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LASER DEMOLDING APPARATUS AND METHOD

This patent application is a continuation-in-part of patent application Serial No. 08/257,801, filed June 10, 1994, for LASER DEMOLDING APPARATUS AND METHOD.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a laser demolding apparatus and method, wherein a molded assembly, comprising a front curve, a spaced back curve and a molded contact lens formed therebetween, are separated or demolded in a manner which improves the efficiency of the demolding operation.

More particularly, the subject invention pertains generally to methods and apparatus for producing ophthalmic lenses, and in particular to a method and apparatus for the improved removal of molded ophthalmic lenses from the molds in which they are produced. In particular, this invention is suited to molded ophthalmic lenses such as hydrogen contact lenses, although the method is also applicable to other small, high-precision ophthalmic lenses such as intraocular lenses.

The present invention is related to patent application Serial No. 08/207,443, filed March 7, 1994, for LASER ASSISTED DEMOLDING OF OPHTHALMIC LENSES.

2. Discussion of the Prior Art

As the ophthalmic lens industry has grown, and in particular the industry related to supplying contact lenses that are provided for periodic frequent replacement, the number of contact lenses that need to

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1 be produced has increased dramatically. This has
required manufacturers to strive for automated methods
and apparatus which are adaptable to automated practices
and consistent performance.

5 It is known in the art to make ophthalmic
lenses, such as soft contact lenses, by forming a
monomer or monomer mixture in a mold such as one made
from polystyrene or polypropylene.

Examples of this prior art can be found in
10 U.S. Patents 5,039,459, 4,889,664 and 4,565,348. These
patents discuss therein the requirement for a
polystyrene mold in which the materials, chemistry and
processes are controlled such that the mold portions do
not require undue force to separate by sticking to the
15 lens or to each other. In contrast to the above
polystyrene molds, another example is the use of
polypropylene or polyethylene molds such as described in
U.S. Patent 4,121,896.

The mold assembly to mold an ophthalmic
20 contact lens typically includes a lower concave mold
portion (referred to as a front curve), and an upper
convex mold portion (referred to as a back curve). The
concave surface of the lower front curve and the convex
surface of the upper back curve define therebetween a
25 mold cavity for a contact lens. A particular problem in
the prior art is that the front and back mold portions
are usually surrounded by a flange, and the monomer or
monomer mixture is supplied in excess to the concave
mold portion prior to the assembly of the molds. After
30 the mold portions are placed together, defining the lens
and forming an edge, the excess monomer or monomer

1 mixture is expelled from the mold cavity and rests on or
between the flange of one or both mold portions. Upon
polymerization, this excess material forms an annular
flange or ring around the formed lens which resists
5 separation of the mold portions during a demolding
operation.

The prior art process for separating the mold
portions and removing the lens consists of preheating,
heating, prying and removal. Hot air provides
10 convective heating, mechanical leverage the prying, and
the removal is manual. Heating the mold by convection
is not an efficient heat transfer technique, and in the
prior art, from the time a mold enters the heating
apparatus until the back mold portion is completely
15 removed requires on the order of one minute.

The prior art method for removing the lens is
to apply heat to the back mold portion by a heated air
stream. The heated air stream is directed against the
exterior of the back mold portion where it transfers
20 heat to the upper surface of the lens. Heat is then
transported by thermal conduction through the back mold,
the molded lens, and the front mold. The heating of the
back mold portion is performed in two sequential steps,
a preheat stage and a heat/pry stage. In the heat/pry
25 stage the mold is clamped in place, and pry fingers are
inserted under the back mold portion. A force is then
applied to each back mold portion by the pry fingers
during a heating cycle.

When the required temperature has been
30 reached, the back mold portion breaks free and one end
thereof is lifted by the pry fingers. After the back

1 mold portion has been detached from the front mold
portion on at least one side, the mold exits the heater.
The back mold portion and annular flashing are then
totally removed.

5 While the aforementioned method has some
efficacy in assisting in the removal of the lens from
between the mold portions, the temperature gradient
achieved from the heated back mold portion, across the
lens to the front mold portion is relatively small. The
10 shortcomings in this approach result from the manner in
which heat is delivered to the mold portion. The
constant temperature air stream heats the exterior
surface of the back mold portion, while thermal
conduction transfers heat to the lens surface. The only
15 way to increase the thermal gradient is to transfer heat
faster, but this would cause the back mold portion to
become too soft for the lift fingers to engage.

 This prior art method has not been entirely
satisfactory because the induced thermal gradient is not
20 sufficient to fully and repeatedly separate the mold
portions.

 In the technical approach taken in the parent
application Serial No. 08/257,801, during each demolding
operation the separating fixture is rotated about an
25 axis which is quite close to the restraining member to
result in a relative rotational pry movement of the back
curve relative to the front curve to progressively
separate and peel the back curve from the front curve.
This rotational demolding operation requires that the
30 curve to pry finger entry clearance, and also the
position of the rotational pivot point, be very

1 precisely controlled in order to prevent point contact
loading of the demolding forces on the back curve.
Point contact loading of the demolding forces leads to
back curve breakage and down time of the assembly line.
5 Since the preciseness of the rotational demolding set-up
is hard to obtain and even harder to maintain, increased
laser heat and slower demold speeds are generally
required to prevent back curve breakage. Another fault
with a poor rotational demolding set-up is the resultant
10 damage to the lens if the back curve rotates around the
edge of the lens.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the
present invention to provide an improved laser demolding
15 apparatus and method that can easily and repeatedly
separate contact lens mold portions without damaging the
contact lens formed therebetween.

A further object of the subject invention is
the provision of a method and apparatus for separating a
20 back curve mold from a front curve mold of a contact
lens mold assembly wherein a substantial temperature
gradient is applied across at least one of the mold
portions. In a preferred embodiment, a substantial
temperature gradient is created between the back curve
25 mold and a contact lens formed in a cavity between the
two mold portions.

Another object of the present invention is to
provide an automated apparatus to mechanically and
reliably pry the mold halves apart in a consistent and
30 reliable manner to thereby enhance the production of

1 defect-free contact lenses, and minimize tearing of the
lens and breakage of the lens mold parts.

A further object of the subject invention to
perform such separation without excessive environmental
5 heating or waste of energy.

In accordance with the teachings herein, the
present invention provides an arrangement for demolding
a mold assembly, which includes a first front mold
portion having a central mold section with a surrounding
10 flange, and a corresponding second back mold portion
also having a central mold section with a surrounding
flange. In a preferred embodiment, the first mold
portion is a concave front curve mold half, and the
second mold portion is a convex back curve mold half,
15 with a contact lens being molded between the first and
second mold halves. The flanges of the front and back
mold portions are spaced apart and parallel to each
other. The demolding apparatus includes restraining
means for restraining the first mold portion of the mold
20 assembly, which includes restraining fingers positioned
between and on opposite sides of the spaced flanges of
the first and second mold portions and against the
flange of the first mold portion. The demolding
apparatus also includes a separating fixture which
25 includes separating fingers positioned between and on
opposite sides of the spaced flanges of the first and
second mold portions and against the flange of the
second mold portion. During demolding, the separating
fixture is subjected to a substantially vertical prying
30 motion relative to the restraining means to separate the
second mold portion from the first mold portion.

1 The previous rotational laser demolding
arrangement, as described in parent application Serial
No. 08/257,801, was converted from an IKO rack and
pinion stepper motor drive with a rotational pry
5 demolding arrangement to an IKO rack and pinion stepper
motor drive with a vertical lift pry demolding
arrangement in less than two hours. The relatively
simple conversion entailed replacing the pry pivot link
arm, and locking the pry finger horizontally to the back
10 curve. The pry pivot link arm was replaced with an L-
shaped link with an inserted cam-follower type bearing.
The L-shaped link pivots around the previous demolding
pivot point, causing the wedge pivot platform to rotate
about its pivot point. The pivot point for the wedge
15 pivot platform is a rotational shaft which is a
substantial radial distance from the pry finger (at
least the length of the wedge pivot platform), so that
the pry action is a substantially vertical pry motion.

 The advantages of the vertical pry demolding
20 arrangement are:

- a. no point loading of back curves, leading
to lower laser heats, faster demolding speeds, and less
down time caused by broken back curves;
- b. exceptional pilot line data from a steam
25 demolding arrangement using a vertical lift demolding
pry motion. A laser demold audit of 672 consecutive
lenses had two hema rings, two edge defects, and one
missing lens (<1%);
- c. a much shorter drive distance for the IKO
30 rack and pinion stepper motor drive during demolding,
reducing the demolding time significantly;

- 1 d. better hema ring removal;
- e. the wedge lift pneumatic drive cylinder
can be speeded up since hema ring removal is completed
by the IKO rack and pinion stepper motor drive. In
5 contrast thereto, with a pivotal demolding arrangement
as in parent application Serial No. 08/257,801, the hema
ring removal is completed by the wedge lift pneumatic
drive cylinder, making the pneumatic drive cylinder a
critical parameter. With a vertical lift demolding
10 arrangement pursuant to the present invention, the wedge
pneumatic drive cylinder is used only to raise the back
curve to a scrape off height;
- f. since the pry fingers are locked in
position, scrape off can occur while the IKO rack and
15 pinion stepper motor drive is returning to a start pry
position. This allows faster movements to the scrape
off position with a reduction in the cycle time; and
- g. the vertical pry demolding arrangement of
the present invention is easier to set up and maintain,
20 while using an acceptable skill and experience level of
personnel.

In greater detail, before demolding, the
second mold portion is irradiated with electromagnetic
radiation, which is absorbed thereby to cause a
25 substantial temperature gradient between the second mold
portion and the contact lens being demolded. The
temperature gradient causes a differential expansion and
shifting of the surface of the heated second mold
portion relative to the surface of the lens to lessen
30 the adhesion therebetween to assist in the separation of
the mold portions, while leaving the lens in the first

1 mold portion. The second mold portion is preferably
irradiated by a laser producing radiation with a wave-
length between 1 μm and 20 μm . The separating fingers
are joined together to form a U-shaped separator, and
5 the laser beam is directed through the U opening in the
U-shaped separator to irradiate the second mold portion.

The mold assembly is carried by a pallet,
which carries an array of similar mold assemblies, and a
conveyor conveys the pallet into a demolding position in
10 the demolding apparatus. The conveyor conveys the mold
assembly on the pallet into the demolding apparatus, to
insert the restraining fingers and the separating
fingers between the flange members of the mold assembly.
The restraining fingers are positioned against the
15 flange of the first mold portion and the separating
fingers are positioned against the flange of the second
mold portion. The separating fixture is supported by a
first movable base to impart a substantially vertical
prying motion thereto relative to the fixedly mounted
20 restraining means during the demolding operation. A
control system sequentially actuates the conveyor to
convey the mold assembly into a demolding position in
the demolding apparatus, and then actuates a
substantially vertical prying motion of the separation
25 fixture to lift the back curve mold portion from the
restrained front curve mold portion, to thereby separate
the back curve mold portion from the front curve mold
portion and the contact lens retained therein.

A plurality of contact lens mold assemblies
30 are carried on a pallet, and the demolding apparatus
includes a plurality of pairs of restraining means and

1 separating fixtures. In one preferred embodiment, the
pallet carries two rows of contact lens mold assemblies,
and the demolding apparatus includes a first set of
restraining means and separating fixtures positioned on
5 a first side of the pallet and a second set positioned
on a second side of the pallet.

The separating fixture is mounted on a first
movable base for elevational movement relative to the
fixedly mounted restraining means. The first movable
10 base is pivotally mounted at one end about a rotational
shaft, and the separating fixture is mounted at the
second, opposite end of the first movable base. With
this arrangement, the separating fixture is spaced from
the rotational shaft of the first movable base by at
15 least the full length of the first base such that
rotational movement thereof results in a substantially
vertical prying motion of the separating fixture
relative to the restraining means. The arrangement
further includes a ramp cam driven by a pneumatic motor.
20 The first movable base includes a cam follower roller
positioned on the ramp cam, such that as the ramp cam is
driven by the pneumatic motor, the cam follower roller
rotates the first movable base about the rotational
shaft to raise and lower the separating fixture. The
25 first movable base is mounted on a second movable base
which is mounted for both X and Y translational
movements relative to a fixed base. An X pneumatic
drive motor drives the second movable base in X
translational movement, and a Y pneumatic drive motor
30 drives the second movable base in Y translational
movement relative to the fixed base.

