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APPARATUS FOR REMOVING AND TRANSPORTING ARTICLES FROM MOLDS

BACKGROUND OF THE INVENTION

5 This application is a continuation-in-part of U.S. Patent application number 08\258,267.

FIELD OF THE INVENTION

This invention generally relates to apparatus for removing and transporting articles from molds. More specifically, the present invention relates to such apparatus that is very well suited for carrying the articles, in a very short period of time, away from the molds and depositing the articles for further processing in a high speed, automated production system.

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DESCRIPTION OF THE PRIOR ART

Recently, attention has been directed toward forming contact lenses in an automated molding system. In such a system, each lens is formed by sandwiching a monomer between front and back mold sections. The monomer is polymerized to form a lens, which is then removed from the mold sections, further treated and then packaged for consumer use.

The mold sections used in the above-outlined process may themselves be formed in injection molding or compression molding processes. These mold sections may be made from the family of thermoplastics, for example polystyrene, which is an excellent material for making these mold sections. Polystyrene does not chemically react with the hydrophilic material used to make the contact lens, therefore, very high quality contact

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REPLACED SHEETS		SG
☒	Description : paged to paged	
☒	Claim(s) : paged to paged	
☒	Drawing(s) : paged to paged	
☒	Abstract : paged to paged	
DATE OF RECEIPT		

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1 lenses may be formed in polystyrene molds. In addition,
polystyrene is widely available and relatively
inexpensive. Because of the ease and low cost with
which polystyrene mold sections may be made and then
5 used to mold contact lenses, each pair of polystyrene
mold sections typically is used to mold only one contact
lens and is then disposed of.

In the above-discussed automated contact lens
production system, it is desirable to eliminate or to
10 minimize any exposure of the hydrophilic monomer to
oxygen. Correspondingly, it is desirable to eliminate
or minimize the exposure of the lens mold sections to
oxygen. Therefore, when polystyrene mold sections are
made and then used in the above-discussed manner, it is
15 desirable to transfer these mold sections quickly from
the mold in which they are made, to a low oxygen
(preferably nitrogen) environment. It is difficult to
achieve the desired transfer speed with conventional
robot assemblies or controls because presently available
20 robots do not move fast enough and precise enough to get
in and out of the mold with the desired speed. In
particular, if these robots are moved with the necessary
speed, they tend to waffle and shake undesirably as they
come to a sudden stop, and the movements of the robot
25 are not sufficiently precise. If the robots are slowed
down to move more precisely, the robots no longer have
the desired speed.

Also, in the above-mentioned automated contact
lens production system, the contact lens mold sections
30 may not be fully solidified when they are ejected from
the mold in which they are made. It is, therefore,

1 important that any robot or apparatus which is used to
carry the lens mold sections away from that mold not
interfere with the desired optical qualities of the
contact lens mold sections. In particular, it is
5 important that any such robot or apparatus absorb the
energy of the lens mold sections as they are transferred
to that robot or apparatus without altering the shape,
form or dimensions of the lens mold sections. That robot
or apparatus must, likewise, be able to carry the lens
10 mold sections in a manner that permits those lens mold
sections to cool and completely harden in the desired
manner.

In addition, in order to maximize the optical
quality of the contact lenses, it is preferred that the
15 optical surfaces of the polystyrene mold sections - that
is, the surfaces of those mold sections that touch or
lie against the hydrophilic monomer as the lens preform
is being molded - not be engaged or touched by any
mechanical handling equipment, as the mold sections are
20 transported and positioned in the lens molding system.

SUMMARY OF THE INVENTION

An object of this invention is to provide an
improved apparatus for removing articles from molds.

25 Another object of this invention is to remove
articles, which may not be completely hardened, from a
mold and to carry those articles away from that mold
without causing undue plastic deformations of the
articles.

30 Another object of the present invention is to
provide a high speed apparatus for removing fragile

1 articles from a mold in which those articles are made,
and then transporting those articles to and depositing
those articles in a high speed, automated manufacturing
system.

5 A further object of this invention is to
transport articles made from the family of
thermoplastics, such as polystyrene, from a mold in
which those articles are made, and into a low oxygen
environment of an automated contact lens molding system,
10 in less than 12 seconds.

 Another object of the present invention is to
remove a plurality of discrete molded articles from a
mold with the molded articles arranged in a matrix
array, and to selectively either preserve that matrix
15 array during subsequent handling of the molded articles,
or reorient the matrix and the relative spacing of the
articles therein according to a second predetermined
matrix.

 These and other objectives are attained with
20 an apparatus for removing and transporting articles from
a mold, which apparatus generally comprises first,
second, and third robots or material handling
assemblies. The first assembly removes the articles
from the mold at the first location and transports the
25 articles to a second location, the second assembly
receives the articles from the first assembly at that
second location and transports the articles to a third
location, and the third assembly receives the articles
from the second assembly and transports the articles to
30 a fourth location. These locations may be selected from
an infinite set of specific locations; and these first,

1 second, third, and fourth locations may change from time
to time and from application to application.

An alternate embodiment of the present
invention further comprises a first intermediate
5 assembly, disposed between the first and second
assemblies, in which embodiment the articles are
transported from the first assembly to the first
intermediate assembly, and said intermediate assembly
transports the articles to the second assembly.

10 Still another embodiment of the present
invention further comprises a second assembly which
changes the relative position of the articles disposed
therein while transporting same from the second location
to the third location, such as moving the articles
15 closer together along one axis and into a denser packed
array. This embodiment further comprises a third
assembly which alters the order of the matrix of
articles.

In each embodiment it is preferable that the
20 first material handling assembly include a receiving
means for retrieving and transporting articles from the
mold to the second location. In several embodiments it
is preferable that the receiving means be a hand having
fingers to receive the articles from the mold and to
25 hold the articles. In other embodiments the first
assembly comprises a vacuum plate having recesses
therein for receiving and securably holding the articles
during translation. With respect to all of the
embodiments, the receiving means is mounted to a support
30 subassembly which, during operation, reciprocates along
an axis, whereby its distal end moves into and out of a

1 proximal position with respect to the locus of mold
section fabrication. The receiving means is mounted on
the support subassembly in a manner which permits
sliding motion along the same axis of reciprocation so
5 that it may reciprocate along the support subassembly
from one end to the distal end. It is understood that
the sliding action of the receiving means, relative to
the support subassembly, may be actuated by a motive
driver of either the receiving means or the support
10 subassembly. The receiving means may, thereby,
reciprocate between the locus of mold section
fabrication and the second location in accordance with
the proper selection of reciprocation rates of the
receiving means and the support subassembly.

15 In addition, the first material handling
assembly further comprises a means for rotationally
pivoting the receiving means between a substantially
vertical orientation and a substantially horizontal
orientation. It is understood that either the receiving
20 means or the support subassembly may comprise a rotating
actuator which drives the rotation.

In the embodiments in which the receiving
means is a hand, the fingers and the hand are preferably
compliant, or are otherwise capable of dampening the
25 energy of the articles, so that transportation of the
articles from the locus of fabrication to the second
location does not cause any undesirable plastic
deformation of the articles, even if those articles are
not completely solidified when they are received by the
30 hand. In embodiments in which the receiving means is a
vacuum plate having recesses, the mounting of the plate

1 to the subassembly is preferably resiliently biased so
that it is similarly dissipative of mechanical energy
imparted during article transference.

The second material handling assembly
5 preferably includes a generally horizontal platform
having receiving ports in its surface which receive the
articles when deposited by the first assembly. The
second assembly translates horizontally from the second
location to the third. In certain embodiments it is
10 additional desired that the platform be mounted on a
support frame having means for move the platform
vertically as well as horizontally at the second
location and/or the third. During operation, the first
assembly transports the articles from the locus of
15 fabrication to the second location and deposits the
articles into the receiving ports in the surface of the
platform. In those embodiments in which the second
assembly moves vertically as well, the assembly moves up
to receive the articles, descends after the articles
20 have been received, and translates horizontally to the
third location.

At the third location a third assembly
retrieves the articles from the second assembly and
transports them to the fourth location, which may be,
25 for example, a pallet. In the preferred variation of
several embodiments, the third assembly comprises a
rotating platform which rotates the articles being
transported by 90 degrees within the horizontal plane.
This reorientation is necessary for use in manufacturing
30 environments having pallets, or other receiving means,
at the fourth location which are oriented orthogonally

1 with respect to the orientation of the matrix of
articles being fabricated and transported by the first
and second assemblies.

In a variant of this embodiment, a first
5 intermediate assembly is disposed between the first and
second assemblies, which intermediate assembly flips the
articles with respect to their vertical orientation, so
that the articles are properly positioned for later
assembly. In such an embodiment the first assembly
10 transports the articles from the first location, which
is the mold station, and deposits the articles into
recessed ports in the first intermediate assembly. Once
the articles have been positioned within the first
intermediate assembly, the assembly rotates about an
15 axis in the horizontal plane, therein flipping the
articles with respect to their vertical orientation, and
deposits them into the ports of the second assembly. In
a preferred variation of this embodiment, the first
intermediate assembly is mounted to both a means for
20 rotating it as well as a means for translating the
platform vertically so that the ports thereof may be
raised in close spaced relation to the receiving means
of the first assembly for accurate deposition of the
articles in the ports, while also more closely
25 approaching the second assembly during transference of
the articles therefrom to the second assembly.

In the preferred variation of the alternative
embodiment in which the second and third assemblies
reorient the articles transported thereby, the second
30 assembly comprises moving blocks on which the articles
are deposited by the first assembly, and which draw

1 together or spread by means of reciprocating elements,
thereby altering the relative spacing of the articles.
In addition, the transference of the articles from the
second assembly to the third assembly is carried out in
5 multiple steps whereby the order of the distribution
matrix may be altered.

The reoriented and redistributed matrix of
articles is then transported to the fourth location by
the third assembly. In this preferred variation the
10 design of the third material handling assembly includes
a plurality of receiving plates having fingers for
grabbing and releasably holding the articles and a
support track to which it is mounted. During operation,
the receiving plate descends to the third position where
15 it removes the articles from the second assembly
platform ports via the grabbing function of the fingers.
The receiving plates and the articles are then raised
and transported to the fourth location, during which
translation the receiving plates may be drawn together
20 to further tighten the distribution of the articles.
Once the third assembly has reached the fourth location,
the articles are lowered and deposited, for example into
pallets in which the articles may be carried to the lens
fabrication stations.

25 Further benefits and advantages of the
invention will become apparent from a consideration of
the following detailed description given with reference
to the accompanying drawings, which specify and show
preferred embodiments of the invention.

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1 BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a simplified perspective view of the first apparatus according to the present invention.

Figures 2a, 2b, and 2c are side views of variation 5 of the first assembly which may be included in the apparatus shown in Figures 1, 5, and 9.

Figure 3 is a perspective view of the second assembly which is included in the first apparatus shown in Figure 1.

10 Figure 4 is a time-function chart illustrating the integrated cycles of operation of the first apparatus.

Figure 5 is a simplified perspective view of the second apparatus according to the present invention.

Figure 6 is a perspective view of the flipper 15 assembly which is included in the apparatus shown in Figure 5.

Figure 7 is a perspective view of the third assembly which is included in both the first and second apparatus.

20 Figure 8 is a time-function chart illustrating the integrated cycles of operation of the second apparatus.

Figure 9 is a simplified perspective view of the third apparatus according to the present invention.

Figure 10 is a perspective view of the collapsing 25 second assembly which is included in the third apparatus shown in Figure 9.

Figure 11 is a perspective view of the third assembly of the third apparatus as shown in Figure 9.

Figure 12 is a time-function chart illustrating the 30 integrated cycles of operation of the third apparatus.

Figures 13a, 13b, 13c, and 13d are edge and top

1 views of the back and front mold sections which may be
transported by this invention.

Figure 14 is a side view of one of the bellowed
fingers which is included in one variation of the first
5 assembly of this invention.

Figure 15 is a side view showing the coupling of
the vacuum plate to the vacuum head of the first
assembly of the first apparatus.

10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This invention relates to the removal of
molded articles, which are used in the fabrication of
contact lenses, at regular intervals from a molding
station at a first location, and subsequent disposition
15 of the articles at a remote location, such as on a
pallet of an assembly line. As such, this application
herein incorporates by reference the specification and
disclosure of U.S. Patent Application 08\258,654 to
Wallace Anthony Martin et al. (attorney Docket No. VTN-
20 0092) for "Consolidated Contact Lens Molding". The
present invention is particularly suited for carrying
out the above identified function in an improved manner
than prior devices and assemblies. The following
descriptions, with references to the corresponding
25 Figures, set forth the salient features and elements of
three distinct embodiments of the present invention; the
first being directed to the removal and transportation
of back curve mold halves; the second being directed to
the removal and transportation of front curve mold
30 halves; and the third being directed to the removal and
transportation of molded packaging elements.

1 BACK CURVE TRANSPORT ASSEMBLY

 The process of fabricating contact lenses, in
a manner for which the present invention would be
useful, comprises creating a pair of mold halves,
5 between which a liquid monomer may be disposed, shaped
into a lens, and subsequently irradiated to prompt
sufficient crosslinking to provide appropriate
structural integrity to the lens. The mold half sections
which are used in creating the lenses are themselves
10 molded; the molding process being especially intolerant
of irregularities to the optical perfection required of
the surfaces. The mold sections are created in a rapid
injection molding machine which produces a multiplicity
of mold sections every six seconds.

15 The molding machine comprises two opposing
elements which interface to shape the mold halves; one
element having an array of regularly spaced concave
recesses, the opposing element having a corresponding
array of convex protuberances. The concave recesses and
20 convex protuberances defining, therebetween, a shaped
volume for producing mold half sections. A more detailed
description of the molding machine, in conjunction with
which the present invention is utilized, may be found in
the copending U.S. Application Number 08\257,785 for
25 "Mold Halves and Molding Assembly for Making Contact
Lenses" (attorney Docket VTN-079), which is incorporated
herein by reference.

 In operation, the opposing elements come
together, the material of the mold halves, for example
30 molten polymer, is injected into the shaped volumes
between the surfaces of the opposing elements, and the

1 mold halves are held for a period of time sufficient to
set their shapes.

Once the shape of the mold half has been set,
the opposing elements of the molding machine separate
5 and the mold halves may be removed. The back curve mold
halves are referred to as such because they provide the
convex optical mold surface which shapes the portion of
the contact lens which contacts the eye. The front curve
mold halves are so called because they provide the
10 concave optical surface which molds the front face of
the lens. In accordance with methods set forth to
maintain optimal optical surface integrity, the molding
machine which produces the back curve mold sections is
designed specifically so that upon separation, the non-
15 optically relevant, concave surfaces of the mold halves
are exposed (the convex surfaces remaining within the
concave recesses). While the machine which produces the
front curve mold sections is identical in nearly every
functional aspect to the above described back curve
20 machine, when the opposing elements of the front curve
molding machine separate, the front curve mold sections
remain in contact with the convex protuberances. In
either case, it is once the opposing elements of the
molding machine have separated that the molded articles
25 may be removed.

Figures 13a-d show front and back curve mold
sections which are used in the manufacture of contact
lenses. Figures 13c and 13d are top and side views,
respectively, of a back curve mold section; which
30 includes a central lens shaping curved portion 452, an
annular flange portion 451, and a tab 461. Because, in

1 the case of the back curve, the central curved portion
is used to form or shape the back curve or surface of a
contact lens, it is desirable to minimize direct contact
therewith; the flange 451 and tab 461 portions are,
5 therefore, used to facilitate handling and positioning
the article. The simultaneous molding of the curve
surface 452 with the annular flange 451 and tab 461
portions has an additional manufacturing benefit in that
it optimizes the injection molding process.

10 Preferably, the mold sections are each
integrally molded from a plastic material from the
family of thermoplastics such as polystyrene or another
suitable material; and preferably each mold section has
a thickness, typically 0.8 mm and 0.6 mm respectively,
15 and rigidity such that the mold section effectively
transmits light and withstands prying forces applied to
separate the mold sections from the mold in which those
section were made. The mold sections are also described
in detail in the above-referenced copending application
20 "Mold Halves and Molding Assembly for Making Contact
Lenses".

The first apparatus to be described is,
accordingly, directed to the removal and rapid and non-
damaging transport of the back curve contact lens mold
25 halves from the molding station to a remote location,
for example to a pallet on a contact lens fabrication
assembly line. More particularly, referring now to
Figure 1, the first apparatus 10 includes first, second,
and third material handling assemblies 20, 30, and 40.
30 The first assembly 20 is provided for removing the
articles from the mold 12 at a first location and

1 transporting the articles to a second location. A second
assembly 30 is positioned for receiving the articles
from the first assembly 20 and transporting the articles
from the second location to a third location. The third
5 assembly 40 is provided for receiving the articles from
the second assembly 30 and for transporting those
articles from the third location to a fourth location,
which is the remote location, for example a pallet 50 on
a contact lens manufacturing line 52.

10 With reference to Figures 2a and 15, the first
assembly 20 includes a vacuum head structure 102, a
horizontally aligned cursol arm 104, a vertically
mounted traveling arm 106 and a stationary support
subassembly 108. The stationary support subassembly 108
15 includes a support frame 110, to which it is fixably
mounted, and a main body structure 112. Within the main
body structure 112 are a vacuum controller unit 114 (the
cover of which is shown), and a translating means (not
shown) which reciprocates the vertically mounted
20 traveling arm 106 along the horizontal axis. In a
preferred embodiment, this translating means comprises a
horizontally oriented ballscrew.

 At its remote end 116, the vertically mounted
traveling arm 106 is fixably coupled to the horizontally
25 aligned cursol arm 104. Reciprocation of the vertical
arm 106, necessarily causes the cursol arm 104 to move
with a regular forward and backward sliding motion, in
accordance with the horizontal translation of the ball
screw. A timing belt (not shown) is coupled to the
30 horizontal ball screw in the main body structure 112 and
extends down the vertical arm 106 and along the extent

1 of the cursol arm 104. Slidably mounted to the cursol
arm 104, and coupled to the timing belt, is the vacuum
head 102 which is translated along the length of the
cursol arm 104. This arrangement permits the additive
5 motion of the vertical arm 106 and the vacuum hand 102,
therein permitting the hand 102 to travel to the first
location, which is between the separating opposing
elements, without either the head or arm having to
attain undesirably high relative velocities, which may
10 lead to vibration. In a preferred embodiment, the timing
belt defines a ratio of velocity of the vacuum head 102
to the cursol arm 104 of 2 to 1.

The vacuum head 102 of the preferred
embodiment comprises a vacuum plate 103 having recesses
15 105 into which the articles may be placed. The vacuum
plate 103 is mounted to the vacuum head via multiple
silicone bellows 27 and a linear slide 29 (also see
Figure 1, elements 121). This mounting permits the plate
103 to reciprocate with respect to the vacuum head 102,
20 in accordance with the drawing of a vacuum in the plate
103.

Once the vacuum head 102 has been translated
into the molding station 12, and is at the extreme point
of its reciprocation, an actuator and timing mechanism
25 (not shown) activates the vacuum drawing means (also not
shown). It is understood that a variety of equivalent
means may be utilized for drawing a vacuum within the
vacuum plate 103, however, a venturi tube system is
particularly well suited for this apparatus 10 as the
30 vacuum drawn in the plate 103 needs to be strong enough
to hold the articles, but not so strong as to deform the

1 optical surfaces of the hardening plastic.

The molding station 12 has ejector pins (not shown) which push the curve articles out of the mold element and into the recesses 105 in the vacuum plate 5 103. The vacuum which is being drawn in the recesses 105 and the plate 103 assists the securing of the articles within the recesses. Once the sealing of the articles to the vacuum plate 103 causes the plate to move toward the vacuum head 102. It is preferable to have a set of 10 resilient silicone bellows which mount the vacuum plate 103 to the vacuum head 102 so that the plate may be biased back to the extended position away from the vacuum head once the vacuum is released.

The recesses 105 may comprise small recesses 15 formed in a surface of the plate, or small cups mounted on that surface of the plate, or the bellowed fingers further described with respect to the front curve transporting apparatus and Figure 14. It is also preferable that the receptacles be connected to a vacuum 20 source, so that the resultant low pressure in the recesses may assist in the transference of articles from the molding station to the plate as the ejector pins eject the articles from the mold. The entire transference process is carried out through the steps 25 of: having the head translate forward to a position adjacent to the mold station element; having ejector pins push the molded articles forward towards the recesses of the plate; the vacuum suction securing the articles within the recesses; the sealed vacuum conduits 30 providing the low pressure within the vacuum plate structure so that the plate is retracted away from the

1 mold station element.

Referring again to the specific embodiment shown in Figure 1, the mounting of the vacuum head 102 to the cursol arm 104, which head is slidably coupled 5 thereto for reciprocation forward and backward, from the first mold half pickup location to the second mold half drop-off location, further comprises a rotating joint 25. This joint 25 is driven, by an air cylinder (not shown) having stops thereon, which permits the head and 10 plate 102,103 to rotate from vertical to horizontal, through a 90 degree rotation, during each linear stroke of the regular reciprocation of the hand. In operation, when the vacuum head 102 begins its linear reciprocation after receiving the mold half articles from the mold 12, 15 it is oriented vertically (in correspondence with the plane of the mold element face). As the head 102 is translated, along with the cursol arm 104, toward the second location, it is rotated into a horizontal position wherein the recesses 105 in the vacuum plate 20 are oriented downward. At the second location the articles are released from the recesses, via release of the vacuum, into a platform of the second assembly 30. Once the articles have been released and the head 102 begins to reciprocate back toward the mold 12, it is 25 rotated back into a vertical orientation for the next pickup.

It is understood that the rotation of the head 102 through the 90 degree rotation be achieved equivalently by a number of different means, for example 30 by providing a translation track along the cursol arm which has a 90 degree twist, the linear reciprocation of

1 the head along the cursor arm, therein also imparting a rotation of 90 degrees to the head 102.

