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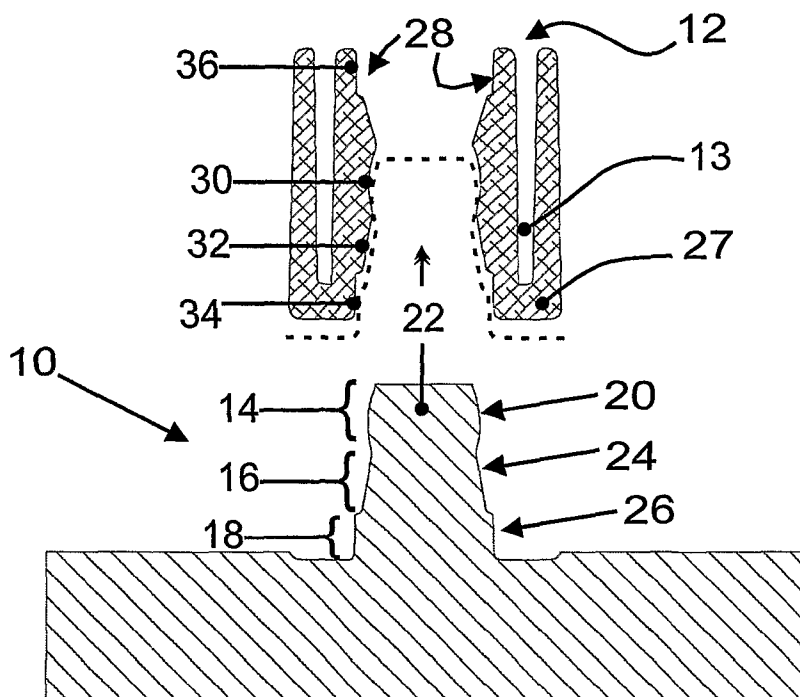
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(54) Title: CONSTRUCTION TOY



(57) Abstract: A construction toy having removably connectable male (10) and female (12) connectors. The female connector (10) elastically expands upon insertion of the male connector (12). Two such female connectors (12) can be formed such that they are oriented in opposite directions along a common axis. The female connector (12) allows rotation of the male connector (10) whilst the two connectors are engaged. The construction toy also includes a component (292, 294) having an adjustable length.

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CONSTRUCTION TOY

FIELD OF THE INVENTION

The present invention relates generally to construction sets, and more particularly
5 to construction toys with multiple shaped components removably connectable
with male and female connectors.

BACKGROUND OF THE INVENTION

Construction toys have been developed over the years for play, education, and
10 industry modeling. Among the various examples are Erector Set (TM), Lego
(TM), K'Nex (TM) and Fischertechnik (TM) construction toys.

In the case of Erector Set, bolts and screws are used to assemble components.
Erector Set components are generally planar and it requires significant effort to
15 build three dimensional models by joining these planar components with bolts and
screws.

In the case of Lego, components are connected by pressing together male and
female portions. Components are three dimensional, however they are limited in
20 the angular orientation of connecting components. Also, the male and female
connector portions generally are smooth and held together with friction, resulting
in reduced stability and ultimately abrasive wear on components. A further
disadvantage of Lego components is that very high manufacturing tolerances are
required to provide an interference fit to allow male and female connector
25 portions to be held together by friction alone.

In the case of K'Nex, two types of component are provided. The first type of component is a straight rod, having shaft with an X-shaped cross-section and a mushroom-shaped connector at each end. The second type of component is a socket having one or more gripping arms disposed in a single plane. The gripping arms can grip either the mushroom-shaped connector of a rod (thereby enabling a rod to be secured in the plane of the socket) or the X-shaped shaft (thereby enabling a rod to be secured perpendicular to the plane of the socket). In the case where the mushroom-shaped connector is to be gripped, the mushroom-shaped connector must be pushed into (and out of) the gripping arms in a direction perpendicular to the axis of the rod, since the sockets are not sufficiently flexible to allow the mushroom-shaped connector to be pushed into the gripping arms in a direction along the axis of the rod. Different types of socket are provided, such as a 360-degree socket with eight arms disposed at forty-five degrees to each other, and a 90-degree socket with three arms disposed at forty-five degrees to each other. The sockets also comprise a through hole perpendicular to the plane of the socket; a rod placed within the through hole is free to rotate about its axis and to slide along its axis. A disadvantage of this arrangement is that the methods of securing rods perpendicular to the plane of the socket are not optimal: if the X-shaped shaft of a rod is placed within a gripping arm, the mushroom-shaped connector protrudes out of the socket, thereby giving an untidy appearance and preventing the socket from lying flat on a surface; alternatively, if the rod is placed within a socket's through hole, it is inadequately secured against linear motion and rotation. A further disadvantage is that rods cannot be connected to each other without the use of separate sockets, so a large number of different pieces are required to construct models and a user is required to expend time and

effort in choosing an appropriate socket for each connection. A construction toy similar to K'Nex is described in United States Patent No. 5,061,219.

In the case of Fischertechnik, a cuboid building block component (Part No. 32879, for example) has a groove running along the centre of five of its surfaces and a peg at the central point of the remaining surface. The peg can slide into the grooves of a similar component, thereby allowing the components to be joined. A disadvantage of this arrangement is that assembled models may be unstable, due to the possibility that pegs can unintentionally slide within the grooves. A further disadvantage arises when two building block components are joined to a single groove of a third such component, and it is desired to add a fourth such component to the same groove in a position between the first two components; in this case, it is necessary to partially disassemble the structure by removing either of the first two components, in order to provide access to the groove in order to allow insertion of the fourth component. A yet further disadvantage is that an axle component cannot be passed through the building block, since grooves on opposite sides of the block are not joined by a through hole.

A further type of Fischertechnik component (Part No. 36294, for example) has an "open box" shape, and resembles a hollow cuboid box having only four external walls (the two "missing" walls are adjacent to each other). A first external wall comprises a groove (as previously described in relation to the Fischertechnik building block component), the external wall opposite the first external wall comprises a peg (also as previously described in relation to the Fischertechnik building block component), and the two remaining adjacent external walls each

comprises a plurality of slots having an enlarged central portion and narrower peripheral regions. A further component can be joined to an "open box component either by (i) sliding a peg of the further component along the groove of the open box component or (ii) by pushing a peg of the further component into the enlarged central portion of the slot and then sliding the peg sideways such that it engages in one of the narrower peripheral regions. This type of component has the disadvantages that: (i) it cannot be manufactured using a simple two-plate injection molding process because the slots are provided in adjacent walls, which requires a third plate (or "side core") to produce the slots in one wall; (ii) the "open box" shape is not strong, particularly when subjected to torsion; (iii) the relatively thin walls cannot withstand large loads applied to components inserted into the slot, which makes the slots unsuitable for supporting an axle, for example; (iv) the slots are only capable of receiving a single peg, so the slots do not allow the connection of two components to corresponding positions on opposing walls of the component (instead, one is required to connect a component to a slot adjacent to that of an already-occupied slot); and (v) it is inconvenient to connect components using the slots, since the pushing and sliding motion requires components to be moved along two orthogonal axes during connection and disconnection.

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International Publication No. WO 99/47224 describes a construction toy component having an elongate rectangular shape. A plurality of circular through holes are provided in a direction perpendicular to the direction of elongation. Two such components can be joined by means of a separate connector that is inserted into a through hole of each component. The connector is substantially

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tubular and has a flange at each end. The connector is pushed into a through hole, such that its flange engages with an annular lip at the opposite end of the hole. The hole is thus fully occupied by a connector, which prevents a further component being connected to the opposite side of the component using the same
5 through hole.

Various others have attempted to overcome some of the limitations of such designs with various levels of success. There continues to be a need for multi-functional construction toys with multi-faceted and multi-angular connectable
10 components. There also continues to be a need for reusable connector portions that lock into position and provide greater stability while being simple to use.

A further problem with known construction toys becomes apparent when one wishes to build a model that requires an elongate component having a specific
15 length. To build such models, one is required to locate such a component (which can be time consuming and difficult if one is required to select a component having the desired length from amongst a number of components having a range of similar, but different, lengths) or to construct a component of the desired length by joining a number of shorter components together (which is time consuming
20 and the resulting assembly of components will have an undesirable non-uniform appearance and may also be less able to bear loads than a single component of the same length).

It is a preferred aim of the invention to overcome or mitigate the aforementioned disadvantages and problems of known construction toys. It is also a preferred aim of the invention to provide a construction toy that can be easily manufactured.

5 SUMMARY OF THE INVENTION

In accordance with the present invention, a multi-functional construction toy includes inter-connectable reusable snap-lock components that are multi-faceted and multi-angular enabling a user to construct assemblies of various shapes.

10 In accordance with a first aspect of the invention, there is provided a female construction toy connector comprising an inner surface with a first shoulder region, a first neck region, and a head region, the first neck region connecting the first shoulder and head regions, said first neck region having an inner circumference that tapers from the first shoulder region to the head region, the
15 head region having an inner circumference that expands from the first neck region and the diameter of the neck region being elastically expandable. Preferably, the first shoulder region has a geometrically shaped inner surface. More preferably, the first shoulder region has an octagonally shaped inner surface.

20 Preferably, the female connector further includes a second neck and a second shoulder region, the second neck region connecting the second shoulder region and the head region, the diameter of the second neck region being elastically expandable. Preferably, one or both of the shoulder regions has a geometrically shaped inner surface. More preferably, one or both of the shoulder regions has an
25 octagonally shaped inner surface. Preferably each of the neck, shoulder, and head

regions are disposed along a common axis. Preferably, the female construction toy connector is sized and proportioned to receive and connect with oppositely disposed male-type connectors. Preferably the female construction toy connector is produced from an injection molding process.

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In accordance with a further aspect of the invention there is provided a male construction toy connector comprising an external surface with a shoulder, a neck, and a head, the neck connecting the shoulder and head, said neck having an outer circumference that tapers inward from the shoulder to the head, and the head
10 having a portion that is wider than the adjoining portion of the neck. Preferably, the shoulder has a geometrically shaped outer surface. Preferably, the shoulder has a circularly shaped outer surface or an octagonally shaped outer surface.

In accordance with a further aspect of the invention there is provided a
15 construction toy component including a female construction toy connector, the female construction toy connector comprising an inner surface with a first shoulder, a first neck, and a head region, the first neck region being elastically expandable to accommodate insertion of a male construction toy connector.

20 Preferably, the first neck region connects the first shoulder and head region, said neck region having an inner circumference that tapers from the first shoulder region to the head region, and the head region has an inner circumference that increases in size from the first neck region to accommodate a male toy connector with a head size that is greater than the circumference of the portion of the neck
25 region that joins the head region. Preferably, the construction toy component

includes a u-shaped connector. Preferably the u-shaped connector has ends that curl inward and are elastically expandable apart for insertion of an axle. Preferably, the construction toy connector includes a second neck and a second shoulder region to accommodate bi-directional connecting with a male connector.

- 5 Preferably, the construction toy connector is connectable simultaneously with two opposing male connectors. Preferably, the construction toy component comprises a rod, the first female construction toy connector connecting to one end, the construction toy component including a construction toy connector connected to the other end. Preferably, the construction toy connector comprises an axle.
- 10 Preferably, the construction toy component comprises an elbow, the first female construction toy connector connecting to one end, wherein the construction toy component includes a construction toy connector connected to the other end.

- Preferably, the construction toy component includes an arm extending at an angle
- 15 with respect to the two ends and including a connector. More preferably, the construction toy component includes multiple arms extending from a central axis, each of said multiple arms including a connector. Preferably, at least one of the connectors is disposed at an angle with respect to at least one other of the connectors. Preferably, at least one of the connectors being connectable bi-
- 20 directionally.

- Preferably, the construction toy component comprises an expandable rod, the first female construction toy connector connecting to one end, the construction toy component including a construction toy connector connected to the other end.
- 25 Preferably, the expandable rod includes a first rod and a second rod, each rod

including one of the connectors, the second rod including an insertable element, the first rod including a receptacle for receiving the insertable element and securing the insertable element in more than one position. The feature of an expandable rod may be provided independently.

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In accordance with a further aspect of the invention there is provided a construction toy component including a male construction toy connector, the male construction toy connector including a head and neck sized and proportioned for insertion within a female construction toy connector, the head having a portion
10 with an external circumference that is greater than an abutting portion of the neck.

Preferably, the construction toy component includes a pulley element, the male construction toy connector being disposed axially with respect to the pulley element. Preferably, the construction toy component includes a second male
15 construction toy connector disposed opposite the other male construction toy connector. Preferably, the male construction toy connector includes a shoulder connecting to the neck, the shoulder having a geometrically shaped external surface for reciprocal engagement with a female construction toy connector. Preferably, the construction toy component includes a female construction toy
20 connector. Preferably, the female construction toy connector is disposed at an angle with respect to the male construction toy connector. Preferably, the construction toy component includes a motor base element, the male construction toy connector being disposed axially with respect to the motor base element.

In accordance with a further aspect of the invention there is provided a construction toy assembly including a first and second construction toy component, the first and second construction toy component being connected, the first construction toy component including a female construction toy connector, the female construction toy connector comprising an elastically expandable neck region and a head region, the second construction toy component including a male construction toy connector including a neck and head, the head having a larger outside diameter than the neck, the male construction toy connector being sized and proportioned for insertion within the female construction toy connector, and the female connector being elastically expandable to accommodate insertion of the male connector and contractable about a portion of the male connector after insertion.

Preferably, the female connector has a female shoulder region with a geometrically shaped inner surface. Preferably, the female shoulder region has an octagonally shaped inner surface. Preferably, the male connector has a male shoulder region with a geometrically shaped outer surface sized and proportioned to mate with the female shoulder region. Preferably, the male connector has a male shoulder region with a circular shaped outer surface sized and proportioned to rotate within the female shoulder region. Preferably, the male connector has a male shoulder region with an octagonally shaped outer surface sized and proportioned to rotate within the female shoulder region. Preferably, the construction toy connector assembly including multiple components with corresponding male and female connectors, the multiple components having varying shapes and sizes, the multiple components connecting to form a three-

dimensional toy structure. Preferably, the multiple components of the assembly include a set of wheels and at least one pulley, wherein the multiple components connect to form a three-dimensional toy crane structure.

