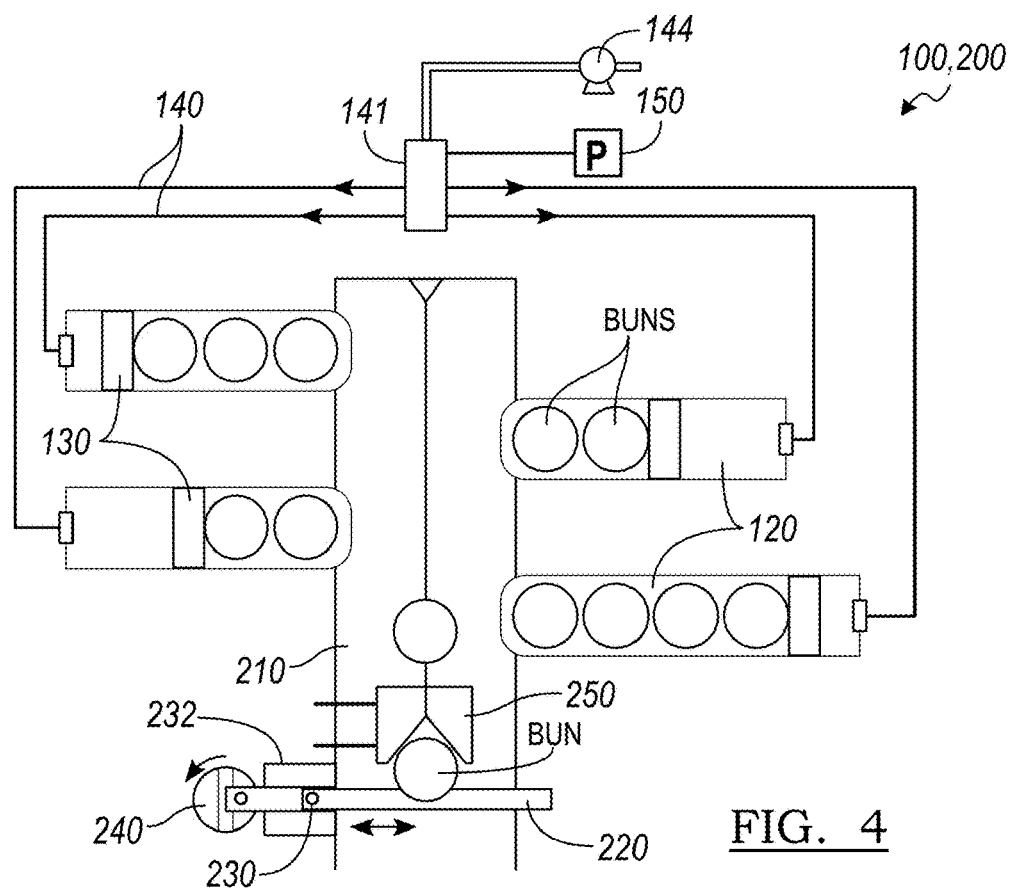
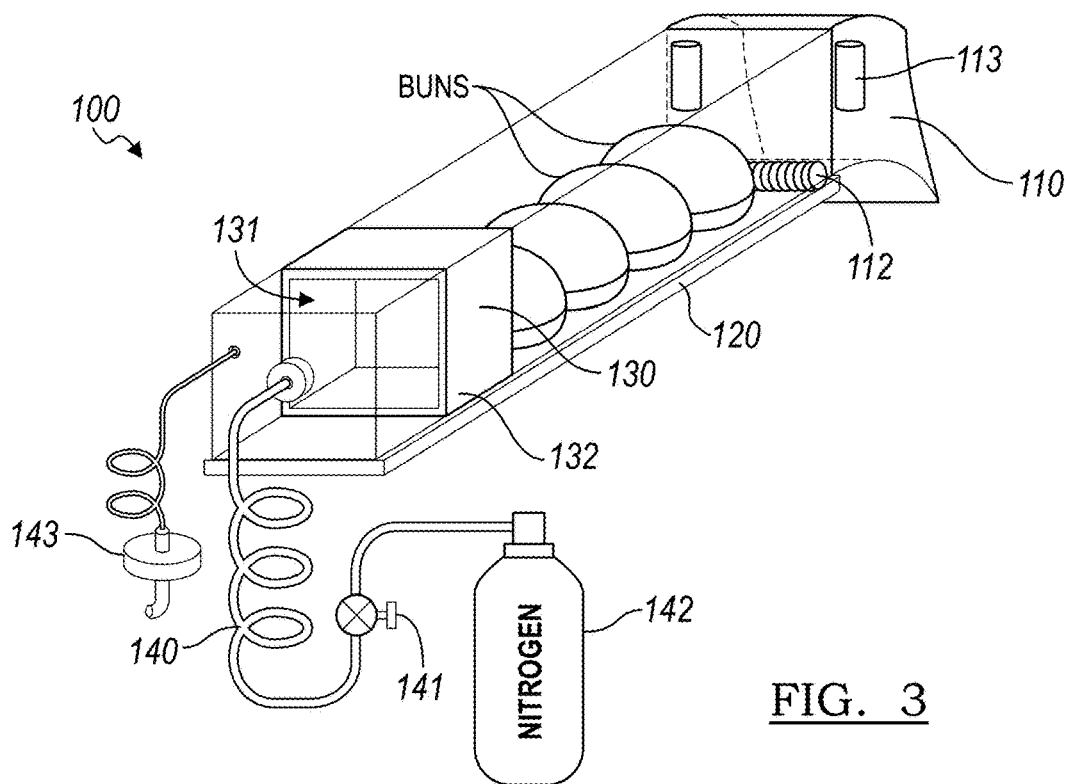


FIG. 2



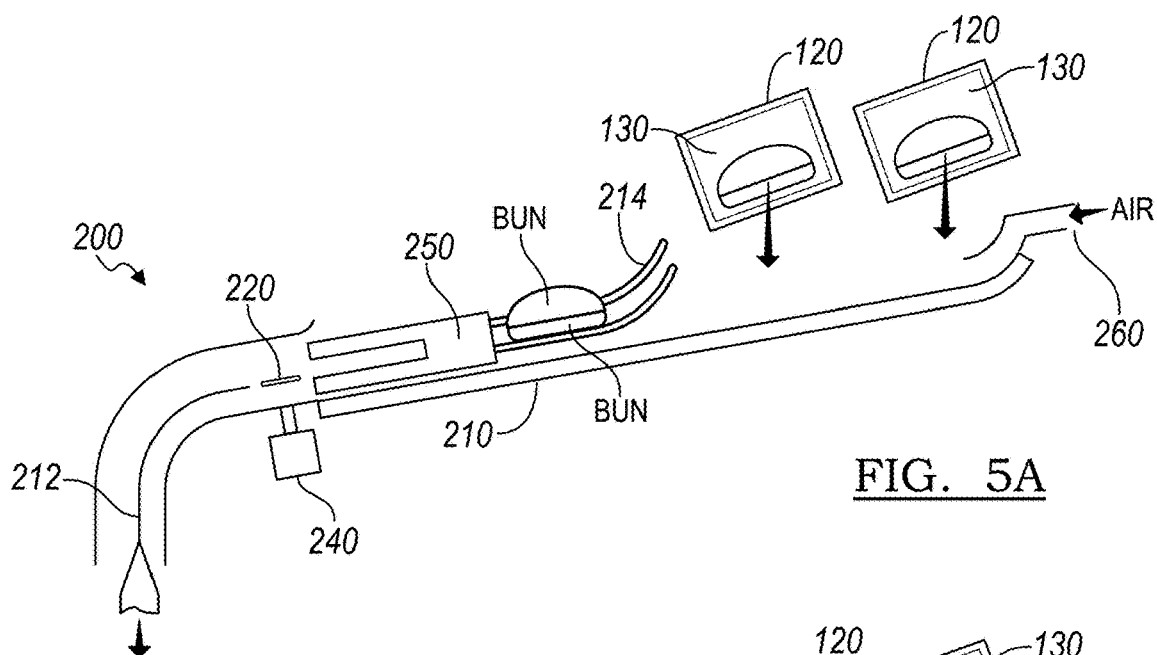


FIG. 5A

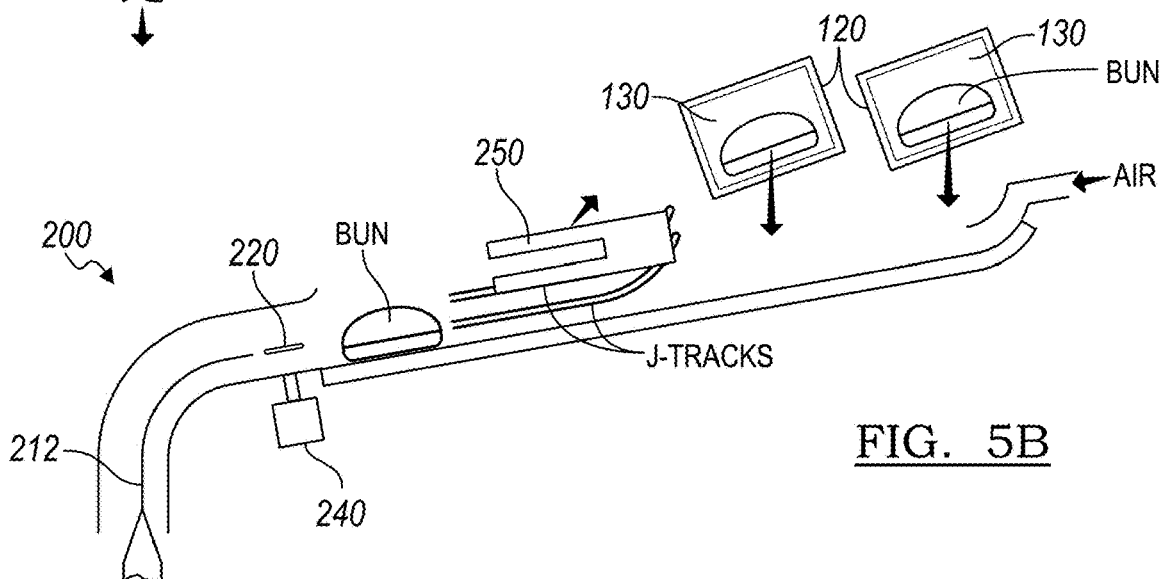


FIG. 5B

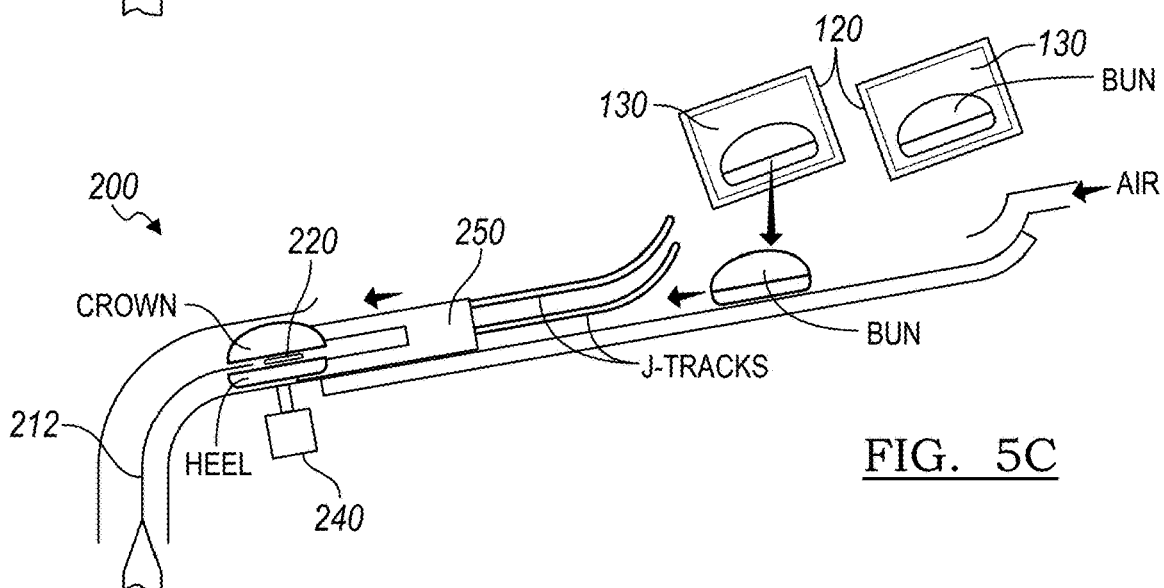


FIG. 5C

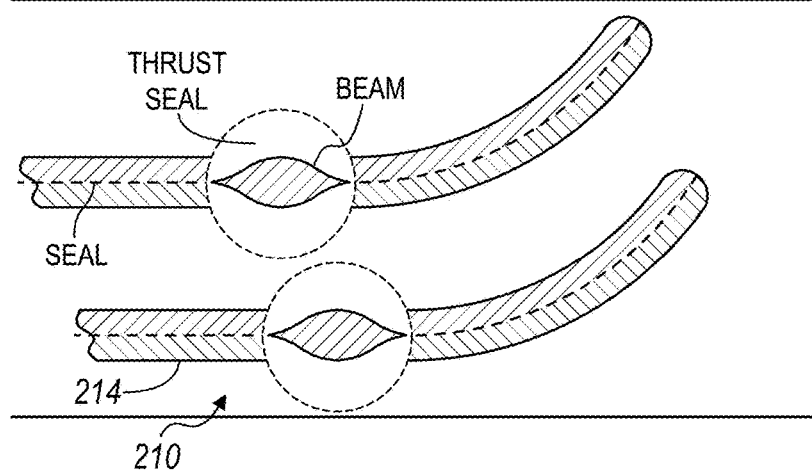


FIG. 6

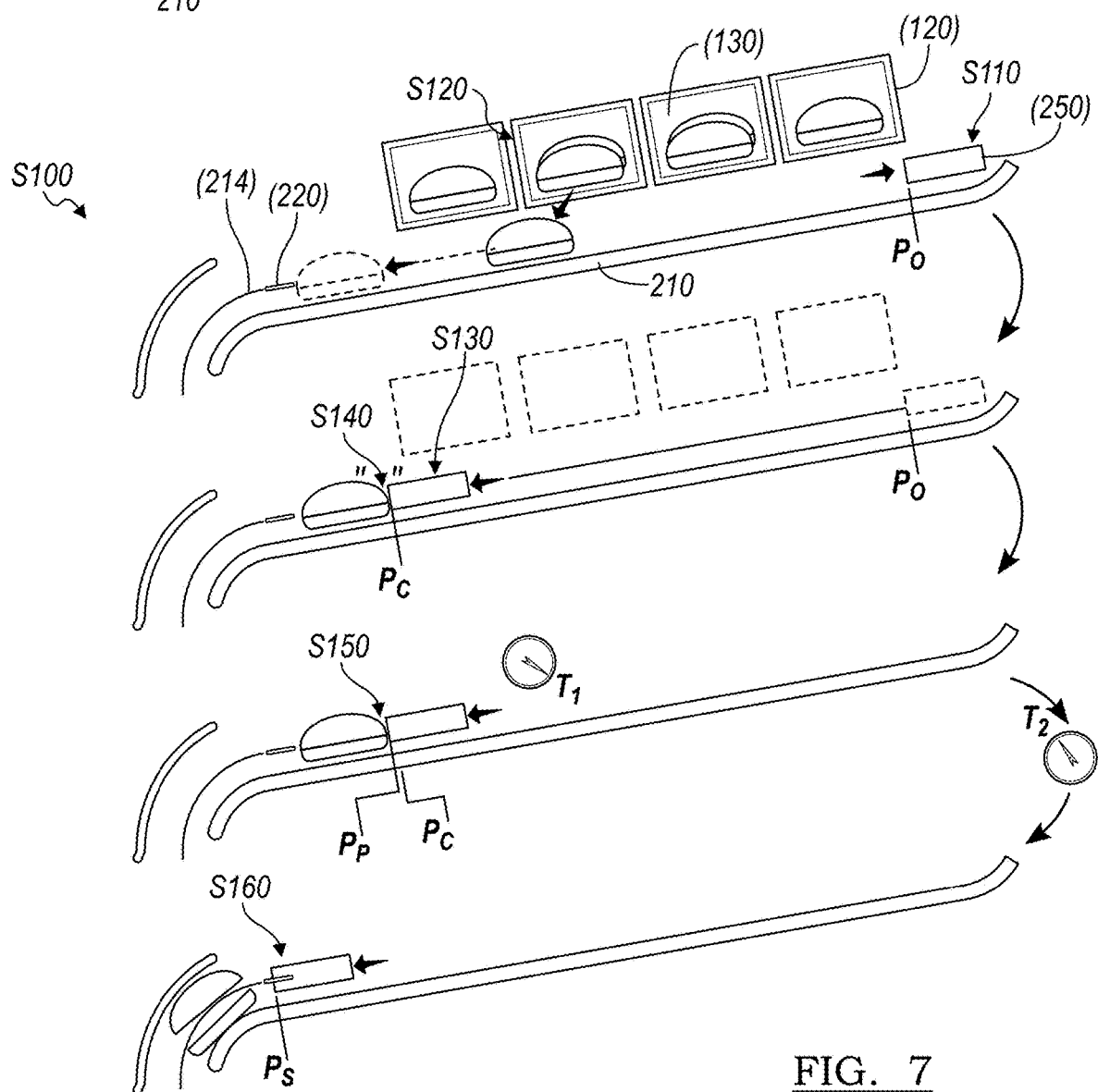


FIG. 7

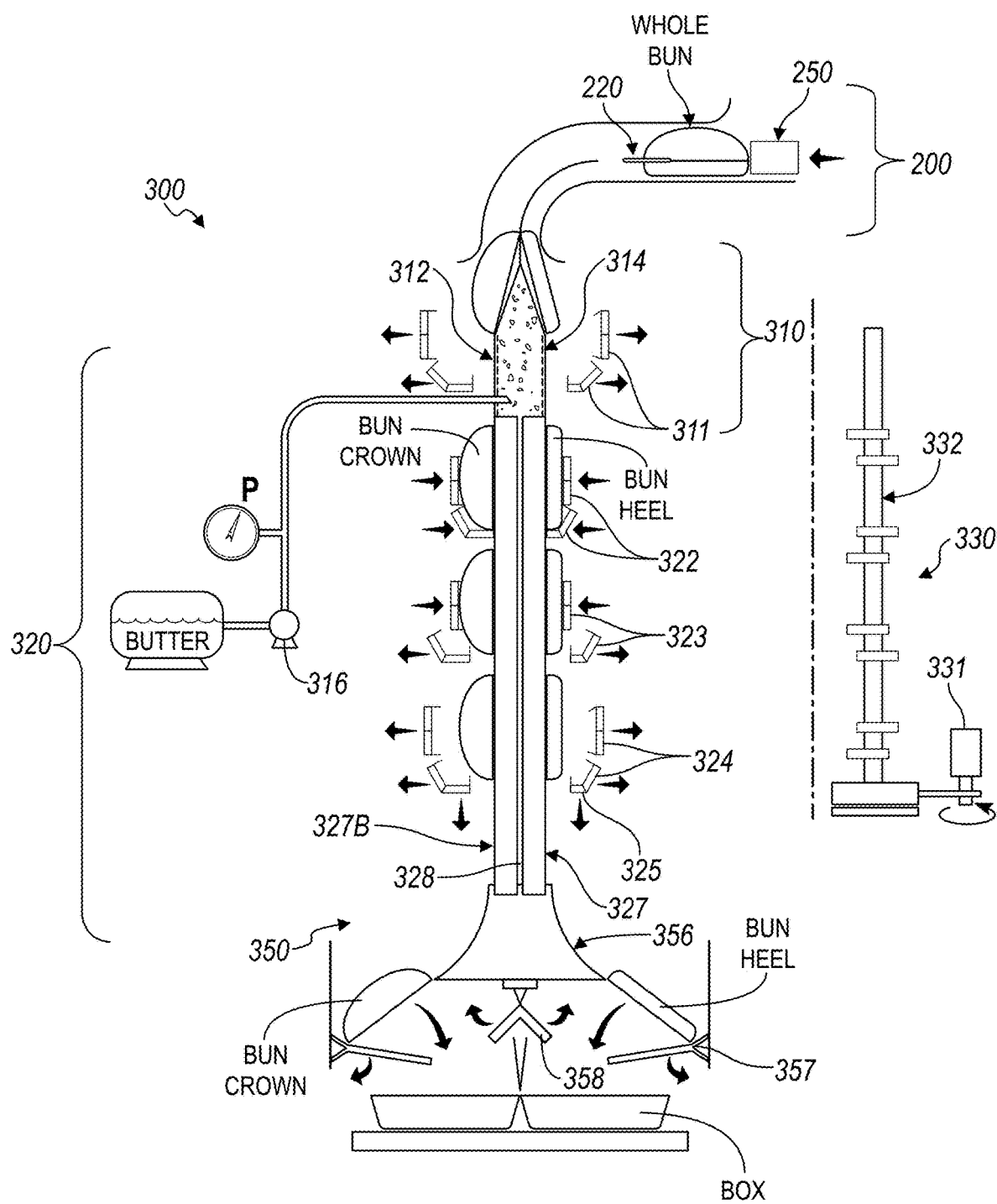


FIG. 8

FIG. 9

300

Camshaft Angle (°) Time	0	60	120	180	240	300	360
<i>Slicing Mechanism 200</i>	T1	T2	T3	T4	T5	T6	T7
Butter Stage: compression	closed (compress bun 3)	closed (compress bun 3)	open	open	open (receive bun 4)	closed (compress bun 4)	closed (compress bun 4)
Butter Stage: gate	closed	open	open	closed	closed	closed	open
Toast Stage: compression (1)	open	open	open (receive bun 3)	closed	closed	closed	open
Toast Stage: gate (1)	open	closed	closed	closed	closed	open	open
Toast Stage: compression (2)	open	closed	closed	open	open	open	open (receive bun 3)
Toast Stage: gate (2)	closed	closed	open	open	open	closed	closed
Toast Stage: compression (3)	closed	closed	open	open	open (receive bun 2)	closed	closed
Toast Stage: gate (3)	closed	open	open (release bun 1)	closed	closed	closed	closed
<i>Boxing Subsystem 350</i>	..	..	receive bun 1, 100% toast	..	..	..	..

FIG. 10A

300

Camshaft Angle (°) Time	0	60	90	120	180	240	300	360
<i>Slicing Mechanism 200</i>	T1	T2	T2.5	T3	T4	T5	T6	T7
Butter Stage: compression 311A	closed (compress bun 3)	closed (compress bun 3)	closed (compress bun 3)	open	open	open (receive bun 4)	closed (compress bun 4)	closed (compress bun 4)
Butter Stage: gate 311B	closed	open	open	open	closed	closed	closed	closed
Toast Stage: compression 322A	open	open	open	open (receive bun 3)	closed	closed	closed	open
Toast Stage: gate 322B	open	closed	closed	closed	closed	closed	open	open
Toast Stage: compression 323A	open	closed	closed	closed	open	open	open	open (receive bun 3)
Toast Stage: gate 323B	closed	closed	closed	open	open	open	closed	closed
Toast Stage: compression 324A	closed	closed	open	open	open (receive bun 2)	closed	closed	closed
Toast Stage: gate 324B	closed	open	open (release bun 1)	open	closed	closed	closed	closed
<i>Boxing Subsystem 350</i>	..	..	receive bun 1, 80% toast	..	..	..	..	..

