

Egg Candling and Relocation Apparatus for Use with *In ovo* Injection Machines

### **CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims benefit of US provisional application No. 62/379,337, filed on 25 August 2016, and herein incorporated by reference in its entirety.

### 5 **INCORPORATION BY REFERENCE**

All references cite below are herein incorporated by reference in their entirety.

### **FIELD OF THE INVENTION**

The invention relates to an automatic egg candling and relocation apparatus and methods of use for candling and relocation of avian eggs.

### 10 **BACKGROUND OF THE INVENTION**

Discrimination between live and non-live poultry eggs is a well-known in the poultry industry. “Candling” is a common name for one such technique. Eggs to be hatched are typically candled to identify clear (unfertilized), rotted, and dead eggs (collectively “non-live eggs”). Non-live eggs are removed to reduce the risk of contamination and the costs of *in ovo* vaccination.

15 Automated egg removal apparatuses are known (e.g. US 7,083,208 to Embrex), but current systems tend to employ *arrays* of suction cups, making it impractical to place non-live eggs into a discrete location for a subsequent use (e.g. filling an egg carton for later sale of unfertilized eggs). Moreover, the poultry industry is constantly looking for improved ways of separating live and non-live eggs that are efficient, that reduce costs, and that reduce the risk of contamination to  
20 live eggs. Applicants thus sought to develop an improved automatic egg candling and relocation apparatus, which can place the non-live eggs in specific locations, including into an egg carton.

### **SUMMARY OF THE INVENTION**

The instant invention is based upon the successful engineering of an improved egg candling and relocation apparatus that rapidly identifies, removes and relocates individual eggs  
25 from an egg carrier, including a hatchery tray. Accordingly, it is one object of the present invention is to provide an egg candling and relocation apparatus that is capable of rapid discrimination, removal and relocation of non-live eggs from a mixed plurality of live and non-

live eggs. Owing to its superior discrimination capability, it is envisioned that the apparatus may also be used to select and relocate live / viable eggs.

In some embodiments, the apparatus is configured to receive an egg carrier / hatchery tray comprising a plurality of live and non-live eggs. The apparatus comprises a tray-conveying means, which is configured to move the tray along the length of the apparatus. After the tray is received into the apparatus, the conveying means moves the tray into a candling position. The apparatus comprises a candling light source, which is configured to direct light at the plurality of eggs. The apparatus also comprises a means for detecting the light that is able to pass through the eggs. In some embodiments, the detecting means is a camera, which is configured to receive the light that passed through the plurality of eggs. The camera is electrically connected to a suitable processing means, such that information about the light passing through the eggs can be processed to determine which eggs are live and which eggs are non-live.

Once the non-live eggs are determined by the processing means, this information is communicated to a robotic arm controlling means, which instructs the arm to remove the non-live eggs from the plurality of eggs. The arm comprises a suction cup, which is configured to releasably engage with the eggs, to allow the arm to pick up eggs from one location, and to drop off or place the eggs in another location. In some embodiments, the arm picks up non-live eggs from the hatchery tray and drops them off directly into a carton, for later use. Once the non-live eggs are removed, the tray is moved to an exit portion of the apparatus. In some embodiments, the apparatus is configured to reversibly attach to an *in ovo* injection apparatus, which comprises a plurality of injectors, and which may be configured to conditionally deliver vaccine and/or other medicaments only when an egg is present beneath one of the injectors.

Accordingly, the egg candling and relocation apparatus minimally comprises: a means for conveying hatchery trays; an egg lifting means comprising a vacuum system, for reversibly supplying suction to eggs, and a robotic arm, which is mechanically and operably connected to the vacuum system, and which is configured to reversibly apply suction to individual eggs; a light source, configured to direct light at the eggs; a vision camera, configured to receive the light that passes through the eggs; a computer, configured to process, store and communicate the information collected by the camera; and, at least one computer control, configured to direct the activities of the components of the apparatus.

In some embodiments, the egg lifting means is a robot that includes: a flexible suction cup; pneumatic circuitry, which is configured to allow air pressure to be raised and lowered inside the suction cup when the suction cup is in contact with an egg; a pedestal; a first arm connected to the pedestal and capable of swiveling around a first axis in relation to the pedestal; 5 a second arm connected to the first arm and capable of swiveling around a second axis that is parallel to the first axis and spaced apart from the first axis, in relation to the first arm; and a wiring section which accommodates a wire therein and conveys the wire from the second arm to the pedestal. The wiring section includes: a duct supporting portion provided to protrude from the pedestal and intersect with the first axis; a first joint connected to the duct supporting portion and capable of swiveling around the first axis in relation to the duct supporting portion; a second 10 joint connected to the second arm and capable of swiveling around the second axis in relation to the second arm; and a duct connected to the first joint and the second joint. The first joint is provided with a first connecting portion forming a predetermined angle relative to the first axis. The second joint is provided with a second connecting portion forming a predetermined angle 15 relative to the second axis. The duct has a first end and a second end. The first end is connected to the first connecting portion. The second end is connected to the second connecting portion. In general, any suitable robotic arm may be used in the practice of this invention, for example, the robotic arm described in US 2014/0109712A1 (to Epson), which is herein incorporated by reference in its entirety.