- 5 In accordance with a further aspect of the invention, there is provided an expandable construction toy component comprising: a first element having a connector and an elongate cavity extending into the first element; a second element having a connector and an elongate member extending from the second element, the elongate member being slidable within the elongate cavity, and a
10 securing means for securing the elongate member to the first element at any of a plurality of positions along the length of the elongate cavity.

Hence, the length of the expandable construction toy component can be adjusted by sliding the elongate member within the elongate cavity, thereby allowing
15 lengthwise expansion (extension) and contraction (shortening) of the component. When the desired length is achieved by sliding the elongate member, the securing means can be used to secure the elongate member to the first element in order to prevent further sliding motion of the elongate member. This locks the position of the first element relative to the second element and fixes the length of the
20 component.

The provision of an expandable component that is capable of being adjusted to a number of different lengths can reduce the need for a construction toy manufacturer to supply a number of different components having different
25 lengths; instead, the expandable component can be adjusted to whichever length

is required. Furthermore, the provision of an expandable component can allow users to create models more quickly and easily, by removing the need for a user to locate a specific component having a particular length required by the model or to construct a component of the required length by joining a number a shorter components; instead, the user can simply adjust the length of the expandable component to fit the model.

Preferably the securing means allows the elongate member to be releasably secured to the first element, such that the length of the expandable component can be repeatedly adjusted.

The connectors of the first and second elements are preferably suitable for engagement with connectors of compatible construction toy components. Hence, the expandable construction toy component can be used to link two compatible construction toy components by engaging the connectors of its first and second members with connectors of the compatible components. Preferably the first and second connectors are oriented along the direction of sliding of the elongate member. Connectors can also or alternatively be provided on the first and/or second elements that are perpendicular to the direction of sliding of the elongate member.

Preferably the securing means is arranged to secure the elongate member to the first element at a plurality of discrete positions along the length of the elongate cavity. By allowing the elongate member to be secured at a plurality of discrete positions, the expandable component can have any of a number of predetermined

lengths. This can allow a user to adjust the expandable component to a particular length with ease and precision.

Preferably at least some of the discrete positions are separated from each other by
5 a distance equal to the distance between the axes of two adjacent parallel
connectors of a compatible construction toy component. This ensures that the
connectors of the first and second elements of the expandable component line up
with corresponding connectors of a compatible component when the length of the
expandable component is changed. Preferably, at least some of the discrete
10 positions are separated from each other by a distance less than the distance
between two adjacent parallel connectors of a compatible construction toy
component. This allows the length of the expandable component to be adjusted
by small increments.

15 Preferably the connectors of the first and/or second elements are connectors as
described herein. In particular, any of the connectors can be a male connector, a
unidirectional female connector or a bi-directional female connector as described
herein.

20 Preferably the securing means is caused to secure and/or to release the elongate
member to the first element by twisting the elongate member relative to the first
element. Such a twisting action is simple to achieve.

Preferably the securing means comprises a plurality of slots formed in a wall of
25 the first element, and a protrusion formed on the elongate member of the second

element, wherein the protrusion is arranged to fit within a slot, thereby securing the elongate member to the first element. This arrangement is particularly advantageous since, provided that the protrusion is sufficiently short so as not to extend through the slots, the securing means is contained entirely within the first
5 element of the expandable component. Thus, the arrangement is compact, has a pleasant appearance and the expandable component can abut against other construction toy components without obstruction from the securing means. Preferably the protrusion is caused to engage with and/or to release from the slot by twisting the elongate member relative to the first element.

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It will be appreciated by those skilled in the art that the securing means might be implemented in many other ways. For example, an adjustable collar may be provided at the opening to the elongate cavity of the second element, whereby the collar can be tightened to grip the elongate member and prevent it from sliding in
15 the cavity, and wherein the collar can be released to allow the elongate member to slide freely.

Preferably the protrusions and slots comprise cooperable ridge and detent formations, whereby the protrusion can be secured within a slot by engagement of
20 a ridge with a detent. This helps to avoid accidental disengagement of the protrusion from the slot, and thereby helps to maintain the elongate member in a fixed position with respect to the first element.

A further aspect of the invention provides a construction toy assembly comprising
25 an expandable construction toy component as described herein and a hinge

comprising a first connector rotatably joined to a second connector, wherein a connector of the expandable component is connected to a connector of the hinge. By connecting the expandable construction toy component to a hinge, the end of the expandable component that is distal from the hinge has two degrees of freedom. That is, the distal end of the expandable component can rotate about the hinge and can also move in a radial direction by expanding and contracting (lengthening and shortening) the expandable component, thereby allowing the distal component to be positioned at many positions within a plane. Thus, the connector at the distal end of the expandable component can be connected to another connector located anywhere within the area swept by the expandable component's connector.

By joining a number of expandable rods to one another via a plurality of hinges, a wide variety of planar polygons can be made. The internal angles and the lengths of the polygons' sides can be adjusted by expanding and contracting the expandable rods, and by rotating the expandable rods about the hinges. For example, a wide range of planar triangles can be made with three expandable rods and three hinges, by joining each of the expandable rods with an interposing hinge.

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In accordance with a further aspect of the invention, there is provided a construction toy component comprising first and second female connectors oriented in opposite directions along a common axis, the first and second female connectors each comprising a neck-shaped region, wherein the two neck-shaped

regions are in communication with each other via a head-shaped region having a greater cross-section than the neck-shaped regions.

The provision of a common head-shaped region permits the two female
5 connectors to engage simultaneously with male connectors of compatible construction toy components, whilst still being capable of being manufactured by a two-plate molding process. The wider head-shaped region enables a female connector to engage securely with a male connectors having a narrow neck region and a wider head region, since the wider head region of the male connectors can
10 be locked in engagement by the narrower neck-shaped region of the female connector; thus, a relatively large force is required to separate the male and female connectors, thereby reducing the risk of the male and female connectors being unintentionally disengaged.

15 Preferably at least one of the neck-shaped regions is elastically expandable. More preferably, both of the neck-shaped regions are elastically expandable. Preferably at least one of the neck-shaped regions is elastically expandable in a direction substantially perpendicular to the axis of the female connector. Preferably the diameter of at least one of the neck-shaped regions is elastically expandable. By
20 providing an elastically expandable neck-shaped region, the female connector can securely engage and disengage with a compatible male connector in a convenient snap-fitting manner. Furthermore, the elastically expandable neck-shaped region also allows the component to be formed by a two-plate molding process, since these ability of this region to expand allows the component to be separated from
25 the plate that forms the head-shaped region. As will be appreciated by those

skilled in the art of molding, the component comprises an undercut because the wide head-shaped region is joined by two narrower neck-shaped regions, and such an undercut might prevent the component being separated from the plate (or plates) that form the undercut during the molding process. However, the provision of an elastically expandable neck-shaped region allows the component to be separated from the plate that forms the undercut.

Preferably the neck-shaped regions and head-shaped regions are defined by a wall, and wherein the wall includes one or more gaps. This arrangement allows the neck-shaped regions to be elastically expandable and can be formed by a simple two-plate molding process.

Preferably the component further comprises a base portion formed at an open end of one of the female connectors, and wherein the wall extends upwards from the base portion. Thus, the walls deflect about the base portion during elastic expansion. The wall therefore forms a pair of leaf springs. This arrangement is particularly simple to form by a two-plate molding process.

Preferably, the neck-shaped regions and head-shaped region are defined by at least two part-annular leaf spring elements connected at one end by a base portion, wherein insertion of a head of a male connector in either female connector causes the leaf spring elements to deflect to allow the male connector to engage in the head-shaped region. Preferably the component further comprises a body at least partly surrounding the leaf spring elements. Preferably, the component provides plug-and-click engagement of a head of a male connector in the head-shaped

region by resilient bending of a shoulder-shaped region at one end of one of the female connectors.

Preferably the construction toy component further comprises a third female
5 connector oriented perpendicular to the common axis of the first and second
female connectors. Thus, the component allows other components to be
connected directly to it in number of different directions, without the need for
separate interposing components dedicated to enabling connections. Preferably
the third female connector comprises an opening extending parallel to its axis to
10 allow a male connector of a compatible construction toy component to be engaged
with the third female connector. A third female connector of this type is simple to
form integrally with the first and second female connectors by means of a two-
plate molding process.

15 Preferably the component comprises one or more further bi-directional female
connectors (each preferably having an axis oriented parallel to the common axis
of the first and second female connectors) and/or one or more unidirectional
female connectors (each preferably being oriented perpendicular to the common
axis of the first and second female connectors) and/or one or more male
20 connectors (each preferably being oriented perpendicular to the common axis of
the first and second female connectors) and/or one or more expandable sections
and/or one or more u-joints and/or one or more axles such that, by
combining these features in an appropriate manner, any of the construction toy
components described herein can be provided. Such components can be made by
25 a simple two-plate molding process.

Preferably the first and second female connectors define a through hole in the construction toy component. The presence of a through hole is advantageous because it allows an axle to be passed through the construction toy component.

5 Thus, not only can the component engage simultaneously with two male connectors, but (when the male connectors are not connected) the component can be used to support an axle. This contrasts with many known construction toy systems which require a dedicated component to support an axle.

10 In accordance with a further aspect of the invention there is provided a construction toy component for connection to second and third construction toy components identical to said construction toy component, wherein the construction toy component comprises: a male connector; and first and second female connectors being oriented in opposite directions along a common axis and

15 being oriented perpendicular to said male connector, wherein the first and second female connectors are arranged to engage simultaneously with male connectors of the second and third construction toy components, and wherein engagement is achieved by moving a male connector of the second or third construction toy components towards the first or second female connector along the axis of that

20 female connector.

The provision of a component having both male and female connectors allows such components to be joined directly to one another, without the need for a separate component that is dedicated to connecting other components. Thus, the

25 number of components required to build a model can be reduced. Orienting the

male connector perpendicular to the female connectors allows the “end” of one component to be connected directly to the “side” of an identical component, thereby permitting components to be connected at 90 degrees to one another without the need for a separate component that is dedicated to connecting other components. The provision of a component having two female connectors oriented in opposite directions along a common axis wherein both are arranged to engage simultaneously with a respective male connector provides greater freedom in the models that can be built with the component; in particular, two further components can be attached to the component simultaneously by means of these female connectors, such that the further components radiate outwards from a single point on the component. A convenient way of connecting of components is achieved by forming the female and male connectors such they engage by being moved relative to one another along the axis of the female connector; in particular, this way of connecting components allows a first component to be connected to a second component, in a position between a third and fourth component that are already connected to the same surface of the second component, without requiring either of the third and fourth components to be removed. A further of this particular arrangement of male and female connectors is that it can easily be molded by the two-plate molding process described herein. Preferably the male and female connectors are integrally formed with the component.

Preferably the construction toy component further comprises a third female connector sharing a common axis with the male connector of the component and having an opposite orientation to the male connector. This allows an number of

such components to be joined directly to one another in an end-to-end manner. Thus, long distances can be spanned by joining a number of these components, without the need for a separate component that is dedicated to connecting these components. Preferably the component is elongated along the axis of the male connector (and, in preferred examples, along the common axis of the male
5 connector and third female connector).

Preferably the third female connector comprises an opening extending parallel to its axis to allow a male connector of the second or third construction toy
10 components to be engaged with the third female connector. Thus, the third female connector can be integrally formed with the first and second female connectors by a two-plate molding process. Preferably, engagement is achieved by moving the male connector of the identical component towards the third female connector and through the opening in a direction perpendicular to the axis of the third female
15 connector.

Preferably the construction toy component further comprises at least two further female connectors, wherein the at least two further female connectors are: oriented in opposite directions along a common axis; oriented perpendicular to
20 said male connector; and oriented parallel to the first and second female connectors, wherein the at least two further female connectors are arranged to engage simultaneously with the male connectors of the second and third construction toy components, and wherein engagement is achieved by moving a male connector of the second or third construction toy components towards either
25 of the at least two further female connectors along the axis of that female

connector. Thus, other components can be connected directly to any of a plurality of different points along the side of the component.

Preferably the female connectors are snap-fit connectors. The term “snap-fit
5 connector” is preferably understood to mean a connector having an engaging member that is operable to deflect to permit a mating member to be positioned in a mating position and then to resiliently deflect towards its original position in order engage with the mating member.

10 In accordance with a further aspect of the invention there is provided a female construction toy connector for engagement with a male construction toy connector, wherein the female construction toy connector is arranged to be elastically deformed by a twisting force applied thereto by the male construction toy connector, thereby allowing the male connector to rotate relative to the female
15 connector from a first orientation to a second orientation.

Thus, the male component can be reoriented *in situ* relative to the female component. Preferably the first and second orientations are stable, in the sense a particular threshold force is required to cause rotation of the male and female
20 connectors away from the first and second orientations. Thus, unintentional rotation of the male and female connectors can be avoided.

It will be appreciated that the precise means of engagement is not essential to this aspect of the invention. For example, the male and female connectors may engage

by means of an interference fit (such that the connectors are held together by friction), by means of a snap-fit, or by some other means.

Preferably the male and female connectors share a common axis when engaged
5 with one another. Preferably the male and female connectors are arranged to rotate relative to each other about this axis when the twisting force is applied. Preferably the female construction toy connector is arranged to remain in engagement with the male construction toy component during rotation. This can be achieve by providing a snap-fit engagement between the male and female
10 connectors.

Preferably the female construction toy connector comprises a deformable portion having an order of rotational symmetry of at least two. Preferably, the order of rotational symmetry of the deformable portion is finite. Preferably the female
15 construction toy connector comprises a deformable portion having a substantially polygonal internal cross-section. Only a relatively small region of the deformable need have an order of rotational symmetry of at least two (or need have a substantially polygonal cross-section) to achieve the same technical effect of allowing *in situ* rotation – for example, only part of the unidirectional female
20 connector described below has a geometrically-shaped cross-section (the remainder of the cross-section being open, to allow a male connector to be inserted). Preferably the polygonal internal cross-section has concave edges.

In accordance with a further aspect of the invention there is provided a male
25 construction toy connector for engagement with a female construction toy

connector, wherein the male construction toy connector is arranged to cause elastic deformation of the female construction toy connector by transmitting a twisting force thereto, thereby allowing the male connector to rotate relative to the female connector from a first orientation to a second orientation.

