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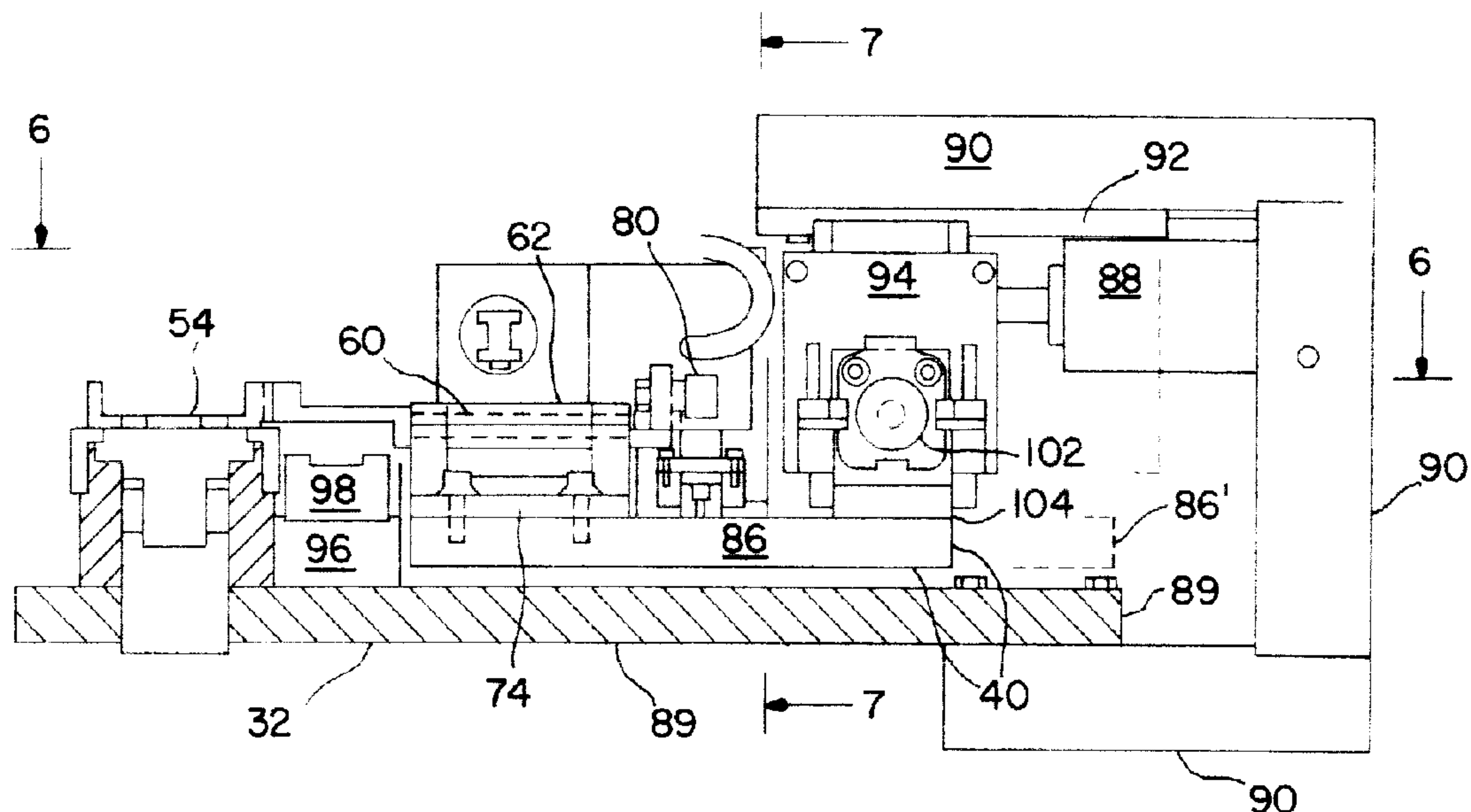
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(54) Titre : APPAREIL ET METHODE DE DEMOULAGE FAISANT APPEL A UN RAYON LASER

(54) Title: LASER DEMOLDING APPARATUS AND METHOD



(57) Abrégé/Abstract:

An automated demolding apparatus for reliably and repeatedly mechanically separating contact lens mold portions of a mold assembly without damaging the contact lens formed therebetween. 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. A molded contact lens is formed between the front and back mold portions, and the flanges of the front and back mold portions are spaced apart and parallel to each other. 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. 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 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 rotated relative to the restraining fingers to progressively separate and peel the second mold portion from the first mold portion.



1 ABSTRACT OF THE DISCLOSURE

An automated demolding apparatus for reliably and repeatedly mechanically separating contact lens mold portions of a mold assembly without damaging the contact lens formed therebetween. 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. A molded contact lens is formed between the front and back mold portions, and the flanges of the front and back mold portions are spaced apart and parallel to each other. 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. 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 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 rotated relative to the

1 restraining fingers to progressively separate and peel
the second mold portion from the first mold portion.

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LASER DEMOLDING APPARATUS AND METHODBACKGROUND OF THE INVENTION

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1. Field of the Invention

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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.

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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.

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2. Discussion of the Prior Art

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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 be produced has increased dramatically. This has required manufacturers to strive for automated methods

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-2-

1 and apparatus which are adaptable to automated practices
and consistent performance.

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

Examples of this prior art can be found in
U.S. Patents 5,039,459, 4,889,664 and 4,565,348. These
patents discuss therein the requirement for a
10 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
lens or to each other. In contrast to the above
polystyrene molds, another example is the use of
15 polypropylene or polyethylene molds such as described in
U.S. Patent 4,121,896.

The mold assembly to mold an ophthalmic
contact lens typically includes a lower concave mold
portion (referred to as a front curve), and an upper
20 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
mold cavity for a contact lens. A particular problem in
the prior art is that the front and back mold portions
25 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
the mold portions are placed together, defining the lens
and forming an edge, the excess monomer or monomer
30 mixture is expelled from the mold cavity and rests on or
between the flange of one or both mold portions. Upon

-3-

1 polymerization, this excess material forms an annular flange or ring around the formed lens which resists separation of the mold portions during a demolding operation.

5 The prior art process for separating the mold portions and removing the lens consists of preheating, heating, prying and removal. Hot air provides convective heating, mechanical leverage the prying, and the removal is manual. Heating the mold by convection
10 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 removed requires on the order of one minute.

 The prior art method for removing the lens is
15 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 heat to the upper surface of the lens. Heat is then transported by thermal conduction through the back mold,
20 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 stage the mold is clamped in place, and pry fingers are inserted under the back mold portion. A force is then
25 applied to each back mold portion by the pry fingers during a heating cycle.

 When the required temperature has been reached, the back mold portion breaks free and one end thereof is lifted by the pry fingers. After the back
30 mold portion has been detached from the front mold portion on at least one side, the mold exits the heater.

2151361

-4-

1 The back mold portion and annular flashing are then
totally removed.

While the aforementioned method has some
efficacy in assisting in the removal of the lens from
5 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
shortcomings in this approach result from the manner in
which heat is delivered to the mold portion. The
10 constant temperature air stream heats the exterior
surface of the back mold portion, while thermal
conduction transfers heat to the lens surface. The only
way to increase the thermal gradient is to transfer heat
faster, but this would cause the back mold portion to
15 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
sufficient to fully and repeatedly separate the mold
portions.

20 SUMMARY OF THE INVENTION

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

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

2151361

-5-

1 temperature gradient is created between the back curve
mold and a contact lens formed in a cavity between the
two mold portions.

Another object of the present invention is to
5 provide an automated apparatus to mechanically and
reliably pry the mold halves apart in a consistent and
reliable manner to thereby enhance the production of
defect-free contact lenses, and minimize tearing of the
lens and breakage of the lens mold parts.

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

In accordance with the teachings herein, the
present invention provides an arrangement for demolding
15 a mold assembly, which 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. In a preferred embodiment, the first mold
20 portion is a concave front curve mold half, and the
second mold portion is a convex back curve mold half,
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
25 other. The demolding apparatus includes restraining
means for restraining the first mold portion of the mold
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
30 flange of the first mold portion. The demolding
apparatus also includes a separating fixture which

2151361

-6-

1 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
5 fixture is rotated relative to the restraining means to
progressively separate and peel the second mold portion
from the first mold portion.

In greater detail, before demolding, the
second mold portion is irradiated with electromagnetic
10 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
15 portion relative to the surface of the lens to lessen
the adhesion therebetween to assist in the separation of
the mold portions, while leaving the lens in the first
mold portion. The second mold portion is preferably
irradiated by a laser producing radiation with a wave-
20 length between 1 μm and 20 μm . The separating fingers
are joined together to form a U-shaped separator, and
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,
25 which carries an array of similar mold assemblies, and a
conveyor conveys the pallet into a demolding position in
the demolding apparatus. The conveyor conveys the mold
assembly on the pallet into the demolding apparatus, to
insert the restraining fingers and the separating
30 fingers between the flange members of the mold assembly.
The restraining fingers are positioned against the

2151361

-7-

1 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
pivot shaft for rotation relative to the fixedly mounted
5 restraining means, and during the demolding operation
the separating fixture is rotated through an angle of
approximately 18 degrees. A control system sequentially
actuates the conveyor to convey the mold assembly into a
demolding position in the demolding apparatus, and then
10 actuates rotation of the separation fixture to
sequentially lift and peel 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
15 therein.

A plurality of contact lens mold assemblies
are carried on a pallet, and the demolding apparatus
includes a plurality of pairs of restraining means and
separating fixtures. In one preferred embodiment, the
20 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
a first side of the pallet and a second set positioned
on a second side of the pallet.

25 The separating fixture pivot shaft is spaced a
distance from the restraining means, and is mounted on a
first movable base for elevational movement relative to
the fixedly mounted restraining means. The first
movable base is pivotally mounted at one end about a
30 rotational shaft, and the separating fixture is mounted
at the second, opposite end of the first movable base.

2151361

-8-

1 The arrangement further includes a ramp cam driven by a
pneumatic motor. 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
5 follower roller rotates the first movable base about the
rotational shaft to raise and lower the separating
fixture. The 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
10 pneumatic drive motor drives the second movable base in
X translational movement, and a Y pneumatic drive motor
drives the second movable base in Y translational
movement relative to the fixed base.

The separating fixture includes a gripping
15 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
portion from the separating fixture after separation of
the mold portions. The separating fixture is translated
20 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
vertically movable into and out of a back curve removal
position relative to the separating fixture.

25 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
surrounding flange, and a corresponding second back mold
portion having a central mold section with a surrounding
30 flange. A molded ophthalmic lens is formed between the
front and back mold portions, and the flanges of the

2151361

-9-

1 front and back mold portions are spaced apart and
parallel to each other. The method comprises
restraining the first mold portion of the mold assembly
by restraining fingers which are positioned between and
5 on opposite sides of the spaced flanges of the first and
second mold portions and against the flange of the first
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
10 second mold portion. The separating fingers are rotated
relative to the restrained first mold portion to
progressively separate and peel the second mold portion
from the first mold portion.