Preferably, this first assembly 20 is a high speed, low mass assembly, and is able to move the head 5 102 into the mold 12 and remove articles therefrom in less than 0.8 seconds, and more preferably, in less than 0.4 seconds. Also, preferably the head 102 is constructed of a low mass, high stiffness material, for example, polyvinylchloride foam core and carbon fiber 10 unidirectional fabric.

Referring now to Figures 1 and 3 the second assembly 30 of this embodiment is shown. The second assembly 30 includes a platform 34, a translating carriage structure 39, and a support frame 36 forming 15 linear tracks 38 along which the translating carriage structure reciprocates from the second location to the third location. It is understood that a variety of suitable means for steady and efficient translation of the assembly may be selected, for example a motor and 20 ball screw, a reciprocating hydraulic arm, or a geared wheel and motor combination. In the preferred embodiment, the translation means is a two ballscrew system, the first of which translates the assembly from the second location to the third, and the second of 25 which raises and lowers the assembly at each location in accordance with the preferred function of the apparatus.

The platform 34 of the second assembly 30 has a regular array of recesses 35 which are suited for the deposition into, and removal therefrom, of mold articles 30 such as are deposited therein by the first assembly 20 at the second location. In operation, the first assembly

1 20 reciprocates back from the mold 12, having extracted
the mold articles therefrom, and rotates from a vertical
orientation to a horizontal orientation by the time that
it reaches the second location. Simultaneously with the
5 proper orientation and positioning of the first assembly
20 at the second location, the second assembly 30 is in
position for receiving the articles. The release of the
vacuum within the vacuum plate 103 of the first assembly
allows the articles to drop into the recesses 35 of the
10 platform of the second assembly 30. Once the articles
have been so positioned, the second assembly 30
translates linearly along the tracks 38 to the third
location.

Referring now to Figures 1 and 7, the third
15 assembly 40 includes a receiving head 42, a support body
46, a rotating coupling means 44, and a horizontal
reciprocating track 48. The first end 45 of the support
body 46 is disposed in the track 48, and coupled to a
translation means whereby the body 46 (and the receiving
20 head et al.) may be reciprocated from the third location
to the fourth location. The means of translation of the
support body, and the receiving head 42, is preferably a
horizontal axis ball screw assembly. The support body
46 is coupled to the rotating coupling means 44, which
25 is, in turn, coupled to the receiving head 42. The
rotating coupling means 44, which may be, for example an
air cylinder with 90 degree rotation stops, is designed
to provide a rotation of the receiving head in the
horizontal plane.

30 In addition, the support body 46 comprises a
vertical axis ball screw which permits translation of

1 the receiving head 42 up and down. This up and down
motion is preferred in the retrieving and depositing
functions of the third assembly at the third and fourth
locations respectively.

5 The receiving head 42 is oriented downward to
enable it to extract the articles from the platform 34
of the second assembly 30 at the third location, and to
subsequently deposit the articles at a fourth location,
for example in a pallet 50 on an assembly line 52. The
10 receiving plate 42 comprises an array of bellowed
fingers 22, which will be more fully described
hereinafter with respect to Figure 14. A low pressure
may be drawn in the fingers for lifting the articles out
from the recesses 35 in the platform 34 of the second
15 assembly 30, and for holding and transporting the
articles from the third location to the fourth location.

 It is understood that individuals ordinarily
skilled in the art may substitute other extraction,
grasping, and holding means and relationships for the
20 exchange of the articles between the assemblies herein
described without removing such an apparatus from the
scope of the invention herein disclosed. Another such
alternative transference means could include a set of
extending pins, disposed in the recesses of the second
25 assembly, which would lift the mold curves out of the
recesses at the third location, and insert them into
receiving recesses in the third platform such as
comprises the first assembly. In such a design, however,
particular care must be taken to prevent misalignment of
30 the articles with respect to one another during the
transference.

1 In operation, the receiving plate 42 of the
third assembly 40 is first positioned at the third
location, oriented so that its fingers (or other
receiving means) are properly positioned for extraction
5 of the articles from the platform 34 of the second
assembly 30. Once the articles have been extracted by
the third assembly 40, the mounting arm is translated
along the track 48 via a ball screw mechanism, toward
the fourth location, during which translation the
10 rotating air cylinder 44 reorients the plate 42 by 90
degrees in the horizontal plane. At the distal end of
the translation, if a receiving structure, such as a
pallet 50, is properly positioned with the plate 42
positioned thereabove, the vertical ball screw within
15 the support body 45 lowers the plate 42, and fingers
thereof, to the deposition pallet. Once in position,
articles are released by the plate and deposited.

 If it is determined that no proper receiving
structure 50 is present at the fourth location, the
20 third assembly 40 is reciprocated via the rotating ball
screw, back toward the third location, stopping briefly
at an intermediate location between the third and fourth
locations and releases the mold half articles into a bin
60. These released mold halves may then be discarded,
25 recycled, or otherwise utilized in other manufacturing
processes. For example, during quality testing of the
mold halves being produced by the mold, a testing
apparatus may be inserted at the intermediate location
which receives the released articles for testing
30 purposes.

 It is to be understood that control means may

1 be provided to move the various elements of this
apparatus in the desired sequence, and to interrupt or
terminate operation of the apparatus under predetermined
conditions. For instance, one or more timers may be
5 provided and programmed to generate signals to initiate
movement of the movable components of assemblies. Timers
may also be provided and programmed to operate solenoid
activated valves that connect bellows or suction plate
receptacles to positive and negative pressure sources at
10 the desired times. Position sensors may also be used to
initiate movement of the movable elements of apparatus
and to operate the above-mentioned valves, in response
to various elements of the apparatus, such as vacuum
head 102, the platform 34 of the second assembly 30, and
15 the third assembly receiving plate 42, reaching
predetermined positions. If desired, position sensors
may be used to sense whether the movable elements of
apparatus 10, such as the reciprocating cursor arm 104
and vacuum head 102, are moving between the appropriate
20 locations.

In addition, sensors may be provided to
determine if each of the recesses receives a respective
one contact lens mold section from mold and to determine
whether these contact lens mold sections are properly
25 transferred from assembly to assembly. For example, such
sensors may be located in and sense the pressures in the
suction lines leading to the internal plenums or volumes
of the assembly platforms.

To elaborate, when contact lens mold sections
30 are properly mounted in the recesses of a platform
element, for example, those lens mold sections close the

1 ends of the internal volumes of the platform. If the
contact lens mold sections do not provide the seal to
the internal volumes, when the low pressure source is
actuated, the pressure does not reduce to the proper
5 securing level. Thus, the pressure inside the internal
plenums through which the vacuum pressure is drawn is an
indication of whether contact lens mold sections are
mounted properly, and a pressure sensor may be employed
to generate a signal or an alarm to indicate when a
10 contact lens mold section is missing from one of the
bellows.

The function and relation of all of the
assemblies which comprise apparatus 10, which together
are one embodiment of the present invention is complex,
15 having been individually described in detail in the
foregoing discussion. Referring now to Figure 4, a time-
position-function table showing the relative positions
and functions carried out by all of the assemblies of
this embodiment is shown. The back curve mold transport
20 apparatus, which is the first embodiment of the present
invention, having first, second, and third assemblies
which function as described above, operates in the
following manner. Beginning with the initial forward
motion of the first assembly, the cursol arm is
25 translated toward the molding station, which is still
closed, forming the mold articles. As the cursol arm
slides forward, the vacuum hand structure rotates into a
vertical position so that the vacuum plate and the
recesses there are properly oriented for receiving the
30 mold articles. The cursol arm comes to a temporary halt
as it waits for the mold station to open. Once the

1 opposing elements separate, the cursor arm translates forward, positioning the vacuum plate adjacent to the mold station element to which the molded articles remain adhered to.

5 In this embodiment, it is important to note that the vacuum plate is coupled to the vacuum head by resilient means, for example silicone bellows and a linear slide. At this moment in the transport cycle, the vacuum plate is in its extended state as no vacuum can
10 be maintained in the vacuum plate because the recesses of the plate are empty. A set of ejector pins within the molding station element are extended, therein pushing the molded articles out of the concave recesses in the molding station element, and pushing them into the
15 recesses of the vacuum plate. If the ejector pins push the molded articles too far into the recesses, the bellowed mounting silicone cups are compressed under the load, moving the plate back, and therein ensuring that the mold sections are not damaged. If the mold sections
20 are not pushed far enough into the recesses the subsequent act of drawing a vacuum in the plate will provide sufficient suction to draw the articles fully into the recesses.

 In the fully inserted position, the external
25 rim of the molded articles contacts the annular rim at the base of the vacuum plate recesses, therein together sealing the internal volume within the plate. The vacuum which is drawn in this volume of the plate secures the molded elements within the plate while simultaneously
30 causing the silicone bellows to retract, thereby pulling the plate away from the mold and closer to the vacuum

1 head.

It is understood that one skilled in the art might substitute equivalent means for resiliently mounting the vacuum plate to the vacuum head, for example with vacuum pistons and biasing springs, or with an actuatable air cylinder. These are equivalent means which, along with a myriad of other equivalencies, are anticipated herein and are within the broad scope of the invention.

10 Once the articles have been secured within the recesses, the cursol arm begins to reciprocate back toward the second location, to the waiting second assembly. As the cursol arm reciprocates back, the vacuum head is rotated down, so that the recesses of the
15 plate are directed downward, the vacuum drawn in the plate keeping the articles within the recesses, and keeping the plate in a retracted position on the silicone bellows.

 Once the first assembly has reciprocated all
20 the way back to the second location, with the vacuum plate rotated down and disposed directly above the platform of the second assembly, the first assembly stops. The second assembly rises slightly via a vertical ballscrew mechanism, bringing its platform closer to the
25 plate, with the recesses of each surface aligned for easy article transference. It is understood that a variety of equivalencies may be substituted for the ball screw mechanism for lifting the platform of the second assembly, such as a mechanically scissoring structure, a
30 pneumatic, or hydraulic lift. These equivalencies are anticipated herein and are, therefore, incorporated as

1 reasonable variations of the present embodiment.

At this moment the vacuum is released within
the vacuum plate of the first assembly, therein
releasing the vacuum grip on the mold articles. In some
5 variations of his embodiment, the vacuum release is
coupled with the application of positive pressure to
ensure the ejection of the mold sections. In either
case, the release of the vacuum causes the vacuum plate
to extend downward to its extended position by the
10 resilient coupling silicone bellows.

Once the articles have been transferred, the
platform of the second assembly drops and begins to
slide from the second location to the third location. As
this happens the first assembly begins to reciprocate
15 forward, and the vacuum plate rotates back into its
vertical position (back in its extended state). By the
time that the first assembly has rotated the plate
vertically, and has halted in anticipation of the mold
station opening, the second assembly has reached the
20 third location, below the waiting third assembly and is
stopped. The receiving plate of the third assembly drops
down to meet the platform of the second assembly, and
the articles are extracted by the receiving plate in a
suitable manner, such as were more fully described
25 above.

Once the articles have been extracted by the
third assembly, the receiving plate rises up, is rotated
90 degrees (thereby rotating the articles) in the
horizontal plane, and begins to slide back to the fourth
30 location. Simultaneous with the third assembly rotating
the receiving plate, the molding station separates and

1 the first assembly enters to extract a new batch of
articles from the station. At the same time, the second
assembly reciprocates back to the left, moving back to
the second location to receive the new batch of
5 articles.

By the time that the third assembly reaches
the fourth location, the first assembly has slid back to
the second location and has rotated the hand to the
horizontal position for depositing the articles into the
10 platform recesses of the second assembly. At the fourth
location, the third assembly drops down and deposits the
articles, for example onto a pallet, in a manner which
is both simultaneous with and similar to the deposition
of the new batch of articles into the second assembly.

15 As the third assembly rises and rotates back
to the orientation for receiving articles from the
second assembly, the first assembly begins to slide
forward again to extract another batch of articles which
are being fabricated in the molding station, and the
20 second assembly slides to the third location to give up
its articles to the third assembly. Thus the repetitive
cycle of the first apparatus, which is to transport a
batch of back curve articles from a molding station at a
first location to a fourth location, has been
25 illustrated.

The advantage of this apparatus over a single
assembly design in which the back curves are extracted
from the molding station and moved to the manufacturing
line by one assembly, is that the distance and velocity
30 which each assembly needs to attain in the present
invention is reduced during the transport of the same

1 number of articles. This advantage is particularly
important when the inertially imparted vibration
associated with high speed translation is considered.

5

FRONT CURVE TRANSPORT ASSEMBLIES

Referring now to Figures 2b, 5-8, 13a-b, and
14, the second embodiment of the invention is the second
apparatus 210, which is used to transport articles, such
as the front curve contact lens mold halves, from a
10 first location, such as an injection molding station
212, to a remote location, such as a pallet 250 on a
contact lens fabrication line 252. This embodiment
includes assemblies 220, 230, 240 which are very similar
in form and function to the similar assemblies described
15 above with respect to the apparatus which transports
back curve mold halves from the mold to the pallet. The
differences between the first and second apparatus being
those related to the additional step of flipping the
articles, the need for which was described earlier. The
20 front curve mold articles are fabricated in an injection
molding station comprising two mated opposing elements,
the first of which has a regular array of convex
protuberances which are aligned with an array of concave
recesses in the opposing face of the second element. The
25 optical shaping surface of the front curve mold half is
the interior surface of the resultant cup. The
manufacturing desirability of minimizing contact with
the optical surface of the mold leads to the front
curves remaining adhered to the convex protuberances
30 upon separation of the mold station elements. The first
assembly 220 of the second apparatus 210, which is shown

1 in Figure 5, and more particularly in Figure 2b,
therefore, extracts the articles from their convex side
(at the annular ring which extends beyond the edge of
the cup 452, as shown in Figures 13a and 13b).

5 With particular reference now to Figures 2b,
5, and 14, the vacuum head structure 102 of first
assembly 220 comprises a hand 102 which includes an
array of resilient fingers 22, extending uniformly from
a vacuum plate 24 which is coupled to the cursol arm 104
10 via the mounting means and the timing belt. The fingers
22 are ideally suited to receive contact lens mold
articles from the molding machine 212 after the opposing
elements separate, and to releasably hold the received
articles while the hand 102 and cursol arm 104 translate
15 back from the first location to the second location.

The embodiment of the vacuum hand 102,
illustrated in Figures 2b, 5, and 14, shows finger 22 as
having a bellows structure 410. This bellows structure
enables the fingers 22 to retract if an external
20 pressure (or internal vacuum) is applied. In the forward
most extended position, the hand 102 and cursol arm 104
align the bellowed fingers 22, which are in their fully
extended state as well, between the separated opposing
elements of the molding machine 212, as shown in Figure
25 5. In this position, each of the fingers 22 is aligned
with a respective one of the convex protuberances of the
corresponding opposing element (not shown) and, thus,
with a respective one of the articles formed in those
mold cavities. Ejector pins (not shown) are used to push
30 the formed articles off the convex protuberances and
into engagement with the extended bellowed fingers 22.

1 With particular reference to Figure 14, each
of the bellowed fingers 22 preferably has an axially
extending annular section 412 that forms an extended
suction-cup shaped tip 414 on which the contact lens
5 mold sections are placed. In particular, when a front
curve is transferred onto one of the fingers 22, the
annular flange 402 of the front curve makes contact with
the extending annular suction-cup tip 414 of the
bellowed finger 22, therewith forming a sealed volume
10 416 within the finger. In this way, the optical surface
401 is not touched by the bellowed finger 22.

As stated above, the bellowed fingers 22
extend outward from a vacuum plate 24, the vacuum plate
comprising at least one internal plenum 418 connecting
15 the volume within the suction cup tips 414 of the
bellowed fingers 22 in gas flow communication with
vacuum lines 26. In the embodiment shown in Figures 2b
and 14, the individual vacuum lines 26 merge at a node
28 to form a single vacuum line 32. The low pressure
20 which may be drawn by a vacuum venturi (not shown) in
the suction cup tips 414 of the bellowed fingers 22 is
useful for handling the articles being transported. In
particular, a low pressure may be developed inside
bellows 410 to help move the articles onto the bellows
25 from mold recesses and that low pressure may be
maintained in the bellows to help hold the articles
thereon as the hand 102 is translated to the second
location. When the low pressure is drawn, the bellowed
fingers 22 retract toward the vacuum plate 24 in
30 accordance with their resiliency.

The low pressure source that is connected to

1 bellows vacuum plate 24 may be, for example, a vacuum
venturi or a vacuum pump, or a source of pressure,
referred to as a negative pressure, that is less than
the ambient pressure. Also, preferably, that at least
5 one internal plenum 418 within the vacuum plate 24,
which connect each of the bellowed fingers 22 of the
hand 102, is a single common plenum which connects the
fingers to the vacuum line. In a preferred variation of
the illustrated embodiment, a solenoid controlled valve
10 (not shown) may be located in the vacuum line 32 to
selectively seal and release the vacuum in the plenum
and, therethrough, selectively evacuating and releasing
the vacuum in the bellowed fingers 22.

As stated above, the bellowed fingers 22 are
15 compressible so that they may dampen and absorb the
energy and momentum of the contact lens mold sections as
those mold sections are transferred from mold 12 to the
fingers 22. In this way, the contact lens mold sections
can be transferred from mold 212 to the bellows 22 at a
20 relatively high speed without damaging or deforming the
contact lens mold sections, even if those mold sections
are not completely solidified or hardened when they are
transferred to the bellows. Problems associated with
mechanical variation in separation distance of the
25 opposing elements interfering with consistent and proper
removal of the mold halves from the mold 212, are solved
with resilient and compressible fingers 22.

A means for providing a positive pressure
within the bellowed fingers 22 may also be provided, via
30 the same vacuum line 32 through which the vacuum is
drawn, and may be controlled by the same solenoid valve

1 (not shown). This positive pressure may be used, if necessary to break any mechanical sealing which may develop between the mold section and the tip 414 of the bellowed finger 22.

5 As may be clearly understood, the first assemblies of the first and second apparatus differ. In the first apparatus a vacuum head, coupled to a vacuum plate with recesses is used; in the second bellowed fingers extending from a vacuum plate is used. In the 10 first apparatus, because the back curves are received in an orientation having the mold halves oriented so that they are extending outward with respect to the receiving plate, in order to ensure that the vulnerable convex surface will not be damaged in transport, the preferred 15 variation is the vacuum plate with recesses. In the second apparatus, because the front curves are extracted from the molding station in an orientation having its convex surface facing inward with respect to the plate, the preferred variation comprises the resilient bellowed 20 fingers.

Both preferred variations of the first assembly comprise a horizontal arm which reciprocates a vacuum hand between a first location and a second location via a ball screw and a timing belt, and are 25 ideally suited for holding their corresponding curve articles by suction means. In this second apparatus, however, the first assembly 220 does not place the articles which it collected from the molding station 212 at the first location into a second assembly. Rather, it 30 places the articles in the recessed ports of a flipper platform 274.

1 Referring now, also, to Figure 6, the action
of the fingers of the first assembly 220 are
particularly suited for both receiving the front curves
from the molding station 212 and the deposition of the
5 curves into the flipper assembly 270. At the mold
station, ejector pins push the articles out to contact
the tips 414 of the fingers 22, whereupon a vacuum is
drawn in the interior volume 416 of the finger tips
which secures the articles thereto. The vacuum also
10 causes the bellowed fingers 22 to retract away from the
mold element, therein providing additional clearance for
the hand as it reciprocates away from the molding
station.

To ensure the smooth operability of the first
15 assembly, it may be desirable to couple various the
appending wires, hoses or flexible lines together and to
one of the structural elements, for example the
stationary support subassembly to guide any such wires
or lines and to help insure that these wires or hoses do
20 not become entangled with one another as the hand 102
and cursor arm 104 reciprocate. This same expedient may
be incorporated into the embodiments of each assembly of
the invention, in each apparatus.

Once the hand 102 has rotated downward and is
25 positioned to drop the secured articles into the flipper
270 assembly, the vacuum is released within the finger
tips 414. The combined effects of gravity and the
extending fingers 22 provides ample force for the
articles to be gently pushed from the tips 414 of the
30 fingers. A variation of this embodiment includes a
positive pressure means coupled to the vacuum line for

1 providing an additional pressure to the articles from
within the tips to ensure that they are deposited by the
fingers.

It is understood that the articles, when
5 transported by the first assembly 20 of the first
apparatus 10, are carried to the second location where
the convex surface of the articles face downward. They
are subsequently deposited into each of the subsequent
assemblies of the apparatus with the convex surface
10 facing down, and are ultimately placed into a pallet
with their convex surfaces down. In the second apparatus
210, the first assembly 220 extracts the articles and
carries them to the second location with the convex
surfaces facing upward.

15 The second apparatus 210, therefore, includes
an additional assembly 270 which receives the articles
from the first assembly and flips them before depositing
them in the second assembly. In this way the articles
are positioned to be ultimately deposited in a pallet
20 with convex surface down.

The flipper element 270 comprises a
substantially flat platform 274 having a regular array
of recesses 275 therein for receiving a plurality of
articles. The platform 274 is mounted to a motive
25 structure 279 which provides for independent vertical
and rotational movement, whereby the platform may be
raised to meet the fingers of the first assembly and
then drop away, thereby providing sufficient spacing for
the platform to flip over. While it is understood that a
30 variety of means may be employed which achieve the
vertical axis motion and the rotational motion described

1 herein, the preferred embodiment of this assembly
comprises a vertical ball screw mechanism 291 mounted
within the base of the motive structure 279, and a
rotating air cylinder 292 for rotation.

5 It is understood that the recesses 275 of the
flipper assembly are preferably coupled to a vacuum
means so that the articles may be secured within the
recesses during inversion. In addition, it is highly
preferable that the vacuum means be selectively
10 disengagable so that the articles may be reliably
released from the recesses 275 when deposition of the
articles into the second assembly is appropriate.