5

Preferably the male construction toy connector is arranged to remain in engagement with the female construction toy component during rotation.

Preferably the male construction toy connector comprises a portion arranged to cause deformation of the female construction toy connector, and wherein that

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portion has an order of rotational symmetry of at least two. Preferably, the order

of rotational symmetry of the portion that is arranged to cause deformation is

finite. Preferably the male construction toy connector comprises a portion

arranged to cause deformation of the female construction toy connector, and

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wherein that portion has a substantially polygonal external cross-section.

Preferably wherein the polygonal external cross-section has convex edges.

In accordance with a further aspect of the invention there is provided a construction toy set comprising: a first component having a female construction

toy connector as herein described; and a second component having a male

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construction toy connector as herein described, wherein the male construction toy

connector of the second component and female construction toy connector of the

first connector are mutually engageable.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification, illustrates several aspects of the present invention, and together with the detailed description in which substantially identical elements, components, or families are commonly numbered, serve to explain the principles of the invention.

In the drawings:

FIG. 1 shows a side view of an embodiment of a male snap-lock connector and female bi-directional snap-lock connector in accordance with the present invention.

FIG. 2 shows a side view of an embodiment of a female snap-lock connector with a spherical cavity in accordance with the present invention.

FIG. 3 shows a side view of an embodiment of two male snap-lock connectors and a female bi-directional snap-lock connector in accordance with the present invention.

FIG. 4A shows an overhead upper view of an embodiment of an elbow component in accordance with the present invention.

FIG. 4B shows an overhead rear view of the elbow component shown in FIG. 4A.

FIG. 4C shows an overhead rear view of an alternative embodiment of an elbow component in accordance with the present invention.

FIG. 4D shows an overhead upper view of the elbow component shown in FIG. 4C.

FIG. 5A shows an overhead upper view of an embodiment of a tee component in accordance with the present invention.

FIG. 5B shows an overhead rear view of an embodiment of a tee component in accordance with the present invention.

FIG. 6A shows an overhead upper view of an embodiment of a star component in accordance with the present invention.

5 FIG. 6B shows an overhead rear view of an embodiment of a star component in accordance with the present invention.

FIG. 7A shows an overhead inside view of an embodiment of a wheel component in accordance with the present invention.

FIG. 7B shows an overhead external view of an embodiment of a wheel
10 component in accordance with the present invention.

FIG. 8A shows a first side view of an embodiment of a base component in accordance with the present invention.

FIG. 8B shows a second side view of an embodiment of the base component shown in FIG 8A.

15 FIG. 8C shows a first perspective view of an alternative embodiment of a base component in accordance with the present invention.

FIG. 8D shows a second perspective view of the base component shown in FIG. 8C.

FIG. 9A shows an overhead rear view of an embodiment of a quad-base
20 component in accordance with the present invention.

FIG. 9B shows an overhead upper view of an embodiment of a quad-base component in accordance with the present invention.

FIG. 10A shows an overhead view of an embodiment of a pulley component in accordance with the present invention.

FIG. 10B shows a side view of an embodiment of a pulley component in accordance with the present invention.

FIG. 11A shows an overhead view of an embodiment of a dual pulley component in accordance with the present invention.

5 FIG. 11B shows a side view of an embodiment of a dual pulley component in accordance with the present invention.

FIG. 12A shows an overhead upper view of an embodiment of a triple pulley component in accordance with the present invention.

10 FIG. 12B shows an overhead inner view of an embodiment of a triple pulley component in accordance with the present invention.

FIG. 13A shows an overhead view of an embodiment of a roto-base component in accordance with the present invention.

FIG. 13B shows a side view of the roto-base component shown in FIG. 13A.

15 FIG. 13C shows an overhead view of an alternative embodiment of a roto-base component in accordance with the present invention.

FIG. 13D shows a side view of the roto-base component shown in FIG. 13C.

FIG. 14A shows a first side view of an embodiment of a motor-base component in accordance with the present invention.

20 FIG. 14B shows a second side view of an embodiment of a motor-base component in accordance with the present invention.

FIG. 15A shows an overhead upward view of an embodiment of a swing-rod component in accordance with the present invention.

FIG. 15B shows an overhead rear view of the swing-rod component shown in FIG. 15A.

FIG. 15C shows an overhead rear view of an alternative embodiment of a swing-rod component in accordance with the present invention.

FIG. 15D shows an overhead upward view of the swing-rod component shown in FIG. 15C.

5 FIG. 16A shows an overhead upward view of an embodiment of an angle-rod component in accordance with the present invention.

FIG. 16B shows an overhead rear view of the angle-rod component shown in FIG. 16A.

FIG. 16C shows an overhead upward view of an alternative embodiment of an
10 angle-rod component in accordance with the present invention.

FIG. 16D shows an overhead rear view of the angle-rod component shown in FIG. 16A.

FIG. 17A shows a side rear view of an embodiment of a large M-F rod component in accordance with the present invention.

15 FIG. 17B shows an overhead upward view of the large M-F rod component shown in FIG. 17A.

FIG. 17C shows a further side rear view of the large M-F rod component shown in FIG. 17A.

FIG. 17D shows a side front view of the large M-F rod component shown in FIG.
20 17A.

FIG. 17E shows a rear orthogonal projection view of the large M-F rod component shown in FIG. 17A.

FIG. 17F shows a front orthogonal projection view of the large M-F rod component shown in FIG. 17A.

FIG. 18A shows a first side view of an embodiment of an expandable M-M rod component in accordance with the present invention.

FIG. 18B shows a second side view of an embodiment of the expandable M-M rod component shown in FIG. 18A.

5 FIGS. 18C, 18D and 18E show side views of the section of the expandable M-M rod component denoted by reference numeral 294 in FIG 18A.

FIGS. 18F, 18G and 18H show side views of the section of the expandable M-M rod component denoted by reference numeral 292 in FIG 18A.

10 FIG. 18I shows a detail view of a protrusion at the end of the section of the expandable M-M rod component denoted by reference numeral 292 in FIG. 18A.

FIG. 18J shows a detail view of a protrusion at the end of the section of the expandable M-M rod component denoted by reference numeral 294 in FIG. 18A.

FIG. 19A shows an overhead upward view of an embodiment of a short M-F rod component in accordance with the present invention.

15 FIG. 19B shows an overhead rear view of an embodiment of a short M-F rod component in accordance with the present invention.

FIG. 20A shows an overhead upward view of an embodiment of a short M-M rod component in accordance with the present invention.

20 FIG. 20B shows an overhead rear view of an embodiment of a short M-M rod component in accordance with the present invention.

FIG. 21A shows an exploded view of a universal joint assembly in accordance with the present invention.

FIGS. 21B to 21F show the universal assembly of FIG 21A with the hinge portion rotated to various angles.

FIG. 22A to 22F show a hinge assembly in accordance with the present invention, in which the hinge is rotated to various angles.

FIG. 23A shows a front perspective view of a male four-way connector in accordance with the present invention. FIG. 23B shows a rear perspective view of
5 the male four-way connector shown in FIG. 23A.

FIG. 23C shows a front orthogonal projection view of the male four-way connector shown in FIG. 23A.

FIG. 23C shows a rear orthogonal projection view of the male four-way connector shown in FIG. 23A.

10 FIG. 24A shows a two-plate mold for molding a female bi-directional snap-lock connector.

FIG. 24B shows the two-plate mold of FIG. 24A when open and with an attached molded female bi-directional snap-lock connector.

FIG. 25A shows a front perspective view of an example of a female unidirectional
15 connector.

FIGS. 25B, 25C and 25D show front, end and rear orthogonal projection views respectively of the female unidirectional connector shown in FIG. 25A.

FIG. 26 shows a composite of parts and assembly steps generating a toy construction vehicle in accordance with the present invention.

20 FIG. 27 shows a composite of parts and assembly steps generating a toy tricycle in accordance with the present invention.

FIG. 28 shows a composite of parts and assembly steps generating a toy crane in accordance with the present invention.

FIG. 29 shows a composite of parts and assembly steps generating a toy all-terrain
25 vehicle in accordance with the present invention.

FIG. 30 shows a set of construction toys generated with construction components in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

5 Referring to FIG. 1, an embodiment of male snap-lock connector 10 and female bi-directional snap-lock connector 12 is shown in accordance with the present invention. Connectors 10, 12 are implemented as a part or portion of construction components. Connectors 10, 12 enable detachable snap-lock connection of various components some of which are described more fully hereinafter as
10 components of a construction toy in accordance with the present invention.

Male snap-lock connector 10 is formed with a rigid plastic and shaped with head 14, neck 16, and shoulder 18. In one embodiment head 14, neck 16, and shoulder 18 are circular-shaped around a central axis extending longitudinally. In the
15 embodiment shown in FIG. 1, head 14 extends from neck 16 and has a widened central diameter region 20 and narrowed tip 22. In another embodiment (as seen in FIG. 3), head 14 has a mushroom shaped tip 22. In yet another embodiment (as may be deduced from FIG. 2), head 14 has a spherical shape. In the embodiment shown in FIG. 1, neck 16 has a conical shape with narrow region 24 joining with
20 the base of head 14 and a wider region 26 joining with shoulder 18. In another embodiment as shown in FIG. 2, neck 16 narrows where it joins with head 14 and has a cylindrical shape. In the embodiment shown in FIG. 1, shoulder 18 is cylindrically shaped with a smooth circular circumference. In another embodiment (as may be deduced from FIG. 4A and 4B) shoulder 18 is
25 octagonally shaped around its perimeter.

Female bi-directional snap-lock connector 12 is formed with a rigid plastic wall that is generally cylindrically shaped with a hollow interior and extends upward from base 27. The interior of wall 28 is sized and proportioned to receive male snap-lock connector 10 when male connector 10 is inserted in the direction shown by the arrow and seated as shown with the dashed lined image of male connector 10. The interior of wall 28 includes head shaped region 30, neck shaped region 32, and shoulder shaped region 34. In one embodiment, shoulder shaped region 34 forms a octagonally shaped wall. Wall 28 includes one or more gaps (or regions of separation) 13 extending longitudinally from upper region 36 (as shown in FIG. 4A and 4B). In one embodiment, the gap extends near to base 27; and in another embodiment, the gap extends through base 27. The gap or gaps enable the interior of wall 28 to elastically expand (or deflect) as the head of male connector 10 is pushed through neck shaped region 32 and to substantially return to its original state once the head 14 of male connector 10 is lodged within the head shaped region 30 of female connector 12. Thus, the male connector 10 and female connector 12 cooperate to provide a snap-fit connection between components. Since the head 14 of the male connector 10 is wider than the narrowest point of the neck shaped region 32 of the female connector 12, the connection is able to bear large axial loads (i.e. forces directed along the axis of the male connector 10). Thus, the connection is more robust than a connection that relies upon friction alone. Furthermore, the head 14 and shoulder 18 are supported around the majority of their circumferences by the corresponding regions 30, 34 of the female connector, thereby allowing the connection to bear large off-axis loads (i.e. loads directed at angle to the axis of the male connector,

which will tend to cause the male connector to twist relative to the female connector).

As the head 14 slips into the head shaped region 30, the shoulder 18 mates with
5 the interior portion of wall 28 forming the shoulder shaped region 34. In the event
that shoulder 18 has a octagonal shape, then male connector 10 is locked into a
particular orientation with respect to female connector 12. The orientation of the
mated connectors may be adjusted by axially twisting with a small amount of
pressure to cause the faces of the octagonal shoulder 18 to shift with respect to the
10 octagonal faces of the shoulder shaped region of wall 28.

This allows *in situ* adjustment of the orientation of a component comprising the
male connector 10, since this twisting action avoids the need for the male
connector 10 to be disconnected from the female connector 12 before
15 reorientation can occur. To put this another way, the presence of geometrically-
shaped regions on corresponding regions of the interior portions of the wall 28
and on the male connector 10 (and, more particularly, on the shoulder-shaped
region and shoulder thereof), allows components to be reoriented with respect to
one another by a convenient turn-and-click action. Thus, components can have
20 multiple discrete stable rotational positions with respect to one another.

The *in situ* reorientation of the components is made possible by the ability of the
female connector to elastically expand. As the male connector 10 is twisted
relative to the female connector, the faces of the male connector's octagonal
25 shoulder 18 move out of parallel alignment with the faces of the female

connector's octagonal shoulder-shaped region 34. This causes the vertices of the male connector's octagonal shoulder 18 to bias against the faces of the female connector's octagonal shoulder-shaped region 34. This biasing force causes the wall 28 of the female connector to expand (or deflect) into the gap 13, which
5 allows the male connector to turn within the female connector. When the male connector 10 has turned to such a degree that its faces are once again in parallel alignment with those of the female connector 12, resilient forces in the wall cause the wall to return to its original position (i.e. the wall contracts, or deflects away from the gap). Thus, the male connector is maintained at a particular orientation
10 by the wall, and will not rotate further unless a twisting force that is sufficiently large to cause the female connector to elastically expand (in the manner previously described) is applied. It will be appreciated that *in situ* orientation might also be achieved with an rigid female connector and an elastically deformable male connector, whereby the male connector is arranged to be
15 compressed slightly by an applied twisting force, thereby allowing the male connector to be reoriented relative to the female connector.

In the event that shoulder 18 is circular, then male connector 10 can spin freely around its axis within female connector 12.

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It may further be appreciated that female connector 12 is bi-directional in that male connector 10 may be inserted from either the direction of base 27 or upper region 36. It may also be appreciated that in the event that head region 30 is oversized to provide for two heads 20, then two male connectors 10 may mate
25 simultaneously with female 12. This is particularly advantageous, since it allows

two male connectors to be joined simultaneously to opposite sides of the same component, such that the two male connectors share a common axis.