In a preferred embodiment of the method, the
15 second mold portion is irradiated with electromagnetic
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
20 shifting of the surface of the heated second mold
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
25 portion. The second mold portion is preferably
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.

30 Pursuant to the method, the mold assembly is
carried by a pallet, which carries an array of similar

2151361

- 10 -

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 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 rotated through an angle of approximately 18 degrees. The separating fingers grip a second mold portion which is separated from a first mold portion. The back curve mold portion is removed from 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 separating fingers are rotated to sequentially lift and peel 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 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 second side of said 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 the art with reference being had to the following detailed description of several preferred embodiments

-11-

1 thereof, taken in conjunction with the accompanying
drawings wherein like elements are designated by
identical reference numerals throughout the several
views, and in which:

5 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,
defining therebetween a mold cavity for a contact lens;

10 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;

 Figure 3 illustrates a preferred sequence of
15 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;

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

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

25 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;

30 Figure 8 is a top plan view similar to Figure
5, illustrating the demolding apparatus positioned

2151361

- 12 -

adjacent to a conveyor system for the sequential movement of pallets containing contact lens mold assemblies through the demolding apparatus;

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

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; and

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

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings in detail, Figure 1 illustrates a front elevational view of a pallet 10 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 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 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

2151361

- 13 -

of mold assemblies after each advance between pairs, and when the last pair is demolded, a new pallet is then advanced into an initial position in the demolding apparatus, as illustrated in Figure 8.

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

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

 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
25 extending therearound. The knife edge 22 is desirable to form a sharp and uniform plastic radius parting line (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
30 flange 26 is formed extending radially outwardly from the surfaces 20 and 24. The concave surface 20 has the

-14-

1 dimensions of the front curve (power curve) of a contact
lens to be produced by the mold assembly, and is
sufficiently smooth such that the surface of a contact
lens formed by polymerization of a polymerizable
5 composition in contact with the surface is of optically
acceptable quality. The front mold half is designed
with a thinness, typically 0.8 mm, and rigidity
effective to transmit heat therethrough rapidly and to
withstand prying forces applied to separate the mold
10 half from the mold assembly during a demolding
operation. The front mold half 14 further defines a
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
15 an injection hot tip which supplies molten thermoplastic
to form the front mold half.

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
20 convex surface 32, and an annular essentially uniplanar
flange 36 formed extending radially outwardly from the
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
25 the back mold half, and is 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 back
mold half is designed with a thinness, typically 0.6 mm,
30 and rigidity effective to transmit heat therethrough
rapidly and to withstand prying forces applied to

2151361

- 15 -

separate the mold half from the mold assembly during demolding. The back mold half 16 also defines a 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 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 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 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 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 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

2151361

-16-

1 front curve 14 in the pallet and against upward
movement. The lifting fingers 44 are positioned below
opposite sides of the flange 36 around the back curve 16
to lift and pry the back curve from the restrained front
5 curve.

Referring to Figure 4, the thin metal pry
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
10 after exposure of the rear mold portion 16 to the laser,
the pry fingers 44 pry the back mold portion up.
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,
15 and are then tilted back, the overall quality of the
removed lens was as good or better than currently
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
20 of a strip of tape from a tape roll, such that the
separation occurs sequentially in a wavefront which
moves across the back and front curves as they are being
separated.

The lens/mold assembly 12 is positioned in a
25 fixture shown in Figure 4. A primary requirement of
this fixture, beyond mechanical stability, is not to
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
30 to demolding, a laser beam is directed through the U-
shaped opening 57 to heat the back curve, thus creating

-17-

1 a substantial thermal gradient across the mold assembly
12 to assist in separating the back curve from the front
curve. For the presently described system, only the
back mold portion 16 is heated by exposure to radiation.
5 The back mold portion is thinner than the front mold
portion 14, and allows rapid, non-destructive heating of
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
10 rapidly, and thereby not produce the same thermal
gradient without localized overheating problems.

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
15 slightly recessed positions and the flanges 36 and tabs
38 of the rear curves 16 being in slightly elevated
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
20 44 readily slide between the separated side flanges 26,
36 of the front and back curves.

Figure 3 illustrates a preferred sequence of
movements of a pry fixture 54, rotationally mounted on a
shaft 60, relative to a pallet 10 supporting a two by
25 four array of front and back curve assemblies 12. In a
first position in the upper left portion of Figure 2,
the 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
30 are positioned above opposite sides of the flange 26
around the front curve 14 to restrain the front curve 14

2151361

- 18 -

in the pallet against upward movement. Lifting fingers 48 are positioned below opposite sides of the flange 36 around the back curve mold 16 to lift and pry the back curve mold 16 from the restrained front curve mold 14.

5 As illustrated in Figure 1, the contact lens mold assemblies 12 are supported in the pallet with the 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
10 the back curve mold 16 raised above the upper surface of the pallet, to allow the retaining fingers 46 and lifting fingers 48 to slide between the spaced flanges 26, 38, as the conveyor moves the pallet into the position shown in Figure 1.

15 In the second position in the middle left portion of Figure 3, after illumination of the back 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
20 separating finger member to rotate to pry apart and separate the back curve from the front curve.

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.

25 In the fourth position in the lower middle left portion of Figure 3, the pallet is moved to the 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
30 detail hereinbelow, to remove the separated back mold half from the pry fixture 54.

2151361

- 19 -

In the fifth position in the lower middle right portion of Figure 3, another pallet, with unseparated back and front curve assemblies, is moved by the conveyor into a position under the pry fixture, and
5 the pry fixture 54 is conveyed back in X and Y directions into a demolding position, as described in further detail hereinbelow.

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

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

Pursuant to the present invention, the back
20 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, which shifts one surface with respect to the other. The resultant shear force breaks the polymerized lens/polymer mold adhesion
25 and assists in separation of the mold portions 14, 16. The greater the temperature gradient between the surfaces of the mold portions, the greater the shearing force and the easier the mold portions separate. This effect is greatest when there is maximum thermal
30 gradient. As time continues, heat is lost through conduction from the back mold portion into the lens

-20-

1 polymer and the front mold portion, and then
collectively into the surrounding environment. The
heated back mold portion is, therefore, promptly removed
so that very little energy is transferred to the polymer
5 lens, avoiding the possibility of thermal decomposition
of the lens.

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

While a CO₂ laser producing radiation in the
15 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
electromagnetic radiation emitter of any type wherein
the radiation produced is absorbed by the mold material
20 sufficiently to cause an increase in mold material
temperature.

In the case of lasers, both mid-infrared and
UV, the laser energy is approximately 60% efficient
because the polystyrene mold material is nearly 100%
25 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,
so only the sample is heated.

Also, because of the absorptive nature of the
30 mold material at these frequencies, most of the laser
energy is absorbed within several wavelengths travel

-21-

1 into the material. From that point, heat is transferred
only by conduction from the surface. For that reason,
on initial exposure to the laser beam, a substantial
thermal gradient is formed between the exposed exterior
5 surface and the surface of the mold portion in contact
with the lens.

Preferably, a carbon dioxide (CO₂) laser
applies radiation to at least one of the mold portions
and may be split into two beams to simultaneously heat
10 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
wavelength of 10.6 μ m. The exposure time of the mold to
the laser is between one half and one second. Lasers of
15 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
cw/pulse laser was utilized.

A preferred embodiment was found by
20 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
can be mechanically separated, it was determined that a
much higher powered laser, up to 500 watts, is
25 preferred. Increasing the laser power and decreasing
the exposure duration was found to increase the thermal
gradient and increase the ease and consistency with
which the mold portions could be separated.

It was found that if a lens/mold combination
30 were sufficiently underexposed, the separation forces

2151361

-22-

1 would still be high. Lens damage such as tearing and
mold damage such as breaking would result.

If a lens/mold combination were overexposed to
the laser energy, separation of the mold portions and
5 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
degrades the lens.

10 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
was determined empirically that such mechanical force
15 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
exposure and mold separation would be between about 0.2
20 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.

A significant quality consideration and
25 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.

With the optimal exposure time and appropriate
30 demolding mechanism, the mold portions can be separated

2151361

-23-

1 and the lens removed from the mold in approximately 5 seconds.

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

10 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
15 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
20 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
25 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
30 stopped, and a laser beam 55 is directed through the opening 57 between the retaining fingers 42 and the

-24-

1 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
force to the back curve mold half 16. The upper part of
5 the pry fixture 54 rotates about axis 56 so that after
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
10 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
15 currently employed 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
20 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
25 seconds.

A preferred 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
30 6 is a plan view taken along section line 6-6 of Figure
5, and Figure 7 is an elevational side view taken along

2151361

-25-

1 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
the sequential movement of pallets containing contact
5 lens mold assemblies through the demolding apparatus.
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
10 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
15 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
20 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
25 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
30 the direction of arrows B, Figures 4 and 7. The pry
fixture 54 is mounted at one end of a platform 74 which

2151361

-26-

1 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
driven in rotation by a slidable cam 78 which engages a
5 roller can follower 80 mounted on the pivotable platform
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
10 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
15 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
20 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
25 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
30 adjacent to a back curve scraper 98, Figure 8, which
removes the back curves from the pry fixture 54 and

2151361

-27-

1 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
the pry fixture 54 over a disposal receptacle 96,
5 Figures 5 and 8. Simultaneously, the back curve scraper
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
10 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
15 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 X
axis, in a downward direction as shown in Figure 6, to
20 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
25 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.

30 After removal of the separated mold curves 16
from the pry fixture 54, platform 86 is then

2151361

-28-

1 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
position, as illustrated in Figures 5 and 8. The
5 slidable cam 78 is then withdrawn by drive motor 84 and
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
10 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
15 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
20 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
25 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
30 members then fall into a back curve disposal
receptacle 96.

-29-

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

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Claims

1. An automated apparatus for automatically demolding a mold assembly, comprising a first front mold portion which has a central mold section with a surrounding flange, a corresponding second back mold portion which has a central mold section with a surrounding flange, a molded ophthalmic lens formed between the front and back mold portions, wherein the flanges of the front and back mold portions are spaced apart relative to each other, the apparatus 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 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 portions and against the flange of the second mold portion;

(c) means for rotating the separating fingers about a fixed axis relative to the restraining means to progressively separate and peel the second mold portion from the lens in the first mold portion; and

(d) means for lifting the second mold portion upwardly to remove the second mold portion from the first mold portion.

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

3. Apparatus as claimed in claim 2, wherein the means for heating includes a

laser producing electromagnetic radiation having a wavelength between 1 μm and 20 μm .

4. Apparatus as claimed in claim 1, 2 or 3, wherein the mold assembly is carried by a pallet, which carries 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 with the restraining fingers against the flange of the first mold portion and the separating fingers against the flange of the second mold portion.

5. Apparatus as claimed in any one of claims 1 to 4, wherein said separating fixture is supported by a pivot shaft for rotation relative to the fixedly mounted restraining means.