1 The separating fixture includes a gripping
means for gripping a second mold portion which is
separated from a first mold portion. A back curve mold
remover is provided to remove the back curve mold
5 portion from the separating fixture after separation of
the mold portions. The separating fixture is translated
relative to the back curve remover, during which
translation the back curve mold portion is removed from
the separating fixture. The back curve remover is
10 vertically movable into and out of a back curve removal
position relative to the separating fixture.

 The present invention also provides a method
for demolding a mold assembly, which includes a first
front mold portion having a central mold section with a
15 surrounding flange, and a corresponding second back mold
portion having a central mold section with a surrounding
flange. A molded ophthalmic lens is formed between the
front and back mold portions, and the flanges of the
front and back mold portions are spaced apart and
20 parallel to each other. The method comprises
restraining the first mold portion of the mold assembly
by restraining fingers which are positioned between and
on opposite sides of the spaced flanges of the first and
second mold portions and against the flange of the first
25 mold portion. Separating fingers are positioned between
and on opposite sides of the spaced flanges of the first
and second mold portions and against the flange of the
second mold portion. The separating fingers are
subjected to a substantially vertical prying motion
30 relative to the restrained first mold portion to

1 separate the second mold portion from the first mold
portion.

In a preferred embodiment of the method, the
second mold portion is irradiated with electromagnetic
5 radiation, which is absorbed thereby to cause a
substantial temperature gradient between the second mold
portion and the contact lens being demolded. The
temperature gradient causes a differential expansion and
shifting of the surface of the heated second mold
10 portion relative to the surface of the lens, lessening
the adhesion between the lens and the second mold
portion to assist in the separation of the mold
portions, while leaving the lens in the first mold
portion. The second mold portion is preferably
15 irradiated by a laser producing radiation with a
wavelength between 1 μm and 20 μm . A laser beam is
directed through the separating fingers to irradiate the
second mold portion.

Pursuant to the method, the mold assembly is
20 carried by a pallet, which carries an array of similar
mold assemblies, and the pallet is conveyed into a
position wherein the restraining fingers and separating
fingers are positioned between the spaced flanges of the
first and second mold portions, with the restraining
25 fingers against the flange of the first mold portion and
the separating fingers against the flange of the second
mold portion. During the demolding operation, the
separating fingers are subjected to a substantially
vertical prying motion. The separating fingers grip a
30 second mold portion which is separated from a first mold
portion. The back curve mold portion is removed from

1 the separating fingers after separation of the mold
portions. The mold assembly is conveyed to insert the
restraining fingers and separating fingers between the
flange members of the mold assembly, and then the
5 separating fingers are subjected to a substantially
vertical prying motion to lift the back curve mold
portion relative to the front curve mold, thereby
separating the back curve mold portion from the front
curve mold portion and the contact lens retained
10 therein. A plurality of mold assemblies are carried on
the pallet in two rows, and a first set of restraining
fingers and separating fingers are positioned on a first
side of the pallet, and a second set of restraining
fingers and separating fingers are positioned on a
15 second side of the pallet.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing objects and advantages of the
present invention for a laser demolding apparatus and
method may be more readily understood by one skilled in
20 the art with reference being had to the following
detailed description of several preferred embodiments
thereof, taken in conjunction with the accompanying
drawings wherein like elements are designated by
identical reference numerals throughout the several
25 views, and in which:

Figure 1 illustrates a front elevational view
of a pallet which holds therein a two by four array of
contact lens mold assemblies, each of which consists of
a lower front curve mold and an upper back curve mold,
30 defining therebetween a mold cavity for a contact lens;

1 Figure 2 is an enlarged side elevational and sectional view of a contact lens mold assembly, illustrating details of construction of a lower front curve mold and an upper back curve mold;

5 Figure 3 illustrates a sequence of movements of a separating finger member, mounted on an articulated separating arm, relative to a pallet supporting thereon an array of front and back curve assemblies;

10 Figure 4 is a view of a fixture apparatus for separating mold portions according to one aspect of the present invention;

 Figure 5 is a front elevational view of one embodiment of a demolding apparatus pursuant to the present invention;

15 Figure 6 is a top plan view of the demolding apparatus taken along arrows 6-6 in Figure 5;

 Figure 7 is a right side elevational view of the demolding apparatus taken along arrows 7-7 in Figure 5;

20 Figure 8 is a top plan view similar to Figure 5, illustrating the demolding apparatus positioned adjacent to a conveyor system for the sequential movement of pallets containing contact lens mold assemblies through the demolding apparatus;

25 Figure 9 is a top planar view of the front curve retaining means used in the laser demolding embodiment of the present invention;

30 Figure 10 is a partially cross-sectional view of a portion of the laser demolding embodiment of Figure 9, further illustrating the front curve retaining guides;

1 Figure 11 illustrates a side elevational view
of a back curve scraper for removing the back curves and
depositing them into a receptacle;

 Figure 12 is a schematic illustration of the
5 movements of the previous demolding apparatus of parent
application Serial No. 08/257,801, showing the previous
rotational demolding action; and

 Figure 13 is a schematic illustration of the
movements of the demolding apparatus pursuant to the
10 present continuation-in-part application, showing the
present substantially vertical demolding action thereof.

DETAILED DESCRIPTION OF THE DRAWINGS

 Referring to the drawings in detail, Figure 1
illustrates a front elevational view of a pallet 10
15 which holds thereon an array, typically a two by four
array, of contact lens mold assemblies 12, as
illustrated in further detail in Figures 8 and 9 wherein
each mold assembly is illustrated schematically by a +.

 In the laser demolding apparatus, pallets 10
20 containing contact lens mold assemblies are advanced
sequentially in the direction of arrow A, Figures 8 and
9, by a conveyor system into and then through the laser
demolding apparatus. The pallets 10 are advanced by
push blocks on the conveyor system, and are initially
25 incrementally advanced to advance an entire pallet
length, and are then incrementally advanced a smaller
distance equal to the distance between centers of pairs
of mold assemblies carried on the pallet 10. This
enables the laser demolding apparatus to demold a pair
30 of mold assemblies after each advance between pairs, and
when the last pair is demolded, a new pallet is then

1 advanced into an initial position in the demolding
apparatus, as illustrated in Figure 8.

Figure 2 is a side elevational and sectional
view of one contact lens mold assembly 12 which consists
5 of a lower front curve mold 14 and an upper back curve
mold 16, defining therebetween a mold cavity 18 for a
contact lens.

The front and back mold halves 14 and 16 are
preferably formed of polystyrene but could be any
10 suitable thermoplastic polymer which is sufficiently
transparent to ultraviolet light to allow irradiation
therethrough with light to promote the subsequent
polymerization of a soft contact lens. A suitable
thermoplastic such as polystyrene also has other
15 desirable qualities such as being moldable to surfaces
of optical quality at relatively low temperatures,
having excellent flow characteristics and remaining
amorphous during molding, not crystallizing, and have
minimal shrinkage during cooling.

20 The front mold half 14 defines a central
curved section with an optical quality concave surface
20, which has a circular circumferential knife edge 22
extending therearound. The knife edge 22 is desirable
to form a sharp and uniform plastic radius parting line
25 (edge) for the subsequently molded soft contact lens. A
generally parallel convex surface 24 is spaced from the
concave surface 20, and an annular essentially uniplanar
flange 26 is formed extending radially outwardly from
the surfaces 20 and 24. The concave surface 20 has the
30 dimensions of the front curve (power curve) of a contact
lens to be produced by the mold assembly, and is

1 sufficiently smooth such that the surface of a contact
lens formed by polymerization of a polymerizable
composition in contact with the surface is of optically
acceptable quality. The front mold half is designed
5 with a thickness, typically 0.8 mm, and rigidity
effective to transmit heat therethrough rapidly and to
withstand prying forces applied to separate the mold
half from the mold assembly during a demolding
operation. The front mold half 14 further defines a
10 generally triangular tab 28, Figures 2 and 9, integral
with the flange 26 which projects from one side of the
flange. Tab 28 is essentially uniplanar and extends to
an injection hot tip which supplies molten thermoplastic
to form the front mold half.

15 The back mold half 16 defines a central curved
section with an optical quality convex surface 32, a
generally parallel concave surface 34 spaced from the
convex surface 32, and an annular essentially uniplanar
flange 36 formed extending radially outwardly from the
20 surfaces 32 and 34. The convex surface 32 has the
dimensions of the rear curve (which rests upon the
cornea of the eye) of a contact lens to be produced by
the back mold half, and is sufficiently smooth such that
the surface of a contact lens formed by polymerization
25 of a polymerizable composition in contact with the
surface is of optically acceptable quality. The back
mold half is designed with a thickness, typically 0.6 mm,
and rigidity effective to transmit heat therethrough
rapidly and to withstand prying forces applied to
30 separate the mold half from the mold assembly during
demolding. The back mold half 16 also defines a

1 generally triangular tab 38, similar to the triangular
tab 28, integral with the flange which projects from one
side of the flange. The tab 38 extends to an injection
hot tip which supplies molten thermoplastic to form the
5 back mold half.

The flanges 26 and 36 are designed to assist
in demolding and part handling, and also protect the
optical surfaces and the knife edge. The geometry of
the triangular tabs 28 and 38 serves an additional
10 function in straightening and orienting the assembled
front curve/back curve assembly 12 prior to demolding.
When a front mold half or curve 14 is assembled with a
back mold half or curve 16, a gap 40 is formed between
the two spaced flanges and projecting tabs which is
15 important for demolding. The gap between the tabs is
preferably in the range of 1.5 mm-3.0 mm, and is
required to assist in the demolding operation, as
explained in greater detail hereinbelow.

Referring to Figures 1 and 2, the contact lens
20 mold assemblies 12 are supported in the pallet 10 with
the annular flanges 26 and tabs 28 of the front curve
mold 14 recessed slightly below the upper surface of the
pallet 10. The annular flanges 36 and tabs 38 of the
back curve mold 16 are raised above the upper surface of
25 the pallet, to allow retaining fingers 42 and lifting or
prying fingers 44 to slide between the spaced flanges
26, 36 of the front and back curves. The retaining
fingers 42 are positioned above opposite sides of the
flange 26 around the front curve 14 to restrain the
30 front curve 14 in the pallet and against upward
movement. The lifting fingers 44 are positioned below

1 opposite sides of the flange 36 around the back curve 16
to lift and pry the back curve from the restrained front
curve.

Referring to Figure 4, the thin metal pry
5 fingers 44, which are shown positioned underneath the
back mold portion flange 36, are machined flat on both
sides. The pry fixture 54 rotates about axis 56 so that
after exposure of the rear mold portion 16 to the laser,
the pry fingers 44 pry the back mold portion up.
10 Whereas it was found that merely prying off the back
mold portion in an arbitrary fashion was acceptable,
when the metal fingers are stopped under the flange 36,
and are then tilted back, the overall quality of the
removed lens was as good or better than currently
15 employed techniques. During the demolding separation,
the back curve is physically peeled from the front curve
and molded contact lens therein, similar to the peeling
of a strip of tape from a tape roll, such that the
separation occurs sequentially in a wavefront which
20 moves across the back and front curves as they are being
separated.

The lens/mold assembly 12 is positioned in a
fixture shown in Figure 4. A primary requirement of
this fixture, beyond mechanical stability, is not to
25 interfere with the beam 55 of electromagnetic radiation.
The separating fingers 44 of the pry fixture 54 define a
U-shaped opening above the back curve mold 16, and prior
to demolding, a laser beam is directed through the U-
shaped opening 57 to heat the back curve, thus creating
30 a substantial thermal gradient across the mold assembly
12 to assist in separating the back curve from the front

1 curve. For the presently described system, only the
back mold portion 16 is heated by exposure to radiation.
The back mold portion is thinner than the front mold
portion 14, and allows rapid, non-destructive heating of
5 the polystyrene sufficient to create a large thermal
gradient. The thicker front mold portion containing a
larger amount of polystyrene would not be heated as
rapidly, and thereby not produce the same thermal
gradient without localized overheating problems.

10 The side-by-side assemblies 12 of the front
and back curves are held in the pallet 10 with the
flanges 26 and tabs 28 of the front curves being in
slightly recessed positions and the flanges 36 and tabs
38 of the rear curves 16 being in slightly elevated
15 positions, such that as the pallet 10 travels on an
assembly line towards the demolding apparatus, the
retaining fingers 42 and separating or lifting fingers
44 readily slide between the separated side flanges 26,
36 of the front and back curves.

