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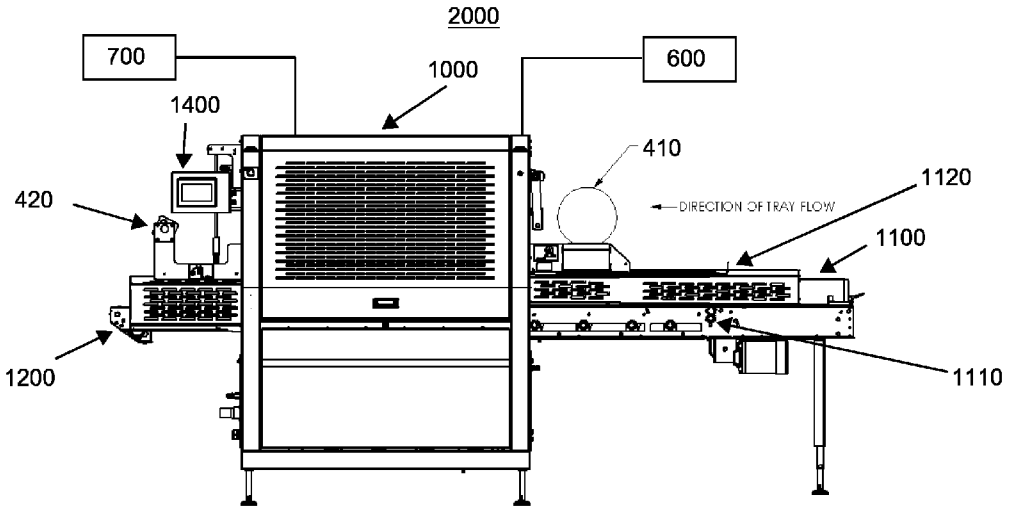
(54) Title: VACUUM SEALING SYSTEM, APPARATUS, AND METHOD

FIG. 1




(57) Abstract: A vacuum sealing system includes a vacuum pump, a lower tool to hold one or more trays carrying product, an upper tool to seal a plastic film onto the one or more trays, the upper tool including at least one seal plate with a seal plate cavity and a vacuum clamp, the system also including a controller to control the vacuum pump, the lower tool, and the upper tool.

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**Declarations under Rule 4.17:**

— *as to the identity of the inventor (Rule 4.17(i))*
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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TITLE OF THE INVENTION

# VACUUM SEALING SYSTEM, APPARATUS, AND METHOD

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority from Provisional Application No. 62/365,038, filed on July 21, 2016, in the United States Patent and Trademark Office, the disclosure of which is incorporated herein in its entirety by reference.

## BACKGROUND OF THE INVENTIVE CONCEPT

**[0002]** Vacuum-sealed products, for example meat or pre-made meals, are customarily arranged on a tray of plastic or Styrofoam, and plastic film is vacuum-sealed onto the product and the tray, making an airtight seal around the product. This helps to preserve the product and also stores it in a standard package size, allowing for easier shipping and display for sale. This process may also be called Vacuum Skin Pack ("VSP"). For the purposes of this application, "product" includes any item or group of items which may be arranged on a tray and vacuum-sealed thereon.

**[0003]** In the conventional process for vacuum sealing, one or more trays carrying product are loaded into a machine. Each tray includes a cavity to hold product, and a flange surrounding the cavity to engage with the packaging machine, such that the tray is held in place in the machine.

**[0004]** Once trays carrying product are loaded into the machine, a vacuum is applied to the chamber above the tray, while a similar vacuum is applied to the chamber below the tray. This vacuum can be any level of vacuum below ambient atmospheric pressure (approx. 1000 millibars (mbar) at sea level), but is customarily very strong, e.g., 10 mbar. At an appropriate time, the vacuum above the tray is released. This generates a pressure differential between the tray and the surrounding air. This pressure differential presses a plastic film onto the tray and around the product.

**[0005]** For the purposes of this application, a "vacuum" is an artificially generated

reduction in air pressure to significantly lower than the ambient pressure. A "stronger" vacuum has a lower pressure, such that the pressure differential between the vacuum and the surrounding air is higher. Similarly, a "weaker" vacuum has a higher pressure.

**[0006]** This conventional process has many drawbacks, and as a result cannot keep up with demand. The meat-packaging industry has a production requirement of approximately 30,000 pigs and 60,000 chickens' worth of packaged food every day, and this requirement is expected to increase as the world population increases. A packaging system is therefore required which can package food fast enough to keep up with this demand for production. However, the packaging process as currently known has several processes which slow down the packaging operation. First, the film must be held in place to be properly affixed to the tray. Unfortunately, holding the film in place according to the conventional method requires closing the tool over the tray. Only after the tool is closed can the vacuum be generated and the food packaged. This requirement of closing the tool before any vacuum can be generated slows down the packaging process. Additionally, since the film is delicate plastic, it is difficult to hold the film steady as the tool is closed such that the film is positioned over the trays. It becomes even more difficult to hold the film steady if heat is applied, which makes the film pliable.

**[0007]** Furthermore, since the pressure differential noted above is key to sealing the plastic film around the product, a strong vacuum of, e.g., 10 mbar is customarily required to ensure a firm seal. However, generating a 10 mbar vacuum takes a prohibitively long time, since the time to generate a vacuum increases exponentially as the desired pressure decreases. Therefore, the requirement of a strong vacuum slows down the process considerably.

**[0008]** Additionally, the conventional packaging process is limited as to what kind of trays and product can be used. If the product is a soft or aerated item such as, for example, mashed potatoes, contacting the film too early (e.g., while the vacuums are being generated) will deform the product, resulting in an undesirable visual appearance, e.g., food that has been flattened or different foods that have been mashed together. Contacting the plastic film too early may even damage the product, making it unusable. Accordingly, to avoid this damage to the product, a tray holding a soft product must have a sufficient depth to hold the product without the

product extending past a flange of the tray. As a result, different products require different trays, depending on the height and consistency of the product. Since each type of tray requires different tooling (e.g., different mechanisms to move the trays in and out of the machine, and different mechanisms to hold the trays while film is affixed to them), using different trays for different products requires re-tooling a machine for each different type of tray, which also slows down the packaging process.

## SUMMARY OF THE INVENTION

**[0009]** It is therefore a primary object of the present invention to provide a system, apparatus, and method which improves upon prior art packaging systems, machines, and processes as described above, and addresses their related drawbacks.

**[0010]** Additional features and utilities of the present general inventive concept will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the general inventive concept.

**[0011]** The foregoing and/or other features and utilities of the present general inventive concept may be achieved by providing a vacuum sealing system, including a vacuum pump, a lower tool to hold one or more trays carrying product, an upper tool to seal a plastic film onto the one or more trays, the upper tool including at least one seal plate, each seal plate including a seal plate cavity, and a plurality of first holes to allow air to be drawn out of the seal plate cavity with the vacuum pump to draw the plastic film into the seal plate cavity, and to allow the seal plate cavity to be vented to equalize an air pressure therein with ambient air pressure, a vacuum clamp disposed around the seal plate, the vacuum clamp including a groove to receive the plastic film, and a plurality of second holes to allow air to be drawn out of the groove with the vacuum pump and thereby hold the plastic film in the groove, and a controller to control the vacuum pump, the lower tool, and the upper tool.

**[0012]** In an exemplary embodiment, the controller includes a user interface to receive a user input to control the vacuum pump, the lower tool, and the upper tool, and a memory device to store one or more timing charts, each timing chart comprising instructions to control the vacuum pump, the lower tool, and the upper tool.

**[0013]** In an exemplary embodiment, the groove includes a square cross-section.

**[0014]** In an exemplary embodiment, the system further includes a set of blades to cut the plastic film.

**[0015]** In an exemplary embodiment, the at least one seal plate further includes a heating element to heat the plastic film to a predetermined temperature.

**[0016]** In an exemplary embodiment, the at least one seal plate further comprises a temperature probe to determine a temperature of the at least one seal plate.

**[0017]** In an exemplary embodiment, the vacuum sealing system further includes a set of grippers to move one or more trays from an entry conveyor to between the upper tool and lower tool, and to move one or more trays from between the upper tool and lower tool and onto an exit conveyor.

**[0018]** The foregoing and/or other features and utilities of the present general inventive concept may also be achieved by providing a vacuum sealing apparatus, including at least one seal plate, each seal plate including a seal plate cavity, and a plurality of first holes to allow air to be drawn out of the seal plate cavity to draw a plastic film into the seal plate cavity, and to allow the seal plate cavity to be vented to equalize an air pressure therein with ambient air pressure, a vacuum clamp disposed around the seal plate, the vacuum clamp including a groove to receive a plastic film, and a plurality of second holes to allow air to be drawn out of the groove and thereby hold the plastic film in the groove.

**[0019]** In an exemplary embodiment, the at least one seal plate further includes a heating element to heat the plastic film to a predetermined temperature.

**[0020]** In an exemplary embodiment, the at least one seal plate further includes a temperature probe to determine a temperature of the at least one seal plate.

**[0021]** The foregoing and/or other features and utilities of the present general inventive concept may also be achieved by providing a method of vacuum sealing, the method including moving one or more trays holding product into a packaging portion comprising an upper tool and a lower tool, forming a first vacuum in the upper tool to hold a plastic film, forming a second vacuum on a first side of the plastic film to draw the plastic film into one or more seal plate cavities over the one or more trays, strengthening the second vacuum to form a third vacuum on the first side of

the plastic film, forming a fourth vacuum on a second side of the plastic film after forming the third vacuum, the second side of the plastic film being opposite from the first side of the plastic film, and releasing the third and fourth vacuums to force the plastic film onto the one or more trays.

**[0022]** In an exemplary embodiment, the method further includes releasing the fourth vacuum after the third vacuum to generate a pressure differential between the plastic film and the tray carrying the product.

**[0023]** In an exemplary embodiment, the method further includes releasing the fourth vacuum after the third vacuum to generate a pressure differential between the plastic film and the tray carrying the product.

**[0024]** In an exemplary embodiment, the method further includes heating the plastic film to a predetermined temperature prior to forming the second vacuum.