FIG. 10B

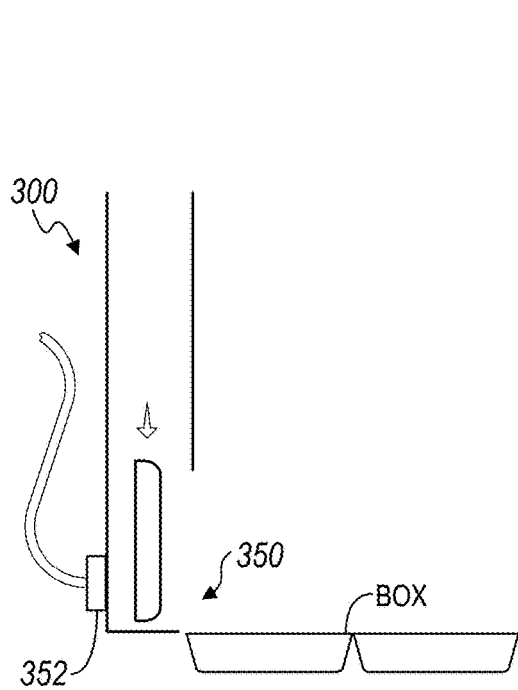


FIG. 12

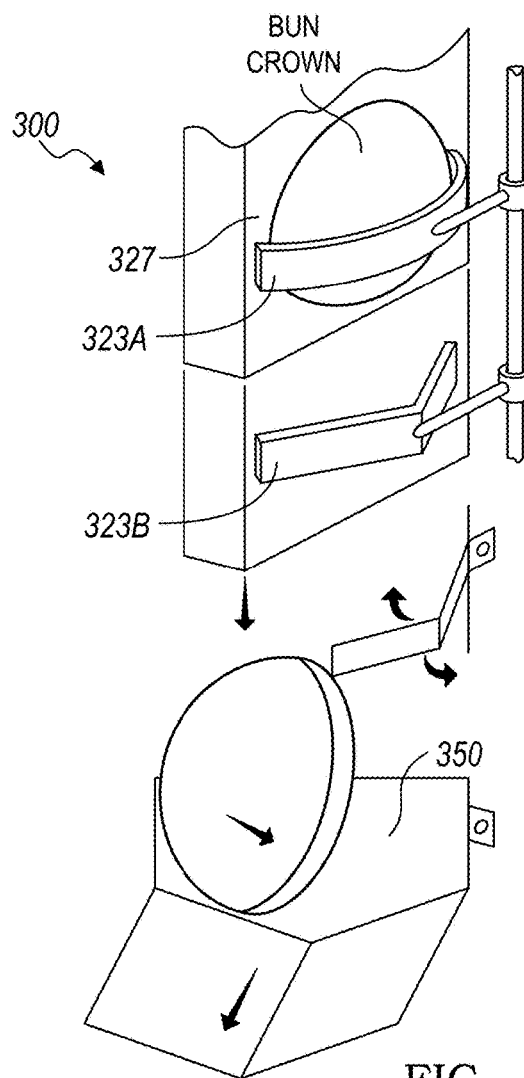


FIG. 11

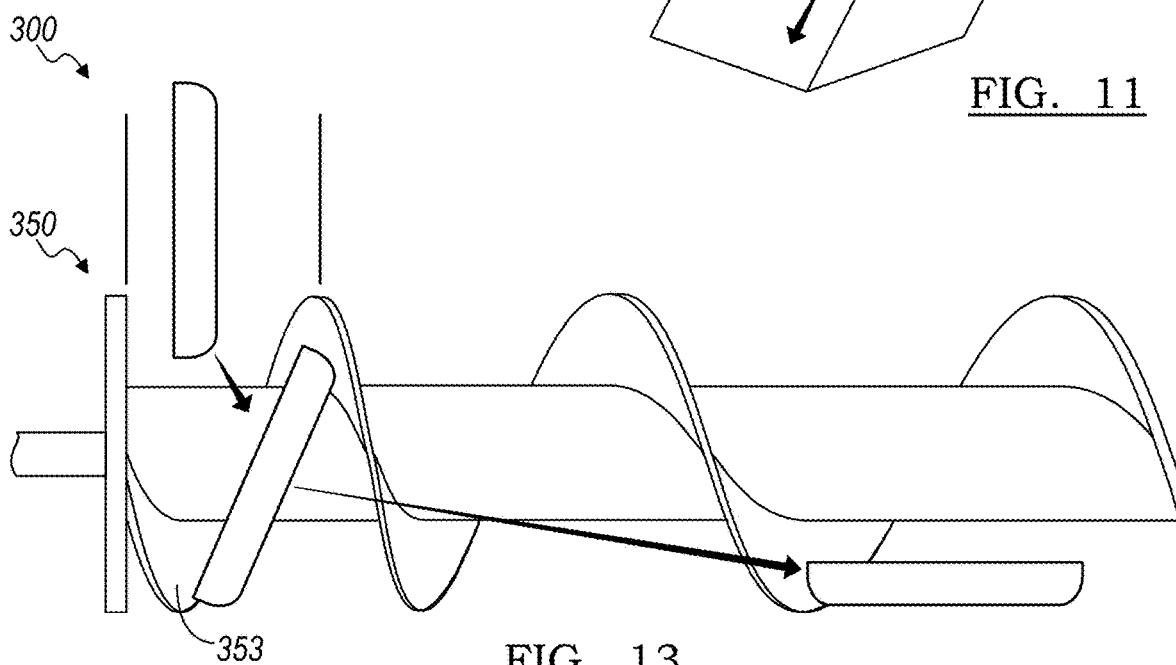


FIG. 13

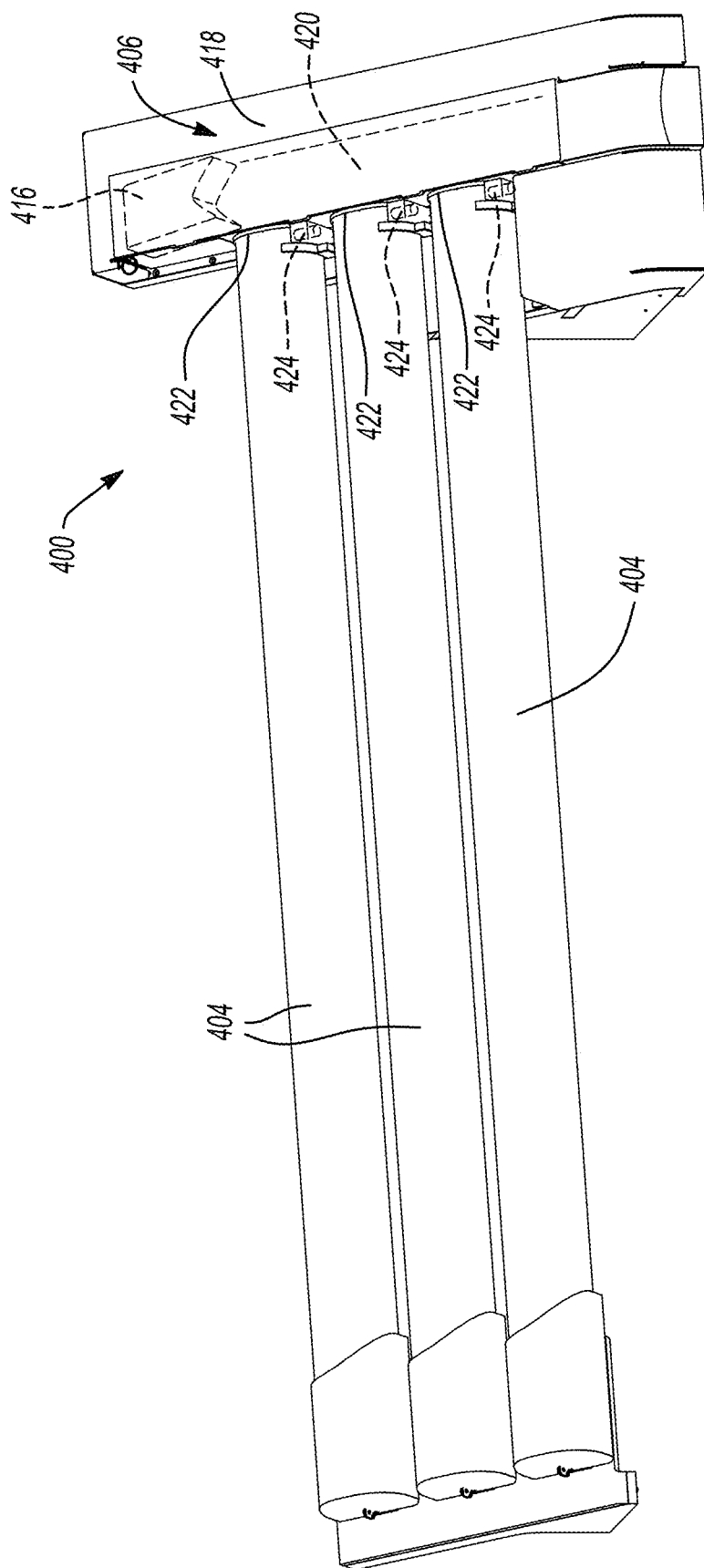


Fig-14

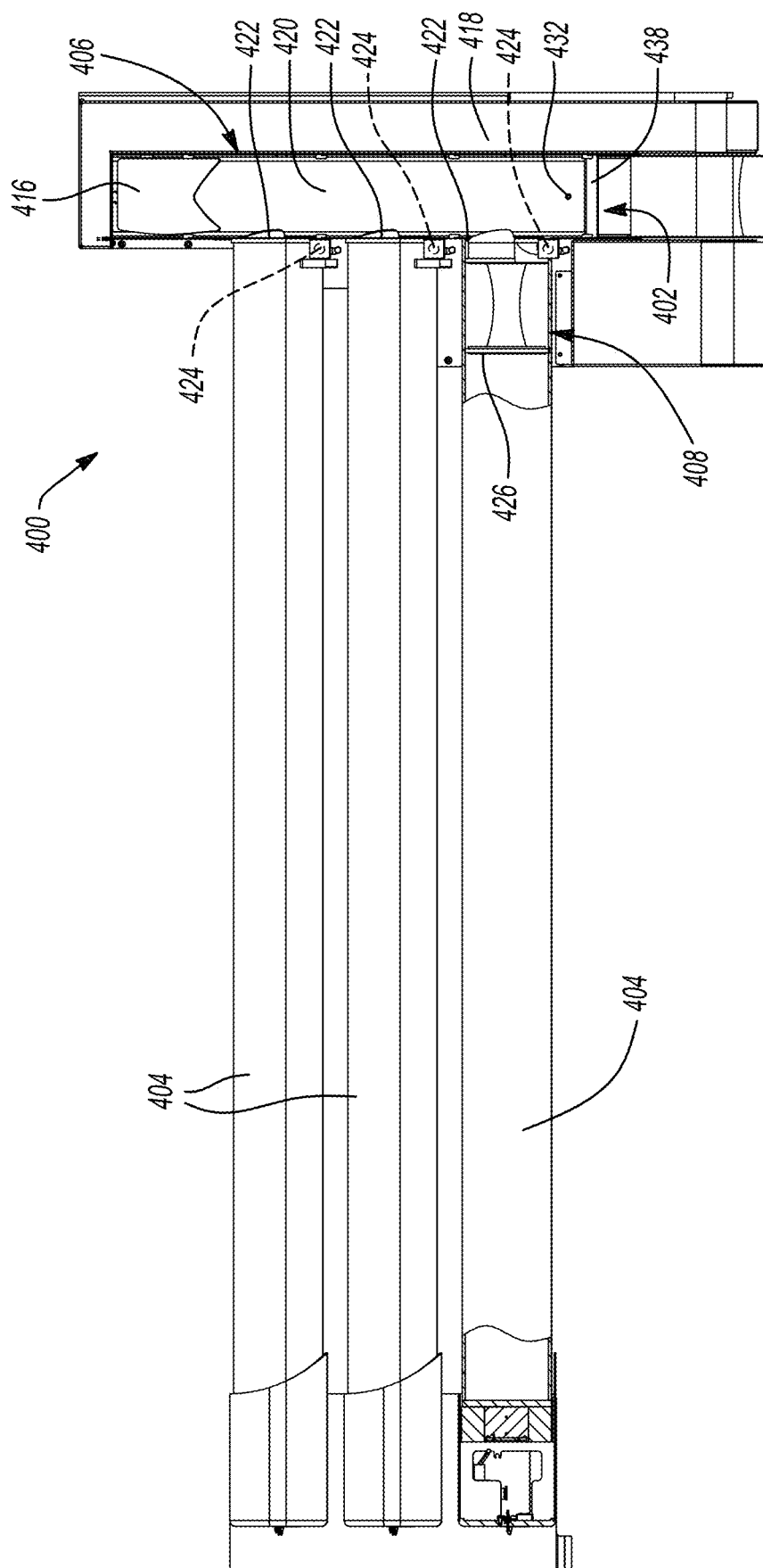


Fig-15

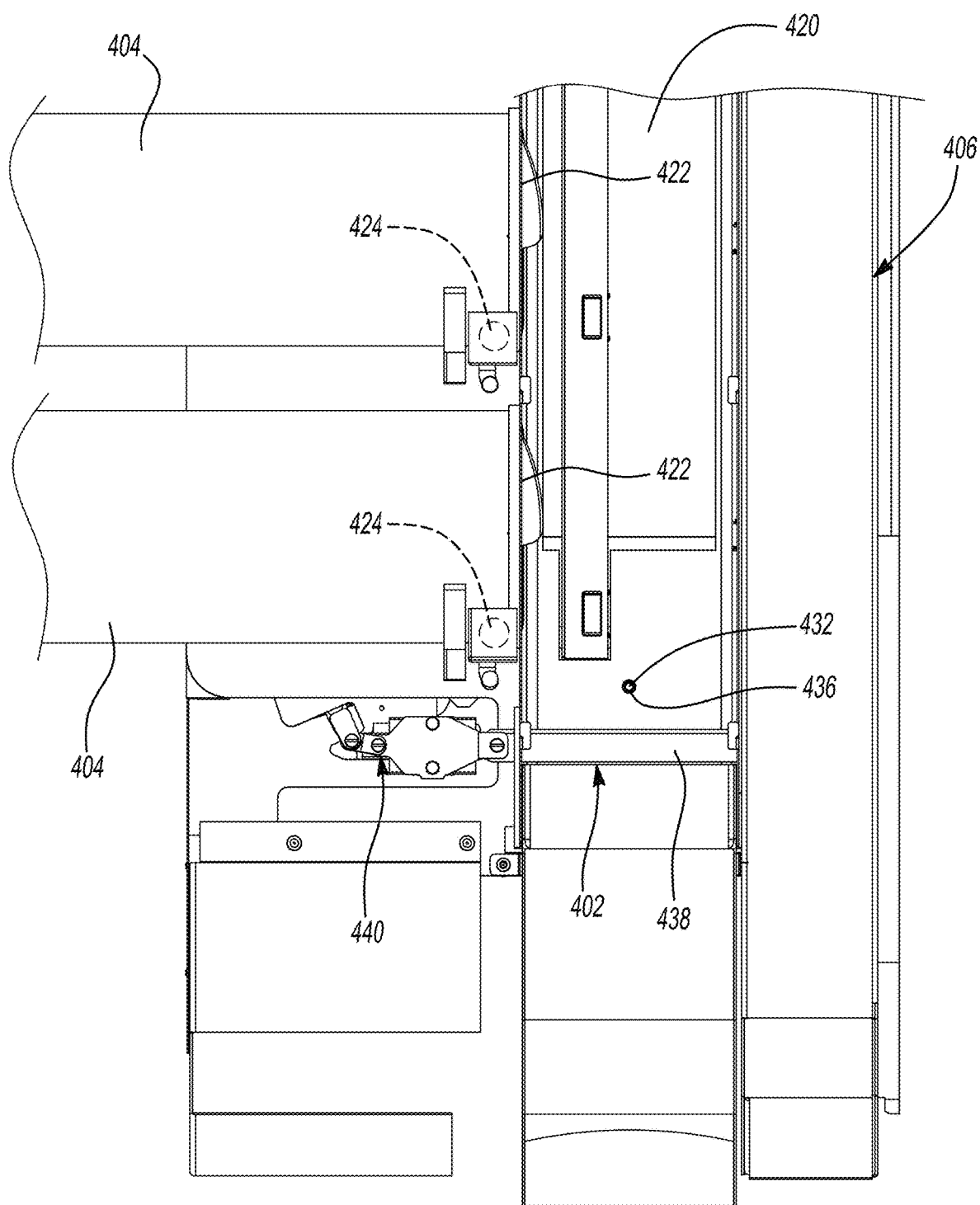


Fig-16

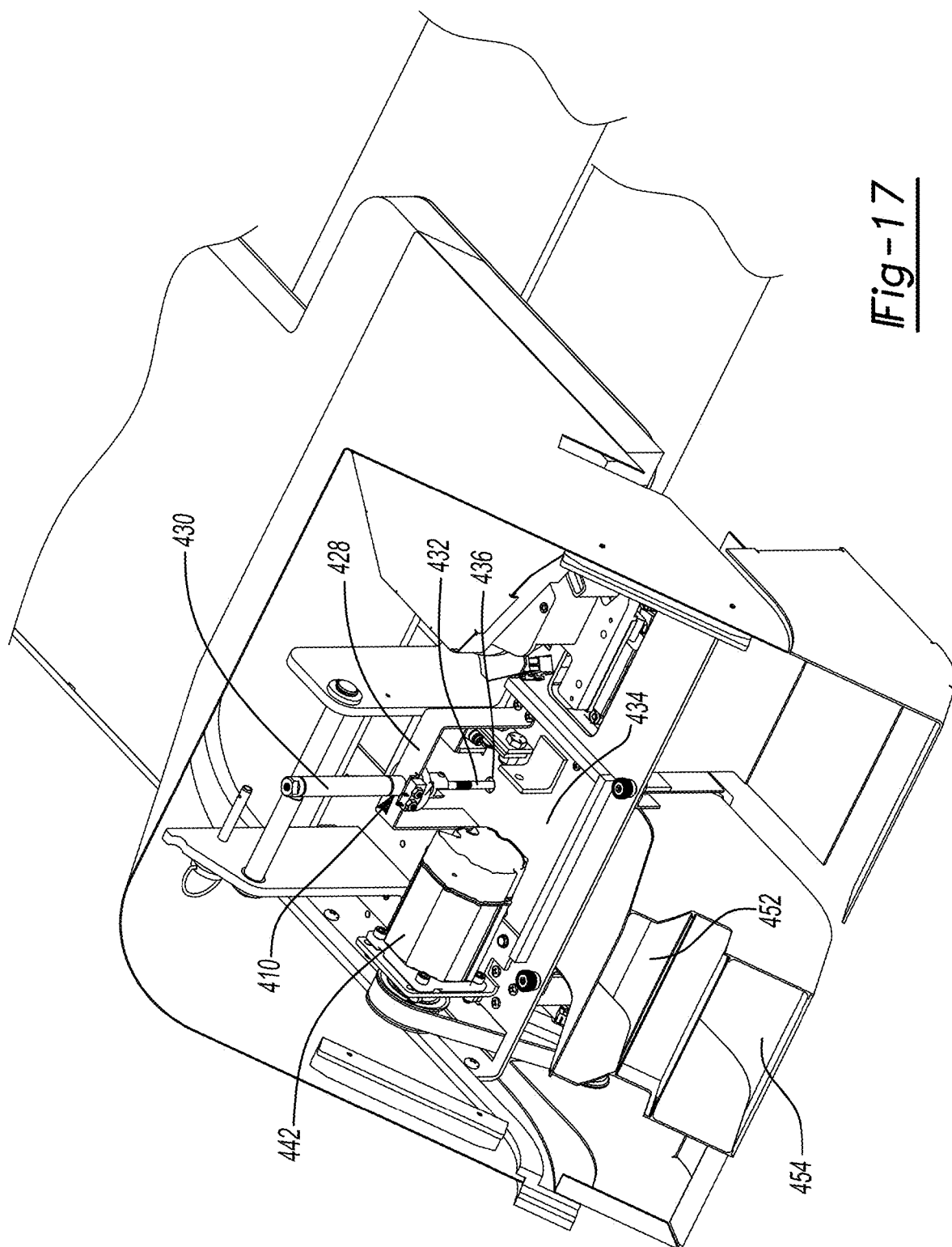


Fig-17

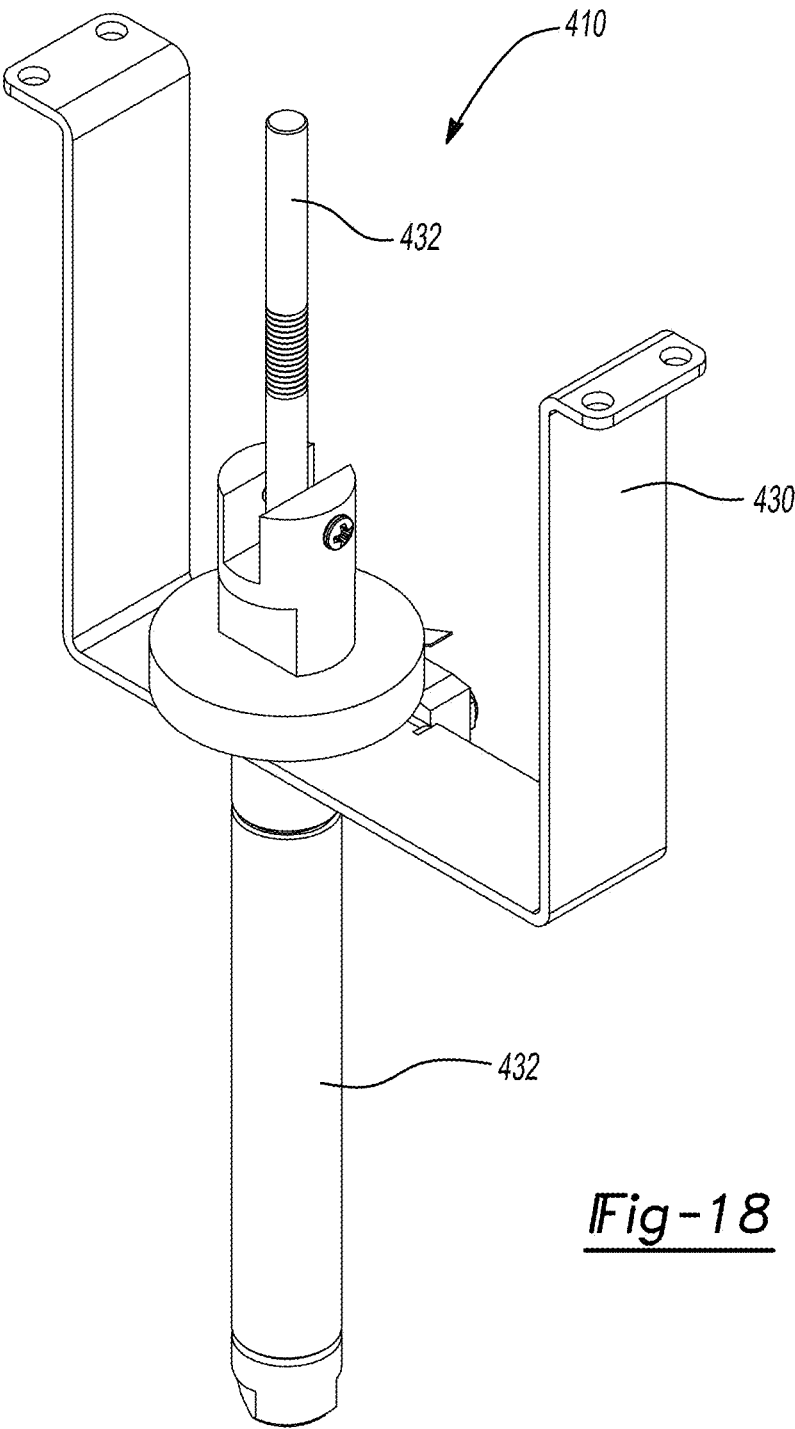


Fig-18

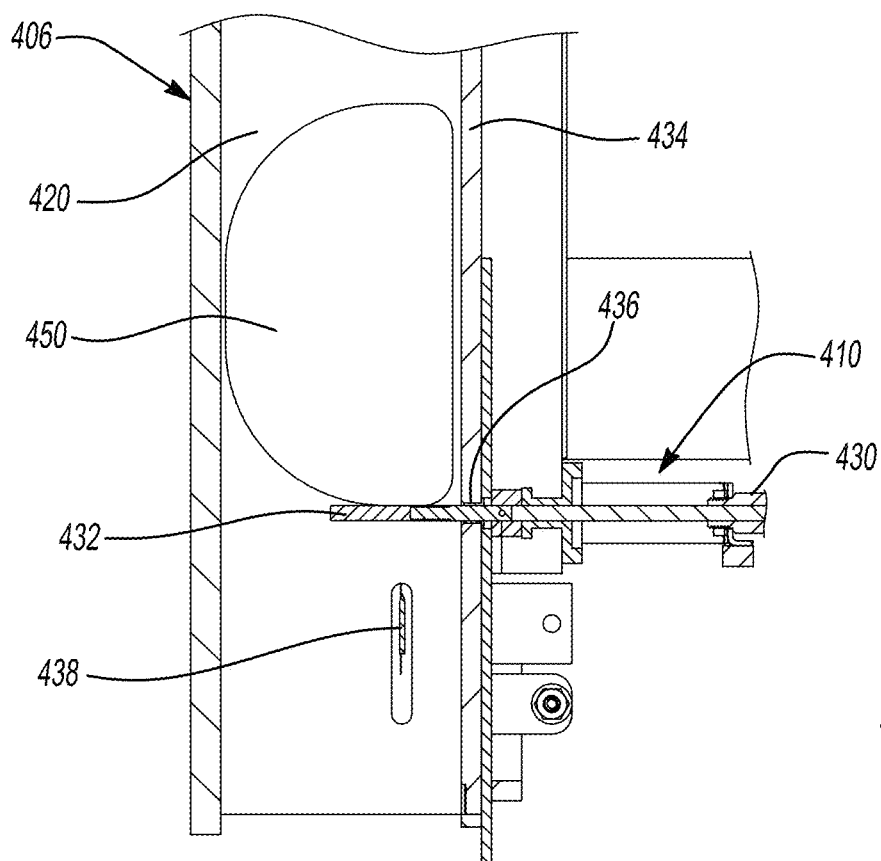


Fig-19

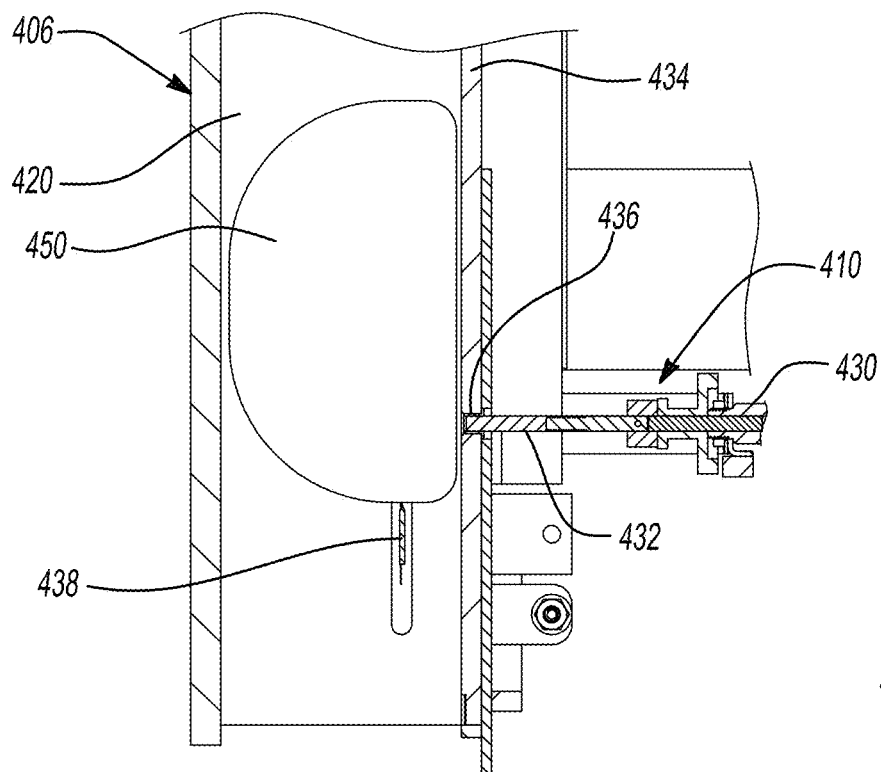
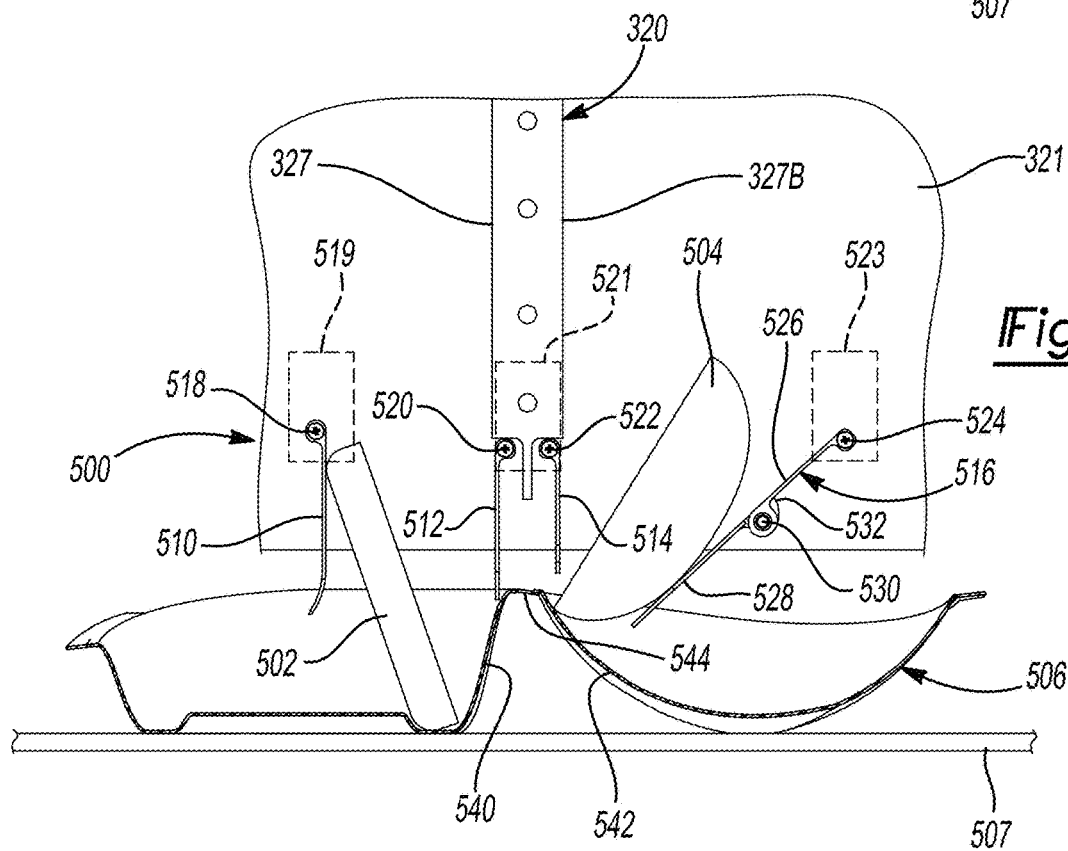
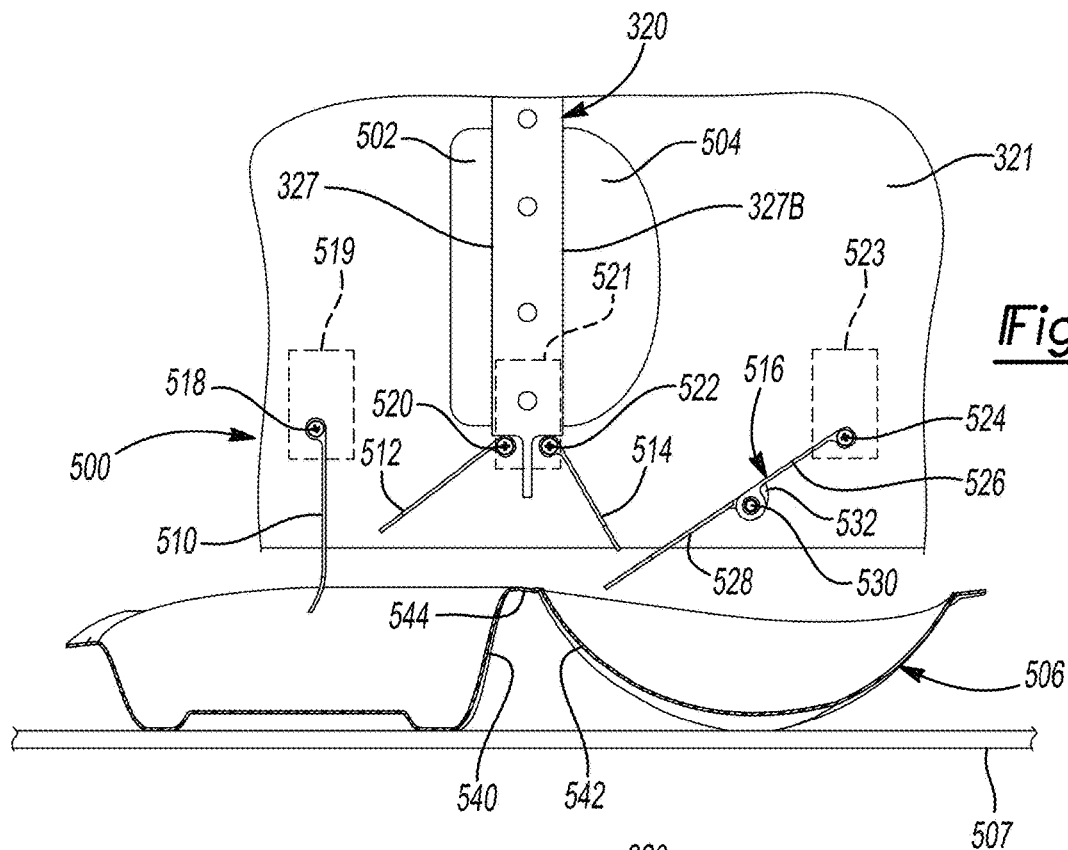
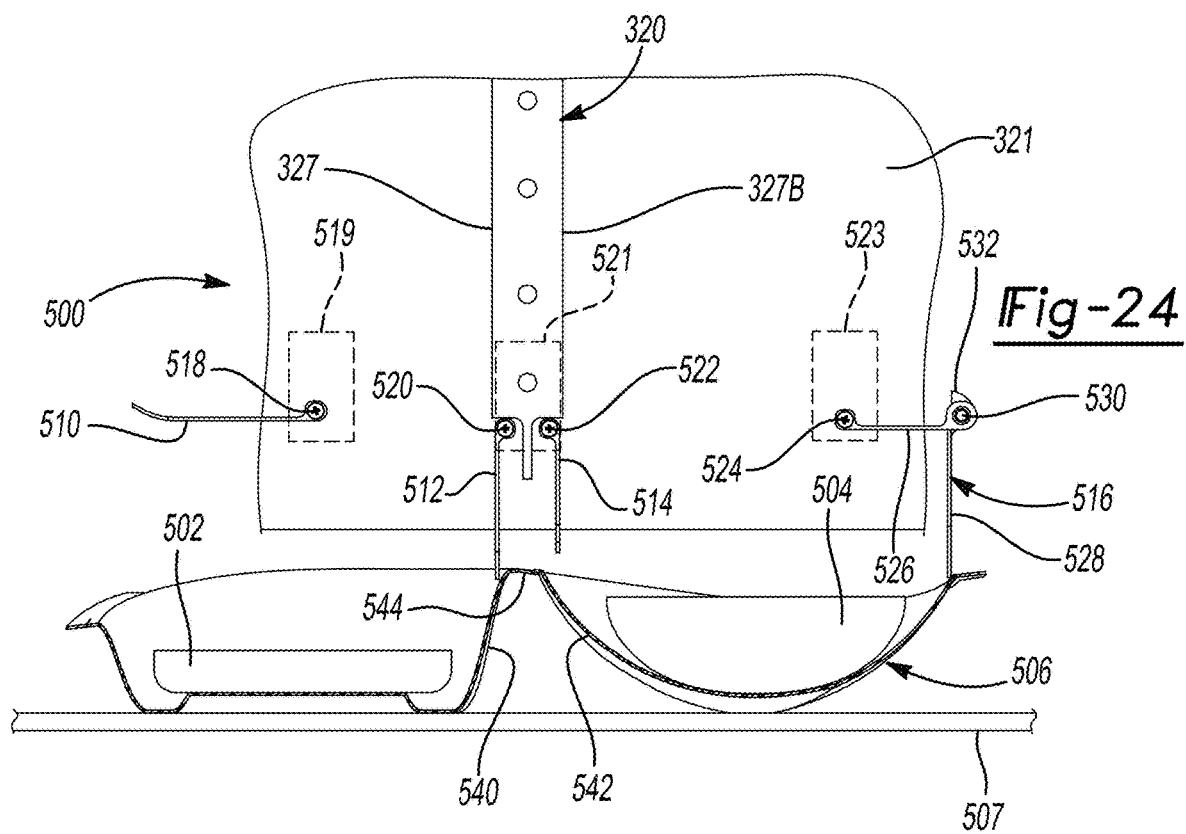
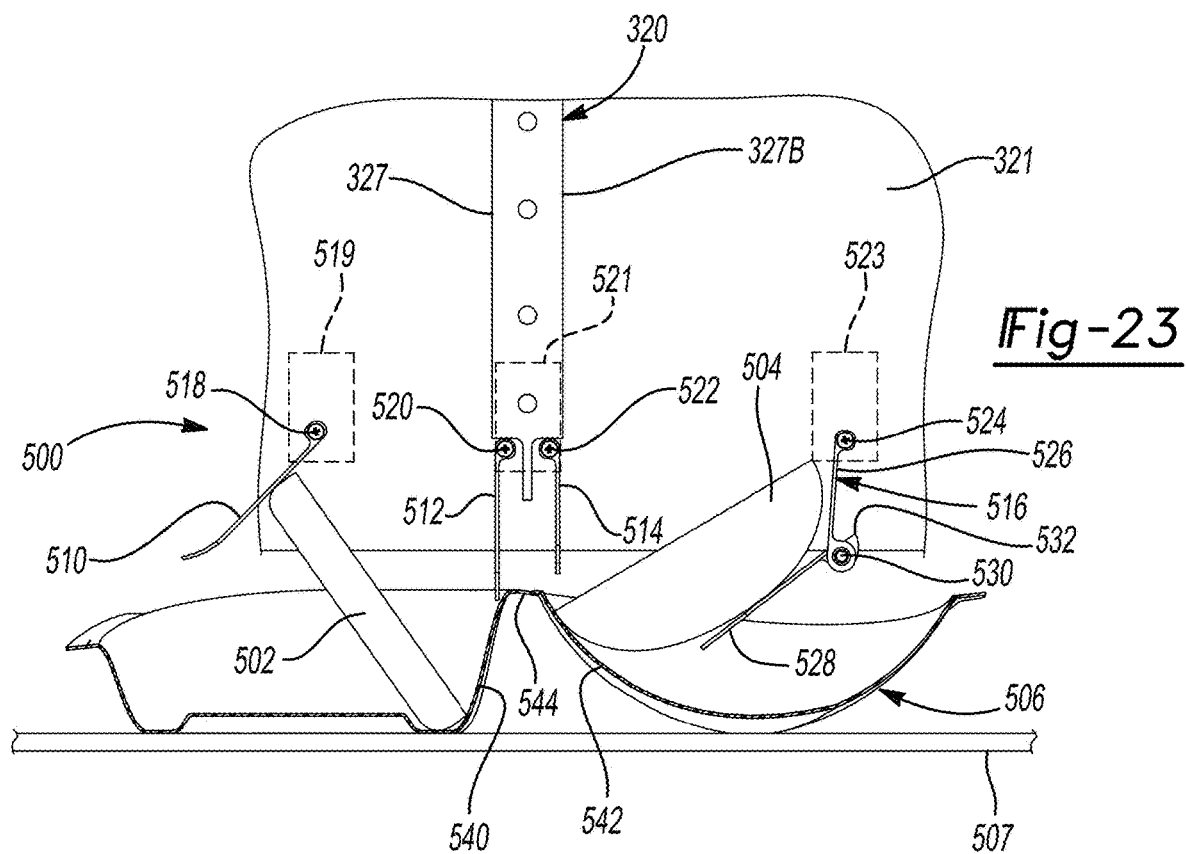


Fig-20





SYSTEMS AND METHODS FOR SLICING AND DISPENSING BREAD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/687,786 filed on Jun. 20, 2018. The entire disclosure of the above application is incorporated herein by reference.

FIELD

[0002] The present disclosure relates generally to the field of food preparation and more specifically to new and useful systems and methods for dispensing, slicing, buttering, and toasting bread.

BACKGROUND

[0003] This section provides background information related to the present disclosure and is not necessarily prior art.

[0004] Preparation of foodstuffs (for example, hamburgers, sandwiches, etc.) according to a consumer's custom order can be time-consuming and labor-intensive. Furthermore, the process of preparing custom-ordered foodstuffs is susceptible to errors and wide variations in quality. The present disclosure provides an automated food preparation system that can quickly and accurately prepare foodstuffs according to a wide variety of possible custom orders with limited human involvement.

[0005] The background description provided here is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] In one form, the present disclosure provides system that may include a chute, a plurality of hoppers, a bun-advancing system, a blade, and a bun-stopper system. The plurality of hoppers are attached to the chute and include outlets in communication with a channel of the chute. The bun-advancing system is configured to move a food product from one of the hoppers to the channel of the chute. The blade may be disposed in the channel and may be configured to reciprocate relative to the chute. The bun-stopper system may include an actuator and a stopper. The stopper may be disposed vertically above the blade. The actuator may be configured to move the stopper between an extended position where the stopper extends into the channel to prevent the food product from contacting the blade and a retracted position where the stopper is retracted from the channel to allow the food product to move into contact with the blade.

[0008] In some configurations, the stopper is a pin.

[0009] In some configurations of the system of either of the above paragraphs, each of the hoppers includes a pin disposed adjacent an outlet of the hopper.

[0010] In some configurations of the system of any of the above paragraphs, the chute includes a pair of outlets disposed beneath the blade.

[0011] In some configurations of the system of any of the above paragraphs, each outlet is configured to receive a respective sliced portion of the food product.

[0012] In some configurations, the system of any of the above paragraphs includes a cutting block configured to move along a length of the channel of the chute and push the food product against the blade.

[0013] In some configurations, the system of any of the above paragraphs includes a plurality of pistons.

[0014] In some configurations of the system of either of the above paragraphs, each of the pistons is disposed within a respective one of the hoppers.

[0015] In some configurations of the system of either of the above paragraphs, the pistons are movable within the respective hoppers to push food products out of the hoppers and into the channel of the chute.

[0016] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0018] FIG. 1 is a representations of a first system;

[0019] FIG. 2 is a schematic representations of one variation of the first system;

[0020] FIG. 3 is a schematic representations of one variation of the first system;

[0021] FIG. 4 is a schematic plan representations of a second system and one variation of the first system;

[0022] FIGS. 5A, 5B, and 5C are schematic representations of one variation of the second system;

[0023] FIG. 6 is a schematic representation of one variation of the second system;

[0024] FIG. 7 is a flowchart representation of one method for dispensing and slicing whole bread buns;

[0025] FIG. 8 is a schematic representation of a third system;

[0026] FIG. 9 is a schematic representation of one variation of the third system;

[0027] FIGS. 10A and 10B are a graphical representations of variations of the third system;

[0028] FIG. 11 is a flowchart representation of one variation of the third system;

[0029] FIG. 12 is a schematic representation of one variation of the third system;

[0030] FIG. 13 is a flowchart representation of one variation of the third system;

[0031] FIG. 14 is a perspective view of an alternative bun dispenser;

[0032] FIG. 15 is a front view of the bun dispenser with a portion of a chute housing removed to show a bun stopper and blade;

[0033] FIG. 16 is a partial front view of the bun dispenser and slicing mechanism;

[0034] FIG. 17 is a perspective view of a portion of the bun dispenser including a bun stopper mechanism;

[0035] FIG. 18 is a perspective view of the bun stopper mechanism;

[0036] FIG. 19 is a partial cross-sectional view of a chute of the bun dispenser with the bun stopper in an extended position;

[0037] FIG. 20 is a partial cross-sectional view of a chute of the bun dispenser with the bun stopper in a retracted position;

[0038] FIG. 21 is a side view of an alternative dispenser paddle assembly in a first position;

[0039] FIG. 22 is a side view of the dispenser paddle assembly of FIG. 21 in a second position;

[0040] FIG. 23 is a side view of the dispenser paddle assembly of FIG. 21 in a third position;

[0041] and

[0042] FIG. 24 is a side view of the dispenser paddle assembly of FIG. 21 in a fourth position.

[0043] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

1. Bun Dispenser

[0044] As shown in FIG. 1, a first system 100 for dispensing bread buns into a bun slicing mechanism, includes: a receiver; a hopper 120 including a substantially transparent elongated housing configured to contain a row of whole bread buns, defining a discharge end configured to transiently engage the receiver 110 and to dispense whole bread buns into the receiver 110, and defining a pressurized end opposite the discharge end; a piston 130 arranged within the hopper 120 between the pressurized end of the hopper 120 and the row of whole bread buns; a permeable seal 132 interposed between an interior wall of the hopper 120 and an adjacent surface of the piston 130, the permeable seal 132 cooperating with the hopper 120 and the piston 130 to define a closed volume between the pressurized end of the hopper 120 and the piston 130, the permeable seal 132 configured to bleed gas from the closed volume toward the discharge end of the hopper 120; a gas supply 140 intermittently supplying gas into the closed volume to displace the piston 130 toward the discharge end of the hopper 120; and a roller 112 arranged between the hopper 120 and the receiver 110 and extending into a boundary defined by a cross-section of the hopper 120 projected toward the receiver 110 parallel to an axis of the hopper 120.

1.1 Applications

[0045] Generally, the first system 100 for dispensing bread buns (herein after “bun dispenser”) functions to sequentially dispense whole bread buns stored in one or more hoppers into a slicing mechanism (shown in FIG. 4) prior to application of a dairy fat (e.g., butter) onto and toasting of sliced surfaces of bun crowns and bun heels. In particular, the bun dispenser can include a hopper 120, a piston 130 arranged within the hopper 120 behind a row of whole buns, and a gas supply 140 that intermittently pumps gas into a volume behind the piston 130 to advance the piston 130 forward, thereby driving whole buns out of the hopper 120 and into an adjacent slicing mechanism. The bun dispenser can therefore include a single moving component in contact with bread buns stored in the hopper 120, thereby minimizing