6. Apparatus as claimed in claim 5, wherein during the demolding operation the separating fixture is rotated through an angle of approximately 18 degrees.

7. Apparatus as claimed in claim 5 or 6, wherein the separating fixture pivot shaft is positioned at a spaced distance from the restraining means.

8. Apparatus as claimed in any one of claims 1 to 7, wherein said separating fixture is mounted on a first movable base for elevational movement relative to the fixedly mounted restraining means.

9. Apparatus as claimed in claim 8, wherein said first movable base is pivotally mounted about a rotational shaft at one end thereof, and said separating fixture is mounted at a second and opposite end of said first movable base.

10. Apparatus as claimed in claim 9, further including a ramp cam driven by a pneumatic motor, and said movable base includes a cam follower roller positioned on said 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 mounted on the second end of the first movable base.

11. Apparatus as claimed in any one of claims 1 to 10, wherein said separating fixture includes a gripping means for gripping a second mold portion which is separated from a first mold portion.

5 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 separation of the mold portions, and means for moving said separating fixture relative to the back curve remover during which the back curve mold portion is removed from the separating fixture.

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

14. Apparatus as claimed in claim 12 or 13, wherein said first movable base is mounted on a second movable base which is mounted for X translational movement relative to a fixed base.
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15. Apparatus as claimed in claim 14, wherein a pneumatic drive motor drives said movable base in X translational movement relative to the fixed base.

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

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

18. Apparatus as claimed in any one of claims 1 to 17, 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 any one of claims 1 to 18, 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 in the U-shaped separator to heat the second mold portion.

21. Apparatus as claimed in any one of claims 1 to 20, including conveyor means for conveying the mold assembly to insert said restraining fingers and separating
5 fingers between the flange members of the mold assembly as a consequence of said conveyance, and control means for sequentially actuating said conveyor means to convey the mold assembly into a demolding position in the demolding apparatus, and then rotating the separating fingers through an arc of approximately 18 degrees to sequentially lift and peel said back curve mold
10 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.

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 and second sets of restraining means and separating fixtures, with a first set
20 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 any one of claims 12 to 23, when dependent on claim 11, further including a back curve mold remover to remove said back curve mold portion from said separating fixtures after separation of the mold portions,
25 and means for independent reciprocal movement of said separating fixture relative to the back curve remover.

25. Apparatus as claimed in claim 13 and 24, wherein said first movable base is mounted on a second movable base which is mounted for X and Y translational movements relative to a fixed base, an X pneumatic drive motor drives said
30 movable base in X translational movement relative to the fixed base, and a Y

pneumatic drive motor drives said movable base in Y translational movement relative to said fixed base.

26. An automated method for automatically demolding a mold assembly, comprising a first front mold portion which has a central mold section with a surrounding flange, a corresponding second back mold portion which has a central mold section with a surrounding flange, and having a molded ophthalmic lens formed between the front and back mold portions, wherein the flanges of the front and back mold portions are spaced apart relative to each other, the method comprising:

10 (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;

15 (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;

 (c) rotating the separating fingers about a fixed axis relative to the restrained first mold portion to progressively separate and peel the second mold portion from the lens in the first mold portion; and

20 (d) lifting the second mold portion upwardly to remove the second mold portion from the first mold portion.

27. A method as claimed in claim 25, including heating the second mold portion with electromagnetic radiation, which is absorbed by the second mold portion to cause a substantial temperature 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 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.

28. A method as claimed in claim 27, wherein the heating step utilizes a laser producing electromagnetic radiation having a wavelength between 1 μ m and 20 μ m.

29. A method as claimed in claim 26, 27 or 28, including carrying the mold assembly in a pallet, which 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 portion and the separating fingers against the flange of the second mold portion.

30. A method as claimed in any one of claims 26 to 29, wherein during the demolding operation the separating fingers are rotated through an angle of approximately 18 degrees.

31. A method as claimed in any one of claims 26 to 30, wherein said separating fingers grip a second mold portion which is separated from a first mold portion.

32. A method as claimed in claim 31, further including removing the second mold portion from said separating fingers after separation of the mold portions.

33. A method as claimed in any one of claims 26 to 32, wherein the first 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.

34. A method as claimed in any one of claims 26 to 33, further including directing a laser beam through the separating fingers to heat the second mold portion.

35. A method as claimed in any one of claims 26 to 34, including conveying the mold assembly to insert the restraining fingers and separating fingers between the flange members of the mold assembly as a consequence of said conveyance, and then rotating the separating fingers through an arc of approximately 18 degrees to sequentially lift and peel the back curve mold

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.

36. A method as claimed in claim 35, including carrying a plurality of mold assemblies on a pallet during said conveying step.

- 5 37. A method as claimed in claim 36, 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 pallet, and positioning a second set of restraining fingers and separating fingers on a second side of said pallet.

FIG. 1

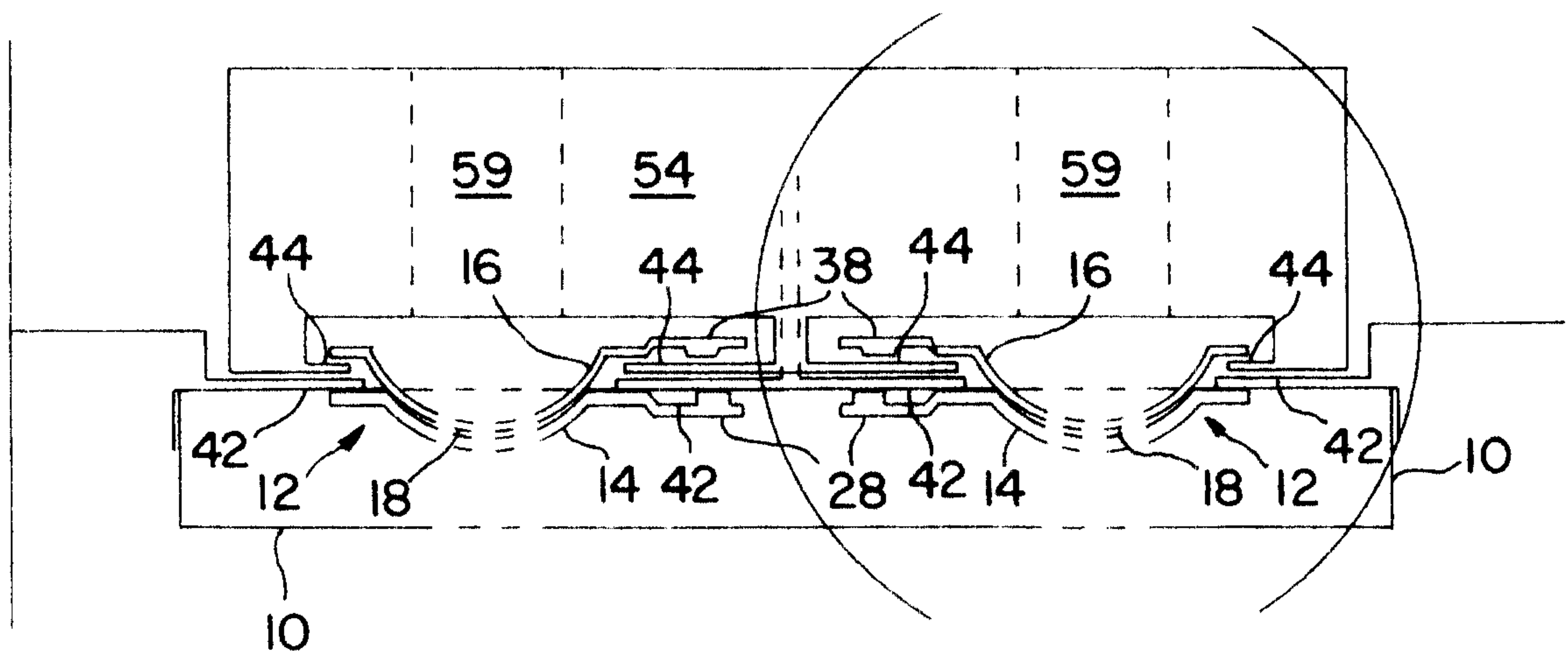
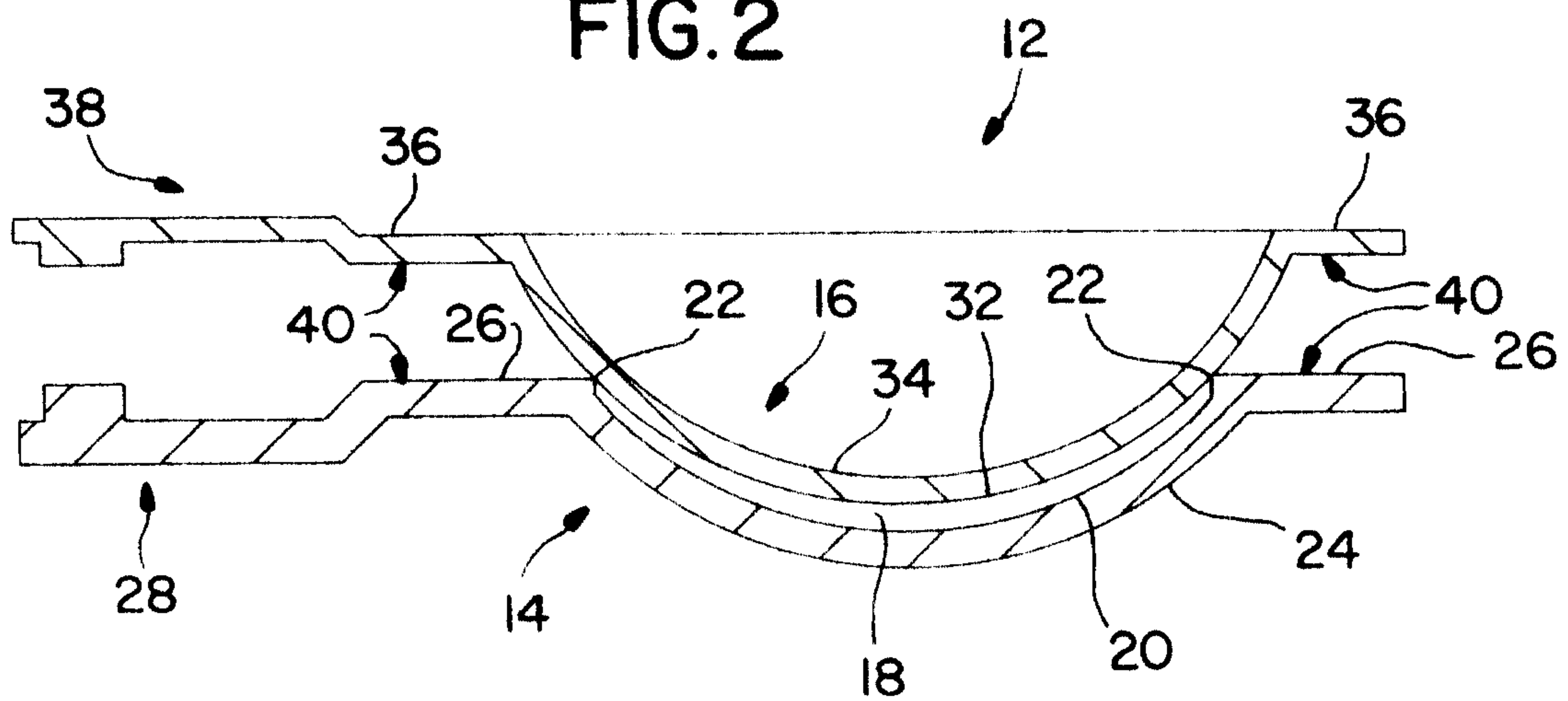