**[0025]** In an exemplary embodiment, the method further includes increasing air pressure against the first side of the plastic film after releasing the third vacuum.

**[0026]** In an exemplary embodiment, the one or more trays are moved into the packaging portion simultaneously as the first vacuum is formed.

**[0027]** In an exemplary embodiment, the method further includes moving the one or more trays out of the packaging portion after forcing the plastic film onto the one or more trays, and simultaneously moving one or more additional trays carrying product into the packaging portion.

**[0028]** In an exemplary embodiment, a non-transitory computer-readable recording medium contains computer-readable codes as a program to execute the method of vacuum sealing.

**[0029]** The foregoing and/or other features and utilities of the present general inventive concept may also be achieved by providing a vacuum sealing system including a lower tool to receive at least one tray carrying a product, and an upper tool including a seal plate cavity with a plurality of first holes therein to receive a vacuum to draw a plastic film into the seal plate cavity and a groove surrounding an outer perimeter of the seal plate cavity and including a plurality of second holes therein to receive a vacuum to draw the plastic film into the groove, wherein at least one of the lower tool and the upper tool moves toward the other tool to seal the

plastic film to the at least one tray.

**[0030]** In an exemplary embodiment, the vacuum sealing system may further include a vacuum pump to form a vacuum, and a controller to control movement of at least one of the upper and lower tools and to control the vacuum pump to create a first and second vacuum to be drawn through the first holes and a third vacuum to be drawn through the second holes.

**[0031]** In an exemplary embodiment, the upper tool further includes a heating element to heat the plastic film to a predetermined temperature.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0032]** The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

**[0033]** FIG. 1 illustrates a side view of a vacuum sealing system according to an exemplary embodiment of the present general inventive concept;

**[0034]** FIG. 2 illustrates an isometric view of upper and lower tools in a vacuum sealing system according to an exemplary embodiment of the present general inventive concept;

**[0035]** FIG. 3 illustrates an isometric view of an upper tool according to an exemplary embodiment of the present general inventive concept;

**[0036]** FIG. 4 is a view of a seal plate and vacuum clamp according to an exemplary embodiment of the present general inventive concept;

**[0037]** FIG. 5 illustrates a cutaway side view of an upper tool prior to forming a vacuum according to an exemplary embodiment of the present general inventive concept;

**[0038]** FIG. 6 illustrates an expanded cutaway side view of an upper tool when a first vacuum is formed to hold a plastic film in a vacuum clamp according to an exemplary embodiment of the present general inventive concept;

**[0039]** FIG. 7 illustrates a cutaway side view of an upper tool when a first vacuum is formed to hold a plastic film in a vacuum clamp according to an exemplary

embodiment of the present general inventive concept;

**[0040]** FIG. 8 illustrates a cutaway side view of an upper tool and a lower tool when the tools are closed together and a vacuum is applied to both tools according to an exemplary embodiment of the present general inventive concept;

**[0041]** FIG. 9 illustrates a cutaway side view of an upper tool and a lower tool when a plastic film is forced onto product held on a tray in the lower tool according to an exemplary embodiment of the present general inventive concept;

**[0042]** FIGS. 10A-10C are expanded views of a timing chart according to an exemplary embodiment of the present general inventive concept;

**[0043]** FIG. 10D is the complete time chart illustrated in FIGS. 10A-10C; and

**[0044]** FIG. 11 is a block diagram of a controller according to an exemplary embodiment of the present general inventive concept.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0045]** Reference will now be made in detail to the embodiments of the present general inventive concept, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present general inventive concept while referring to the figures. Also, while describing the present general inventive concept, detailed descriptions about related well-known functions or configurations that may diminish the clarity of the points of the present general inventive concept are omitted.

**[0046]** It will be understood that although the terms “first” and “second” are used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. Thus, a first element could be termed a second element, and similarly, a second element may be termed a first element without departing from the teachings of this disclosure.

**[0047]** Expressions such as “at least one of,” when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

**[0048]** All terms including descriptive or technical terms which are used herein should be construed as having meanings that are obvious to one of ordinary skill in the art. However, the terms may have different meanings according to an intention of one of ordinary skill in the art, case precedents, or the appearance of new technologies. Also, some terms may be arbitrarily selected by the applicant, and in this case, the meaning of the selected terms will be described in detail in the detailed description of the preferred embodiments. Thus, the terms used herein are defined based on the intended meaning of the terms together with the description throughout the specification.

**[0049]** Also, when a part "includes" or "comprises" an element, unless there is a particular description contrary thereto, the part can further include other elements, not excluding the other elements.

**[0050]** Exemplary embodiments of the present general inventive concept are directed at speeding up the process of vacuum sealing product P, as well as allowing for product P which extends past the flange 1510 of a tray 1500, thereby allowing a single type of tray 1500 to be used for a variety of different products. Exemplary embodiments of the present general inventive concept include multiple processes which may occur simultaneously, thereby increasing packaging efficiency. Exemplary embodiments of the present general inventive concept also include processes of holding film 400 in place prior to tools 100 and 300 (illustrated for example in FIG. 2) being closed over a tray 1500, thereby allowing a vacuum to be formed earlier in the packaging operation.

**[0051]** A packaging system 2000 according to the present general inventive concept includes several components to package product P. An overall outside view of such a system 2000 is illustrated in FIG. 1. As illustrated therein, the system 2000 includes an entry conveyor 1100 leading into a packaging portion 1000 and an exit conveyor 1200 leading away from the packaging portion 1000. The entry conveyor 1100 may include one or more sensors 1110 and a plurality of retractable tray stops 1120. As trays 1500 move down the entry conveyor 1100 and are detected by the sensor(s) 1110, tray stops 1120 may be raised to separate and space the trays 1500 at a preset distance from each other, so that grippers 1300 (described below) can more readily grasp trays 1500 and move them into the packaging portion 1000.

**[0052]** The system 2000 may further include a film feeding apparatus which advances film through the packaging portion. The film feeding apparatus may include an upstream roll 410 to feed fresh film into the packaging portion, and a downstream roll 420 to take up used film 400 exiting the packaging portion 1000 and to add tension to the film 400, thereby allowing the film to be held in place per the apparatuses and processes described below.

**[0053]** Trays 1500 (illustrated, for example, in FIG. 8) may be "staged," i.e. loaded with product P, after which they may be placed on the entry conveyor 1100, and separated by tray stops 1120. In an exemplary embodiment of the present general inventive concept, when a predetermined number of trays 1500 (e.g., three trays 1500) have been detected on the entry conveyor 1100, a set of grippers 1300 grasps the trays 1500 and moves them into the packaging portion 1000. The grippers 1300 may be configured such that as they carry one set of trays 1500 from the entry conveyor 1110 and into the packaging portion 1000, they simultaneously carry another set of trays 1500 from the packaging portion 1000 and onto the exit conveyor 1120.

**[0054]** As illustrated, for example, in FIG. 2, inside the packaging portion 1000 are an upper tool 100 and a lower tool 300 which can be separated and brought together. The upper tool 100 may include one or more seal plates 200, each of which corresponds to one of the trays 1500 which is brought into the packaging portion 1500. As illustrated in FIGS. 2 and 5, each seal plate 200 may define a seal plate cavity 210 therein. Each seal plate 200 may include a plurality of holes 220 to allow a vacuum pump to generate a vacuum in the seal plate cavity 210 and draw plastic film 400 against the seal plate 200, as well as to vent the seal plate 200 to the ambient atmospheric pressure. Each seal plate 200 may also include a heating element 230 and a temperature probe 240 (illustrated in FIG. 4) to heat the film 400, in a process described below.

**[0055]** The lower tool 300 may include a carrier 310 and a tray pad assembly 320 to support the trays 1500 which are brought into the packaging portion 1000, and to hold the trays 1500 in place as the upper tool 100 and lower tool 300 are closed together.

**[0056]** As illustrated in FIG. 3 and FIG. 4, the upper tool 100 may include a

vacuum clamp 110 around each seal plate 200. The vacuum clamp 110 may comprise a groove 111 and a plurality of holes 112 formed therein to enable a vacuum pump 600 to form a vacuum in the groove 111. This vacuum pump 600 is illustrated in FIG. 1 as a single pump. However, it will be understood that any number of vacuum pumps 600 may be included in the system 2000, to form the vacuums which will be described in detail infra. The vacuum pump 600 may be attached to the holes 112 through various through holes 120 formed in the upper tool 100 and extending through the upper tool 100, connecting to the plurality of the holes 112 as illustrated in FIGS. 4-9. The through holes 120 may optionally include plugs which allow the through holes 120 to be sealed or opened according to a specific embodiment of the present general inventive concept.

**[0057]** The groove 111 of the vacuum clamp 110 may have, for example, a square cross-section, but may have any cross-section shape to allow it to hold film 400, per the process described in greater detail below.

**[0058]** The upper tool 100 may also include an O-ring 130 around the perimeter of the seal plate(s) 200 to help form an airtight seal when the upper tool 100 and lower tool 300 are closed together.

**[0059]** Each seal plate 200 may also include a plurality of holes 220 formed in the surface thereof. A vacuum pump 600 may draw air out through these holes 220 to draw the film up into the seal plate cavity. The vacuum pump 600 attached to these holes may be the same or different from the vacuum pump 600 which draws air out of the vacuum clamp 110.

**[0060]** In an exemplary embodiment, the lower tool 300 may be physically lower than the upper tool 100, such that gravity helps to hold the trays 1500 on the carrier 310 and tray pad assembly 320. However, it will be understood that the terms “upper” and “lower” are used only for convenience and to distinguish the tools 100 and 300 from each other, and are not intended to be limiting.

**[0061]** Another part of the system 2000 is a controller 1400, which may be, for example, a computer. The controller 1400 may include a user interface 1410 (e.g., a touchscreen, a monitor, mouse, and keyboard, etc.) to allow a user to input commands to the system 2000. The controller 1400 may further include a memory device 1420 to store electronic data. A block diagram of the controller 1400 is

illustrated in FIG. 11. The controller 1400 may be used to control the functions of the various components of the system 2000 and the timing of the operations, as described below.