It may also be appreciated that while symmetrical octagonally shaped female
5 shoulder cavities and corresponding male shoulder regions have been shown and
described herein, other geometric shapes may be implemented including three,
four, five, and n-sided shapes which may be symmetrical or asymmetrical, 'n'
being an integer value ('n' is preferably greater than or equal to three). The terms
"geometric shape" and "geometrically shaped" used herein are preferably
10 understood to mean that the relevant portions of the connectors (for example, the
male shoulder region and female connectors) have an external cross-section that is
shaped substantially as a polygon (that is, a geometric figure having at least three
substantially straight edges). As can be seen from FIGS 4A and 4B, the
geometrically-shaped portions need not to have perfectly straight edges, but can
15 instead by slightly curved (so as to be concave or convex); the provision of
curved edges allows the orientation of the male and female connectors to be
adjusted *in situ* more easily. More preferably, the terms "geometric shape" and
"geometrically shaped" are understood to mean that the relevant portions of the
connectors have an external cross-section that is shaped substantially as a regular
20 polygon (that is, a geometric figure having at least substantially three straight
edges, and wherein all edges are equal in length); such shapes have an order of
rotational symmetry that is equal to the number of sides of the polygon, such that
the number of orientations of the connector is also equal to the number of sides of
the polygon. By allowing a number of different orientations, great freedom is
25 provided to design models with the construction toy – unlike previous

construction toys, models need not have all of their components oriented on mutually orthogonal axes. Alternatively, the relevant portions of the connectors have an external cross-section that is shaped substantially as an irregular polygon. For example, the shoulder regions may have a rectangular cross-section, such that only two orientations of the connector are possible. It may be further appreciated that while substantially sharp edges have been described herein, shapes with rounded edges are conceivable, such as, by example, a shamrock (four-sided) or cloverleaf (three-sided) shape. It will also be appreciated that the neck and/or head portions of the male and female connectors can be geometrically-shaped to allow components to be joined at particular orientations and reoriented *in situ* (and, in such cases, the shoulder portions could have a circular cross-section); however, it is preferable for the shoulder portion – as opposed to the head or neck portion – to be geometrically shaped since this enables components to be fitted together most easily.

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As a further feature of the invention, it may be noted that the male and female components connect axially (i.e. by moving the male connector relative to the female connector along the lengthwise axes of the two connectors). This connection provides both axial and lateral support when the head lodges into position in the female head cavity and the neck cavity elastically contracts to surround the neck of the male.

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Additionally, in the manufacturing process, plastic may be efficiently injected to produce male and female components. The components can be manufactured with simple 2-plate injection molds without the need for side core pulling. The

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injection molds can simultaneously produce multiple female connectors and associated components without the constraints imposed by the side-core pulling mechanisms. A side core is used to mold objects having cavities extending perpendicularly to the cavities that could be produced by two plate molding alone;

5 a third core (or "side core") produces the perpendicular cavities and "side core pulling" describes the requirement to move the side core perpendicular to the direction of motion of the moving plate of a two-plate mold in order to eject the object from the mold. The need for the side core to move perpendicularly prevents large arrays of components being molded simultaneously, and therefore

10 reduces the number of components that can be formed at any given time. The male and female connectors described herein can advantageously be manufactured without the use of side core pulling (thereby allowing a larger number of components to be molded simultaneously) because the cavities of the components extend in only two (parallel) directions.

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Continuing to refer to FIG. 1, it may be appreciated that in the manufacturing process, a moving plate may be applied axially from the top and surrounding the volume to be filled by the female connector and the associated component, and, a base plate (ejector plate) may extend up from the base to fill the cavity of the

20 lower shoulder, lower neck and head of the female connector. The moving plate inserts into the cavity to be formed between the upward reaching base portion of the component and the female external surface and also inserts into the shoulder and neck cavity of the female connector to be formed. The plastic may be injected into the volume including the female connector and associated

25 component. When the injection molds opens, the moving plate is no longer

pressing on the inner and outer surfaces of the component, allowing the supporting circular wings of the female cavity to deflect while the part is ejected from the plate.

5 FIG. 24A shows a two-plate mold for forming a female bi-directional snap-lock connector by an injection molding. The two plate mold comprises a moving plate 2600 and a base plate 2602 that together define a cavity 2612 having the same shape as a female bi-directional connector 12. The cavity 2612 has a head shaped region 2609 and an upper neck shaped region 2605, which correspond to the head
10 shaped region 30 and upper neck shaped region of the female bi-directional connector 12 shown in FIG. 1. The parting line 2604 (i.e. the point at which the moving plate 2600 abuts the base plate 2602) does not coincide with the horizontal axis 2608 of the head shaped region 2609, but is instead located at the interface of the upper neck shaped region 2605 and the head shaped region 2609.
15 The lower half of the head shaped region 2609 comprises an undercut i.e. an outwardly-diverging region that will tend to hinder separation of the molded connector from the base plate 2602. The moving plate 2600 has an annular portion 2610 that is concentric with the cavity 2612, and which extends towards the base plate 2602. The annular portion 2610 defines a gap (indicated by
20 reference numeral 13 in FIG. 24B) that surrounds that walls 28 of the female bi-directional connector 12. As can be seen clearly in FIGS. 4A, 4B, 17E and 17F, the gap defined by the annular portion 2610 also extends radially so as to divide the walls into two portions each having a substantially semi-circular cross-section. Plastic is injected into the cavity 2612 to form a female bi-directional connector
25 12.

FIG. 24B shows the two-plate mold of FIG. 24A after plastic has been injected into the cavity 2612 to form a connector 12, and after the moving plate 2600 has been separated from the base plate 2602. The upper part of the connector 12 has a draft angle (i.e. the cavities in the upper part of the connector taper outwards in the direction of motion of the moving plate 2600), which enables the moving plate 2600 to be separated easily from the molded connector 12. After the moving plate 2600 has been separated from the base plate 2602, the molded connector is retained on the base plate 2602.

Those skilled in the art will appreciate that it is undesirable for molded components to comprise undercuts, since undercuts can make it difficult (if not impossible) to separate the molded component from the molding plate. However, the design of the bi-directional female connector 12 allows it to be easily separated from the base plate 2602, despite the present of an undercut in the head shaped region 2609. Easy separation is achieved by virtue of the annular gap 13, which permits the walls 28 of the connector 12 to deflect into the gap, thereby allowing the walls 28 to deflect away from the undercut head shaped region 2609 of the base plate 2606. Ejector pins (not shown) are provided in the base plate 2602 to force the connector 12 away from the base plate. The force applied by the ejector pins causes the walls 28 to deflect into the annular gap 13, such that the walls 28 are sufficiently distant from the head shaped region 2609 of the base plate 2602 to allow the connector 12 to be ejected from the base plate 12. Thus, the same structural features (and, in particular, a resilient wall 28 that can deflect into an annular gap 28) that allow snap-fitting of male connectors 10 to the bi-

directional female connector 12 advantageously also allow easy ejection of the connector from the base plate 2602.

It will be appreciated that this molding process can be used to form the any of the female bi-directional components described herein.

The components are preferably formed from Acrylonitrile Butadiene Styrene (ABS). However, it will be appreciated that the components may alternatively be formed from other suitable polymers. Suitable polymers should be sufficiently resilient and durable to allow repeated snap-fitting of components.

Referring to FIG. 2, a second embodiment of female snap-lock connector 42 is shown fixed to and connected to base 43 in accordance with the present invention. Female connector 42 extends upward from base 43 and is tubular shaped with a substantially spherical top portion. The interior of female connector 42 is hollow and the interior wall includes a spherically shaped head region 44, cylindrically shaped neck region 46, and sloping shoulder region 48. The interior wall of female connector 42 is shaped and proportioned to accommodate a male connector with a ball-shaped head. Gap 50 is shown separating opposing sides of the wall forming female connector 42. Gap 50 extends longitudinally towards base 43 sufficiently to enable the opposing walls of female connector 42 to elastically separate as the head of a male connector is pressed through neck region 46 and to spring back into position as the head of the male connector slips into head region 44 of female connector 42.

Referring to FIG. 3, female snap-lock connector 12 is shown with two alternative embodiment male snap-lock connectors 54, 56. Male snap-lock connectors 54, 56 have similar necks and shoulders as male connector 10. Heads 58, 60 of male connectors 54, 56 are mushroom-shaped and sized with an axial length of approximately $\frac{1}{2}$ of head 14 of male connector 10 permitting both heads 58, 60 to share the cavity of head region 30 of female connector 12.

Referring to FIG. 4A, elbow component 70 is shown with four bi-directional female connectors 12 extending upward from base 27 in accordance with the present invention. (For frame of reference, the view shown in FIG. 4A is referred to as the upper view). Elbow component 70 has corner 72 joining arms 74, 76 which are fixed at a ninety degree angle with respect to each other. Elbow component 70 also includes a forty-five degree arm 78 which is spaced forty-five degrees from arms 74, 76 and on the x-y plane formed by arms 74, 76. A single female connector 12 extends upward from corner 72, arms 74, 76, and forty-five degree arm 78 such that male connectors (such as male connectors 54 shown in FIG. 3) may be mated with the upper end of female connectors 12 at a ninety-degree angle with respect to the x-y plane. Also, as may be seen by referring to FIG. 4B (for frame of reference referred to as the rearward view), male connectors (such as male connectors 56 shown in FIG. 3) may be simultaneously connected with the rearward end of female connectors 12.

Elbow component 70 includes two uni-directional female connectors 80 which respectively extend outward along arms 74, 76 in the x-y plane, such that male

connectors (e.g. male connector 10, 54, or 56) may be snapped into position along the x-y plane.

Referring to FIG. 4A, 4B, uni-directional female connector 80 includes head 86,
5 neck 88, and shoulder 90. Female connector 80 has a gap 92 that extends longitudinally along the upward facing wall. Female connector 80 has an open surface joining with base 27. Head 86 and neck 88 of female connector 80 has inner walls that extend sufficiently (greater than 180 degrees) around the circumference of female connector 80 to permit a male connector to be pressed
10 either longitudinally into or axially onto female connector 80 and to snap back into place once the male connector slips into the head, neck, and shoulder cavities of female connector 80. Additionally, the interior perimeter of shoulder 90 of female connector 80 is octagonally shaped to lock a male connector with a octagonally shaped exterior perimeter of its shoulder into a particular orientation
15 with respect to the female connector. The orientation of the male connector can be changed by applying pressure axially to shift the orientation of the male shoulder with respect to the female shoulder.

The unidirectional female connector 80 shown in FIG. 4 is a particular example of
20 the female connector 42 shown in FIG. 2. Detailed views of the unidirectional female connector 80 are shown in FIGS. 25A and 25B. A feature of the unidirectional connector 80 is that it has openings on two sides of the component in which it is formed, i.e. a first opening substantially in the vicinity of that shoulder 90 that is perpendicular to the axis of the connector 80, and a second
25 opening extending along the entire length of the connector that is parallel to the

axis of the connector 80. The provision of an opening that extends along the length of the connector allows the unidirectional female connector 80 to be aligned perpendicular to a bi-directional female connector 12 in a two-plate molding process (as explained in more detail below).

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The provision of an opening that extends along the length of the unidirectional female connector 80 also allows a male connector 12 to be connected by pushing the male connector 12 in a direction substantially parallel to the axis of the female connector 80. The neck region of the female connector 80 deflects under the force applied by the male connector 12 in a similar to that previously described in connection with the bi-directional female connector 12 (the main difference being that the neck, rather than the head, of the male connector urges against the walls of the female connector to cause deflection of the female connector's neck region), thereby enabling the neck of the male connector to fit within the neck shaped region of the female connector. The unidirectional connector 80 is capable of receiving and securing a mushroom-shaped male connector 54, 56 of the type shown in FIG. 3.

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The unidirectional female connector 80 provides many of the advantages of the bi-directional female connector 20. In particular, the unidirectional female connector 80 allows robust snap-fit connections to be made (by virtue of its narrow elastically expandable neck region and wide head shaped region), can be shaped so as to be compatible with the same male connectors 10 that are used to connect to the bi-directional female connector 20, and the provision of a

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geometrically-shaped shoulder region allows components to be secured by the connector 80 at a number of different orientations.

A further advantage of the unidirectional connector 80 is that it is formed as a
5 downwardly-extending depression (due to the presence of an opening extending along the length of the connector), rather than as an enclosed tubular cavity. Thus, a unidirectional connector 80 can be integrally formed in the same component as a bi-directional connector 20, such that the unidirectional connector 80 and bi-directional connector 20 are at an angle to one another, using a two-
10 plate molding process (i.e. without the need to use a side core). The surface of the unidirectional connector 80 that receives a male connector can be formed by the base plate of a two-plate mold, and the opposite surface can be formed by the moving plate; and the same base plate can also be used simultaneously to form the lower part of a bi-directional connector as shown in FIGS. 24A and 24B whilst
15 the moving plate forms the upper part of the bi-directional component.

By combining bi-directional female connectors 12 and unidirectional female connectors 80, a connector can be provided that allows connections to be made simultaneously in both the positive and negative directions of all three axes of a
20 Cartesian coordinate system (as illustrated by the star component 110 of FIG. 6A). Advantageously, such a component can be formed entirely by two-plate injection molding.

Elbow component 70 includes female U-joint connector 84 extending outward
25 from forty-five degree arm 78. The arms of female U-joint connector 84 are open

sufficiently (less than one eighty degrees) to permit a shaft connector to be pressed between the open arms and oriented to snap back into place to grasp a shaft connector at a ninety degree angle with respect to the x-y plane. By mating with U-joint connector 84, a construction component (such as the swing-rod component 240 of FIG. 15A) with a mating male shaft connector can be attached to elbow connector 70 and rotate in the x-y plane. It may be appreciated that the U-joint connector 84 may alternatively be replaced by a male shaft connector or that the orientation of the connector with respect to the x-y plane may be disposed at a different angle (such as at a zero degree angle with respect to the x-y plane). Also, it may be appreciated that various combinations of female or male connectors may be implemented at the ends of the respective arms of elbow component 70 and that the representation shown in FIG. 4A & 4B is simply one example.

FIGS. 4C and 4D show a further example of an elbow component, in which the U-joint connector 84 and the bi-directional connector 12 nearest to the U-joint connector shown in FIGS 4A and 4B are replaced by a unidirectional connector 80.

Referring to FIG. 5A, an upper view of tee component 100 is shown comprising two arms 102, 104 joined together in a tee in accordance with the present invention and describing an x-y plane. Arm 102 extends along the x-axis and includes three bi-directional female connectors 12 extending upward from base 27 and two uni-directional female connectors 80 extending from the ends of arm 102 along the x-axis. Arm 104 extends along the y-axis and includes one bi-

directional female connector 12 extending upward from base 27 and one uni-directional female connector 80 extending from the end of arm 104 along the y-axis. Male connectors are insertable into female connectors 12 perpendicular to the x-y plane (z-axis); and, in the event that the shoulders of the male connectors are octagonally-shaped so they can mate with octagonally-shaped female shoulders 36, then the respective male connectors can be locked into a selected orientation with respect to the respective female connectors.