20 In some embodiments, the egg lifting robot includes a vacuum generator having first and second passageways, in fluid communication with the first and second passageways, and a flexible cup positioned at a terminal end of a robotic egg-lifting arm, wherein the flexible cup comprises an interior that is in fluid communication with the vacuum generator second passageway. The vacuum generator produces subatmospheric pressure (vacuum) within the 25 second passageway upon actuation of a vacuum generator pneumatic control valve. The control valve may be actuated by any suitable actuator, including an electrical, pneumatic or hydraulic actuator. The flexible cup is configured to engage and retain an egg in seated relation therewith when subatmospheric pressure is provided within the flexible cup interior via the vacuum generator second passageway.

30 In some embodiments, the flexible cup is removably secured to a suction cup mount, which is operably connected to a vertical quill of the robotic arm. A screen may be positioned

within the interior of the flexible cup and may be configured to prevent foreign matter from being pulled into the passageway of the vacuum generator.

In some embodiments, an apparatus for removing eggs from an egg carrier (e.g. a hatchery tray) includes a frame, a pressurized air source, and a platform comprising at least one robotic arm egg lifting apparatus.

In some embodiments, a method of cleaning and/or sterilizing the egg lifting apparatus includes immersing the flexible cup in a bath of cleaning solution, and inducing vacuum within the interior of the vacuum cup by forcing air flow through the vacuum housing first passageway, wherein contaminants are pulled upwardly through the second passageway and out assembly.

In some embodiments, the egg-relocation apparatus is adaptable to *in ovo* injection machines, for example, but not limited to INTELLIJECT<sup>®</sup> and OVOJECTOR<sup>®</sup>. In still other embodiments, the egg-relocation apparatus may comprise an additional egg-lifting robot, which may be configured to fill empty spaces in an egg carrier with viable eggs. In such an embodiment, there the subsequent *in ovo* injection machine need not be configured to deliver vaccine or other fluids only when an egg is present, since the entire egg carrier will be populated with viable eggs, ready for injection.

In some embodiments, the egg-candling and relocation apparatus may remove clear eggs from a production line before vaccination at any time between day 17 + 12 hours and day 19 + 12 hours of incubation. "Clear" eggs are defined herein as entirely infertile, early dead (gestation cessation at day 1-5) and most early-mid dead (gestation cessation at day 6-11); non-clear eggs are defined herein as late-mid dead (gestation cessation at day 11-14), late dead (gestation cessation at day 15-transfer), contaminated and live. In ideal embodiments, the egg-candling and relocation apparatus is capable of discriminating among infertile, early dead, most early-mid dead, late-mid dead, late dead, contaminated and live; and, the apparatus is capable of relocating all non-live / non-viable eggs. In this way, only live / viable eggs will remain in the egg carrier, to be presented to a suitable *in ovo* injection machine for subsequent injection.

In a particular embodiment, the apparatus is at least 99.9% accurate in identifying and relocating clear eggs, and is 100% accurate in not relocating viable eggs. Clear eggs remain intact during removal and may be automatically relocated into egg cartons for resale.

Accordingly, it is an object of the invention to not encompass within the invention any previously known product, process of making the product, or method of using the product such that Applicant reserves the right and hereby disclose a disclaimer of any previously known product, process, or method. It is further noted that the invention does not intend to encompass within the scope of the invention any product, process, or making of the product or method of using the product, which does not meet the written description and enablement requirements of the USPTO (51 U.S.C. §112, first paragraph) or the EPO (Article 83 of the EPC), such that Applicant reserves the right and hereby disclose a disclaimer of any previously described product, process of making the product, or method of using the product.

These and other embodiments are disclosed or are obvious from and encompassed by, the following Detailed Description.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The following detailed description, given by way of example, but not intended to limit the invention solely to the specific embodiments described, may be best understood in conjunction with the accompanying drawings, in which:

FIG. 1 is a side view of an egg candling and relocation apparatus, according to embodiments of the present invention.

FIG. 2 is an internal and elevated view of the apparatus of FIG. 1 that illustrates the various components thereof.

FIG. 3 is an internal and elevated view of the apparatus of FIG. 1 with the egg relocation robot removed.

FIG. 4 is a detailed view of the actuators and track that are configured to convey egg carriers along the length of the apparatus of FIG. 1, from its loading area to its egg candling station.

FIG. 5 is detailed view of the carriage that conveys the egg carrier from the viable egg staging area to the exit of the apparatus of FIG. 1. The apparatus is configured to be reversibly connectable to a subsequent and compatible *in ovo* injection apparatus, as depicted in FIGs. 7 to 8.