**[0062]** Example of Operation

**[0063]** In an exemplary embodiment of the operation of the invention, product P is staged in one or more trays 1500 on the entry conveyor 1100, separated by tray stops 1120 such that the grippers 1300 will be able to move the staged trays 1500 into the packaging portion 1000. As part of staging, product P may be arranged in a specific manner, for example arranged so that packaged food will be readily visible through the final packaging.

**[0064]** In operation of the packaging portion 1000, plastic film 400 is first fed into the packaging portion 1000, extending over the seal plate(s) 200 in the packaging portion 1000 as illustrated in FIG. 5. The film 400 may be, e.g., 0.006" thick, and may optionally include an adhesive layer on one side, for example, the side facing the seal plate(s) 200. Once extended over the seal plate(s) 200, a vacuum pump 600 may draw air out of the vacuum clamp 110, which draws the film 400 into the vacuum clamp 110 and holds it in place over each seal plate 200 as illustrated in FIG. 6. During this operation, the upper tool 100 and lower tool 300 may be vented, i.e., maintained at a pressure equal to the ambient pressure around the packaging portion 1000. As a venting operation, vents in the upper tool 100 and lower tool 300 which allow a vacuum pump 600 to draw out air are opened to ambient atmosphere. According to an exemplary embodiment of the present general inventive concept, the holes 220 in the seal plate 200 allow effective venting of the seal plate 200 and upper tool 100. "Venting" as used herein may also be used to describe releasing a vacuum that has been formed in one or both of the tools 100 and 300, thereby allowing air pressure in the tool 100 or 300 to equalize with the ambient air pressure.

**[0065]** Once the film is held in place, each seal plate 200 may be heated via the heating element 230 in each seal plate 200, to transfer heat into the film 400. The temperature of each seal plate 200 may be monitored by the controller 1400 via the temperature probe 240 in each seal plate 200, and may be heated to a temperature of, e.g., about 380 to 400 degrees Fahrenheit, or any other temperature according to the specific film 400 in use. The temperature is set such that preheating the film 400

at this temperature causes the film 400 to become pliable while still being held in place by the vacuum clamp 110.

**[0066]** The vacuum clamping and preheating steps may take, for example, approximately 1 second. Once the film 400 is clamped and preheated, a second vacuum may be formed by drawing air through the holes 220 in each seal plate. This second vacuum draws the film up 400 into each seal plate 200, such that the film 400 has an overall shape matching that of each seal plate 200, as illustrated in FIG. 7. The second vacuum may also be called a "gentle vacuum," as it has a relatively higher pressure as compared to subsequent vacuums (described in detail below). Having a higher pressure relative to the ambient pressure means the pressure differential between the vacuum and the outside air is smaller. As a result, a relatively lower force is exerted on the film 400 by this second vacuum, which reduces the risk of damaging the film 400 as it is drawn up into the seal plate(s) 200.

**[0067]** Once drawn up into the seal plate cavity 210, the film 400 may be held in place by the second vacuum. If the film 400 includes an adhesive layer on the side facing the seal plate(s) 200, the film 400 may additional be held in place by this adhesive. Significantly, the film 400 cannot be held on a heated seal plate 200 for too long, or it will be damaged or melt. Accordingly, simultaneously with the above process of feeding film 400 into the packaging portion 1000, clamping the film 400 in place, and drawing the film 400 up into the seal plate(s) 200, the grippers 1300 may be moving one or more trays 1500 from the entry conveyor 1100 and into the packaging portion 1000. At the same time, the grippers 1300 may be moving other trays 1500 from the packaging portion 1000 and onto the exit conveyor 1200. The grippers 1300 position trays 1500 in the packaging portion 1000 such that each tray 1500 lines up with and corresponds to a separate seal plate 200.

**[0068]** Once trays 1500 are moved from the entry conveyor 1100 and into the packaging portion 1000, the grippers 1300 may retract to the home position to be ready to move more trays 1500 into the packaging portion 1000. Simultaneously with the grippers 1300 moving to the home position, the upper tool 100 and lower tool 300 may be moved together to form an airtight seal therebetween, as illustrated in FIG. 8. In an exemplary embodiment, the lower tool 300 may be moved up to contact the upper tool 100 while the upper tool 100 is held stationary. Alternatively, the upper tool 100 may be moved down to contact the lower tool 300 while the lower

tool 300 is held stationary, or both the upper tool 100 and lower tool 300 may be moved to contact each other.

**[0069]** Since each seal plate 200 defines a seal plate cavity 210, and the film 400 lines the inside of the seal plate 200, product P may extend beyond a flange 1510 of each tray 1500 and into this space defined by the seal plate 200 and film 400, without contacting the film 400 or the seal plate 200, as illustrated in FIG. 8. Significantly, care must be taken so that the product P does not extend so far that it contacts the seal plate 200, since the seal plate 200 is heated and contact therewith may sear the product P.

**[0070]** Once the upper tool 100 and lower tool 300 are brought together such that the O-ring 130 around the seal plate(s) 200 contacts the lower tool 300 to form an airtight seal and hold the film 400 to the edges of the seal plate(s) 200, the first vacuum is no longer necessary to hold the film 400 in place, since the film 400 is held in place by the upper tool 100, lower tool 300, and the second vacuum. At this point, the vacuum clamp 110 may be released, i.e. the first vacuum is no longer maintained by a vacuum pump 600. After releasing the vacuum clamp 110, a third vacuum may be formed in the upper tool 100 by drawing air out through the seal plates 200. This third vacuum is, in effect, an enhancement of the second vacuum. The third vacuum functions similarly to the second vacuum, above, but has a lower pressure and is therefore a “stronger” vacuum. The third vacuum is unlikely to damage the film 400, since by the time the third vacuum is formed the film 400 has already been drawn up into the seal plates 200 by the second vacuum. Although the third vacuum is stronger than the second vacuum, the third vacuum may be weaker than prior art vacuums, since by the time the third vacuum is formed the film 400 has been preheated and drawn up into the seal plate(s) 200. According to the prior art, a film cannot be manipulated and a vacuum cannot be formed until the film is held in place by closing the tools, and as a result a significantly stronger vacuum (e.g., 10 mbar) is required to push the film down onto the product. In comparison, in exemplary embodiments of the present general inventive concept, due to the use of first and second vacuums to hold the film 400 in place during preheating before the tools 100 and 300 are closed, the third vacuum may be, for example, 100-200 mbar. This increased pressure of the third vacuum results in increased efficiency of the packaging process, as detailed below.

**[0071]** The third vacuum may be formed with the same vacuum pump 600 that forms the second vacuum, or a different vacuum pump 600. The third vacuum may be formed immediately after switching off the vacuum clamp 110, or optionally may be formed after a preset delay has passed (e.g., 0.1 seconds after the vacuum clamp is released).

**[0072]** Shortly after starting to form the third vacuum, a fourth vacuum may be formed in the space between the tools, corresponding to the space occupied by the product. The fourth vacuum may be formed, for example, with valves in the lower tool 300 connected to a vacuum pump 600, which may be the same or different from the vacuum pump(s) 600 which generates the first, second, and/or third vacuums. In an exemplary embodiment of the present general inventive concept, the fourth vacuum may start being formed 0.1 seconds after the third vacuum has started being formed, but this delay may be changed depending on the particular embodiment. This delay ensures that the fourth vacuum does not draw the film 400 away from the seal plate(s) 200, thereby avoiding any risk of the film 400 contacting the product P prematurely. Furthermore, since the film 400 held on the seal plates(s) 200 forms an airtight seal between the upper tool 100 and the lower tool 300, forming the fourth vacuum does not interfere with the third vacuum. In an exemplary embodiment of the present general inventive concept, the fourth vacuum may be as strong as the third vacuum, e.g., 100-200 mbar.

**[0073]** Once the third and fourth vacuums are formed, the third vacuum may be released, such that the upper tool 100 is allowed to equalize with the ambient pressure (approximately 1000 mbar at sea level). The fourth vacuum may subsequently be released after a brief delay (e.g., 0.22 seconds), such that the lower tool 300 is allowed to equalize with the ambient pressure shortly after the upper tool 100. Releasing the third and fourth vacuums in this manner packages the product P in the film 400, taking advantage of two pressure differentials to do so. The process is detailed as follows:

**[0074]** The third vacuum generates a pressure differential between the upper tool 100 and the ambient pressure. When the third vacuum is released (and the upper tool 100 is optionally pressurized, as detailed below), this creates a force that pushes the film 400 towards the product P. Furthermore, the fourth vacuum generates a pressure differential between the upper tool 100 and the lower tool 300. Since the

fourth vacuum is released after the third vacuum, such that the fourth vacuum still exists when the film 400 is being pushed towards the product P by the third vacuum being released, this pressure differential between the upper tool 100 and lower tool 300 also generates a force drawing the film 400 towards the product P. The two pressure differentials (between the upper tool 100 and the ambient pressure, and between the upper tool 100 and lower tool 300) therefore generate a combined force that presses the film 400 down onto the tray 1500 and the product P. If the film 400 has been heated and is therefore pliable, the film 400 can efficiently conform to the shape of the product P and the tray 1500, as illustrated in FIG. 9. As the film 400 cools, it may solidify, and may thereby make a firm seal over the product P and the tray 1500. This process may happen rapidly, such that when the film 400 conforms to the shape of the product P and solidifies, it may do so without damaging the product P or even deforming the product P's appearance. In other words, packaged product P leaving the packaging portion 1000 has the same appearance as staged product P entering the packaging portion 1000.

**[0075]** Optionally, the system 2000 described herein may also artificially increase pressure to further increase the force pressing the film 400 against the tray 1500 and the product P. After the upper tool 100 equalizes with the ambient pressure (a process taking, e.g., approximately 0.5 seconds), pressure on the upper tool 100 may be artificially increased, for example with an air pump 700, which may pump air through the holes 220 in each seal plate 200. This enhances the pressure differential between the upper tool 100 and lower tool 300 and therefore further helps to press the film 400 onto the product P and the tray 1500.