 Once the platform 274 has inverted, therein
inverting the articles disposed therein, the flipper 270
15 drops the articles into the recesses 235 of a second
assembly 230 which is generally similar to the second
assembly 30 of the first apparatus 10. This version of
the second assembly comprises a platform 234 having
recesses 235, a translating carriage structure 239, and
20 a support frame 236 forming linear tracks 238 along
which the translating carriage structure 239
reciprocates from the second location to the third
location. As before, as well, this version of the
invention includes means within the support frame 236
25 for lifting the platform 234 vertically to meet the
flipper element and to receive the articles therefrom
with the least exposure of the molds. It is understood
that a variety of different means for lifting the
platform would be suitable, for example a selectively
30 extendable piston coupled between the bottom of the
platform and the carriage structure, or a ballscrew and

1 motor drive system. In the preferred embodiment of both variations of the second assembly 30, 230, the translation means in both the horizontal and vertical planes are both ball screw mechanisms, one having a vertical orientation, the other being horizontal. It is desirable for the horizontal ball screw element to be mounted within the support frame 236, and for the vertical ball screw element to be mounted in the translating carriage structure 239.

10 Once the articles have been placed into the recesses 235 of the second assembly 230, the platform is lowered and translated to the third position via the translating carriage structure 239 which moves horizontally along tracks 238. At the third location the
15 lifting means again raises the platform 234, this time to meet the third assembly 240, which extracts the articles therefrom.

 The third assembly 240 of the second apparatus 210, which comprises a similar set of elements as the
20 third assembly 40 of the first apparatus 10, further has a support body 246 which is motively coupled to a track 248 which has means for translating the assembly from the third location to the fourth location, and to lower (and raise) the platform to (from) the second assembly
25 230 or the pallet 250 during exchange of the articles. As before, it is preferred that ball screw elements, both horizontally and vertically oriented be used to motively translate the appropriate assembly elements. In addition, also, the third assembly 240 rotates in the
30 horizontal plane while transporting the articles to the fourth location for deposition, for example into a

1 pallet. The means for imparting the rotation is preferably an air cylinder, having 90 degree rotation stops. As in the first apparatus, if the appropriate pallet 250 is not present at the fourth location at the 5 appropriate time for deposition, the third assembly 240 transports the articles back to an intermediate position, between the third and fourth locations, and releases the articles into a bin 260.

It is to be understood that, as with respect 10 to the first apparatus, control means may be provided to move the various elements of this apparatus in the desired sequence, and to interrupt or terminate operation of the apparatus under predetermined conditions. For instance, one or more timers may be 15 provided and programmed to generate signals to initiate movement of the assemblies. Timers may also be provided and programmed to operate solenoid activated valves that connect the bellowed fingers of the first assembly, vacuum head, and the vacuum lines to positive and 20 negative pressure sources at the desired times.

Position sensors may also be used to initiate movement of the assemblies and to operate the above-mentioned valves, in response to various other assembly parts such as the vacuum hand, the flipper assembly, or the second 25 assembly reaching their corresponding predetermined positions.

In addition, sensors may be provided to determine if each of the bellowed fingers 22, or the recesses in the platforms of subsequent assemblies, 30 receives a respective one contact lens mold section from the mold. Sensors may further be employed to determine

1 whether the contact lens mold sections are properly
transferred from the first assembly to subsequent
assemblies. For example, such sensors may be located in
and sense the pressures in the suction lines leading to
5 the bellowed fingers, recesses, and vacuum platforms of
the flipper, second and third assemblies.

To elaborate, when contact lens mold section
are properly mounted on all of the bellowed fingers 22,
and the bellows 410 are connected to a low pressure
10 source, the pressure inside the internal plenums 418 and
lines 26 leading to the fingers is reduced to a
predetermined level. In contrast, if contact lens mold
sections do not seal the tips of all of the bellows
fingers 414, when those bellows 410 are connected to the
15 low pressure source, the pressure inside the lines 26
and plenums 418 is not reduced to the vacuum securing
level. Thus, the pressure inside the lines and internal
plenums is an indication of whether contact lens mold
sections are mounted on all of the bellows, and a
20 pressure sensor may be employed to generate a signal or
an alarm to indicate when a contact lens mold section is
missing from one of the bellows.

The most important difference between the
first apparatus 10 and the second apparatus 210 is
25 understood to be the inclusion of an additional assembly
270 which flips the articles over. The function and
relation of all of the assemblies which comprise
apparatus 210, which together form the second embodiment
of the present invention, having been individually
30 described in detail in the foregoing discussion are now
described in relation to one another.

1 Referring now to Figure 8, a time-position-
function table showing the relative positions and
functions carried out by all of the assemblies of this
embodiment is shown. The front curve mold transport
5 apparatus, which is the second embodiment of the present
invention, having first, flipper, second, and third
assemblies which function as described above, operates
in the following manner. Beginning with the initial
forward motion of the first assembly, the cursol arm is
10 translated toward the molding station, which is still
closed, forming the mold articles. As the cursol arm
slides forward, the vacuum hand structure rotates into a
vertical position so that the vacuum plate and the
fingers which extend outwardly therefrom are properly
15 oriented for receiving the mold articles. The cursol arm
comes to a temporary halt as it waits for the mold
station to open. Once the opposing elements separate,
the cursol arm translates forward, positioning the
bellowed fingers adjacent to the mold station element to
20 which the molded articles remain adhered. It is
important to note that, with no artificially applied
force, the resilient bellowed fingers are in their
extended state.

 Once the fingers are in position, a set of
25 ejector pins within the molding station element are
extended to push the molded articles off the convex
protuberances to which the articles have adhered and
onto the tips of the bellowed fingers. The bellowed
fingers have a cup shaped tip, the external rim of which
30 contacts the annular rim of the molded article, therein
together forming sealed internal volumes in each of the

1 bellowed fingers. If the ejector pins push the molded
articles beyond the tips, the resilient fingers compress
under the load, therein ensuring that the mold sections
are not damaged. If the mold sections are not pushed far
5 enough outward toward the fingers, the subsequent
drawing of a vacuum in the fingers provides sufficient
suction to draw the articles fully onto the finger tips.
By drawing a vacuum in this volume, the first assembly
secures the molded elements to the fingers while
10 simultaneously causing the bellowed fingers to retract.
In this partially retracted state the length of the
fingers may be reduced by as much as half.

Once the articles have been secured to the
tips of the fingers, the cursor arm begins to
15 reciprocate back toward the second location, to the
waiting flipper assembly. As the cursor arm reciprocates
back, the hand rotates down, so that the retracted
fingers are directed downward. The vacuum drawn in the
hand keeps the articles secured to the tips of the
20 fingers.

Once the first assembly has reciprocated all
the way back, with the vacuum plate rotated down and
disposed directly above the platform of the flipper
assembly and the fingers aligned for deposition of the
25 articles into the recesses of the platform, the flipper
assembly rises slightly. The release of the vacuum in
the fingers (or the application of a positive pressure)
causes the articles to drop from the tips of the fingers
into the recesses of the flipper plate.

30 Once the articles have been deposited a vacuum
is drawn in the flipper plate to secure the articles

1 within the recesses. At this point the articles are
still oriented with their convex sides directed upward.
The flipper plate drops down from its slightly elevated
position and rotates 180 degrees, turning the platform
5 over and correspondingly inverting the mold sections.

At the time that the flipper plate rotates,
the first assembly begins to move forward toward the
molding station and that vacuum head reorients into a
vertical alignment.

10 The transference of the articles from the
flipper assembly to the second assembly occurs next. The
second assembly rises up to meet the inverted flipper
assembly such that the recesses in the platforms of each
assembly are aligned. At this moment the vacuum is
15 released within the flipper assembly (and preferably a
positive pressure is applied), therein releasing the
vacuum grip on the mold articles. At this time a vacuum
may be drawn in the recesses of the second assembly as a
precaution to insure the secure fixation of the articles
20 within the recesses.

Once the articles have been transferred, the
platform of the second assembly drops and begins to
slide from the second location to the third location. As
this happens the platform of the flipper assembly
25 rotates back so that its recesses are facing upward to
anticipate the arrival of the next batch of articles. At
this time also, the mold station separates allowing the
first assembly in to retrieve the next batch of
articles.

30 By the time that the first assembly has
entered the mold station, the second assembly has

1 reached the third location, and is positioned below the
waiting third assembly. The receiving plate of the third
assembly is lowered, by means of the articulated shaft
assembly of the mounting, to meet the platform of the
5 second assembly. The second assembly rises slightly to
meet the lowered plate of the third assembly, in order
to make the transference as quickly as possible.

The manner in which the articles are
transferred from the second assembly to the third
10 assembly may be achieved in two different ways, each of
which is functional, but each comprising different
embodiments of the third assembly. Both variations
include ejector pins in the platform of the second
assembly which push the articles out of the recesses of
15 the platform and push them to a position from which they
may be easily received by the third assembly. In the
first variation, the third assembly comprises a vacuum
plate which has recesses, into which the raised articles
are pushed, after which a vacuum system is engaged to
20 secure the articles in place. In the second variation,
the third assembly comprises an array of bellowed
fingers, similar in function to the bellowed fingers of
the first assembly, onto which the ejector pins push the
articles. A vacuum system is subsequently engaged to
25 secure the articles in place.

Once the articles have been extracted by the
third assembly, the receiving plate rises up, is rotated
90 degrees (thereby rotating the articles) in the
horizontal plane, and begins to slide back to the fourth
30 location. Simultaneous with the third assembly rotating
the receiving plate, the second assembly drops down and

1 slides back to the second location to receive the next
batch of articles from the flipper assembly. At this
time, the molding station has separated and the first
assembly has entered and extracted the new batch of
5 articles from the station.

By the time that the third assembly reaches
the fourth location and drops to deposit the articles in
a receptacle, such as a pallet, the first assembly has
slid back to the second location and has rotated the
10 hand to the horizontal position for depositing the
articles into the platform recesses of the flipper
assembly. The flipper assembly has correspondingly risen
to receive the next batch of articles, as the second
assembly has arrived at the second location and prepares
15 to rise to receive the articles from the flipper, once
it has rotated.

As the fourth assembly rises and rotates back
to the orientation for receiving articles from the
second assembly, the first assembly releases the
20 articles into the flipper assembly and the repetitive
cycle of the apparatus begins again.

The operation of the above-described apparatus
210, as each set of contact lens mold sections is moved
from mold to one of the pallets, the spatial
25 relationships of the lens mold sections in the set are
preserved. In particular, the lens mold sections in
each set of lens mold sections form a matrix array that
is preserved as the lens mold sections are moved through
apparatus.

30 Throughout this repetitive cycle, and
continuing down the assembly line, a spatial

1 relationship may be preserved between the lens mold
sections after they are placed in pallets and even
during subsequent handling or use of the lens mold
sections, and a spatial relationship may be preserved
5 between the contact lenses formed between each pair of
line mold sections. Under these circumstances, the
spatial position of the mold sections and even of the
formed contact lenses indicate the mold cavity in which
either the mold sections or the mold sections add to
10 make the contact lenses were made. In this case, if
flaws are detected in contact lenses, and operator can
readily determine the mold cavity or cavities in which
the lens mold sections, which were used to make the
contact lenses, were themselves made.

15

PACKAGING TRANSPORT ASSEMBLIES

Unlike the front and back curve mold transport
apparatus, the packaging transport apparatus does not
maintain the spatial relationship of the articles as a
20 constant through the transport from mold station to
pallet, but translates the array in a predetermined
manner, which if desired, would enable tracking of
individual articles from individual mold stations.

The third embodiment, described hereinbelow,
25 is an apparatus which is directed to the removal,
transport, and depositing of injection molded articles
which form the package receptacle in which contact
lenses may be inspected, stored, shipped, and/or sold.

Referring now to Figures 2c, 9-12, and 14, the
30 third apparatus comprises assemblies which are generally
similar to the common assemblies of the embodiments

35

1 described previously. The general assemblies are a first
320 for removing the molded packaging articles from a
molding station to a second location, a second 330 for
transporting the articles from a second location to a
5 third, and a third assembly 340 for removing the
articles from the second assembly at the third location
and transporting them to a receiving structure 350 at a
fourth location, for example a pallet on a manufacturing
line 52. The specific differences between the previous
10 apparatus and the present apparatus, as alluded to
above, is that the second and third assemblies 330, 340
of this apparatus 310 carry out the additional steps of
altering the spatial loci of the articles with respect
to one another. The spatial relationship of the
15 articles, and their array relationship is altered from
an original 4x4 array, which is desirable from a mold
efficiency standpoint to a 2x8 array which facilitates
optical inspection by automated lens inspection system.

The first assembly 330 of this apparatus is
20 structurally similar to the first assembly 220 of the
front curve transport apparatus in that it preferably
comprises a vacuum head 302 having bellowed fingers 22
which extend outward from a vacuum plate 324, and which
receive the packaging articles at the tips 414 of those
25 fingers 22. The operative timing of this assembly,
especially with respect to the functions of the other
assemblies is particular to this apparatus, and shall be
discussed below, with respect to Figure 12.

The second assembly 330 comprises a set of
30 parallel elongate blocks 334, preferably four, coupled
to one another in a substantially co-planar manner,

1 whereby the top surfaces of the blocks 334 define a
platform. Each of the elongate blocks 334 includes a row
receiving ports 335 in the surface thereof, for
receiving articles deposited thereon by the first
5 assembly 320. The number of receiving ports 335 per
block 334 is also preferably four, wherein the total
number of ports is sixteen, in a biaxially perpendicular
array of four by four. For the purposes of describing
the operative function of this element, the array of
10 receiving ports may be divided into two groups, a right
group 337 and a left group 333. The right group 337 is
defined as the two by four array which is the right half
of the receiving ports 335, the left group 333 is
defined as the two by four array which is the left half
15 of the ports. The blocks 334 are held in the parallel
alignment by a pair of linear guide rails 370, on which
rails the blocks may be translated along a single axis.
The means of this translation is a set of hydraulic
piston/ cylinder elements 371,372.

20 More specifically, the blocks 334 may be
laterally repositioned, reciprocated between an open and
a closed position, with respect to one another by means
of extending and retracting piston/cylinder elements
371,372 to which the blocks are motively coupled.

25 Referring now particularly to Figure 10, the blocks 334
of this assembly are shown in an open position. In this
illustration the first and third blocks are coupled by
one piston cylinder assembly 371, whereby retraction of
the piston draws them together. The third and fourth
30 blocks are similarly mounted to a second piston/cylinder
element 372 which can draw the fourth block toward the

1 third. A set of secondary piston/ cylinders 373,374 are
coupled to the outer blocks and to guide plates 375,376,
and, when actuated, draw the guide plates together into
the blocks, thereby centering the blocks in accordance
5 with their proper compactified position.

The articles are deposited by the first
assembly 320 onto the platform (blocks 334) of the
second assembly when the blocks are in their open
position.

10 In operation, from an open position, the first
and third blocks are drawn together by retraction of the
first piston 371, then the second piston 372 draws the
fourth block in. Once the guide plates 375,376 are drawn
into the blocks, to center them, the fully retracted
15 position the blocks are in full contact with one another
and therein define a continuous platform. Articles
deposited on the receiving ports 335 of the blocks 34
when the blocks are separated are thereby spatially
reoriented with respect to each other in the one
20 direction of retraction.

The entire block and piston subassembly is
mounted to a frame 339 which is in turn mounted to a
vertically lifting means for raising and lowering the
platform during deposition or retrieval of the articles
25 thereon. This vertically lifting means may comprise a
hydraulic lifting piston, a ballscrew element, a
pneumatic lift, a mechanically scissoring lift means, or
any other suitable means for selectively raising and
lowering the frame to which the blocks and pistons are
30 mounted. In the preferred embodiment, the vertically
lifting means is a vertically oriented ball screw

1 mechanism.

It is further understood that equivalent means could be substituted in the second assembly for the piston/cylinder elements 371-374 which retract and
5 separate the blocks 334 and the guide plates 375,376. Such equivalent means include mechanically scissoring extension means, ballscrew elements, geared wheel and track elements, and other motive means.

All of the above described elements of the
10 second assembly 330 of the third apparatus are mounted on a track 338 which permits the entire assembly to reciprocate between second and third locations. This track comprises a second ball screw mechanism for translating the assembly. Other equivalent means are
15 functionally similar and may be substituted, but the preferred mechanism is the ball screw.

Referring now, also, to Figure 11, the third assembly 340, which picks up and deposits the articles at a fourth location, such as a pallet 350, suited for
20 receiving the articles, is shown. In this embodiment, the third assembly comprises a vacuum head 341 mounted to a support body 346, which is in turn coupled to a track 348 on which the vacuum head 341 and the support body 346 reciprocate horizontally from the third
25 location to the fourth location. It is understood that the motive means by which the vacuum head reciprocates may comprise a variety of equivalent means, for example a geared track and a motor driven geared wheel or a hydraulic piston. The preferred means is a ball screw
30 mechanism.

The vacuum head 341 itself is comprised of

1 separate horizontal columns 343 of bellowed fingers 22.

In the illustrated variation of this assembly there are two separate parallel columns 343 of fingers 22 which descend from two separate parallel vacuum plates 344.

5 These horizontal columns 343 of fingers extend in the same direction as the reciprocating axis of the third assembly, and are together correspondingly perpendicular to the blocks (and receiving ports 335 thereon) and reciprocating axis of the second assembly. In the

10 preferred variation, the spacing of the fingers 22 of each plate 344 with respect to the adjacent fingers 22 of the same plate, is equal to the spacing of the 334 blocks of the second assembly 330 when they are in their retracted position.

15 The separate vacuum plates 344 are coupled to the vacuum head 341 so that they may be reciprocated laterally with respect to one another, whereby the columns 343 of fingers 22 may be moved closer or farther apart from one another. The preferred means by which
20 this reciprocation is actuated is by at least one small linear air piston/cylinder 347, although a ball screw mechanism would be an acceptable substitute. The air cylinder is preferred for weight minimization reasons. This relative repositioning, which is uniaxial,
25 maintains the columns 343 of fingers 22 in a substantially parallel alignment.

In the preferred variation, the number of bellowed fingers 22 per column 343 is equal to twice the number of blocks 334 in the second assembly 330, therein
30 defining a two by eight array of fingers 22. For the purposes of this description it is understood that this

1 array of fingers 22 may be divided into a front group
351 and a rear group 353, wherein the front group is
defined to be the two by four array of fingers 22 which
is disposed on the vacuum head 341 closest to the
5 molding station 312, and the rear group 353 is defined
to be the two by four array of fingers which is farther
from the molding station 312. This division of the
fingers into two groups is not purely semantic, as the
fingers 22 of the front group 351 are coupled to one
10 common vacuum drawing means, and the rear group 353 is
coupled to a separate vacuum drawing means. (It is
understood that, in another variation, the two groups
may be separately selectively coupled - by a solenoid -
to the same vacuum drawing means.)

15 In addition, the support body 346 further
comprises a vertical ball screw mechanism 355 for
raising and lowering the vacuum head 341 into position
for receiving and depositing the articles.

The operation of the second and third
20 assemblies 330, 340 with respect to one another is
carried out in two steps. The first step of the
operation is to move the vacuum head 341 of the third
assembly 340 fully forward to a first position at the
third location. The second assembly 330 is
25 simultaneously moved along a perpendicular axis to a
second position, which is below the third assembly. In
these corresponding positions the rear group 351 of
fingers 22 of the third assembly 340 is aligned above
the right group 337 of receiving ports 335 in the
30 platform (compact blocks 334) of the second assembly
330. Once the assemblies are so aligned, the vacuum head

1 341 drops down so that the corresponding fingers 22 of
the rear group 353 of the third assembly contact the
articles in the right group 337 of receiving ports. A
vacuum is then drawn in the fingers 22 of the rear group
5 thereby securing the articles to the tips 414 of the
fingers as the vacuum head 341 is raised by the
vertically aligned ball screw mechanism in the support
body 346.

The second assembly 330 then continues to the
10 right, moving into the third position of the third
location. The third assembly 340 simultaneously
reciprocates the raised vacuum head 341 backward, by
means of the horizontally aligned ball screw 357, to a
position directly above the second assembly. It is
15 understood that the relative motion of the two
assemblies is perpendicular as the axes along which the
assemblies are translated are perpendicular. At this
position the left group 333 of receiving ports 335 is
aligned with the front group 351 of fingers 22 above. At
20 this position the vacuum head 341 is lowered again to
receive the second half of the articles which were
deposited on the platform of the second assembly. Again,
a vacuum is drawn, this time in the front group 351 of
fingers 22, and the second set of articles are secured
25 to the tips 414 of the fingers 22. The vacuum head 341
of the third assembly 340 is then lifted and
reciprocated to the fourth location, and the second
assembly 330 translates back to the second location. The
second assembly must first expand into the article
30 receiving configuration, and then it receives a new
batch of packaging articles from the first assembly 320.

1 The uniaxial drawing together of the blocks
334, and thereby the articles, of the second assembly
alters the spacing of the articles along a first axis.
The transference of the articles from the second to the
5 third assembly alters the relative distribution of
articles, from a four by four array to a two by eight
array. The drawing together of the vacuum plates 344 of
the third assembly, during the reciprocation back to the
fourth location, completes the two axis spatial
10 distribution change in the separation distance of
adjacent articles. The 2x8 pallet 350 which receives the
articles at the fourth location is correspondingly
characterized by a matching array of receiving ports
which is aligned to the altered distribution of the
15 articles.