FIG. 2



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Dwight Ogilvy Renault

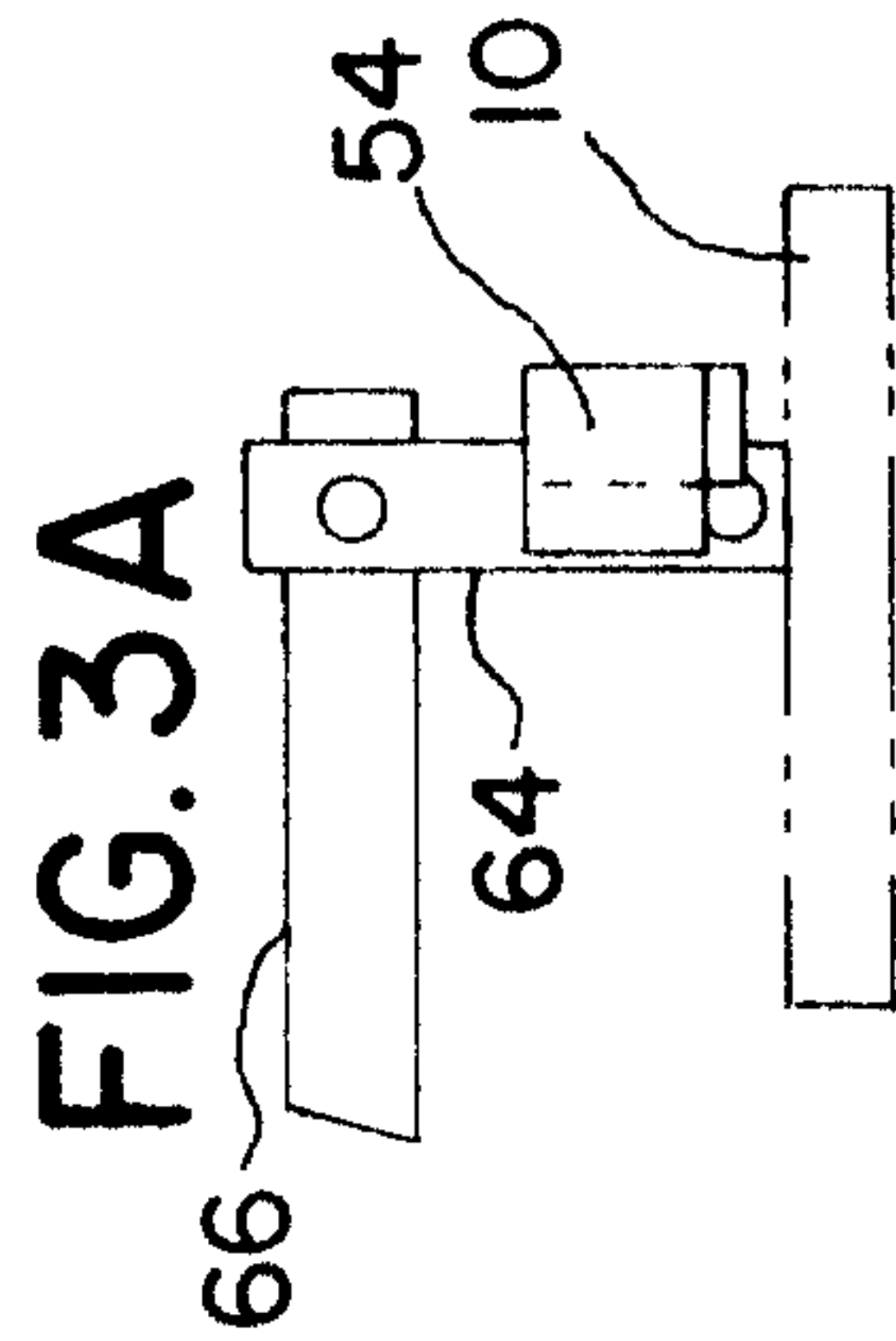


FIG. 3A

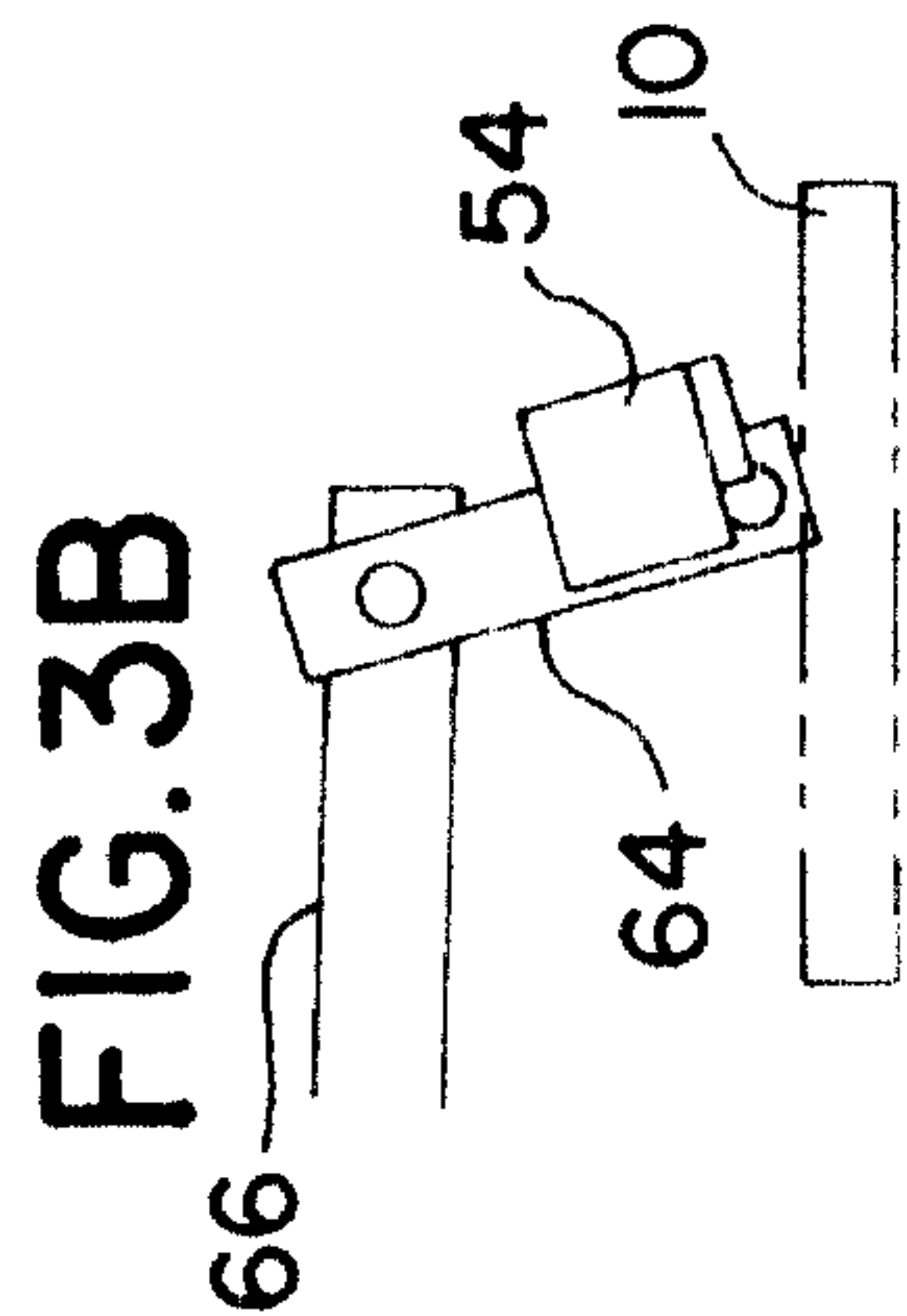