**[0076]** In effect, exemplary embodiments of the present general inventive concept use the first and second vacuums with preheating to prepare the film 400, and then the third and fourth vacuums, and optionally a pressurization operation, to generate a combined force on the film 400. As a result of using this four-vacuum process with preheating, each of the third and fourth vacuums may be made relatively "weaker" than the vacuums of a prior art packaging apparatus. Whereas a prior art packaging apparatus may use vacuums of approximately 10 mbar as noted above, a packaging system 2000 according to the present general inventive concept may use third and fourth vacuums of, for example, approximately 100 to 200 mbar. When the third and fourth vacuums are sequentially generated and released as described above, and

the upper tool 100 is optionally pressurized, the resulting force on the film 400 pushes the film 400 towards the tray 1500 to efficiently vacuum seal the product P held thereon. Since the time to create a vacuum increases exponentially as the desired pressure is decreased, by increasing the required vacuum pressure to, e.g., 100 to 200 mbar, the time needed to generate the third and fourth vacuums is significantly reduced from conventional packaging apparatuses, without compromising the packaging effectiveness.

**[0077]** Once the film seal is formed, the upper tool 100 and lower tool 300 may be vented again to ensure equalization with the ambient pressure (for example, if the upper tool 100 was artificially pressurized). After a delay of, e.g., 0.1 seconds, to allow the pressure around the sealed package to equalize with the ambient pressure, retractable blades 500 may cut the film around the tray(s) 1500. These blades 500 may extend, e.g., from around the seal plate(s) 200.

**[0078]** After the film 200 is cut by the blades 500, the upper tool 100 and lower tool 300 may be separated. Optionally, there may be a delay between cutting the film 400 and separating the tools 100 and 300, to allow the system 2000 to settle (e.g., for the film 400 to cool further). Whichever tool moved to bring the tools 100 and 300 together may be moved to separate the tools 100 and 300. The film 400 may then be advanced, such that the used film 400 is removed from the packaging portion 1000 and fresh film 400 is positioned over the seal plate(s) 200. At this point the cycle is completed, and may be repeated with new trays 1500 and new product P, which may have already been staged and moved onto the entry conveyor 1100 by the time the upper tool 100 and lower tool 300 are separated. As described above, as the grippers 1300 move new trays 1500 into the packaging portion, they may simultaneously move the completed (film-wrapped) packages out of the packaging portion 1000 and onto the exit conveyor 1200, where they can be moved along in the shipping process, for example being inserted into cardboard boxes, etc.

**[0079]** Notably, the above process may be used regardless of the type of product P or type of tray 1500 being used, without any significant re-tooling of a packaging apparatus. As noted above, the construction of the seal plate 200 and the upper and lower tools 100 and 300 allows the system to physically accommodate different types of product P. However, different products P may require using different vacuums and/or different timing of the operations (for example, slower equalization

with the ambient pressure) to avoid damaging the product P. For example, when the product P is relatively soft or delicate (e.g., mashed potatoes), the upper tool 100 may be equalized more slowly with the ambient pressure, such that the film 400 is pushed down onto the product P with relatively lower force, followed by a sharper equalization for greater force to firmly affix the film 400 to the tray 1500 and the product P. Similarly, whether additional pressure is added to the upper tool 100 to force the film 400 onto the tray 1500 and product P, whether the fourth vacuum is maintained longer to maintain the pressure differential between the upper tool 100 and lower tool 300, the length of any delay before each operation, and so on may also allow for different packaging for different products P. Put another way, a timing chart 1430 of the system 2000 can be adjusted according to the product P being packaged.

**[0080]** The timing chart 1430 defines the timing for the various operations of the system 2000 to package product P, as well as other relevant details such as, e.g., the strength of each vacuum formed during packaging. A sample timing chart 1430 according to an exemplary embodiment of the present general inventive concept is illustrated in FIGS. 10A-10C, which are expanded views of the complete sample timing chart 1430 illustrated in FIG. 10D. The timing chart 1430 further includes instructions for the controller 1400 to control the system 2000 according to the listed timing. Adjustments to the operation of the system 2000 can be made entirely by adjusting the timing chart 1430 via the user interface 1410 of the controller 1400. By adjusting the timing chart 1430 in this manner, a user may set different strengths of vacuum and timing of the processes for packaging. Since as noted above the strengths of the vacuums and the timing of the processes are all that need to be changed for different products P, the system 2000 therefore may package different products P without needing to change its tooling or other physical components.

**[0081]** It will be understood that the timing chart 1430 illustrated in FIGS. 10A-10D is only an example, and that not all timing charts 1430 will include the same timing or the same processes. For example, another timing chart 1430 according to an exemplary embodiment of the present general inventive concept may omit the operation of pressurizing the upper tool 100.

**[0082]** In an exemplary embodiment, a plurality of timing charts 1430a-n, corresponding to, e.g., a plurality of different products P, may be preprogrammed

into the controller 1400 and stored in the memory device 1420, such that a user simply uses the user interface 1410 to select a timing chart 1430 (for example, according to which type of product P is being packaged) and the controller 1400 controls the system 2000 according to the corresponding timing chart 1430. The result is a more efficient and flexible vacuum packaging process. FIG. 11 is a block diagram of the controller 1400, and additionally illustrates the communication between the controller 1400 and the packaging portion 1000.

**[0083]** The present general inventive concept can also be embodied as computer-readable codes on a computer-readable medium. The computer-readable medium can include a computer-readable recording medium and a computer-readable transmission medium. The computer-readable recording medium is any data storage device that can store data as a program which can be thereafter read by a computer system. Examples of the computer-readable recording medium include a semiconductor memory, a read-only memory (ROM), a random-access memory (RAM), a USB memory, a memory card, a blue-ray disc, CD-ROMs, magnetic tapes, floppy disks, and optical data storage devices. The computer-readable recording medium can also be distributed over network coupled computer systems so that the computer-readable code is stored and executed in a distributed fashion. The computer-readable transmission medium can transmit carrier waves or signals (e.g., wired or wireless data transmission through the Internet). Also, functional programs, codes, and code segments to accomplish the present general inventive concept can be easily construed by programmers skilled in the art to which the present general inventive concept pertains.

**[0084]** The foregoing disclosure of the preferred embodiments of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many variations and modifications of the embodiments described herein will be apparent to one of ordinary skill in the art in light of the above disclosure. The scope of the invention is to be defined only by the claims, and by their equivalents.

CLAIMS

What is claimed is:

1. A vacuum sealing system, comprising:

a vacuum pump;

a lower tool to hold one or more trays carrying product;

an upper tool to seal a plastic film onto the one or more trays, the upper tool comprising:

at least one seal plate, each seal plate comprising:

a seal plate cavity; and

a plurality of first holes to allow air to be drawn out of the seal plate cavity with the vacuum pump to draw the plastic film into the seal plate cavity, and to allow the seal plate cavity to be vented to equalize an air pressure therein with ambient air pressure;

a vacuum clamp disposed around the seal plate, the vacuum clamp comprising:

a groove to receive the plastic film; and

a plurality of second holes to allow air to be drawn out of the groove with the vacuum pump and thereby hold the plastic film in the groove; and

a controller to control the vacuum pump, the lower tool, and the upper tool.

2. The vacuum sealing system of claim 1, wherein the controller comprises:

a user interface to receive a user input to control the vacuum pump, the lower tool, and the upper tool; and

a memory device to store one or more timing charts, each timing chart comprising instructions to control the vacuum pump, the lower tool, and the upper tool.

3. The vacuum sealing system of claim 1, wherein the groove comprises a square cross-section.

4. The vacuum sealing system of claim 1, further comprising a set of blades to cut the plastic film.

5. The vacuum sealing system of claim 1, wherein the at least one seal plate further comprises a heating element to heat the plastic film to a predetermined temperature.

6. The vacuum sealing system of claim 5, wherein the at least one seal plate further comprises a temperature probe to determine a temperature of the at least one seal plate.

7. The vacuum sealing system of claim 1, further comprising:

a set of grippers to move one or more trays from an entry conveyor to between the upper tool and lower tool, and to move one or more trays from between the upper tool and lower tool and onto an exit conveyor.

8. A vacuum sealing apparatus, comprising:

at least one seal plate, each seal plate comprising:

a seal plate cavity; and

a plurality of first holes to allow air to be drawn out of the seal plate cavity to draw a plastic film into the seal plate cavity, and to allow the seal plate cavity to be vented to equalize an air pressure therein with ambient air pressure;

a vacuum clamp disposed around the seal plate, the vacuum clamp comprising:

a groove to receive the plastic film; and

a plurality of second holes to allow air to be drawn out of the groove and thereby hold the plastic film in the groove.

9. The vacuum sealing apparatus of claim 8, wherein the at least one seal plate further comprises a heating element to heat the plastic film to a predetermined temperature.

10. The vacuum sealing system of claim 9, wherein the at least one seal plate further comprises a temperature probe to determine a temperature of the at least one seal plate.

11. A method of vacuum sealing, the method comprising:

moving one or more trays holding product into a packaging portion comprising an upper tool and a lower tool;

forming a first vacuum in the upper tool to hold a plastic film;

forming a second vacuum on a first side of the plastic film to draw the plastic film into one or more seal plate cavities over the one or more trays;

strengthening the second vacuum to form a third vacuum on the first side of the plastic film;

forming a fourth vacuum on a second side of the plastic film after forming the third vacuum, the second side of the plastic film being opposite from the first side of the plastic film; and

releasing the third and fourth vacuums to force the plastic film onto the one or more trays.

12. The method of claim 11, further comprising:

releasing the fourth vacuum after the third vacuum to generate a pressure differential between the plastic film and the tray carrying the product.

13. The method of claim 11, further comprising:

heating the plastic film to a predetermined temperature prior to forming the second vacuum.

14. The method of claim 11, further comprising increasing air pressure against the first side of the plastic film after releasing the third vacuum.

15. The method of claim 11, wherein the one or more trays are moved into the packaging portion simultaneously as the first vacuum is formed.

16. The method of claim 15, further comprising:

moving the one or more trays out of the packaging portion after forcing the plastic film onto the one or more trays; and

simultaneously moving one or more additional trays carrying product into the packaging portion.

17. A non-transitory computer-readable recording medium to contain computer-readable codes as a program to execute the method of claim 11.