Referring now to Figure 12, the time-function
chart of the packaging transport apparatus shown. The
third embodiment of the present invention, having first,
second, and third assemblies which function as described
20 above, operate in the following manner. Beginning with
the initial forward motion of the first assembly, the
cursol arm is translated toward the molding station,
which is still closed, forming the mold articles. As the
cursol arm slides forward, the vacuum hand structure
25 rotates into a vertical position so that the vacuum
plate and the fingers which extend outwardly therefrom
are properly oriented for receiving the mold articles.
The cursol arm comes to a temporary halt as it waits for
the mold station to open. Once the opposing elements
30 separate, the cursol arm translates forward, positioning
the bellowed fingers adjacent to the mold station

1 element to which the molded packaging articles remain
adhered. It is important to note that, with no
artificially applied force, the resilient bellowed
fingers are in their extended state.

5 Once the fingers are in position, a set of
ejector pins within the molding station element are
extended to push the packaging articles out of the mold
and onto the tips of the bellowed fingers. The bellowed
fingers have a cup shaped tip, the external rim of which
10 contacts a flat surface of the molded article, therein
together forming sealed internal volumes in each of the
bellowed fingers. If the ejector pins push the molded
articles beyond the tips, the resilient fingers compress
under the load, therein ensuring that neither the
15 fingers nor the molded articles are damaged. If the mold
sections are not pushed far enough outward toward the
fingers, the subsequent drawing of a vacuum in the
fingers provides sufficient suction to draw the articles
fully onto the finger tips.

20 By drawing a vacuum in this volume, the first
assembly secures the articles to the fingers while
simultaneously causing the bellowed fingers to retract.
In this partially retracted state the length of the
fingers may be reduced by as much as half.

25 Once the articles have been secured to the
tips of the fingers, the cursor arm begins to
reciprocate back toward the second location, to the
waiting second assembly. During this stroke of the
reciprocation the vacuum head of the first assembly
30 rotates horizontally and pauses at an intermediate
location. If the second assembly is not in proper

1 receiving position, the vacuum in the fingers is
released and the articles secured thereto are dropped
into a receiving bin. In this event, the cursol arm is
translated back to the waiting position in front of the
5 molding station, the vacuum head is rotated to a
vertical orientation, and the first assembly prepares to
extract another set of articles once the mold station
opens.

In the case that the second assembly is in
10 proper receiving position at the second position, the
first assembly continues from the intermediate position
to the second location for deposition of the articles
onto the second assembly. Once the assemblies are
properly positioned, the second assembly rises up so
15 that the fingers extending downward from the horizontal
vacuum plate, and the articles secure thereto contact
the receiving ports of the second assembly. At this time
the vacuum in the fingers is released and a vacuum in
the receiving ports is drawn, therein securing the
20 articles to the blocks.

As the vacuum hand rotates vertically and the
cursol arm translates forward from the second location,
the second assembly drops back to its reciprocating
position and begins the operation of altering the
25 spatial separation of the blocks with respect to one
another. The step of the drawing together of the blocks
to the retracted position happens in three stages, via
the contraction of three piston/cylinder assemblies; the
first step being the drawing together of the inner two
30 blocks, followed immediately by the outer two blocks,
and followed thereby the contraction of the guide

1 plates.

Once the guide plates have been contracted the second assembly slides to the right, to an intermediate position (the second position of the third location) and
5 waits for the third assembly to position its rear group of fingers above the right group of receiving ports. With the receiving ports positioned below, the vacuum head of the third assembly drops, via the vertical ballscrew drive, to pick up the first half of the
10 articles.

Once the articles are secured to the fingers, by a drawn vacuum in the rear group thereof, the vacuum head of the third assembly is raised by the vertical ballscrew drive and is translated back toward the
15 intermediate pick up position (the fourth position at the third location). Simultaneous with the motion of the vacuum head of the third assembly, the second assembly continues to move to the right, therein positioning itself so that the left group of receiving ports, and
20 the remaining group of articles, are aligned below the front group of fingers of the third assembly.

Once the assemblies are properly aligned, the third assembly drops so that the front group of fingers contacts the left group of articles to pick them up. As
25 the third assembly drops and picks up the second set of articles, the mold station opens and the first assembly slides into position to receive a new batch of articles.

Once the second set of articles has been picked up by the third assembly vacuum head, the vacuum
30 head rises via the vertical ballscrew drive, and is translated back to the fourth location via the

1 horizontal ball screw drive. As it travels back, the vacuum plates of the third assembly are drawn together by an air piston/cylinder to change the relative spacing of the articles.

5 It is as the third assembly moves together that the second assembly moves left, back into position to receive a new batch of articles from the first assembly. Once in position at the second location, the piston/cylinder elements of the second assembly extend,
10 therein moving the blocks and guide plates into their spaced arrangement.

By the time the second assembly has reached the second location, the first assembly has already received the new batch of articles and is moving back to
15 deposit them into the receiving ports of the second assembly as described above. It is as the first assembly is moving back to deposit the articles that the third assembly moves into position above the pallet at fourth location and the vertical ballscrew drive engages again
20 to lower the vacuum head and fingers into contact therewith. Once in position to drop the articles, the third assembly releases its vacuum and the articles are deposited on the pallet.

Having deposited the articles, the third
25 assembly rises and moves forward, during which time, the vacuum plates and fingers are moved apart to their positions for receiving the articles from the second assembly.

By means of this repetitive cycle the spatial
30 relationship of the articles taken from the molding station may be altered to the distribution which is

1 compatible with the pallet on which the articles are
ultimately carried through the subsequent stations of
the assembly line. While it is apparent that the
invention herein disclosed is well calculated to fulfill
5 the objects previously stated, it will be appreciated
that numerous modifications and embodiments may be
devised by those skilled in the art, and it is intended
that the appended claims cover all such modifications
and embodiments as fall within the true spirit and scope
10 of the present invention.

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1 CLAIMS

1. An apparatus for efficient and rapid removal and transportation molded contact lens fabricating articles, each having optical surfaces thereof, from a molding station at a first location to a remote fourth location, without touching the optical surfaces of the articles, comprising:

a linearly reciprocating first assembly, having receiving means for releasably holding and transporting the articles, without contacting the optical portions thereof, to a second location from said molding station;

a linearly reciprocating second assembly for receiving the articles from the linearly reciprocating first assembly at the second location and transporting the articles to a third location, without contacting the optical portions of the articles; and

a linearly reciprocating third assembly for receiving the articles from the linearly reciprocating second assembly at the third location and transporting the articles to a fourth location, without contacting the optical portions of the articles.

2. An apparatus according to Claim 1, wherein the linearly reciprocating first assembly comprises:

an angularly reciprocating head to receive and releasably hold the articles; and

a means for linearly reciprocating the head between the first and second locations.

3. An apparatus according to Claim 2, wherein the angularly reciprocating head comprises:

means for rotating said head from a vertical to a horizontal orientation;



- 1 a vacuum head;
 a vacuum plate resiliently coupled to said
vacuum head;
 a multiplicity of recesses in said vacuum
5 plate into which the articles may be releasably secured
by a vacuum drawn therein.
4. An apparatus according to Claim 3, wherein the
resilient coupling of the vacuum plate to the head
comprises at least one silicone bellowed element.
- 10 5. An apparatus according to Claim 2, wherein the
head further comprises a angularly rotating vacuum head
having a multiplicity of resiliently bellowed fingers
extending therefrom, said vacuum head and fingers having
at least one internal volume in which a vacuum may be
15 drawn, whereby articles may be releasably secured to the
tips of the fingers by said vacuum.
6. An apparatus according to claim 2, wherein the
means for reciprocating the head between the first and
second locations comprises a ball screw mechanism.
- 20 7. An apparatus according to claim 2, wherein the
means for reciprocating the head between the first and
second locations comprises a piston/cylinder element.
8. An apparatus according to claim 2, wherein said
linearly reciprocating first assembly further comprises
25 a rotating air cylinder, said air cylinder having stops
for selective reciprocation of said head between a
vertical and a horizontal orientation.
9. An apparatus according to claim 1, wherein the
linearly reciprocating second assembly comprises:
30 a platform;
 at least one recess in said platform for



1 receiving the articles transported thereto by the
linearly reciprocating first assembly; and

a means for reciprocating said platform
between said second and third locations.

5 10. An apparatus according to claim 9, wherein said
means for reciprocation said platform comprises at least
one ball screw mechanism.

11. An apparatus according to claim 10, wherein
said at least one ball screw mechanism comprises at
10 least one vertically oriented ball screw mechanism for
raising and lowering said platform, and at least one
horizontally oriented ball screw mechanism for
translating said platform along a horizontal axis.

12. An apparatus according to claim 1, wherein said
15 linearly reciprocating third assembly comprises: a
receiving plate, said plate having recesses therein for
receiving said articles from said second assembly, said
plate further comprising vacuum means coupled to said
recesses for selectively and securably holding said
20 articles therein; at least one linear reciprocating
means for reciprocating said plate between said third
and fourth locations; and at least one rotating means
for selectively reorienting said plate in accordance
with differences in directional orientation of the
25 articles at said third and fourth locations.

13. An apparatus according to claim 12, wherein
said at least one linear reciprocating means comprises
at least one vertically oriented ball screw mechanism
for raising and lowering said platform, and at least one
30 horizontally oriented ball screw mechanism for
translating said platform along a horizontal axis.



1 14. An apparatus according to claim 12, wherein
said means for selectively reorienting said plate
comprises a rotating air cylinder, said air cylinder
having stops for selective reciprocation of said head
5 between at least two orientations.

15. An apparatus for rapid and efficient removing
and transporting molded contact lens fabricating
articles, each having optical surfaces thereof, from a
molding station at a first location to a remote fourth
10 location without contacting the optical surfaces,
comprising:

 a linearly reciprocating first assembly for
removing the articles from the molding station,
releasably holding the articles, and transporting the
15 articles to an intermediate location, without contacting
the optical surfaces thereof;

 a rotating flipper assembly for inverting said
articles about an axis in the horizontal plane and
depositing the inverted articles at a second location,
20 without contacting the optical surfaces thereof;

 a linearly reciprocating second assembly for
receiving the articles from the rotating flipper
assembly at a second location and transporting the
articles to a third location, without contacting the
25 optical surfaces thereof; and

 a linearly reciprocating third assembly for
receiving the articles from the linearly reciprocating
second assembly at the third location and transporting
the articles to a fourth location without contacting the
30 optical surfaces thereof.

16. An apparatus according to claim 15, wherein the



1 rotating flipper assembly comprises:

a platform having recesses therein for
receiving articles deposited therein; and

a means for rotating said platform about an
5 axis in the horizontal plane.

17. An apparatus according to claim 16, wherein
said rotating flipper assembly further comprises a means
for linearly reciprocating along the vertical axis.

18. An apparatus according to claim 16, wherein
10 said means for rotating said platform comprises a
rotating air cylinder, said air cylinder having stops
for selective reciprocation of said head between at
least two orientations.

19. An apparatus according to claim 17, wherein
15 said means for linearly reciprocating comprises a ball
screw mechanism.

20. An apparatus for efficient and rapid removal
and transportation molded contact lens packaging
articles from a molding station at a first location,
20 said articles being removed in a first spatial
distribution, and depositing the articles at a remote
fourth location in a second spatial distribution,
comprising:

a linearly reciprocating first assembly for
25 removing the articles from the molding station and
transporting the articles to a second location;

a linearly reciprocating second assembly for
receiving the articles from the first assembly at the
second location and transporting the articles to a third
30 location; and

a linearly reciprocating third assembly for



1 receiving the articles from the second assembly at the
third location and transporting the articles to a fourth
location;

wherein at least one of the linearly reciprocating
5 second and third assemblies further comprises means for
altering the spatial distribution of the articles.

21. An apparatus according to claim 20, wherein
said linearly reciprocating second assembly comprises:

a platform comprising

10 a plurality of blocks having at least one
receiving port therein for receiving an article;

at least one guide rail on which said
plurality of blocks are mounted, said blocks being
mounted such that they may translate along said at least
15 one guide rail;

and means for reciprocating said
plurality of blocks along said at least one guide rail
such that the at least one receiving port of each block
is translated with respect to one another; and

20 means for linearly reciprocating said platform
between the second and third locations.

22. An apparatus according to claim 21, wherein
said means for reciprocating said plurality of blocks
long said at least one guide rail comprises at least one
25 piston/cylinder element coupled to the blocks which is
capable of drawing the blocks together and spacing the
blocks apart from one another in accordance with its
reciprocating action.

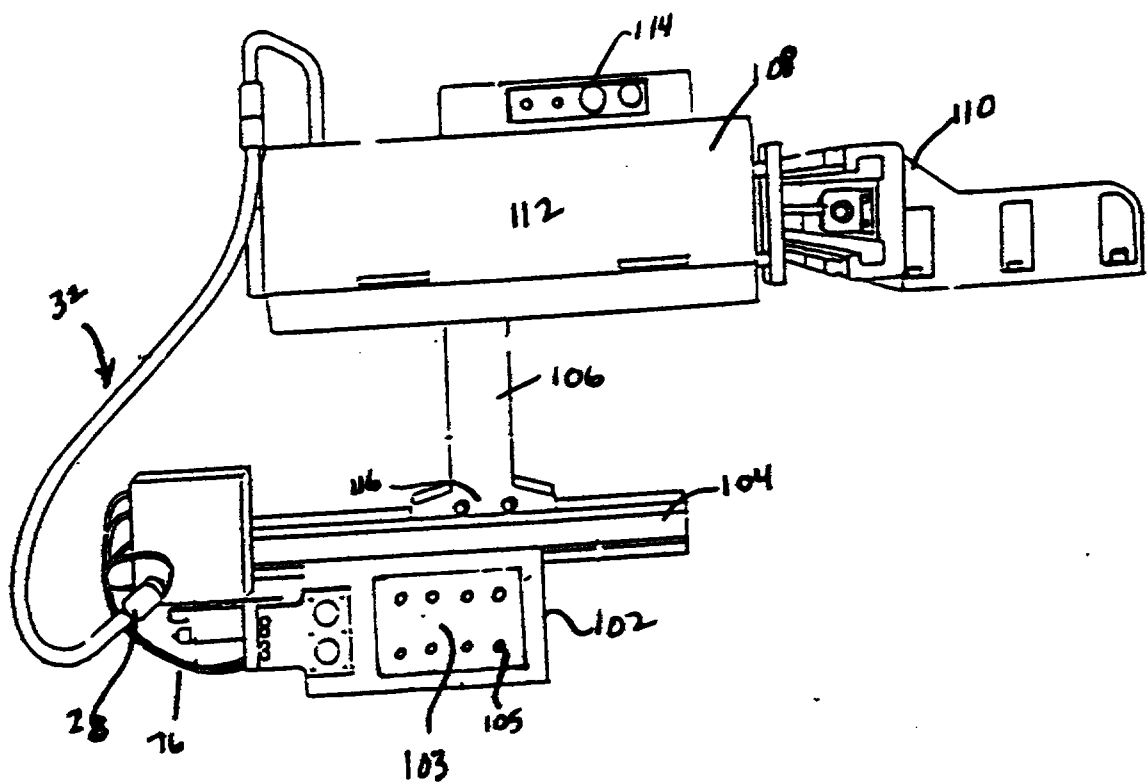
23. An apparatus according to claim 21, wherein
30 said means for linearly reciprocating said platform
comprises at least one ball screw mechanism.



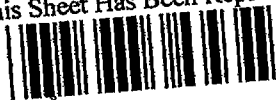
- 1 24. An apparatus according to claim 23, wherein
said at least one ball screw mechanism comprises at
least one vertically oriented ball screw mechanism for
raising and lowering said platform, and at least one
5 horizontally oriented ball screw mechanism for
translating said platform along a horizontal axis.
25. An apparatus according to claim 20, wherein
said linearly reciprocating third assembly comprises:
a vacuum head comprising:
10 at least two vacuum plates;
 means for reciprocating said vacuum
plates together and apart;
 a column of at least one resiliently
bellowed finger extending from each of said at least to
15 vacuum plates, said finger being capable of grasping and
selectively and securably holding said article from said
second assembly; and
 means for linearly reciprocating said vacuum
head between said third and fourth locations.
- 20 26. An apparatus according to claim 25, wherein
said means for reciprocating said vacuum plates
comprises an air piston/cylinder mechanism.
27. An apparatus according to claim 26, wherein
said means for linearly reciprocating said vacuum head
25 comprises at least one ball screw mechanism.
28. An apparatus according to claim 27, wherein
said at least one ball screw mechanism comprises at
least one vertically oriented ball screw mechanism for
raising and lowering said platform, and at least one
30 horizontally oriented ball screw mechanism for
translating said platform along a horizontal axis.