FIG. 3B

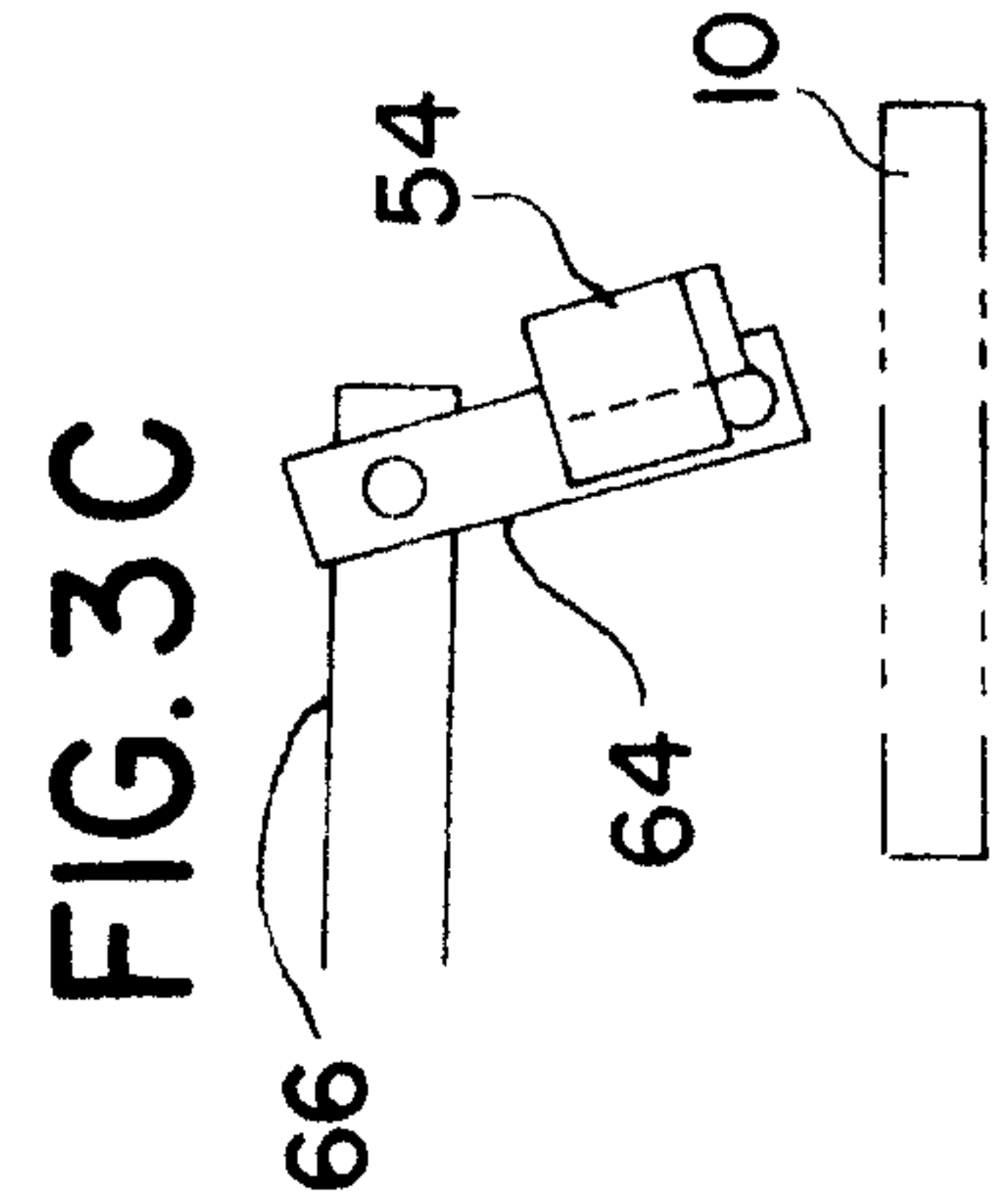


FIG. 3C

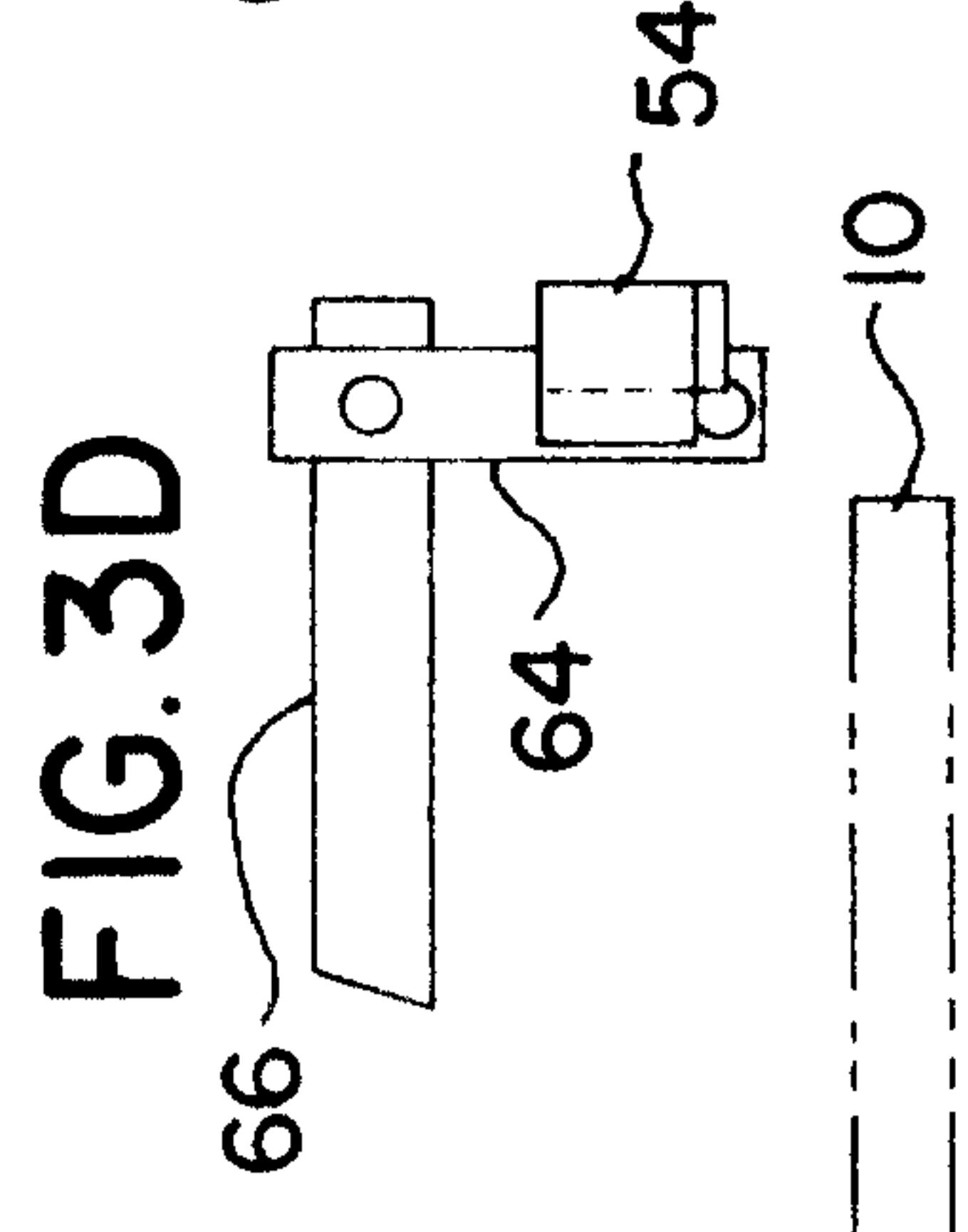


FIG. 3D

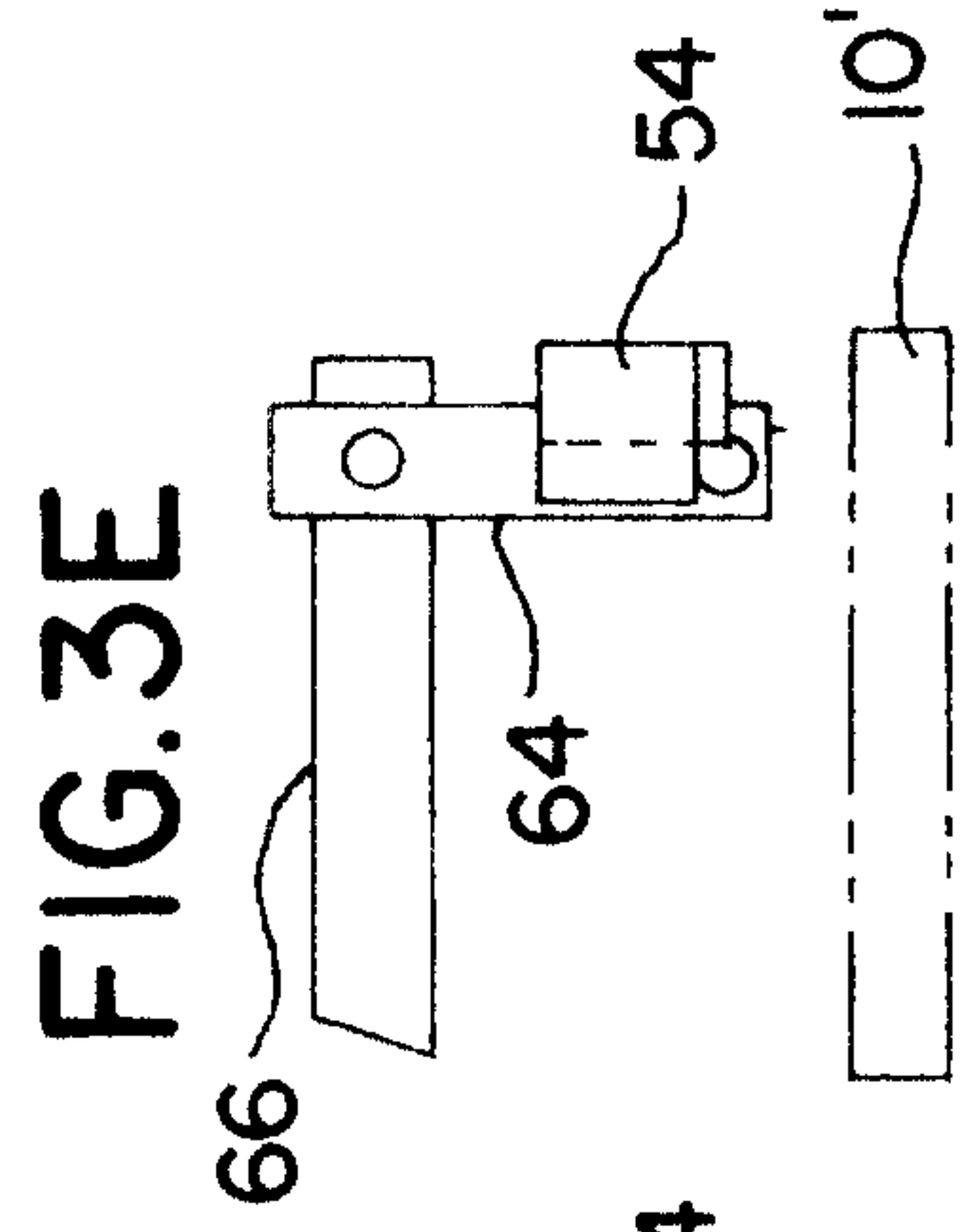