Tee component 100 also includes two forty-five degree arms 106 which are spaced forty-five degrees from arm 104 and on the x-y plane formed by arms 102, 104. Arms 102, 104, 106 include uni-directional female connectors 80 which respectively extend outward along each arm and in the x-y plane, such that male connectors (e.g. male connector 10, 54, or 56) may be snapped into position along the direction of the respective arm and in the x-y plane.

Referring to FIG. 5B, a rear view of an embodiment of tee component 100 shows octagonally-shaped shoulders 34 of female components 12 connected to base 27 and the open portion of uni-directional female connectors 80 in accordance with the present invention. With respect to the base end of female components 12, male components are insertable simultaneously with or independently of male components inserted from the upper face.

It may further be appreciated that various combinations and types of female or male connectors may be implemented at the ends of the respective arms of tee component 100 and that the representation shown in FIG. 5A & 5B is simply one

example. Also, fewer bi-directional female connectors 12 may be incorporated in alternative embodiments.

Referring to FIG. 6A, an upper view of star component 110 is shown comprising
5 arm 102 and two arms 104 joined together in a cross in accordance with the present invention and describing an x-y plane. Star component 110 also includes four forty-five degree arms 106 which are spaced forty-five degrees from arms 102, 104 and on the x-y plane formed by arms 102, 104. Arms 102, 104, 106 include uni-directional female connectors 80 which respectively extend outward
10 along each arm and in the x-y plane, such that male connectors (e.g. male connector 10, 54, or 56) may be snapped into position along the direction of the respective arm and in the x-y plane.

Referring to FIG. 6B, a rear view of an embodiment of star component 110 shows
15 octagonally-shaped shoulders 34 of female components 12 connected to base 27 and the open portion of uni-directional female connectors 80 in accordance with the present invention.

It may further be appreciated that various combinations and types of female or
20 male connectors may be implemented at the ends of the respective arms of star component 110 and that the representation shown in FIG. 6A & 6B is simply one example. Also, fewer bi-directional female connectors 12 may be incorporated in alternative embodiments.

Referring to FIG. 7A, the inner surface of wheel component 120 is shown with exposed base 27 centered at the axle and bi-directional female connector 12 extending axially from base 27 towards the external surface of wheel component 120 in accordance with the present invention. Shoulder 34 of female connector 12 is octagonally shaped for mating with a male connector (e.g. male connector 10, 54, or 56) with a rounded or octagonally shaped shoulder depending on whether wheel component 120 is to be freely turning or in fixed orientation with the male connector.

10 The combination of both unidirectional female connectors 80 and bi-directional female connectors on the elbow component 70, tee component 100 and star component 110 is particularly advantageous. The unidirectional female connectors 80 can be used to connect components within the plane of the elbow/tee/star component (the plane labelled as x-y in FIGS. 4 to 7). The bi-
15 directional female connectors 12 can be used to connect components perpendicularly to the plane of the elbow/tee/star component. The bi-directional female connectors are particular advantageously for such out-of-plane connections since, when connected, the male connector is entirely contained within the female connector and does not protrude from the elbow/tee/star component; hence, it is
20 possible for the elbow/tee/star component (and a model comprising such a component) to lie flat on a surface. Furthermore, the presence of bi-directional female connectors also allows connections to be made both above and below the plane of the elbow/tee/star component simultaneously and without the need to add any additional components dedicated to enabling out-of-plane connections. For
25 example, if the star component 100 is considered to lie within the x-y plane of a

Cartesian coordinate system, connections can be made simultaneously along the positive and negative x-axis using the unidirectional female connectors 80 of arms 102, along the positive and negative y-axis using the unidirectional female connectors 80 of arms 104, and along the positive and negative z-axis using the
5 bi-directional female connectors 12; connections can be made simultaneously in six mutually orthogonal directions.

Referring to FIG. 7B, the external surface of wheel component 120 is shown with female connector 12 extending axially from base 27 in accordance with the
10 present invention. Female shoulder 36 is octagonally-shaped for mating and fixing the orientation of a male connector with a octagonally-shaped shoulder mounted onto female connector 12 through the upper portion.

It may be further appreciated that various alternate connectors may be
15 implemented as a connector for wheel component 120, such as implementing a uni-directional female or male connector in place of bi-directional female connector 12 or combinations thereof.

Referring to FIG. 8A and 8B, base component 130 is shown with male connector
20 10 extending axially from a first side of base 27 and female U-joint connector 84 extending axially from an opposite side of base 27 in accordance with the present invention. The base component 130 can be used to create a hinge assembly and a universal joint assembly, as described below. FIGS. 8C and 8D show a further example of a base component, in which ridged protrusions are provided adjacent

the U-joint connector to allow the base component to be more easily gripped when it is connected to (and disconnected from) other components.

Referring to FIG. 9A, a rear view of quad-base component 140 is shown with female connector 12 extending axially from base 27 and four female U-joint connectors 142 extending outward from the center axis in accordance with the present invention. Female shoulder 36 is octagonally-shaped for mating and fixing the orientation of a male connector mounted onto female connector 12 through the upper portion and having a octagonally-shaped shoulder. The U-portion of U-joint connectors 142 include an inner surface 144 that extends circumferentially greater than 180 degrees in order to grasp an inserted axle or other mate-able connector. The quad-base component 140 can be used to create a hinge assembly and a universal joint assembly, as described below.

Referring to FIG. 9B, an upper view of quad-base component 140 is shown with female connector 12 extending axially from base 27 in accordance with the present invention. Female shoulder 36 is octagonally-shaped for mating and fixing the orientation of a male connector with a octagonally-shaped shoulder mounted onto female connector 12 through the upper portion in accordance with the present invention.

It may be further appreciated that various alternate connectors may be implemented with quad-base component 140 or that the U-joint connectors may be oriented with different angular relations to the axis of female connector 12.

Referring to FIG. 10A and 10B, a pulley component 150 is shown including male connectors 152, 154 connected axially and perpendicular to the plane described by base 156 in accordance with the present invention. Octagonally shaped shoulder 158 of male connector 154 may be mated with a octagonal shaped shoulder of a female connector to lock a particular orientation between mated connectors. Smooth circular shaped shoulder 160 of male connector 152 permits male connector 152 to be mated with a female connector and freely rotate with respect to the female connector while pulley component 150 is supported by components with corresponding female connectors. Base 156 has a concave surface 162 along its circular perimeter for retaining a line (or cable, chain, thread, cord, belt, rubber band or similar article) for operation with pulley component 150.

Referring to FIG. 11A and 11B, dual pulley component 170 is shown with two parallel concave shaped perimeter surfaces 172, 174 for retaining respective lines (as described by example above) and a hollow center described a smooth interior surface 176 in accordance with the present invention. Smooth interior surface 176 enables dual pulley component 170 to be mounted and supported for free rotation in accordance with the demands of attached lines.

Referring to FIG. 12A and 12B, triple pulley component 180 is shown with three axially centered pulleys 182, 184, 186 having successively increasing diameters in accordance with the present invention. Pulleys 182, 184, 186, respectively include concave shaped perimeter surfaces 188, 190, 192 for retaining respective lines (as described by example above). Triple pulley component 180 includes a smooth interior surface 194 with two parallel struts 196 connected to the inner

surface such that triple pulley component 180 can be mounted in fixed relation onto another component that is sized and proportioned to abut the surfaces of the rods. Smooth interior surface 194 has a depth that extends from the top surface 198 of pulley 182 to the bottom surface 200 of pulley 186 such that axial support is provided to each pulley. It may be appreciated that the combination of interior surface 194 and struts 196 provide a slot opening such that triple pulley component can be adjustably connected with another component upon which triple pulley component is mounted.

Referring to FIG. 13A and 13B, roto-base component 210 is shown with a central interior surface 212 describing a circular opening and two male connectors 214, 216 extending on a common axis from oppositely disposed portions of external surface 218 in accordance with the present invention. Octagonally shaped shoulders of male connectors 214, 216 enable respective female components to mate in a fixed orientation. Central interior surface 212 enables roto-base component 210 to freely rotate when mounted and includes a sufficient width to form a ring and provide axial and transverse axis support (e.g. circular opening is sized $\frac{3}{4}$ " and interior surface width is $\frac{1}{4}$ "). FIGS. 13C and 13D shown an alternative example of a roto-base component, which comprises only one male connector.

A preferred example of the roto-base component 210 has a circular opening sufficiently large to allow a rod component (such as the large M-F rod component 280 illustrated in FIG. 17A or the expandable M-M rod component 290 illustrated in FIG. 18A) to be inserted lengthwise along the axis of the circular opening. The

diameter of the circular opening should be slightly larger than the cross-section of the rod component, such that the rod component can rotate freely about the axis of the circular opening. Thus, the roto-base component 210 can act as a shaft support to allow rod components having a square cross-section to act as rotatable shafts.

For example, a rod component can be inserted through two roto-base components 210 to allow rotation of the rod component along the common axis of the circular openings, whilst avoiding rotation perpendicular to the common axis; in such an example, a wheel component 120 (see FIG. 7A) can be attached to each end of the rod to allow the rod to act as an axle. In another example, one end of the rod component may be rotatably connected to another component by means of a pulley component 150 (see FIG. 10A), and a roto-base component 210 can support the rod at a point distal from the pulley component 150, thereby preventing the rod from rotating perpendicular to the axis of the pulley component 150.

Referring to FIG. 14A and 14B, motor-base component 220 is shown with male connector 222 connected to base 224 of clip 226 in accordance with the present invention. Clip 226 includes semi-circular surfaces 228, 230 for cradling and gripping another component such as a motor or transmission. Semi-circular surfaces by example may be sized to surround an object of 1" diameter and have a depth of ½" to provide axial and lateral support to a mounted object. Semi-circular surfaces 228, 230 include ends 232, 234 which may elastically be widened to enable insertion of the object to be mounted.

Referring to FIG. 15A and 15B, swing-rod component 240 is shown including two bi-directional female components 12 extending upward from base 27, uni-directional female connector 80 extending from one end, and axle connector 242
5 extending from the other end in accordance with the present invention. The swing-rod component can be used to create a hinge assembly and a universal joint assembly, as described below. FIGS 15C and 15D show an alternative example of a swing-rod component that does not comprise any bi-directional female connectors.

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Referring to FIG. 16A and 16B, angle-rod component 260 is shown including rod portion 262 with two bi-directional female components 12 extending upward from base 27 and uni-directional female connector 80 extending open at end 264 and including angled rod portion 266 disposed at an angle with respect to the axis of
15 rod portion 262 in accordance with the present invention. Male connector 268 extends from end 270. By example, a selected angle may be 30, 45, 60 degrees. Thus, the angle-rod component 260 can be interposed between two components to allow the components to be rigidly joined to each other at an angle that could not be achieved by connecting the components directly to each other. FIGS 16C and
20 16D show an alternative example of an angle rod component that does not comprise any bi-directional female connectors.

Referring to FIGS. 17A to 17F, large M-F rod component 280 is shown with
25 multiple bi-directional female connectors extending upward from base 27 and

male connector 282 and uni-directional female connector 12 extending from respective ends in accordance with the present invention. The M-F rod component 280 is of particular importance to the construction toy described herein. The elongated shape of the rod component 280 allows it to span large distances and thereby form the chassis of various models. The presence of male 282 and female 80 connectors on opposing surfaces of the long axis of the rod component allows a number of rod components to be joined directly to one another in an end-to-end manner without the need for any separate interposing connectors. Furthermore, the presence of bi-directional female connectors 12 disposed perpendicularly to the male connector 282 and unidirectional female connector 80 allows components to be joined directly to both sides of the rod component, again without the need for any separate interposing connectors.

Referring to FIG. 18A and 18B, expandable M-M rod component 290 is shown with multiple representations of adjustable rod sections 292, 294 demonstrating the connection states of the respective sections in accordance with the present invention. Rod section 292 is shown individually in FIGS. 18F to 18H, and rod section 294 is shown individually in FIGS. 18C to 18E. Rod section 292 includes open end 296, slotted section 298, and end section 300. Slotted section 298 is shaped rectagonally and includes two series of slots 299 and centrally disposed ridges 301 extending in parallel relation on opposite sides. End section 300 includes bi-directional female connector 12 extending upward from base 27 and male connector 302 extending axially. Rod section 294 includes insertable expansion section 304 and end section 306. End section 306 includes two bi-directional female connectors 12 extending upward from base 27 and male connector 308 extending axially. Expansion section 304 includes a parallelogram-

like shaped protrusion 310 disposed with its longer axis extending parallel with the axis of bi-directional female connectors 12. Parallelogram-like shaped protrusion 310 includes two opposite sides 312 with concave perimeters.

5 Image (1) and (4) of FIG. 18A and 18B show the orientation of rod sections 292, 294 when connected and locked into position. Image (2) and (3) show the orientation of rod sections 292, 294 in order to in order to unlock the two sections and to adjust the extension of expandable M-M rod component 290. When oriented in position (2) and (3), vertex 314 of protrusion 310 is oriented with
10 vertex 316 of open end 296 and concave sides 312 are oriented with disposed ridges 301 so that rod section 294 can slide freely in and out of rod section 292. Rod section 294 is locked into place by twisting the rod clock-wise when vertex 314 abuts one of the series of slots 299 and by sliding vertex 314 into the cavity of slot 299 as may best be seen in image (4). When locked into place, each of the
15 female connectors 12 from both rod sections are aligned in parallel. The rod sections 292, 294 can be unlocked by twisting rod section 294 counter clockwise while holding rod section 292 stationary.

As shown in detail in FIG. 18J, the surface of protrusion 310 that is oriented in the
20 direction of insertion of rod section 294 is provided with a pair of ridges 317. The ridges 317 are aligned substantially along the longer diagonal axis of the parallelogram-like protrusion 310. As shown in detail in FIG. 18I, each of the surfaces of the slots 299 that faces the ridges 317 is provided with a detent 319. The detents 319 are aligned substantially perpendicularly to both the length of the
25 slots 299 and the direction of insertion of rod section 294. The detents 319 are

shaped and positioned so as to engage with the ridges 317 when rod section 294 is locked into place. When rod section 294 is twisted (when being locked into place and when being subsequently released), an additional twisting force is required to bring the ridges 317 into and out of engagement with the detents 319. This provides a positive snap-fitting action that allows a user to tell when the rod section is correctly locked into place, and helps to avoid small twisting forces causing accidental disengagement of the protrusion 310 from a slot 299. The detents 319 and slots 299 are substantially identically shaped, such that a uniform force is required to lock (and unlock) the rod section 294 in each slot.