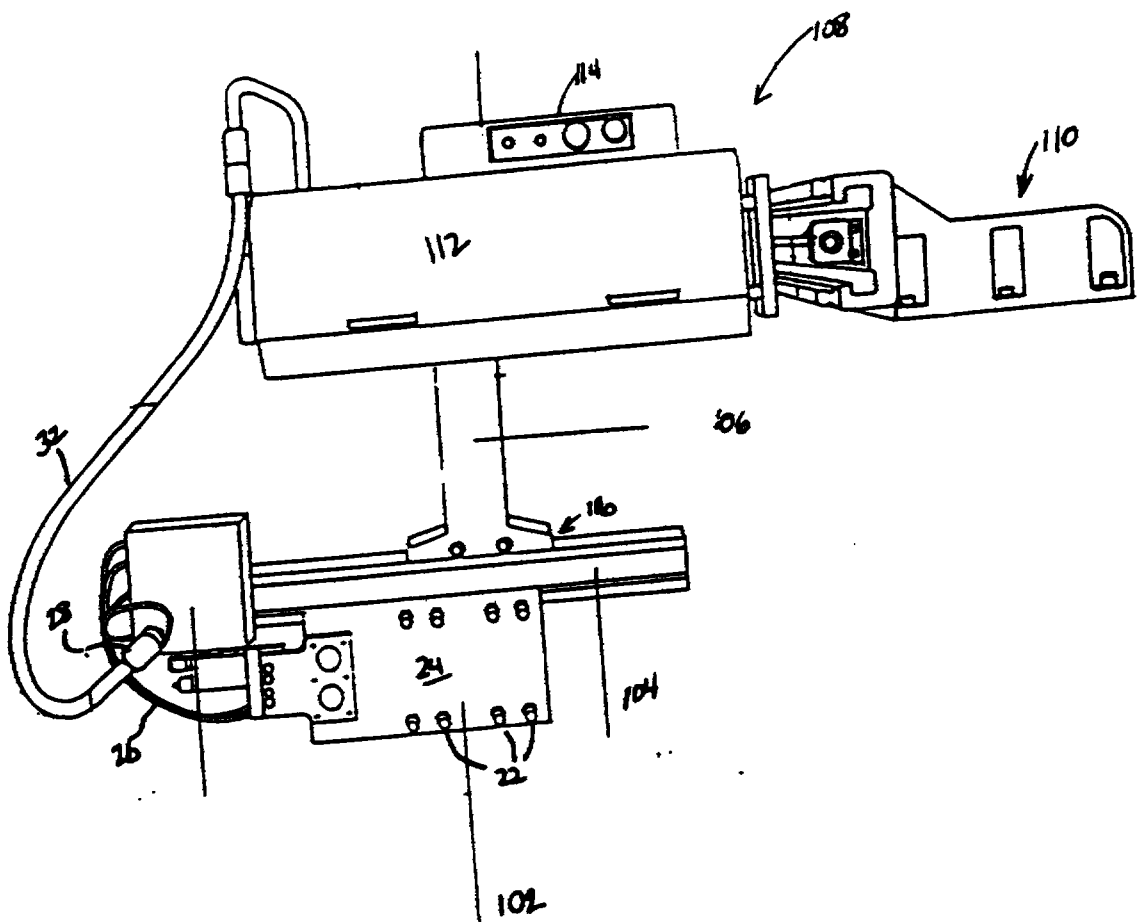


PARTS DESIGNATION



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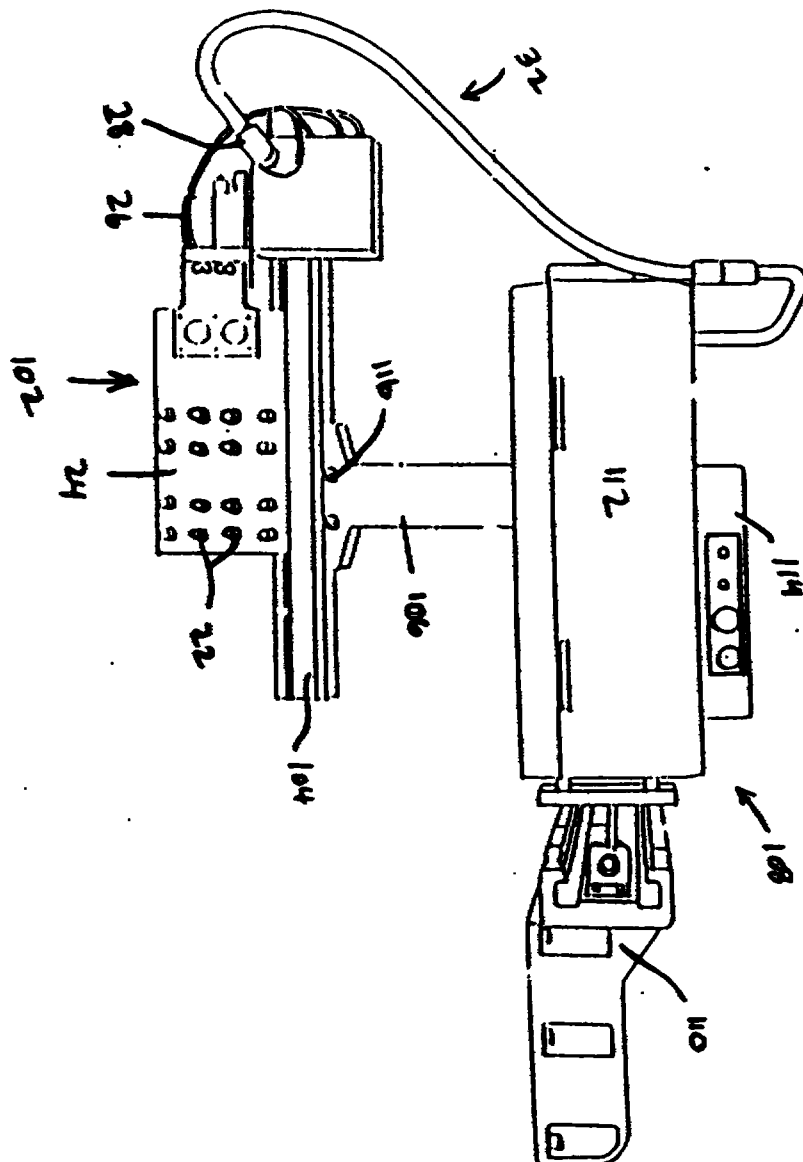
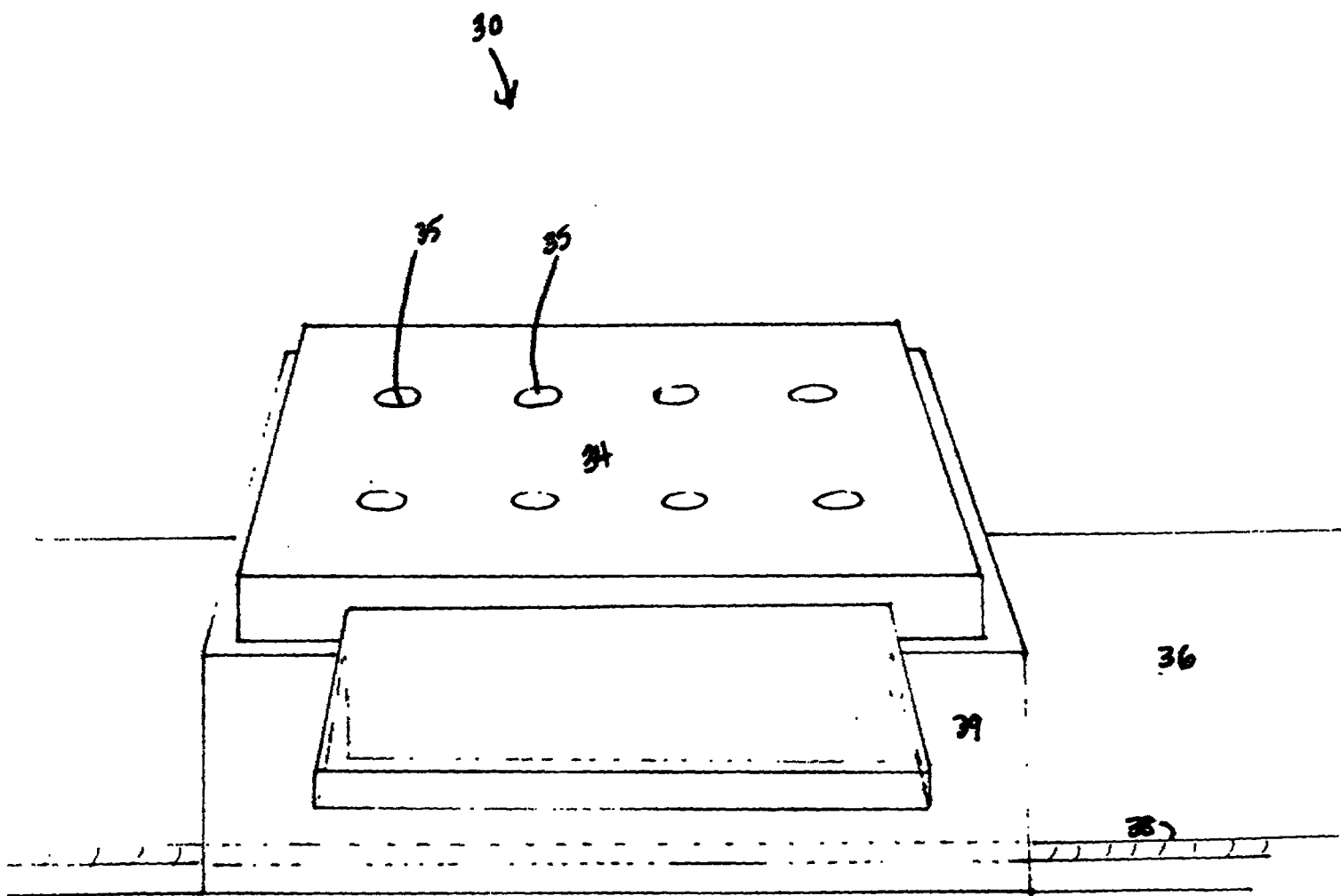


Fig 2a

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Fig 3

	FIRST ASSEMBLY	SECOND ASSEMBLY	THIRD ASSEMBLY
1	TRANSLATE FORWARD	TRANSLATE RIGHT	LOWER PLATFORM
2	ROTATE HAND VERTICAL	STOP	STOP
3	STOP	TRANSFER ARTICLES	RECEIVE ARTICLES
4	WAIT	STOP	RAISE PLATFORM
5	CONTINUE INTO MOLD	TRANSLATE LEFT	ROTATE
6	GRASP ARTICLES (VACUUM)	TRANSLATE LEFT	TRANSLATE BACK
7	TRANSLATE BACK	TRANSLATE LEFT	TRANSLATE BACK
8	ROTATE HAND HORIZONTAL	STOP	TRANSLATE BACK
9	STOP	RAISE UP PLATFORM	LOWER PLATFORM
10	RELEASE VACUUM	STOP	DEPOSIT ARTICLES
11	EJECT ARTICLES	RECEIVE ARTICLES	RAISE PLATFORM
12	WAIT	LOWER PLATFORM	ROTATE PLATFORM
13	WAIT	TRANSLATE RIGHT	TRANSLATE FORWARD
14	TRANSLATE FORWARD	TRANSLATE RIGHT	TRANSLATE FORWARD

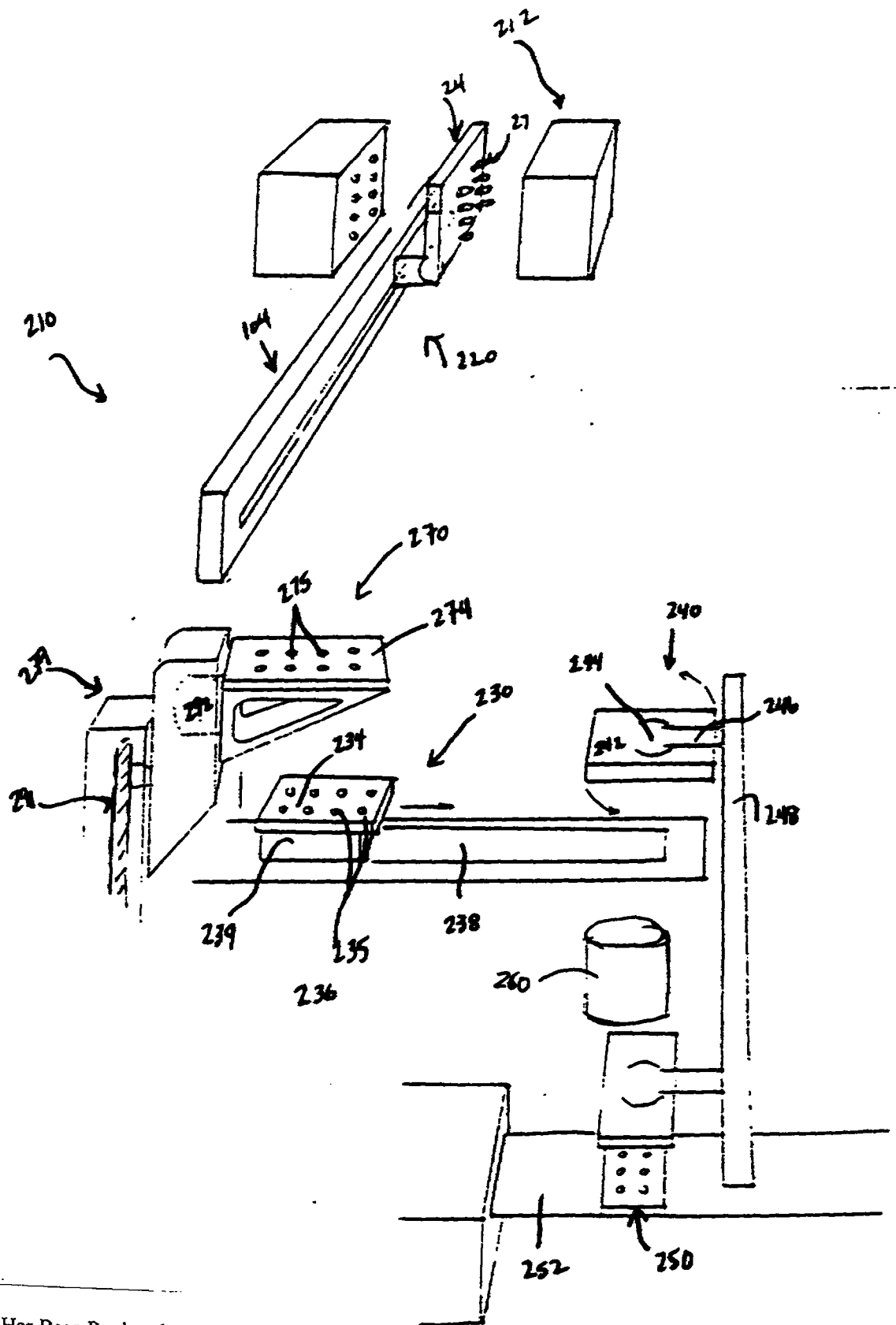
INCREASING
TIME
(IN STEPS)



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Fig 4



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Fig 5

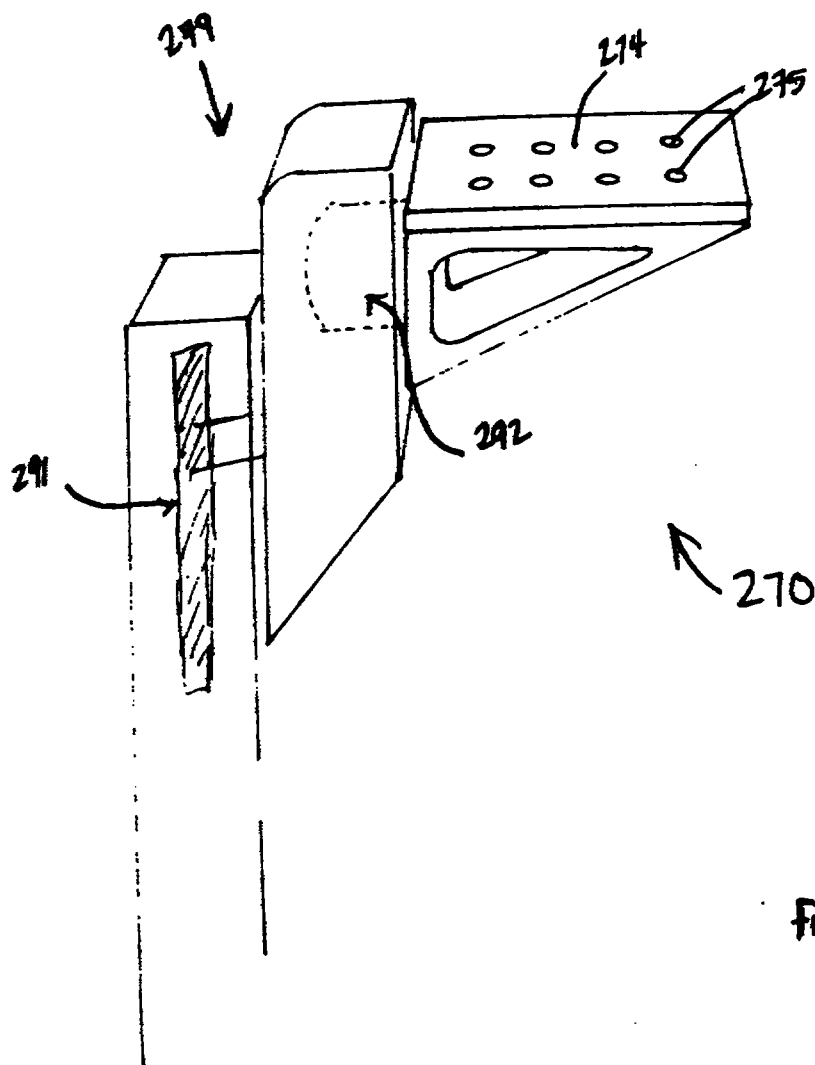
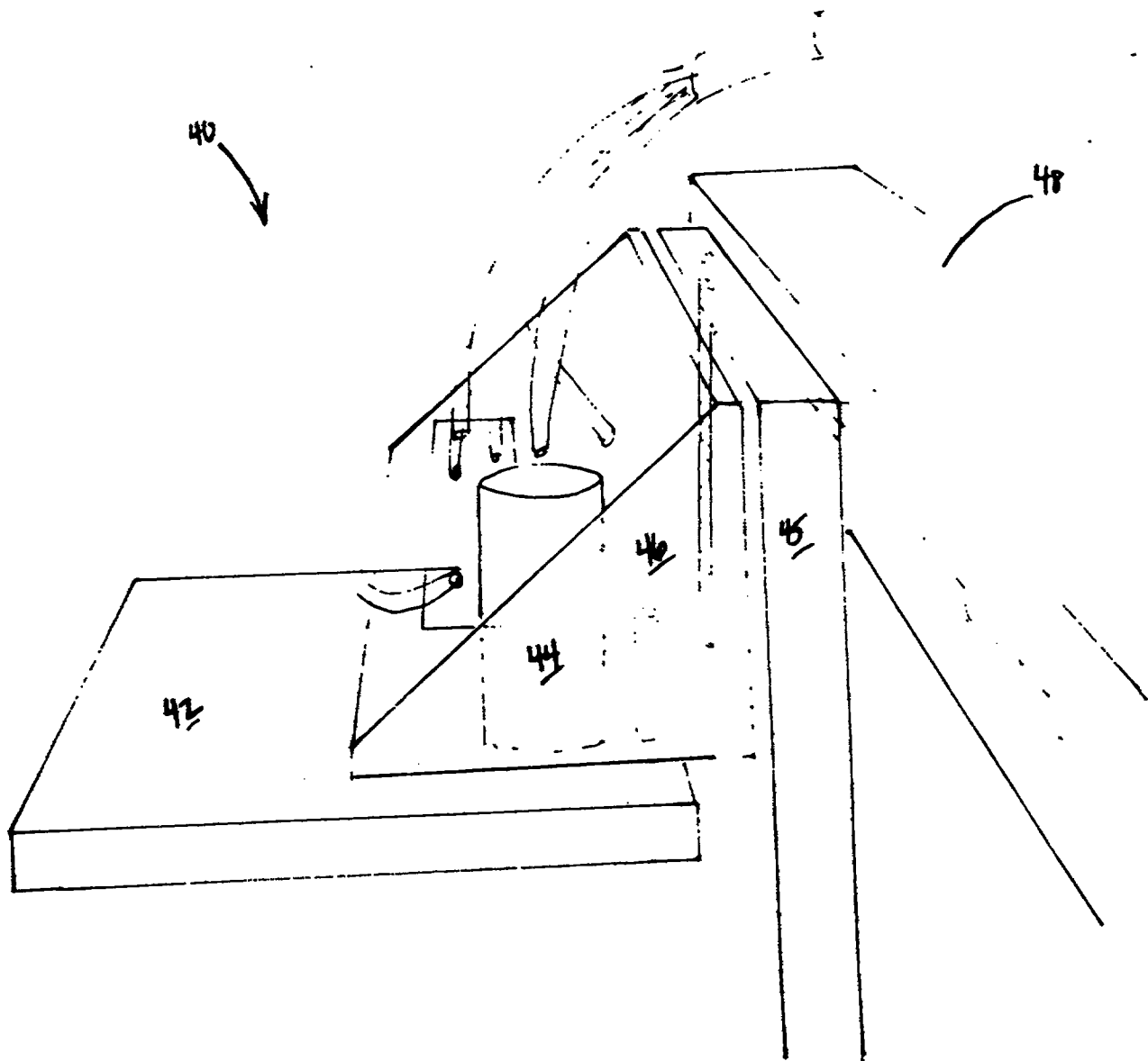


Fig 6

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Fig. 7

FIRST ASSEMBLY		FLIPPER ASSEMBLY		SECOND ASSEMBLY		THIRD ASSEMBLY	
1	TRANSLATE FORWARD	ROTATES OVER		WAIT		TRANSLATE FORWARD	
2	ROTATE HAND VERTICAL	WAITS		PLATFORM RISES		ROTATES	
3	STOP	RELEASE ARTICLES		RECEIVES ARTICLES		TRANSLATE FORWARD	
4	WAIT	WAIT		PLATFORM DROPS		STOP	
5	WAIT	ROTATE BACK		TRANSLATE RIGHT		PLATFORM DROPS	
6	TRANSLATE INTO MOLD	STOP		PLATFORM RISES		STOP	
7	RECEIVE ARTICLES	WAIT		RELEASE ARTICLES		RECEIVE ARTICLES	
8	TRANSLATE BACK	WAIT		WAIT		PLATFORM RISES	
9	ROTATE HORIZONTAL	WAIT		PLATFORM DROPS		ROTATES	
10	STOP	WAIT		TRANSLATE LEFT		TRANSLATES BACK	
11	WAIT	PLATFORM RISES		WAIT		PLATFORM DROPS	
12	RELEASE ARTICLES	RECEIVE ARTICLES		WAIT		RELEASE ARTICLES	
13	WAIT	PLATFORM DROPS		WAIT		PLATFORM RISES	