FIG. 3E

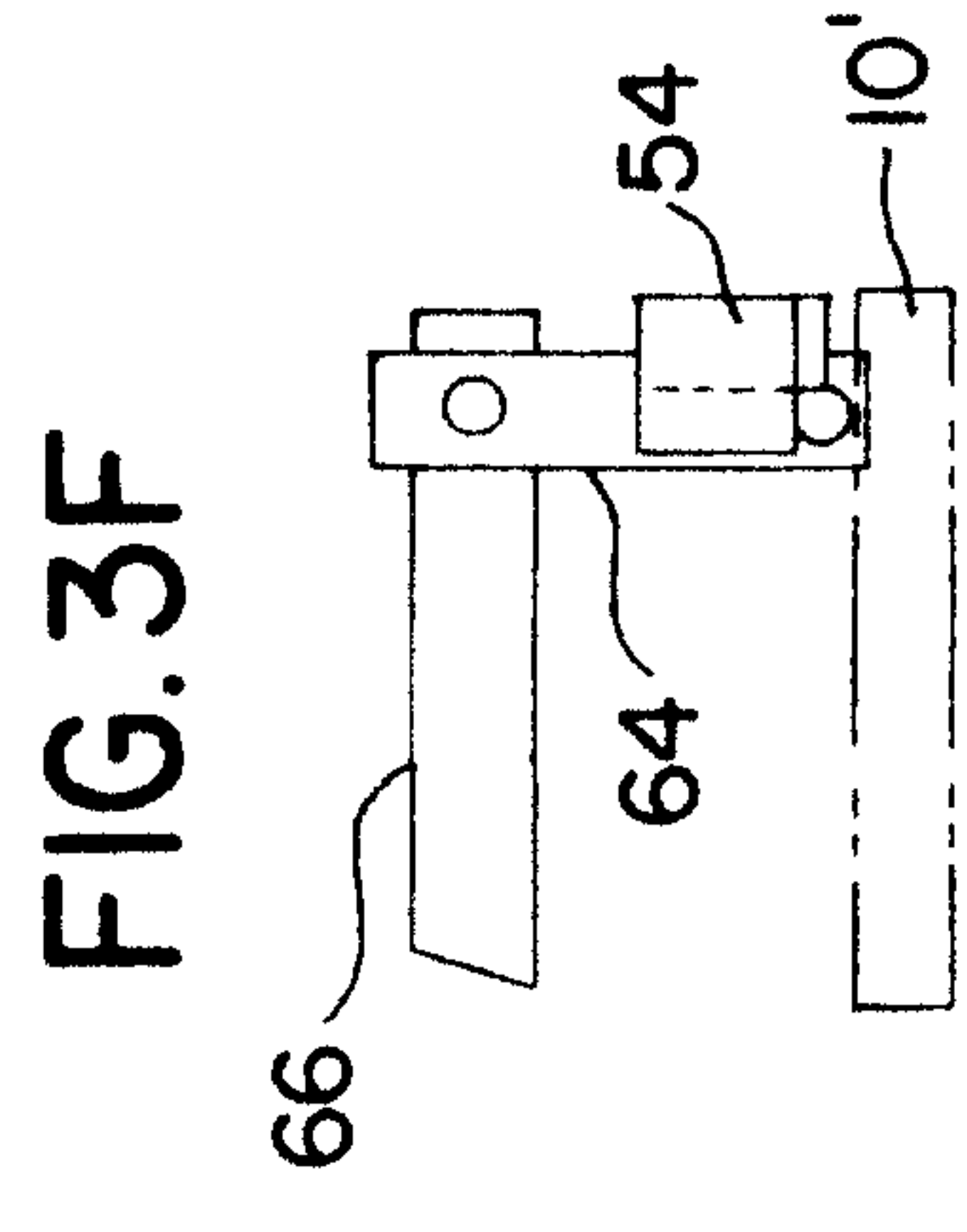


FIG. 3F

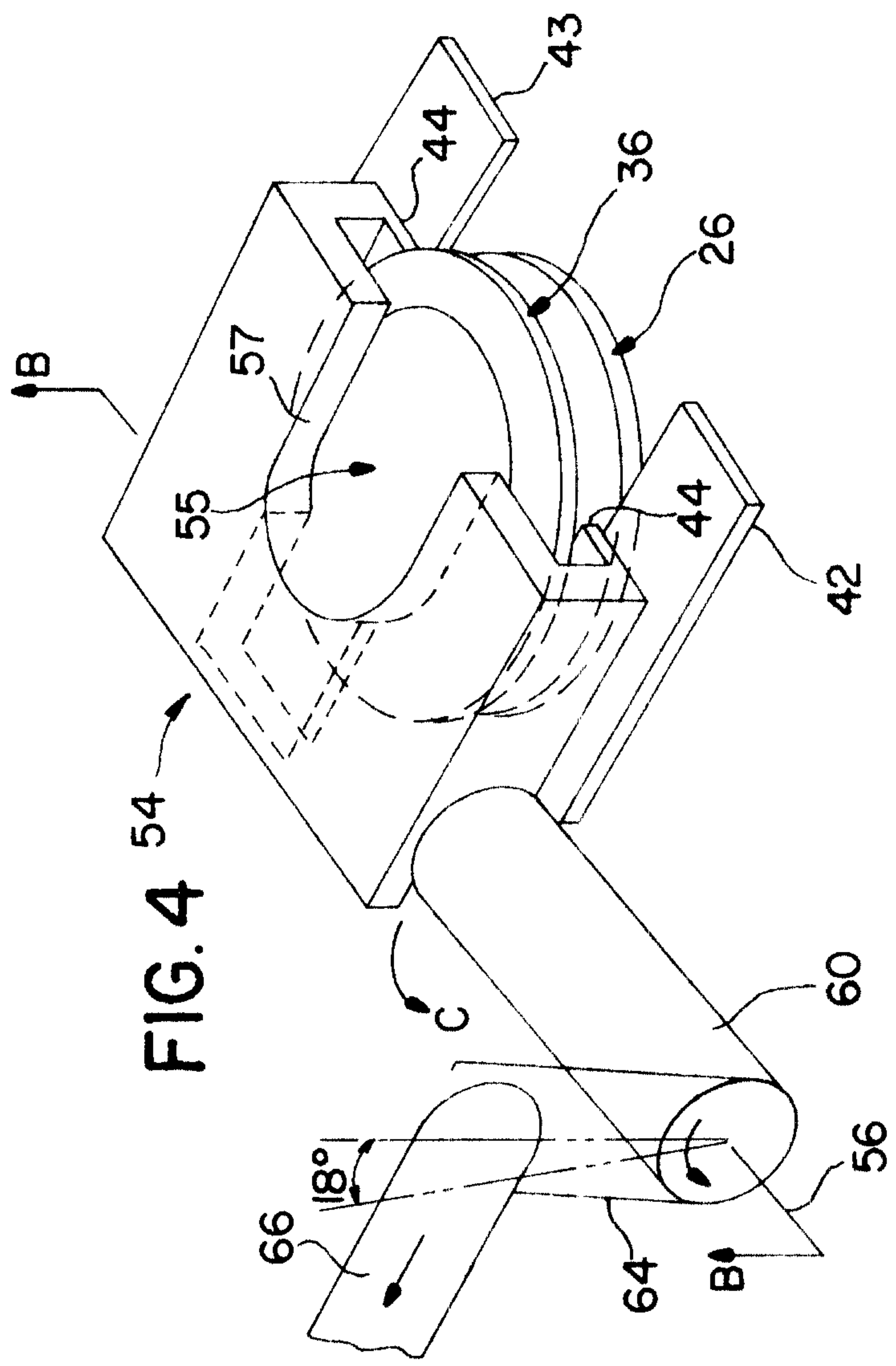
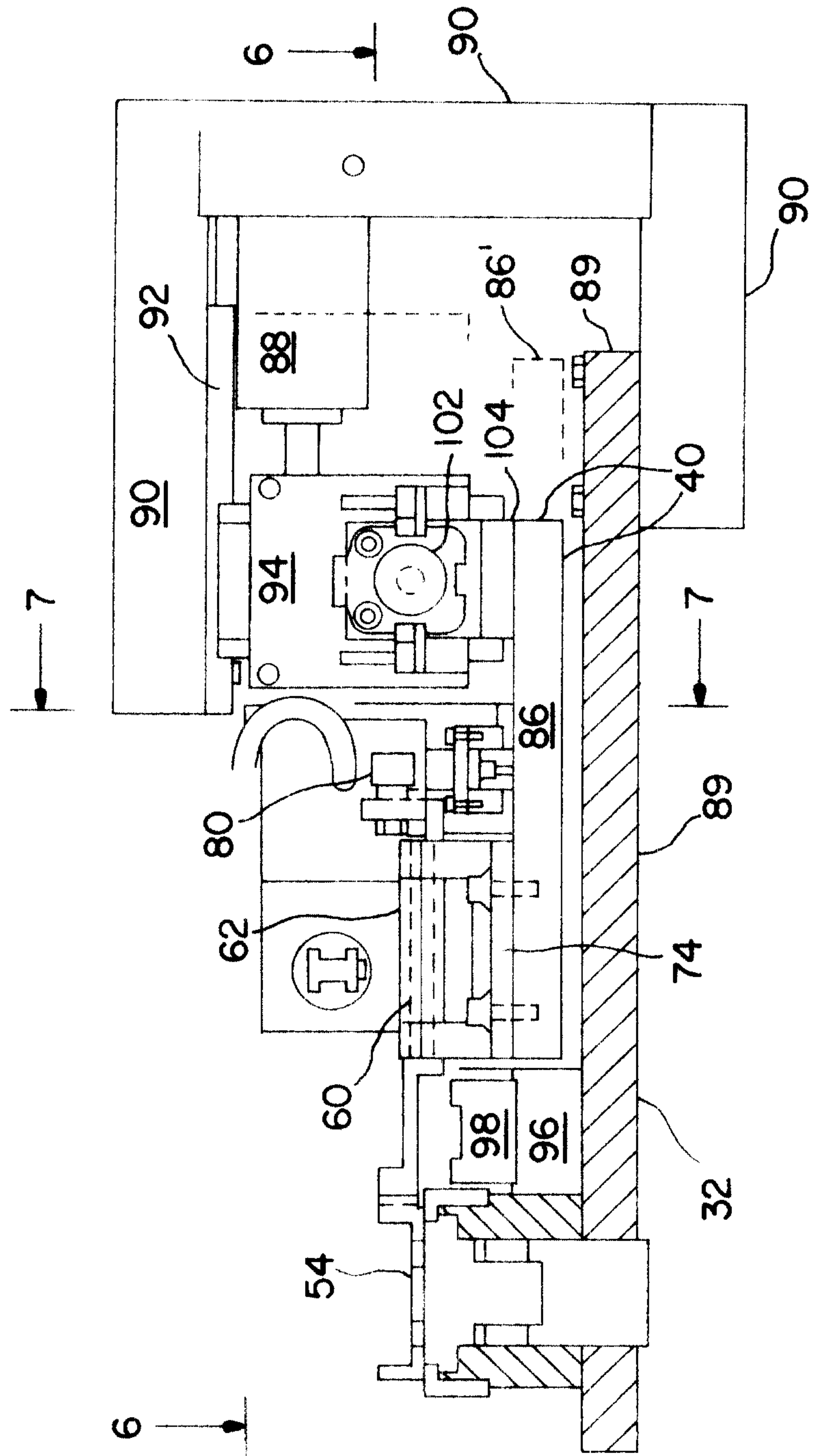