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Rod section 294 is the only component described herein that is manufactured by a three-plate injection molding process. In this process, two opposing plates are used to form the two sets of slots 299 and the bi-directional female connector 12, and in which a perpendicularly disposed plate (or side core) is used to form the elongate cavity into which rod section 292 is inserted.

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Although the expandable rod 190 is illustrated in FIG. 18A and FIG. 18B with a male connector at each end, it will be appreciated that the expandable rod component may alternatively have a female connector at each end, or a male connector at one end and a female connector at the other end.

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Referring to FIG. 19A and 19B, short M-F rod component 340 is shown with bi-directional female connector 12 extending from base 27, uni-directional female connector 80 extending from one end, and male connector 342 extending axially from the other end in accordance with the present invention.

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Referring to FIG. 20A and 20B, short M-M rod component 350 is shown with bi-directional female connector 12 extending from base 27 and two male connectors 352, 354 extending axially from opposite ends in accordance with the present invention.

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FIGS 22A to 22F show a hinge assembly that is created by connecting the U-joint connector 84 of a base component 130 (see FIGS. 8A and 8B) to the axle connector 242 of a swing-rod component 240 (see FIGS. 15A and 15B). An alternative hinge assembly (not shown) can be created by connecting any U-joint connector 142 of a quad-base component 140 (see FIGS. 9A and 9B) to the axle connector 242 of a swing-rod component 240 (see FIGS. 15A and 15B). Such hinge assemblies allow the swing-rod component 240 to rotate relative to the base component 130 (or quad-base component 140) about the axis of the axle connector 242. It will be recalled that the swing-rod component 240 comprises a plurality of connectors 10, 80 and that the base component 130 also comprises a connector 10; other components can be connected to these connectors, thereby allowing those other components to be rotatably joined to each another via the hinge assembly.

FIG 21A to 21F shows a universal joint assembly that is created by joining a short M-F rod component 340 (see FIGS 19A and 19B) to the hinge assembly of FIG 21. As was previously noted, a female connector permits *is situ* rotation of a connected male connector when a sufficiently large axial twisting force is applied. Thus, the universal joint assembly functions as a universal joint by permitting rotation at the junction of the U-joint connector and axle connector whilst also

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permitting rotation of male connectors that are inserted into the female connectors at each end of the end universal joint connector.

FIGS. 23A to 23D show a four-way male connector. The four-way male connector has a generally cubic shape, and comprises a bi-directional female connector 12 and four male connectors 10. The four male connectors 10 are oriented perpendicular to the axis of the bi-directional female connector. The four-way male connector allows six different components to be connected to each other at a single point.

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In a preferred example of a construction toy set, the heads 14 of the male connectors 10 of small components have a smaller diameter (measured in the direction perpendicular to the axis of the male connector) than the heads of the male connectors of larger components. For example, the heads of the male connectors 352, 354 of the short M-M rod 350 of FIG. 20A have a smaller diameter than the head of the large M-F rod 280 of FIG. 17A. All female connectors 12, 80 in this example of a construction toy set have the same dimensions. A smaller force is required connect and disconnect small components than is required to connect and disconnect larger components, because the smaller heads 14 of the male connectors 10 of smaller components require less deformation of female connectors during their insertion and removal. Thus, the problem that some users may experience in gripping smaller components is overcome by allowing such components to be connected and disconnected more easily. In use, the connectors of larger components may experience larger moments of force (because a turning force can act at a greater

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distance from the connector), so requiring a larger force to disconnect larger components improves the strength of models involving larger components; since larger components are easier to grip than smaller components, this larger force does not present difficulties to users connecting and disconnecting larger components. Thus, there is provided a construction toy set comprising at least two components each having at least one connector, wherein one of said at least two components is smaller than the other component, and wherein the connector of the smaller component is arranged to have a smaller connection force and/or disconnection force than the connector of the larger component. It will be appreciated that this feature can alternatively be implemented by providing larger head shaped regions 30, 44 on the female connectors 12, 80 of the smaller components, whilst all male connectors 10 have the same dimensions.

Referring to FIG. 26, toy bi-ped vehicle 2100 is shown assembled from components herein described in accordance with the present invention. Step 1 (2110) in FIG. 26 shows the layered combination of wheel 120 mated with pulley 150, mated with tee 100, mated with two pulleys 150, mated with two expandable rods 290, mated with two pulleys 150, mated with tee 100, and mated with two pulleys to produce a multi-rotational section. Step 2 (2120) in FIG. 26 shows the combination of two pulleys 150 with tee 100, mated with expandable rod 290, mated with oppositely disposed angle rods 260, and mated with two additional angle rods 260 producing a second section. Step 3 (2130) in FIG. 26 shows the joining of the two sections with two expandable rods 290, mated with small M-M rod 350, and mated with wheel 120 to generate toy bi-ped vehicle 2100.

Referring to FIG. 27, toy tricycle 2200 is shown assembled from components herein described in accordance with the present invention. Step 1 (2210) in FIG. 27 shows the combination of two big rods 280 with two small M-M rods 350, mating of two M-M rods 350 with uni-directional female connectors of big rods 280, mating of small M-M rod 350 with the two small M-M rods 350, and mating small M-F rod 340 with small M-M rod 350 connected at the lower end of big rods 280 to generate a first main frame section. Step 2 (2220) in FIG. 27 shows the combination of two more big rods 280 with the first main frame section using two pairs of small M-M rods 350 and the mating of angle rod 260 with bi-directional female connector 12 of small M-F rod 340 to generate a second main frame section (2230). Step 3 (2240 and 2250) shows the combination of six angle rods 260 to generate a pair of handle bars which are mated with bi-directional female connector 12 of small M-M rod 350 located at the upper portion of main frame section to generate the third main frame section (2260). Step 4 (2270) shows the combination of expandable rod 290 and two large M-F rods with the bi-directional female connectors 12 of three lower small M-M rods 350 located on main frame section (2260) and the addition of two pulleys 150 to the M-F outside rods 280 located on main frame section (2260) to generate a fourth main frame section (2280). Step 5 shows the combination of wheels 120 with pulleys 150, mating of two pulleys 150 with the outside portion of wheels 120, mating two pulleys with expandable rod 290, and the mating of four additional wheels to the respective pulleys 150 to generate the toy tricycle 2200.

Referring to FIG. 28, toy crane 2300 is shown assembled from components herein described in accordance with the present invention.

Referring to FIG. 29, toy all-terrain vehicle 2400 is shown assembled from components herein described in accordance with the present invention.

5 Referring to FIG. 30, various constructable toys are shown assembled from components herein described in accordance with the present invention.

The above description of illustrated embodiments of the invention is not intended to be exhaustive or to limit the invention to the precise forms disclosed. While
10 specific embodiments of, and examples for, the invention are described herein for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. By example, it has been shown and mentioned several times that the various male and female connectors may be changed with respect to the example components
15 which have been discussed and described herein. Additionally, various embodiments of the invention may utilize values that are different from what is specified herein. Furthermore, the terms used in the following claims should not be construed to limit the invention to the specific embodiments disclosed in the specification and the claims.

CLAIMS

PCT/CY2007/000001

1. A female construction toy connector comprising an inner surface with a first shoulder region, a first neck region, and a head region;

5 the first neck region connecting the first shoulder and head regions, said first neck region having an inner circumference that tapers from the first shoulder region to the head region;

 the head region having an inner circumference that expands from the first neck region;

10 the diameter of the neck region being elastically expandable.

2. The female construction toy connector as in Claim 1, the female construction toy connector including a second neck and a second shoulder region;

 the second neck region connecting the second shoulder region and the
15 head region;

 the diameter of the second neck region being elastically expandable.

3. The female construction toy connector as in Claim 1, the first shoulder region having a geometrically shaped inner surface.

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4. The female construction toy connector as in Claim 2, each of the neck, shoulder, and head regions being disposed along a common axis.

5. The female construction toy connector as in claim 2, the female construction toy connector being sized and proportioned to receive and connect with oppositely disposed male-type connectors.
- 5 6. The female construction toy connector as in claim 2, one of the shoulder regions having a geometrically shaped inner surface.
7. The female construction toy connector as in claim 2, the shoulder regions having geometrically shaped inner surfaces.
- 10 8. The female construction toy connector as in Claim 3, the first shoulder region having an octagonally shaped inner surface.
9. The female construction toy connector as in Claim 6, one of the shoulder regions having an octagonally shaped inner surface.
- 15 10. The female construction toy connector as in Claim 7, the shoulder regions having octagonally shaped inner surfaces.
- 20 11. A female construction toy connector as in any one of the preceding claims, wherein the connector is produced from an injection molding process.
12. A male construction toy connector comprising an external surface with a shoulder, a neck, and a head;

the neck connecting the shoulder and head, said neck having an outer circumference that tapers inward from the shoulder to the head;

the head having a portion that is wider than the adjoining portion of the neck.

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13. The male construction toy connector as in Claim 12, the shoulder having a geometrically shaped outer surface.

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14. The male construction toy connector as in Claim 13, the shoulder having a circularly shaped outer surface.

15. The male construction toy connector as in Claim 13, the shoulder having an octagonally shaped outer surface.

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16. A construction toy component including a female construction toy connector, the female construction toy connector comprising an inner surface with a first shoulder, a first neck, and a head region, the first neck region being elastically expandable to accommodate insertion of a male construction toy connector.

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17. The construction toy component as in Claim 16, the first neck region connecting the first shoulder and head region, said neck region having an inner circumference that tapers from the first shoulder region to the head region;

the head region having an inner circumference that increases in size from the first neck region to accommodate a male toy connector with a head size that is

greater than the circumference of the portion of the neck region that joins the head region.

18. The construction toy component as in Claim 16, the construction toy
5 component including a u-shaped connector,

the u-shaped connector having ends that curl inward and are elastically expandable apart for insertion of an axle.

19. The construction toy component as in Claim 16, the construction toy
10 connector including a second neck and a second shoulder region to accommodate bi-directional connecting with a male connector.

20. The construction toy component as in Claim 19, the construction toy
connector being connectable simultaneously with two opposing male connectors.

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21. The construction toy component as in Claim 16, the construction toy component comprising a rod, the first female construction toy connector connecting to one end;

the construction toy component including a construction toy connector
20 connected to the other end.

22. The construction toy component as in Claim 21, the construction toy connector comprising an axle.

23. The construction toy component as in Claim 21, the construction toy connector comprising a u-shaped connector.

24. The construction toy component as in Claim 16, the construction toy
5 component comprising an elbow, the first female construction toy connector connecting to one end;

the construction toy component including a construction toy connector connected to the other end.

10 25. The construction toy component as in Claim 24, the construction toy component including an arm extending at an angle with respect to the two ends and including a connector.

26. The construction toy component as in Claim 16, the construction toy
15 component including multiple arms extending from a central axis, each of said multiple arms including a connector.

27. The construction toy component as in Claim 26, at least one of the connectors disposed at an angle with respect to at least one other of the connectors.

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28. The construction toy component as in Claim 26, at least one of the connectors being connectable bi-directionally.

29. The construction toy component as in Claim 16, the construction toy component comprising an expandable rod, the first female construction toy connector connecting to one end;

the construction toy component including a construction toy connector
5 connected to the other end.

30. The construction toy component as in Claim 29, the expandable rod including a first rod and a second rod;

each rod including one of the connectors;

10 the second rod including an insertable element;

the first rod including a receptacle for receiving the insertable element and securing the insertable element in more than one position.

31. A construction toy component including a male construction toy connector,
15 the male construction toy connector including a head and neck sized and proportioned for insertion within a female construction toy connector, the head having a portion with an external circumference that is greater than an abutting portion of the neck.

20 32. The construction toy component as in Claim 31, the construction toy component including a pulley element, the male construction toy connector being disposed axially with respect to the pulley element.

33. The construction toy component as in Claim 32, the construction toy component including a second male construction toy connector disposed opposite the other male construction toy connector.

5 34. The construction toy component as in Claim 31, the male construction toy connector including a shoulder connecting to the neck, the shoulder having a geometrically shaped external surface for reciprocal engagement with a female construction toy connector.

10 35. The construction toy component as in Claim 31, the construction toy component including a female construction toy connector.

36. The construction toy component as in Claim 35, the female construction toy connector being disposed at an angle with respect to the male construction toy
15 connector.

37. The construction toy component as in Claim 31, the construction toy component including a motor base element, the male construction toy connector being disposed axially with respect to the motor base element.

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38. A construction toy assembly including a first and second construction toy component, the first and second construction toy component being connected;

the first construction toy component including a female construction toy connector, the female construction toy connector comprising an elastically
25 expandable neck region and a head region;

the second construction toy component including a male construction toy connector including a neck and head, the head having a larger outside diameter than the neck, the male construction toy connector being sized and proportioned for insertion within the female construction toy connector;

5 the female connector being elastically expandable to accommodate insertion of the male connector and contractable about a portion of the male connector after insertion.

39. The construction toy assembly as in Claim 38, the female connector having a
10 female shoulder region with a geometrically shaped inner surface.

40. The construction toy assembly as in Claim 39, the female shoulder region having an octagonally shaped inner surface.

15 41. The construction toy connector assembly as in Claim 39, the male connector having a male shoulder region with a geometrically shaped outer surface sized and proportioned to mate with the female shoulder region.

42. The construction toy connector assembly as in Claim 39, the male connector
20 having a male shoulder region with a circular shaped outer surface sized and proportioned to rotate within the female shoulder region.

43. The construction toy connector assembly as in Claim 40, the male connector having a male shoulder region with an octagonally shaped outer surface sized and
25 proportioned to rotate within the female shoulder region.

44. The construction toy connector assembly as in Claim 38, the construction toy connector assembly including multiple components with corresponding male and female connectors,

5 the multiple components having varying shapes and sizes;

 the multiple components connecting to form a three-dimensional toy structure.