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Fig. 8

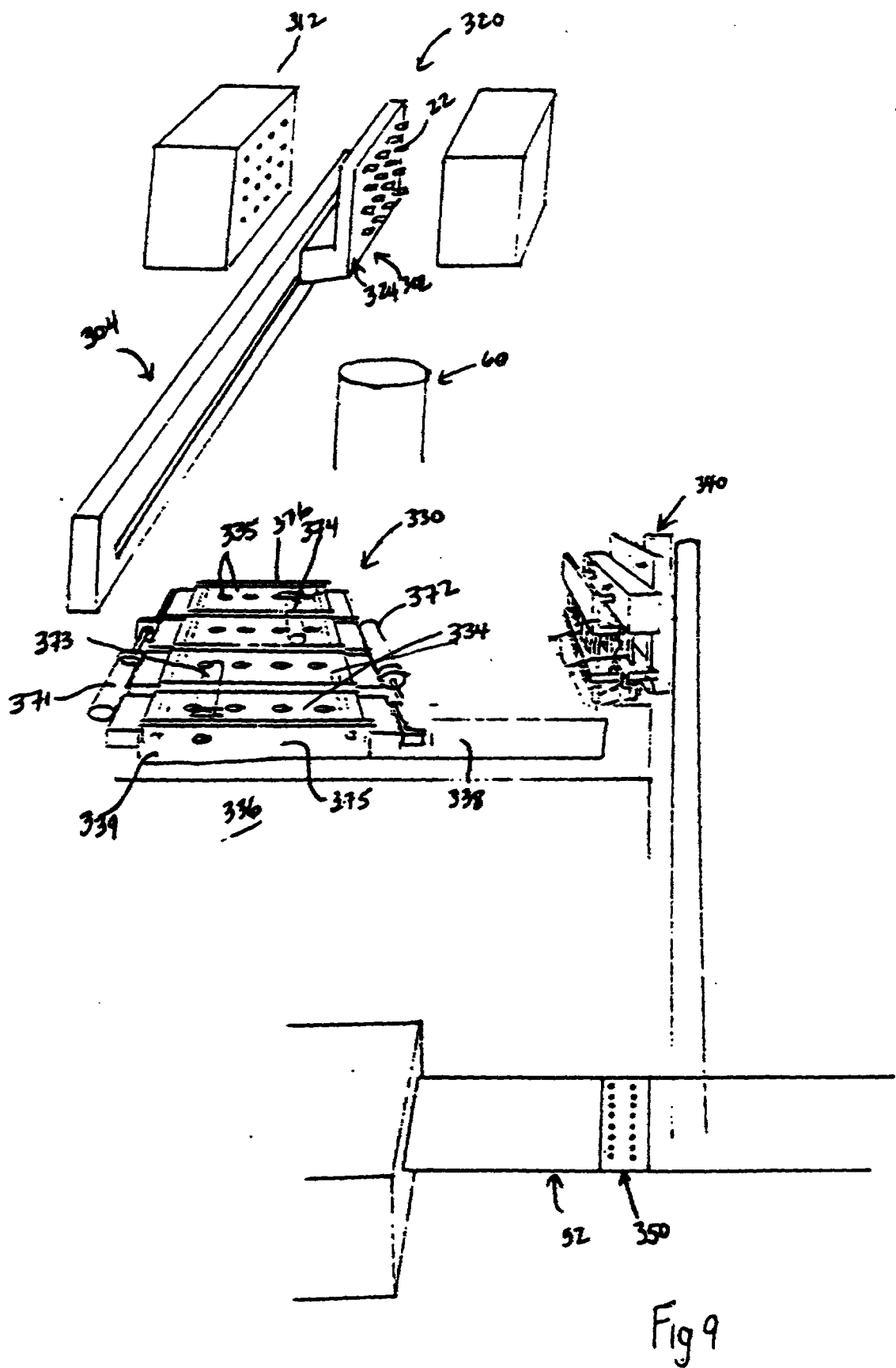


Fig 9

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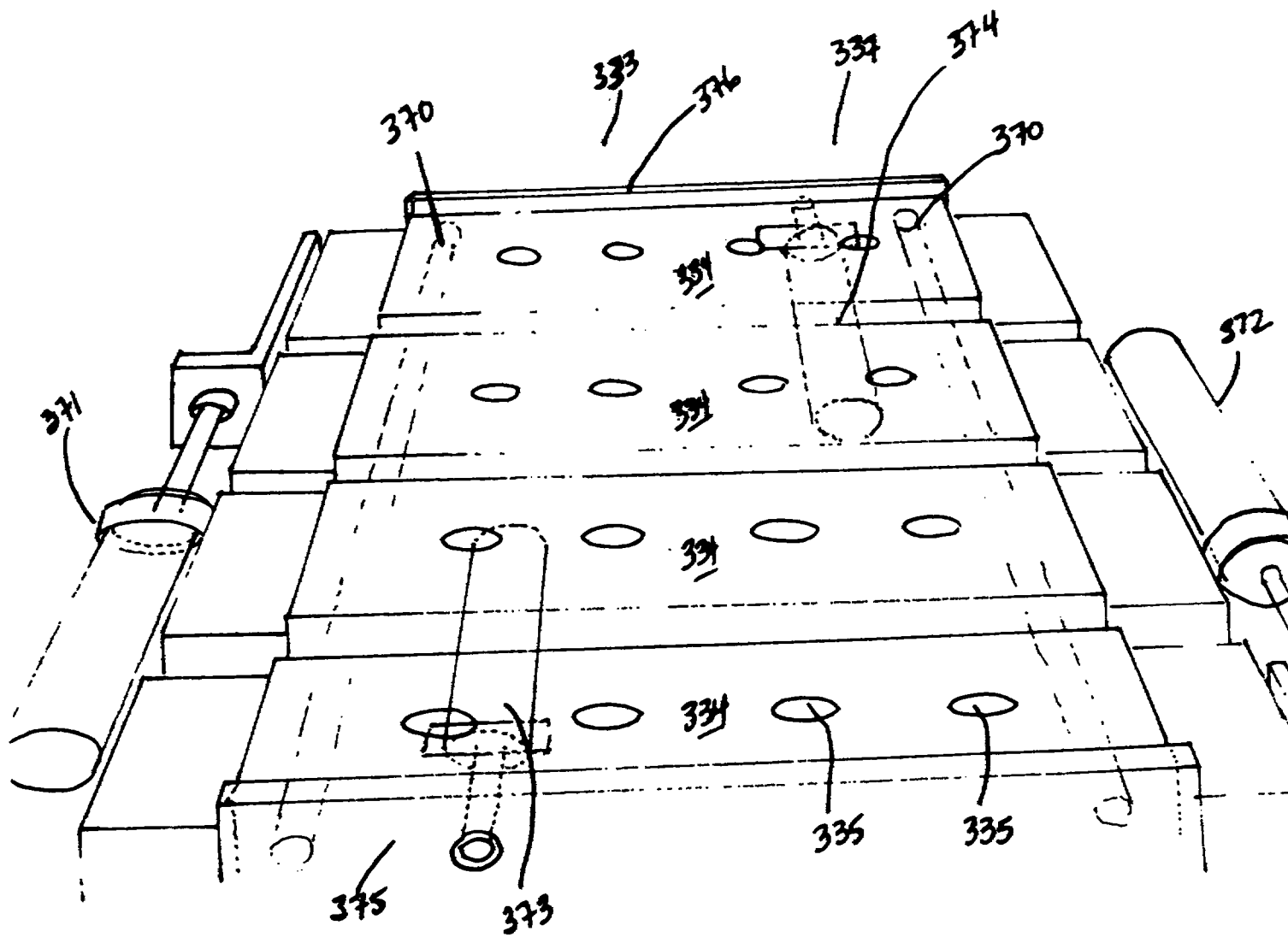


Fig 10

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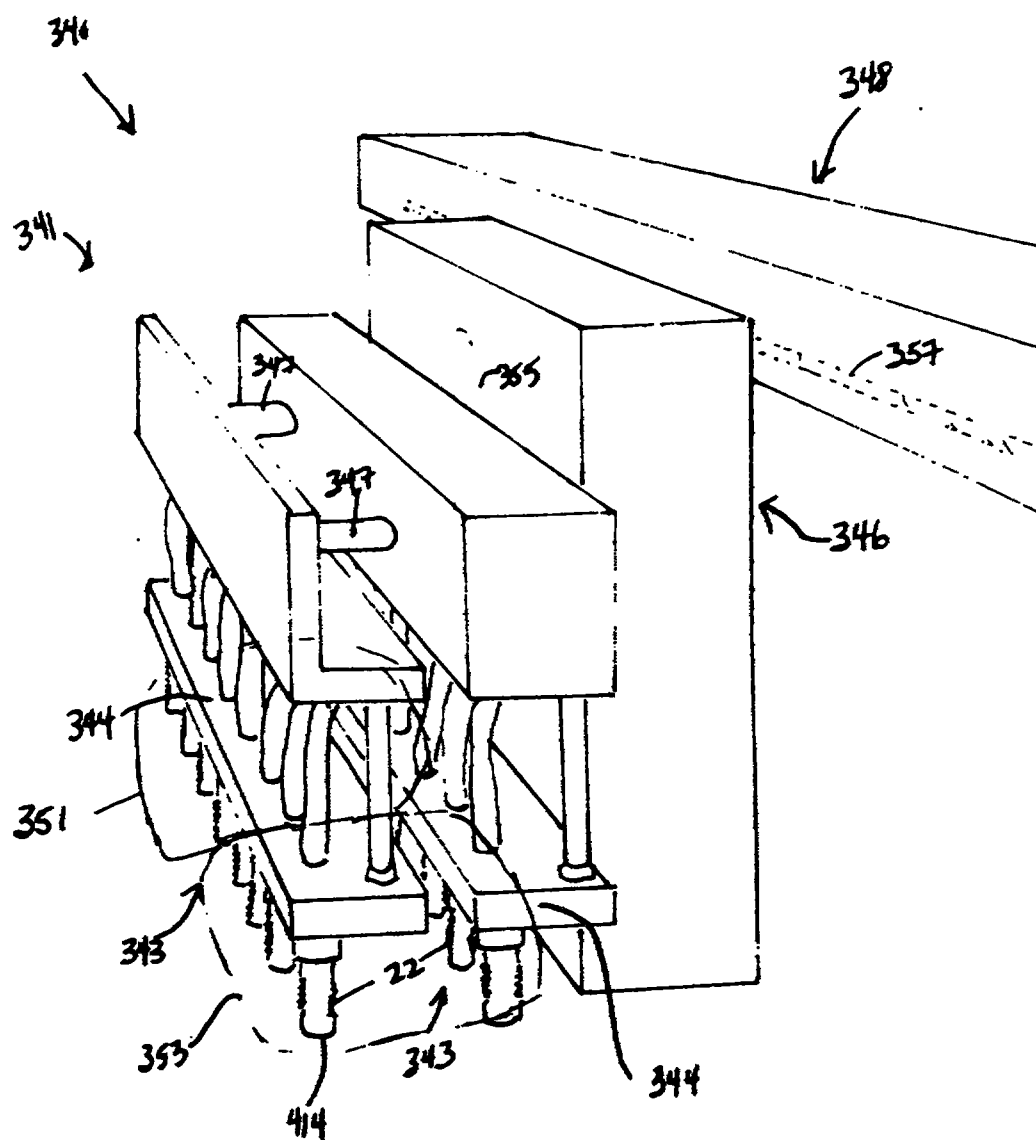
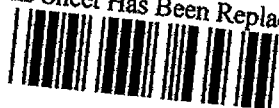


Fig 11

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	FIRST ASSEMBLY	SECOND ASSEMBLY	THIRD ASSEMBLY
1	TRANSLATE FORWARD	COMPACTIFY	VACUUM HEAD DROPS
2	ROTATE VERTICAL	TRANSLATE RIGHT	STOP
3	TRANSLATE FORWARD	RELEASE ARTICLES (FIRST)	GRASP ARTICLES (FIRST)
4	STOP	STOP	VACUUM HEAD RISES
5	WAIT	TRANSLATE RIGHT	TRANSLATE BACK
6	WAIT	STOP	VACUUM HEAD DROPS
7	WAIT	RELEASE ARTICLES (SECOND)	GRASP ARTICLES (SECOND)
8	TRANSLATE INTO MOLD	STOP	VACUUM HEAD RISES
9	GRASP ARTICLES	TRANSLATE LEFT	DRAW ROWS TOGETHER
10	TRANSLATE BACK	STOP	TRANSLATE BACK
11	ROTATE HORIZONTAL	WAIT	VACUUM HEAD DROPS
12	TRANSLATE BACK	PLATFORM RISES	RELEASE ARTICLES
13	WAIT	STOP	VACUUM HEAD RISES
14	RELEASE ARTICLES	RECEIVE ARTICLES	EXPAND ROWS
15	STOP	PLATFORM DROPS	TRANSLATES FORWARD

INCREASING
TIME
(IN STEPS)



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Fig 12

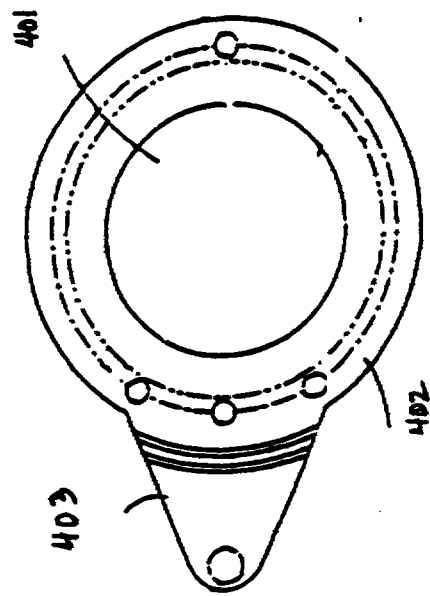


Fig. 13a

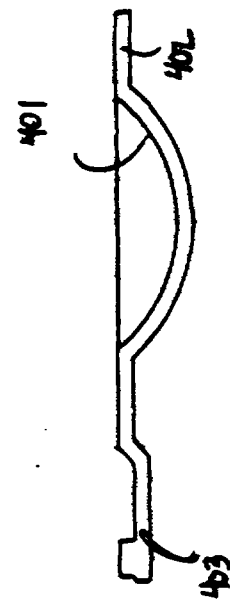


Fig. 13b

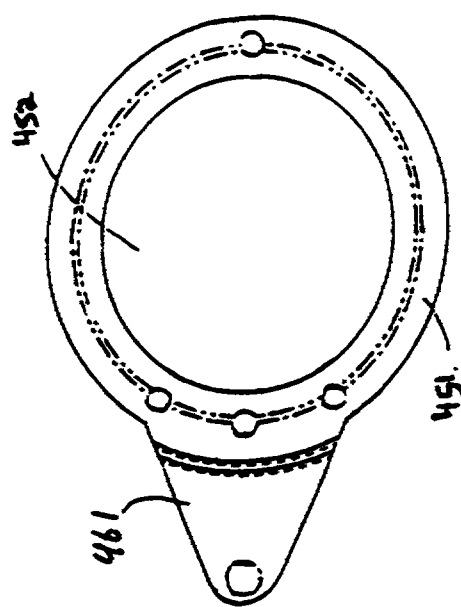


Fig. 13c

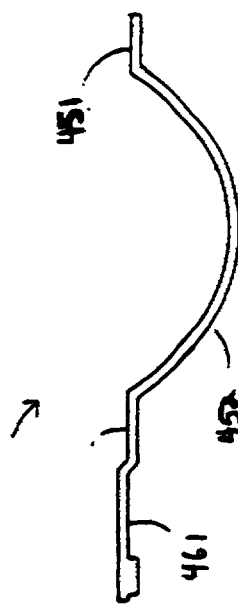
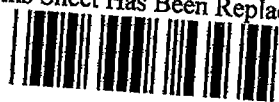
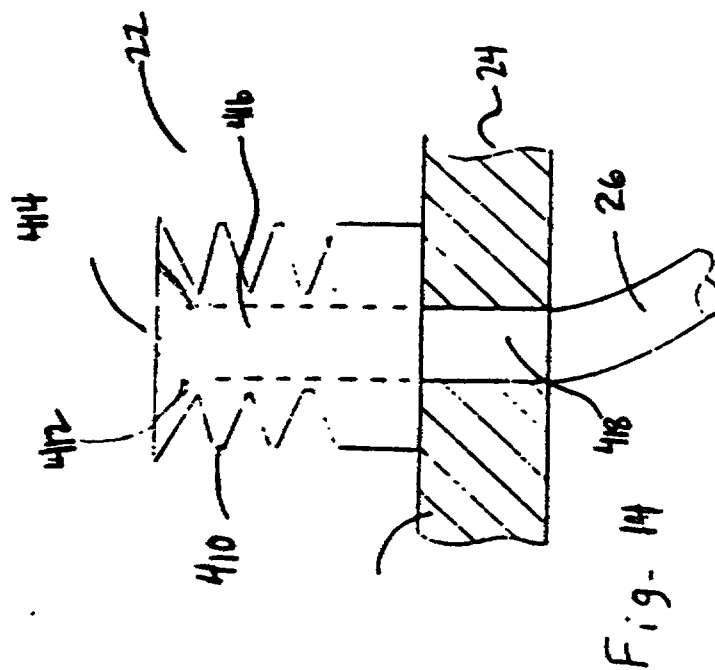


Fig. 13d

Fig. 13

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APPARATUS FOR REMOVING AND TRANSPORTING ARTICLES FROM MOLDS

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ABSTRACT

This invention relates to a device for removing and transporting articles, such as ophthalmic lens mold sections, or packaging elements from a mold. The invention, in one embodiment includes first, second, and third assemblies; the first of which removes the articles from the molding station at a first location and transports them to a second location; the second assembly receives the articles from the first assembly and transports them to a third location, and the third assembly receives the articles from the second assembly and transports them to a fourth location. A second embodiment includes a flipper assembly disposed between the first and second assemblies, which flipper receives the articles from the first assembly and inverts them before depositing them onto the second assembly. This second embodiment is useful in conjunction with molded articles which are transported to the flipper assembly in an inverted position. A third embodiment includes second and third assemblies which further include means for altering the relative spacing of the articles while the articles are transported.

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APPARATUS FOR REMOVING AND TRANSPORTING ARTICLES FROM MOLDS

BACKGROUND OF THE INVENTION

5 This application is a continuation-in-part of
U.S. Patent application number 08\258,267.

FIELD OF THE INVENTION

This invention generally relates to apparatus
for removing and transporting articles from molds. More
10 specifically, the present invention relates to such
apparatus that is very well suited for carrying the
articles, in a very short period of time, away from the
molds and depositing the articles for further processing
in a high speed, automated production system.

15

DESCRIPTION OF THE PRIOR ART

Recently, attention has been directed toward
forming contact lenses in an automated molding system.
In such a system, each lens is formed by sandwiching a
20 monomer between front and back mold sections. The
monomer is polymerized to form a lens, which is then
removed from the mold sections, further treated and then
packaged for consumer use.

The mold sections used in the above-outlined
25 process may themselves be formed in injection molding or
compression molding processes. These mold sections may
be made from the family of thermoplastics, for example
polystyrene, which is an excellent material for making
these mold sections. Polystyrene does not chemically
30 react with the hydrophilic material used to make the
contact lens, therefore, very high quality contact

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REPLACEMENT SHEETS		SG
☒	Description	: paged 1 to paged 1
☐	Claim(s)	: paged 1 to paged 1
☒	Drawing(s)	: paged 1 to paged 1
☒	Abstract	: paged 1 to paged 1
DATE OF RECEIPT 20/2/97		

REPLACEMENT SHEET
20 FEB 1997

APPARATUS FOR REMOVING AND TRANSPORTING ARTICLES FROM MOLDS

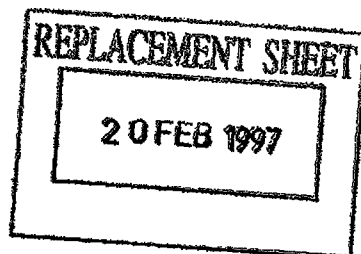
1

ABSTRACT

This invention relates to a device for removing and transporting articles, such as ophthalmic lens mold sections, or packaging elements from a mold. The invention, in one embodiment includes first, second, and third assemblies; the first of which removes the articles from the molding station at a first location and transports them to a second location; the second assembly receives the articles from the first assembly and transports them to a third location, and the third assembly receives the articles from the second assembly and transports them to a fourth location. A second embodiment includes a flipper assembly disposed between the first and second assemblies, which flipper receives the articles from the first assembly and inverts them before depositing them onto the second assembly. This second embodiment is useful in conjunction with molded articles which are transported to the flipper assembly in an inverted position. A third embodiment includes second and third assemblies which further include means for altering the relative spacing of the articles while the articles are transported.

Figure 1

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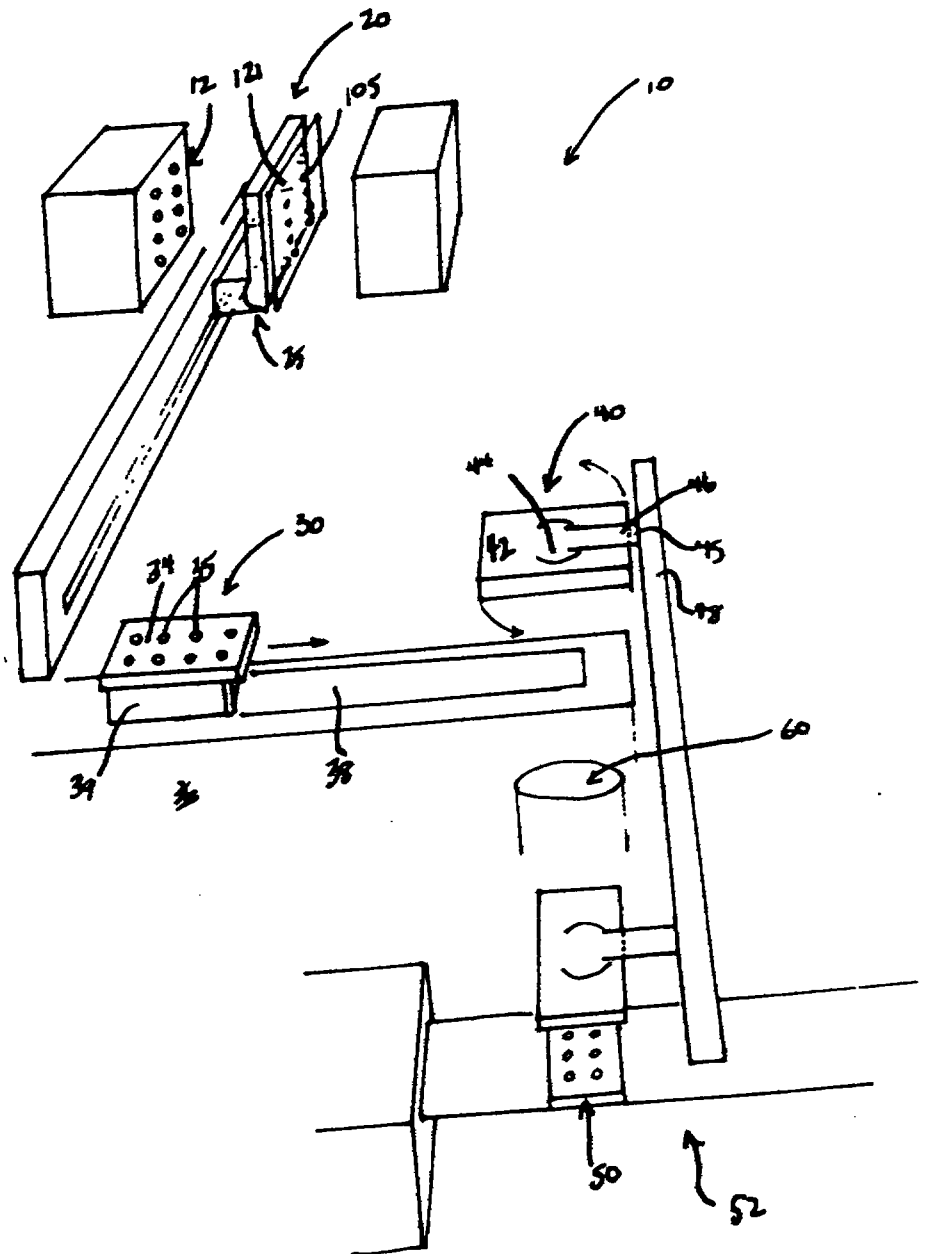
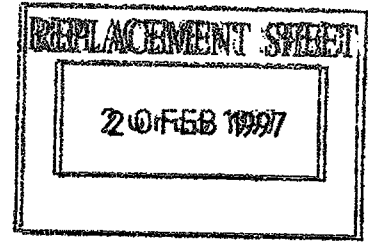
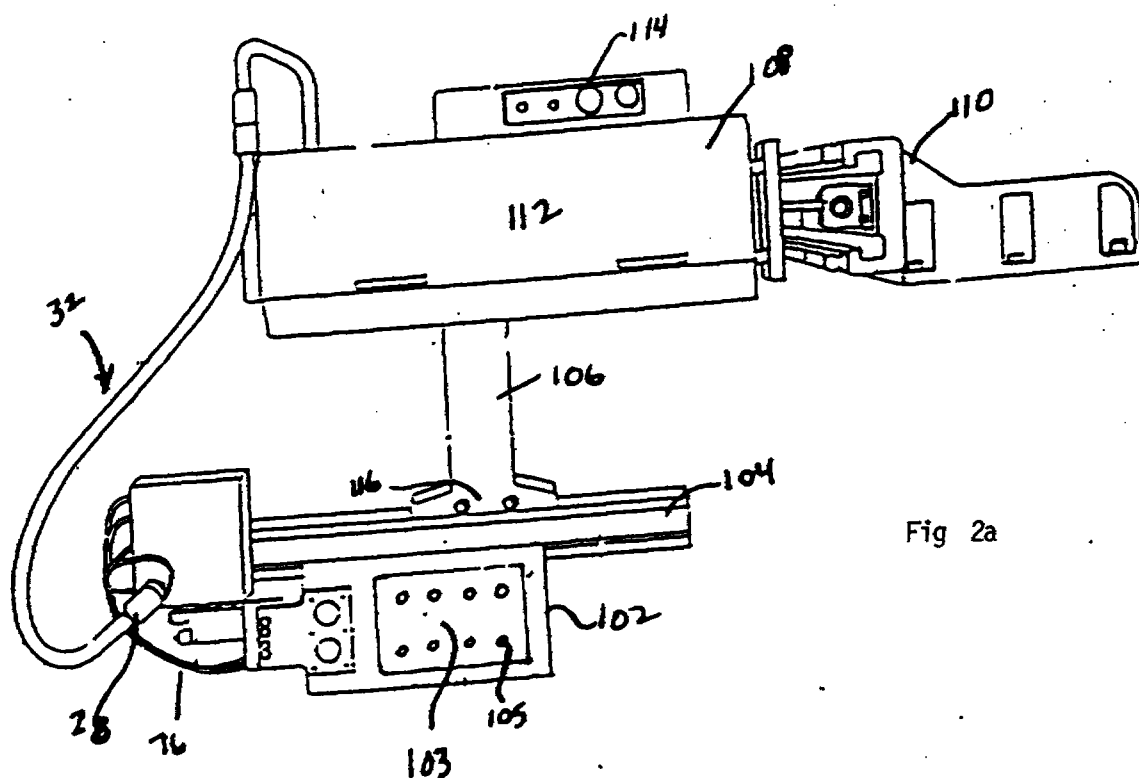