complexity of the system, minimizing component wear, and maintaining relatively high cleanability of the system, etc.

[0046] The first system 100 can also include a sensor configured to detect a relative position of the row of whole buns in the hopper 120, and the bun dispenser can be configured to dispense a single bread bun per dispense cycle by implementing closed loop feedback to commence and cease supply of gas to the volume behind the piston 130 based on outputs of the sensor. In particular, rather than index the piston 130 to discrete, preset positions along the length of the hopper 120, the bun dispenser can advance and pause the piston 130 at any position along the length of the hopper 120 by controlling fluid pressure behind the piston 130. The bun dispenser can also include a permeable seal 132 interposed between the piston 130 and the interior wall of the hopper 120 and configured to bleed gas pressure from behind the piston 130 such that the piston 130 stops relatively quickly once the gas supply 140 is closed without necessitating active evacuation of gas from behind the piston 130 with a secondary pump and without necessitating actuation of a pressure release valve 141 fluidly coupled to the volume behind the piston 130. The hopper 120 can therefore be loaded with various types of whole buns of different geometries, and the bun dispenser can dispense a single bun per dispense cycle regardless of bun type loaded into the hopper 120 without necessitating selection of alternative preset piston 130 positions or physical modification of any subcomponent with the bun dispenser to accommodate for a different bread bun geometry. Similarly, the hopper 120 can be loaded with a row of a single type of whole bread bun exhibiting significant variations in bun width, height, mass, and/or texture, etc.—such as gourmet brioche buns that vary from 2.5" to 5" in diameter and from 2" to 3.5" in height—and the bun dispenser can implement closed-loop techniques to selectively open and close the gas supply 140 based on outputs of the sensor in order to advance the piston 130 until a bun is dispensed and to then stop the piston 130 before a second bun is dispensed from the hopper 120 in the same dispense cycle. Elements within the first system 100 can therefore cooperate to compensate for variations in geometry of buns of a single bread bun type loaded into the hopper 120.

[0047] The bun dispenser can define a subsystem within an automated foodstuff assembly system including one or more other subsystems that cooperate to automatically prepare, assemble, and deliver foodstuffs for and/or to consumers. For example, the automated foodstuff assembly system can include a patty grinding subsystem that grinds and presses custom hamburger patties from raw meat (e.g., based on custom patty orders), a patty grilling subsystem that grills patties (e.g., rare, medium, or well-done based on custom patty orders), a bun slicing mechanism that slices buns received from the bun dispenser (as described below), a bun buttering subsystem that applies butter to each side of sliced buns prior to toasting the sides of the bun (as described below), a bun toaster subsystem that toasts each side of the bun (as described below), a topping module that loads toppings onto bun heels (e.g., based on custom topping orders), and a boxing subsystem 350 that closes completed hamburgers into paper boxes for delivery to patrons. The bun dispenser can similarly deliver bread products for assembly into sandwiches, hotdogs, burritos, tacos, wraps, or other foodstuffs, such as according to custom food orders. The bun dispenser can therefore be incorporated into an

automated foodstuff assembly system to store and then dispense a fresh, whole, and/or locally-sourced bread bun into a slicing mechanism only one an order for a foodstuff is submitted and as the foodstuff is being fulfilled.

[0048] The bun dispenser can include a substantially transparent section containing fresh buns and a minimum of moving components such that the buns are visible to patrons near the automated foodstuff assembly system substantially without visual obstruction, such that a number of (moving) components and materials near and in contact with whole bread buns during operation of the bun dispenser is substantially limited, and/or such that the components of the bun dispenser remain substantially simple and straightforward to disassemble and to clean (e.g., by a human operator). The bun dispenser can further include multiple receivers and multiple hoppers, each configured to store multiple buns and installed in a corresponding receiver, and the bun dispenser can include a processor **150** configured to interface with one or more gas supplies, valves, reservoirs, and/or pumps, etc. to sequentially, intermittently, and cyclically dispense buns from the hopper **120(s)** into a single slicing mechanism, as shown in FIGS. **2** and **4** and described below.

[0049] The bun dispenser is described herein as a system for dispensing hamburger buns, such as whole gourmet brioche buns. However, the bun dispenser can additionally or alternatively dispense bread loaves, hot dog buns, rolls, bagels, or any other suitable bread or grain product of any other form or format. The slicing mechanism (or “bun slicer”) can similarly slice bread loaves, hot dog buns, rolls, or any other suitable bread product of any other form or format.

1.2 Receiver

[0050] The bun dispenser includes a receiver **110** arranged over a bun slicing mechanism and/or over a buttering and toasting system within the automated foodstuff assembly apparatus and functions to receive buns dispensed from the discharge end of a connected hopper **120**. The receiver **110** can receive a hopper **120**, transiently retain the hopper **120** in place, release the hopper **120** once emptied, and then receive a second, full hopper **120** filled with a row of whole bread buns. For example, the receiver **110** can include a (manually- or automatically-actuated) lock or latch that engages the hopper **120** to constrain the hopper **120** in alignment over an adjacent slicing mechanism. The receiver **110** can also include one or more features that locate the discharge end of the hopper **120**, such as vertically and horizontally, with a long axis of the hopper **120** parallel to an inlet of the receiver **110**, and the receiver **110** can define an internal cross-section of sufficient size and geometry to receive whole bread buns from the hopper **120** and to guide whole bread buns into the slicing mechanism and/or toaster below.

[0051] In one variation, the bun dispenser also includes a receptacle **116** offset from the receiver **110**, fluidly coupled to the gas supply **140**, configured to transiently receive and to seal against the pressurized end of the hopper **120**, and configured to cooperate with the receiver **110** to transiently support the hopper **120**. In this variation, the receptacle **116** can be arranged in-line with and longitudinally offset from the receiver **110**, as shown in FIG. **1**, and the receptacle **116** can lock and/or engages the pressurized end of the hopper **120**, thereby cooperating with the receiver **110** to transiently constrain the hopper **120** in position during dispensation of

buns from the hopper **120**. In one example, the receptacle **116** (and/or the receiver **110**) is spring loaded and can be retracted longitudinally away from the receiver **110**—such as manually by an operator—to release the hopper **120** once emptied of buns; the receptacle **116** can be similarly retracted to accept a second hopper loaded with buns. In this example, the receptacle **116** can be released, and a spring or damper coupled to the receptacle **116** can drive the receptacle **116** into a pressurized end of the second hopper to retain the second hopper in place in preparation for dispensation of buns from the second hopper, as described below.