20 Figure 3 illustrates one sequence of movements
of a pry fixture 54, rotationally mounted on a shaft 60,
relative to a pallet 10 supporting a two by four array
of front and back curve assemblies 12. In a first
position in the upper left portion of Figure 2, the
25 pallet 10, moving on a conveyor, moves the front and
back curve assemblies 12 in the pallet into the position
illustrated in Figure 1 in which retaining fingers 46
are positioned above opposite sides of the flange 26
around the front curve 14 to restrain the front curve 14
30 in the pallet against upward movement. Lifting fingers
48 are positioned below opposite sides of the flange 36

1 around the back curve mold 16 to lift and pry the back
curve mold 16 from the restrained front curve mold 14.
As illustrated in Figure 1, the contact lens mold
assemblies 12 are supported in the pallet with the
5 annular flanges 26 and tabs 28 of the front curve mold
14 recessed slightly below the upper surface of the
pallet, and with the annular flanges 36 and tabs 38 of
the back curve mold 16 raised above the upper surface of
the pallet, to allow the retaining fingers 46 and
10 lifting fingers 48 to slide between the spaced flanges
26, 38, as the conveyor moves the pallet into the
position shown in Figure 1.

In the second position in the middle left
portion of Figure 3, after illumination of the back
15 curve by a laser beam, the articulated arm 64 rotates
the pry fixture 54 to separate the upper back curve from
the lower front curve, with the rotation causing the
separating finger member to rotate to pry apart and
separate the back curve from the front curve.

20 In the third position in the lower extreme
left portion of Figure 3, the pry fixture 54 is raised
upwardly approximately 10 mm from the pallet.

In the fourth position in the lower middle
left portion of Figure 3, the pallet is moved to the
25 left by the conveyor, the pry fixture is rotated back to
its original position, and the pry fixture 54 is
conveyed in X and Y directions, as described in further
detail hereinbelow, to remove the separated back mold
half from the pry fixture 54.

30 In the fifth position in the lower middle
right portion of Figure 3, another pallet, with

1 unseparated back and front curve assemblies, is moved by
the conveyor into a position under the pry fixture, and
the pry fixture 54 is conveyed back in X and Y
directions into a demolding position, as described in
5 further detail hereinbelow.

In the sixth position in the lower extreme
right portion of Figure 3, the pry fixture 54 is lowered
adjacent to the next pallet to reposition the pry
fixture 54 relative to the next pallet 10' for the next
10 demolding operation.

The pallet 10' is then conveyed to the left to
reassume the first position, in the upper left portion
of Figure 3, in which the separating fingers and
retaining fingers are positioned between the spaced
15 opposed flanges of the joined back and front curve
assemblies.

The back curve lens mold 16 is heated by a
laser beam to create a differential expansion of the
heated mold polymer relative to the cooler lens polymer,
20 which shifts one surface with respect to the other. The
resultant shear force breaks the polymerized
lens/polymer mold adhesion and assists in separation of
the mold portions 14, 16. The greater the temperature
gradient between the surfaces of the mold portions, the
25 greater the shearing force and the easier the mold
portions separate. This effect is greatest when there
is maximum thermal gradient. As time continues, heat is
lost through conduction from the back mold portion into
the lens polymer and the front mold portion, and then
30 collectively into the surrounding environment. The
heated back mold portion is, therefore, promptly removed

1 so that very little energy is transferred to the polymer
lens, avoiding the possibility of thermal decomposition
of the lens.

Heating the back curve is accomplished by the
5 use of a source of electromagnetic radiation, preferably
a carbon dioxide (CO₂) laser, applied to at least one of
the mold portions. The laser is preferably of about 80
watts at a wavelength of 10.6 μ m. The exposure of the
mold portion to the laser is between one half and one
10 second.

While a CO₂ laser producing radiation in the
mid-infrared range at a wavelength of 10.6 microns was
used in one embodiment, it is also possible to use a
high powered UV laser or a high intensity
15 electromagnetic radiation emitter of any type wherein
the radiation produced is absorbed by the mold material
sufficiently to cause an increase in mold material
temperature.

In the case of lasers, both mid-infrared and
20 UV, the laser energy is approximately 60% efficient
because the polystyrene mold material is nearly 100%
absorptive and only a tiny fraction of the incident
radiation is reflected or scattered. In this way,
little or no energy is lost to atmospheric absorption,
25 so only the sample is heated.

Also, because of the absorptive nature of the
mold material at these frequencies, most of the laser
energy is absorbed within several wavelengths travel
into the material. From that point, heat is transferred
30 only by conduction from the surface. For that reason,
on initial exposure to the laser beam, a substantial

1 thermal gradient is formed between the exposed exterior
surface and the surface of the mold portion in contact
with the lens.

Preferably, a carbon dioxide (CO₂) laser
5 applies radiation to at least one of the mold portions
and may be split into two beams to simultaneously heat
the back curve of two mold assemblies. It has been
found through empirical testing that the laser is
preferably of about 80 watts per mold assembly at a
10 wavelength of 10.6 μ m. The exposure time of the mold to
the laser is between one half and one second. Lasers of
this power range are available both in flowing gas and
sealed laser types. In one embodiment of the laser
demolding apparatus, a Laser Photonics model 580
15 cw/pulse laser was utilized.

A preferred embodiment was found by
experimentation. While it has been found that a laser
power output of 3 to 4 watts is sufficient to cause
heating of a polystyrene mold portion so that the mold
20 can be mechanically separated, it was determined that a
much higher powered laser, up to 500 watts, is
preferred. Increasing the laser power and decreasing
the exposure duration was found to increase the thermal
gradient and increase the ease and consistency with
25 which the mold portions could be separated.

It was found that if a lens/mold combination
were sufficiently underexposed, the separation forces
would still be high. Lens damage such as tearing and
mold damage such as breaking would result.

30 If a lens/mold combination were overexposed to
the laser energy, separation of the mold portions and

1 removal of the lens would again be difficult. Mold
damage would result such as oxidizing and melting
(softening), and loss of mold rigidity would frustrate
mold separation. In addition, overexposure thermally
5 degrades the lens.

After heating the back mold portion with the
laser, a preferred method for removing the back mold
portion from the front mold portion is to apply a
relative tensile force between the mold portions. It
10 was determined empirically that such mechanical force
was best applied less than 0.3 seconds after exposure to
the radiation. Although no adverse effects would be
contemplated if there was less time between exposure and
mechanical removal, in practical terms the time between
15 exposure and mold separation would be between about 0.2
and about 1.5 seconds. Beyond a delay of 1.5 seconds
the difficulties in mold separation and lens removal
would be the same as those resulting from underexposure,
as described above.

20 A significant quality consideration and
advantage of the present invention is the consistent
retention of the lens in the front mold portion when the
back mold portion is laser heated and removed in
accordance with the above technique.

25 With the optimal exposure time and appropriate
demolding mechanism, the mold portions can be separated
and the lens removed from the mold in approximately 5
seconds.

The above is, by way of explanation, for the
30 preferred polystyrene mold system, and as can be readily
appreciated by one skilled in the art, the radiation

1 wavelengths, power levels, and exposure times must be
appropriately adjusted according to the above
considerations to achieve optimal characteristics for
other lens/mold material systems.

5 To apply a tensile force between the mold
halves, the front curve mold half is held in place as
illustrated in Figures 9 and 10, wherein a pair of thin
metal retaining fingers 42, 43 are fixably mounted above
track rails 46 and pallet 10 to secure the front curve
10 mold half 14 in pallet 10 during the prying operation.
Retaining finger 43 is an inverted T shaped member and
secures one front curve mold half 14 with one flange 43a
of the inverted T, and engages a second front curve mold
half with a second flange 43b. The second flange 43b
15 cooperates with a further flange 42b to secure the
second front curve mold half in position.

 As the pallet 10 is sequentially advanced
through the laser demolding apparatus, the flanges 42-43
sequentially engage each row of mold assemblies to
20 secure the front curve mold half. The back curve mold
half flanges 36 are engaged by a pry fixture 54,
diagrammatically illustrated in Figure 4, which engages
both sides of flange 36 as the pallet 10 is advanced
into position by the conveyor system. Pallet 10 is then
25 stopped, and a laser beam 55 is directed through the
opening 57 between the retaining fingers 42 and the
prying fingers 44 against the back mold half 16. The
pry fixture 54 is then rotated about axis 56 in the
direction of arrow C in Figure 4 to apply a tensile
30 force to the back curve mold half 16. The upper part of
the pry fixture 54 rotates about axis 56 so that after

1 exposure of the back curve mold portion to the laser,
the fingers 44 pry the back curve mold portion up. The
entire assembly is then lifted approximately 10 mm as
indicated by arrows B-B in Figure 4 to remove the back
5 curve mold part completely. It has been empirically
determined that when the metal pry fingers 44 are
stopped under the flange, and then tilted back
approximately 18°, the overall quality of the lens
removed, and the resultant yield was better than
10 currently employed prior art pry techniques which only
lift from a single side, and do not control the axis of
the pivot point.

It was also empirically determined that the
mechanical prying force was best supplied less than 0.3
15 seconds after exposure to the radiation. Although no
adverse effects would be contemplated if there was less
time between exposure and mechanical removal, in
practical terms the time between exposure and mold
separation would be between about 0.2 and about 1.5
20 seconds.

A first embodiment of the apparatus for
demolding the back curve mold halves is more fully
illustrated in Figures 5, 6, 7, 8, 9 and 10, wherein
Figure 5 is an elevational view of the apparatus, Figure
25 6 is a plan view taken along section line 6-6 of Figure
5, and Figure 7 is an elevational side view taken along
section 7-7 of Figure 5. Figure 8 is a top plan view
similar to Figure 5, illustrating the demolding
apparatus positioned adjacent to a conveyor system for
30 the sequential movement of pallets containing contact
lens mold assemblies through the demolding apparatus.

1 Figure 9 is a top planar view of the front curve
retaining elements, while Figure 10 is a partially
cross-sectional view of a portion of the laser demolding
embodiment of Figure 9, also illustrating the front
5 curve retaining guide elements.

As illustrated in Figure 9, pallet 10 is on
the second of a plurality of demolding cycles wherein a
laser delivers intense electromagnetic energy beams 55
directed through laser masks 58 to the second row of
10 mold assemblies in pallet 10. Simultaneously therewith,
the first row of mold assemblies is being demolded by
the pry fixture 54, as illustrated and described with
respect to Figure 4. Pry fixture 54 is rotated by shaft
60 about axis 56 within journal bearing 62 by a pair of
15 links 64 and 66 which are illustrated in Figures 4 and
7. As illustrated in Figure 7, link 66 is pulled in the
direction of arrow E by a rack 68 which is driven by a
pinion on a stepper motor 70. Stepper motor 70 thereby
rotates shaft 60 in the direction indicated by the arrow
20 C in Figures 4 and 7 through approximately 18° of arc to
separate the back curve mold half 16 from the front
curve mold half 14.

After the pry fixture 54 and shaft 60 have
been rotated, the pry fixture 54 is lifted upwardly in
25 the direction of arrows B, Figures 4 and 7. The pry
fixture 54 is mounted at one end of a platform 74 which
pivots about a shaft 76 at the second and opposite end
of the platform 74 to raise and lower the pry fixture
54. The platform 74 is pivoted about shaft 76, and is
30 driven in rotation by a slidable cam 78 which engages a
roller cam follower 80 mounted on the pivotable platform

1 74. Slidable cam 78 is advanced by a pneumatic drive
motor 84 to raise shaft 60 approximately 10 mm so that
the attached pry fixture 54 may be retracted for
disposal of the back curve mold halves 16 after they
5 have been separated from the mold assembly.

Each of the aforementioned components are
mounted on a further movable platform 86 which is
translatable in both the X and Y directions, as shown in
Figures 6 and 8, in order to dispose of the separated
10 back curve mold halves 16, as will be described
hereinafter. The demolding apparatus includes a
stationary base 89, upon which is mounted a stationary
tower 90, relative to which the movable platform 86 is
translated in both X and Y directions. Platform 86 is
15 suspended from the stationary tower 90 and is mounted
for reciprocal movement along the X axis along an X
track 92. Once the pry fixture 54 has separated the
back curve mold halves 16, and the pry fixture has been
lifted free of pallet 10, platform 86 is shifted to the
20 right along the X axis, as illustrated in Figures 6 and
8, by a pneumatic X drive motor 88 to the position 86',
shown in phantom in Figure 5. In the right position of
the movable base, illustrated by dashed lines 86' in
Figure 5, the pry fixture 54 is moved to a position
25 adjacent to a back curve scraper 98, Figure 8, which
removes the back curves from the pry fixture 54 and
deposits the back curves in a receptacle 96. Platform
86 is shifted to the right in the X direction in order
to place the separated back curve mold halves held by
30 the pry fixture 54 over a disposal receptacle 96,
Figures 5 and 8. Simultaneously, the back curve scraper

1 98 is elevated by a pneumatic motor 100 to a position parallel with, and just below, the surface of pry fixture 54.