FIG. 6 is a detailed view of a compatible *in ovo* injection machine, which is configured to reversibly connect to the egg candling and relocation apparatus of FIG. 1.

FIG. 7 is a detailed view of the apparatus of FIG. 1 connected to a compatible *in ovo* injection machine.

5        FIG. 8 is a side view of the apparatus of FIG. 1 connected to a compatible *in ovo* injection machine.

FIG. 9A is a side view of a robotic egg relocation apparatus, according to embodiments of the present invention.

FIG. 9B is a detailed top view of the egg relocation apparatus of FIG. 9A.

10       FIG. 9C is a detailed side view of the egg relocation apparatus of FIG. 9B, showing the vacuum generator and the electrical and pneumatic circuitry.

FIG. 9D is a detailed rear view of the vacuum module shown in FIGs. 9A-9C.

FIG. 9E is a detailed view of the flexible cup shown in FIG. 9A.

15       FIG. 10 illustrates the flexible vacuum cup of the egg relocation apparatus of FIG. 9A being immersed in a bath of cleaning/disinfection solution;

FIG. 11 shows an embodiment of the egg relocation apparatus wherein the robotic arm is mechanically connected to a plurality of flexible cups, each cup operably connected to its own vacuum generator and electrical and pneumatic circuitry. This version of the egg relocation apparatus is capable of removing and relocating multiple eggs at a time;

20       FIG. 12 is a magnified view of the array of vacuum generators and egg removers;

FIG. 13 is a magnified view of multiple vacuum generators mounted on a vacuum generator base;

FIG. 14 is a magnified view of the forty-two (42) egg remover head **530**;

FIG. 15 is a view focusing on the six (6) egg remover head **540**;

25       FIG. 16 shows an embodiment of the apparatus equipped with a single-egg remover head **525** and configured to accommodate wide format egg trays. An optional egg receiving tray **800** is also depicted.

**DETAILED DESCRIPTION**

It is noted that in this disclosure and particularly in the claims and/or paragraphs, terms such as “comprises”, “comprised”, “comprising” and the like can have the meaning attributed to it in U.S. Patent law; e.g., they can mean “includes”, “included”, “including”, and the like; and that terms such as “consisting essentially of” and “consists essentially of” have the meaning ascribed to them in U.S. Patent law, e.g., they allow for elements not explicitly recited, but exclude elements that are found in the prior art or that affect a basic or novel characteristic of the invention.

Unless otherwise explained, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. The singular terms “a”, “an”, and “the” include plural referents unless context clearly indicates otherwise. Similarly, the word “or” is intended to include “and” unless the context clearly indicates otherwise. Finally, “about” has the ordinary meaning of “plus or minus 10%.”

The present invention now is described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety.

In the drawings, the thickness of lines, layers and regions may be exaggerated for clarity. It will be understood that when an element is referred to as being “on” another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being “directly on” another element, there are no intervening elements present. It will be understood that when an element is referred to as being “connected” or “attached” to another element, it can be directly connected or attached to the other element or intervening elements may also be present. In contrast, when an element is referred to as being “directly connected” or “directly attached” to another element, there are no intervening elements

present. The terms “upwardly”, “downwardly”, “vertical”, “horizontal” and the like are used herein for the purpose of explanation only. In one aspect, the present invention provides

Egg candling and relocation apparatus according to embodiments of the present invention may be utilized for distinguishing and relocating various types and sizes of eggs (e.g. live/viable, clear, unfertilized, dead, and the like) and in conjunction with various egg processing techniques (e.g., *in ovo* inoculation/injection, *in ovo* virus cultivations, etc.). Egg candling and relocation apparatus according to embodiments of the present invention may be used with any type of avian eggs including, but not limited to, chicken eggs, turkey eggs, duck eggs, geese eggs, quail eggs, pheasant eggs, exotic bird eggs, etc.

Referring now to FIGs. 1–10, an egg candling and relocation apparatus **10**, according to embodiments of the present invention is illustrated. The illustrated candling and relocation apparatus **10** includes a set of outer loading rails **15**, configured to receive an egg carrier **7** (e.g. hatchery tray) into a loading area **1**. The outer rails **15**, inner rails **17** and support member **16** collectively form a table or shelf, which may be collapsible to facilitate transportation of the apparatus. The support member **16** is configured to reversibly attach to a support member rod **18** (not shown), which supports the table in its horizontal or non-collapsed position. After entering the apparatus at the loading area **1**, the egg carriers **7** are conveyed into the candling station **100**, where non-viable eggs are removed and relocated, and then, the remaining viable eggs are transported to the viable egg staging station **200**. Finally, the eggs are conveyed out of the apparatus, and, ideally, directly into a compatible *in ovo* injection machine.

Affixed near or adjacent to loading area **1** is a user interface touch screen **50**, which is mounted to the apparatus via mounting means **52**. The screen **50** is electrically connected to, and is capable of controlling, all the mechanical and electrical functions of the apparatus **10**.

Atop the apparatus **10** is a camera enclosure **55**, for housing a camera **56**, which is configured to receive light that passes through a plurality of eggs **5**, which are contained within an egg carrier/hatchery tray **7**. Light captured by the camera is converted therein into digital information, which is accessible by a processor or controller that controls the motion of an egg relocation apparatus **101**. Various panels provide containment and protection for the eggs as they are conveyed through the apparatus **10**, including: an entrance panel **20**; a candling station top panel **145**, onto which the camera enclosure **155** is mounted, and comprising an orifice **157**

through which the light or the camera **156** may pass; and, a viable egg staging area **200** top panel **228**. Panel **145** is affixed to and supported by horizontal frame members **146** and vertical frame members **147**. Similarly, panel **228** is affixed to and supported by curved frame members **229**. Other panels are presented in subsequent Figures, and all of the panels and supportive structures  
5 may be routinely modified (e.g. opaque materials may be exchanged for transparent or translucent materials; metallic materials may be exchanged for composite/synthetic materials).

Within the space immediately above the robot controller **180** cabinet door **160**, a sanitation fluid tank **170** and an egg relocation robot **101** are mounted to horizontal portions of the frame of the apparatus. The robot **101** must be situated such that it can lift and relocate any of  
10 a plurality of eggs **5** contained within an egg carrier **7**, while still being able to extend the flexible egg-relocation cup **145** into the sanitation tank **170** for cleaning. Alternatively, the robot could be suspended from above instead of mounted as shown in FIG. 1. To the right of the robot controller cabinet **160** is a cabinet **260**, which house an electrical controller **280** and a pneumatic controller **281**. Appropriate conduits and electrical connectivity are included to allow a user to  
15 control all aspects of the apparatus using interface **50**.

An egg carrier **7** is shown entering the “loading table,” via rails **15**. The carrier will next be guided to the candling area **100**, then to the viable egg staging area **200**, and finally to an exit area **300**. From the exit area **300**, the carrier **7** will be conveyed or transferred to a compatible *in ovo* injection machine **400**. An egg carrier transfer component/carriage **303** (equipped with  
20 clasp means **304**, **306**) and apparatus joining means **305** are configured to allow the egg candling and relocation apparatus **10** to reversibly connect to a compatible *in ovo* injection machine **400**. Securing means **310** are configured to allow the apparatus **10** to be reversibly locked or secured to the *in ovo* injection machine **400**. Finally, the apparatus **10** is configured such that it is portable, yet stable once it has been moved into the desired position. Lockable  
25 casters **80** and braking means **85** provide the apparatus with these necessary portability and stability functionality.

Turning now to FIG. 2, which shows an internal and elevated view of the apparatus of FIG. 1, with its top enclosure and frame portions removed. The external rails **15**, along with the internal rails **17**, form a table or shelf, which may be collapsible from its depicted horizontal  
30 position to a vertical storage/transportation position. In the case where the table or shelf is

collapsible, the support member **16** is configured to reversibly attach to a support member rod **18** (not shown), which may be pivotably affixed to the frame of the egg candling area **200**, such that the rod **18** can extend to connect to a support the table. With the top enclosure and frame portions removed, an egg flat/carrier **7** is shown adjacent to an egg flat/tray carriage **191**, which  
5 is configured to reversibly engage with and move the egg flat **7** from the egg candling area **100** to the viable egg staging area **200**.

As indicated in FIG. 2, the egg flat carriage **191** comprises 2 orifices through which air cylinder **195** and air cylinder **193** extend. Air cylinders **195** and **193** are operably connected to a front transfer cylinder **190**, such that when the transfer cylinder **190** is actuated by pneumatic  
10 force, cylinders **195** and **193** are moved laterally. When actuated, cylinder **195** engages with the flat, such that when cylinder **195** is moved laterally, so too does the flat. As such, cylinder **195** functions like a retractable hook, such that when extended behind the egg flat, cylinder **190** is then actuated, and the egg flat is pulled along the track. Cylinder **193** is only actuated while the robot is pulling out the identified eggs, such that cylinder **193** secures the flat so that the removal  
15 of the eggs does not move the flat and eggs out of position, relative to when the eggs to be removed were identified. When the last egg to be removed has been pulled out by the robot and suction cup, cylinder **193** retracts to allow the egg flat to be pulled along the track by the action of cylinder **195**. Accordingly, in this embodiment, the sole purpose of cylinder **193** is to grip/push the flat against the side rail during the egg removal, so that the flat **7** does not move  
20 during this step. If the flat were to move, the eggs could be moved out of position, relative to the positions determined during the candling step, and the robot controller would no longer have the proper coordinate of the eggs to be removed.

During typical operation of the apparatus, a user loads a flat **7** carrying a plurality of eggs onto the shelf formed by rails **15** and **17**. Once the flat **7** is moved sufficiently far enough into the  
25 egg candling area **100**, the gripper cylinder **193** is actuated, and reversibly engages with the flat **7**. The carriage **191** then moves along the length of the cylinder **190**, thereby moving the flat **7** from the egg candling area **100** to the viable egg staging area **200**. Once the tray is placed in the staging area **200**, the gripper cylinder **193** disengages from the flat **7**, allowing the carriage to return to its starting position at the beginning or entrance of the egg candling area **100**, ready to  
30 engage with the next incoming flat **7**. In this manner, egg flats **7** are serially fed into the apparatus at the far left end of the rails **15**, pushed into the egg candling area **100**, picked up by

the carriage **191** and gripper cylinder **193**, and then moved by cylinder **190** into the viable egg staging area **200**.

Once the flat **7** is in the viable egg staging area **200**, the carriage **303** is moved along the cylinder **302**, and underneath the flat, to the end of the flat closest to the egg candling area **100**  
5 from which the flat **7** just arrived. While the carriage **302** is moving underneath the flat **7**, the carriage fingers **304**, **306**, which are pivotably connected to the carriage **302**, pivot downward as a result of making physical contact with the egg flat **7**. In other words, the fingers **304**, **306** are pressed down by the flat **7** as they slide beneath it. The fingers are thus configured to pivotably retract when they move beneath the egg flat **7**, and configured to return to their initial positions  
10 after they clear the underside of the flat **7**. In a particular embodiment, the carriage **302** moves underneath the flat **7** until the first set of fingers **306** clears the underside of the flat and returns to its initial position. The carriage **302** then reverses its direction of lateral movement, such that the fingers **306** engage with the flat **7** and move the flat from the viable egg staging area **100** toward the exit of the apparatus (i.e. toward the awaiting *in ovo* injection machine **400**). Once the  
15 carriage reaches its ending point along cylinder **302** (e.g. as shown in FIG. 2), the carriage **302** reverses direction once more, bringing the second set of fingers **304** out from underneath the flat **7**, where now all four (4) fingers **304**, **306** are in their extended (i.e. initial or resting) positions. At this point, the cylinder **302** will move the carriage **303**, which in turn moves the front fingers **304** to engage with the flat **7**. The carriage **303** then moves into the position shown in FIG. 2,  
20 which moves the flat **7** to the end of the apparatus **10** (as shown in FIG. 3), and either off the apparatus, or onto a waiting second apparatus, for example, the *in ovo* injection machine **400** shown in FIG. 8.

FIG. 3 is an internal and elevated view of the apparatus of FIG. 1 with the egg relocation robot removed, and the egg flat **7** shown at its most distal position, ready to be transferred off the  
25 apparatus and on to an awaiting secondary apparatus. With the enclosure and upper frame portions removed, a candling light shroud **108** having a plurality of orifices **187** may be visualized. In the embodiment shown in FIGs. 1 to 10, the apparatus **10** comprises a candling light source positioned beneath the shroud **108** and configured to shine light at the shroud **108** and through the plurality of orifices **187**. Applicants found surprisingly that candling  
30 fidelity/accuracy could be significantly improve by guiding the candling light through the orifices. Necessarily, the holes **187** are configured to align with the positions of the plurality of

eggs held within the tray/flat 7. Also shown in FIG. 3 is a stabilizing member 88 having a foot portion 87 and a retractable pneumatic cylinder 89 configured to allow for extension and retraction of the support 88. Any suitable such supporting means may be used in the practice of the invention. Finally, a robotic arm support 102 can be seen from this view, as well as the egg tray 7 and egg tray carriage 303, which are shown at their most distal positions along the apparatus 10. In this position, the tray 7 must be supported by some downstream apparatus, for example, the *in ovo* injection machine shown in FIG. 8. Both the candling and relocation apparatus 10 and any downstream apparatus must be configured to reversibly connect to one another (see e.g. FIGs. 5 to 8)

FIG. 4 shows a close-up view of the pneumatic cylinder 190, which is configured to move a carriage table 182 laterally from a starting/proximal position to an ending/distal position. An egg flat carriage 181 (shown in FIG. 3) operably connects egg flat carrier cylinder 195 to egg flat gripper cylinder 193. Cylinders 195 and 193 may have different sized mounting spacers 196, 194, respectively, and gripper rod 187 is configured to extend to engage with and “grip” the egg tray 7, at the same time the robot picks and relocates the eggs. As indicated in this embodiment, a hardware mounting orifice 186 may be present atop the carriage table 182. Cylinder 190 is attached to the apparatus via cylinder end cap 197 (i.e. the mounting point for the rodless cylinder 190), and adjustable stroke limiter block 183, 198 may be placed at any point along cylinder 190 to meet a variety of range of motion requirements. Shock absorber 185 (e.g. an air or hydraulic cushion) is configured to reduce impact when base 182 moves to its proximal- or distal-most position (i.e. when the stroke limiter block strikes the mounting end cap 197), and an adjustable hard stop 184 is configured to provide an absolute hard stop location for the limiter block 183. The adjustability and shock absorbing features allow the apparatus 10 to be configured to suit a variety of conditions, including, but not limited to, different sized egg flats 7. Further, the apparatus 10 comprises suitable pneumatic and electrical connectivity to allow a user to control all aspects of the apparatus, including those of cylinders 190, 195 and 193. And finally, electrical and pneumatic features of the apparatus are controllable via user interface 50.

FIG. 5 is detailed view of the apparatus 10 new the carriage 303 and its pivotably retractable fingers 304, 306, which convey the egg carrier laterally along the rodless cylinder 302, from the viable egg staging area 200 to the exit of the apparatus of FIG. 1. The apparatus is configured to be reversibly connectable to a subsequent and compatible *in ovo* injection

apparatus 400, as depicted in FIGs. 7 to 8. Carriage rails 305 and outer rail 307 form a table or support for the egg tray/flat 7, similarly to the way rails 15 and 17 formed a table at the entrance of the apparatus 10. The rails 305 and 307 are configured to match up with corresponding partner pieces on the downstream *in ovo* injection machine 400. Likewise, carriage 303 is configured to be compatible with downstream *in ovo* injection machine components, such that the egg tray 7 may be safely and efficiently handed off from the candling and removal apparatus 10 to the *in ovo* injection machine 400. Inter-apparatus connecting means 310 (e.g. draw latches, pull latches, and the like) are mounted onto mounting means 311 (e.g. brackets, braces, flanges, or the like), which themselves are mounted onto the frame of the apparatus 10. As shown, each draw latch 310 includes a handle 313 and a hook 312. The hook connects to corresponding hook receiver 401 (see FIG. 6), which is mounted onto the frame of the *in ovo* injection machine 400.

FIG. 6 shows the *in ovo* injection machine 400 components that are configured to receive and/or connect with corresponding candling and removal apparatus 10 components. Shown are the handles 420, which are used to move the *in ovo* injection machine; and hook receivers 401, which are configured to receive and reversibly attach to the hooks 312 from the candling and removal apparatus 10. Carriage receiving rails 416 are configured to align with apparatus rails 305, such that the candling apparatus carriage 303 may be moved all the way up to *in ovo* machine carriage 410, which comprises wheels 412.

FIG. 7 shows the meeting and/or connection of corresponding components when the apparatus 10 is connected to the *in ovo* injection machine 400. The connecting means 310 and hook receivers 401 are sufficient to keep the apparatuses physically connected to one another, and the corresponding components are configured to allow and facilitate the hand off or exchange of the egg tray 7 from the apparatus 10 to the *in ovo* machine 400. In FIG. 7, the carriage 303 is shown at its distal-most position, having pushed the egg tray/flat 7 into the entrance of the *in ovo* injection machine 400. Carriage 410, which may be similarly equipped with pusher fingers (i.e. like the carriage 303), is configured to move the egg tray 7 from the beginning portion of the *in ovo* machine and onto subsequent portions of the machine. Finally, FIG. 8 shows the egg candling and relocation apparatus 10 connected the *in ovo* injection machine 400, collectively referred to herein as an egg candling, relocation and injection system 600. In a particular embodiment, the *in ovo* injection machine 400 is as described in US Patents US 7,430,987, US 7,721,674, or US 8,201,518, each to David Smith (Profilax).

FIGs. 9A to 9E, and 10 provide details of the egg candling and relocation robotic arm **101**. An example robotic arm is described in US 2014/0109712 (“the ‘712 publication”), to Epson. As further detailed in the Epson publication, the robot **101** is a horizontal multi-joint robot. A pedestal **110** is fixed to a robot arm support **102**, with bolts or the like. The first arm **120** is connected to an upper end of the pedestal **110**. The first arm **120** is capable of swiveling around a first axis **A1** that extends along a vertical direction, in relation to the pedestal **110**. Inside the pedestal **110**, a first motor **111** which causes the first arm **120** to swivel, and a first decelerator **112** are installed. An input axis of the first decelerator **112** is connected to a rotation axis of the first motor **111**. An output axis of the first decelerator **112** is connected to the first arm **120**. Therefore, when the first motor **111** is driven and a driving force thereof is transmitted to the first arm **120** via the first decelerator **112**, the first arm **120** swivels within a horizontal plane around the first axis **A1** in relation to the pedestal **110**. The first motor **111** is provided with a first encoder **113** which outputs a pulse signal corresponding to the amount of rotation of the first motor **111**. Based on the pulse signal from the first encoder **113**, driving (amount of swiveling) of the first arm **120** in relation to the pedestal **110** can be detected. The second arm **130** is connected to a distal end of the first arm **120**. The second arm **130** is capable of swiveling around a second axis **A2** that extends along a vertical direction, in relation to the first arm **120**. Other details of this robot, or other functionally equivalent robots, are readily available to the skilled person, for example, in product literature from robot manufacturers.

As shown in FIG. 9A, the robotic arm **101** is fitted with a variety of pneumatic and electrical circuitry, which allows the arm **101** to pick up and relocate eggs. The arm **101** of the egg candling and relocation apparatus **10** comprises flexible/elastomeric cup **140**, which is configured to pick up and release spherical and ovoid objects, including avian eggs. The cup **140** is connected to a hollow shaft **147** by cup mount **146**. The robotic arm **101** is configured to move the shaft **147** vertically, up and down, allowing the cup to come into contact with eggs, pick them up, and move the eggs to a selected location. Any suitable length and type of shaft **147** may be used in the practice of the invention, provided that the shaft **147** is hollow and configured to serve as a conduit for air, such that the cup **140** can be reversibly presented with subatmospheric pressure. It is this subatmospheric pressure that allows the flexible cup **140** to pick up the round and ovoid objects. The user interface **50** allows a user to control the robot controller **180**, which

controller is electrically connected to the robot **101**, and configured to control all aspects of the robot's functions.

Vacuum generator **132**, which is mounted on the robot's second arm **130** via a mounting plate **134**, is in fluid communication with the cup **140** via conduit **149**, shaft **147** and cup mount **146**. The generator **132** is configured to reversibly supply sub-atmospheric pressure to the cup **140** in response to the opening and closing of a vacuum generator pneumatic control valve **135**. As shown, the valve **135** is an electrical actuator, which configured to open or close pneumatic valve **135** in response to electrical signals from the electrical controller **280**. In other embodiments, the valve may be opened by pneumatic or hydraulic forces, instead of by electrical actuation. When valve **135** opens, air pressure from the air pressure supply line **133** is permitted to pass through the valve **135**, through conduit **139** (air pressure supply line to venturi), into the vacuum generator **132**, and out the exhaust/muffler **132m**. The flow of pressurized air through **139** and out the muffler creates a venturi effect, whereby subatmospheric pressure is produced in conduit **149**. This subatmospheric pressure is communicated to the cup **140**, such that when the cup **140** is pressed down against an egg to be relocated, and the subatmospheric pressure is applied, the egg is sealably held to the cup **140** by the negative pressure. Once the robot **101** moves the egg to a desired new location, an electrical signal carried along wire **137** causes the valve **135** to close, thereby releasing the temporary subatmospheric pressure, and releasing the egg. Connection point **136** facilitates routine valve **135** replacement by obviating the need to cut and splice wire **137**. And as shown in FIG. 9D, an air valve base ported aluminum block **129** directs the airflow to the components, to and from valve **135**.

As shown in FIG. 9E, the flexible cup **140** comprises a mounting point "P", a vacuum passage **144**, a soft lower lip **141**, a filter screen **142**, and a semi-rigid double below **143**. The skilled person will appreciate that other suitable flexible suction cups may be used in the practice of this invention.

As shown in FIG. 10, the apparatus **10** may comprise a reservoir/tank **170** for holding a volume of cleaning/sanitizing solution. At user-selected or pre-programmed intervals, the robotic arm dips the shaft **147** and flexible cup **140** into the tank **170**. Negative pressure is applied, by action of the pneumatic controller and the vacuum generator **132**, to draw solution into the shaft

**147** through the cup **140**. Solution is then circulated throughout the shaft **147** and conduits for a period of time sufficient to sanitize/clean said shaft **147** and conduits.

The cycle of egg picking and relocating is repeated until each of the eggs to be relocated is removed from the tray **7** and placed into its desired location (e.g. egg carton, box, crate, tray, bin, and the like). Once the non-viable eggs are removed, the tray **7** containing only viable eggs is moved from the candling area **100** to the viable egg staging area **200**. Here, empty spaces may be filled (or not) with viable eggs, either by hand or by another robotic arm.

Accordingly, in an embodiment, the egg picking and relocation cycle may be performed by the apparatus **10** according to the following steps:

- 10        1. Information describing the location of the non-viable eggs is acquired and stored;
2. Egg location information is communicated to the robot controller;
3. The robot controller determines what motions are required to bring the cup **140** into contact with the non-viable egg(s) to be relocated;
4. The robot controller instructs the robot **101** to move arm **120** about axis **A2**, arm **130** about axis **A1**, and shaft **147** vertically, to pick up a non-viable egg to be relocated;
- 15        5. Once the shaft **147** is moved sufficiently downward to cause the cup **140** to contact a non-viable egg to be relocated, the electrical controller **280** instructs the valve **135** to open, allowing pressurized air from conduit **133** to pass through valve **135**, into conduit **139** and into vacuum generator **132**;
- 20        6. Pressurized air passing through the vacuum generator **132** and out the muffler produces negative pressure in conduit **149**, which produces subatmospheric pressure in the air between the cup **140** and the egg to be relocated, thereby temporarily holding the egg to the cup;
7. The robot controller instructs the robot **101** to move shaft **147** vertically, arm **120** about axis **A2** and arm **130** about axis **A1**, to carry the egg to a new location;
- 25        8. The electrical controller **160** instructs the valve **135** to close, allowing the air between the cup **140** and the egg to return to atmospheric pressure, which allows the egg to be released from the cut **140**;
9. The cycle is repeated until all non-viable eggs are removed from the tray and
- 30        relocated.

The cup **140** may be cleaned at any time by moving the cup into the sanitization vessel **170** and passing air back and forth to cause sanitizer solution to cleanse the cup. The solution may also be drawn up into the shaft **147** and various conduits, to cleanse the shaft and conduits.

As described below, different egg remover “heads” may be mounted on the robot, in a modular fashion, to accommodate the needs of different hatcheries (e.g. to accommodate different types of egg trays).

*Forty-two-egg remover head.* As indicated in FIG. 11, the egg removal and relocation apparatus may comprise a robot **101** that is mechanically and operably connected to an array of suction cups **140**. As shown, each suction cup **140** is mechanically connected to, and movable by, an independent actuator **504**. Each actuator **504** is mounted to an egg remover base **500**, which base is mounted on shaft **147** of robot **101**. As shown in FIG. 14, shaft **147** may connect to the egg remover base **500** via shaft attachment means **520**. The attachment means may be a segmented annual ring system, or any other mechanically suitable means for attaching the cylindrical shaft to the egg remover base **500**. Each suction cup **140** is in fluid communication with an individual vacuum generator **132** via a conduit (not shown), which fluidly connects each suction cup **140** with its corresponding vacuum generator **132**. Each conduit is sealably connectable to an airline receiver **508**. Moreover, each actuator **504** is operably connected to the robot **101** (e.g. via electrical wires for electric actuators, or via air conduits for pneumatic actuators), such that each combination of suction cup **140** and actuator **504** (together referred to as “egg remover”, or **510**) is individually controllable to remove and relocate eggs. The independent actuator **504** provides an additional benefit, which is to reduce the risk of contamination and improve biosecurity (i.e. so that each suction cup **140** only comes into contact with the non-viable eggs). Furthermore, since each suction cup **140** has its own independently controllable vacuum generator **132**, only the cups **140** that are picking out bad eggs generate vacuum, reducing the risk of cross-contamination. The vacuum generators **132** may be mounted as banks **512** (as shown), mounted to a vacuum generator bank base **514**, which base may be mounted on the robot **101**. As indicated by the dotted line, another base **514** (having banks of vacuum generators **132** mounted thereto) is present on the opposite side of the robot **101**. Finally, the embodiment disclosed in FIGs. 11 to 14 is capable of removing and relocating from 0 to 42 eggs per move / cycle. Thus, the apparatus shown in FIGs. 11 to 14 comprises an array of 42 egg removers **510**, and is capable of picking, removing and relocating 42 eggs (e.g. non-

viable eggs) per move. Accordingly, this apparatus can process an eighty-four (84) egg flat in two moves. Although not shown (to simplify the drawings), the apparatus comprises suitable air conduits and/or electrical wires to connect the vacuum generators to the egg removers **510**.

5       *Six-egg remover head.* In another embodiment, the egg removing and relocation apparatus may be equipped with a six (6) egg per move egg remover head **540** (FIG. 15). Like the 42 egg remover head **530**, each egg remover **510** is independently controllable, allowing the apparatus to remove and relocate 0 to 6 eggs per move / cycle.

10       *Single-egg remover head.* In still another embodiment (FIG. 16), the apparatus may be equipped with a single-egg remover head **525**, like the apparatus depicted in FIGs. 1 to 4, and be configured to accommodate wide-format trays (e.g. 150-egg trays). In this embodiment, cycle time is necessarily dependent upon the number of eggs that must be to be removed & relocated per cycle. However, this configuration offers several benefits including reduced manufacturing costs, reduced maintenance requirements and greater simplicity. And similar to the embodiment shown in FIGs. 1 to 4, the embodiment shown in FIG. 16 is capable of precisely repacking removed eggs. In such a case, a receiving tray **800** may be positioned such that the apparatus is capable of filling the receiving tray with the removed eggs. When the receiving tray is full of removed eggs (e.g. non-viable eggs), the apparatus expels the filled receiving tray, so that an empty receiving tray **800** may be placed into the receiving position, thus allowing the repacking process to continue.

20       Advantageously, each egg remover head (e.g. single-egg, six-egg, forty-two-egg, etc.) may be used with any egg flat configuration, based upon each hatchery's needs.

Now that the invention has been disclosed, Applicants envision many mechanically reasonable configurations for the various components of the apparatus.

The invention will now be described by the following set of non-limiting claims.

25

\* \* \*