[0052] However, the bun dispenser can include a receiver and/or a receptacle **116** of any other form or geometry and configured to transiently (i.e., removably) support hoppers in any other suitable way.

1.3 Hopper

[0053] The bun dispenser includes a hopper **120** including a substantially transparent elongated housing configured to contain a row of whole bread buns, defining a discharge end configured to transiently engage the receiver **110** and to dispense whole bread buns into the receiver **110**, and defining a pressurized end opposite the discharge end. Generally, the hopper **120** functions as a container for storing a row of whole bread buns and dispenses buns, through its discharge end, into the receiver **110** as the piston **130** is driven longitudinally through the hopper **120** toward the receiver **110**. As described above, the hopper **120** can be transiently (i.e., removably) coupled to the receiver **110** and can therefore be removed and replaced with a second, full hopper **120** loaded with a second row of buns while the (first) hopper **120** is replenished with buns.

[0054] The hopper **120** can be of a length suitable to contain multiple whole bread buns in a row (i.e., a “full” hopper **120**). For example, the hopper **120** can be approximately four feet in length, which may be sufficient to hold at least ten buns averaging four inches in diameter (with some deviation in diameter and height) when the buns are arranged side by side in a row within the hopper **120**. Alternatively, the hopper **120** can store multiple buns in a stack with the heel of one bun in arranged over (or under) a crown of an adjacent bun. However, the hopper **120** can store any other number of buns in any other arrangement.

[0055] The hopper **120** can define a rectilinear, curvilinear, circular, or elliptical cross-section or a cross-section of any other suitable form to accommodate one or more types of whole bread buns, such as sufficient to accommodate a particular type of bun characterized by relatively high variability (e.g., 50%) in diameter, height, and/or shape. However, the hopper **120** can define an internal cross-section of any other form suitable to accommodate a set of buns arranged in a row, stack, or other format.

[0056] In one implementation, the hopper **120** defines a rectangular internal cross-section and stores buns arranged side by side in a row. In this implementation, the receiver **110** (and the receptacle **116**) can support the hopper **120** such that the longitudinal axis of the hopper **120** is substantially parallel to the ground but such that the bottom (planar) surface of the hopper **120** is held at an angle to the horizon (i.e., nonparallel to gravity), such as at an angle of 20°, as shown in FIG. **2**. In one example, the hopper **120** can define a first planar surface (e.g., a side) and a second planar surface (e.g., a bottom) substantially perpendicular to the first planar surface, wherein the first planar (surface extends

from the pressurized end to the discharge end and is configured to support a vertical side of each whole bread bun in the row of whole bread buns, and wherein the second planar surface extends from the pressurized end to the discharge end and is configured to support a bottom side of each bun in the row of whole bread buns. In this example, the receiver 110 can support the hopper 120 with the first planar surface of the hopper 120 at an angle of approximately 45° to gravity. In this example, buns contained in the hopper 120 can be drawn into a lowest corner of the hopper 120 defined by the first and second planar surfaces by gravity. The first and second planar surfaces can therefore cooperate to locate buns in a reference corner of the hopper 120; thus, as the piston 130 is advanced forward toward the discharge end of the hopper 120 to dispense a whole bread bun from the hopper 120, gravity can maintain buns substantially in alignment in the hopper 120.

[0057] In the foregoing implementation, the heel of each whole bun stored in the hopper 120 can rest on bottom surface of the hopper 120, and a side of each bun stored in the hopper 120 can rest—due to gravity—on a side of the hopper 120 perpendicular to the bottom surface of the hopper 120, as shown in FIG. 2. The receiver 110 can therefore orient the hopper 120 such that the bottom surface of the hopper 120 and an adjacent (e.g., perpendicular) side of the hopper 120 constrains buns contained therein in two degrees of translation, thereby substantially reducing opportunity for buns stored in the hopper 120 to pack or “bunch” within the hopper 120 as the piston 130 drives the row buns toward the receiver 110.

[0058] As described above, the hopper 120 can include a transparent section to enable an operator, a patron, and/or a sensor to visually (or optically) detect a status of the row of buns contained in the hopper 120, such as what type and number of buns currently stored in the hopper 120. For example, the hopper 120 can include a glass (e.g., borosilicate) or polymer (e.g., acrylic, polycarbonate) tube: open at the discharge end; including features proximal the discharge end that engage the receiver 110; open at the pressurized end; and including features proximal the discharge that engage the receptacle 116. In the variation of the system that includes a receptacle 116, as described above: the receptacle 116 can close and seal against the pressurized end of the hopper 120 when the hopper 120 is installed in the automated foodstuff assembly apparatus; and the gas supply 140 can be (intransiently) connected directly to the receptacle 116 and can release gas into the hopper 120 through the receptacle 116 when the hopper 120 is installed in the automated foodstuff assembly apparatus. Alternatively, the hopper 120 can be closed at the pressurized end of the tube, and the gas supply 140 can connect directly to the hopper 120 at the pressurized end, such as with a quick-disconnect coupler.

[0059] The hopper 120 can further include perforations along its bottom and/or along one or more adjacent sides, such as relatively small (e.g., 500-micron-diameter) perforations along the first planar surface and/or along the second planar surface of the hopper 120 described above, and the bun dispenser can include a second gas supply that supplies gas to a chamber(s) behind these perforations in the hopper 120 when the hopper 120 is installed in the receiver 110. In this implementation, the perforations can bleed gas from the chamber to form a cushion of gas under buns stored in the hopper 120, thereby reducing stiction between buns and

adjacent surfaces in the hopper 120 and/or reducing opportunity for buns to stick to interior surfaces hopper 120. In this variation, the second gas supply can supply nitrogen, argon, or another inert gas to the hopper 120 to maintain freshness of buns stored therein. Alternatively, the second gas supply can supply heated and/or humidified air or steam to the hopper 120 in order to preserve a target moisture content and/or temperature of the buns stored in the hopper 120. Yet alternatively, the second gas supply can supply heated or cooled air or carbon dioxide or any other suitable (food-safe) gas to the hopper 120.

[0060] The hopper 120 can further include a handle—or an engagement feature that accepts a handle—that enables an operator to grasp the hopper 120 when transported to and from the receiver 110. For example, an operator tasked with maintaining an automated foodstuff assembly apparatus including the bun dispenser can: installed a removable handle onto the hopper 120 once the hopper 120 is emptied; remove the hopper 120 from the receiver 110; load the hopper 120 with whole fresh bread buns from a local supplier; return the hopper 120 to the receiver 110; and then release the handle from the hopper 120 to complete installation of the hopper 120 into the receiver 110. In this example, the bun dispenser can include a second receiver, a second hopper, and a second piston 130—as described below—that dispenses buns from a second column of buns while the (first) hopper 120 is removed from the bun dispenser for reloading.

1.4 Piston and Seal

[0061] The bun dispenser includes a piston 130 arranged within the hopper 120 between the pressurized end of the hopper 120 and the row of whole bread buns. Generally, the piston 130 translates longitudinally within the hopper 120 to displace a row (or a stack) of buns toward the receiver 110, thereby dispensing buns from the hopper 120. In particular, the gas supply 140 supplies gas at an elevated pressure (i.e., a pressure exceeding local atmospheric pressure) to the closed volume behind the piston 130 to displace the piston 130 forward toward the receiver 110. Therefore, the piston 130 (in-unit with the permeable seal 132) can define the single moving component within the bun dispenser that dispenses buns into the slicing mechanism.

[0062] The bun dispenser also includes a permeable seal 132 interposed between an interior wall of the hopper 120 and an adjacent surface of the piston 130, wherein the permeable seal 132 cooperates with the hopper 120 and the piston 130 to define a closed volume between the pressurized end of the hopper 120 and the piston 130, and wherein the permeable seal 132 is configured to bleed gas from the closed volume toward the discharge end of the hopper 120. Generally, the permeable seal 132 functions to form an incomplete (e.g., “loose”) seal between the piston 130 and the interior wall of the hopper 120 such that fluid pressure in the closed volume behind the piston 130 bleeds through (or past) the seal, thereby enabling the closed volume return to (near) local atmospheric pressure when the gas supply 140 is closed (e.g., without opening a pop-off valve 143 or actively pumping gas out of the closed volume with a second pump fluidly coupled to the closed volume).

[0063] In one implementation, the piston 130 includes a substantially rigid mass defining a first end facing the pressurized end of the hopper 120, defining a second end facing the dispense end of the hopper 120, and defining an

external dimension (e.g., cross section) undersized for the internal cross-section of the hopper 120. In one example, the permeable seal 132 includes a first perforated polymer seal arranged about the circumference of the piston 130 adjacent the first end of the piston 130 and a second perforated polymer seal arranged about the circumference of the piston 130 adjacent the second end of the piston 130. In this example, the first perforated polymer seal can include a closed-cell silicone-foam ring with perforations extending through the ring substantially parallel to the long axis of the hopper 120. The second polymer seal can include a similar closed-foam silicone ring and can cooperate with the first perforated polymer seal to bleed gas from the first end of the piston 130 to the second end of the piston 130. In another example, the permeable seal 132 includes a felt seal arranged about the perimeter of the piston 130 and sized to engage the internal surface of hopper 120 according to a running fit. In yet another example, the permeable seal 132 includes a food-safe open-celled foam. However, the bun dispenser can include a seal of any other suitable material, geometry, or arrangement on the piston 130.

[0064] The permeable seal 132 can thus allow gas pressure to build behind the piston 130 when gas is released from the gas supply 140 into the hopper 120 but can also allow gas to seep past the piston 130 such that gas pressure on each side of the piston 130 may relatively quickly equilibrate once the gas supply 140 is closed to the hopper 120. In particular, because the permeable seal 132 may permit gas may leak past the piston 130, the piston 130 may stop substantially immediately when the gas supply 140 is closed, thereby enabling substantially accurate cessation of bun row advancement once a bun is dispensed from the hopper 120 during a dispense cycle by merely closing the gas supply 140 with a dispense event is detected. The bun dispenser can therefore exclude one or more sensors that may otherwise be sampled to monitor gas pressure behind the piston 130 and/or to monitor a volume of gas released into the hopper 120 to displace the piston 130 toward the receiver 110. For example, the bun dispenser can exclude both a pressure sensor arranged within or coupled to the hopper 120 can be configured to detect gas pressure inside the hopper 120 and a flow meter coupled to the gas supply 140 to detect quantities of gas pumped into the hopper 120.

[0065] Alternatively, the piston 130 can be sealed to the hopper 120 with an impermeable seal 132ed (e.g., a pair of solid (i.e., unperforated) silicone O-rings), and the piston 130 can include one or more bores (of substantially small cross-sectional area) configured to bleed gas from behind the piston 130 toward the receiver 110. In particular, the piston 130 can include multiple bores of substantially small cross-section such that gas pressure can build behind the piston 130 when the gas supply 140 is opened but such that gas can seep past the piston 130 passively to enable gas pressure on each side of the piston 130 to equilibrate relatively quickly—thereby enabling the piston 130 to slow to a stop inside the hopper 120 relatively quickly—once the gas supply 140 is closed (e.g., in response to detection of a dispense event), as described above. However, the bun dispenser can include a piston 130 and/or a permeable seal configured to bleed gas pressure through and/or across the piston 130 in any other suitable way.

[0066] In one example, the piston 130 includes a substrate of solid hardwood, such as carved or machined walnut or cherry. Alternatively, the piston 130 can include a metallic

substrate, such as cast aluminum or machined steel, or a polymer substrate, such as injection-molded nylon or cast polycarbonate. The piston 130 can also be sized (or undersized) to mate with the interior wall of the hopper 120. For example, for a hopper 120 defining a rectangular cross-section 6" wide and 4" tall, the piston 130 can define a rectilinear substrate 5.8" wide and 3.8" tall. In this example, the permeable seal 132 can include a first perforated polymer seal and a second perforated polymer seal, each 0.12" in height and configured to crush to 0.1" in height between the piston 130 and the interior wall of the hopper 120 when installed about the circumference of the first end and the second end, respectively, of the hopper 120. However, the piston 130 can be of any other suitable material or geometry.

[0067] The rear of the piston 130 can further define a well 131, as shown in FIG. 3, such that gas under pressure behind the piston 130 acts on the piston 130 substantially near the leading face of the piston 130 to advance the piston 130 toward the receiver 110, which may substantially limit a tendency of the piston 130 to pitch within the hopper 120. The piston 130 can also include a tongue 133 extending toward the discharge end of the hopper 120 and over a crown of a whole bread bun, in the row of whole bread buns, adjacent the piston 130, as shown in FIG. 1. Generally, the tongue 133 can function to constrain the bottom surface of the last bun in the row of buns (i.e., the bun adjacent the piston 130) against the bottom surface (e.g., the second planar surface) of the hopper 120. In particular, the tongue 133 can prevent the last bun in the row of buns from pitching relatively to the hopper 120 as the piston 130 is advanced forward along the hopper 120 and pushes the row of buns toward the receiver 110. In one example, the tongue 133 includes a static, cantilevered beam extending outwardly from the second end of the piston 130 at a height about the bottom surface of the hopper 120 (e.g., the second planar surface of the hopper 120) by a distance approximating an average (or allowable maximum) height of the type of whole bread bun loaded into the hopper 120. In another example, the tongue 133 include a substantially rigid beam extending from the second end of the hopper 120 and sprung downward toward the bottom of the hopper 120. In this example, the tongue 133 can then be sprung downward toward and can rest on the top of the last bun in the row of buns stored in the hopper 120. Furthermore, in this example, the tongue 133 can include a stop that prevents the tongue 133 from pivoting (or translating) upwardly away from the bottom surface of the hopper 120 by more than the allowable maximum height of the type of whole bread bun loaded into the hopper 120.

[0068] In one implementation, the piston 130 is unique to (i.e., remain with) the hopper 120. In particular, the piston 130 can remain with the hopper 120 when the hopper 120 is both installed in the automated foodstuff assembly apparatus to dispense buns into the slicing mechanism and removed from the automated foodstuff assembly apparatus, such as for reloading with buns. For example, the hopper 120 can define features at each open end to prevent the piston 130 from passing fully through the hopper 120, such as when the piston 130 moves fully toward the receiver 110 once the last bun is dispensed from the hopper 120 or when the piston 130 is retracted toward the pressurized end of the hopper 120 in preparation for reloading the spent hopper 120 with more buns. In this example, these features that capture the piston 130 within the hopper 120 can also be operable to release the

piston 130 from the hopper 120, such as by an operator in preparation for separately cleaning the hopper 120 and the piston 130.

[0069] Alternatively, the piston 130 can remain with the automated foodstuff assembly apparatus when the emptied hopper 120 is removed from the automated foodstuff assembly apparatus and replaced with a full hopper 120. For example, upon dispensation of a last bun from the hopper 120, gas (e.g., air) can be withdrawn from the hopper 120 between the trailing face of the piston 130 and the pressurized end of the hopper 120—such as through the gas supply 140 or through a gas return line coupled to the hopper 120—to yield a partial vacuum within the hopper 120. In this example, the partial vacuum can draw the piston 130 back toward the pressurized end of the hopper 120 and fully into the receptacle 116 adjacent the pressurized end of the hopper 120. The hopper 120 can then be removed from the apparatus sans the piston 130, a full hopper 120 filled with buns can be installed in the apparatus, and the piston 130 can then be moved forward into the full hopper 120 by introducing as under pressure into the full hopper 120 to displace buns toward and into the receiver 110.

1.5 Gas Supply

[0070] The bun dispenser includes a gas supply 140 configured to intermittently supply gas into the closed volume to displace the piston 130 toward the discharge end of the hopper 120. Generally, the gas supply 140 functions to supply gas under pressure to the hopper 120 behind the piston 130 to displace the piston 130 toward the receiver 110 during a dispense cycle, thereby dispensing a bun from the hopper 120 into the receiver 110, which then releases the bun into the slicing mechanism for subsequent slicing into a bun crown and a bun heel.

[0071] In one implementation, the gas supply 140 is connected substantially intransiently to the receptacle 116 opposite the receiver 110 and includes a flexible line that absorbs movement of the receptacle 116, such as when the receptacle 116 is retracted during removal of a spent hopper 120 and when the receptacle 116 is retracted during installation of a full hopper 120. Alternatively, the gas supply 140 can be transiently connected directly to the hopper 120, such as with a quick disconnect coupler such that the gas supply 140 can be quickly connected and disconnected from each new hopper 120 installed in the receiver 110.

[0072] The gas supply 140 can include a reservoir 142, a pump 144, a gas generator, and/or any other suitable type of gas pressure device arranged in the automated foodstuff assembly apparatus and configured to output pressurized gas, such as air, argon, or nitrogen at pressures exceeding local ambient air pressure. Alternatively, the gas supply 140 can couple the hopper 120 (or the receptacle 116) to an external pressurized gas line that supplies gas to the automated foodstuff assembly apparatus. The gas supply 140 can additionally or alternatively include a valve 141 (shown in FIG. 3) arranged between a gas pressure device and the hopper 120, such as a solenoid valve 141.

[0073] As described above, the gas supply 140 functions to supply gas to the hopper 120 to increase fluid pressure behind the piston 130, which in turn displaces the piston 130 toward the discharge end of the hopper 120. However, a weak or loose seal between the hopper 120 and the piston 130 may allow gas to seep passed the piston 130 such that gas pressure on each side of the piston 130 may to equalize

relatively quickly, thereby stopping the piston 130 stop relatively abruptly when the gas supply 140 is closed (e.g., when the valve 141 is closed, when the gas pressure device is deactivated). The bun dispenser can therefore close the gas supply 140 in response to detected dispensation of a bun through the receiver 110, and the permeable seal 132 between the piston 130 and the hopper 120 (and/or a bore passing through the piston 130) bleed gas across the piston 130 such as fluid pressure equilibrates on each side of the piston 130, thereby enabling substantially precise (i.e., accurate and repeatable) position control of the piston 130 without necessitating close monitoring of the gas pressure within the hopper 120 and without monitoring a volume of gas pumped into the hopper 120 behind the piston 130.

[0074] Furthermore, because the permeable seal 132 may bleed gas from behind the piston 130 into the volume of the hopper 120 containing buns, the gas supply 140 can supply a particular type and/or quality of gas supplied to the closed volume behind the piston 130. For example, the gas supply 140 can release an inert gas (e.g., argon, nitrogen) from a pressurized inert gas reservoir 142 into the closed volume behind the piston 130. Alternatively, the gas supply 140 can include a pump 144 and a humidifier that cooperate to supply humidified air into the hopper 120, such as to maintain a target moisture content of the row of buns.

[0075] In one implementation, the gas supply 140 includes a pop-off valve 143 fluidly coupled to the pressurized end of the hopper 120, such as in addition to or in replacement of the permeable seal 132. In this implementation, the bun dispenser can open the pop-off valve 143 in response to detection of a dispense event (i.e., in response to release of a whole bread bun, in the row of whole bread buns, into the receiver 110) during a dispense cycle. The bun dispenser can therefore actively release fluid pressure behind the piston 130 by actuating the pop-off valve 143. The pop-off valve 143 can be fluidly connected to the gas supply 140, such as between a solenoid valve 141 and the hopper 120. Alternatively, gas supply 140 can include a valve 141 that selectively opens the hopper 120 to a pressure reservoir 142 or other gas pressure device and to ambient; the valve 141 in the gas supply 140 can thus function as a pop-off valve 143.

[0076] However, the bun dispenser can manipulate fluid pressure behind the piston 130 in any other suitable way.

1.6 Sensors

[0077] In one variation, the bun dispenser includes one or more sensors that output signals corresponding to the position of the row of buns in the hopper 120 and/or to dispensation of a bun into the slicing mechanism.

[0078] In one implementation, the bun dispenser includes a distance sensor 160 aligned with the axis of the hopper 120 opposite the receiver 110 and configured to output a signal proportional to a distance between the distance sensor 160 and a surface of a nearest whole bread bun in the row of whole bread buns arranged in the hopper 120. For example, the distance sensor 160 can include an optical (e.g., laser) or acoustic (e.g., sonar) distance sensor 160 offset from the receiver 110 ahead of the hopper 120 and defining a field of view extending from the dispense end of the hopper 120 toward the pressurized end of the hopper 120. The bun dispenser can thus sample the distance sensor 160 to determine a position—in the hopper 120—of a whole bread bun approaching the receiver 110.

[0079] The bun dispenser can also include a mechanical contact switch, optical break switch, or any other suitable type of switch or sensor proximal the dispense end of the hopper 120, such as within or across an outlet of the receiver 110. The bun dispenser can sample the switch to identify a dispense event, such as in addition to sampling the distance sensor 160 to achieve sensor redundancy in the system. However, the bun dispenser can include any other number and/or type of sensor configured to output a signal corresponding to a position of a bun in the system.

1.7 Roller

[0080] The bun dispenser can also include a roller 112 proximal an outlet of the receiver 110 between the receiver 110 and the slicing mechanism. In this variation, the roller 112 can function as a soft or rolling stop for whole buns passing into the receiver 110 to prevent multiple buns from dropping into the slicing mechanism below as the piston 130 slows within the hopper 120 once a whole bread bun has been dispensed and once the gas supply 140 has been closed. In one implementation, the roller 112 is arranged between the hopper 120 and the receiver 110 and extends into a boundary defined by a cross-section of the hopper 120 projected toward the receiver 110 parallel to an axis of the hopper 120.

[0081] In the implementation described above in which the hopper 120 defines a rectangular cross section including a first planar surface (e.g., a side) and a second planar surface (e.g., a bottom), the roller 112 can be interposed between hopper 120 and the receiver 110 with an axis of the roller 112 parallel to (e.g., offset below, offset above, or aligned with) the second planar surface (e.g., the bottom) of the hopper 120. The roller 112 can include a cylindrical roller supported on bearings or bushings and can define a rolling surface that extends into the dispense end of the hopper 120. The roller 112 can thus impede a row of buns remaining in the hopper 120 from continuing to move into the receiver 110 following a dispense event. However, the roller 112 can rotate across the bottom of a bun as the row of buns is actively driven toward the dispense end of the hopper 120 by the piston 130 in order to mitigate physical damage to a bun forced past the roller 112 during a dispense cycle.

[0082] The bun dispenser can also include a second roller 113 that similarly defines a second rotational axis parallel to the second planar surface (e.g., the side) of the hopper 120 and that defines a second rolling surface offset from the second planar surface toward the axis of the hopper 120. The second roller 113 can rotate across the side of a first bun in the row of buns as the row of buns is actively driven toward the dispense end of the hopper 120 by the piston 130, and the second roller 113 can cooperate with the (first) roller 112 to impede a row of buns remaining in the hopper 120 from continuing to move into the receiver 110 once the first bun is dispensed into the receiver 110.

[0083] The bun dispenser can additionally or alternatively include a flap extending into a path of the row of buns and similarly functioning to inhibit release of a whole bread bun, in the row of whole bread buns, into the receiver 110. For example, the flap can include a silicone-foam flap or a spring-loaded rigid beam coupled to an inlet of the receiver 110 and extending from proximal the first planar surface (e.g., the side) of the hopper 120 and toward the long axis of the hopper 120 in an initial position. The flap can deflect

away from the pressurized end of the hopper 120 as a first bun is actively driven past the flap and through the receiver 110, but the flap can return to the initial position to inhibit advancement of a second bun behind the first bun once the first bun is dispensed from the hopper 120, the gas supply 140 is closed, and the piston 130 has ceased advancement within the hopper 120.

1.7 Dispensing Operation

[0084] Generally, the bun dispenser selectively opens the gas supply 140 to the hopper 120 during each dispense cycle to pressurize the closed volume between the piston 130 and the pressurized end of the hopper 120. During a dispense cycle, gas under pressure in the closed volume acts on the piston 130, thereby displacing the piston 130 toward the discharge end of the hopper 120, which displaces the row of whole bread buns toward the receiver 110. Once a dispense event is detected (i.e., once a single bread bun is released into the receiver 110), the bun dispenser closed the gas supply 140 to cease advancement of the piston 130 and to cease advancement of buns into the receiver 110.

[0085] In one implementation, the bun dispenser selectively actuates a gas generator (e.g., a nitrogen generator) or a pump 144 coupled to the hopper 120 to intermittently pressurize the closed volume behind the piston 130. Alternatively, the bun dispenser can trigger a valve 141 arranged between the hopper 120 and a reservoir 142 containing gas under pressure (e.g., arranged within or external to the automated foodstuff assembly system) to selectively release gas from the reservoir 142 into the hopper 120. The bun dispenser can also selectively actuate a humidifier in-line with the gas supply 140 to control a moisture content of gas (e.g., air) release into the hopper 120.

[0086] In one implementation, the bun dispenser opens gas supply 140 (e.g., opens a valve 141, actuates a pump 144, etc. to release a preset volume (or mass) of gas into the closed volume behind the piston 130. In this implementation, the bun dispenser can set or select the preset volume of gas to achieve a target displacement distance of the piston 130 toward the discharge end of the hopper 120 corresponding to a minimum or average diameter of a type of bread bun loaded into the hopper 120. In this variation, bun dispenser can release a constant, initial volume of gas into the hopper 120 for each dispense cycle. For example, the bun dispenser can open the gas supply 140 (e.g., trigger a valve 141 to open) for a preset period of time, such as two seconds, corresponding to the initial volume of gas to advance the piston 130 forward by the target distance for each dispense cycle. Alternatively, the bun dispenser can release present volumes of gas that are unique to each indexed position of the piston 130 for each subsequent dispense cycle as buns in the row of buns are sequentially released into the receiver 110. For example, the bun dispenser can: open the gas supply 140 for 1.0 second to release thirty cubic inches of gas into the hopper 120, thereby displacing the piston 130 forward by a distance sufficient to release a first bun I the row of buns into the receiver 110; then open the gas supply 140 for 1.2 seconds to release thirty-six cubic inches of gas into the hopper 120, thereby advancing the piston forward by a distance sufficient to release a second bun—previously behind the first bun—into the receiver 110; and then open the gas supply 140 for 1.6 seconds to release forty-eight cubic inches of gas into the hopper 120, thereby displacing

the piston **130** by a distance sufficient to dispense a third bun—previously behind the second bun—into the receiver **110**.