Figure 11 illustrates the back curve scraper 5 98 which is secured to a pivotally mounted scraper fixture 110, which rotates about a shaft 112. The scraper fixture 110 is driven by a pneumatic motor 100 and drive shaft 114, to assume one of two positions 98, 110, or 98', 110', as illustrated in Figure 11. The 10 position 98, 110 illustrated in Figure 11 places the back curve scraper 98 in an elevated position to remove or scrape the separated back curve molds from the pry fixture 54 as the platform 86 is shifted along the Y axis, in a downward direction as shown in Figure 8, to 15 scrape the separated mold curves 16 from the pry fixture 54 and cause them to thereby drop into the receptacle 96. Platform 86 is shifted in the Y axis by a pneumatic motor 102 which is fixedly mounted to the platform 86 and the drive shaft of which engages vertical column 94 20 which extends downwardly from track 92 on stationary tower 90. Platform 86 has a Y track 104 mounted thereon, as illustrated best in Figures 5 and 6, such that the platform 86 and track 104 can translate along the Y axis relative to vertical column 94.

25 After removal of the separated mold curves 16 from the pry fixture 54, platform 86 is then reciprocated back along the Y axes, upwardly as illustrated in Figure 8, and then back along the X axes, to the left as illustrated in Figure 8, to its original 30 position, as illustrated in Figures 5 and 8. The slidable cam 78 is then withdrawn by drive motor 84 and

1 the pry fixture 54 is lowered into a demolding position
above pallet 10, ready for the next demolding operation.
The laser is then energized to heat the second row of
mold assemblies in pallet 10, and pallet 10 is then
5 incrementally advanced by the conveyor to place the
heated second row of mold assemblies into a demold
position. Pallet 10 is constrained through the
demolding apparatus on the conveyor by rails 46 which
prevent vertical movement and any pitch, yaw or roll of
10 the pallet during the demolding operation.

The pneumatic drive motors 88 and 102
basically drive the movable base 86 in an L path back
and forth between end stop positions, and end stop
detectors are employed to sense the end positions and
15 deactivate the motors. One leg of the L translates the
pry fixture 54 in an X direction between the position
illustrated in Figure 5 and the position 86' at which
the pry fixture 54 is positioned adjacent to the back
curve scraper 98. The second leg of the L translates
20 the pry fixture 54 in a Y direction as illustrated in
Figure 8 to translate the pry fixture 54, and the rear
curve members supported thereby after demolding, by the
back curve scrapers 98 which remove the rear curve
members from the pry fingers 44, and the back curve
25 members then fall into a back curve disposal
receptacle 96.

Figure 12 is a schematic illustration of the
demolding movement of the previous demolding apparatus
of Figures 4 through 11, as disclosed in parent
30 application Serial No. 08/257,801, showing the previous
rotational demolding action thereof. The arm 64 and the

1 separating fixture 54 are fixed together and rotate
together about shaft 60.

Figure 13 is a schematic illustration of the
movements of the present demolding apparatus pursuant to
5 the present continuation-in-part application, showing
the present vertical demolding action thereof. The
previous rotational laser demolding arrangement, as
described in Figures 4 through 11 in parent application
Serial No. 08/257,801, was converted from an IKO rack 68
10 and pinion stepper motor 70 drive with a rotational pry
demolding arrangement to an IKO rack 68 and pinion
stepper motor 70 drive with a vertical lift pry
demolding arrangement as illustrated in Figure 13 in
less than two hours. The conversion entailed replacing
15 the pry pivot link arm 64, and locking the pry finger 54
horizontally to element C and pivot platform 74. The
pry pivot link arm 64 was replaced with an L-shaped link
120 with an inserted cam-follower bearing 122, which
contacts and rolls on the movable base 86. The L link
20 120 pivots around the previous demolding pivot shaft 60,
causing the wedge pivot platform 74 to rotate about its
shaft 76, as illustrated in Figure 13. The pivot shaft
for the wedge pivot platform 74 is a substantial radial
distance (at least the length of the wedge pivot
25 platform 74) from the pry finger 54 so that the pry
action is virtually straight up. The pry fixture 54 is
now fixed to mount C and pivot platform 74, and L link
120 pivots relative thereto about shaft 60.

The advantages of the vertical pry demolding
30 arrangement of Figure 13 are a much shorter drive
movement distance for the IKO rack 68 and pinion stepper

1 motor 70 during demolding, thereby reducing the
demolding time significantly. Moreover, the wedge lift
pneumatic cylinder 84 can be speeded up since hema ring
removal is completed at demolding. It should be noted
5 that with a pivotal demolding arrangement as illustrated
in Figure 12, the hema ring removal is completed by the
wedge platform lift pneumatic drive cylinder 84, making
the pneumatic drive cylinder 84 a critical parameter.
With a vertical lift demolding arrangement pursuant to
10 the present invention as illustrated in Figure 13, the
wedge platform pneumatic drive cylinder 84 is used only
to raise the back curve to a scrape off height. Since
the pry fingers 54 are locked in position, scrape off
can occur while the IKO rack 68 and pinion stepper motor
15 70 drive is returning to a start of pry position. This
allows faster movements to the scrape off position and a
reduction in cycle time.

While several embodiments and variations of
the present invention for a laser demolding apparatus
20 and method are described in detail herein, it should be
apparent that the disclosure and teachings of the
present invention will suggest many alternative designs
to those skilled in the art.

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1 WHAT IS CLAIMED IS:

1. Apparatus for demolding a mold assembly,
comprising a first front mold portion which has a
central mold section with a surrounding flange, and a
5 corresponding second back mold portion which has a
central mold section with a surrounding flange, with a
molded ophthalmic lens being formed between the front
and back mold portions, and the flanges of the front and
back mold portions being spaced apart relative to each
10 other, comprising:

a. restraining means for restraining the
first mold portion of the mold assembly, including
restraining fingers which are positioned between and on
opposite sides of the spaced flanges of the first and
15 second mold portions and against the flange of the first
mold portion;

b. a separating fixture including separating
fingers which are positioned between and on opposite
sides of the spaced flanges of the first and second mold
20 portions and against the flange of the second mold
portion; and

c. means for subjecting the separating
fixture to a substantially vertical prying motion
relative to the restraining means to separate the second
25 mold portion from the first mold portion.

2. Apparatus as claimed in claim 1, wherein
the separating fixture is positioned at a first end of a
pivot platform, which pivots about a shaft at a second
end of the pivot platform, such that the separating
30 fixture is pivoted about the pivot platform shaft



1 through a lever arm of at least the length of the pivot platform.

3. Apparatus as claimed in claim 2, wherein the pivot platform is pivotally driven by a stepper
5 motor and rack mounted on said pivot platform.

4. Apparatus as claimed in claim 3, wherein said pivot platform is pivotally mounted on a movable base.

5. Apparatus as claimed in claim 4, wherein
10 an L link with a roller is pivotally supported at the first end of the pivot platform, with the rack pivotally connected to one leg of the L link and the roller connected to a second leg of the L link, with the roller resting on the movable base.

15 6. Apparatus as claimed in claim 4, wherein said movable base is translationally driven for X translation by an X pneumatic drive motor and is translationally driven for Y translation by a Y pneumatic drive motor.

20 7. Apparatus as claimed in claim 2, further including a ramp cam driven by a pneumatic motor, wherein said pivot platform includes a cam follower roller positioned on said ramp cam, such that as the ramp cam is driven by the pneumatic motor, the cam
25 follower roller pivots the pivot platform about the pivot platform shaft to raise and lower the separating fixture.

8. Apparatus as claimed in claim 1, including means for irradiating the second mold portion with
30 electromagnetic radiation, which is absorbed by the second mold portion to cause a substantial temperature



1 gradient between the second mold portion and the contact
lens being demolded, with the temperature gradient
causing a differential expansion and shifting of the
surface of the heated second mold portion relative to
5 the surface of the lens to lessen the adhesion between
the lens and the second mold portion to assist in the
separation of the mold portions, while leaving the lens
in the first mold portion.

9. Apparatus as claimed in claim 8, wherein
10 the irradiating means includes a laser producing
electromagnetic radiation having a wavelength between
1 μm and 20 μm .

10. Apparatus as claimed in claim 1, wherein
the mold assembly is carried by a pallet, which carries
15 an array of mold assemblies, and further including a
conveyor means for conveying the pallet into a position
in the demolding apparatus wherein said restraining
fingers and separating fingers are positioned between
the spaced flanges of the first and second mold portions
20 with the restraining fingers against the flange of the
first mold portion and the separating fingers against
the flange of the second mold portion.

11. Apparatus as claimed in claim 1, wherein
said separating fixture includes a gripping means for
25 gripping a second mold portion which is separated from a
first mold portion.

12. Apparatus as claimed in claim 11, further
including a back curve mold remover to remove said back
curve mold portion from said separating fixture after
30 separation of the mold portions, and means for moving
said separating fixture relative to the back curve



1 remover during which the back curve mold portion is
removed from the separating fixture.

13. Apparatus as claimed in claim 12, further
including means for vertically moving said back curve
5 remover into and out of a back curve removal position
relative to said separating fixture.

14. Apparatus as claimed in claim 12, wherein
said pivot platform is mounted on a movable base which
is mounted for X translational movement relative to a
10 fixed base.

15. Apparatus as claimed in claim 14, wherein
an X pneumatic drive motor drives said movable base in X
translational movement relative to the fixed base.

16. Apparatus as claimed in claim 15, wherein
15 said movable base is also mounted for Y translational
movement relative to a fixed base.

17. Apparatus as claimed in claim 16, wherein
a Y pneumatic drive motor drives said movable base in Y
translational movement relative to the fixed base.

20 18. Apparatus as claimed in claim 1, wherein
the first mold portion is a concave front curve mold
half and the second mold portion is a convex back curve
mold half, with a contact lens molded between the first
and second mold halves.

25 19. Apparatus as claimed in claim 1, wherein
said separating fingers are joined together to form a
U-shaped separator.

20. Apparatus as claimed in claim 19, further
including means for directing a laser beam through the U
30 in the U-shaped separator to irradiate the second mold
portion.



1 21. Apparatus as claimed in claim 1,
including conveyor means for conveying the mold assembly
to insert said restraining fingers and separating
fingers between the flange members of the mold assembly,
5 and control means for sequentially actuating said
conveyor means to convey the mold assembly into a
demolding position in the demolding apparatus, and then
actuating said platform to lift said back curve mold
portion relative to the front curve mold portion to
10 thereby separate said back curve mold portion from said
front curve mold portion and the contact lens therein.

22. Apparatus as claimed in claim 21, wherein
a plurality of contact lens mold assemblies are carried
on a pallet by said conveyor means, and said demolding
15 apparatus includes a plurality of pairs of restraining
means and separating fixtures.

23. Apparatus as claimed in claim 22, wherein
said pallet carries two rows of contact lens mold
assemblies, and said demolding apparatus includes first
20 and second sets of restraining means and separating
fixtures, with a first set positioned on a first side of
said pallet and a second set positioned on a second side
of said pallet.

24. Apparatus as claimed in claim 23, wherein
25 the first mold portion is a concave front curve mold
half and the second mold portion is a convex back curve
mold half, with a contact lens molded between the first
and second mold halves.

25. Apparatus as claimed in claim 24, wherein
30 the mold assembly is carried by a pallet, which carries
an array of mold assemblies, and further including a



1 conveyor means for conveying the pallet into a position
in the demolding apparatus wherein said restraining
fingers and separating fingers are positioned between
the spaced flanges of the first and second mold portions
5 with the restraining fingers against the flange of the
first mold portion and the separating fingers against
the flange of the second mold portion.

26. Apparatus as claimed in claim 25, wherein
the separating fixture is positioned at a first end of a
10 pivot platform, which pivots about a shaft at a second
end of the pivot platform, such that the separating
fixture is pivoted about the pivot platform shaft
through a lever arm of at least the length of the pivot
platform.

15 27. Apparatus as claimed in claim 26, wherein
the pivot platform is pivotally driven by a stepper
motor and rack mounted on said pivot platform.