Fig 1

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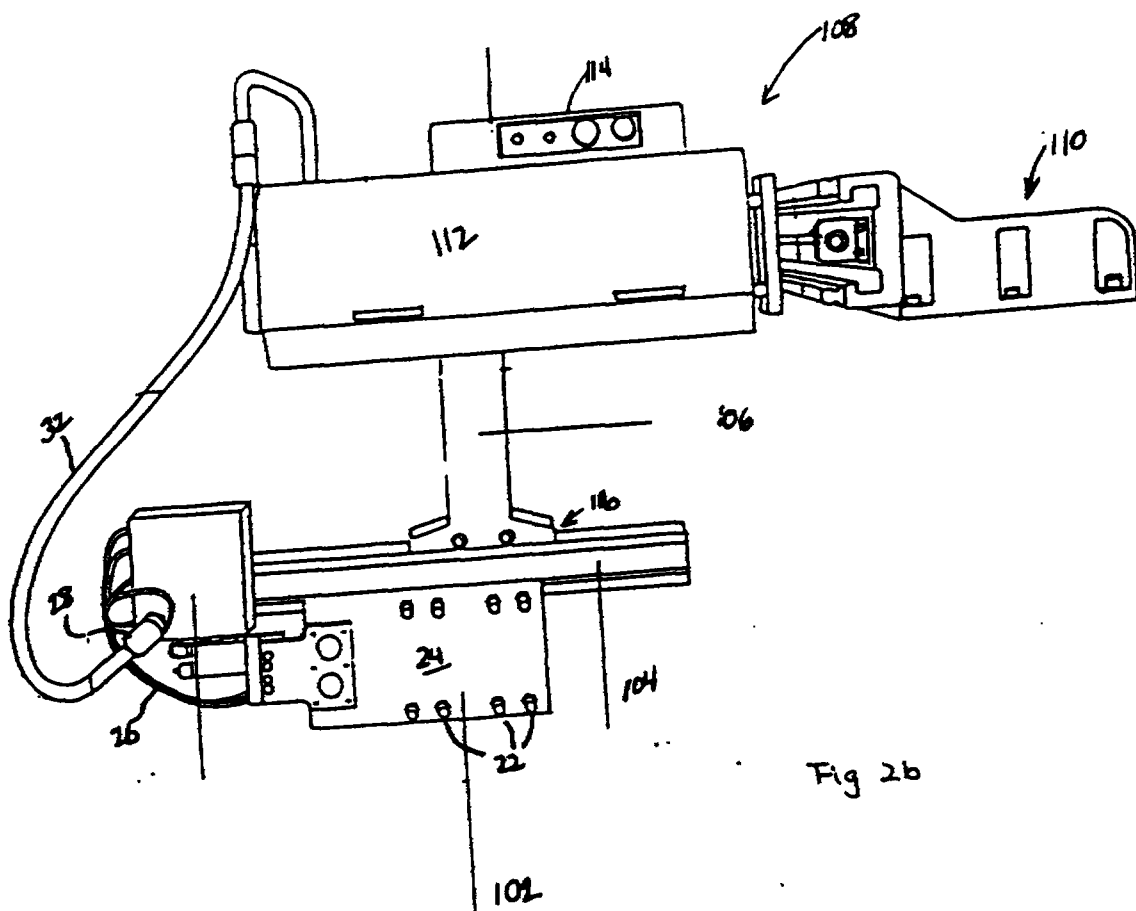
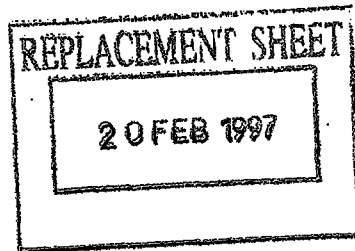
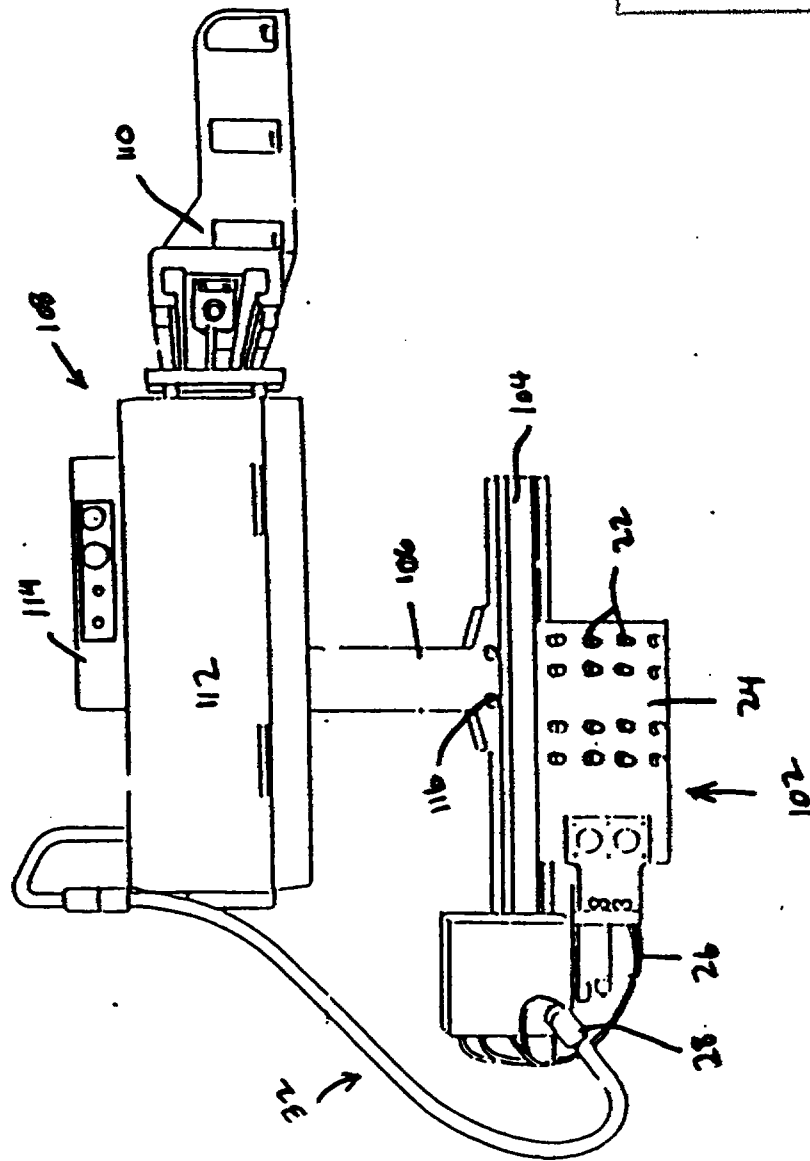
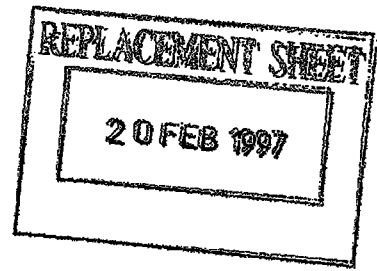


Fig 2b





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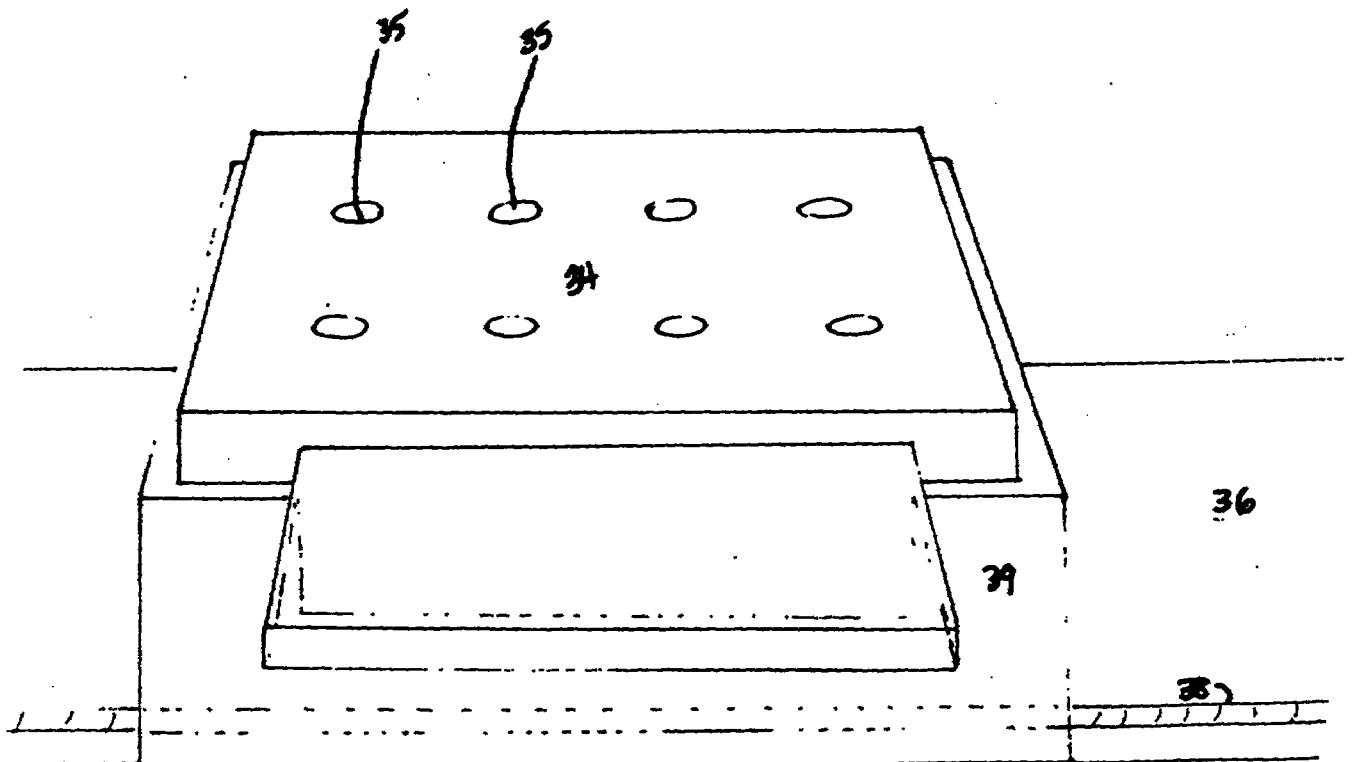


Fig 3

INCREASING
TIME
↓
(IN STEPS)

	FIRST ASSEMBLY	SECOND ASSEMBLY	THIRD ASSEMBLY
1	TRANSLATE FORWARD	TRANSLATE RIGHT	LOWER PLATFORM
2	ROTATE HAND VERTICAL	STOP	STOP
3	STOP	TRANSFER ARTICLES	RECEIVE ARTICLES
4	WAIT	STOP	RAISE PLATFORM
5	CONTINUE INTO MOLD	TRANSLATE LEFT	ROTATE
6	GRASP ARTICLES (VACUUM)	TRANSLATE LEFT	TRANSLATE BACK
7	TRANSLATE BACK	TRANSLATE LEFT	TRANSLATE BACK
8	ROTATE HAND HORIZONTAL	STOP	TRANSLATE BACK
9	STOP	RAISE UP PLATFORM	LOWER PLATFORM
10	RELEASE VACUUM	STOP	DEPOSIT ARTICLES
11	EJECT ARTICLES	RECEIVE ARTICLES	RAISE PLATFORM
12	WAIT	LOWER PLATFORM	ROTATE PLATFORM
13	WAIT	TRANSLATE RIGHT	TRANSLATE FORWARD
14	TRANSLATE FORWARD	TRANSLATE RIGHT	TRANSLATE FORWARD

Fig 4

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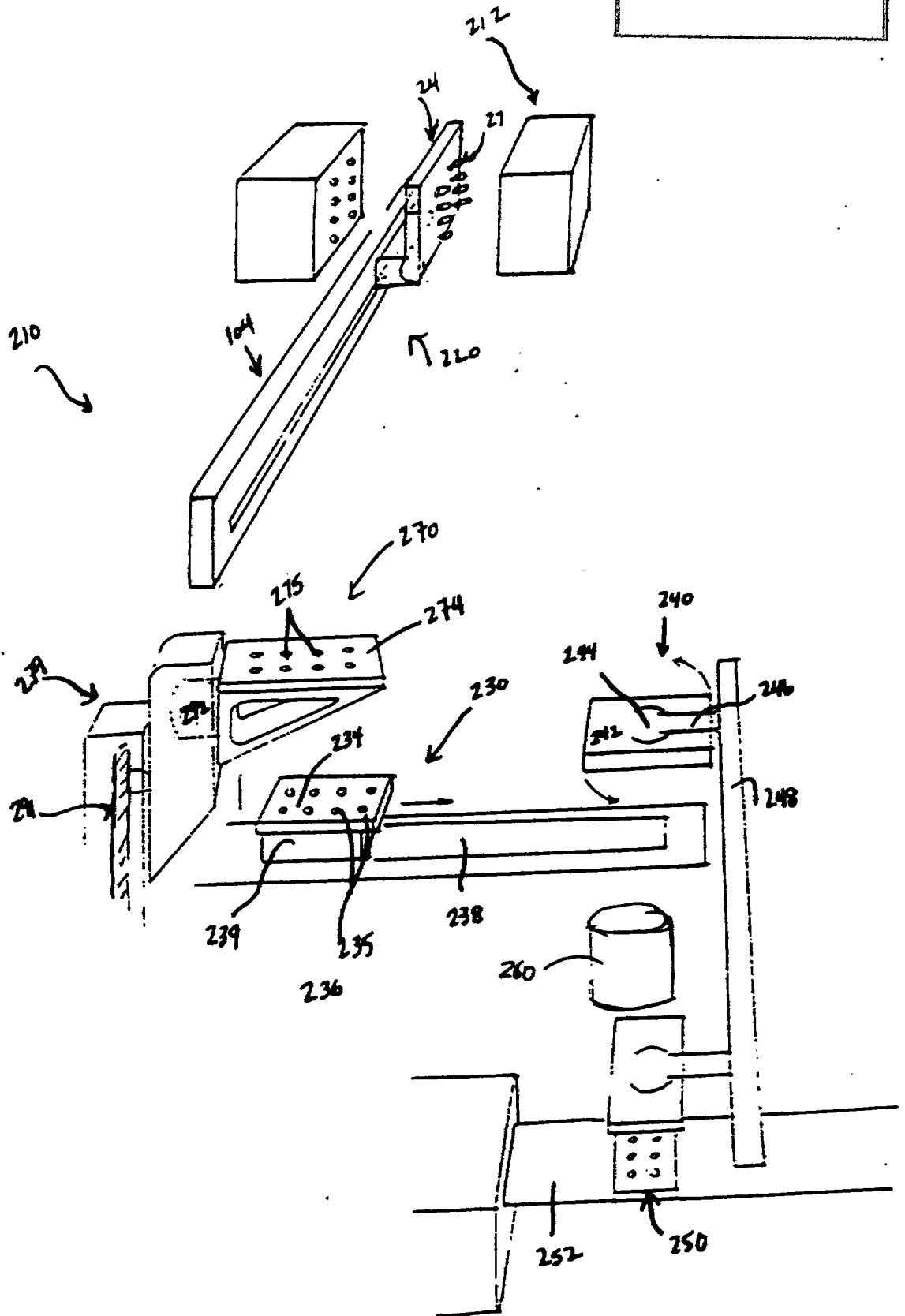