[0087] Alternatively, the bun dispenser can implement a hysteresis controller **112** to selectively open and close the gas supply **140** during a dispense cycle based on a signal output by a sensor coupled to the receiver **110** and corresponding to passage of a bun through the receiver **110**. In one example, the bun dispenser includes an optical emitter outputting a light beam across the receiver **110** and offset ahead of the roller **112** by a distance corresponding to a tipping point at which buns that have passed the roller **112** fall (typically) through outlet of the receiver **110**. (Similarly, the optical emitter can output a light beam offset ahead of the roller **112** by a distance corresponding to a tipping point less a typical distance displaced by the piston **130** after the gas supply **140** is closed.) In this example, the bun dispenser also includes an optical detector pointing toward the optical emitter opposite the internal section of the receiver **110**. In this example, while gas is flowed through the gas supply **140** into the hopper **120**, the bun dispenser can sample an output of the optical detector during a dispense cycle to detect when a bun has passed the tipping point, and the bun dispenser can close the gas supply **140** when the beam output from the optical emitter to the optical detector is broken (i.e., by a bun), thereby ceasing flow of gas into the closed volume behind the piston **130**, ceasing motion of the piston **130** toward the discharge end of the hopper **120**, and ceasing release of additional buns into the receiver **110** for the dispense cycle. In a similar example, the bun dispenser can include a mechanical contact sensor in line with a path of buns dispensed from the hopper **120** into the receiver **110** or in line with the path of buns dispensed from the receiver **110** into the slicing mechanism. In this example, once the gas supply **140** is opened, the bun dispenser can sample an output of the sensor during a dispense cycle and can then close the gas supply **140** to cease delivery of gas to the hopper **120** in response to a change in the output state of the sensor (e.g., in response to contact by a bun).

[0088] Yet alternatively, the bun dispenser can implement closed-loop feedback to selectively open and close open the gas supply **140** during a dispense cycle based on an output of one or more sensors coupled to the receiver **110**. For example, the bun dispenser can include a distance sensor **160** coupled to the receiver **110** opposite a chute **210** within the slicing mechanism, aligned with the hopper **120**, and facing the piston **130**, as described above, and the bun dispenser can sample the sensor can selectively open and close the valve **141** based on a output of the distance sensor **160** (e.g., based on a distance between the distance sensor **160** and a bun—in the row of buns—nearest the receiver **110**). In this example, during a dispense cycle, the bun dispenser can intermittently open the gas supply **140** (e.g., a valve **141**) at a duty cycle proportional to a signal output by the distance sensor **160**. In particular, the bun dispenser can open the gas supply **140** at an initial duty cycle at the beginning of a dispense cycle and reduce this duty cycle as a signal output by the sensor during the dispense cycle indicates that a first bun in the row of buns is nearing the sensor. For example, the gas supply **140** can supply gas to the closed volume behind the piston **130** at a first aggregate volume flow rate based on a first distance value output from the distance sensor **160**, and the gas supply **140** can supply gas to the closed volume at a second aggregate volume flow

rate less than the first aggregate volume flow rate based on a second distance value output from the distance sensor **160**, the second distance value less than the first distance value. The gas supply **140** can thus supply a greatest flow rate of gas to the closed volume behind the piston **130** at the beginning of the dispense cycle and can supply gas at a flow rate that decreases as a bun nearest the receiver **110** (i.e., a “first bun”) approaches a tipping point in the receiver **110**. **[0089]** Furthermore, the distance sensor **160** can output a signal characterized by a (near-) step change at an instant that a second bun—behind the first bun—comes into the field of view the sensor when the first bun is released from the receiver **110** into the adjacent slicing mechanism. The bun dispenser can thus detect (or confirm) a dispense event in response to receipt of such a step change in the output of the distance sensor **160**, and the bun dispenser can close the gas supply **140** in response to this (near-) step change in distance values output by the distance sensor **160** during a dispense cycle.

[0090] The bun dispenser can also update (e.g., index) a bun counter for the hopper **120** after each dispense event, can trigger an auditory and/or visual alarm or transmit a notification to a nearby operator to replace the hopper **120** with a second, full hopper **120** when the counter expires (i.e., reaches “0”), and reset a second bun counter for the second hopper once the second hopper is installed and operational within the bun dispenser.

[0091] In one variation, the bun dispenser also includes a camera (e.g., a three-dimensional camera, an a RGB camera) or other optical sensor arranged over or adjacent the hopper **120** and/or the receiver **110**, and the bun dispenser can sample images from the camera (e.g., at a sampling rate of 10 Hz) as gas is flowed into the hopper **120** during a dispense cycle. In this implementation, the bun dispenser can implement machine vision techniques to identify buns in digital images captured from the camera and to detect dispense dispensation of an identified bun into the receiver **110** or dispensation of an identified bun from the receiver **110** into the slicing mechanism. The bun dispenser can also implement machine vision techniques to identify buns in the hopper **120** from images captured by the camera and can update a bun counter for the hopper **120** accordingly after each dispense cycle, as described above.

[0092] As shown in FIG. 1, the bun dispenser can include a processor **150** configured to control various subsystems therein according to the foregoing methods.

1.8 Variations

[0093] One variation of the bun dispenser further includes: a second receiver adjacent and offset above the receiver **110**; a second hopper configured to contain a second row of whole bread buns, defining a second discharge end configured to transiently engage the second receiver and to dispense whole bread buns into the second receiver, and defining a second pressurized end opposite the second discharge end; a second piston **130** arranged within the second hopper between the second pressurized end of the second hopper and the second row of whole bread buns; and a second permeable seal **132** interposed between an interior wall of the second hopper and an adjacent surface of the second piston **130**, the second permeable seal **132** cooperating with the second hopper and the second piston **130** to define a second closed volume between the second pressurized end of the second hopper and the second piston **130**, the

second permeable seal **132** configured to bleed gas from the second closed volume toward the second discharge end of the second hopper. In this variation, the gas can supply selectively supply gas to the closed volume and to the second closed volume to advance the hopper **120** toward the discharge end of the hopper **120** and to advance the second hopper toward the second discharge end of the second hopper, respectively. Alternatively, the bun dispenser can include multiple gas supplies, including one gas supply **140** per receiver. In this variation, the bun dispenser can also include multiple additional receivers, hoppers, and pistons, such as four total receiver, hopper **120**, and piston **130** sets aligned in a column along the slicing mechanism.

[0094] In this variation, the bun dispenser can empty each hopper **120** in the set of cycles in sequence, such as by dispensing buns from a first hopper **120** until the first hopper **120** is empty, then dispensing buns from a second hopper until the second hopper is empty, then dispensing buns from a third hopper until the third hopper is empty, etc. In particular, the bun dispenser can sequence dispensation of buns from each hopper **120** in the set of hoppers such that one or more expired hoppers (e.g., three of four hoppers loaded in the automated foodstuff assembly system) can be replaced with full hoppers while at least one hopper **120** (e.g., a fourth hopper) remains loaded with buns, thereby enabling the automated foodstuff assembly system to remain in continuous operation while additional buns are loaded into the bun dispenser.

[0095] In one implementation, the bun dispenser includes multiple hoppers that are loaded with a different type of bun and then installed in corresponding receivers with the bun dispenser. For example, at a given time, a first hopper **120** installed in a first receiver in the bun dispenser can be loaded with white buns, a second hopper installed in a second receiver in the bun dispenser can be loaded with whole wheat buns, and a third hopper installed in a third receiver in the bun dispenser can be loaded with poppy seed buns. The bun dispenser can then selectively release gas from one or more gas supplies into one of the first, second, or third hoppers to dispense a particular type of bun into the slicing mechanism, such as based on a custom food order received from a patron, assigned to a next hamburger to be assembled, and specifying the particular type of bun thus dispensed. The bun dispenser can therefore accept multiple hoppers loaded with different types, sizes, etc. of whole buns and can selectively dispense whole buns according to custom food orders submitted by patrons of the automated foodstuff assembly apparatus.

[0096] In this variation, multiple hoppers can be linked and/or connected in sets. For example, a set of four hoppers can be connected in a stack such that the whole stack of four hoppers can be removed from the automated foodstuff assembly system in unison once emptied, and a new stack of four hoppers similarly connected and filled with buns can be simultaneously installed in the automated foodstuff assembly apparatus.

2. Slicing Mechanism

[0097] As shown in FIG. 4, a second system **200** for slicing whole bread buns includes: a chute **210** defining a load end, defining a slice end vertically below the load end, and configured to receive whole bread buns from the receiver **110** between the load end and the slice end; a blade **220** extending across the chute **210** proximal the slice end of

the chute **210**; and a cutting block **250** arranged in the chute **210** and configured to advance from a load position to a pierce position to a slice position during a dispense cycle, the cutting block **250** adjacent the load end of the chute **210** in the load position to receive a whole bread bun from the receiver **110**, arranged between the receiver **110** and the blade **220** in the pierce position offset from the blade **220** by less than a length of the whole bread bun for a pierce duration to pierce the whole bread bun with the blade **220**, and extending past the blade **220** in the slice position to sever a crown of the whole bread bun from a heel of the whole bread bun.

[0098] In one variation, the second system **200** includes: a chute **210** defining an elongated section and an outlet, the elongated section receiving a bun dispensed from a bun dispenser; a blade **220** arranged across the chute **210** proximal the outlet and sealed about a wall of the chute **210**; a reciprocating linkage **230** coupled to the blade **220** and housed within an isolated chamber **232** adjacent the chute **210**; an actuator **240** arranged outside of the isolated chamber **232** and coupled to the blade **220** via the reciprocating linkage **230**; and a cutting block **250** arranged within the chute **210** and operable between a first position, a second position, and a third position. In this variation, the cutting block **250** is retracted longitudinally in the chute **210** and at a first offset height above the chute **210** in the first position (shown in FIG. 5A) to restrain a bun within the chute **210**; is elevated vertically to a second offset height—greater than the first height—over the chute **210** in the second position (shown in FIG. 5B) to release the bun toward the blade **220**; and drives a bun into the blade **220** between the second position and the third position (shown in FIG. 5C).

2.1 Applications

[0099] Generally, the second system **200** (hereinafter “slicing mechanism”) can be arranged within an automated foodstuff assembly apparatus to slice whole buns received from one or more hoppers in a bun dispenser mechanism described above. The slicing mechanism also advances the cutting block **250** between a load position in which a whole bun is dispensed from the bun dispenser into the chute **210**, a pierce position in which the cutting block **250** slight compresses the whole bun against the blade **220** as the blade **220** is actuated (e.g., reciprocated) in order to pierce the skin of the whole bun, and a slice position in which the cutting block **250** has driven the whole bun fully through the blade **220** to separate the crown of the bun from the heel of the bun. In particular, the slicing mechanism can advance the cutting block **250** into the pierce position and hold the cutting block **250** in the pierce position for an extended duration of time (e.g., eight seconds) typically sufficient for the blade **220** to pierce the skin of the whole bun. With the skin of the bun thus pierced by the blade **220**, the whole bun can be slicing relatively easily, and the cutting block **250** can drive the bun through the blade **220** relatively rapidly without substantially compressing or otherwise deforming the bun. Once a bun is sliced, the slicing mechanism can dispense the sliced bun into a butter stage **310** and/or into a toast stage **320** before condiments, toppings, and/or a meat (e.g., a hamburger patty), etc. are deposited onto the sliced, buttered, and toasted bun.

2.2 Chute

[0100] The chute **210** defines an elongated section and an outlet, the elongated section receiving a bun dispensed from

a bun dispenser. Generally, the chute **210** functions to receive a series of buns from one or more hoppers of the bun dispenser arranged over the chute **210** and to funnel the buns serially toward the cutting block **250** and on to the reciprocating blade.

[0101] In the implementation described above in which the bun dispenser includes a set of hoppers that intermittently and serially dispense buns into corresponding receivers, the receivers can be arranged over and along the length of the chute **210** and can dispense buns directly into the chute **210**. For example, a set of receivers can be arranged along one side of the chute **210** such that hoppers installed in the receivers extend from one side of the chute **210** and substantially perpendicular to the chute **210**. Alternatively, receivers can be arranged along the chute **210** such that hoppers installed into corresponding receivers extend outwardly from both sides of the chute **210**.

[0102] The chute **210** can therefore be of a length suitable to accommodate multiple receivers that dispense buns (e.g., via gravity) from various hoppers into the chute **210**. The chute **210** can also be of a width and height sufficient to accommodate buns of a particular geometry or range or geometries. The chute **210** can also be angled downward toward the reciprocating blade such that whole buns dispensed into the chute **210** are guided toward the blade **220** by gravity. The slicing mechanism can additionally or alternatively include an air knife **260** arranged at one end of the chute **210** opposite the blade **220** and configured to direct blasts of air (or nitrogen, argon, humidified air, etc.) toward the blade **220**, thereby impelling buns held in the chute **210** toward the blade **220**, as shown in FIG. 5B. Yet alternatively, a bottom surface of the chute **210** configured to support a dispensed buns can be perforated, and a second pump or a second valve connected to a gas reservoir within the automated foodstuff assembly apparatus can release air through the perforations to form a cushion of air under the buns, thereby reduce friction and/or stiction between buns and the chute **210** and enabling the buns to fall toward the blade **220** once dispensed from a corresponding hopper **120**.

[0103] The chute **210** can further include a vane **214** immediately behind the blade **220** to maintain separation of the bun heel from the crown of the bun once the bun is sliced, as shown in FIG. 5C. The vane **214** can extend from behind the blade **220** toward a butter stage **310** and/or a toast stage **320** arranged below the chute **210**. In particular, the vane **214** can partition the cross-section of the chute **210** vertically into two sections, including a lower section configured to pass bun heels to one side of the butter stage **310** and an upper section configured to pass bun crowns to the opposite side of the butter stage **310**. The chute **210** and the vane **214** can further include a transition from an angled (or substantially horizontal) section to a substantially vertical section over the butter stage **310**, as shown in FIG. 5A. In particular, once a bun is sliced into a bun heel and a bun crown, the chute **210** and the vane **214** can dispense the bun heel and the bun crown into corresponding sides of the butter stage **310** below.

[0104] The chute **210** and the vane **214** can be of a food-safe material, such as stainless steel, nylon, or polycarbonate. However, the chute **210** can be of any other form, dimension, and/or material.

2.3 Blade

[0105] The blade **220** is arranged across the chute **210** proximal the outlet of the chute **210** and is sealed against adjacent walls of the chute **210**. Generally, the blade **220** functions to slice buns as buns are fed into the blade **220**. In one implementation, the blade **220** is coupled to a reciprocating linkage **230** that translates rotary motion of the actuator **240** into linear oscillating (i.e., reciprocating) motion at the blade **220**. Alternatively, the blade **220** can include a continuous bladed band supported on two wheels—at least once of which is driven in continuous rotary motion by the actuator **240**—with one linear span of the blade **220** between the two wheels extending across the chute **210**.

[0106] The blade **220** can include a serrated blade, a flat blade, a pair of serrated or flat blades, or any other suitable type of blade and can be of any suitable material, such as stainless steel, ceramic, or any other food-safe material that can hold a sharpened edge.

[0107] The blade **220** is arranged across the chute **210** at a height above the base surface of the chute **210** corresponding to a target thickness of bun heels to be dispensed from the slicing mechanism into the butter stage **310**. The blade **220** passes through a wall of the chute **210** on one or both sides of the base surface and is sealed against the wall(s) of the chute **210**. For example, the chute **210** can define a pair of rectangular bores in its vertical walls near an outlet of the chute **210**, the chute **210** can include seals arranged in the rectangular bores, and the blade **220** can pass through the seals to prevent crumbs and other debris from sliced buns from exiting the chute **210** area and entering a reciprocating linkage **230** or other mechanism outside of the chute **210**. For example, the chute **210** can include closed-cell silicone foam seals that seals a sharpened portion of the blade **220** within the chute **210** to prevent egress of food debris out of the chute **210** as buns are sliced by the slicing mechanism.

[0108] The actuator **240** is coupled to the blade **220** via the reciprocating linkage **230** and cooperated with the reciprocating linkage **230** to reciprocate the blade **220** across the chute **210** in a direction substantially perpendicular to the motion of buns into the blade **220**. In one variation, the actuator **240** includes a rotary motor, such as an electric motor or a compressed-air-powered motor, that outputs torque through an output shaft. In this variation, the reciprocating linkage **230** is arranged between the motor output shaft and the blade **220** and transforms rotary motion from the motor into reciprocating linear motion of a suitable maximum displacement (e.g., 3 mm) and at a suitable rate (e.g., 4000 cycles per minute). In this variation, all or a portion of the reciprocating linkage **230** can be contained within the isolated chamber **232** that functions as a secondary containment area for food waste that may shifted past the seal(s) around the blade **220** during operation. The isolated chamber **232** can thus contain any such food waste and substantially prevent this debris from moving back through the seals and into the chute **210**. The actuator **240** can be arranged outside of the isolated chamber **232**, and a portion of the reciprocating linkage **230** can pass from the motor through a wall of the isolated chamber **232**, such as through a sealed linear bearing, to the blade **220**.

[0109] However, the actuator **240** and the reciprocating linkage **230** can be coupled to the blade **220** in any other suitable way to reciprocate the blade **220** back laterally.

[0110] Alternatively, the blade 220 can include a circular blade—such as a circular blade with a smooth or serrated edge—arranged across the chute 210 near an outlet of the chute 210, and the actuator 240 can rotate the blade 220 to slice buns during operation. However, the blade 220 can be of any other form or geometry, and the actuator 240 can actuate the blade 220 in any other suitable way.

2.4 Cutting Block

[0111] In one variation, the cutting block 250 is arranged within the chute 210 and is operable between a first position, a second position, and a third position. In this variation, the cutting block 250: is retracted longitudinally in the chute 210 and at a first offset height above the chute 210 in the first position (shown in FIG. 5A) to restrain a bun within the chute 210 above the blade 220; is elevated vertically to a second offset above the first offset height over the chute 210 in the second position (shown in FIG. 5B) to release the bun toward the blade 220; and drives the bun into the blade 220 between the second position and the third position (shown in FIG. 5C) to sever the blade 220 into heel and crown halves. Generally, in the first position, the cutting block 250 functions as a stop for buns dispensed from one or more hoppers arranged along the chute 210, and, in the second position, the cutting block 250 functions to release a bun from a “stopped” position into an initial slicing position between the cutting block 250 and the blade 220. Furthermore, as the cutting block 250 transitions from the second position into the third position, the cutting block 250 guides and secures the bun through the blade 220.

[0112] The cutting block 250 is arranged within the chute 210 between the blade 220 and a nearest receiver of the bun dispensing mechanism and runs along a curvilinear path parallel to a length of the chute 210. For example, the cutting block 250 can run along a “J” path, wherein the apex of the “J” defines the first position, the end of the short section of the “J” defines the second position, and the end of the long section of the “J” defines the third position, the long section of the “J” running along and substantially parallel to the chute 210 toward the blade 220, and the short section of the “J” extending upward from the chute 210 (e.g., toward one or more hoppers above). In this example, with the cutting block 250 in the first position, a bun dispensed into the chute 210 runs into and is impeded by the cutting block 250 rather than running straight into the blade 220. Thus, all buns dispensed into the chute 210, regardless of when along the chute 210 and by what receiver arranged there over, are stopped by the cutting block 250 and enter the blade 220 at substantially identical speeds once released by the cutting block 250 retracted to the second position. Furthermore, in this example, as the cutting block 250 is raised above the chute 210 in the second position, a bun is released toward blade, and the cutting block 250 then engages the bun and forces the bun into the blade 220 as the cutting block 250 transitions toward the third position (at the top of the “J”).

[0113] The cutting block 250 defines a trailing face and a leading face, the trailing face facing receivers of the bun dispenser arranged along the chute 210, and the leading face facing the blade 220 and opposite the trailing face. The trailing face can be flat, can be substantially perpendicular to the base surface of the chute 210, and can be substantially rigid, such as of stainless steel or nylon. Alternatively, the trailing face can be concave or angled into the base surface of the chute 210 to inhibit vertical motion of a bun away

from base surface upon impact within the cutting block 250. The trailing face of the cutting block 250 can also include a material that absorbs impact by buns on the cutting block 250. For example, a bumper of silicone foam can be arranged across the trailing face of the cutting block 250. The leading face of the cutting block 250 defines a V-shaped mouth that constrains a bun between non-parallel surfaces as the cutting block 250 advances forward to feed the bun into the blade 220. The (substantially) vertical surfaces of the V-shaped mouth of the cutting block 250 can be smooth, rough, serrated, or of any other suitable profile or surface finish suitable to substantially prevent rotation of a bun as the bun passes fully through the blade 220. The mouth of the cutting block 250 can also define a concave recess extending toward the trailing face of the cutting block 250, the blade 220 passing into the concave recess within contacting the cutting block 250 as the cutting block 250 is driven into the third position.

[0114] The cutting block 250 can be suspended in the chute 210 from one or more beams passing through one or more walls of the chute 210 and coupled to an actuator that drives the cutting block 250 between the first, second, and third positions. In one implementation, a vertical wall of the chute 210 defines (or is physically coextensive with a plate that defines) a pair of offset J-tracks 214, and one beam extends through each of the J-tracks 214 to support the cutting block 250. One or both beams are coupled to a chain suspended between a driven sprocket and an idler sprocket, and the actuator powers the driven sprocket to shift the position of the chain, thereby moving the cutting block 250 along the track. For example, the actuator can rotate the driven sprocket in a first direction to move the cutting block 250 from the third position to the first position and then into the second position, and then rotate the actuator in the opposite direction to move the cutting block 250 from the second position (through the first position) into the third position.

[0115] In the foregoing implementation, the beams supporting the cutting block 250 can be sealed about the J-tracks 214. For example, a silicone foam panel 334 can be arranged across the vertical wall of the chute 210 opposite the cutting block 250, and the silicone foam panel 334 can define slits aligned with the J-tracks 214. The beams supported the cutting block 250 through the vertical wall of the chute 210 can pass through corresponding slits in the silicone foam panel 334, which can seal the beams to the vertical wall of the chute 210, as shown in FIG. 6. In particular, the silicone foam panel 334 can prevent egress of buns crumbs (and other such food waste) from the chute 210 and similarly prevent ingress of food waste or other particulate (such as gear or motor grease) into the chute 210. In this example, each beam can define a teardrop or similar profile (shown in FIG. 6) over at least a portion of the beam the passed through the silicone foam seal to improve sealing capacity of the silicone foam panel 334 into the beams. Static or spring-loaded thrust seals can additionally or alternatively be arranged about the beams and engage the vertical wall of the chute 210 adjacent the cutting block 250 and/or the silicone foam panel 334 opposite the chute 210 to further seal the beams to the chute 210, as shown in FIG. 6. However, the cutting block 250 can be supported in any other way within the chute 210, can be driven between the first, second, and

third positions within the chute **210** in any other way, and can be sealed within the chute **210** with any other suitable type or configuration of seal.

[0116] In another variation, the cutting block **250** is advanced and retracted linearly along the chute **210** between a load position, a pierce position, and a slice position. In this variation, in the load position the cutting block **250** can be retracted above the first (e.g., highest) receiver in the bun dispenser to enable each receiver in the bun dispenser to dispense whole buns into the chute **210** between the cutting block **250** and the blade **220**. In this variation, the cutting block **250** can be sealed against wall of the chute **210** and can define a V-block geometry as described above. The cutting block **250** can also be connected to and repositioned within the chute **210** by a linear actuator, such as connected to a timing belt and rotary actuator, as described above. However, the cutting block **250** can be sealed against the chute **210** in any other way, can be of any other geometry, and can be actuated by any other suitable type of mechanism or actuator.

2.5 Slicing Operation

[0117] As shown in FIG. 7, the slicing mechanism can execute a method **S100** for dispensing and slicing whole bread buns including: retracting a cutting block **250** along a chute **210** into a load position in Block **S110**; dispensing a whole bread bun into the chute **210** between the cutting block **250** and a blade **220** extending across the chute **210** in Block **S120**; advancing the cutting block **250** along the chute **210** toward the blade **220** in Block **S130**; detecting contact between the cutting block **250** and the blade **220** at a contact position in Block **S140**; at a first time, advancing the cutting block **250** into a pierce position offset from the contact position toward the blade **220** by a pierce distance less than a common width of the type of whole bread buns in Block **S150**; and, at a second time succeeding the first time by a pierce duration, advancing the cutting block **250** from the pierce position into a slice position adjacent the blade **220** to drive the whole bread bun fully through the blade **220** in Block **S160**.

[0118] Generally, the slicing mechanism can execute the method to retract the cutting block **250** into the load position, to dispense a whole bread bun into the chute **210**, to advance the cutting block **250** into the whole bread bun to slightly compress the whole bread bun against the blade **220** for a pierce duration (e.g., for several seconds), and to advance the cutting block **250** into the slice position to drive the whole bread bun fully through the blade **220** once the blade **220** pierces the skin of bun during the pierce duration.