28. Apparatus as claimed in claim 27, wherein
said pivot platform is pivotally mounted on a movable
20 base.

29. Apparatus as claimed in claim 28, wherein
an L link with a roller is pivotally supported at the
first end of the pivot platform, with the rack pivotally
connected to one leg of the L link and the roller
25 connected to a second leg of the L link, with the roller
resting on the movable base.

30. Apparatus as claimed in claim 29, further
including a ramp cam driven by a pneumatic motor, and
said movable base includes a cam follower roller
30 positioned on said ramp cam, such that as the ramp cam
is driven by the pneumatic motor, the cam follower



1 roller rotates the first movable base about the rotational shaft to raise and lower the separating fixture mounted on the second end of the first movable base.

5 31. Apparatus as claimed in claim 30, wherein said separating fixture includes a gripping means for gripping a second mold portion which is separated from a first mold portion.

10 32. Apparatus as claimed in claim 31, further including a back curve mold remover to remove said back curve mold portion from said separating fixtures after separation of the mold portions, and means for independent reciprocal movement of said separating fixture relative to the back curve remover.

15 33. Apparatus as claimed in claim 32, further including means for vertically moving said back curve remover into and out of a back curve removal position relative to said separating fixture.

20 34. Apparatus as claimed in claim 33, wherein said pivot platform is mounted on a movable base which is mounted for X and Y translational movements relative to a fixed base, an X pneumatic drive motor drives said movable base in X translational movement relative to the fixed base, and a Y pneumatic drive motor drives said
25 movable base in Y translational movement relative to said fixed base.

 35. Apparatus as claimed in claim 34, wherein said separating fingers are joined together to form a U-shaped separator.

30 36. Apparatus as claimed in claim 35, further including means for directing a laser beam through the U



1 in the U-shaped separator to irradiate the second mold
portion.

37. Apparatus as claimed in claim 36,
including conveyor means for conveying the mold assembly
5 to insert said restraining fingers and separating
fingers between the flange members of the mold assembly,
and control means for sequentially actuating said
conveyor means to convey the mold assembly into a
demolding position in the demolding apparatus, and then
10 actuating said platform rotating means to sequentially
lift said back curve mold portion relative to the front
curve mold portion to thereby separate said back curve
mold portion from said front curve mold portion and the
contact lens therein.

15 38. Apparatus as claimed in claim 37, wherein
a plurality of contact lenses and mold assemblies are
carried on a pallet by said conveyor means, and said
demolding apparatus includes a plurality of pairs of
restraining means and separating fixtures.

20 39. Apparatus as claimed in claim 38, wherein
said pallet contains two rows of contact lenses and mold
assemblies, and said demolding apparatus includes first
and second sets of restraining means and separating
fixtures, with a first set positioned on a first side of
25 said pallet and a second set positioned on a second side
of said pallet.

40. A method for demolding a mold assembly,
comprising a first front mold portion which has a
central mold section with a surrounding flange, and a
30 corresponding second back mold portion which has a
central mold section with a surrounding flange, and



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1 having a molded ophthalmic lens formed between the front and back mold portions, and wherein the flanges of the front and back mold portions are spaced apart relative to each other, comprising:

5 a. restraining the first mold portion of the mold assembly by restraining fingers which are positioned between and on opposite sides of the spaced flanges of the first and second mold portions and against the flange of the first mold portion;

10 b. positioning separating fingers between and on opposite sides of the spaced flanges of the first and second mold portions and against the flange of the second mold portion; and

 c. subjecting the separating fingers to a
15 substantially vertical prying motion relative to the restrained first mold portion to separate the second mold portion from the first mold portion.

 41. A method as claimed in claim 40,
including positioning the separating fingers at a first
20 end of a pivot platform, which pivots about a shaft at a second end of the pivot platform, such that the separating fingers are pivoted about the pivot platform shaft through a lever arm of at least the length of the pivot platform.

25 42. A method as claimed in claim 41, including pivotally driving the pivot platform with a stepper motor and rack mounted on the pivot platform.

 43. A method as claimed in claim 40,
including irradiating the second mold portion with
30 electromagnetic radiation, which is absorbed by the second mold portion to cause a substantial temperature



1 gradient between the second mold portion and the contact
lens being demolded, with the temperature gradient
causing a differential expansion and shifting of the
surface of the heated second mold portion relative to
5 the surface of the lens, lessening the adhesion between
the lens and the second mold portion to assist in the
separation of the mold portions, while leaving the lens
in the first mold portion.

44. A method as claimed in claim 43, wherein
10 the irradiating step utilizes a laser producing
electromagnetic radiation having a wavelength between
1 μm and 20 μm .

45. A method as claimed in claim 40,
including carrying the mold assembly in a pallet, which
15 carries an array of mold assemblies, and conveying the
pallet into a position wherein the restraining fingers
and separating fingers are positioned between the spaced
flanges of the first and second mold portions, with the
restraining fingers against the flange of the first mold
20 portion and the separating fingers against the flange of
the second mold portion.

46. A method as claimed in claim 40, further
including removing the back curve mold portion from said
separating fingers after separation of the mold
25 portions.

47. A method as claimed in claim 40, wherein
the first mold portion is a concave front curve mold
half and the second mold portion is a convex back curve
mold half, with a contact lens molded between the first
30 and second mold halves.



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1 48. A method as claimed in claim 40, further
including directing a laser beam through the separating
fingers to irradiate the second mold portion.

 49. A method as claimed in claim 40,
5 including conveying the mold assembly to insert the
restraining fingers and separating fingers between the
flange members of the mold assembly, and then subjecting
the separating fingers to a substantially vertical
prying motion to sequentially lift the back curve mold
10 portion relative to the front curve mold portion to
thereby separate the back curve mold portion from the
front curve mold portion and the contact lens therein.

 50. A method as claimed in claim 49,
including carrying a plurality of mold assemblies on a
15 pallet during said conveying step.

 51. A method as claimed in claim 50, wherein
said pallet contains two rows of contact lenses and mold
assemblies, and positioning a first set of restraining
fingers and separating fingers on a first side of said
20 pallet, and positioning a second set of restraining
fingers and separating fingers on a second side of said
pallet.

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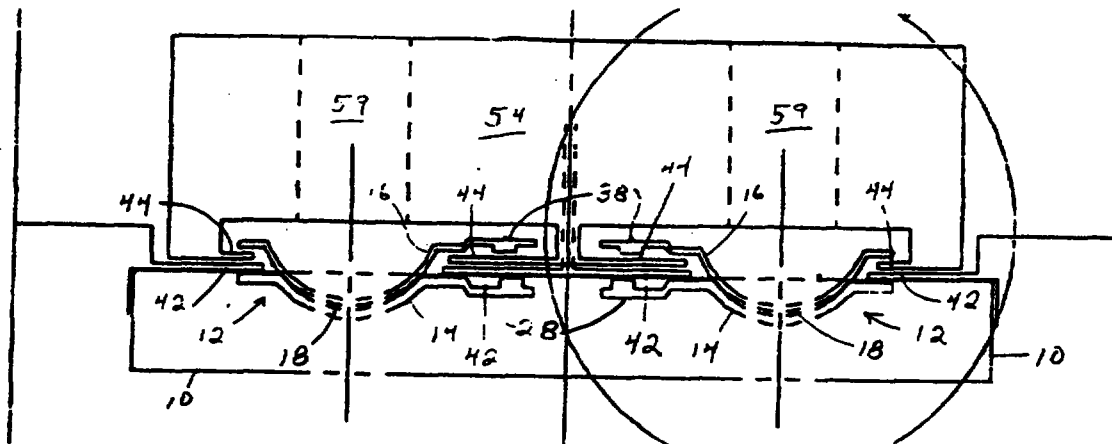


Fig. 1

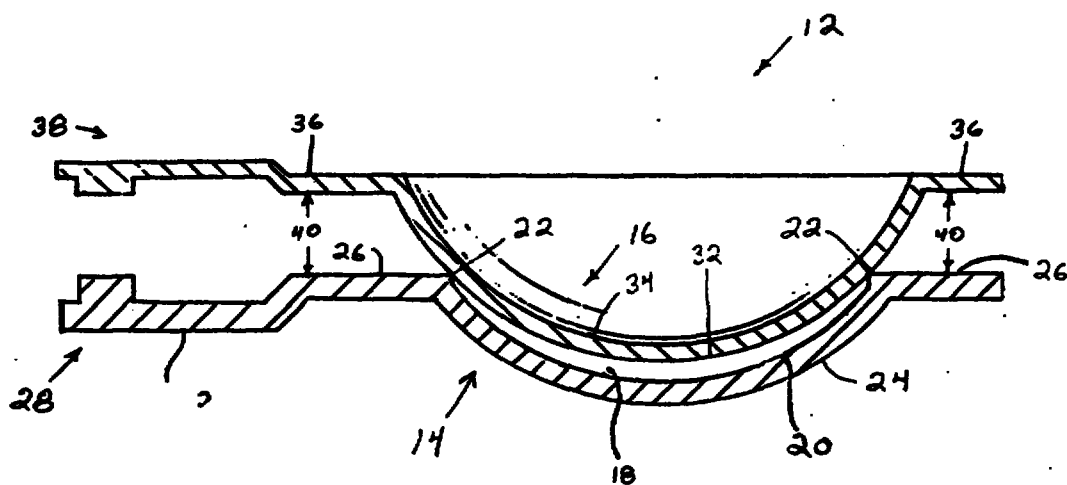


Fig 2

This Sheet Has Been Replaced



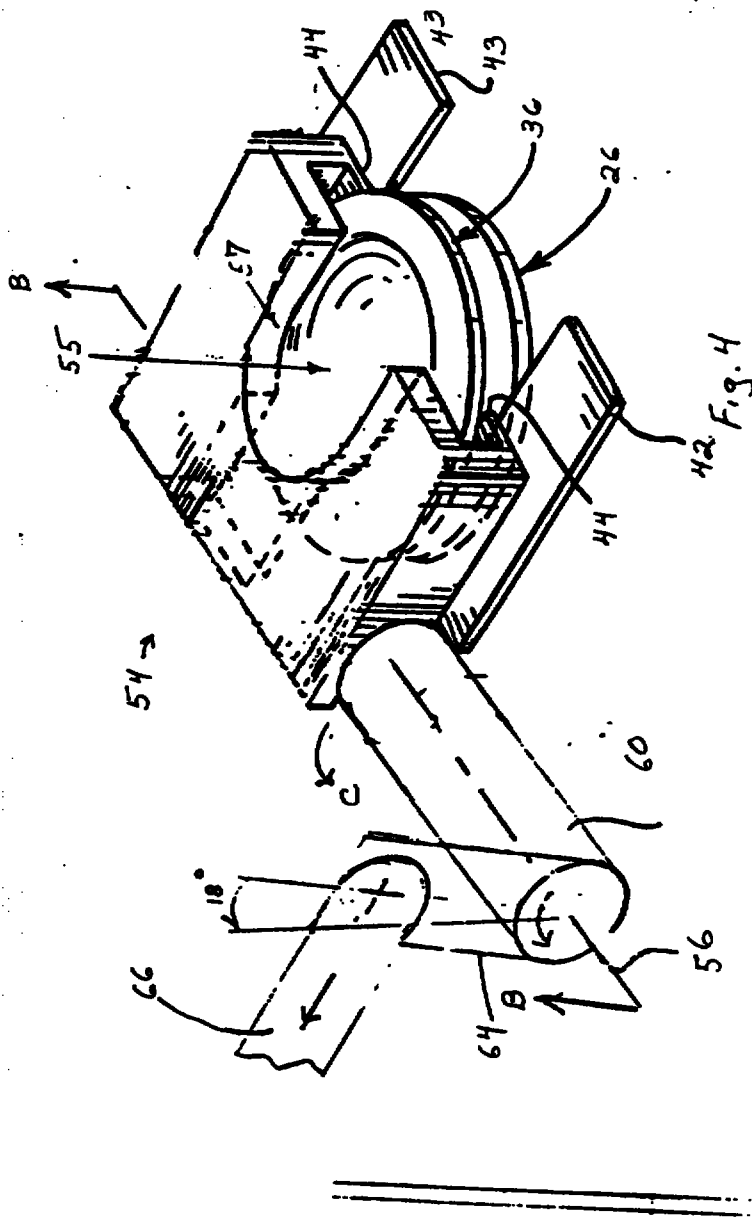
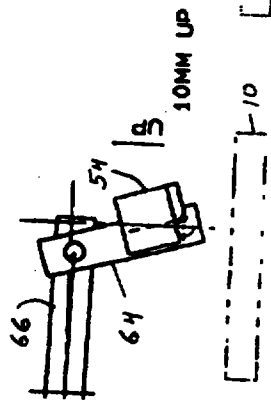
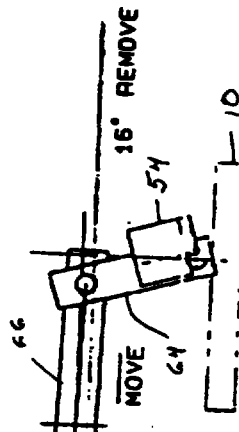
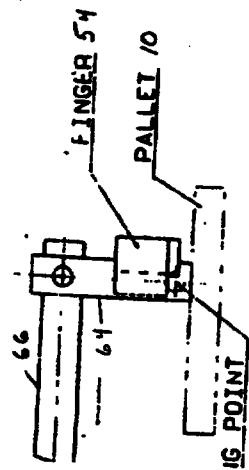
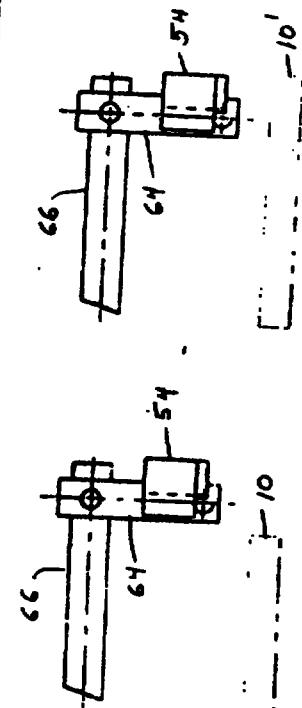