18. A vacuum sealing system comprising:

a lower tool to receive at least one tray carrying a product; and

an upper tool including a seal plate cavity with a plurality of first holes therein to receive a vacuum to draw a plastic film into the seal plate cavity and a groove surrounding an outer perimeter of the seal plate cavity and including a plurality of second holes therein to receive a vacuum to draw the plastic film into the groove;

wherein at least one of the lower tool and the upper tool moves toward the other tool to seal the plastic film to the at least one tray.

19. The vacuum sealing system of claim 18, further comprising:

a vacuum pump to form a vacuum; and

a controller to control movement of at least one of the upper and lower tools and to control the vacuum pump to create a first and second vacuum to be drawn through the first holes and a third vacuum to be drawn through the second holes.

20. The vacuum sealing system of claim 18, wherein the upper tool further comprises a heating element to heat the plastic film to a predetermined temperature.

FIG. 1

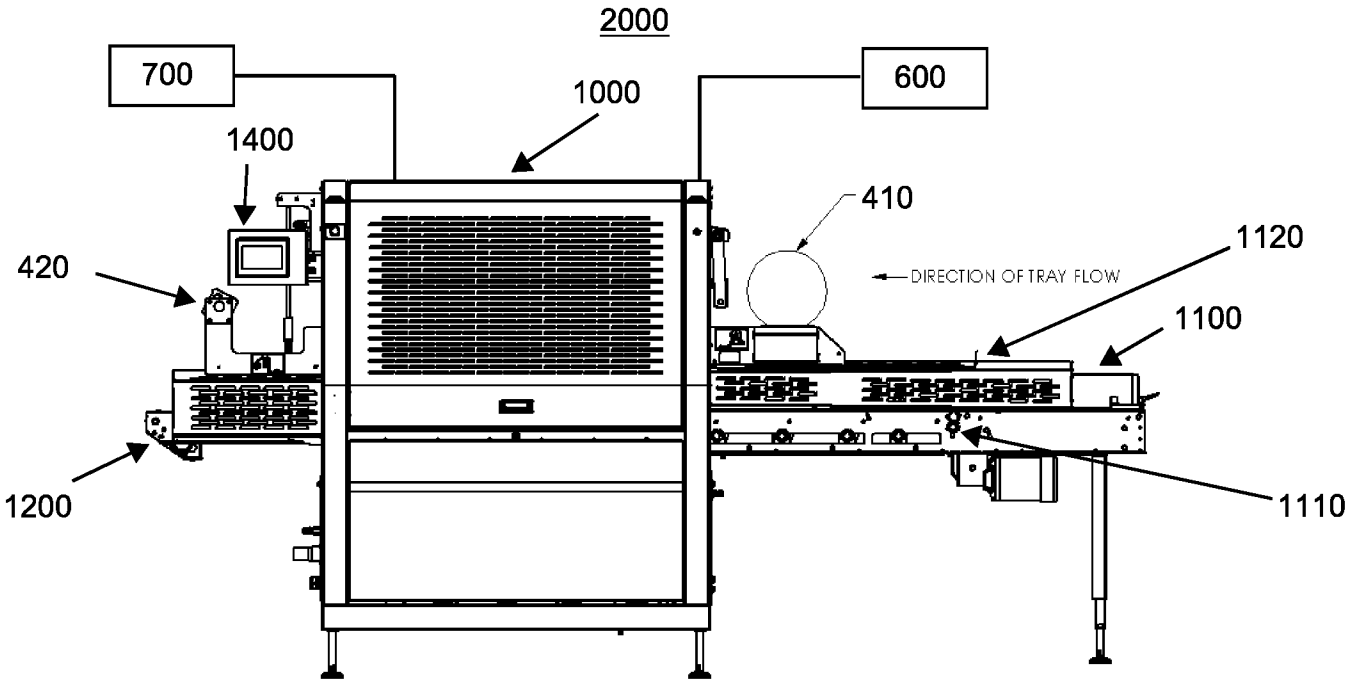

2000
700
600
1000
1400
410
420
DIRECTION OF TRAY FLOW
1120
1100
1200
1110

FIG. 2

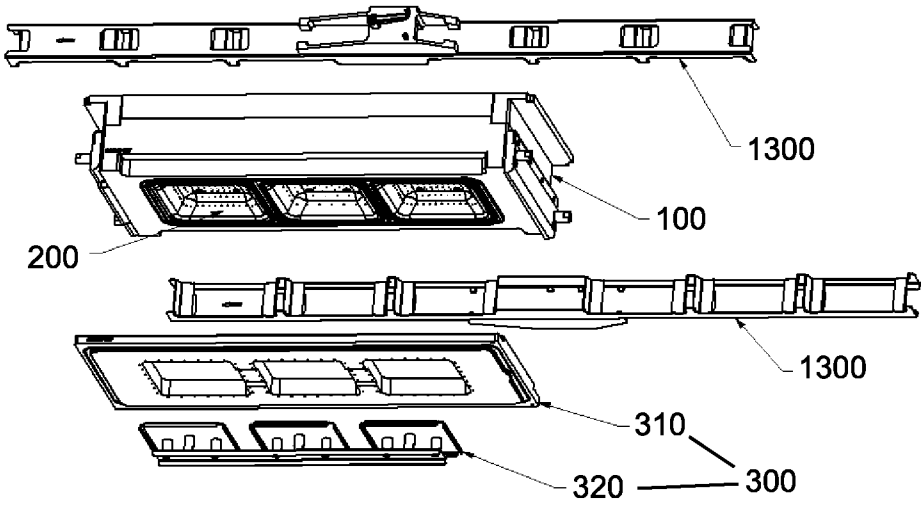


FIG. 3

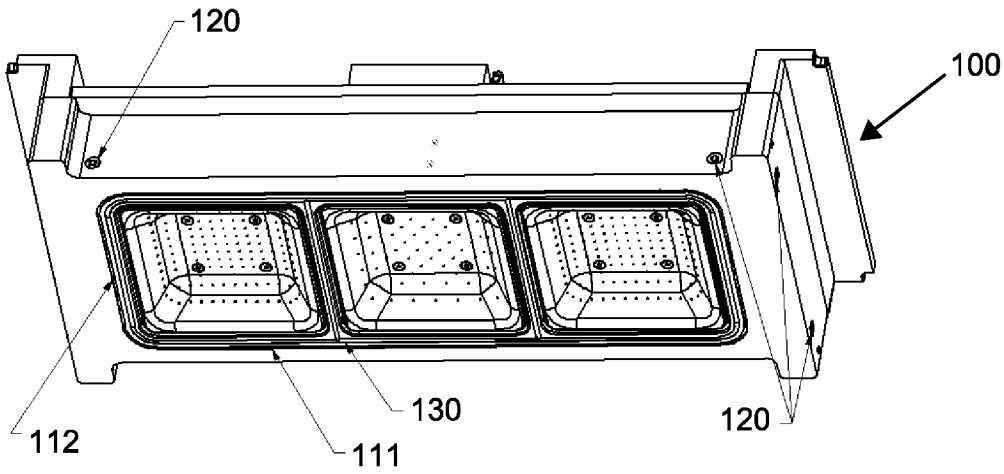


FIG. 4

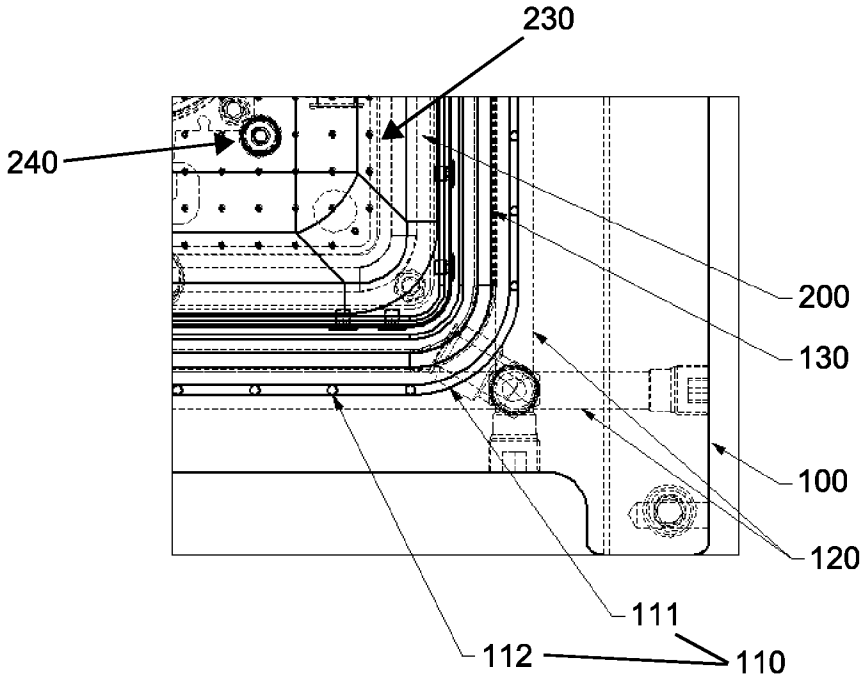


FIG. 5

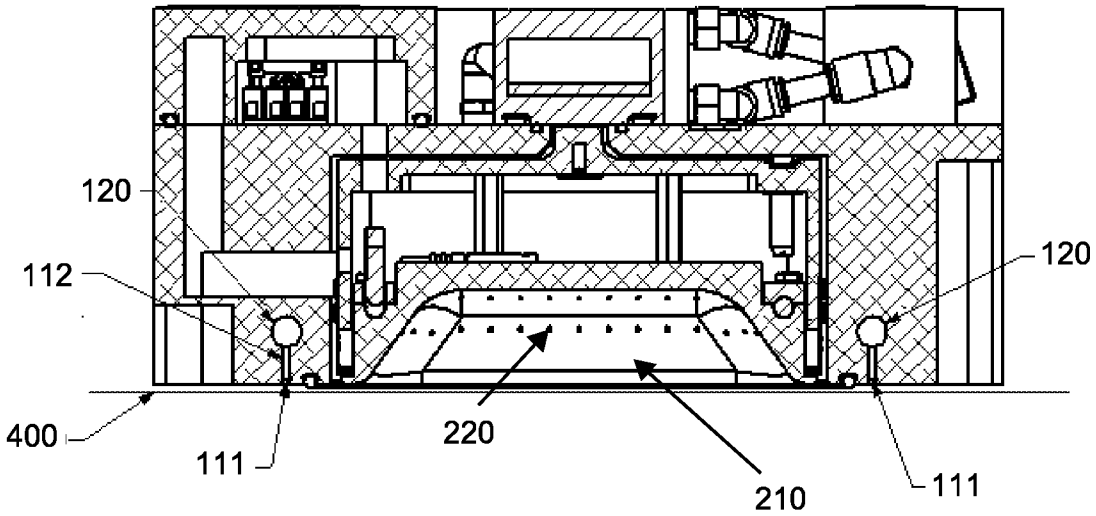


FIG. 6

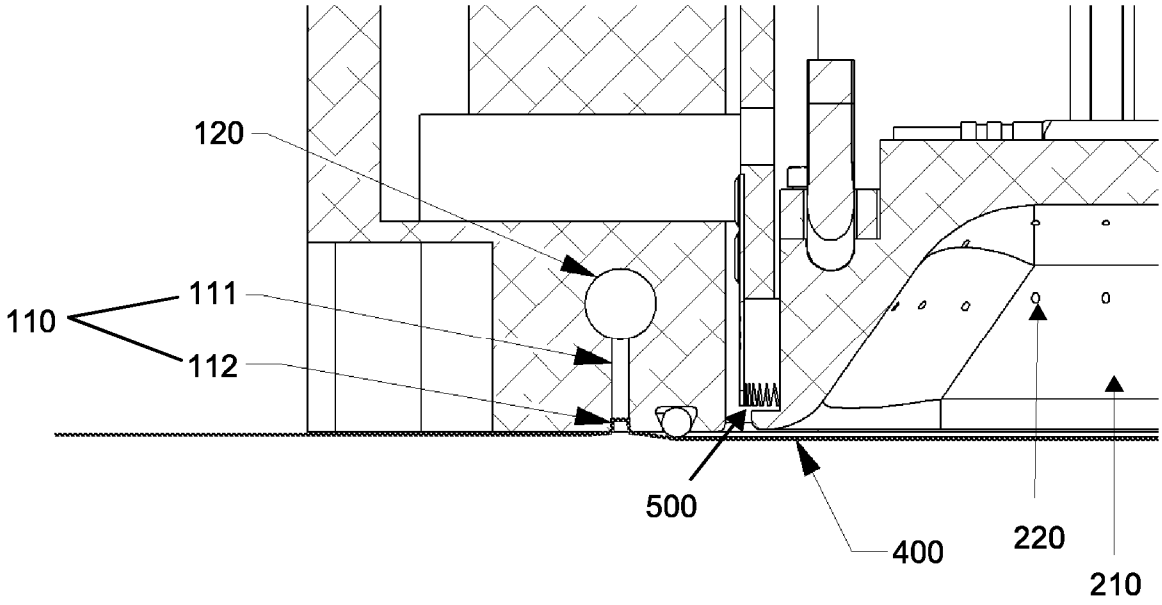


FIG. 7

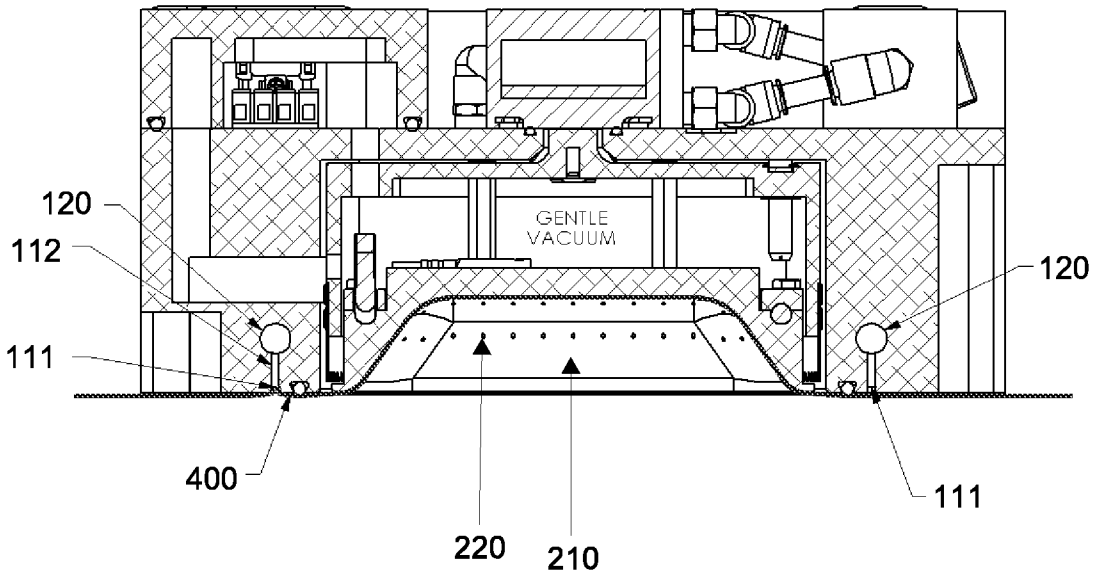


FIG. 8

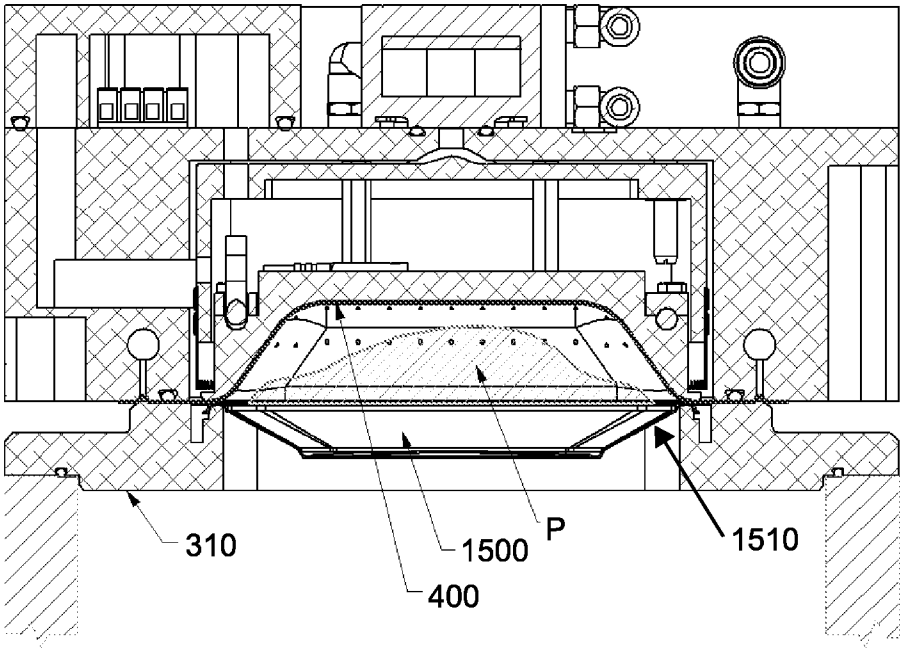


FIG. 9

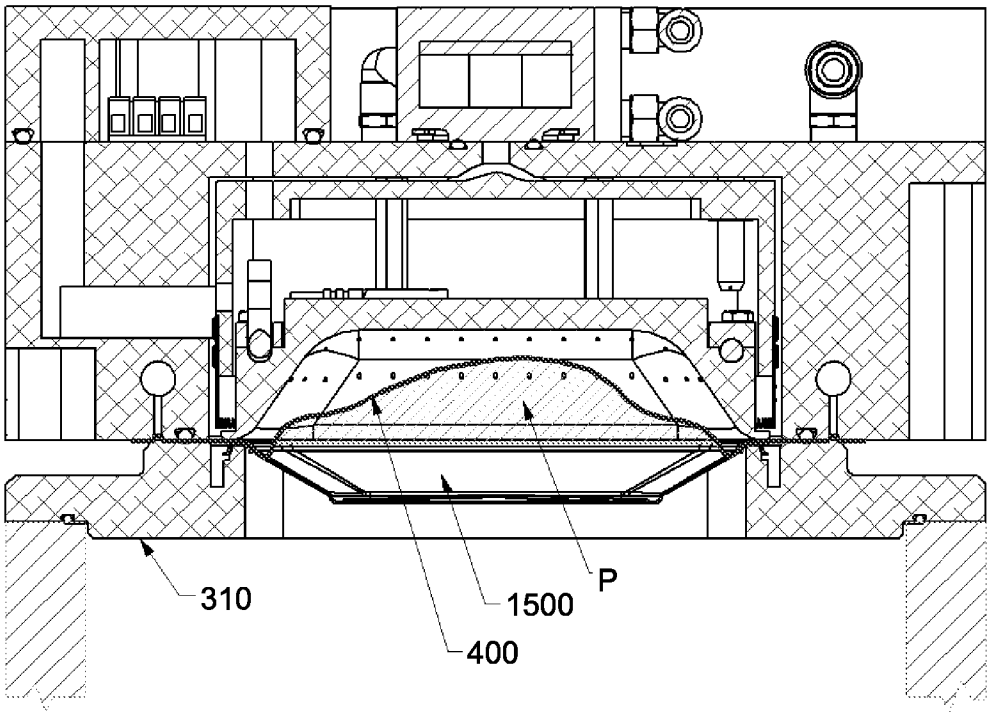


FIG. 10A

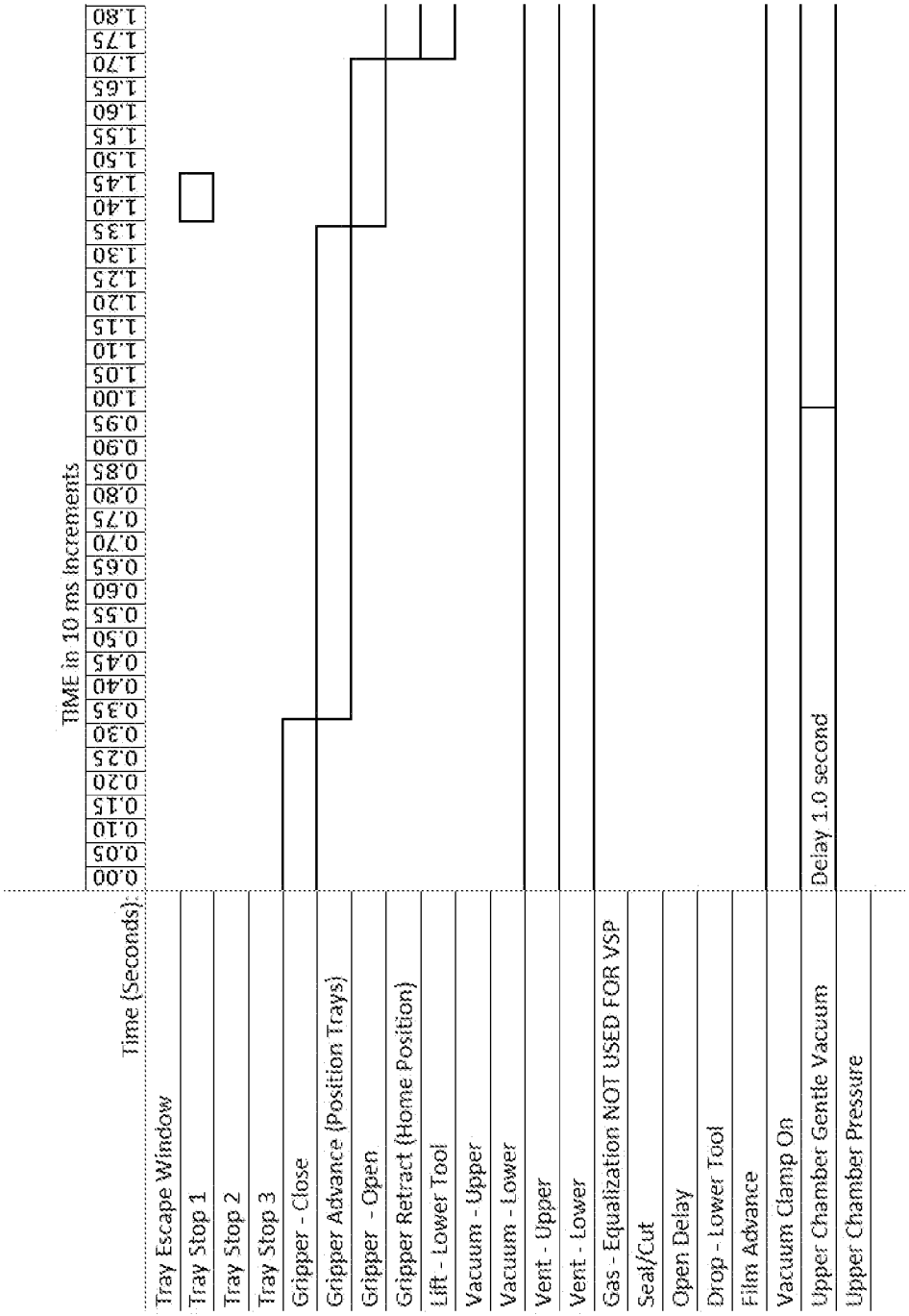

TIME in 10 ms Increments
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00
1.05
1.10
1.15
1.20
1.25
1.30
1.35
1.40
1.45
1.50
1.55
1.60
1.65
1.70
1.75
1.80
Time (Seconds)
Tray Escape Window
Tray Stop 1
Tray Stop 2
Tray Stop 3
Gripper - Close
Gripper Advance (Position Trays)
Gripper - Open
Gripper Retract (Home Position)