FIG. 4

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Awakey Ogilvy Renault

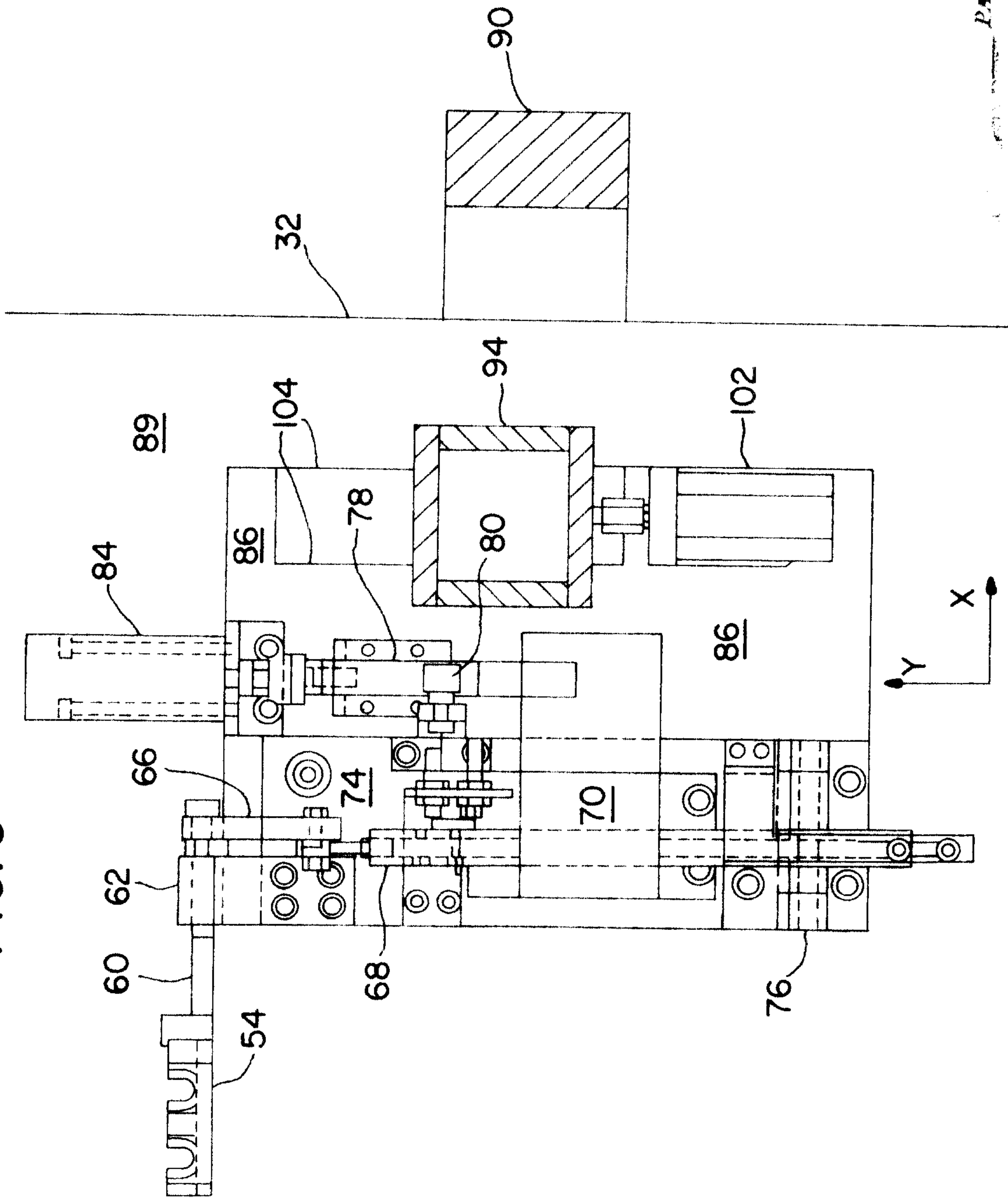
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PATENT AGENTS

Rowley Ogilvy Kenault

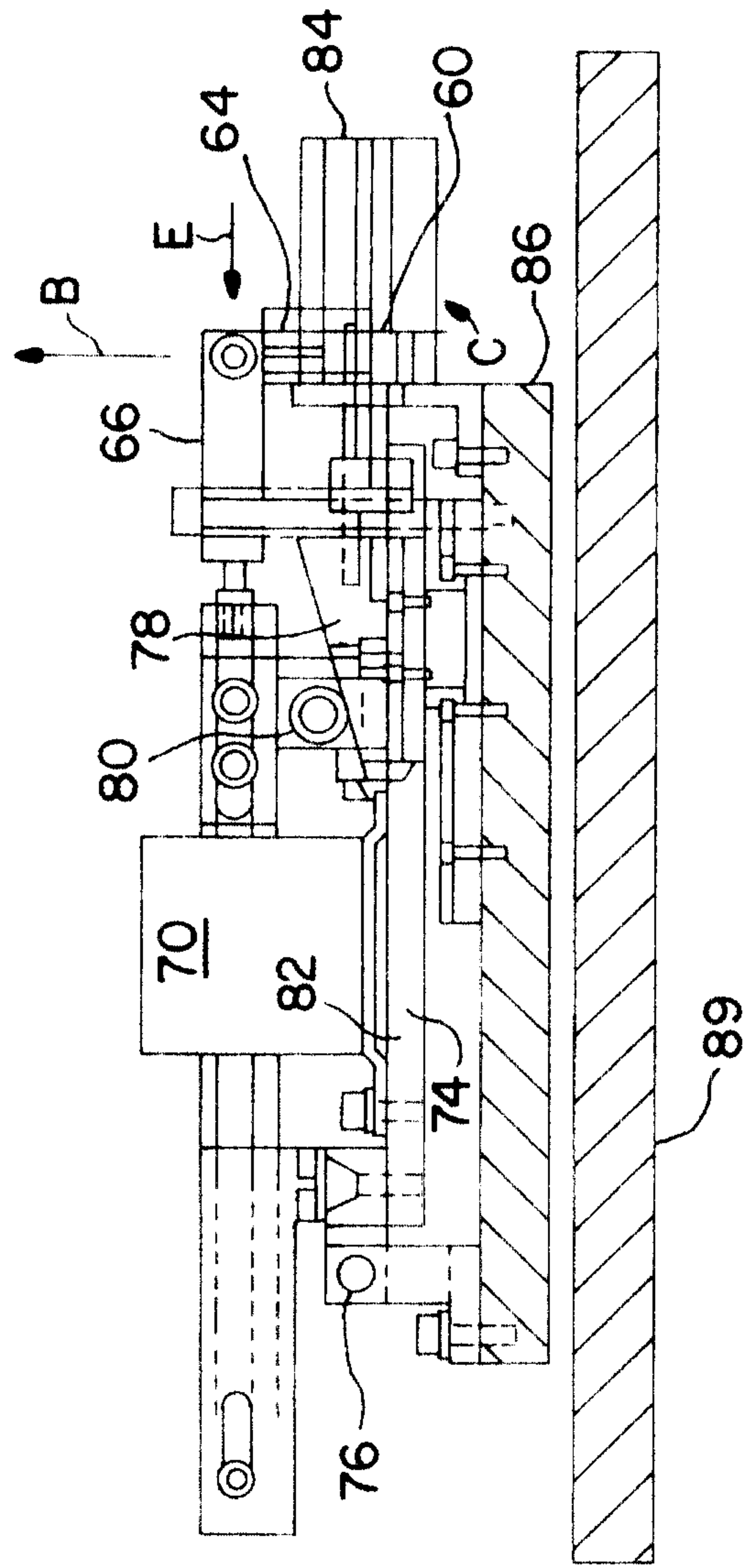
FIG. 6



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FIG. 7



PATENT AGENTS

Swatkey Ogilvy Renault

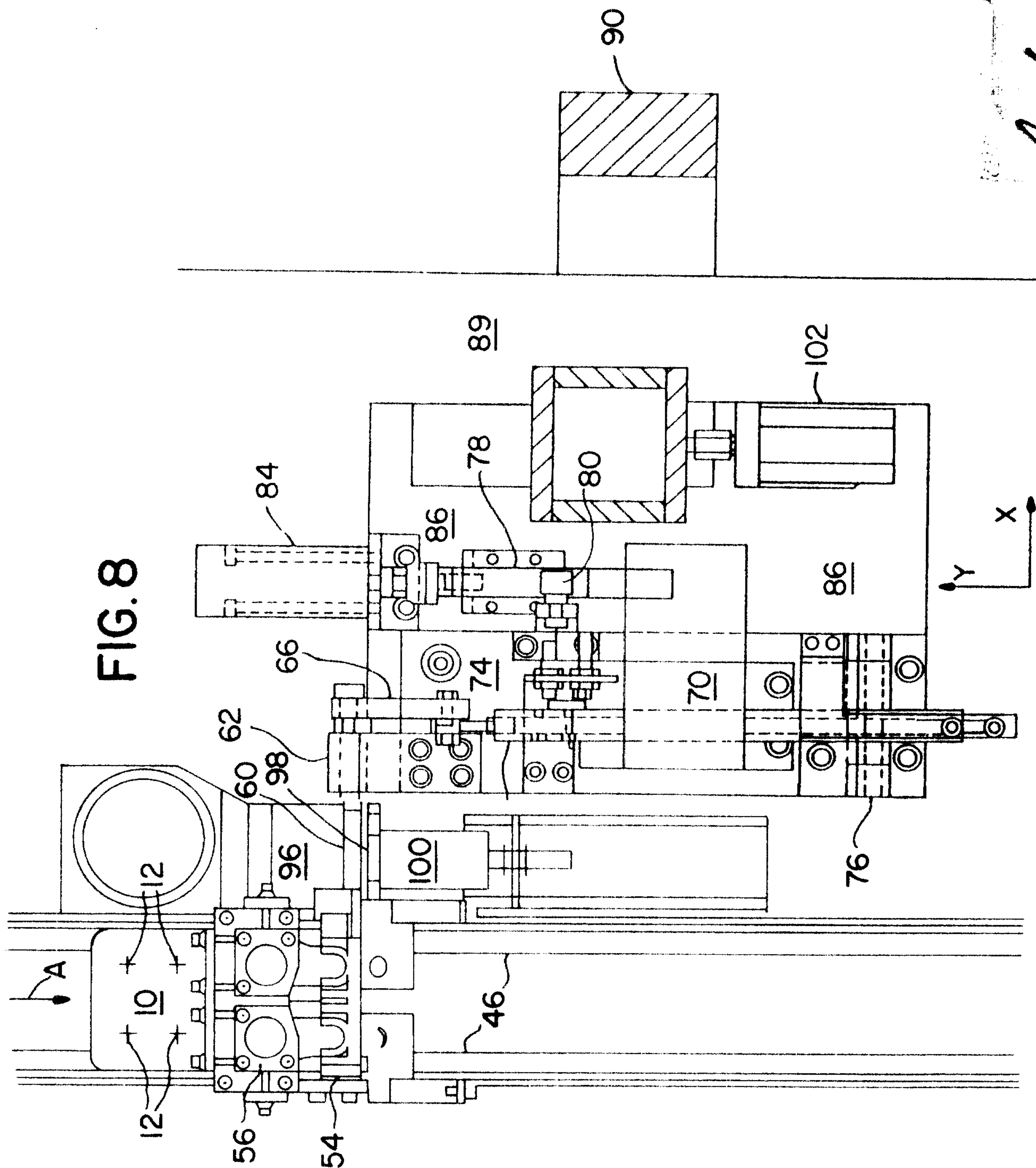
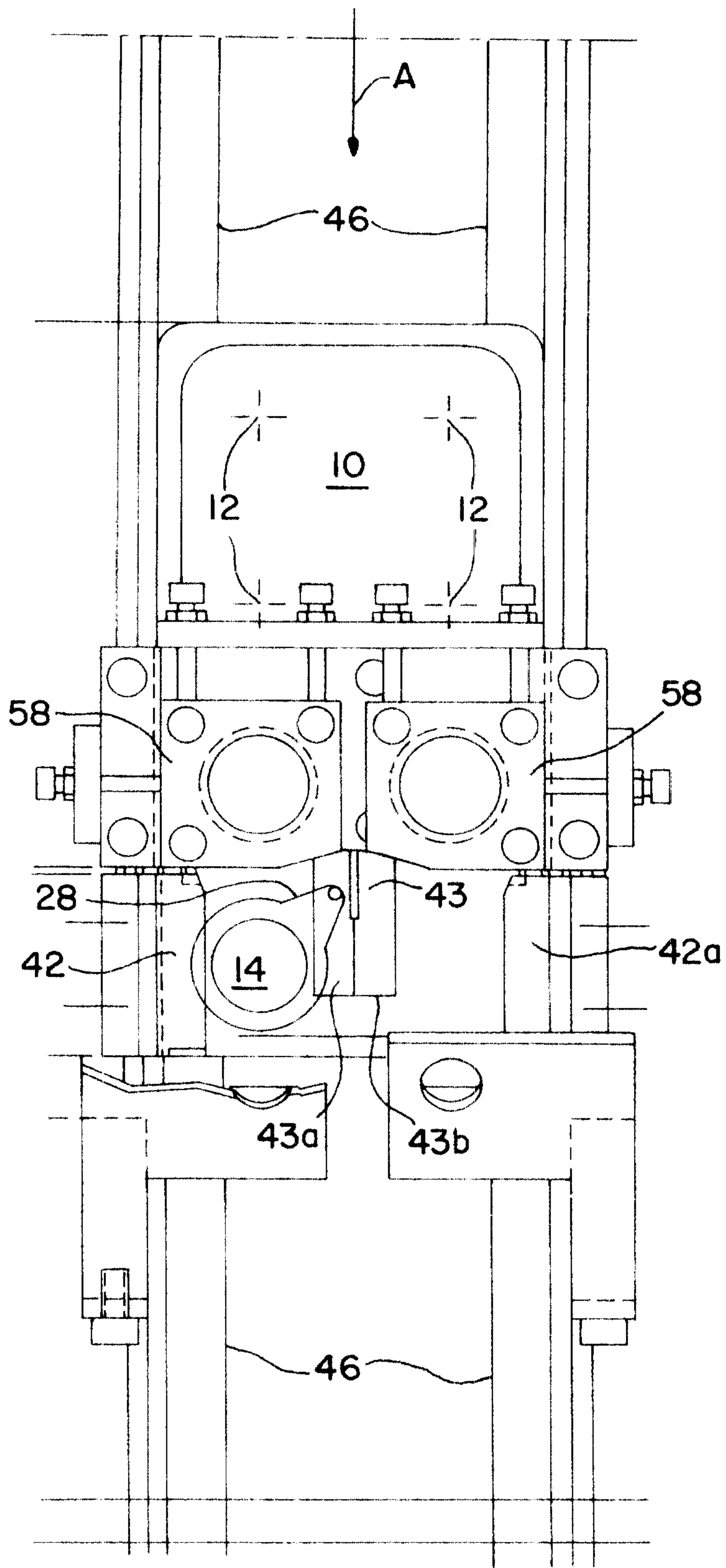


FIG. 9



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FIG. 10

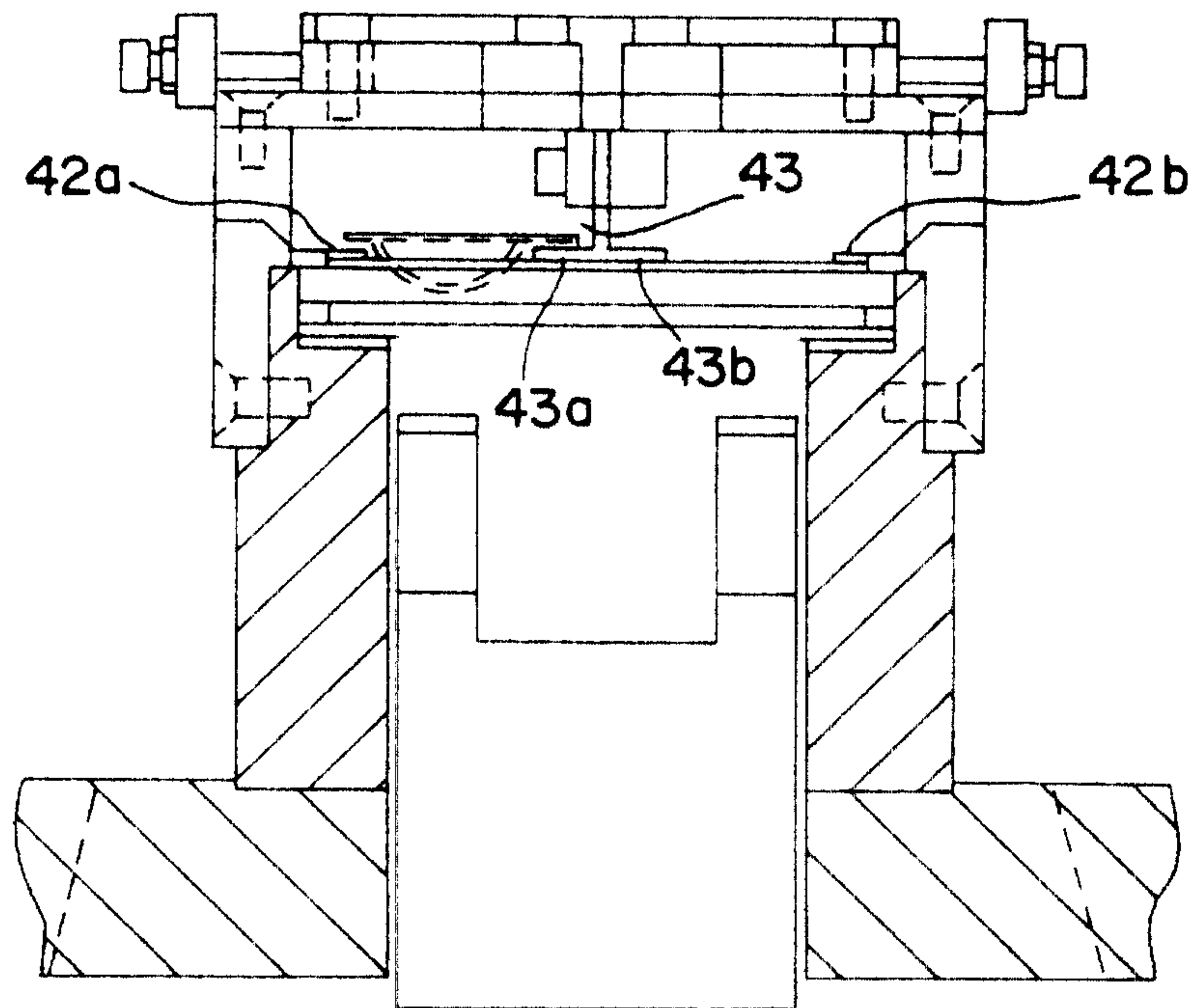
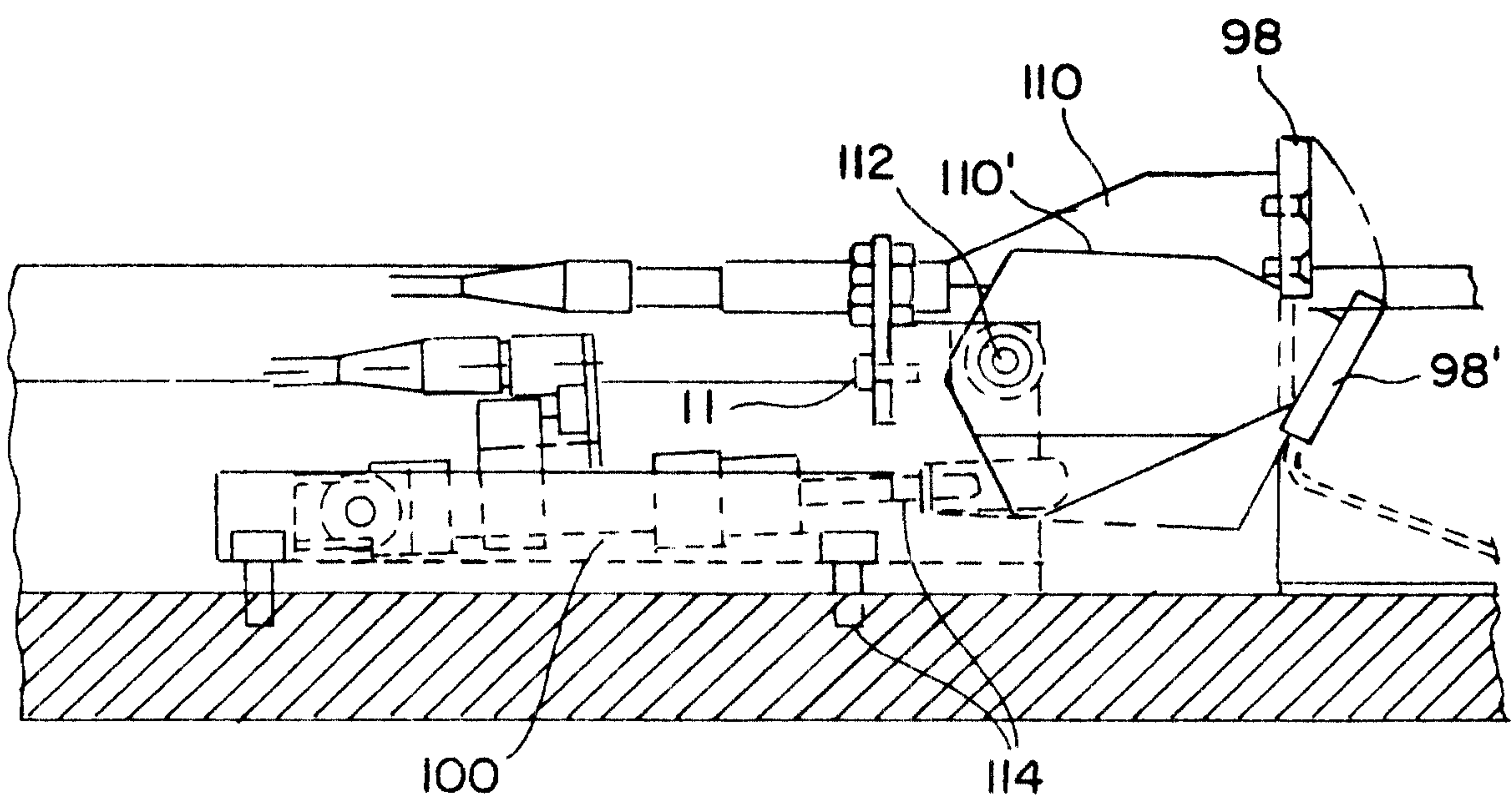


FIG. 11



PATENT AGENTS

Swaney Ogilvy Renault

1 ABSTRACT OF THE DISCLOSURE

An automated demolding apparatus for reliably and repeatedly mechanically separating contact lens mold portions of a mold assembly without damaging the contact lens formed therebetween. 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. A molded contact lens is formed between the front and back mold portions, and the flanges of the front and back mold portions are spaced apart and parallel to each other. 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. 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 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 rotated relative to the

1 restraining fingers to progressively separate and peel
the second mold portion from the first mold portion.

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