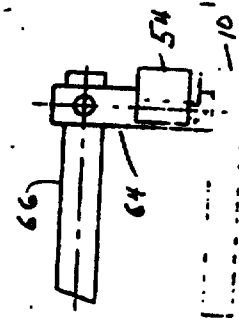
Fig. 4



PALLET MOVE
PICKUP UNIT RIGHT FROM LEFT
FINGER ORIGIN POSITION



PICKUP UNIT REV FROM FWD



PICKUP UNIT DOWN
PICKUP UNIT LEFT FROM RIGHT
PICKUP UNIT FWD FROM REV

Fig. 3

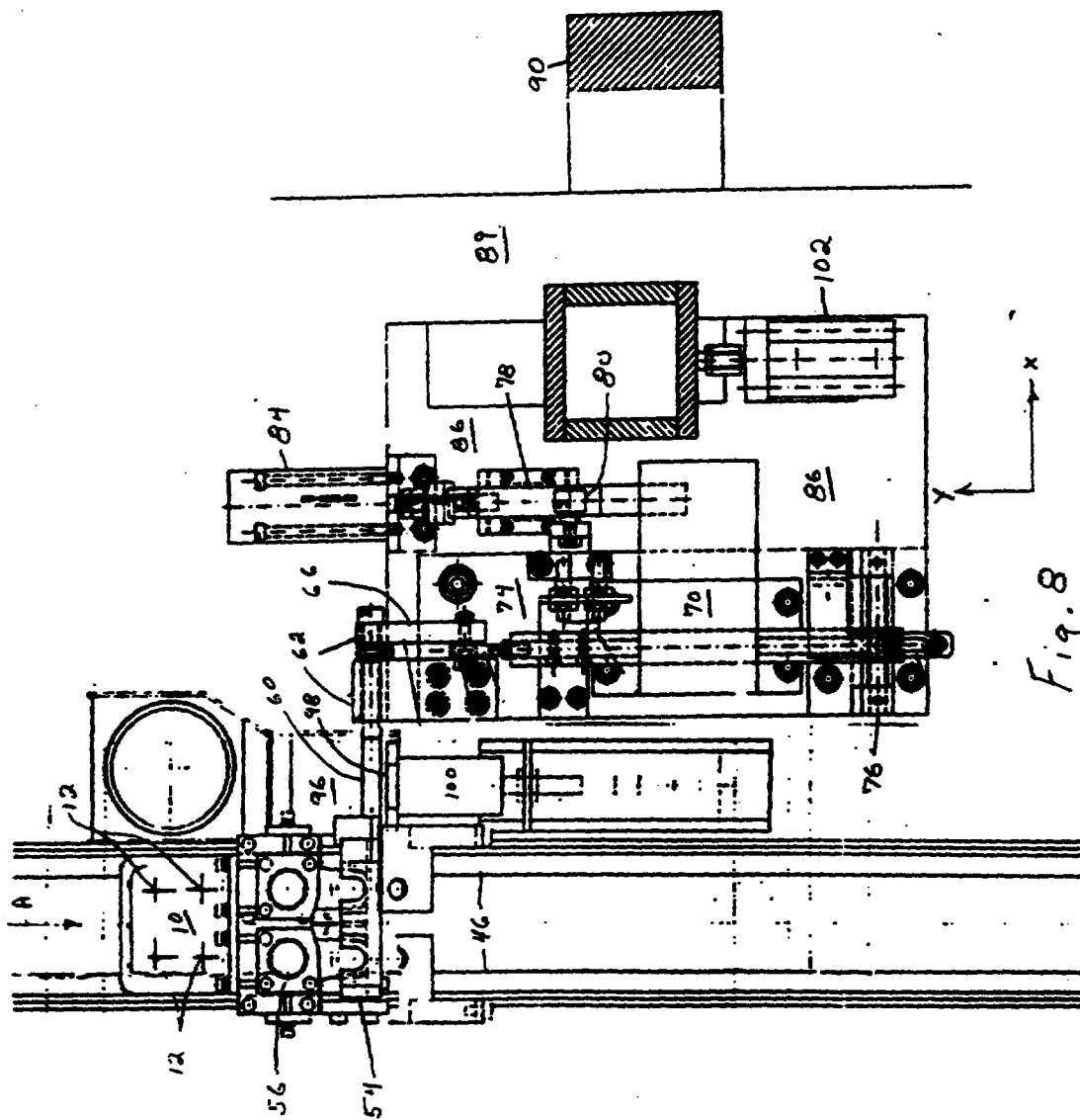


Fig. 8

This Sheet Has Been Replaced



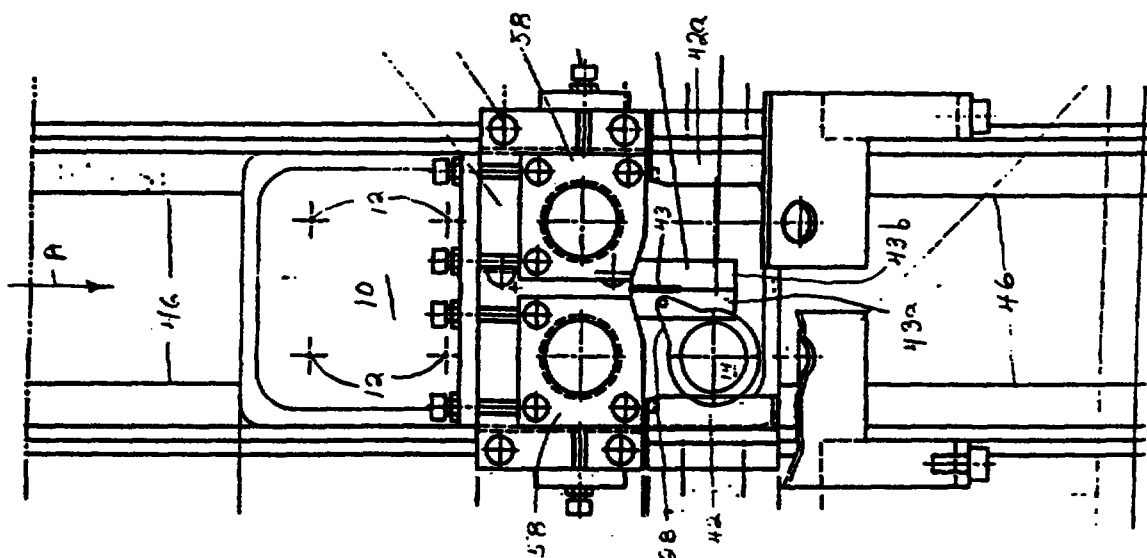


Fig. 9

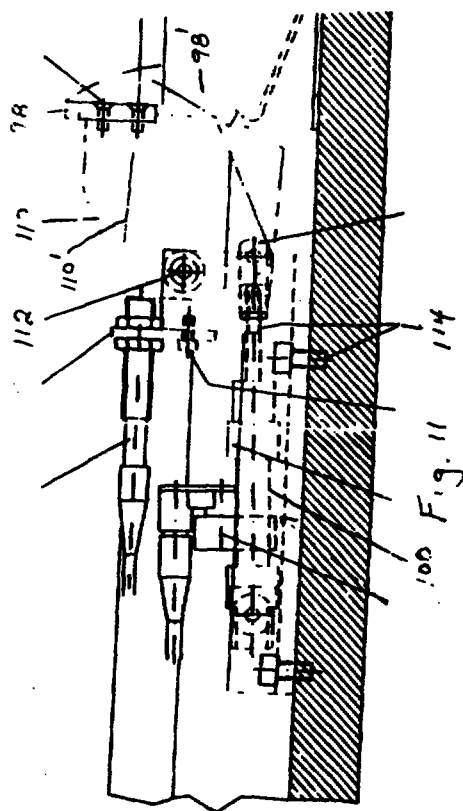


Fig. 11

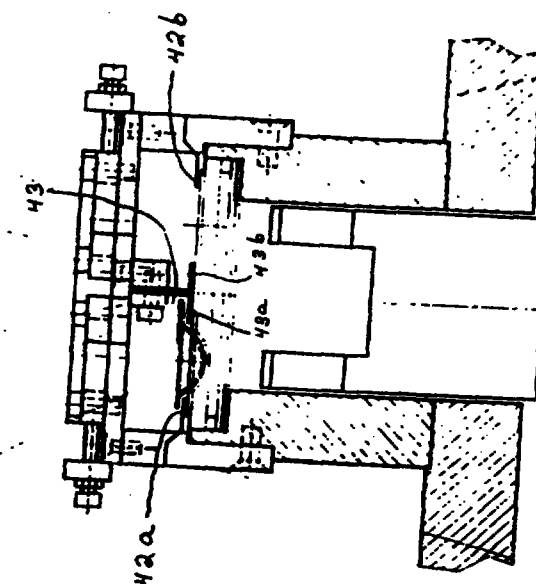


Fig. 10



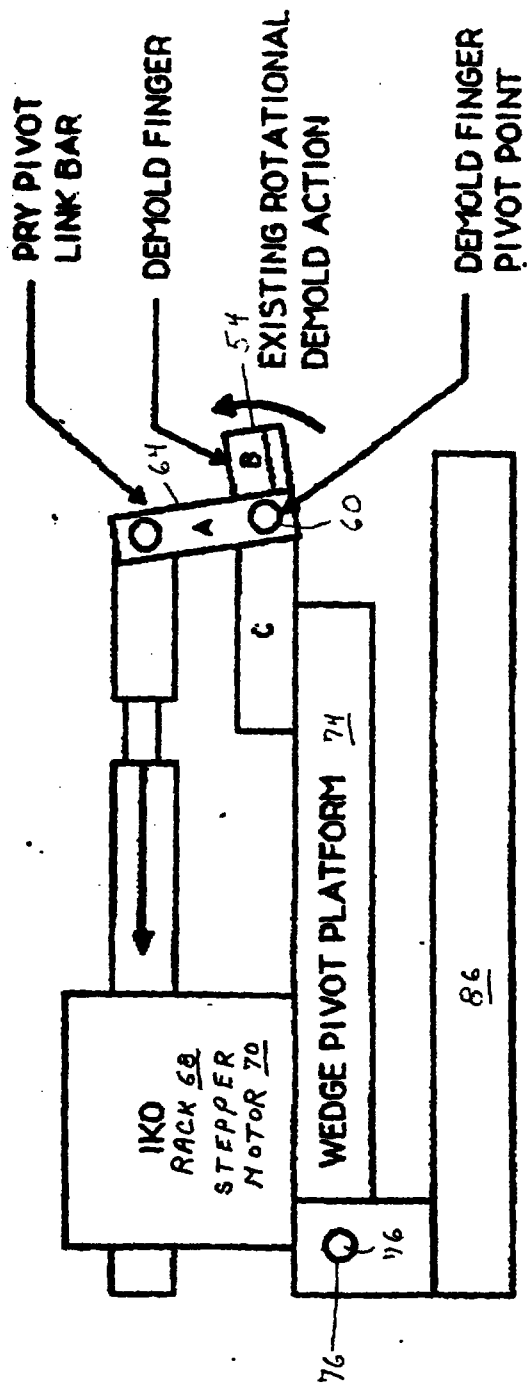


Fig. 12

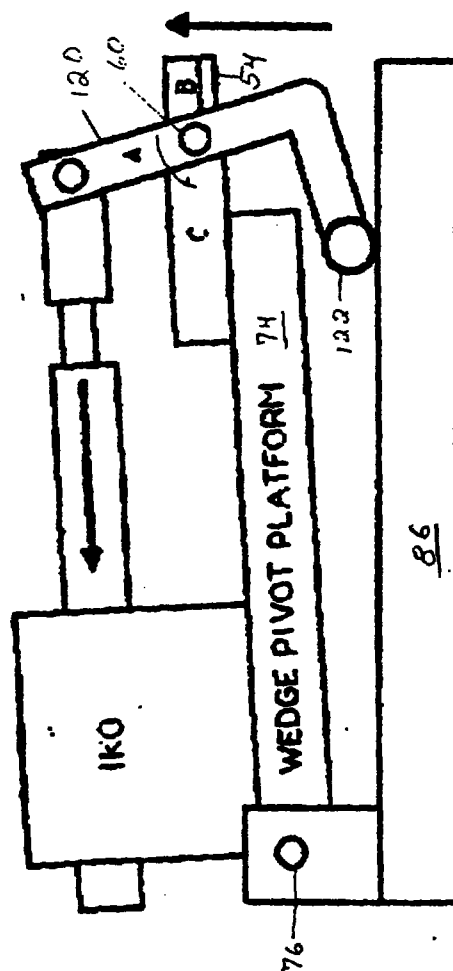


Fig 13

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LASER DEMOLDING APPARATUS AND METHOD

1 ABSTRACT OF THE DISCLOSURE

An automated demolding apparatus for mechanically separating contact lens mold portions of a mold assembly. The mold assembly includes a first front
5 mold portion having a central mold section with a surrounding flange, and a corresponding second back mold portion also having a central mold section with a surrounding flange, with a molded contact lens being formed between the front and back mold portions. The
10 demolding apparatus includes restraining fingers positioned between and on opposite sides of the spaced flanges of the first and second mold portions and against the flange of the first mold portion. A separating fixture includes separating fingers