[0119] Because whole buns may vary in diameter, the slicing mechanism can advance the cutting block **250** to a pierce position substantially unique to each whole bun. The slicing mechanism can therefore advance the cutting block **250** toward the blade **220** until the cutting block **250** contacts a bun and then further advance the cutting block **250** toward the blade **220** by the pierce distance to compress the bun toward the knife. For example, as an actuator drives the cutting block **250** from the load position toward the blade **220**, the slicing mechanism can monitor a current draw of the actuator, correlate a detected change in this current draw with contact between the cutting block **250** and the whole bread bun, and storing a position of the cutting block **250** (and/or the actuator) at a time of the detected change in electrical current as a contact position for the bun. Alternatively,

the cutting block **250** can include an optical, acoustic, mechanical, or other type of switch or sensor arranged on or adjacent a face of the cutting block **250** configured to contact a bun, and the slicing mechanism can sample the switch while the cutting block **250** is driven from the load position toward the blade **220** and can identify contact between the cutting block **250** and a bun based on a change in the output of the switch. For example, the cutting block **250** can define a V-shaped mouth and can include a mechanical momentary switch arranged on each concave side of the V-shaped mouth. In this example, because a bun may contact one mechanical momentary switch on one side of the V-shaped mouth and then translate laterally before contacting the second mechanical momentary switch on the opposite side of the V-shaped mouth, the slicing mechanism can determine that the cutting block **250** has made full contact with the bun when both mechanical momentary switches are closed. Thus, in this example, the slicing mechanism can store a position of the cutting block **250** (and/or the actuator) at a time at which both mechanical momentary switches are closed as a contact position for the bun. However, the slicing mechanism can detect contact between the cutting block **250** and a bun in any other way.

[0120] Subsequently, the slicing mechanism can advance the cutting block **250** from the contact position toward the blade **220** by a preset pierce distance substantially less than a common width of whole bread buns in the row of whole bread buns. For example, the slicing mechanism can advance the cutting block **250** by a pierce distance between 0.5 millimeter and 2.0 millimeters from the contact position—along the long axis of the chute **210**—for a type of bread bun ranging from 2.5 inches in diameter to 5 inches in diameter. For example, the slicing mechanism can advance the cutting block **250** from the contact position into the pierce position by a pierce distance slightly greater than the skin thickness typical of the type of bun dispensed into the slicing mechanism. The slicing mechanism can then constrain the cutting block **250** in the pierce position for a pierce duration, such as for a period of time between five seconds and ten seconds, before advancing the cutting block **250** from the pierce position into the slice position. Thus, during the pierce duration, the slicing mechanism can compress the bun—between the cutting block **250** and blade—to a diameter 0.5 to 2.0 millimeters less than the nominal diameter of the bun. While the cutting block **250** is in the pierce position during the pierce duration, the slicing mechanism also actuates (e.g., reciprocates) the blade **220**, which may pierce the skin of the bun by (approximately) the pierce distance as the bun expands toward the blade **220** at it attempts to return to its nominal diameter. Upon expiration of the pierce duration, the slicing mechanism can advance the cutting block **250** from the pierce position to the slice position to drive the bun fully through the blade **220**. For example, the slicing mechanism can advance the cutting block **250** from the pierce position to the slice position as a rate of 0.2 meters per second. Therefore, the slicing mechanism can slightly compress a bun into the blade **220**, wait for the blade **220** to pierce the bun, and then drive the bun through the blade **220** rather than forcing the bun through the blade **220** in one motion, which may plastically deform the bun.

[0121] In the foregoing implementation, the slicing mechanism can also implement a dynamic pierce time. For example, the slicing mechanism can determine that the blade **220** has pierced a bun in response to a change in current

draw of the actuator driving the blade **220**. In another example, the slicing mechanism includes a camera or other optical sensor directed toward the leading edge of the blade **220**, and the slicing mechanism implements machine vision techniques to determine that the blade **220** has pierced the bun from digital images output by the camera.

[0122] In another implementation, the slicing mechanism can measure a diameter of each bun dispensed into the chute **210** and can advance the cutting block **250** to a pierce position offset from the blade **220** by the measured diameter of a bun in the chute **210** less the pierce distance. For example, the slicing mechanism can include a distance sensor—as described above—coupled to the chute **210**, aligned with the axis of the chute **210**, and facing the blade **220**, wherein the distance sensor defines a field of view and outputs a signal corresponding to a distance from the distance sensor to a (nearest) surface within the field of view. In this example, the cutting block **250** can include a window aligned with the field of view of the distance sensor, and the distance sensor can thus sense a surface of a bun between the blade **220** and the cutting block **250** through the window in the cutting block **250**. The slicing mechanism can thus measure the diameter of a bun dispensed into the chute **210** by subtracting a distance value output by the distance sensor from a known distance between the distance sensor and the blade **220** once a dispense event is detected during a dispense cycle. In this example, for a type of bun exhibiting significant variations in diameter (or width and/or length), a point on a bun located in the chute **210** nearest the distance sensor may not coincide with the field of view of the distance sensor because the bun may not land and remain aligned with the center of the chute **210**. The slicing mechanism can these also include a second distance sensor facing the blade **220** along a second axis nonparallel to the long axis of the chute **210**. The slicing mechanism can thus merge distance values output by the (first) distance sensor and the second distance sensor to calculate the diameter of a bun dispensed into the chute **210**.

[0123] Alternatively, in the foregoing implementation, the slicing mechanism can include a mechanical wiper adjacent the blade **220** and configured to displace the bun laterally across the chute **210** until the bun abuts a reference surface; the slicing mechanism can sample a position sensor coupled to the wiper (e.g., an optical encoder, a potentiometer) to determine this final (angular or linear) position of the wiper and can then correlate this position with a width of the bun. The slicing mechanism can then implement the method described above to advance the cutting block **250** into the pierce position and, as some time later, drive the cutting block **250** to the slice position to separate the heel of the bun from the crown of the bun.

2.6 Error Handling

[0124] In one variation, the slicing mechanism: detects dispensation of a second whole bread bun followed by dispensation of a third whole bread bun into the chute **210**; opening a discard chute **210** adjacent the blade **220** opposite the cutting block **250**; at a fourth time succeeding the third time, advancing the cutting block **250** along the chute **210** into a second pierce position to compress the second whole bread bun between the third whole bread bun and the blade **220**; and at a fifth time succeeding the fourth time by the pierce duration, advancing the cutting block **250** into the

slice position to drive the second whole bread bun fully through the blade **220** and into the discard chute **210**.

[0125] Generally, the slicing mechanism can execute such an error handling method to discard one or both buns dispensed into the chute **210** when two buns are released into the chute **210** in a single dispense cycle. In one example, the slicing mechanism samples optical sensors, capacitive sensors, and/or proximity sensor arranged along the chute **210** to determine a total length of a line contact along the chute **210** and determines that two buns have been dispensed into the chute **210** if the total length of the line contact exceeds a threshold maximum diameter of single bun of a type loaded into the bun dispenser. In another example, the slicing mechanism samples optical break sensor arranged along the chute **210** and counts a number of optical breaks at a single optical break sensor during a single dispense cycle; if the number of optical breaks at the single optical break sensor exceeds one (or if the number of state changes of the optical break sensor exceeds two) in a single dispense cycle, the slicing mechanism can determine that two buns have been dispensed into the chute **210**. The slicing mechanism can then execute this error handling method to discard one or more buns in the chute **210**. However, the slicing mechanism can detect a double-dispense event in any other suitable way.

[0126] In one implementation, the slicing mechanism includes a first trap configured to transiently engage the chute **210** behind the vane **214** and to guide a bun crown from the vane **214** into a discard container; in this implementation, the slicing mechanism includes a second trap configured to transiently engage the chute **210** behind the vane **214** and to guide a bun heel from the vane **214** into the discard container. Thus, when a double-dispense event is detected, the slicing mechanism can advance the first and second traps forward into discard positions adjacent the vane **214**, and the slicing mechanism can then drive the cutting block **250** from the load to the slice position in a single motion to slice and discard both buns. Alternatively, the slicing mechanism can implement methods and techniques described above to advance the cutting block **250** to a pierce position for a first bun immediately adjacent the blade **220**, thereby compressing the first bun between the blade **220** and a second bun interposed between the first bun and the cutting block **250**, and then drive the cutting block **250** to the slice position in a single subsequent motion to slice and discard both buns.

[0127] Thus, by first piercing the first bun by slowly compressing the first bun against the blade **220**, the blade **220** can constrain the first bun to prevent the first bun from otherwise skipping across the blade **220** and lifting out of the chute **210** when the cutting block **250** is driven fully to the slice position. In this implementation (and the foregoing implementations), the cutting block **250** can also include a substantially rigid or spring-loaded tab extending toward the blade **220** and offset above the bottom surface of the chute **210** by at least a typical height of a type of bun loaded into the hopper **120** (e.g., offset above the bottom surface of the chute **210** by a distance substantially equivalent to a maximum allowable height of the type of bun loaded into the hopper **120**). For example, the tab extending from the cutting block **250** can be substantially similar to the tab extending from the piston **130**, as described above. The tab extending from the cutting block **250** can thus prevent the second bun—behind the first bun—from pitching suffi-

ciently to lift out of the chute **210** as the cutting block **250** is advanced into the slice position during a discard cycle. Furthermore, in this implementation, because the second bun may have pitched slightly within the chute **210** as the first bun is sliced, the second bun may not be lying flush with the bottom surface of the chute **210** when caught by the blade **220**. Therefore, because the second bun may meet the blade **220** off-angle, thereby yielding a wedge-shaped bun heel, the slicing mechanism can also discard the second bun following a double-discard event.

[0128] However, the slicing mechanism can implement any other method or technique to discard one or both buns following a double-discard event.

3. Buttering and Toasting System

[0129] As shown in FIG. 8, a third system **300** for buttering and toasting bread buns includes a butter stage **310** and a toast stage **320**. The butter stage **310** includes: a vessel **312** containing liquefied dairy fat and defining a permeable surface **314**; a pressure supply **316** fluidly coupled to the vessel **312**; a first paddle assembly **311** configured to catch a bun crown dispensed into the butter stage **310**, to compress a sliced face of the bun crown directly against the permeable surface **314**, and to release the bun crown from the butter stage **310**. The toast stage **320** includes: a toasting surface **327** arranged vertically below the permeable surface **314**; a heating element **328** arranged behind the toasting surface **327**; a second paddle assembly **322** arranged vertically below the first paddle assembly **311** and configured to catch the bun crown released from the first paddle assembly **311**, to compress the sliced face of the bun crown directly against the toasting surface **327**, and to release the bun crown from the toasting surface **327**; and a third paddle assembly **323** arranged vertically below the second paddle assembly **322** and configured to catch the bun crown released from the second paddle assembly **322**, to compress the sliced face of the bun crown directly against the toasting surface **327**, and to release the bun crown from the toasting surface **327**.

[0130] One variation of the third system **300** includes: a dispenser configured to dispense a bun crown and a bun heel sliced from a whole bread bun; a heating device arranged below the dispenser and including a first toasting surface **327**, a second toasting surface **327B** opposite and parallel to the first toasting surface **327**, and a heating element **328** interposed between the first toasting surface **327** and the second toasting surface **327B**; a first set of compression paddles arranged in a first row adjacent the first toasting surface **327**, each compression paddle in the first set of compression paddles operable between a compress position and a release position, configured to sequentially compress the bun crown directly onto the first toasting surface **327** in the compress position, and configured to release the bun crown in the release position; a first set of gate paddles, each gate paddle in the first set of gate paddles arranged below a corresponding compression paddle in the first set of compression paddles, operable between a retain position and a dispense position, configured to sequentially support the bun crown vertically in the retain position, and configured to release the bun crown downward in the dispense position; a second set of compression paddles arranged in a second row adjacent the second toasting surface **327B**, each compression paddle in the second set of compression paddles operable between a compress position and a release position, configured to sequentially compress the bun heel directly

onto the second toasting surface **327B** in the compress position, and configured to sequentially release the bun heel in the release position; a second set of gate paddles, each gate paddle in the second set of gate paddles arranged below a corresponding compression paddle in the second set of compression paddles, operable between a retain position and a dispense position, configured to sequentially support the bun heel in approximate vertical and horizontal alignment with the bun crown in the retain position, and configured to sequentially release the bun heel downward in the dispense position; and an actuator system **330** configured to selectively transition compression paddles in the first set of compression paddles and in the second set of compression paddles between compress positions and release positions and configured to selectively transition gate paddles in the first set of gate paddles and in the second set of gate paddles between retain positions and dispense positions according to a paddle sequence to sequentially advance the bun crown and the bun heel, in a row of bun crown and bun heel pairs, down the first toasting surface **327** and down the second toasting surface **327B**.

3.1 Applications

[0131] Generally, the third system **300** for buttering and toasting bread buns (herein after the “buttering and toasting system”) functions to receive a series of bun heel and bun crown pairs, such as from the bun slicing mechanism, to butter the inner faces of the bun heel and bun crown pairs, and to toast the inner faces of the bun heel and bun crown pairs before dispensing the bun heels and bun crowns into or onto containers—such as boxes, plates, or sandwich assembly platens—supported a conveyance platform below. The buttering and toasting system can thus form a subsystem of an automated foodstuff assembly system including one or more other subsystems that cooperate to automatically prepare, assemble, and deliver foodstuffs for and/or to consumers. For example, the automated foodstuff assembly system can include a patty grinding subsystem that grinds and presses custom hamburger patties from raw meat (e.g., based on custom patty orders), a patty grilling subsystem that grills patties (e.g., rare, medium, or well-done based on custom patty orders), a bun dispenser subsystem that stores whole buns, a slicing mechanism subsystem that slices buns received from the bun dispenser subsystem, a bun buttering subsystem that applies butter to each side of sliced buns prior to toasting each halve of the bun, a bun toasting subsystem that toasts bun halves, a topping module that loads toppings onto bun heels (e.g., based on custom topping orders), and a boxing subsystem **350** that closes completed hamburgers into paper boxes for delivery to patrons. The buttering and toasting system can similarly butter can toast bread products for assembly into sandwiches, hotdogs, burritos, tacos, wraps, or other foodstuffs, such as according to custom food orders entered by patrons of an automated restaurant. The buttering and toasting system can therefore be incorporated into an automated foodstuff assembly system to butter and toast one or more halves of freshly-cut buns before dispensing the buttered and toasted buns into or onto a container for subsequent assembly into a sandwich for a customer.

[0132] The buttering and toasting system can feed bun heels substantially vertically downward over a substantially translucent or transparent heated surface (i.e., the toasting surface **327**) such that both sides of the bun heel are visible

to patrons near the automated foodstuff assembly system, thereby enabling patrons to view bun heels changing color (e.g., from off-white to light brown) as the bun heels advance through subsequent toasting stages of the buttering and toasting system. The buttering and toasting system can similarly feed bun crowns over an adjacent translucent or transparent surface to enable patrons to view both sides of a bun crown as it is toasted.

[0133] The buttering and toasting system is described herein as a system for buttering and toasting bun heels. However, the system can also butter and toast bun crowns, such as simultaneously with matched bun heels. An automated foodstuff assembly apparatus can include the buttering and toasting system to butter and toast bun heels on one side of the butter and toast stages and to butter and toast bun crowns on an opposite side of the butter and toast stages. For example, bun heels can be fed vertically downward along one side of a butter stage 310 and bun crowns can be fed vertically downward along an opposite side of a butter stage 310, a single heating element 328 can be arranged between the heel-side toasting surface 327 and a crown-side toasting surface 327—parallel and offset from the heel-side toasting surface 327—such that bun crowns and bun heels are heated with the same heating element 328, and a single actuator can drive both a set of gate and compression paddles adjacent the heel toasting surface 327 and a set of gate and compression paddles adjacent the crown toasting surface 327 such that bun heel and bun crown pairs are advanced in unison through the heel-side and crown-side butter and toast stages. In this example, the buttering and toasting system can advance a bun heel and bun crown in vertical alignment (and in horizontal alignment or offset horizontally) along the buttering surfaces (i.e., the permeable surfaces) and the toasting surfaces such that the bun heel and bun crown pair remain paired and matched throughout processing.

3.2 Butter Stage

[0134] The butter stage 310 includes a substantially vertical surface that dispenses butter onto a bun heel. Generally, the butter stage 310 functions to receive a bun heel from a slicing mechanism and to portion butter onto the interior face of the bun heel before the bun heel is toasted. The slicing mechanism can deliver the bun heel vertically downward into the butter stage 310, and the butter stage 310 can dispense butter through the vertical surface onto the interior surface of the bun heel. The bun heel can therefore continue to pass vertically downward along the vertical surface of the butter stage 310 and then enter the toasting surface 327 in a substantially vertical orientation.

[0135] In one implementation, the first paddle assembly 311 includes a first compression paddle and a first gate paddle adjacent the butter stage 310. As a bun heel is dispensed from the slicing mechanism, the first compression paddle can be in a release position and the first gate paddle can be in the retain position such that a portion of the bun heel passes the first compression paddle and is stopped by the first gate paddle. The actuator—coupled to the first compression and gate paddles, such as via a camshaft 332—can then transition the first compression paddle into the compress position to compress the bun heel into the vertical surface of the butter stage 310. Once sufficient butter is applied to the bun heel, then the first gate paddle can open into a dispense position and the first compression paddle can

then open into the release position to dispense the bun heel downward into the toast stage 320. For example, a second compression paddle adjacent the toasting surface 327 can be set in the release position and a second gate paddle—adjacent the toasting surface 327, below the second compression paddle, and cooperating with the second compression paddle to define defining a second stage—can be set in the retain position to receive and retain the buttered bun heel thus received from the butter stage 310 above.

[0136] The butter stage 310 can dispense salted butter, unsalted butter, clarified butter, olive oil, margarine, canola oil, or other liquefied dairy fat or other suitable foodstuff onto buns heels dispensed into the butter stage 310. In one implementation, the butter stage 310 includes a vessel 312 containing liquefied dairy fat (e.g., butter or any other suitable foodstuff) and defining a permeable surface 314; and a pressure supply 316 (e.g., a pump) fluidly coupled to the vessel 312. In this implementation, the vessel 312 can store liquefied dairy fat and can dispense liquefied dairy fat through perforations, pores, or other through-bores across the permeable surface 314 when the pressure supply 316 pressurized the vessel 312, such as by pumping gas (e.g., air) or additional liquefied dairy fat into the vessel 312. In particular, in this implementation, when the first compression paddle compresses the inner face (i.e., the sliced face) of a bun heel against the permeable surface 314 in the butter stage 310, the pressure supply 316 can pump liquefied dairy fat into the vessel 312, which then releases liquefied dairy fat through these perforations, thereby butting the heel. In one example, the vessel 312 can define a set of bores patterned across a permeable region—on the permeable surface 314—of diameter approximating a maximum, minimum, or average diameter of a type of the bun heel dispensed into the buttering and toasting system. In another example, the vessel 312 can include an open-celled substrate (e.g., a silicone foam, a polymer foam, a porous ceramic) defining the permeable surface 314. The pressure supply 316 can thus pressurize the vessel 312 as the first compression paddle compresses the bun heel against the permeable surface 314 of the butter stage 310, and the permeable surface 314 of vessel 312 can thus pass (e.g., excrete, leak, exude, ooze) liquefied dairy fat onto the interior surface of a bun heel.

[0137] In the foregoing implementation, the vessel 312, a supply line coupling the vessel 312 to the pressure supply 316, a remote reservoir coupled to (e.g., interposed between) the pressure supply 316 and the vessel 312, and/or the permeable surface 314 of the butter stage 310 can be heated to maintain sufficient temperature within the butter stage 310 to maintain dairy fat (or other foodstuff contained therein) in liquefied form. For example, the butter stage 310 can include one or more inductive heating elements arranged behind the permeable surface 314, within or under the vessel 312, around the remote reservoir, etc. Alternatively, the vessel 312 and its contents can be heated by a heating element 328 in the adjacent the toast stage 320.

[0138] In the foregoing implementation, the pressure supply 316 intermittently pressurizes the vessel 312 in response to compression of the bun crown against the permeable surface 314 by the first paddle assembly 311. In one variation of the buttering and toasting system, the butter stage 310 further includes a fourth paddle assembly 324—opposite the first paddle assembly 311—configured to catch a bun crown dispensed from the slicing mechanism with a corresponding bun heel; to compress a sliced face of the bun crown directly

against a second permeable surface **314** of the vessel **312** opposite the (first) permeable surface **314**; and to release the bun crown from the butter stage **310** substantially simultaneously with the bun heel. In this variation, the buttering and toasting system can include a single pressure supply **316** that pressurizes the vessel **312** to force liquefied dairy fat out of both the (first) permeable surface **314** and the second permeable surface **314** to butter the bun heel and the bun crown substantially simultaneously. In this variation, like the (first) permeable surface **314**, the second permeable surface **314** of the butter stage **310** can define a group of perforations across a second permeable region approximating the geometry of a type of bun dispensed into the buttering and toasting system, such as a 4-inch-diameter region for brioche buns ranging from 2.5 inches to 5 inches in diameter and averaging—3.9" in diameter. In this variation, the second permeable region on the second permeable surface **314** can be vertically aligned with the (first) permeable region of the (first) permeable surface **314** but can be offset horizontally from the (first) permeable region, such as by half of or by a full width of an average bun; the compression and gate paddles on each side of the butter and toast stage can maintain this horizontal offset as bun heels and crowns are advanced downward such that both sides of the bun heel and both sides of the bun crown may be visible through the toast stage **320**.

[0139] In another implementation, the butter stage **310** includes a vertical surface defining a set of open sections, such as perforations in a grated area or a set of adjacent vertical vanes, and the butter stage **310** includes a spray nozzle arranged behind the series of open sections and a pump that drives liquefied dairy fat from a heated reservoir, through the nozzle, and onto the bun heel compressed against the open section of the vertical surface by the first compression paddle.

[0140] In another implementation, the butter stage **310** includes a vertical surface defining one or more orifices, and the butter stage **310** includes a roller **112** that collects liquefied dairy fat from a heated reservoir (e.g., by advancing into the reservoir prior to a butter application cycle) and then rolls across the orifice(s) to dispense butter onto the interior surface of a bun heel held against the vertical surface by the first compression paddle.

[0141] However, the butter stage **310** can include any other suitable mechanism arranged in any other suitable way to dispense butter onto a surface of a bun heel.

[0142] As shown in FIG. 9, the butter stage **310** can also include a drip pan **340** interposed between the permeable surface **314** and the toasting surface **327**, wherein the drip pan **340** defines a recess offset behind the permeable surface **314**. In this implementation, the drip pan **340** can catch excess dairy fat released from the butter stage **310** and can catch crumbs and other debris released from the bun heel and/or from the slicing mechanism. In one example, the drip pan **340** includes: a first lip extending downward from the bottom of the permeable surface **314** and angled backward behind the permeable surface **314** (e.g., at a shallow angle of 15° from the permeable surface); and a second lip in plane with the permeable surface **314** and offset vertically below the first lip; and a heated waste reservoir arranged behind the second lip and configured to catch excess dairy fat and debris. However, the drip pan **340** can be of any other suitable geometry and can function in any other way to collect excess dairy fat and debris from the butter stage **310**.

3.3 Toast Stage

[0143] The toasting stage includes a toasting surface **327** arranged vertically below the permeable surface **314** and a heating element **328** arranged behind the toasting surface **327**. Generally, the toasting surface **327** functions to conduct heat into bun heels held against the toasting surface **327**, such as by compression paddles, to toast the surfaces of the bun heels in contact with the toasting surface **327**. The toasting surface **327** can therefore define an elongated section containing and/or adjacent one or more heating elements, and the actuator **331** can cycle the compression and gate paddles along the butter and toast stages according to a particular sequence to sequentially and intermittently release bun heels from the butter stage **310** vertically downward through sub-stages along the toasting surface **327**. In one implementation, the permeable surface **314** and the toasting surface **327** are substantially planar, and the permeable surface **314** is arranged over and in alignment with the toasting surface **327**, and the paddle assemblies can thus intermittently drop bun heels downward through sub-stages on the toasting surface **327**.

[0144] In one implementation, the toasting surface **327** can include a first transparent glass plate (e.g., alkali-aluminosilicate glass), a second transparent glass plate, and a wire-based heating element **328** (e.g., cupronickel nanowire, carbon crystal nanowire) interposed between the first and second glass plates. The buttering and toasting system can also include a power supply that passes current through the heating element **328** to heat the first and/or second glass plate. In this implementation, the first glass plate can be relatively thin, such as 0.5 mm to 2.0 mm in thickness, and can define the toasting surface **327** configured to directly contact and to toast the interior surfaces of bun heels, and the second glass plate can be relatively thick, such as 4 mm in thickness, such that heat is predominately conducted from the heating element **328** through the first plate (rather than through the second plate). However, the toast stage **320** can include any other number of resistance heating elements, inductance heating elements, and/or other suitable type of heating element **328**.

[0145] In one variation, the buttering and toasting system is further configured to butter and toast bun crowns. In this variation, the exterior surface of the first plate can define a first toasting surface **327** configured to toast bun heels, and an exterior surface of the second plate can define a second toasting surface **327B** configured to toast bun crowns; a single heating element **328** (or single set of heating elements) interposed between the first and second plates can thus heat both the first and second toasting surfaces. In this variation, paddle assemblies on each side of the first and second plates can cooperate to sequence a bun heel and a bun crown pair (i.e., a bun heel and a bun crown cut from the same bun) downward in unison along the first heating surface and the second heating surface, respectively, such that the bun heel and the bun crown are toasted and dispensed from the buttering and toasting system (such as into a box or other container) together. Furthermore, in this variation, a first set of paddle assemblies adjacent the first plate can restrain bun heel along a first vertical path along the first plate, and a second set of paddle assemblies adjacent the second plate can restrain bun crowns along a second vertical path—offset laterally from the first vertical path—

along the second plate such that both sides of the bun heel and the bun crown are visible through the transparent or translucent toasting surfaces.

[0146] The toasting surface 327 can alternatively be of aluminum, stainless steel, Teflon-coated steel, or any other suitable conductive material(s). A heating element 328 or heat source coupled to the toasting surface 327 can also be of any other suitable type or configuration.

3.4 Paddles

[0147] The buttering and toasting system includes stack of paddle assemblies arranged vertically along the toasting surface 327. Each paddle assembly can include a compression paddle that is operable between a compress position and a release position, wherein the compression paddle depresses a bun heel against the toasting surface 327 in the compress position and releases the bun heel in the release position. Each paddle assembly can also include a gate paddle: arranged below a compression paddle in the corresponding paddle assembly; that cooperates with the corresponding compression paddle to define a toasting stage; and that is operable between a retain position and a dispense position, wherein the gate paddles vertically supports a bun heel in the retain position and passes the bun heel downward in the dispense position.

[0148] The paddle assemblies can include compression and gate paddles that are substantially transparent (or translucent) to enable bun heels passing downward along the toasting surface 327 to be viewed by an operator and/or by patrons near the automated foodstuff assembly apparatus. For example, the paddles can be of transparent or translucent heat-resistant plastic, of glass, or of a metal (e.g., aluminum) mesh of a high aspect ratio (i.e., open area to wire size). Alternatively, the paddles can be of aluminum, stainless steel, Teflon-coated mild steel, or of any other suitable material.

[0149] In one implementation, the paddle assemblies are arranged in a vertical stack adjacent the butter stage 310 and the toast stage 320 with one compression paddle arranged over a corresponding gate paddle per paddle assembly. Each compression paddle in the vertical stack can pivot about an axis substantially parallel to the toasting surface 327. In particular, a compression paddle can pivot inwardly into the compress position to compress an adjacent bun heel directly onto the toasting surface 327 (or onto the permeable surface 314 of the butter stage 310), and the compression paddle can pivot outwardly into the release position to release a bun heel from the toasting surface 327. Similarly, a gate paddle can pivot inwardly into the restrain position to vertically support a bun adjacent the toasting surface 327 (or adjacent the permeable surface 314 of the butter stage 310), and the gate paddle can pivot outwardly into the dispense position to pass a bun heel downward into a subsequent paddle assembly (or into a box or other container below). The compression and gate paddles can pivot about the same or dissimilar axes. Alternatively, the compression paddles can be supported by linkages that translate and/or rotate the compression paddles between the compress and release positions, and the gate paddles can be similarly supported by linkages that translate and/or rotate corresponding gate paddles between the restrain and dispense positions.

[0150] Each compression paddle can define a concave cupped or domed cavity facing the toasting surface 327, wherein the cavity receive a bun heel (or a bun crown) and

functions to substantially center the bun heel within the compression paddle, such as shown in FIG. 11. Furthermore, each gate paddle can define a spaded end facing the toasting surface 327, as shown in FIG. 11, wherein the spaded end of the gate paddle receives a bun heel (or a bun crown) and functions to catch a bun heel dispensed from a paddle assembly or the slicing mechanism above and to guide the bun heel back toward the toasting surface 327. Each gate paddle can additionally or alternatively include a lip 325 extending toward the toasting surface 327 and configured to catch a bun heel (or a bun crown) dispensed from above.

[0151] Each compression paddle can further define a flexure or other flexible structure between a pivot (or other linkage connection) and the end of the compression paddle adjacent the toasting surface 327. In particular, a flexibility (or elasticity) of a compression paddle can be tuned to an elasticity (or “loft” and/or height) of bun heels (and/or bun crowns) dispensed into the buttering and toasting system such that the paddle does not plastically deform or “squish” bun heels (and/or crown heels) passing through the buttering and toasting system. For example, each compression paddle can include a first rigid section coupled to the actuator, a second rigid section defining a broad surface for contacting and compressing bun heels, and a metallic spring arranged between and connecting the first rigid section to the second rigid section, the metallic spring sized for a spring constant suitable to prevent plastic deformation of a bun heel (or a bun crown) by the paddle. In another example, the compression paddle can be of a flexible material and can define a flexure section of sufficient length and sufficiently minimal cross-section between the camshaft and the cup such that the flexure section yields (i.e., bends) under resistance by the bun heel to prevent over-compression of the bun heel. However, the compression paddle can be of any other suitable form and/or of any other suitable material.

[0152] Alternatively, because the slicing mechanism can cut bun heels of substantially uniform thickness and dispense these bun heels into the buttering and toasting system, each compression paddle in a first set of compression paddles configured to handle bun heels can include a cam follower and a cup rigidly coupled to the cam follower and configured to constrain the bun heel directly against the second toasting surface 327B. In this implementation, each cam follower coupled to a compression paddle in the first set of compression paddles can be positioned to achieve a target gap between a cup at the end of the corresponding compression paddle and the toasting surface 327 (or the buttering surface), wherein the target gap approximates the thickness of bun heels cut by the slicing mechanism less a target compression of the bun heels onto the toasting surface 327 (e.g., 2 millimeters). However, because the height of whole bread buns may vary and because the slicing mechanism may dispense bun crowns of varying heights, each compression paddle in the second set of compression paddles configured to handle bun crowns can include: a cam follower; a cup opposite the cam follower and configured to constrain a bun heel directly against the first toasting surface 327; and a spring (or flexure, or other flexible structure or mechanism) interposed between the cam follower and the cup and characterized by an effective spring constant less than a spring constant characteristic of a material of the bun crown. Each compression paddle in the second set of compression paddles can therefore be “tuned” to apply a target pressure onto an adjacent bun crown, wherein the target pressure is

sufficient to achieve proper contact between the interior surface of the bun crown and the second toasting surface 327B but not so great as to permanently deform the bun crown, as described above.

3.5 Actuator

[0153] The actuator 331 selectively transitions the compression paddles between the release position and the compress position and selectively transitions the gate paddles between the retain position and the dispense position according to an operational sequence to sequentially advance a series of bun heels down the toasting surface 327. Generally, the actuator 331 functions to drive the compression paddles between compress and release positions and to drive the gate paddles between restrain and dispense positions according to the operational sequence in order to serially shift buns downward from the slicing mechanism, into the butter stage 310, and along the toasting surface 327 (and into a chute that deposits the bun heels into a box or other container).

[0154] In one implementation, the actuator 331 includes a rotary motor (e.g., an electric stepper motor, a DC motor, a servo motor, an air motor) and a camshaft 332 actuated by the rotary motor. In this implementation, the camshaft 332 can be arranged vertically and adjacent the toasting surface 327 with cam lobes 333 aligned with each compression paddle and with each gate paddle along the butter stage 310 and the toast stage 320. In one example implementation, each paddle is retained by a pivot between the camshaft 332 and the toasting surface 327, and each paddle defines a cam follower extending from the pivot toward the camshaft 332 to contact a corresponding cam lobe on the camshaft 332. In another example implementation, each paddle is retained by a pivot offset from the toasting surface 327, the camshaft 332 is arranged between the pivots and the toasting surface 327, and each paddle defines a cam follower (between the corresponding pivot and broad surface that contacts bun heels) extending toward the camshaft 332 to contact a corresponding cam lobe. Thus, as the rotary motor rotates the camshaft 332, the cam lobes on the camshaft 332 can contact corresponding cam followers of the compression and gate paddles to transition the compression and gate paddles between the compress and release positions and between the restrain and dispense positions, respectively.

[0155] In one example, the buttering and toasting system can include: a first paddle assembly 311 including a first compression paddle 311A and a first gate paddle 311B, wherein the first compression paddle is mechanically coupled to a first lobe on the camshaft 332, and wherein the first gate paddle is arranged vertically below the first compression paddle and is mechanically coupled to a second lobe on the camshaft 332; and a second paddle assembly 322 including a second compression paddle 322A and a second gate paddle 322B, wherein the second compression paddle is arranged vertically below the first gate paddle and is mechanically coupled to a third lobe on the camshaft 332, and wherein the second gate paddle is arranged vertically below the second compression paddle and is mechanically coupled to a fourth lobe on the camshaft 332, as shown in FIGS. 9 and 10A.

[0156] In the foregoing implementation, each cam lobe can define a closed track that captures the cam follower coupled to the corresponding paddle such that the position of the corresponding paddle is (nearly) fully constrained throughout actuation of the paddle. Alternatively, the but-

tering and toasting system can include a spring 335 arranged between each cam lobe and the corresponding paddle and configured to drive the cam follower into the cam lobe. In one example, the buttering and toasting system includes a coil spring (e.g., a hairpin spring) between each cam and cam follower and configured to drive the cam follower onto the corresponding cam lobe. In this example, the spring can be characterized by an effective spring constant (projected at the cup) less than a spring constant characteristic a material of the type of bun dispensed by the slicing mechanism in order to prevent over-compression of bun heel (or bun crown), as described above.

[0157] Alternatively, the buttering and toasting system can include a foam panel 334 (e.g., a silicone foam panel) adjacent the camshaft 332 and opposite the toasting surface 327, and each paddle can include a finger extending from its cam follower to the foam panel 334. The foam panel 334 can yield to a finger as the corresponding paddle is open and closed, and the foam can supply sufficient resistance to the finger to drive the cam follower of the paddle onto the corresponding cam lobe and/or toward either the fully-open or fully-closed position adjacent the toasting surface 327. In this example, the (single) foam panel 334 can thus locate (e.g., provide a restorative spring force onto) all paddles in the set of paddle assemblies, and the foam panel 334 can be replaced in a single unit, such as if the foam panel 334 is soiled or worn. The foam panel 334 can also be characterized by a durometer tailored to the hardness of buns dispensed into the buttering and toasting system such that a suitable amount of pressure is applied to bun heels (and bun crowns) by the compression paddles without substantially (or plastically) deforming the bun heels (and bun crowns), as described above. The foam panel 334 can therefore also be exchanged with a second foam panel 334 of alternate durometer in order to accommodate a different type of bun (e.g., harder buns, softer buns) loaded into the bun dispenser.

[0158] The camshaft 332 can define a set of cam lobes at various phases and characterized by various dwell durations such that continuous rotation of the camshaft 332 at a substantially constant speed cycles the compression paddles between compress and release positions and the gate paddles between restrain and dispense positions according to the operational sequence, thereby serially and intermittently releasing a column of bun heels downward along the buttering surface and the toasting surface 327. In particular, a first compression paddle adjacent the butter stage 310 can open (i.e., transition from the compress position into the release position) while a first gate paddle adjacent the butter stage 310 remains closed in order to receive and vertically support a first bun heel received from the slicing mechanism above. As the camshaft 332 rotates, a first cam lobe can release (or actively drive) the first compression paddle into the first bun heel to force the first bun heel against the permeable surface 314 of the butter stage 310. Subsequently, the first gate paddle can open as a second compression paddle adjacent the toast stage 320 also opens. With the second gate paddle adjacent the toast stage 320 closed, the first compression paddle can open to release the first bun heel from the butter stage 310 into the toast stage 320. The second compression paddle can then close to drive the first bun heel against the toasting surface 327 as the first gate paddle closes in preparation to receive a second bun heel from the slicing mechanism above. Additional toast sub-stages below the second compression paddle and the second

gate paddle can further cooperate to receive the first bun heel, to compress the first bun heel against the toasting surface 327 to achieve a target degree of toast for the corresponding toast sub-stage, and to release the first bun heel downward.

[0159] Therefore, the actuator 331 can rotate the camshaft 332 to: sequentially open the first compression paddle to catch the bun crown on the first gate paddle; close the first compression paddle to compress the sliced face of bun crown against the permeable surface 314; open the first gate paddle; open the first compression paddle to release the bun crown from the butter stage 310. The actuator 331 can further rotate the camshaft 332 to: sequentially open the second compression paddle to catch the bun crown on the second gate paddle; close the second compression paddle to compress the sliced face of bun crown against the toasting surface 327; open the second gate paddle; and open the second compression paddle to release the bun crown toward the third paddle assembly 323.

[0160] Alternatively, in a paddle assembly, a gate paddle can open after a corresponding compression paddle to release a heel bun into a lower stage, or a compression paddle and a corresponding gate paddle in a paddle assembly can open substantially simultaneously to release a heel bun into a lower stage.

[0161] In one example, the buttering and toasting system includes: a first paddle assembly 311 including a first compression paddle 311A mechanically coupled to a first lobe on the camshaft 332 and a first gate paddle 311B arranged vertically below the first compression paddle and mechanically coupled to a second lobe on the camshaft 332; a second paddle assembly 322 including a second compression paddle 322A arranged vertically below the first gate paddle and mechanically coupled to a third lobe on the camshaft 332 and a second gate paddle 322B arranged vertically below the second compression paddle and mechanically coupled to a fourth lobe on the camshaft 332; and a third paddle assembly 323 including a third compression paddle 323A arranged vertically below the second gate paddle and mechanically coupled to a fifth lobe on the camshaft 332 and a third gate paddle 323B arranged vertically below the third compression paddle and mechanically coupled to a sixth lobe on the camshaft 332. In this example, the fifth lobe and the sixth lobe can be phased on the camshaft 332 in advance of the third lobe and the fourth lobe, and the third lobe and the fourth lobe can be phased on the camshaft 332 in advance of the first lobe and the second lobe. The actuator 331 can therefore rotate the camshaft 332 in a forward direction to serially release a third bun crown from the third paddle assembly 323, to release a second bun crown from the second paddle assembly 322 into the third paddle assembly 323, and to then release a first bun crown from the first paddle assembly 311 into the second paddle assembly 322.

[0162] Furthermore, for the buttering and toasting system that includes four paddle assemblies, the camshaft 332 can actuate the compression and gate paddles in the four paddle assemblies according to the operational sequence shown in FIG. 10A. For example, in addition to the example described above, the toast stage 320 can further include a fourth paddle assembly 324 arranged vertically below the third paddle assembly 323 and configured to catch a bun heel (or a bun crown) released from the third paddle assembly 323, to

compress the sliced face of the bun heel directly against the toasting surface 327, and to release the bun heel from the toast stage 320.

[0163] The actuator 331 can thus rotate the camshaft 332 at a substantially constant speed such that bun heels enter into subsequent stages of the buttering and toasting system at a substantially constant rate, thereby yielding a substantially consistent degree of toast on the interior surface of each bun heel passing through the buttering and toasting system. The actuator 331 can also vary the speed of rotation of the camshaft 332 to alter an amount of time that a bun heels contacts (e.g., is compressed against) the toasting surface 327, thereby controlling a degree of toast of the bun heel. For example, for a buttering and toasting system that includes four stages for a total bun heel capacity of four bun heels at any time during operation, the buttering and toasting system can track an amount of time that each bun heel is in contact with the toasting surface 327. In this example, the automated foodstuff assembly apparatus can receive custom hamburger orders specifying desired toast levels (e.g., light, medium, or dark or levels 1 through 10) and can assign a toast level to a particular bun (i.e., to each bun heel and bun crown pair) based on a particular custom hamburger order corresponding to the particular bun. The actuator 331 can thus speed up and slow down rotation of the camshaft 332 as the particular bun enters and exits the butter and toast stages to achieve (approximately) the toast level specified for the particular bun in the custom hamburger order.

[0164] In one implementation, the buttering and toasting system adjusts the degree to which a bun heel is toasted by timing release of the bun heel from the lowest paddle assembly in the toast stage 320. In the example of the buttering and toasting system that includes four paddle assemblies, the fourth (i.e., the lowest) paddle assembly can be phased in advance of the third paddle assembly 323, which can be phased ahead of the second paddle assembly 322, etc. The actuator 331 can thus index the camshaft 332 forward to release a bun heel from the fourth paddle assembly 324 once a target toast duration for the bun heel. In this example, the actuator 331 can close the second paddle assembly 322 against the bun heel for a static toast duration, close the third paddle assembly 323 against the bun heel for the same static toast duration, and then close the fourth paddle assembly 324 against the bun heel for a variable toast duration between a minimum toast duration defined by a maximum speed of the camshaft 332 and the static toast duration, as shown in FIG. 10B. In particular, for a lightest degree of toast specified for a particular bun heel currently in the third paddle assembly 323, the actuator 331 can rotate the camshaft 332 through a full rotation to release the particular bun heel from the third paddle assembly 323 into the fourth paddle assembly 324, to release a second bun heel from the second paddle assembly 322 into the third paddle assembly 323, to release a third bun heel from the first paddle assembly 311 into the third paddle assembly 323, etc., thereby indexing the set of buns down the toast stage 320. In this example, the actuator 331 can continue to rotate camshaft 332 past a full rotation (e.g., 30° passed a full 360° rotation) at a full rotation speed to immediately release the particular bun heel from the fourth paddle assembly 324, thereby achieving a minimum degree of toast on the particular bun heel. Alternatively, the actuator 331 can pause between the full 360° rotation and the 30° additional rotation—which releases the particular bun heel from the fourth

paddle assembly 324—for a variable toast duration in order to corresponding to a higher degree of toast for the bun heel. Yet alternatively, the actuator 331 can pause for the full static toast duration between the full 360° rotation and a subsequent full 360° rotation to index the set of buns down the toast stage 320 and to release the particular bun heel from the toast stage 320. Therefore, for each bun heel (and for each bun crown) passing through the toast stage 320, the buttering and toasting system can calculate a variable toast duration proportional to a custom degree of toast associated with a bun heel (and bun crown) and can release the bun heel from the final paddle assembly in the toast stage 320 once the bun has been compressed against the toasting surface 327 by the final paddle assembly for the variable toast duration.

[0165] However, the actuator 331 can manipulate the compression and gate paddles in any other suitable way to index bun heels through the buttering and toasting system to achieve a consistent, target, and/or custom degree of toast on each bun heel dispensed there through.

[0166] In a similar implementation, the buttering and toasting system can include a first camshaft 332 and a second camshaft 332, the first camshaft 332 defining lobes that actuate the set of compression paddles, and the second camshaft 332 defining lobes that actuate the set of gate paddles. The actuator 331 (e.g., one or more electric motors) can thus drive the first and second camshafts in unison or independently to advance bun heels through the butter and toast stages.

[0167] In another implementation, the buttering and toasting system can include a set of actuators that are independently controlled, and each actuator in the set can be coupled to one paddle (or a subset of paddles in the sets of paddles) to selectively and independently open and close each paddle. For example, each actuator in the set can include an independently-controlled pneumatic or electromechanical linear solenoid coupled to a corresponding compression paddle or gate paddle. However, the buttering and toasting system can include any other type and/or number of actuators that can function in any other way to actuate the compression and gate paddles to move bun heels across the vertical surface of the butter stage 310 and the toast stage 320.

3.6 Dispenser

[0168] One variation of the buttering and toasting system further includes a dispenser 350 that functions to guide the bun heel into a box (or other container). Generally, the dispenser 350 functions to receive a bun heel released—from a substantially vertical orientation—from a final toasting stage, to transition the bun heel into a substantially horizontal, toasted-side-up orientation, and to deposit the bun heel into a sandwich box. (Alternatively, the dispenser 350 can deposit the bun heel onto a plate, onto a sandwich or hamburger assembly platen, etc.)

[0169] In one implementation, the buttering and toasting system includes a dispenser paddle assembly 355 arranged below the final (e.g., the third or the fourth) paddle assembly and configured to receive the bun heel (or the bun crown) from the toast stage 320, to rotate the bun heel, and to dispense the bun heel into a container arranged below the dispenser paddle assembly with the sliced face of the bun heel facing upward toward the toast stage 320. In this implementation, the dispenser paddle assembly can include a slide 356, a layer paddle 357, and a box support platen 158,

as shown in FIG. 8. In this implementation, the slide 356 extends downward (from substantially vertical) proximal a lowest edge of the toasting surface 327 (and/or proximal a lowest toasting gate along the toasting surface 327) and curves away from the toasting surface 327 such that a bun heel released onto the slide 356 is released toward the layer paddle 357 at an angle from horizontal with the exterior surface of the bun heel facing downward and the toasted interior surface of the bun heel facing upward. The layer paddle 357 defines a leading edge that extends toward and under the exit of the slide 356, and the layer paddle 357 is pivot about a laterally-supported axle by a first actuator (e.g., an electromechanical solenoid) coupled to the lateral axle or to the layer paddle 357. Once a bun heel lands on the layer paddle 357 (with toasted face up) after release from the slide 356, the first actuator pivots the leading edge of the layer paddle 357 downward, thereby dispensing the bun heel (with toasted face up) into an open box arranged below. The box support platen 158 is arranged below the layer paddle 357 and the kicker paddle 358 and aligns one side of an open hinged box below the dispenser 350. In particular, the box support platen 158 can support an individual or a stack of cardboard boxes, Styrofoam boxes, paper boxes, or boxes of any other suitable material defining a first box half hinged to a second box half (e.g., by a living hinge), the first box half defining a circumferential wall surrounding a top of the box (as defined when the box is closed), and the second box half defining a circumferential wall surrounding a bottom of the box, each half of the box thus defining an interior corner along and below the hinge of the box when the box is open. Thus, by pivoting downward toward an open box below, the layer paddle 357 can release the bun heel toward the interior corner of the second half of the box. With one end of the bun heel constrained by the interior corner of the second half of the box, the bun heel can drop fully into the second half of the box with the bottom of the bun heel lying against the bottom of the second half of the box and the toasted surface of the bun heel facing upward.

[0170] In the foregoing implementation, the dispenser 350 further includes a kicker paddle 358 arranged under the exit of the slide 356 and opposite the layer paddle 357. In particular, the kicker paddle 358 can be supported by a second laterally-supported axle driven by a second actuator, and the actuator can pivot the kicker paddle 358 toward the layer panel if a heel bun dispensed onto the layer paddle 357 sticks to the layer paddle 357 or falls incorrectly into the interior corner of the second half of the box. In particular, the kicker paddle 358 can tap a stuck bun heel off of the layer paddle 357 and/or realign a bun heel within the second half of the box.

[0171] In the foregoing implementation, the slide 356 can define a concave (e.g., semicircular, elliptical) profile along its outlet edge. The slide 356 can also include one or more linear section, curvilinear sections, or sections of any other suitable geometry. Furthermore, a wall or other surface behind the layer paddle 357 opposite the slide 356 output can be substantially elastic or “soft” to absorb impact of a bun heel on the wall. For example, a silicone foam sheath can be arranged over a vertical wall behind the layer paddle 357, and a bun heel can contact and can then be slowed by the silicone foam sheath before being dispensed into the second half of the box. The dispenser 350 can also include an actuatable plunger arranged over the second end of the box and extensible toward the second half of the box to

settle a bun heel dispensed therein. The dispenser **350** can additionally or alternatively include a guide—such as a flapper—arranged over the second half of the box or along a conveyor supporting the box support platen **158**, wherein the guide contacts a bun heel contained within the second half of a box to drive the bun heel into a particular corner of the second half of the box. However, the dispenser **350** can include any other one or more components arranged in any other way within the automated foodstuff assembly apparatus, and the components of the dispenser **350** can cooperate in any other suitable way to deposit a bun heel from a final toasting stage adjacent the toasting surface **327** into a half of an open box below.

[0172] The dispenser **350** can selectively manipulate the kicker paddle **358** and the layer paddle **357** as each additional bun is dispensed from the toasting surface **327**, such as based on sensed contact between a bun heel or crown and a mechanical sensor arranged within the chute or based on a position of a bun heel or crown determined by analyzing an image of the chute area captured by a camera (or other optical sensor) based on one or more machine vision techniques. However, the dispenser **350** can selectively manipulate the kicker paddle **358** and the layer paddle **357** based on or in response to any other detected event or trigger detected in any other way.

[0173] In another implementation, the dispenser **350** includes a nozzle **351** coupled to a compressed gas (e.g., air, nitrogen) supply via a valve. The nozzle is arranged proximal an outlet end of the toasting surface **327**, as shown in FIG. **12**, and the dispenser **350** selectively actuates the valve to displace a bun heel from the toasting surface **327** into a box (or other container) below the toasting surface **327**.

[0174] In another implementation, the dispenser **350** includes a variable-pitch auger **353** arranged below the toasting surface **327**, as shown in FIG. **13**. In this implementation, the auger defines a narrow pitch at its inlet side directly below the outlet end of the toasting surface **327**, the inlet end of the auger thus supporting a bun heel substantially vertically on its end once dispensed from the toasting surface **327**, as shown in FIG. **13**. The dispenser **350** can then trigger a rotary actuator coupled to the auger to drive the bun heel along the auger and toward an outlet end of the auger. However, the auger can define an increasingly wider pitch toward its outlet to enable a bun heel to rotate down into a horizontal, face up position proximal an outlet end of the auger. The auger can then dispense the bun heel face up into an open box (or other container) arranged below the outlet end of the auger, as shown in FIG. **13**. The geometry of the auger can also be such that less than one full rotation of the auger can rotate a bun heel from the substantially vertical orientation—as received from bun toaster subsystem—into a substantially horizontal orientation for dispensation into a box below.