45. The construction toy connector assembly as in Claim 44, the multiple
10 components including a set of wheels and at least one pulley;

 the multiple components connecting to form a three-dimensional toy crane structure.

46. An expandable construction toy component comprising:

15 a first element having a connector and an elongate cavity extending into the first element;

 a second element having a connector and an elongate member extending from the second element, the elongate member being slidable within the elongate cavity, and

20 a securing means for securing the elongate member to the first element at any of a plurality of positions along the length of the elongate cavity.

47. An expandable construction toy component in accordance with claim 46, wherein the securing means is arranged to secure the elongate member to the first
25 element at a plurality of discrete positions along the length of the elongate cavity.

48. An expandable construction toy component in accordance with claim 47,
wherein at least some of the discrete positions are separated from each other by a
distance equal to the distance between the axes of two adjacent parallel connectors
5 of a compatible construction toy component.

49. An expandable construction toy component in accordance with any one of
claims 46 to 48, wherein the connectors of the first and/or second elements are
connectors in accordance with any one of claims 1 to 15.
10

50. An expandable construction toy component in accordance with any one of
claims 46 to 49, wherein the securing means comprises:
a plurality of slots formed in a wall of the first element;
a protrusion formed on the elongate member of the second element,
15 wherein the protrusion is arranged to fit within a slot, thereby securing the
elongate member to the first element.

51. An expandable construction toy component in accordance with claim 50,
wherein the protrusions and slots comprise cooperable ridge and detent
20 formations, whereby the protrusion can be secured within a slot by engagement of
a ridge with a detent.

52. A construction toy assembly comprising:
an expandable construction toy component in accordance with any one of
25 claims 46 to 51; and

a hinge comprising a first connector rotatably joined to a second connector,

wherein a connector of the expandable component is connected to a connector of the hinge.

5

53. A construction toy component comprising first and second female connectors oriented in opposite directions along a common axis, the first and second female connectors each comprising a neck-shaped region, wherein the two neck-shaped regions are in communication with each other via a head-shaped region having a greater cross-section than the neck-shaped regions.

10

54. A construction toy component in accordance with claim 53, wherein at least one of the neck-shaped regions is elastically expandable.

15

55. A construction toy component in accordance with claim 54, wherein the neck-shaped regions and head-shaped regions are defined by a wall, and wherein the wall includes one or more gaps.

56. A construction toy component in accordance with claim 55, wherein the component further comprises a base portion formed at an open end of one of the female connectors, and wherein the wall extends upwards from the base portion.

20

57. A construction toy in accordance with any one of claim 53, wherein the neck-shaped regions and head-shaped region are defined by at least two part-annular leaf spring elements connected at one end by a base portion, wherein

25

insertion of a head of a male connector in either female connector causes the leaf spring elements to deflect to allow the male connector to engage in the head-shaped region.

5 58. A construction toy component in accordance with any one of claims 53 to 57, further comprising a third female connector oriented perpendicular to the common axis of the first and second female connectors.

10 59. A construction toy component in accordance with claim 58, wherein the third female connector comprises an opening extending parallel to its axis to allow a male connector of a compatible construction toy component to be engaged with the third female connector.

15 60. A construction toy component in accordance with any one of claims 53 to 59, wherein the first and second female connectors define a through hole in the construction toy component.

20 61. A construction toy component for connection to second and third construction toy components identical to said construction toy component, wherein the construction toy component comprises:

 a male connector; and

 first and second female connectors being oriented in opposite directions along a common axis and being oriented perpendicular to said male connector, wherein the first and second female connectors are arranged to engage
25 simultaneously with male connectors of the second and third construction toy

components, and wherein engagement is achieved by moving a male connector of the second or third construction toy components towards the first or second female connector along the axis of that female connector.

5 62. A construction toy component in accordance with claim 61, further comprising a third female connector sharing a common axis with the male connector of the component and having an opposite orientation to the male connector.

10 63. A construction toy component in accordance with claim 62, wherein the third female connector comprises an opening extending parallel to its axis to allow a male connector of the second or third construction toy components to be engaged with the third female connector.

15 64. A construction toy component in accordance with any one of claims 61 to 63, further comprising at least two further female connectors, wherein the at least two further female connectors are:

oriented in opposite directions along a common axis;

oriented perpendicular to said male connector; and

20 oriented parallel to the first and second female connectors,

wherein the at least two further female connectors are arranged to engage simultaneously with the male connectors of the second and third construction toy components, and wherein engagement is achieved by moving a male connector of the second or third construction toy components towards either of the at least two
25 further female connectors along the axis of that female connector.

65. A construction toy component in accordance with any one of claims 61 to 64, wherein the female connectors are snap-fit connectors.

5 66. A female construction toy connector for engagement with a male construction toy connector, wherein the female construction toy connector is arranged to be elastically deformed by a twisting force applied thereto by the male construction toy connector, thereby allowing the male connector to rotate relative to the female connector from a first orientation to a second orientation.

10

67. A female construction toy connector in accordance with claim 66, wherein the female construction toy connector is arranged to remain in engagement with the male construction toy component during rotation.

15 68. A female construction toy connector in accordance with claim 66 or claim 67, wherein the female construction toy connector comprises a deformable portion having an order of rotational symmetry of at least two.

69. A female construction toy component in accordance with any one of
20 claims 66 to 68, wherein the female construction toy connector comprises a deformable portion having a substantially polygonal internal cross-section.

70. A female construction toy component in accordance with claim 70, wherein the polygonal internal cross-section has concave edges.

71. A male construction toy connector for engagement with a female construction toy connector, wherein the male construction toy connector is arranged to cause elastic deformation of the female construction toy connector by transmitting a twisting force thereto, thereby allowing the male connector to rotate
5 relative to the female connector from a first orientation to a second orientation.

72. A male construction toy connector in accordance with claim 71, wherein the male construction toy connector is arranged to remain in engagement with the female construction toy component during rotation.

10

73. A male construction toy connector in accordance with claim 71 or claim 72, wherein the male construction toy connector comprises a portion arranged to cause deformation of the female construction toy connector, and wherein that portion has an order of rotational symmetry of at least two.

15

74. A male construction toy component in accordance with any one of claims 71 to 73, wherein the male construction toy connector comprises a portion arranged to cause deformation of the female construction toy connector, and wherein that portion has a substantially polygonal external cross-section.

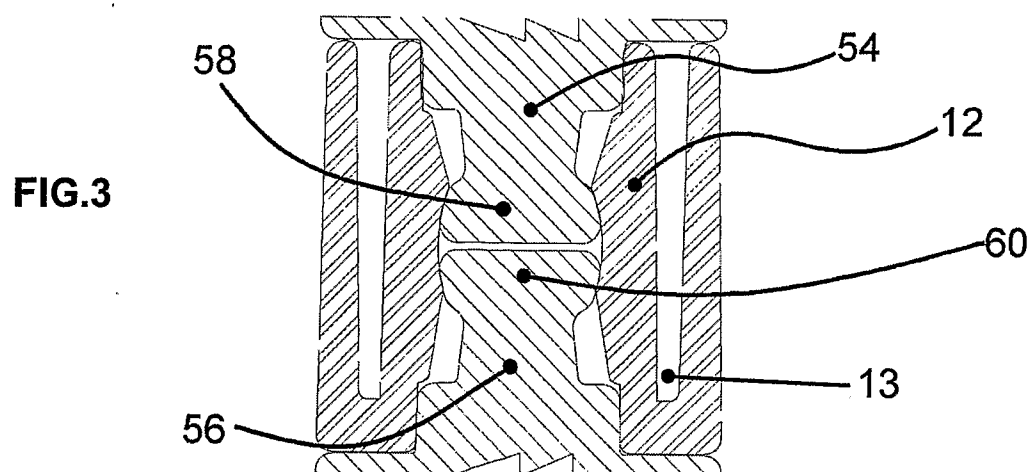
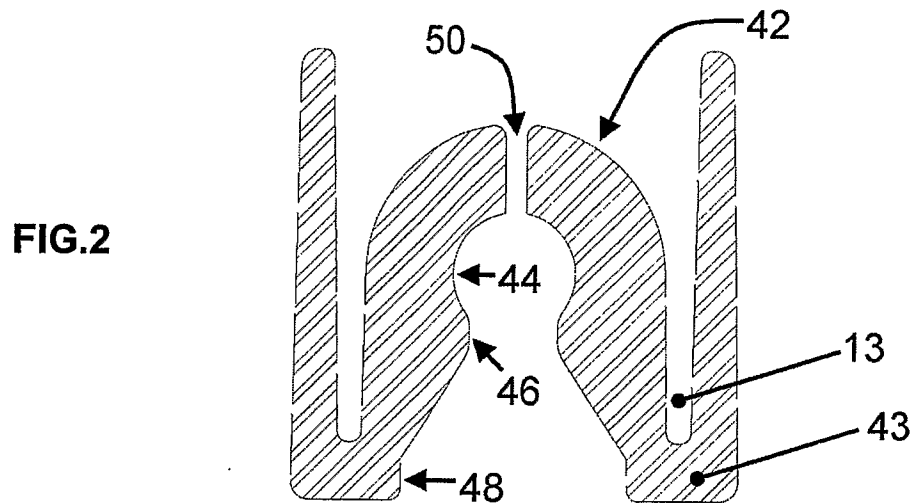
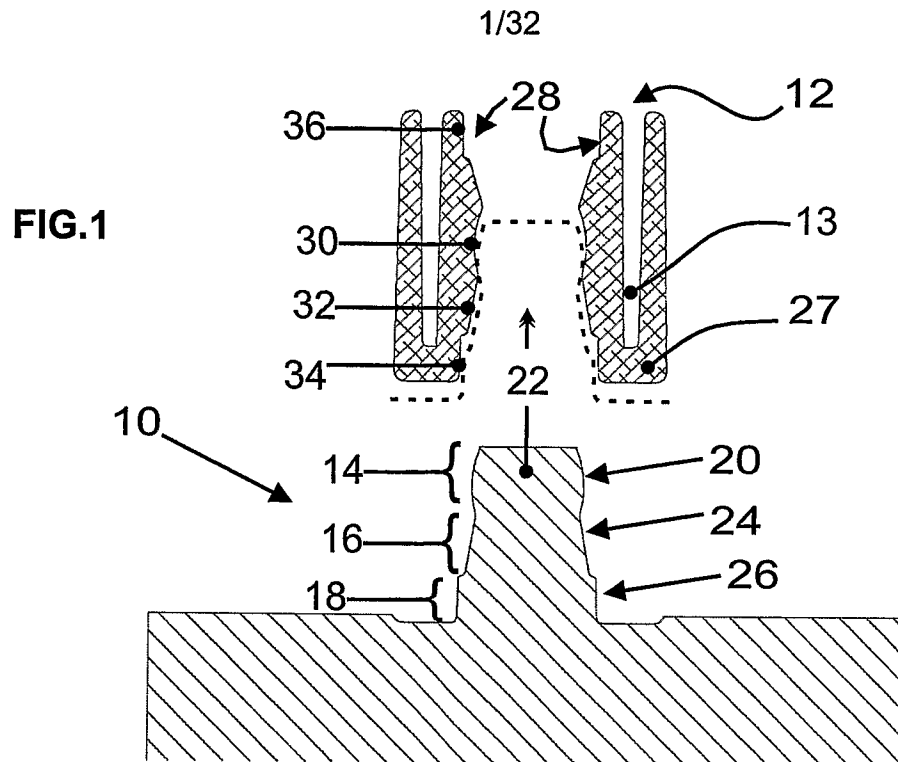
20

75. A male construction toy component in accordance with claim 75, wherein the polygonal external cross-section has convex edges.

76. A construction toy set comprising:

a first component having a female construction toy connector in accordance with any one of claims 66 to 70; and

a second component having a male construction toy connector in accordance with any one of claims 75, wherein the male construction toy
5 connector of the second component and female construction toy connector of the first connector are mutually engageable.