15 positioned between and on opposite sides of the spaced flanges of the first and second mold portions and against the flange of the second mold portion. Before demolding, the second mold portion is irradiated by a laser beam, which is absorbed thereby to cause a
20 substantial temperature gradient between the second mold portion and the contact lens being demolded. The temperature gradient causes a differential expansion and shifting of the surface of the heated second mold portion relative to the surface of the lens to lessen
25 the adhesion therebetween to assist in separation of the mold portions, while leaving the lens in the first mold portion. During demolding, the separating fixture is subjected to a substantially vertical prying motion relative to the restraining fingers to separate the
30 second mold portion from the first mold portion.



1

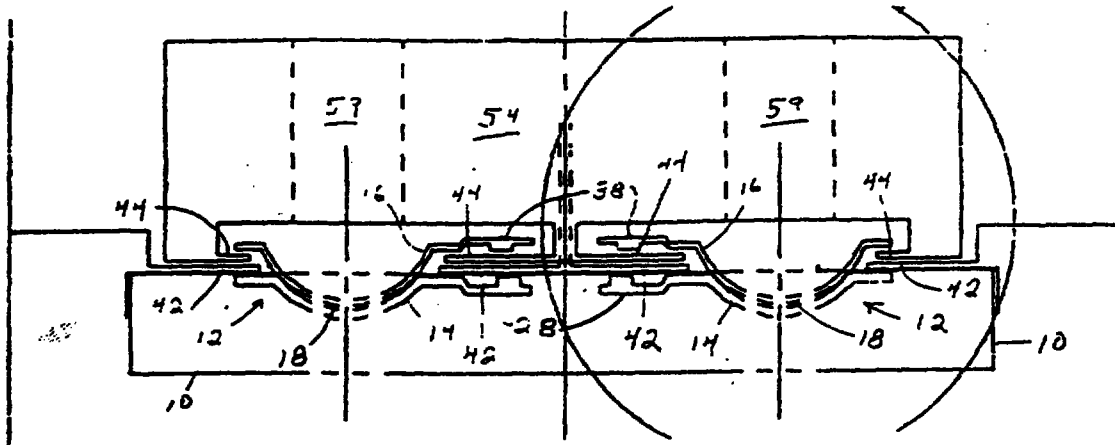


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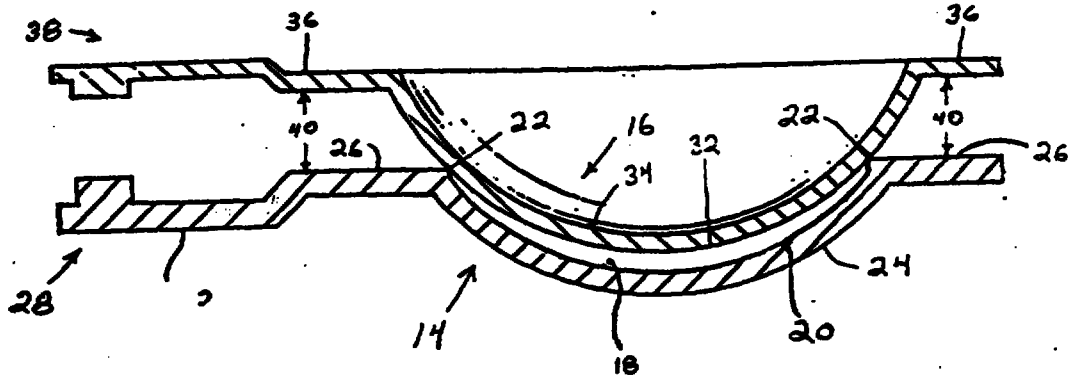
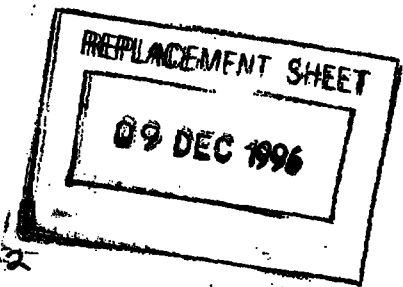


Fig. 2

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DATE OF RECEIPT		9/12/96

REPLACED

09 DEC 1996

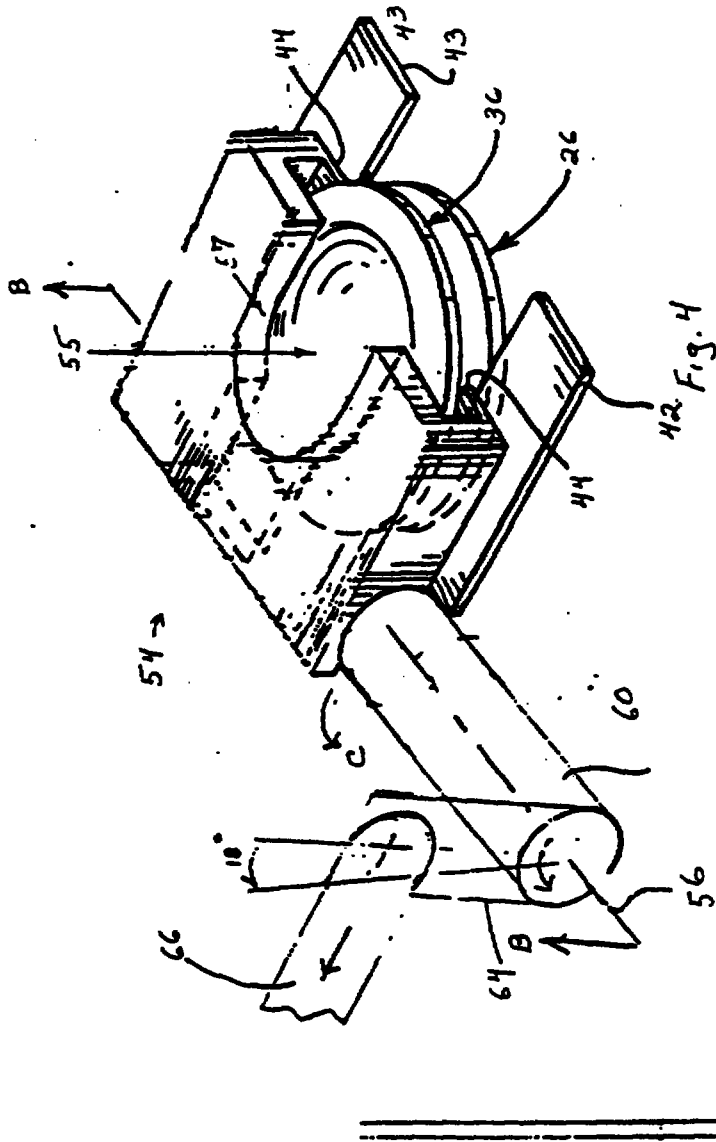
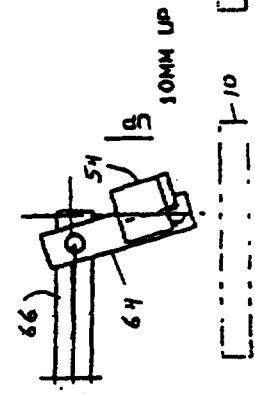
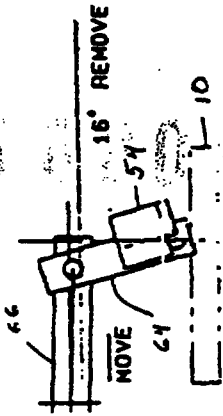
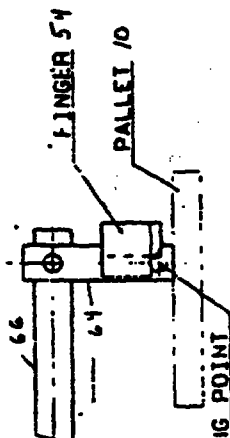