3.7 Bun Crown

[0175] One variation of the buttering and toasting system additionally or alternatively includes: a second butter stage **310** including a second substantially vertical surface dispensing butter onto a bun crown; a second toasting surface **327B** including a second substantially vertical translucent toasting surface **327**; a second set of compression paddles arranged vertically in a stack adjacent and substantially parallel the second toasting surface **327B**, a compression paddle in the second set of paddles operable between a

compress position and a release position, a compression paddle depressing a bun crown against the second toasting surface **327B** in the compress position and releasing the bun crown in the release position; a second set of gate paddles, a gate paddle in the second set of gate paddles arranged below a corresponding compression paddle in the second set of compression paddles, cooperating with the corresponding compression paddle to define a toasting stage, and operable between a retain position and a dispense position, a gate paddle vertically supporting a bun crown in the retain position and releasing the bun crown in the dispense position; and an actuator (physically coextensive or physically distinct from the actuator described above) selectively transitioning the second set of compression paddles between the release position and the compress position and selectively transitioning the second set of gate paddles between the retain position and the dispense position according to a sequence to sequentially advance a series of bun crowns down the second toasting surface **327B**. In this variation, the buttering and toasting system can also additionally or alternatively a second dispenser that guides a bun crown into a box.

[0176] In this variation, the second butter stage **310**, the second sets of compression and gate paddles, the second toasting surface **327B**, the second actuator, and/or the second dispenser can operate substantially simultaneously with the butter stage **310**, the toast stage **320**, the set or paddle assemblies, etc. described above to substantially simultaneously receive a bun crown and a bun heel, to butter interior surfaces of both the bun crown and the bun heel, to toast the interior surfaces of both the bun crown and the bun heel, and to dispense the bun crown and the bun heel, such as into a first half and a second half of an open box, such as shown in FIG. **8**. In this implementation, a single camshaft **332**—driven by the actuator as described above—can actuate compression and gate paddles in both the first and second sets of paddle assemblies. Alternatively, a first camshaft **332** can actuate the first set of paddle assemblies, a second camshaft **332** can actuate the second set of paddle assemblies, and a single actuator can drive both the first and second camshafts. Yet alternatively, a first actuator can drive a first camshaft **332** to actuate the first set of paddle assemblies, and a second actuator can drive a second camshaft **332** to actuate the second set of paddle assemblies.

[0177] The butter stage **310** can also incorporate a single vessel **312** into which (liquefied or heated) butter is pumped or stored, and perforated or otherwise butter-permeable surfaces on a first side and on a second side of the vessel **312** (opposite the first side) can dispense butter onto bun heels and onto bun crowns, respectively. Alternatively, the butter stage **310** and the second butter stage **310** can be discrete components within the automated foodstuff assembly apparatus. Furthermore, as described above, a single heating element **328** or set of heating elements can be interposed between the toasting surface **327** and the second toasting surface **327B** to define a substantially transparent toasting unit, and the first and second sets of paddle assemblies can retain bun heels bun and crowns along the first and second toasting surfaces, respectively, as shown in FIG. **9**, such that both a bun heel and a matched bun crown can be viewed simultaneously from various vantage points around the buttering and toasting system. However, the buttering and toasting system for bun heels and/or the buttering and toasting system for bun crowns can be arranged in any other

way and can cooperate in any other way to received freshly-sliced bun heels and bun crowns and to output freshly-buttered and freshly-toasted bun heels and bun crowns, respectively.

4. Alternative Bun Dispenser and Slicing Mechanism

[0178] With reference to FIGS. 14-20, an alternative bun dispenser 400 and slicing mechanism 402 (FIG. 16) are provided. As shown in FIGS. 14 and 15, the bun dispenser 400 may include a plurality of hoppers 404, a chute 406, a bun-advancing system 408 (FIG. 15), and a bun-stopper system 410 (FIGS. 17-20). A plurality of buns (e.g., hamburger buns, sandwich buns, rolls, etc.) may be queued in the hoppers 404. The bun-advancing system 408 may advance the buns in the hoppers 404 into the chute 406. The bun-stopper system 410 may stop the bun in the chute 406 to ensure proper positioning of the bun in the chute 406 for slicing by the slicing mechanism 402.

[0179] The chute 406 can include a generally vertically oriented housing 418 that defines a channel 420 that is sized to receive the buns and allow the buns to fall or slide down the length of the channel 420 under the force of gravity. The hoppers 404 may be mounted to the chute 406 and may extend horizontally from the chute 406. The hoppers 404 may be tubular members and may have a generally D-shaped cross-sectional profile or any other shape that suits the shape of the particular bun or food product that will be stored in and dispensed from the hoppers 404.

[0180] Outlets 422 of the hoppers 404 are open to the channel 420 of the chute 406 so that buns in the hoppers 404 can be pushed into the chute 406. As shown in FIGS. 14-16, each hopper 404 may include a pin 424 (or a lip, bump, protrusion, or other stopper) disposed adjacent the outlet 422. The pin 424 prevents buns in the hoppers 404 from inadvertently rolling out of the outlets 422 of the hoppers 404 and into the chute 406 but still allows the buns to be forced out of the outlets 422 by the bun-advancing system 408. In some embodiments, the pins 424 can be fixed relative to the hoppers 404. In some embodiments, movable pins or blockers may selectively retract to allow a bun to pass through the outlets 422 and selectively extend to prevent buns from passing through the outlets 422.

[0181] As shown in FIG. 15, the bun-advancing system 408 may include a plurality of pistons 426 and a gas supply (not shown). Each of the pistons 426 is slidably disposed within a corresponding one of the hoppers 404. The pistons 426 may be cross-sectional shapes that substantially match the cross-sectional shapes of the hoppers 404. The pistons 426 can be similar or identical to the pistons 130 described above. That is, the pistons 426 may define a leaky seal with the inner walls of the hoppers 404. The gas supply can be similar or identical to the gas supply 140 described above. That is, the gas supply can be connected to each of the hoppers 404 via conduits and valves (not shown) to selectively provide compressed gas to the hoppers 404. The compressed gas may push the pistons 426 toward the outlets 422 of the hoppers 404 to push the buns through the outlets 422 and into the chute 406 on demand.

[0182] In some embodiments, rather than defining leaky seals, the pistons 426 could include valves to relieve pressure behind the pistons 426. In some embodiments, the pistons 426 could be driven by motor-driven linear actuators (or some other type of actuator) instead of the compressed gas from a gas supply.

[0183] As shown in FIGS. 17-20, the bun-stopper system 410 may include a mounting bracket 428, an actuator 430, and a stopper 432. The mounting bracket 428 may be fixedly attached to a back wall 434 of the chute 406. The actuator 430 may be fixed to the bracket 428 and may drive the stopper 432 for reciprocating motion relative to the bracket and the chute 406. The actuator 430 can be a solenoid or a pneumatic actuator, for example, or any other suitable actuator.

[0184] The stopper 432 can be a pin, rod, or thin plate, for example. As shown in FIGS. 19 and 20, the actuator 430 may move the stopper 432 between a retracted position (FIG. 20) and an extended position (FIG. 19). In the extended position, the stopper 432 extends into the channel 420 of the chute 406 through an aperture 436 in the back wall 434 of the chute 406. In the retracted position, the stopper 432 is retracted out of the channel 420.

[0185] As shown in FIG. 16, the slicing mechanism 402 may include a blade 438, a linkage 440, and an actuator (or motor) 442 (FIG. 17) that drives the linkage 440 to reciprocate the blade 438. The blade 438, linkage 440 and actuator 442 may be similar or identical to the blade 220, linkage 230 and actuator 240 described above, and therefore, will not be described again in detail.

[0186] As shown in FIGS. 19 and 20, the stopper 432 is disposed vertically above the blade 438. When a bun 450 is dispensed from one of the hoppers 404 into the channel 420 of the chute 406, the actuator 430 may move the stopper 432 into the extended position (FIG. 19) so that when the bun 450 slides down the chute 406 toward the blade 438, the stopper 432 can stop the bun 450 at a position just above the blade 438. Stopping the bun 450 with the stopper 432 above the blade 438 allows the bun 450 to settle against the back wall 434 of the chute 406 so that the bun 450 is sitting in a more preferred position for slicing. The stopper 432 will remain in the extended position for a predetermined amount of time (a sufficient amount of time to allow the bun 450 to settle on the stopper 432 and against the back wall 434). After the predetermined amount of time, the actuator 430 may move the stopper 432 to the retracted position (FIG. 20) to allow the bun 450 to move the remaining short distance to the blade 438 so that the blade 438 can slice through the bun 450. A cutting block 416 (FIGS. 14 and 15) (similar or identical to the cutting block 250) may move down the channel 420 of the chute 406 to and apply a downward force on the bun 450 to aid the slicing of the bun 450.

[0187] After the bun 450 is sliced into halves, the two halves may exit the chute 406 through respective outlets 452, 454 (FIG. 17). The outlets 452, 454 may direct the bun halves to a buttering a toasting station (e.g., similar or identical to the butter stage 310 and toast stage 320 described above) and/or to a food assembly station (not shown).

[0188] While the dispenser 400 and slicing mechanism 402 are described above as dispensing and slicing buns, it will be appreciated that the dispenser 400 and slicing mechanism 402 could dispense and slice other food products, such as rolls, English muffins, bagels, croissants, or other bread products or pastries, for example.

5. Alternative Dispenser Paddle Assembly

[0189] Referring now to FIGS. 21-24, an alternative dispenser paddle assembly 500 is provided. The dispenser paddle assembly 500 can be incorporated into the buttering

and toasting system 300 (FIG. 8) instead of the dispenser paddle assembly 355 described above. The dispenser paddle assembly 500 receives a bun heel 502 and a bun crown 504 from the toasting stage 320 (e.g., from the final toasting paddle assembly 324) and transitions the bun heel 502 and bun crown 504 from a vertical orientation (FIG. 21) above an open box 506 (or other container) to a generally horizontal, toasted-side-up orientation (FIG. 24) within the box 506.

[0190] The dispenser paddle assembly 500 may include a first paddle 510, a second paddle 512, a third paddle 514, and a fourth paddle 516. The paddles 510, 512, 514, 516 may be pivotably mounted to a fixed structure, such as a base or frame 321 of the toasting stage 320, for example. The first paddle 510 may be pivotably mounted to the frame 321 at a first pivot 518 (defining a first pivot axis). The second paddle 512 may be pivotably mounted to the frame 321 at a second pivot 520 (defining a second pivot axis). The third paddle 514 may be pivotably mounted to the frame 321 at a third pivot 522 (defining a third pivot axis). The fourth paddle 516 may be pivotably mounted to the frame 321 at a fourth pivot 524 (defining a fourth pivot axis). The first, second and third paddles 510, 512, 514 can be rigid, one-piece paddles. Each of the pivots 518, 520, 522, 524 may be or include a pin or shaft. A first actuator 519 (e.g., an electric motor and gears) may drive rotation of the first paddle 510 relative to the frame 321 about the first pivot 518. A second actuator 521 (e.g., an electric motor and gears) may drive rotation of the second and third paddles 512, 514 relative to the frame 321 about the second and third pivots 520, 522, respectively. In some configurations, the second and third paddles 512, 514 could be driven by separate actuators. A third actuator 523 (e.g., an electric motor and gears) may drive rotation of the fourth paddle 516 relative to the frame 321 about the fourth pivot 524.

[0191] The fourth paddle 516 may be a two-piece paddle having a first portion 526 and a second portion 528. The first portion 526 is pivotably coupled to the frame 321 at the fourth pivot 524. The second portion 528 is pivotably connected to the first portion 526 at a fifth pivot 530 (e.g., a pin or shaft) defining a fifth pivot axis. The second portion 528 is freely pivotable relative to the first portion 526. The second portion 528 may include a stop member 532 (e.g., a protrusion) that limits the range of relative rotational motion between the first and second portions 526, 528. As shown in FIGS. 21 and 22, the stop member 532 abuts the first portion 526 when the first and second portions 526, 528 are at a first angle relative to each other (i.e., at a 180 degree angle). The interference between the stop member 532 and the first portion 526 prevents the second portion 528 from rotating from the first angle in a first direction (counterclockwise when viewed from the frame of reference of FIGS. 21-24) relative to the first portion 526. However, as shown in FIGS. 23 and 24, the stop member 532 does not restrict the second portion 528 from rotating from the first angle in a second direction (clockwise when viewed from the frame of reference of FIGS. 21-24) relative to the first portion.

[0192] FIG. 21 depicts the bun heel 502 and bun crown 504 in a first position in which the bun heel 502 and bun crown 504 are in a vertical orientation and in contact with respective toasting surfaces 327, 327B of the toasting stage 320. As the bun heel 502 and bun crown 504 fall downward from the first position, the second actuator 521 may rotate the second and third paddles 512, 514 in opposite rotational

directions (generally toward each other) to guide or deflect the bun heel 502 and bun crown 504 into first and second box portions 540, 542, respectively, in a second position shown in FIG. 22.

[0193] In the second position (FIG. 22), a first end of the bun heel 502 is positioned at or near a corner (near a middle portion 544 of the box 506 between the first and second portions 540, 542) of the first box portion 540, and a first end of the bun crown 504 may contact a sloped surface of the second box portion 542 near the middle portion 544. In the second position, the bun heel 502 and bun crown 504 may be standing generally upright in the box 506 and may be leaning onto the first paddle 510 and the fourth paddle 516, respectively.

[0194] With the bun heel 502 leaning on the first paddle 510, the first actuator 519 may rotate the first paddle 510 toward the position shown in the FIG. 24 to allow the bun heel 502 to fall generally flat into the first box portion 540 (see FIGS. 22-24). With the bun crown 504 leaning on the fourth paddle 516, the third actuator 523 may rotate the fourth paddle 516 toward the position shown in the FIG. 24 to allow the bun crown 504 to fall generally flat into the second box portion 542. As the fourth paddle 516 moves from the position shown in FIG. 22 to the position shown in FIG. 23, the weight of the bun crown 504 on the second portion 528 of the fourth paddle 516 may cause the second portion 528 to rotate relative to the first portion 526 about the fifth pivot 530. As the fourth paddle 516 continues to rotate the fourth paddle 516 toward the position shown in FIG. 24, the second portion 528 gently lowers the bun crown 504 into the generally flat position in the second box portion 542. Thereafter, the first, second, and third actuators 519, 521, 523 may rotate the first, second, third and fourth paddles 510, 512, 514, 516 back to the positions shown in FIG. 21.

[0195] It will be appreciated that in some configurations, the dispenser paddle assembly 500 may transition the bun heel 502 and bun crown 504 from the toasting stage 320 into other types of boxes (other than the box 506), onto a plate, or directly onto the conveyor 507 of a food-assembly or food-processing apparatus, for example.

Overall

[0196] The foregoing description is merely illustrative in nature and is in no way intended to limit the disclosure, its application, or uses. The broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent upon a study of the drawings, the specification, and the following claims. It should be understood that one or more steps within a method may be executed in different order (or concurrently) without altering the principles of the present disclosure. Further, although each of the embodiments is described above as having certain features, any one or more of those features described with respect to any embodiment of the disclosure can be implemented in and/or combined with features of any of the other embodiments, even if that combination is not explicitly described. In other words, the described embodiments are not mutually exclusive, and permutations of one or more embodiments with one another remain within the scope of this disclosure.

[0197] Spatial and functional relationships between elements (for example, between modules, circuit elements, semiconductor layers, etc.) are described using various terms, including “connected,” “engaged,” “coupled,” “adjacent,” “next to,” “on top of,” “above,” “below,” and “disposed.” Unless explicitly described as being “direct,” when a relationship between first and second elements is described in the above disclosure, that relationship can be a direct relationship where no other intervening elements are present between the first and second elements, but can also be an indirect relationship where one or more intervening elements are present (either spatially or functionally) between the first and second elements.

[0198] As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A OR B OR C), using a non-exclusive logical OR, and should not be construed to mean “at least one of A, at least one of B, and at least one of C.” The term subset does not necessarily require a proper subset. In other words, a first subset of a first set may be coextensive with (equal to) the first set.

[0199] In the figures, the direction of an arrow, as indicated by the arrowhead, generally demonstrates the flow of information (such as data or instructions) that is of interest to the illustration. For example, when element A and element B exchange a variety of information but information transmitted from element A to element B is relevant to the illustration, the arrow may point from element A to element B. This unidirectional arrow does not imply that no other information is transmitted from element B to element A. Further, for information sent from element A to element B, element B may send requests for, or receipt acknowledgements of, the information to element A.

[0200] In this application, including the definitions below, the term “module” or the term “controller” may be replaced with the term “circuit.” The term “module” may refer to, be part of, or include: an Application Specific Integrated Circuit (ASIC); a digital, analog, or mixed analog/digital discrete circuit; a digital, analog, or mixed analog/digital integrated circuit; a combinational logic circuit; a field programmable gate array (FPGA); a processor circuit (shared, dedicated, or group) that executes code; a memory circuit (shared, dedicated, or group) that stores code executed by the processor circuit; other suitable hardware components that provide the described functionality; or a combination of some or all of the above, such as in a system-on-chip.

[0201] The module may include one or more interface circuits. In some examples, the interface circuit(s) may implement wired or wireless interfaces that connect to a local area network (LAN) or a wireless personal area network (WPAN). Examples of a LAN are Institute of Electrical and Electronics Engineers (IEEE) Standard 802.11-2016 (also known as the WIFI wireless networking standard) and IEEE Standard 802.3-2015 (also known as the ETHERNET wired networking standard). Examples of a WPAN are the BLUETOOTH wireless networking standard from the Bluetooth Special Interest Group and IEEE Standard 802.15.4.

[0202] The module may communicate with other modules using the interface circuit(s). Although the module may be depicted in the present disclosure as logically communicating directly with other modules, in various implementations the module may actually communicate via a communications system. The communications system includes physical and/or virtual networking equipment such as hubs, switches, routers, and gateways. In some implementations, the com-

munications system connects to or traverses a wide area network (WAN) such as the Internet. For example, the communications system may include multiple LANs connected to each other over the Internet or point-to-point leased lines using technologies including Multiprotocol Label Switching (AWLS) and virtual private networks (VPNs).

[0203] In various implementations, the functionality of the module may be distributed among multiple modules that are connected via the communications system. For example, multiple modules may implement the same functionality distributed by a load balancing system. In a further example, the functionality of the module may be split between a server (also known as remote, or cloud) module and a client (or, user) module.

[0204] Some or all hardware features of a module may be defined using a language for hardware description, such as IEEE Standard 1364-2005 (commonly called “Verilog”) and IEEE Standard 1076-2008 (commonly called “VHDL”). The hardware description language may be used to manufacture and/or program a hardware circuit. In some implementations, some or all features of a module may be defined by a language, such as IEEE 1666-2005 (commonly called “SystemC”), that encompasses both code, as described below, and hardware description.

[0205] The term code, as used above, may include software, firmware, and/or microcode, and may refer to programs, routines, functions, classes, data structures, and/or objects. The term shared processor circuit encompasses a single processor circuit that executes some or all code from multiple modules. The term group processor circuit encompasses a processor circuit that, in combination with additional processor circuits, executes some or all code from one or more modules. References to multiple processor circuits encompass multiple processor circuits on discrete dies, multiple processor circuits on a single die, multiple cores of a single processor circuit, multiple threads of a single processor circuit, or a combination of the above. The term shared memory circuit encompasses a single memory circuit that stores some or all code from multiple modules. The term group memory circuit encompasses a memory circuit that, in combination with additional memories, stores some or all code from one or more modules.

[0206] The term memory circuit is a subset of the term computer-readable medium. The term computer-readable medium, as used herein, does not encompass transitory electrical or electromagnetic signals propagating through a medium (such as on a carrier wave); the term computer-readable medium may therefore be considered tangible and non-transitory. Non-limiting examples of a non-transitory computer-readable medium are nonvolatile memory circuits (such as a flash memory circuit, an erasable programmable read-only memory circuit, or a mask read-only memory circuit), volatile memory circuits (such as a static random access memory circuit or a dynamic random access memory circuit), magnetic storage media (such as an analog or digital magnetic tape or a hard disk drive), and optical storage media (such as a CD, a DVD, or a Blu-ray Disc).

[0207] The apparatuses and methods described in this application may be partially or fully implemented by a special purpose computer created by configuring a general purpose computer to execute one or more particular functions embodied in computer programs. The functional blocks and flowchart elements described above serve as

software specifications, which can be translated into the computer programs by the routine work of a skilled technician or programmer.

[0208] The computer programs include processor-executable instructions that are stored on at least one non-transitory computer-readable medium. The computer programs may also include or rely on stored data. The computer programs may encompass a basic input/output system (BIOS) that interacts with hardware of the special purpose computer, device drivers that interact with particular devices of the special purpose computer, one or more operating systems, user applications, background services, background applications, etc.

[0209] The computer programs may include: (i) descriptive text to be parsed, such as HTML (hypertext markup language), XML (extensible markup language), or JSON (JavaScript Object Notation), (ii) assembly code, (iii) object code generated from source code by a compiler, (iv) source code for execution by an interpreter, (v) source code for compilation and execution by a just-in-time compiler, etc. As examples only, source code may be written using syntax from languages including C, C++, C #, Objective-C, Swift, Haskell, Go, SQL, R, Lisp, Java®, Fortran, Perl, Pascal, Curl, OCaml, Javascript®, HTML5 (Hypertext Markup Language 5th revision), Ada, ASP (Active Server Pages), PHP (PHP: Hypertext Preprocessor), Scala, Eiffel, Smalltalk, Erlang, Ruby, Flash®, Visual Basic®, Lua, MATLAB, SIMULINK, and Python®.

What is claimed is:

1. A system comprising:
 - a chute;
 - a plurality of hoppers attached to the chute and including outlets in communication with a channel of the chute;
 - an advancing system configured to move a food product from one of the hoppers to the channel of the chute;
 - a blade disposed in the channel and configured to reciprocate relative to the chute; and
 - a stopper system including an actuator and a stopper, wherein:
 - the stopper is disposed vertically above the blade, and the actuator is configured to move the stopper between an extended position where the stopper extends into the channel to prevent the food product from contacting the blade and a retracted position where the stopper is retracted from the channel to allow the food product to move into contact with the blade.
2. The system of claim 1, wherein the stopper is a pin.
3. The system of claim 1, wherein each of the hoppers includes a pin disposed adjacent an outlet of the hopper.
4. The system of claim 1, wherein:
 - the chute includes a pair of outlets disposed beneath the blade, and
 - each outlet is configured to receive a respective sliced portion of the food product.
5. The system of claim 1, further comprising a cutting block configured to move along a length of the channel of the chute and push the food product against the blade.
6. The system of claim 1, further comprising a plurality of pistons, wherein:
 - each of the pistons is disposed within a respective one of the hoppers, and
 - the pistons are movable within the respective hoppers to push food products out of the hoppers and into the channel of the chute.

7. A food preparation system comprising:

- a toasting stage including a first toasting surface and a second toasting surface; and
- a dispenser paddle assembly configured to receive a bun heel and a bun crown from the toasting stage and transition the bun heel and bun crown from a vertical orientation above an to a horizontal, toasted-side-up orientation,

wherein:

- the dispenser paddle assembly includes a first paddle, a second paddle, a third paddle, and a fourth paddle, the first, second, third, and fourth paddles are movably mounted to a fixed structure and pivotable relative to the fixed structure about first, second, third, and fourth pivot axes, respectively,
- the first and second paddles cooperate to transition the bun heel from the vertical orientation to the horizontal, toasted side-up orientation, and
- the third and fourth paddles cooperate to transition the bun heel from the vertical orientation to the horizontal, toasted side-up orientation.

8. The food preparation system of claim 7, wherein the fourth paddle includes a first portion and a second portion, wherein the second portion is rotatable relative to the first portion about a fifth axis.

9. The food preparation system of claim 8, wherein a stop member limits a range of relative rotation between the first and second portions.

10. The food preparation system of claim 8, wherein the first, second, and third paddles are rigid, one-piece paddles.

11. The food preparation system of claim 7, wherein the first and fourth paddles are rotatable independently of each other.

12. The food preparation system of claim 11, wherein the second and third paddles are rotatable independently of the first and fourth paddles.

13. The food preparation system of claim 12, wherein an actuator drives the second and third paddles simultaneously and in opposite rotational directions.

14. The food preparation system of claim 7, further comprising a buttering stage configured to apply butter to the bun heel and bun crown, wherein the toasting stage receives the bun heel and bun crown from the toasting stage.

15. The food preparation system of claim 7, further comprising:

- a chute;
- a plurality of hoppers attached to the chute and including outlets in communication with a channel of the chute;
- an advancing system configured to move a whole bun from one of the hoppers to the channel of the chute;
- a blade disposed in the channel and configured to reciprocate relative to the chute; and
- a stopper system including an actuator and a stopper, wherein:
 - the stopper is disposed vertically above the blade, and the actuator is configured to move the stopper between an extended position where the stopper extends into the channel to prevent the whole bun from contacting the blade and a retracted position where the stopper is retracted from the channel to allow the whole bun to move into contact with the blade to allow the blade to slice the whole bun to separate the bun heel from the bun crown.

16. The food preparation system of claim **15**, wherein the stopper is a pin.

17. The food preparation system of claim **15**, wherein each of the hoppers includes a pin disposed adjacent an outlet of the hopper.

18. The food preparation system of claim **15**, wherein:
the chute includes a pair of outlets disposed beneath the blade, and
each outlet is configured to receive a respective one of the bun heel and bun crown.

19. The food preparation system of claim **15**, further comprising a cutting block configured to move along a length of the channel of the chute and push the whole bun against the blade.

20. The food preparation system of claim **15**, further comprising a plurality of pistons, wherein:

each of the pistons is disposed within a respective one of the hoppers, and

the pistons are movable within the respective hoppers to push whole buns out of the hoppers and into the channel of the chute.

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