Lift - Lower Tool
Vacuum - Upper
Vacuum - Lower
Vent - Upper
Vent - Lower
Gas - Equalization NOT USED FOR VSP
Seal/Cut
Open Delay
Drop - Lower Tool
Film Advance
Vacuum Clamp On
Upper Chamber Gentle Vacuum
Delay 1.0 second
Upper Chamber Pressure

FIG. 10B

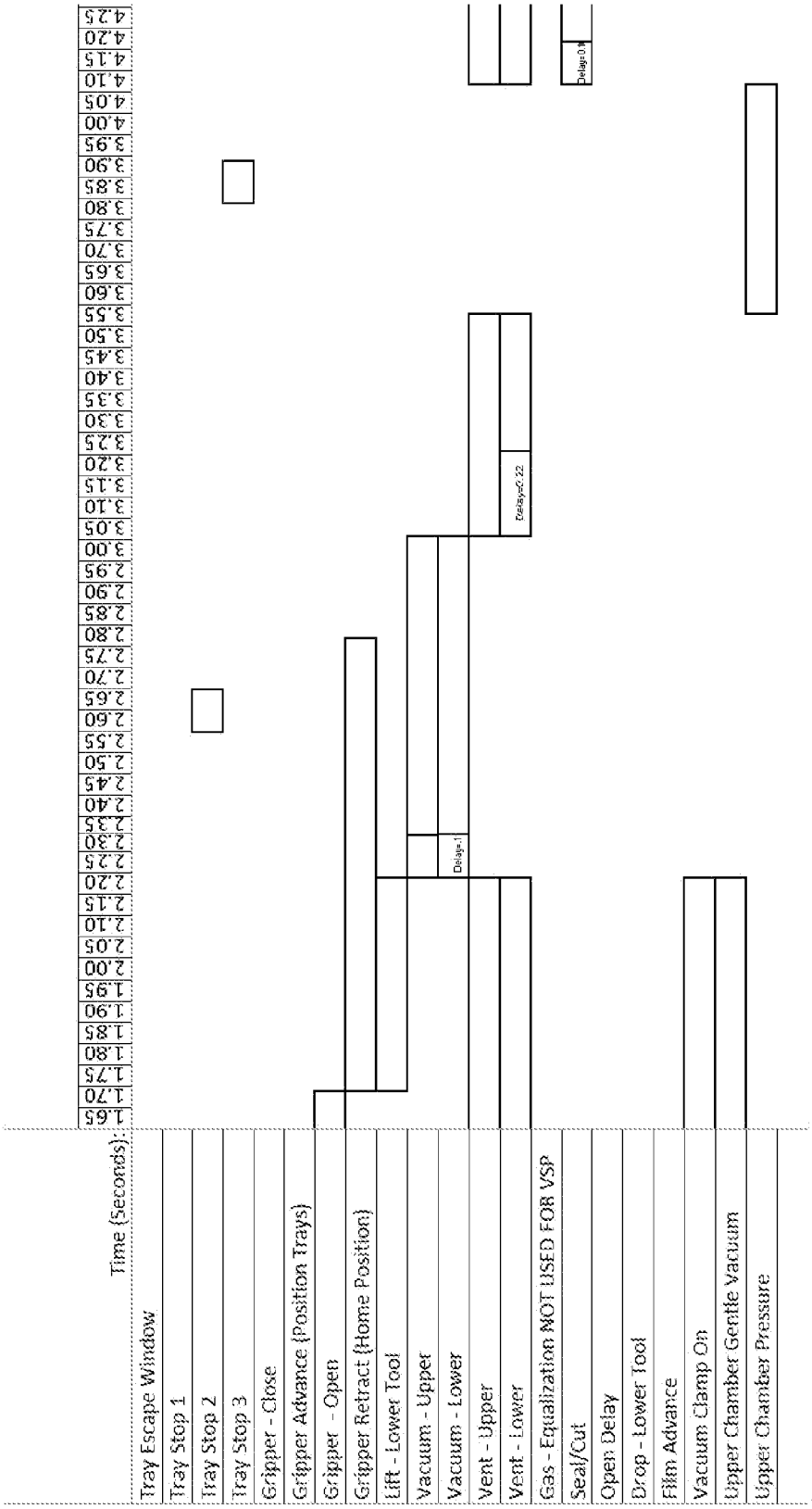

Time (Seconds):
1.65
1.70
1.75
1.80
1.85
1.90
1.95
2.00
2.05
2.10
2.15
2.20
2.25
2.30
2.35
2.40
2.45
2.50
2.55
2.60
2.65
2.70
2.75
2.80
2.85
2.90
2.95
3.00
3.05
3.10
3.15
3.20
3.25
3.30
3.35
3.40
3.45
3.50
3.55
3.60
3.65
3.70
3.75
3.80
3.85
3.90
3.95
4.00
4.05
4.10
4.15
4.20
4.25
Tray Escape Window
Tray Stop 1
Tray Stop 2
Tray Stop 3
Gripper - Close
Gripper Advance (Position Trays)
Gripper - Open
Gripper Retract (Home Position)
Lift - Lower Tool
Vacuum - Upper
Vacuum - Lower
Vent - Upper
Vent - Lower
Gas - Equalization NOT USED FOR VSP
Seal/Cut
Open Delay
Drop - Lower Tool
Film Advance
Vacuum Clamp On
Upper Chamber Gentle Vacuum
Upper Chamber Pressure
Delay=.1
Delay=.22
Delay=0.1