Fig 5

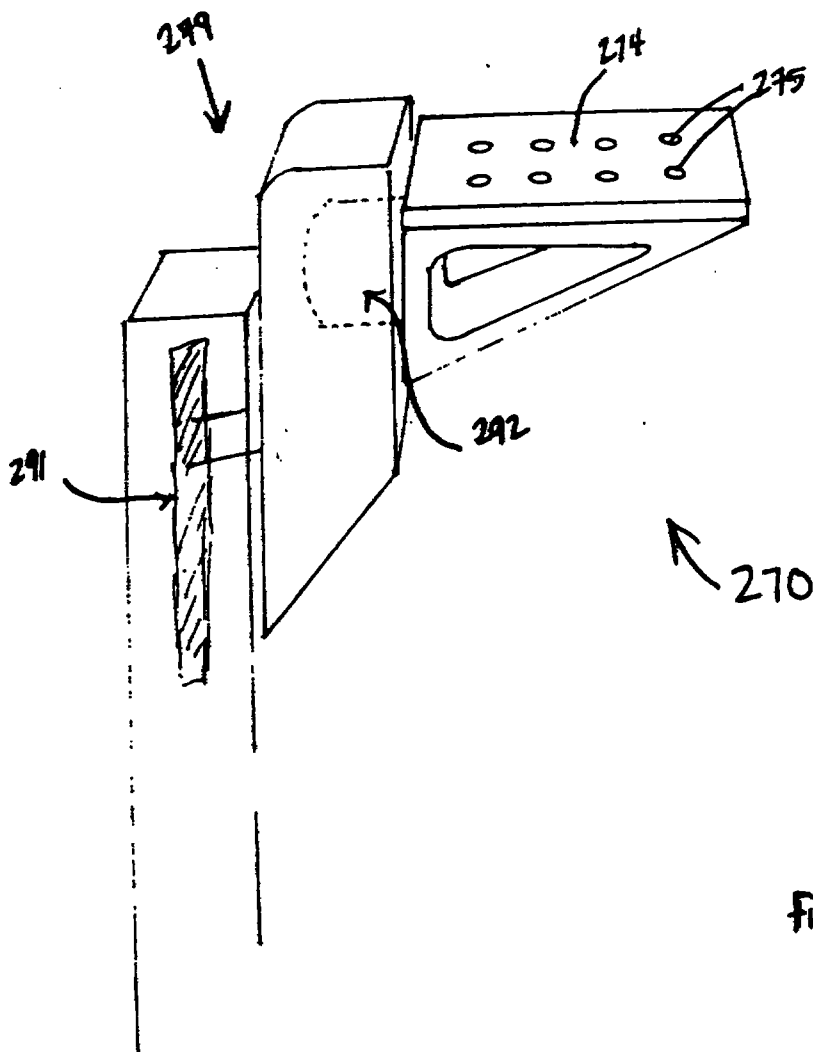


fig 6

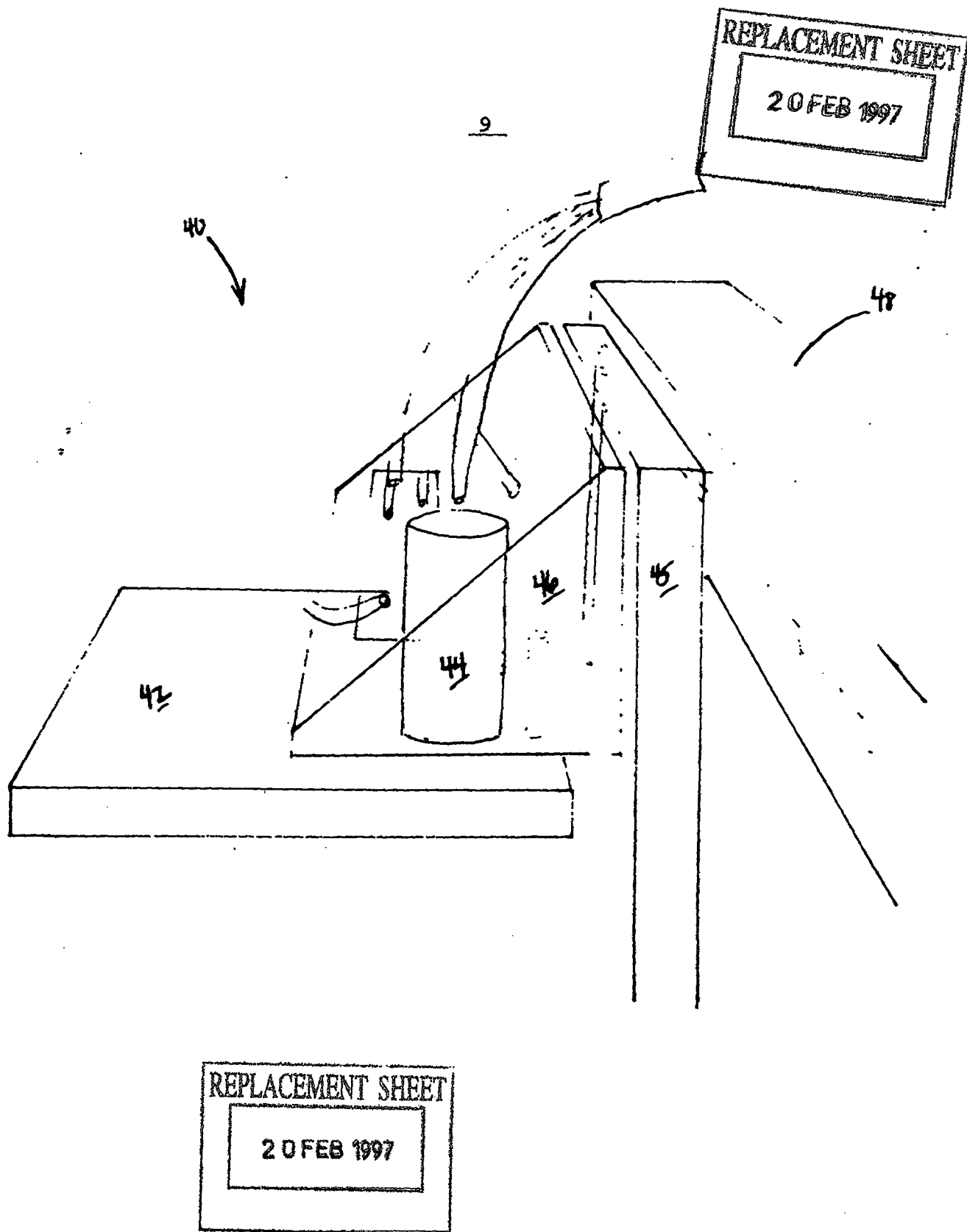


Fig. 7

FIRST ASSEMBLY		FLIPPER ASSEMBLY		SECOND ASSEMBLY		THIRD ASSEMBLY	
1	TRANSLATE FORWARD	ROTATES OVER		WAIT		TRANSLATE FORWARD	
2	ROTATE HAND VERTICAL	WAITS		PLATFORM RISES		ROTATES	
3	STOP	RELEASE ARTICLES		RECEIVES ARTICLES		TRANSLATE FORWARD	
4	WAIT	WAIT		PLATFORM DROPS		STOP	
5	WAIT	ROTATE BACK		TRANSLATE RIGHT		PLATFORM DROPS	
6	TRANSLATE INTO MOLD	STOP		PLATFORM RISES		STOP	
7	RECEIVE ARTICLES	WAIT		RELEASE ARTICLES		RECEIVE ARTICLES	
8	TRANSLATE BACK	WAIT		WAIT		PLATFORM RISES	
9	ROTATE HORIZONTAL	WAIT		PLATFORM DROPS		ROTATES	
10	STOP	WAIT		TRANSLATE LEFT		TRANSLATES BACK	
11	WAIT	PLATFORM RISES		WAIT		PLATFORM DROPS	
12	RELEASE ARTICLES	RECEIVE ARTICLES		WAIT		RELEASE ARTICLES	
13	WAIT	PLATFORM DROPS		WAIT		PLATFORM RISES	

INCREASING TIME [IN STEPS]

↓

INCREASE IN

TIME

[IN STEPS]

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Fig. 8

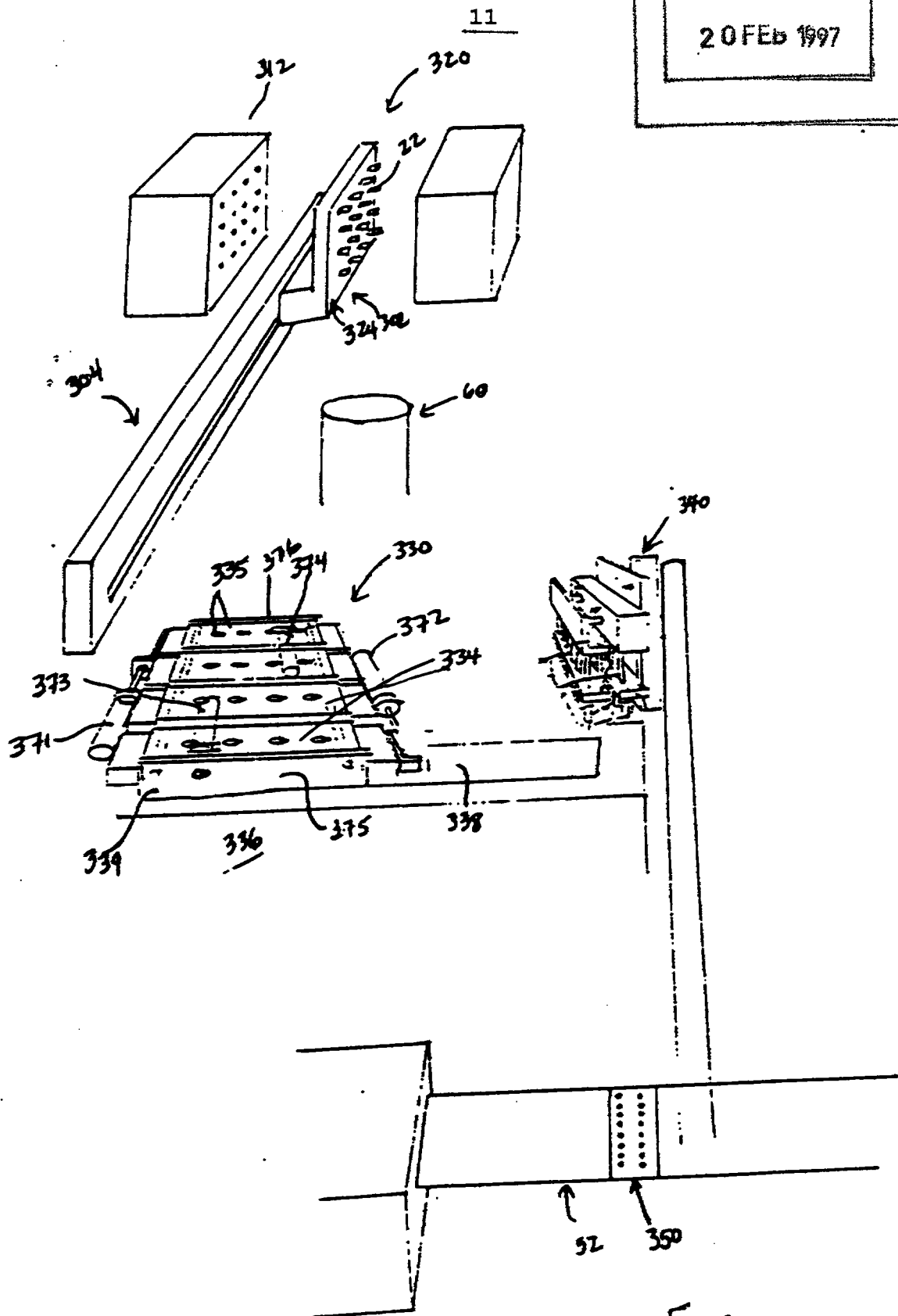


Fig 9

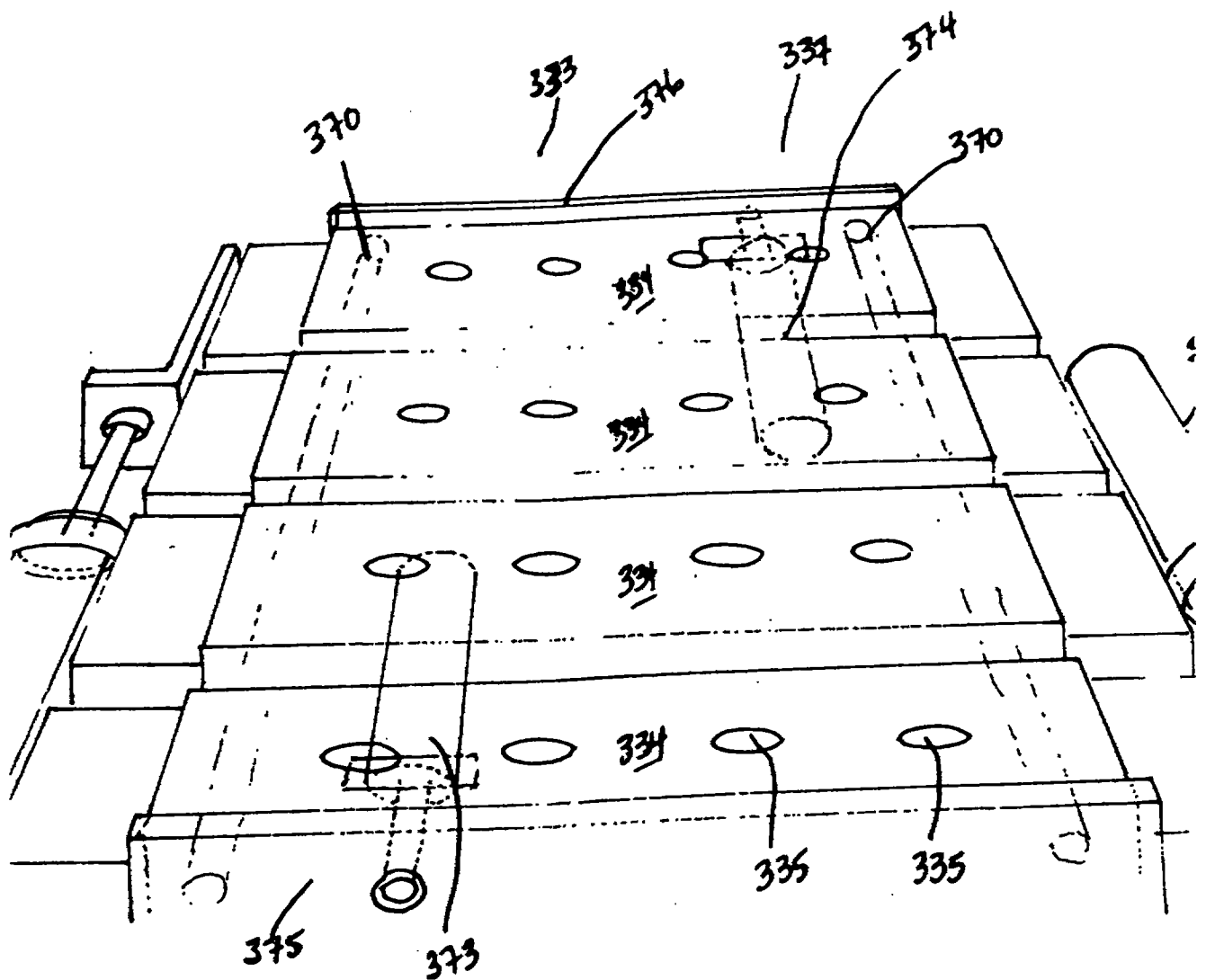


Fig 10

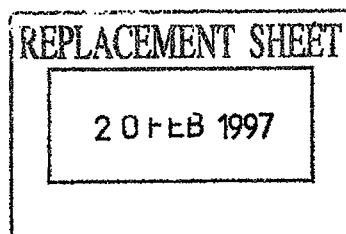
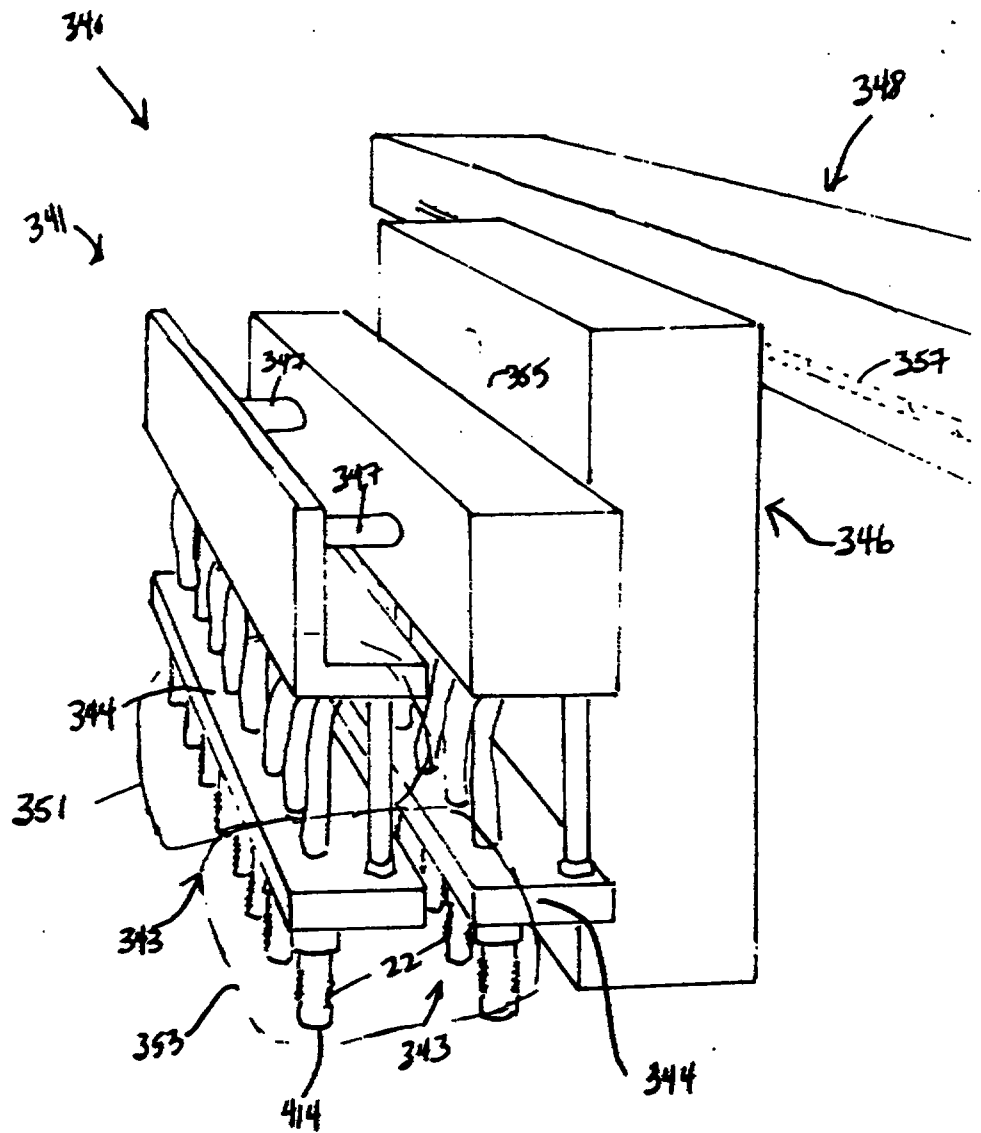


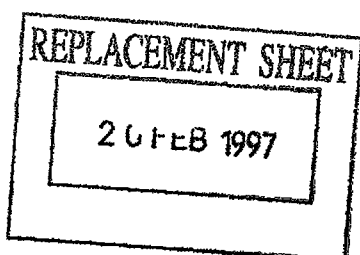
Fig 11

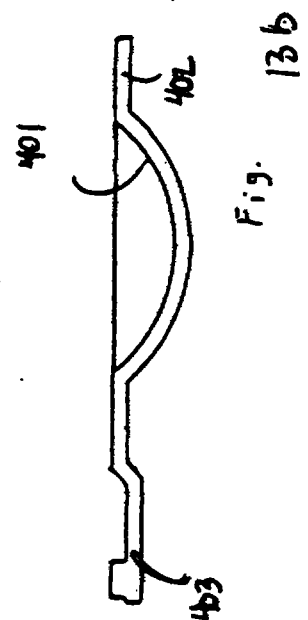
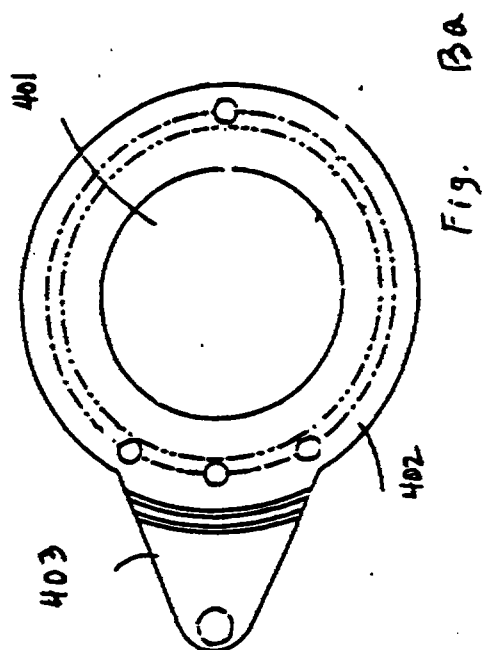
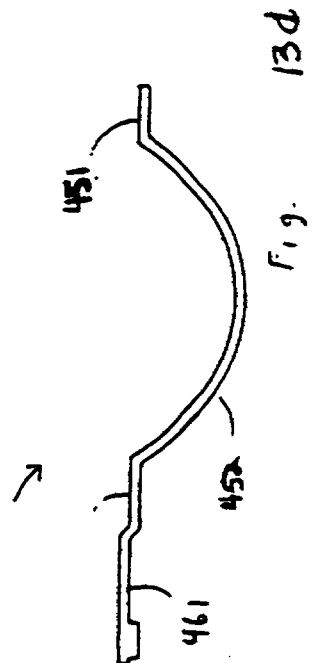
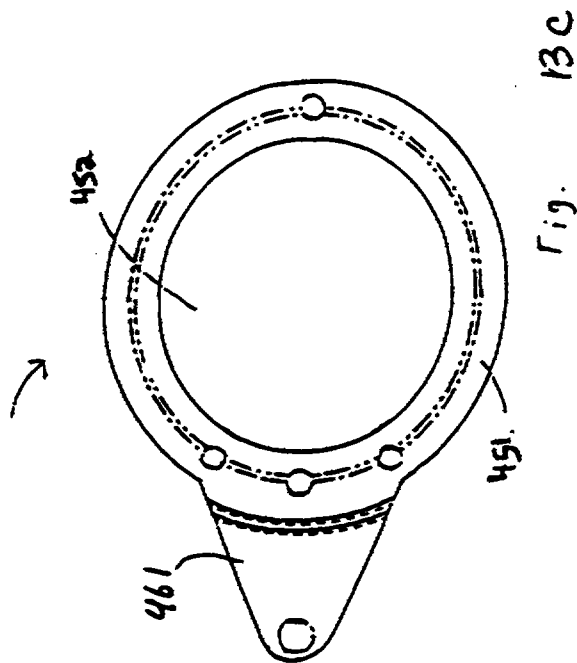
	FIRST ASSEMBLY	SECOND ASSEMBLY	THIRD ASSEMBLY
1	TRANSLATE FORWARD	COMPACTIFY	VACUUM HEAD DROPS
2	ROTATE VERTICAL	TRANSLATE RIGHT	STOP
3	TRANSLATE FORWARD	RELEASE ARTICLES (FIRST)	GRASP ARTICLES (FIRST)
4	STOP	STOP	VACUUM HEAD RISES
5	WAIT	TRANSLATE RIGHT	TRANSLATE BACK
6	WAIT	STOP	VACUUM HEAD DROPS
7	WAIT	RELEASE ARTICLES (SECOND)	GRASP ARTICLES (SECOND)
8	TRANSLATE INTO MOLD	STOP	VACUUM HEAD RISES
9	GRASP ARTICLES	TRANSLATE LEFT	DRAW ROWS TOGETHER
10	TRANSLATE BACK	STOP	TRANSLATE BACK
11	ROTATE HORIZONTAL	WAIT	VACUUM HEAD DROPS
12	TRANSLATE BACK	PLATFORM RISES	RELEASE ARTICLES
13	WAIT	STOP	VACUUM HEAD RISES
14	RELEASE ARTICLES	RECEIVE ARTICLES	EXPAND ROWS
15	STOP	PLATFORM DROPS	TRANSLATES FORWARD

INCREASING
TIME
(IN STEPS)

14
↓

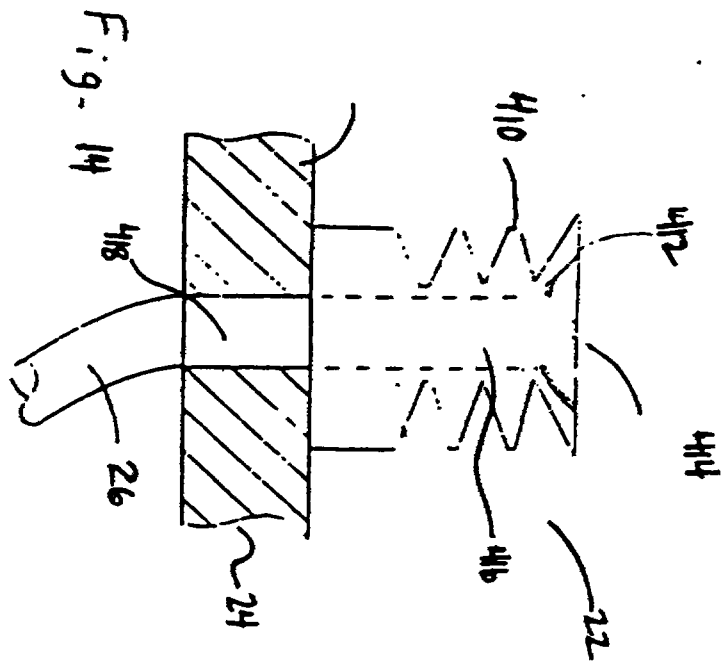
Fig 12





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