Fig. 4



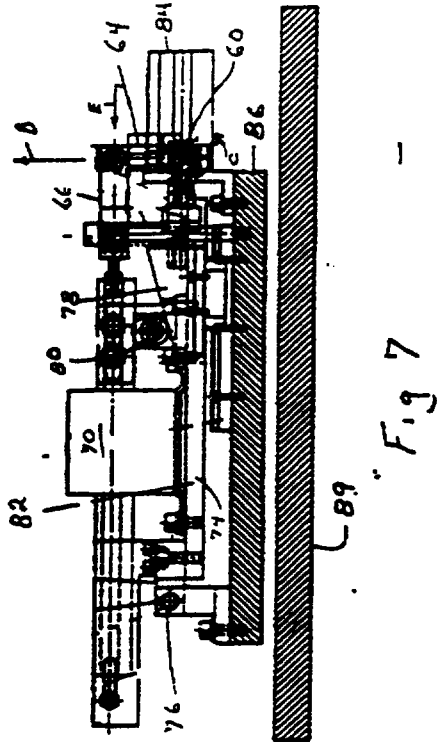
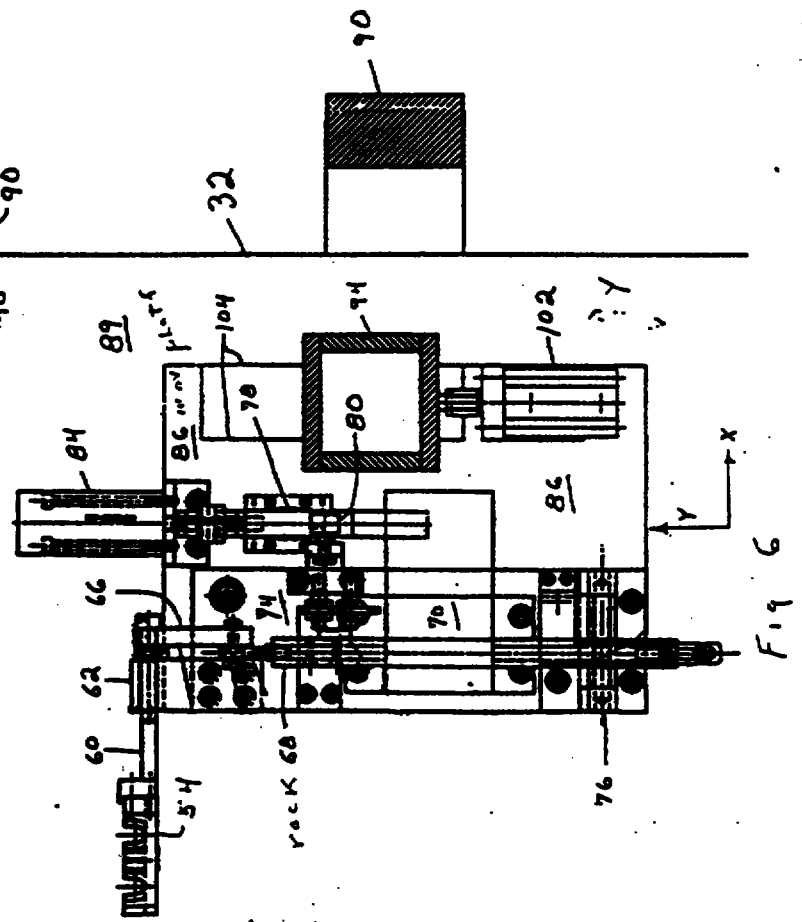
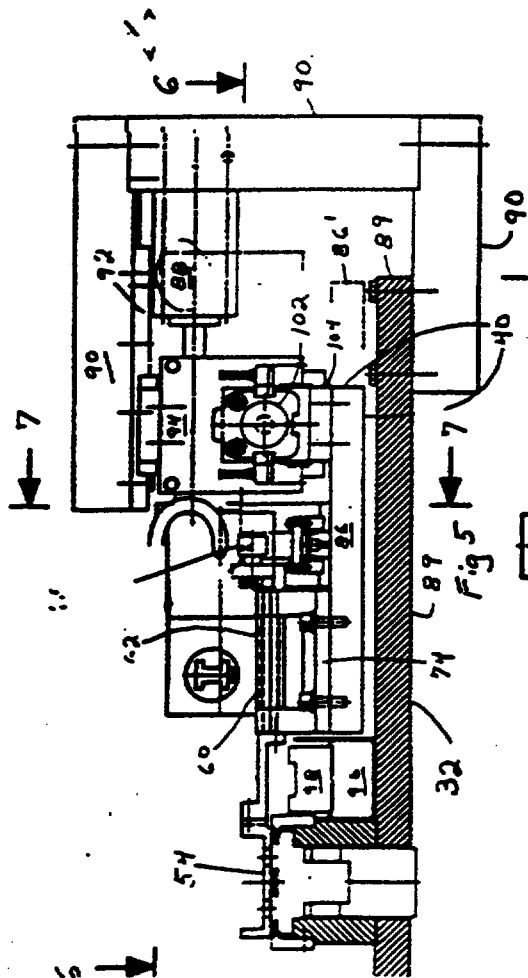
PALLET MOVE
PICKUP UNIT RIGHT FROM LEFT
FINGER ORIGIN POSITION

PICKUP UNIT DOWN
PICKUP UNIT LEFT FROM RIGHT
PICKUP UNIT FWD FROM REV.

PICKUP UNIT REV FROM FWD

Fig. 3

REPLACEMENT SHEET
09 DEC 1996



09 DEC 1996

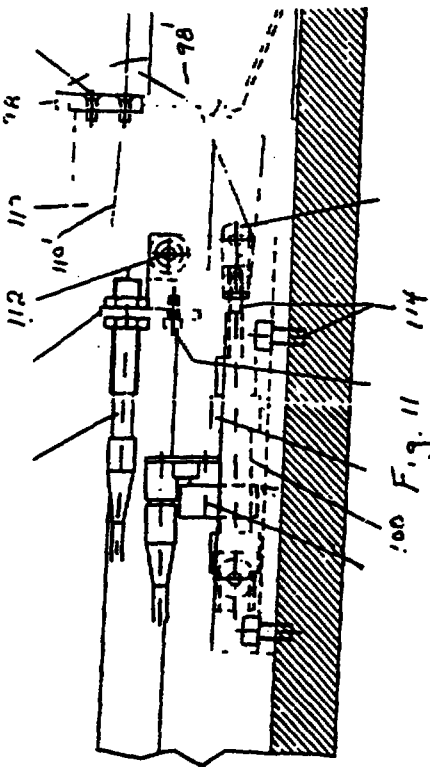


Fig. 8

REPLACEMENT SHEET
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Fig. 10



11.9.11

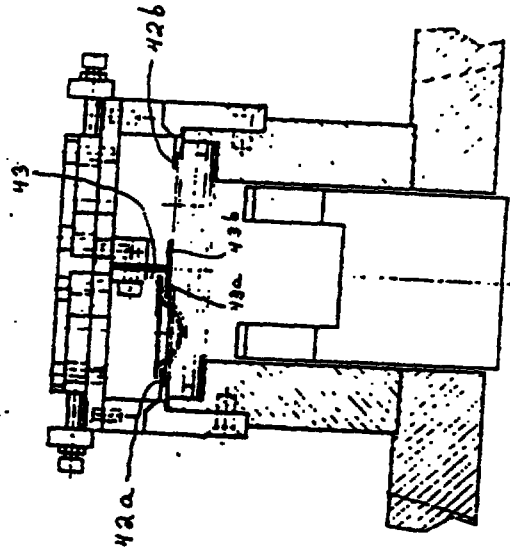


Fig. 10

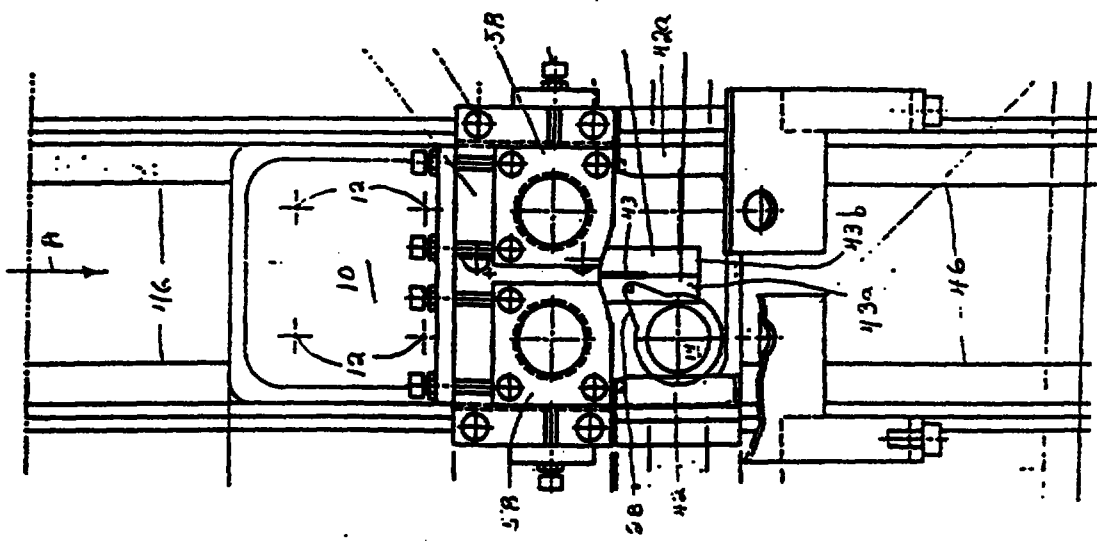


Fig. 9

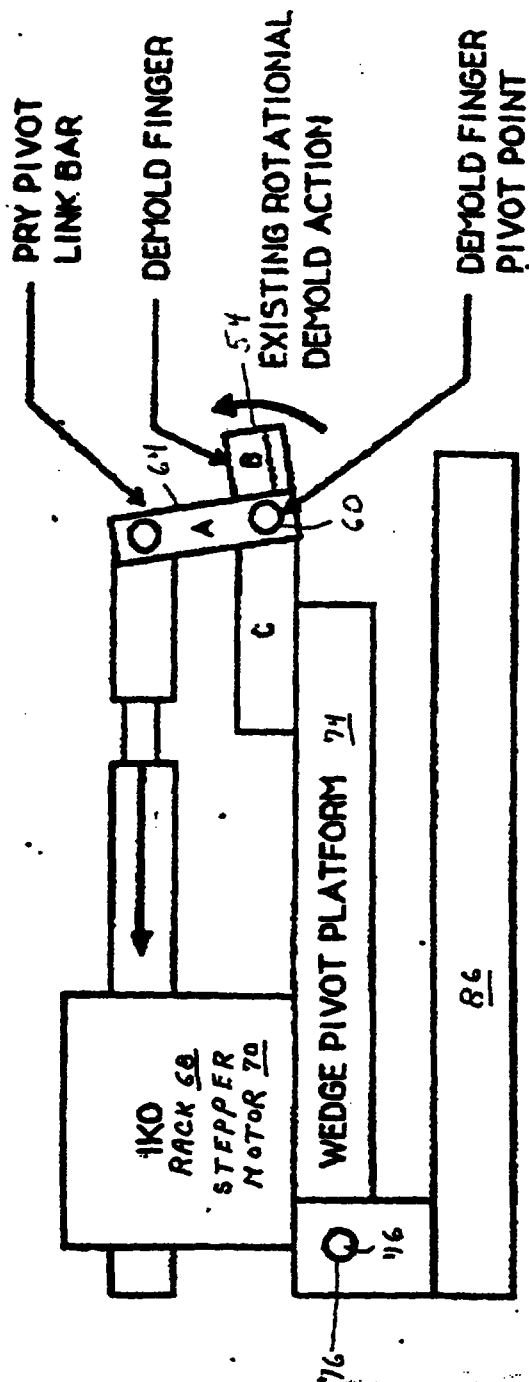


Fig. 12

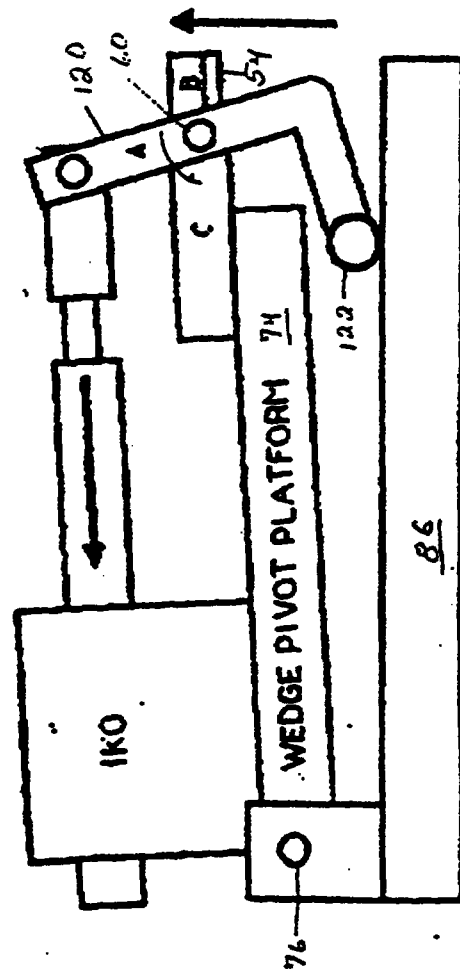
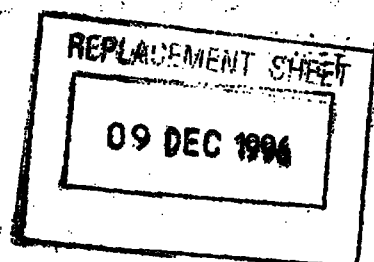


Fig. 13





TEXT OF THE ABSTRACT

LASER DEMOLDING APPARATUS AND METHOD

An automated demolding apparatus for mechanically separating contact lens mold portions of a mold assembly. The mold assembly includes a first front mold portion having a central mold section with a surrounding flange, and a corresponding second back mold portion also having a central mold section with a surrounding flange, with a molded contact lens being formed between the front and back mold portions. The demolding apparatus includes restraining fingers positioned between and on opposite sides of the spaced flanges of the first and second mold portions and against the flange of the first mold portion. A separating fixture includes separating fingers positioned between and on opposite sides of the spaced flanges of the first and second mold portions and against the flange of the second mold portion. Before demolding, the second mold portion is irradiated by a laser beam, which is absorbed thereby to cause a substantial temperature gradient between the second mold portion and the contact lens being demolded.

Fig. 4