FIG. 10C

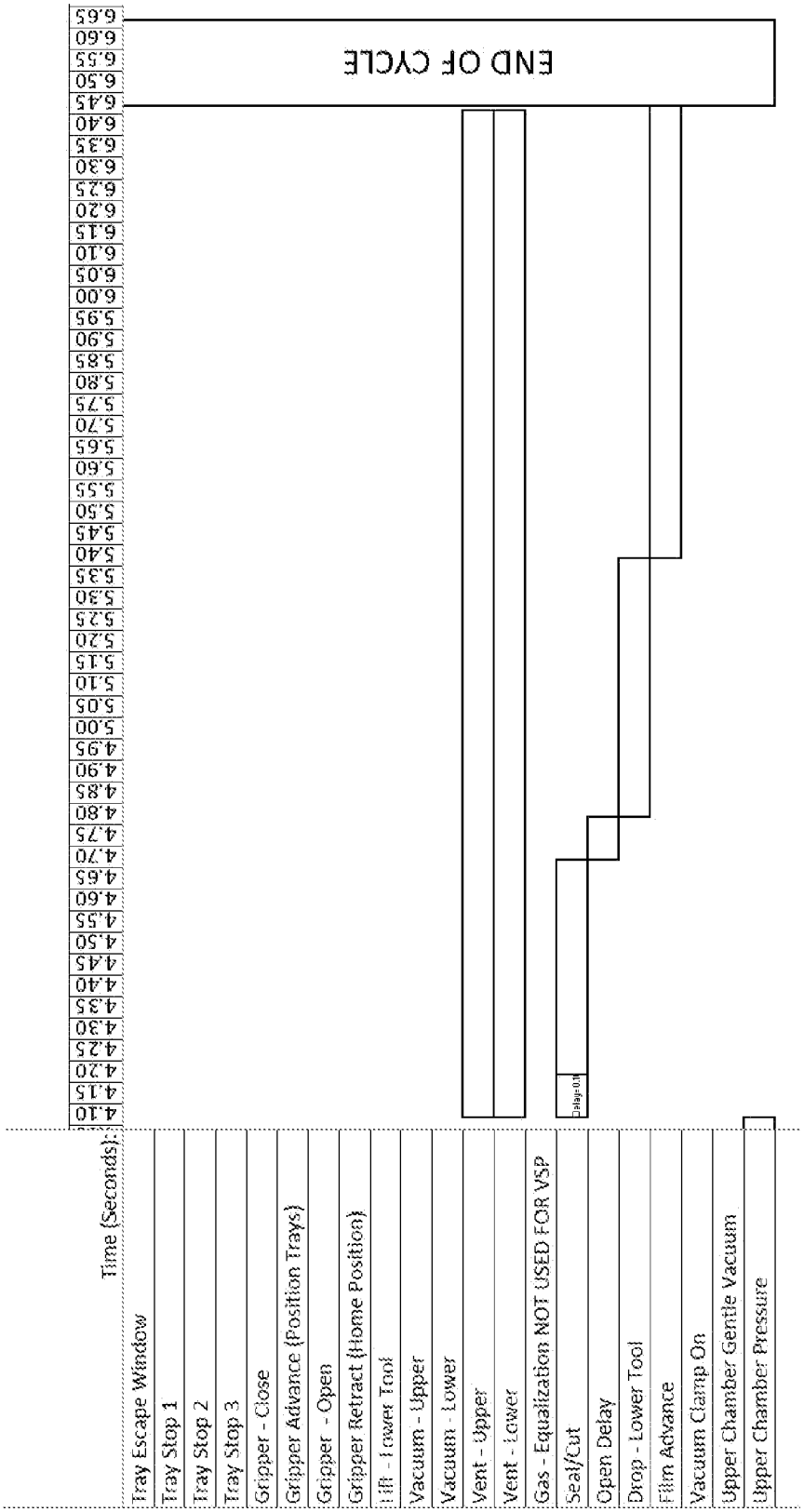

Time (Seconds):
4.10
4.15
4.20
4.25
4.30
4.35
4.40
4.45
4.50
4.55
4.60
4.65
4.70
4.75
4.80
4.85
4.90
4.95
5.00
5.05
5.10
5.15
5.20
5.25
5.30
5.35
5.40
5.45
5.50
5.55
5.60
5.65
5.70
5.75
5.80
5.85
5.90
5.95
6.00
6.05
6.10
6.15
6.20
6.25
6.30
6.35
6.40
6.45
6.50
6.55
6.60
6.65
END OF CYCLE
Tray Escape Window
Tray Stop 1
Tray Stop 2
Tray Stop 3
Gripper - Close
Gripper Advance (Position Trays)
Gripper - Open
Gripper Retract (Home Position)
Lift - Lower Tool
Vacuum - Upper
Vacuum - Lower
Vent - Upper
Vent - Lower
Gas - Equalization NOT USED FOR VSP
Seal/Cut
Delay=0.1
Open Delay
Drop - Lower Tool
Film Advance
Vacuum Clamp On
Upper Chamber Gentle Vacuum
Upper Chamber Pressure

FIG. 10D

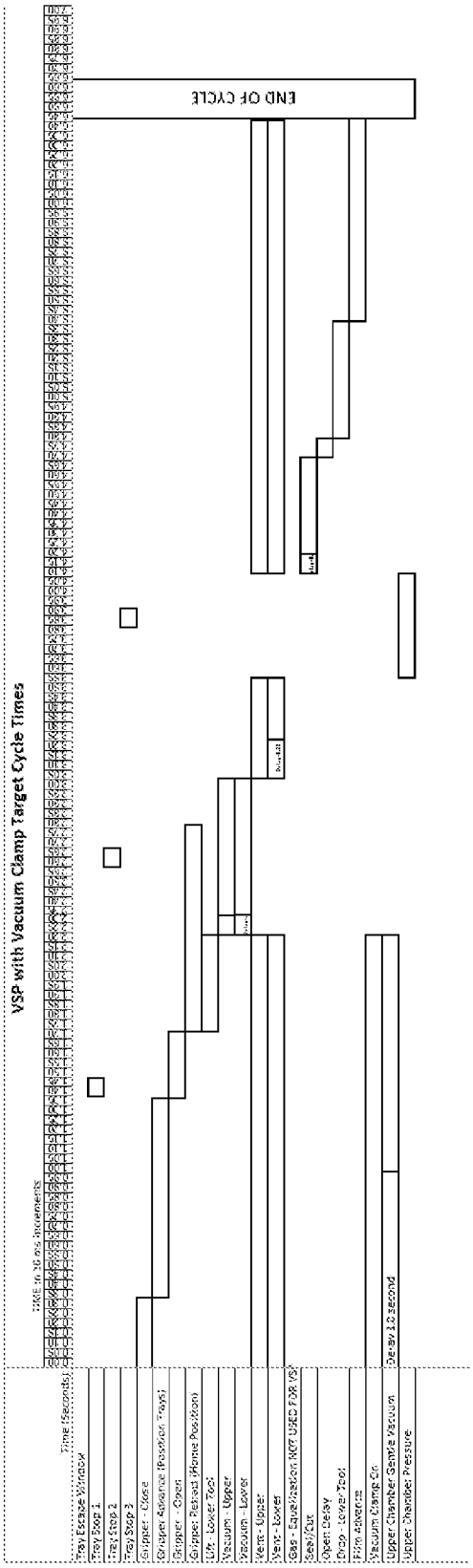
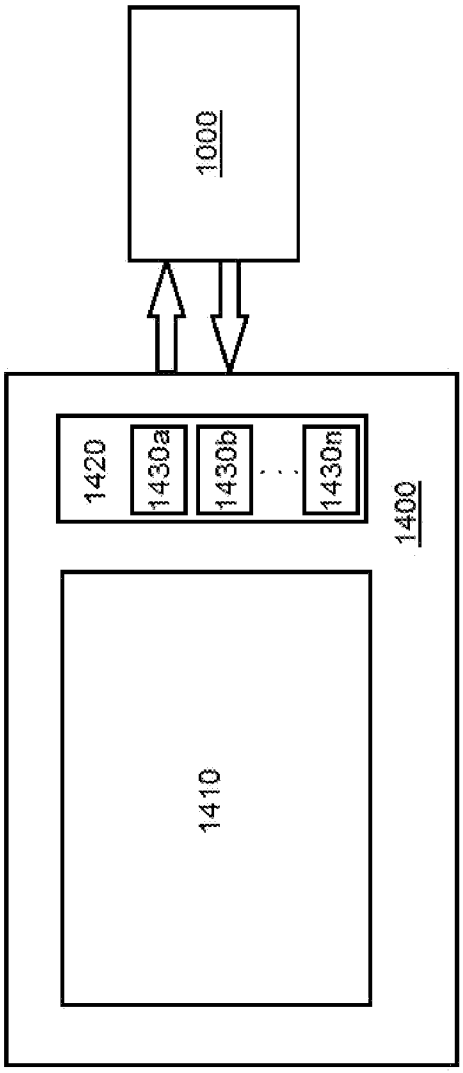

VSP with Vacuum Clamp Target Cycle Times
Time (Seconds)
Tray Escape Window
Tray Stop 1
Tray Stop 2
Tray Stop 3
Gripper - Close
Gripper Advance (Position Trays)
Gripper - Open
Gripper Retract (Home Position)
Lift - Lower Tool
Vacuum - Upper
Vacuum - Lower
Vent - Upper
Vent - Lower
Gas - Equalization (NOT USED FOR VS
Seal/Cut
Open Delay
Drop - Lower Tool
Trim Advance
Vacuum Clamp On
Upper Chamber Gentle Vacuum
Upper Chamber Pressure
Delay 1.0 second
END OF CYCLE

FIG. 11



# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US17/43394

A. CLASSIFICATION OF SUBJECT MATTER

IPC - B65B 11/00, 15/00, 31/04, 35/16, 41/06, 51/10, 65/00 (2017.01)

CPC - B29C 66/00145; B65B 7/00, 11/52, 31/028, 31/04, 41/06, 51/10, 51/30

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | EP 2722279 A1 (CRYOVAC, INC.) 23 April 2014; entire document | 1-20 |
| A | US 2005/0257501 A1 (NATTERER, J.) 24 November 2005; entire document | 1-20 |
| A | WO 2014/180823 A1 (CRYOVAC, INC.) 13 November 2014; entire document | 1-20 |
| A | US 5,560,182 A (GARWOOD, A. J. M.) 01 October 1996; entire document | 1-20 |
| A | US 2012/0198797 A1 (SPILLNER, W. et al.) 09 August 2012; entire document | 1-20 |
| A | US 2011/0072764 A1 (DANIEK, V. M. et al.) 31 March 2012; entire document | 1-20 |
| A | US 5,048,268 A (BREMBILLA, S. et al.) 17 September 1991; entire document | 1-20 |
| A | US 3,830,365 A (KREUGER, L. R. et al.) 20 August 1974; entire document | 1-20 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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| Name and mailing address of the ISA/<br>Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-8300 | Authorized officer<br>Shane Thomas<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |