

INLAY STATION WITH ALIGNMENT
ASSEMBLIES AND TRANSFER TUBES

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CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of Parnell et al. U.S. Serial No. 09/925,403 filed August 9, 2001, having the same title, which is fully incorporated herein by reference.

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an inlay station with alignment assemblies and inlay tubes, and more particularly pertains to an inlay station with alignment assemblies and transfer tubes which may be used to provide for the precise location and alignment of front curve (FC) and back curve (BC) molds in pallets after their transfer from an injection molding machine (IMM) machine on an assembly line in a high speed automated commercial production operation.

2. Discussion of the Prior Art

In a typical prior art soft contact lens manufacturing process, metal inserts are used in an injection molding machine (IMM) in an injection molding process to produce many thermoplastic injection molded front curve (FC) molds and back or base curve (BC) molds, each of which FC and BC molds is subsequently used only once to mold a single soft hydrogel contact lens. In this process, the thermoplastic FC and BC mold halves are subsequently joined in the course of the soft contact lens production process to form a mold cavity. The mold cavity formed by the injection molded FC and BC molds is filled with monomer which is polymerized to form a lens, which is then removed from the mold and further processed to yield the final soft hydrogel lens product. The FC and BC molds may be manufactured from any thermoplastic material which is capable of being injection molded and which provides the final cast lens with the required optical properties, with preferred materials for mold frames being

polystyrene and polypropylene. To injection mold the FC and BC molds, metal tool inserts of the required configuration are machined and mounted in the injection molding machine. The injection molded FC and BC molds are exact inverse reproductions of the metal mold inserts.

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SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide an inlay station with alignment assemblies and transfer tubes which provide for the precise location and alignment of the FC and BC molds in pallets preferably that can be used after their transfer from an injection molding machine (IMM) machine on an assembly line in a high speed automated commercial production operation. Additionally, this invention provides an inlay station with alignment assemblies and transfer tubes that can be used to transfer contact lenses and other parts that need to be precisely and/or carefully deposited on an inlay tube and/or then transferred to a carrier means, e.g. contact lens holder, pallet, or other part carrier, or package.

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BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing objects and advantages of the present invention for an inlay station with alignment assemblies and transfer tubes may be more readily understood by one skilled in the art with reference being had to the following detailed description of several embodiments thereof, taken in conjunction with the accompanying drawings wherein like elements are designated by identical reference numerals throughout the several views, and in which:

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Figure 1 is an overview of the inlay station of the subject invention which transfers front curve (FC) molds and base or back curve (BC) molds from an injection molding machine (IMM) in which they are molded to pallets which support and align the front curve (FC) and base curve (BC) molds. The pallets are moved on a conveyor system.

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Figure 2 is a top plan view of the inlay station, and the right side of Figure 2 illustrates a top view of one of the pallets having a 2 x 4 array of generally cylindrical cavities which support the FC or BC molds.

- 5 Figure 3 is a front elevational view of the inlay station of Figure 2, and illustrates how each pallet is aligned and loaded in the inlay station with the aid of four vertically reciprocating alignment and inlay tube assemblies, with Figure 3 illustrating the front left assembly for the left pallet in a raised position and the front right assembly for the right pallet in a lowered recessed position.

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Figure 4 is a side elevational view of the inlay station of Figure 3, and illustrates the right front (as viewed in Figure 3) assembly in a lowered position, and illustrates the right rear (as viewed in Figure 3) assembly in a raised position.

- 15 Figure 5 is an enlarged view of one of the inlay tubes, the exterior diameter of which is slightly smaller than the exterior diameter of a cylindrical cavity in the pallet, and which defines a central vacuum duct which enables a vacuum to be applied therethrough to a FC or BC mold being transferred by the inlay tube.

- 20 Figures 6 and 7 are front elevational views of respectively the FC transfer arm and the BC transfer arm, and illustrate the rotational travel paths of both transfer arms wherein each of the FC and BC transfer arms carries a pick up/placement head at its outer extremity which functions to pick up an array of respectively FC or BC molds.

- 25 Figure 8 illustrates the positions of the FC and BC pick up/placement heads at opposite ends of rotation of the FC and BC transfer arms, and illustrates how the BC pick up/placement head is held at a stationary attitude during rotation of the BC transfer arm by a toothed pulley and a toothed belt arrangement such that it does not rotate with the BC transfer arm.

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Figure 9 illustrates displacement versus time charts for respectively the IMM positioner, the FC transfer arm, the BC transfer arm, the x-axis cylinder, and the four inlays FC-1, BC-1, FC-2 and BC-2.

5 **DETAILED DESCRIPTION OF THE INVENTION**

Figure 1 is a sylistic overview of the inlay station 10 of the subject invention which transfers front curve (FC) molds and base or back curve (BC) molds from an injection molding machine (IMM) in which they are molded on one side of the inlay station (above the inlay station as viewed in Figures 1 and 2- see the arrow pointing to IMM) to
10 pallets 12, which support and align the front curve (FC) molds and base curve (BC) molds, on a conveyor system which advances the pallets into and through the inlay station.

Referring to Figures 1 and 2, an empty FC pallet 12-FC and an empty BC pallet 12-BC
15 are advanced to the left along arrow 14 into the inlay station where they are loaded respectively with FCs and BCs, and then they are advanced further to the left out of the inlay station, before being advanced downwardly along arrow 16 by the conveyor system.

20 Figure 2 is a top plan view the inlay station 10. The right side of Figure 2 illustrates a top view of one of the pallets 12, and shows a 2 x 4 array of generally cylindrical cavities 18 with top support flanges 20 extending circumferentially therearound. Each pallet is rectangular in shape and supports a 2 x 4 array of either front curve (FC) molds or base curve (BC) molds in an array of 2 x 4 cylindrical cavities therein. Each cavity
25 includes a generally cylindrical void 18 with an annular flange 20 formed around the upper edge of the cylindrical void, such that a mold is supported at its generally circular outer edge by the annular flange. Each support flange includes a small V shaped depression 22 extending toward the center of a 4 x 4 cluster of the support cavities which supports and aligns a projecting tab on each of the FC and BC molds to precisely
30 align the mold therein. It should be appreciated that some of the FC and BC molds

must be angularly aligned as they are not symmetrical in shape because they are used to mold asymmetrical contact lenses such as toric contact lenses designed to correct for astigmatism. Four circular alignment holes 24 extend vertically through the pallet, with two holes being adjacent to each 2 x 2 cluster of support cavities, and the four alignment
5 holes are used to precisely align the pallet in the inlay station.

Two side by side pallets as shown in Figure 1 are advanced into the inlay station 10 on a conveyor system, and the left pallet shown in Figure 1 is loaded with an array of 2 x 4 FC molds, and the right pallet shown in Figures 1 is loaded with an array of 2 x 4 BC
10 molds in the inlay station 10. The FC pallet position is identified in Figure 2 as 120-FC, and the BC pallet position is identified as 120-BC in Figure 2. The pallets are not shown on the inlay station 10 shown in Figure 2; however, two pallets (only one is shown) moved in the direction indicated by arrow 14 would cover the four inlay plates 160 when positioned in the inlay station 10. Hold down rails 161 are stationary and
15 spaced from the surface of the inlay plates 160 to align the pallets 12 with the inlay plates 160, and to prevent any vertical movement of the pallets 12 during the operation of the inlay station 10. After loading the pallets with BC and FC molds, the loaded pallets are then advanced out of the inlay station (to the left as viewed in Figures 1 and 2) and replaced by another pair of side by side pallets (from the right as viewed in
20 Figures 1 and 2), and the operation is repeated continuously in a high speed automated commercial production line to transfer FC and BC molds from the IMM in which they are molded to pallets on a conveyor system. The FC and BC molds are subsequently used to mold soft hydrogel contact lenses in a molding operation in which a pair of FC and BC molds is used only once to mold a single contact lens and is then disposed of.

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The molds and injection molding systems and transfer station robots that are part of injection molding machines have been disclosed in the prior art and are generally known to a persons of ordinary skill in the art. The preferred mold and molding machine are disclosed in US Patent 09/305,886, titled "Mold, Molding System, and

Molding Machine for Ophthalmic Devices filed May 5, 1999, assigned to the same assignee, and incorporated herein by reference.

5 It should be appreciated that the precise location and alignment of the FC and BC molds in the pallets after their transfer from the IMM machine on an assembly line in a high speed automated commercial operation can be a problem. The present invention for an inlay station with alignment assemblies and inlay transfer tubes was designed specifically to address that problem.

10 As shown schematically in Figure 1, a rotatable FC transfer arm 26 and a rotatable BC transfer arm 28, which rotate about an axis 30 extending generally parallel to the top of Figure 1, as indicated by circular arrow 32, are used to transfer the FC and BC molds from the IMM machine to the pallets in the inlay station, as described in greater detail hereinbelow. The FC transfer arm 26 and BC transfer arm are also supported on a
15 common translatable support to be translatable along an axis 34 to pick up the FCs and BCs from the IMM machine and deposit them in the pallets 12.

Pick up/placement heads 36 and 38 at the outer end of each of the FC and BC transfer arms 26 and 28 transfer a 2 x 2 array of FCs and BCs at one time. In the loading
20 process, first the two 2 x 2 clusters shown on the bottom of the two pallet positions 120-BC and 120-FC, as viewed in Figure 2, are loaded with FC and BC molds, and then the FC and BC transfer arms are translated upwardly and rotated, as viewed in Figure 1, along arrows 34 and 32, loaded with additional FC and BC molds, rotated and translated downwardly, and secondly the two 2 x 2 clusters shown on the top of the two pallets 12
25 (pallet positions 120-FC and 120-BC in Figure 2), as viewed in Figures 1 and 2, are loaded with molds.

Figure 3 is a front elevational view of the inlay station of Figure 2, and illustrates further details thereof. Each pallet is aligned and loaded in the inlay station with the aid
30 of four vertically reciprocating alignment and inlay tube assemblies 40, with Figure 3

illustrating the front left assembly 40-1 for the left pallet in a raised position and illustrating the front right assembly 40-2 for the right pallet in a lowered recessed position.

- 5 Figure 4 is a side elevational view of the inlay station of Figure 3, and illustrates the right front (as viewed in Figure 3) assembly 40-2 in a lowered position, and illustrates the right rear (as viewed in Figure 3) assembly 40-3 in a raised position. Each of the four assemblies is raised and lowered in a reciprocating manner by a separate pneumatic actuator 42.

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- Each alignment and inlay tube assembly 40 includes two vertically extending alignment rods 44 having generally frusto-conical tops 46 which are raised upwardly after the pair of pallets enter and are roughly aligned in the inlay station. After the pallets 12 are positioned in the inlay station 10, two rising alignment rods pass through the two alignment holes 162 in the inlay plate 160, and through two alignment holes 24 for each 2 x 2 cluster of support cavities in the pallet 12 positioned above the inlay tube assembly 40 to more precisely align the pallet with the alignment rod in the inlay station. Each alignment rod is spring 48 mounted in a cylindrical cavity in the main body of each assembly to provide a limited amount of resiliency thereto.

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- Each assembly 40 includes a 2 x 2 array of inlay tubes 50, one of which is shown in further detail in Figure 5, which are raised and lowered through a 2 x 2 array of cylindrical cavities 18 in the pallet to assist in removing the FC and BC molds from a placement head 36 and 38 which holds an array of 2 x 2 molds at the end of each of the rotatable FC transfer arm and the rotatable BC transfer arm. The 2 x 2 array of inlay tubes 50 aid in lowering and precisely positioning and aligning the molds in the array of 2 x 2 mold cavities in the pallet.

- Each assembly 40 also includes a generally cylindrically shaped compliance module 51, which is commercially available from SMC corporation, positioned immediately above

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the pneumatic actuator 42. The compliance module is a compliant assembly which allows limited x, y translational and rotational movements between its lower surface, which is adjacent to the pneumatic actuator 42, and its upper surface, which supports the assembly of the spring mounted alignment rod 44 and the 2 x 2 array of inlay tubes 50.

5 The compliance module allows limited aligning movements in each assembly 40 to allow each alignment rod 44 to align first with the alignment holes 24 in a pallet 12 and then with the alignment apertures 39 in a transfer arm 26 or 28 (which is considered to be the reference alignment position, to which the positions of the pallet 12 and alignment rods 44 are adjusted and aligned) as the assembly is raised from its lower
10 position to its upper position by the pneumatic actuator. By the alignment of the transfer arm and the inlay tubes, by the use of the alignment rod, the FC or BC molds or any other parts that are to be transferred by the transfer arm and inlay station are placed precisely on the inlay tubes, and then by lowering the inlay tubes, precisely onto the pallet or other carrier means, if desired.

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In the preferred mode the alignment rod from the inlay station is used to align the pallet and the transfer arm; however, alternatively, alternative alignment means could be used. The in-lay station could be provided with a snap-in, or drop-in feature for receiving the pallets in the proper position, or movable side walls that could be raised or lowered to
20 properly position the pallet in the inlay station. Alternatively, the inlay station could be provided with an electronic or visible inspection feature or features that would communicate with mechanical means for adjusting the positioning of the pallet. Additionally, separate alignment means could be provided on the transfer arm or the pick up/placement heads of the transfer arm, such as alignment rods that could be
25 received by an aperture on the pallet or on the inlay station to align the pick up/placement heads with the pallet and/or the inlay station, or the transfer heads could be shaped to fit into a space defined by the movable side walls optionally used to align the pallet, or the transfer heads could be provided with any of the other alignment means described above for the pallet or inlay station. Alternative alignment means,
30 (mechanical or other types of alignment means) for the inlay station to position the

pallet and/or to position the transfer head and/or alternative alignment means for the transfer head with the inlay station alone (if a pallet or other carrier means would not be included in the embodiment) would be obvious to a skilled person based on the teachings herein.

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Figures 6 and 7 are front elevational views of respectively the FC transfer arm and the BC transfer arm, and illustrate the rotational travel paths of both transfer arms. Each of the FC and BC transfer arms 26 and 28 carries a pick up/placement head 36 and 38 at its outer extremity which functions to pick up a 2 x 2 array of respectively FC or BC
10 molds.

The right side of Figure 6 illustrates the FC placement head 36 facing upwardly in a position in which an array of 2 x 2 FC molds are received from the IMM on the upper surface of the placement head. The array of 2 x 2 FC molds are secured thereto and
15 held by an array of 2 x 2 individual holders and vacuum ducts in the FC placement head.

The right side of Figure 7 illustrates the BC placement head facing downwardly in a position in which an array of 2 x 2 BC molds are received from the upper surface of a
20 BC holder nest 54 held on a stationary BC holder arm 55. The BC nest 54 does not rotate with transfer arm 28; however, it is mounted on the same mechanism as transfer arm 28 as shown in Figure 7 and translates with transfer arm 28 in direction 34 as shown in Figure 1. The BC molds on the BC holder nest 54 are received from the IMM. Alternatively, the BC nest could be a separate station not attached to transfer arm
25 28, and located next to the IMM station for receipt of the BC molds from the IMM transfer station. The 2 x 2 array of BC molds which are received by the downwardly facing BC placement head 38 are secured thereto and held by an array of 2 x 2 individual holders and vacuum ducts in the BC placement head.

The right side of Figure 8 also illustrates the upwardly facing FC placement head 36 and the 2 x 2 array of mold holders and the two circular alignment apertures 39 which are engaged by two alignment rods in a manner as described in further detail hereinbelow.

The right side of Figure 8 also illustrates the upwardly facing BC holder nest 54 and the
5 2 x 2 array of mold holders thereon.

Figure 9 illustrates displacement versus time charts for the FC transfer arm, the BC transfer arm, and the four inlays FC-1, BC-1, FC-2, and BC-2. The FC and BC transfer arms 26 and 28 operate in synchronized sequence, with the FC transfer arm being
10 slightly advanced in timing relative to the BC transfer arm, to first load a 2 x 2 array of FC molds in the lower half, as viewed in Figures 1 and 2, of the FC pallet (FC-1), and secondly load a 2 x 2 array of BC molds in the lower half of the BC pallet (BC-1). Then the support for the FC and BC transfer arms is translated upwardly along arrow 34, as viewed in Figures 1 and 2, and the FC and BC transfer arms thirdly load a 2 x 2 array of
15 FC molds in the upper half of the FC pallet (FC-2), and fourthly load a 2 x 2 array of BC molds in the upper half of the BC pallet (BC-2). For each loading sequence of a 2 x 2 array, each transfer arm is rotated approximately 180 degrees to pick up a 2 x 2 array of molds from a transfer station in the IMM machine or the BC holder nest 54 and is then rotated approximately 180 degrees to transfer the 2 x 2 array of molds to a pallet,
20 and then the operation is repeated in sequence as described above. The FC pick up/placement head 36 at the end of the FC transfer arm picks up the 2 x 2 array of FC molds, concave side down, from a pick up station at the IMM machine, at which they are placed in the pick up/placement head 36. The BC pick up/placement head 38 at the end of the BC transfer arm 28 picks up the 2 x 2 array of BC molds, concave side up,
25 from the stationary BC holder nest 54 supported by the stationary BC holder arm 55.

After a pair of pallets are initially positioned and roughly aligned in the inlay station, the alignment assemblies 40 are raised in the synchronized sequence described above. In each alignment assembly 40, two alignment rods 44 rise upwardly through two
30 alignment holes 24 in a pallet to more precisely align the pallet 12 relative to the

alignment rods 44 in the inlay station. As each assembly 40 continues to rise, the array of inlay tubes rise up into the array of cylindrical cavities 18 in the pallet 12, but do not clear the top of the pallet. At that time, the transfer arm has rotated to a position above the pallet such that the placement head at the end of the transfer arm stops at a position
5 approximately $\frac{1}{2}$ inch above the pallet. The assembly 40 is then raised further such that the array of inlay tubes 50 are raised upwardly through the array of cylindrical cavities 18 and the two alignment rods are raised upwardly into two circular alignment holes 39 in the transfer arm 26 or 28 and lastly the inlay tubes are positioned immediately adjacent to the placement head 36 or 38. The alignment holes 39 in the transfer arm 36
10 or 38 extend vertically through the placement head 36 or 38 at the end of each transfer arm 36 or 38, as shown in Figure 8.

The arrangement is such that the two alignment rods, as they are raised upwardly, first align the pallet relative to the alignment assembly 40, and then align the pallet and the
15 alignment assembly relative to the transfer arm. The alignment rods are preferably hardened steel or stainless steel, and the alignment holes in the pallets and transfer arms preferably hardened steel or stainless steel have bushings surrounding the alignment rods. The arrangement of the overall system is such that the FC and BC molds are aligned in the support cavities of the pallet with a tolerance of +/- 100 microns.

20 In each alignment and inlay tube assembly 40, the spring mounted alignment rods 44 therein first align a pallet, by the alignment holes 24 therein, with the alignment rods, and then align the pallet and the alignment rods with the transfer arm 26 or 28, by the alignment holes 39 in the transfer arm, to align the inlay tubes 50 supported by the
25 assembly 40 with the placement head 36 or 38 of the transfer arm 26 or 28. The compliance module 51 allows for limited x/y translations and rotation to precisely align the array of inlay tubes 50 to the placement head 36 or 38 supported on the transfer arm 26 or 28.

The individual FC or BC molds are secured to the FC or BC placement head by individual holders and vacuum ducts, and after the inlay tubes are positioned immediately adjacent to a placement head, the vacuums in the placement head are terminated, and preferably a pressurized shot of air (blow off) is introduced into the vacuum ducts, to release the 2 x 2 array of molds into the 2 x 2 array of inlay tubes, preferably onto the top surfaces of the inlay tubes, and preferably the individual vacuums in each of the inlay tubes are turned on to transfer the molds from the placement head to the raised inlay tubes and secure the molds to the raised inlay tubes while not disturbing and preserving the angular alignment of the molds. After the transfer, the vacuum in each inlay tube is checked to ensure that each inlay tube is in fact holding a mold. The assembly 40 is then lowered such that the array of inlay tubes descends into the pallet, and the vacuums in the individual inlay tubes are terminated at the same time to allow the vacuum to dissipate while the inlay tubes are being lowered. When the molds are in a position to be supported by the flanges of the cavities in the pallet, the vacuum can be completely aspirated by a pressurized shot of air (blow off) into the vacuum ducts of the inlay tubes, to release the molds to be supported by the flanges of the cavities of the pallet while not disturbing and preserving the angular alignment of the molds, and the assembly 40 continues downwardly to its fully lowered position.

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The alignment rods 44 serve an important alignment function while the inlay tubes are being lowered, in that the alignment rods initially remain aligned within the placement head as the assembly is being initially lowered to maintain all of components in correctly aligned positions until the molds are transferred to their support positions in the pallet, which enables the tight alignment tolerances of the molds in the pallet to be achieved.

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Figure 5 is an enlarged view of one of the inlay tubes 50, the exterior diameter of which is slightly smaller than the exterior diameter of a cylindrical cavity 18. The inlay tube is preferably fabricated of a resin such as polyetheretherketone, known as PEEK, which

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has a high melting point of approximately 300 degrees C and is a very durable material. Each inlay tube defines a central vacuum duct 52 which enables a vacuum to be applied therethrough to a mold being transferred by the inlay tube. Preferably the inlay tube is a hollow tube, however, a solid tube with or without a narrow central vacuum duct could
5 be used in this invention.

The pick up/placement head 36 at the end of the FC transfer arm picks up the 2 x 2 array of FC molds, concave side down, from a pick up station at the IMM machine. The FC transfer arm then rotates approximately 180 degrees, and the pick up/placement head
10 36 rotates therewith and then deposits the 2 x 2 array of FC molds in an inverted position, concave side up, in the FC pallet, as illustrated by Figure 6.

The BC pick up/placement head 38 at the end of the BC transfer arm 28 picks up a 2 x 2 array of BC molds, concave side up, from the stationary BC holder 54 that is located
15 adjacent to the IMM machine to receive the BC molds from the IMM machine. The BC transfer arm then rotates approximately 180 degrees, and the pick up/placement head then deposits the 2 x 2 array of BC molds in the same position, concave side up, in the BC pallet. In order to deposit the 2 x 2 array of BC molds in the same position, concave side up, in the BC pallet, the BC pick/up placement head must remain in the
20 same attitude or orientation while the BC transfer arm rotates 180 degrees. To accomplish this, the BC pick up/placement head must rotate 180 degrees relative to the BC transfer arm while the BC transfer arm rotates 180 degrees.

Figure 8 illustrates a toothed belt 56 and toothed pulley 58 arrangement to accomplish
25 this relative rotation of the BC pick up/placement head 38 relative to the BC transfer arm 28, wherein the belt 56 is held stationary and does not rotate with the BC transfer arm, such as by the belt 56 extending around a stationary mounted pulley 60 mounted on the axis of rotation of the BC transfer arm. The toothed belt 56 extends around the toothed pulley 58 which is mounted to rotate with the pick up/placement head 38. The
30 arrangement is such that as the BC transfer arm rotates, the stationary belt causes the

pulley 58, and attached pick up/placement head 38, to rotate relative to the BC transfer arm, and the pick up/placement head remains in the same horizontal orientation, such that it deposits the 2 x 4 array of BC molds (in two translations and rotations of the transfer arm) in the same orientation, concave side up, onto the BC pallet.

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Figure 9 illustrates displacement versus time charts for respectively the IMM positioner which translates the support for the FC and BC transfer arms along arrow 34, the FC transfer arm, the BC transfer arm, the x-axis cylinder, and the four inlays FC-1, BC-1, FC-2, and BC-2. The rotations of the FC transfer arm and the BC transfer arm are
10 synchronized with each other, but the FC transfer arm is slightly advanced relative to the BC transfer arm, which allows the FC transfer arm to accomplish its tasks and to clear out of the way before the BC transfer arm accomplishes its tasks and movements.

Referring to the waveforms of Figures 9-2 and 9-3, the bottom horizontal portions of the
15 waveforms represent the positions of the transfer arms when the molds are being placed on a pallet, and the top horizontal portions of the waveforms represent the positions of the transfer arms when the molds are being picked up from the IMM. As indicated by Figure 9-2, the FC transfer arm has basically two positions, an FC mold pick up position and an FC mold placement position. As indicated by Figure 9-3, the BC
20 transfer arm has basically three positions, a BC mold pick up position, a clearance position in which the BC transfer arm is waiting for the FC transfer arm to complete its tasks and clear out of the way, shown as the intermediate step in Figure 9-3, and a BC mold placement position. The waveforms of Figures 9-5 through 9-8 have already been explained hereinabove.

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While several embodiments and variations of the present invention for an inlay station with alignment assemblies and transfer tubes are described in detail herein, it should be apparent that the disclosure and teachings of the present invention will suggest many alternative designs to those skilled in the art. For example the inlay transfer tubes and
30 the alignment mechanisms could be used to precisely align products, such as contact

lenses or other ophthalmic devices or medical products for example, an inspection step to be performed while the contact lens is located on the tube. The inspection apparatus could be located above, below, or within the inlay tubes. Alternatively the transfer arms taught herein can be used alone to transfer products other than molds that require to be

5 rotated 180 degrees or not rotated during the rotation of the transfer arm step. Further, the pallet could be replaced with any carrier means, such as a single carrier with a hole in the center for the inlay tube to pass through, or a carrier means could be sized to fully fit within the inlay tube in an embodiment when the product can be larger than the carrier means to which it is transferred. Additionally, the size and shape of the inlay

10 tube could be modified depending upon the size of the product.

CLAIMS

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. An arrangement for transferring items from a first station on an assembly line to a second station on the assembly line, comprising:
 - a rotationally mounted transfer arm for rotating and transferring items from the first station on the assembly line to the second station on the assembly line, the transfer
 - 5 arm having an alignment aperture;
 - a receptacle for receiving the transferred items at the second station on the assembly line, the receptacle having an alignment aperture;
 - means for precisely aligning the receptacle with the transfer arm at the second station, after the transfer arm has rotated from the first station to the second station,
 - 10 including a reciprocating alignment assembly having an alignment rod at the second station, which aligns the receptacle with the alignment assembly by passing the alignment rod through the alignment aperture in the receptacle, and then aligns the receptacle and the alignment assembly with the transfer arm by passing the alignment rod through the alignment aperture in the transfer arm, to precisely align the receptacle
 - 15 with the transfer arm at the second station.
2. The arrangement of claim 1, wherein the alignment assembly is mounted for reciprocating vertical movement at the second station.
3. The arrangement of claim 1, wherein the transfer arm includes first and second alignment apertures which are aligned with first and second alignment apertures in the
- 20 receptacle by first and second alignment rods of the alignment assembly passing through the first and second alignment apertures in the receptacle and then passing through the first and second alignment apertures in the transfer arm.

4. The arrangement of claim 1, wherein the receptacle comprises a pallet which defines an array of individual openings for receiving an array of individual items.
5. The arrangement of claim 4, including:
a plurality of alignment assemblies;
- 5 first and second transfer arms, each of which is rotationally reciprocated between the first station and the second station, and each of which includes first and second alignment apertures which are aligned with first and second alignment apertures in a pallet by first and second alignment rods of an alignment assembly passing through the first and second alignment apertures in the pallet and then passing through the first
10 and second alignment apertures in one of the first and second alignment arms.
6. The arrangement of claim 4, in an inlay station which transfers molds from an injection molding machine in which the molds are molded to pallets which support and align the molds on a conveyor system which advances the pallets into and through the inlay station.
- 15 7. The arrangement of claim 6, wherein a first front curve transfer arm transfers front curve molds to a front curve pallet and a second back curve transfer arm transfers back curve molds to a back curve pallet.
8. The arrangement of claim 4, wherein each pallet is rectangular and supports a rectangular array of molds in a rectangular array of cylindrical cavities therein, and each
20 cavity includes a generally cylindrical void with an annular flange formed around the circumferential upper edge of the cylindrical void, such that a mold is supported at its generally circular outer edge by an annular flange.
9. The arrangement of claim 7, wherein a conveyor system advances first and second pallets into the inlay station, the first pallet is loaded with an array of front curve
25 molds, and the second pallet is loaded with an array of back curve molds, and each

pallet is aligned in the inlay station by at least one vertically reciprocating alignment assembly.

10. The arrangement of claim 9, wherein each alignment assembly includes two vertically extending alignment rods having generally pointed tips which are raised
5 upwardly after a pallet enters and is roughly aligned in the inlay station, and the rising alignment rods pass through the alignment holes in the pallet to more precisely align the pallet with the alignment rods and then pass through two alignment holes in one of the transfer arms to more precisely align the pallet and alignment assembly with the transfer arm.
- 10 11. The arrangement of claim 6, wherein each alignment assembly includes an array of transfer tubes which is raised and lowered through an array of cylindrical cavities in the pallet to assist in removing the molds from a placement head which holds an array of molds at the end of a rotatable transfer arm, and the array of transfer tubes is raised
15 upwardly through the array of cylindrical cavities until the transfer tubes are positioned adjacent to a placement head.
12. The arrangement of claim 11, wherein individual molds are secured to the placement head by individual vacuums which are terminated to release the array of molds into the raised array of transfer tubes, and individual vacuums in each of the transfer tubes are turned on to transfer the molds from the placement head to the raised
20 array of transfer tubes without disturbing the alignment of the molds.
13. The arrangement of claim 12, wherein after release of the molds from the placement head, the alignment assembly is lowered such that the array of transfer tubes descends into the pallet, and the vacuums in the individual transfer tubes are terminated to allow the molds to be supported in correctly aligned positions in the cavities in the
25 pallet.

14. The arrangement of claim 13, wherein as the transfer tubes are being lowered, the alignment rod initially remains aligned within the transfer arm as the alignment assembly is being initially lowered to maintain the pallet, the alignment assembly and the transfer arm in correctly aligned positions until the molds are transferred to the
5 cavities in the pallet.

15. The arrangement of claim 1, wherein each alignment assembly includes a compliance module which allows limited x/y translations and rotation within the alignment assembly to align the receptacle with the transfer arm.

16. An arrangement for transferring an array of items from a placement head to a
10 pallet comprising:

a placement head for receiving an array of items, the placement head having an alignment aperture;

a pallet for receiving the array of items transferred from the placement head, the pallet having an alignment aperture;

15 means for precisely aligning the pallet with the placement head, including a vertically reciprocating alignment assembly having an alignment rod which aligns the pallet with the placement head by passing the alignment rod through the alignment aperture in the pallet and then through the alignment aperture in the placement head, to precisely align the pallet with the placement head;

20 the alignment assembly include an array of transfer tubes which is raised and lowered through an array of cavities in the pallet to assist in transferring the items from the placement head to the pallet, wherein the array of transfer tubes is raised upwardly through the array of cavities until the transfer tubes are positioned adjacent to the placement head, and the items are then transferred from the placement head to the
25 transfer tubes;

after transfer of the items to the transfer tubes, the alignment assembly is lowered such that the array of transfer tubes descends into the pallet, and as the transfer tubes are being lowered, the alignment rod initially remains aligned with the placement

head as the alignment assembly is initially lowered to maintain the pallets in correctly aligned relative to the placement head until the items are transferred to the pallet.

17. The arrangement of claim 16, wherein the placement head includes first and second alignment apertures which are aligned with first and second alignment apertures in the pallet by first and second alignment rods of the alignment assembly passing through the first and second alignment apertures in the pallet and then passing through the first and second alignment apertures in the placement head.

18. The arrangement of claim 16, in an inlay station which transfers items which are molds from an injection molding machine in which the molds are molded to the pallets which support and align the molds on a conveyor system which advances the pallets into and through the inlay station.

19. The arrangement of claim 16, wherein each pallet is rectangular and supports a rectangular array of items which are molds in a rectangular array of cylindrical cavities therein, and each cavity includes a generally cylindrical void with an annular flange formed around the circumferential upper edge of the cylindrical void, such that a mold is supported at its generally circular outer edge by an annular flange.

20. The arrangement of claim 16, wherein the alignment assembly includes two vertically extending alignment rods having generally pointed tips which are raised upwardly, and the rising alignment rods pass through the alignment holes in the pallet to more precisely align the pallet with the alignment rods and then pass through two alignment holes in the placement head to more precisely align the pallet and the alignment assembly with the placement head.

21. The arrangement of claim 16, wherein individual items are secured to the placement head by individual vacuums which are terminated to release the array of items into the raised array of transfer tubes, and individual vacuums in each of the

transfer tubes are turned on to transfer the items from the placement head to the raised array of transfer tubes without disturbing the alignment of the items.

22. The arrangement of claim 21, wherein after release of the items from the placement head, the alignment assembly is lowered such that the array of transfer tubes
5 descends into the pallet, and the vacuums in the individual transfer tubes are terminated to allow the items to be supported in correctly aligned positions in cavities in the pallet.

23. The arrangement of claim 16, wherein the alignment assembly includes a compliance module which allows limited x/y translations and rotation within the alignment assembly to align the pallet with the placement head.
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24. An arrangement for moving an item from a first station to a transfer tube comprising:
a transfer tube,
a transfer arm for placement of said item on said transfer tube, and
15 alignment means for aligning said item with said transfer tube.