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FIG.4A

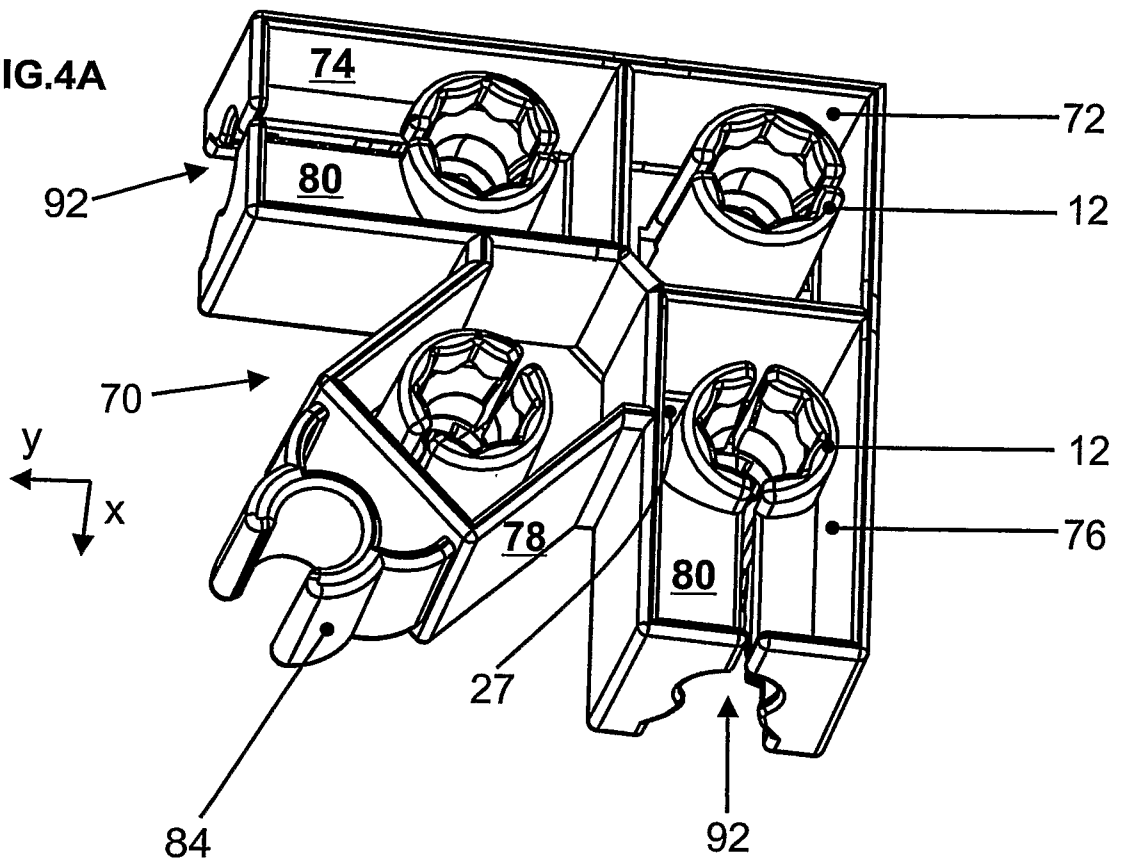
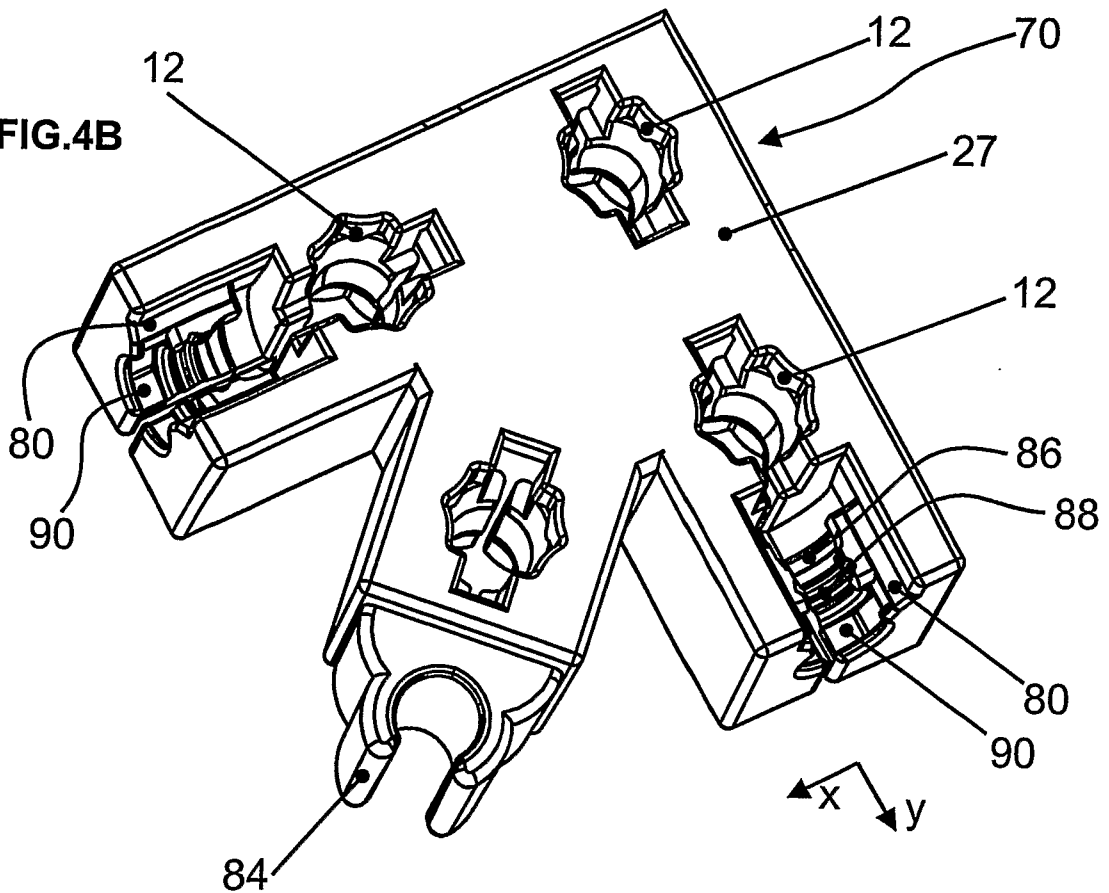


FIG.4B



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FIG.4C

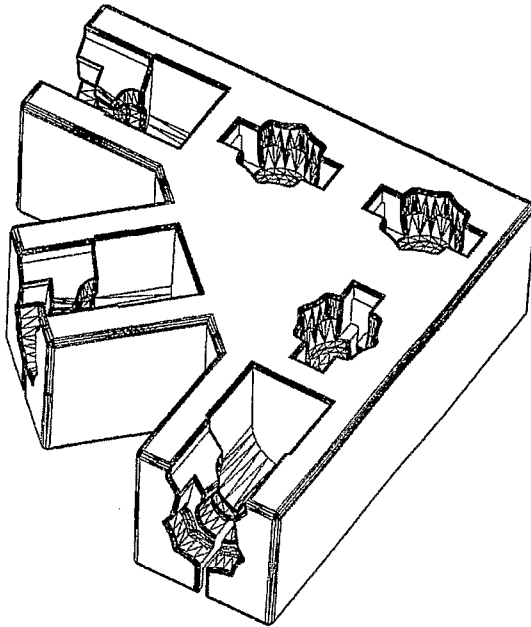


FIG.4D

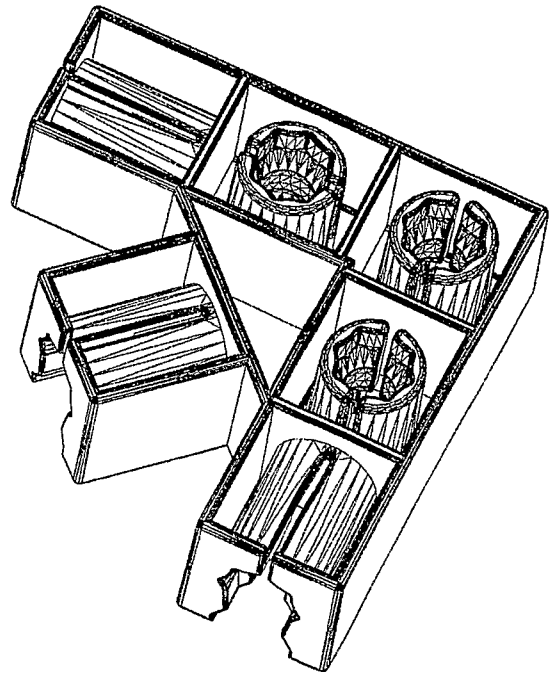


FIG.8C

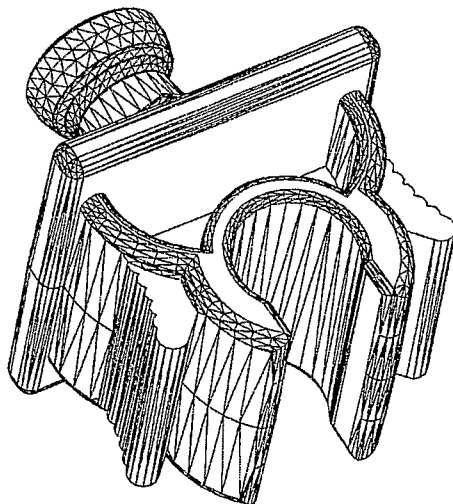
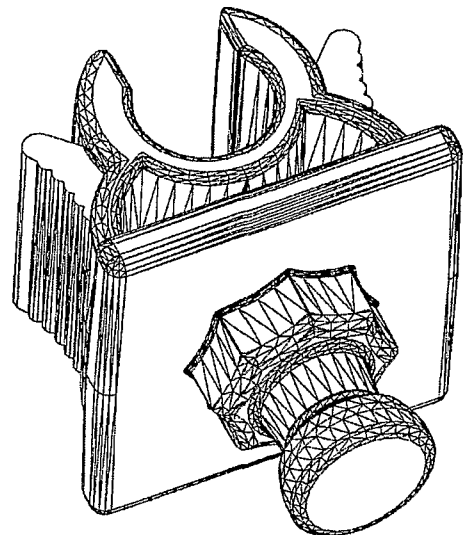


FIG.8D



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FIG.5A

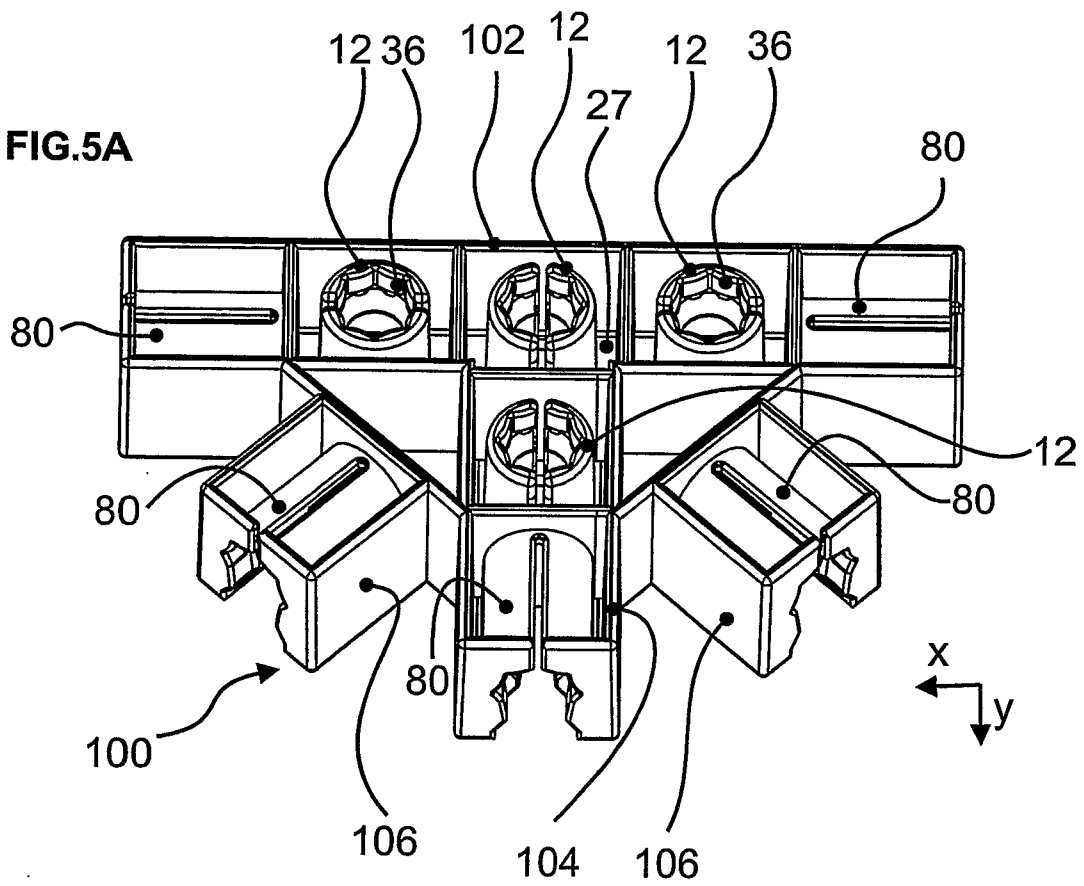
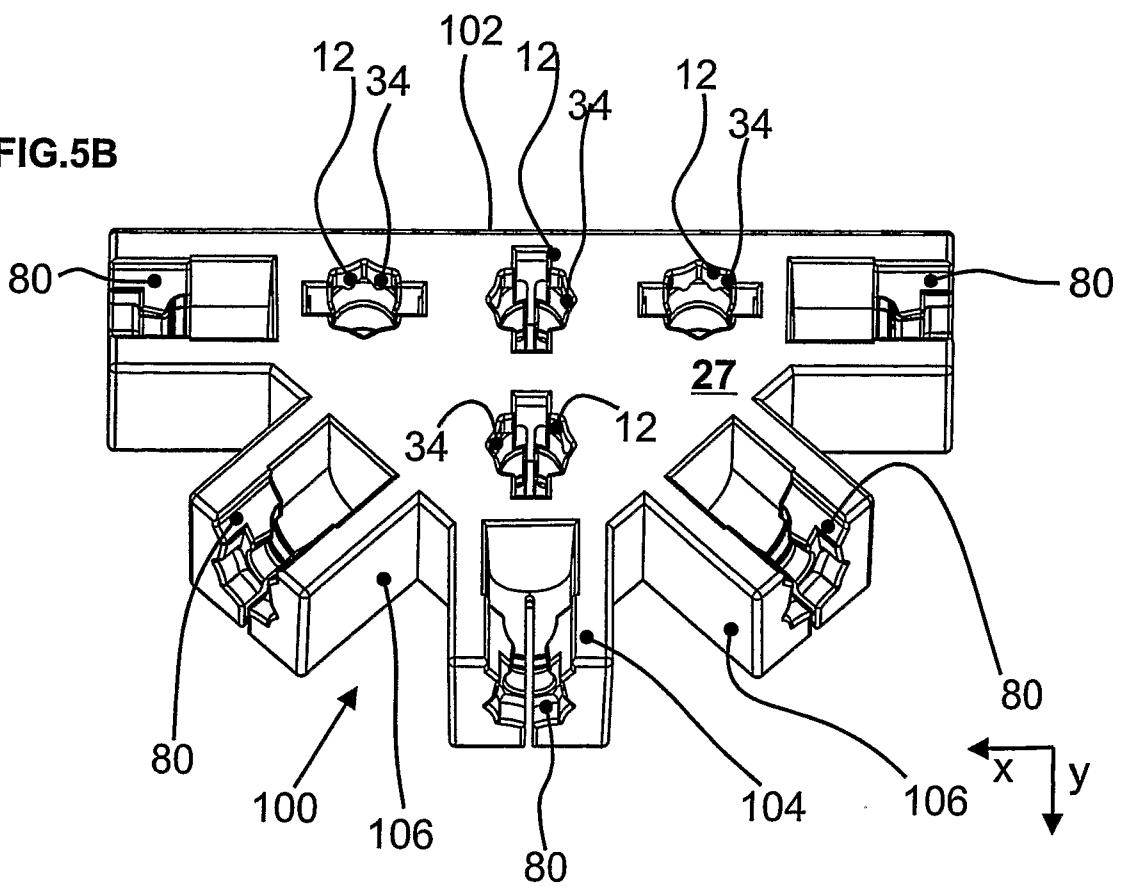


FIG.5B



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FIG.6A

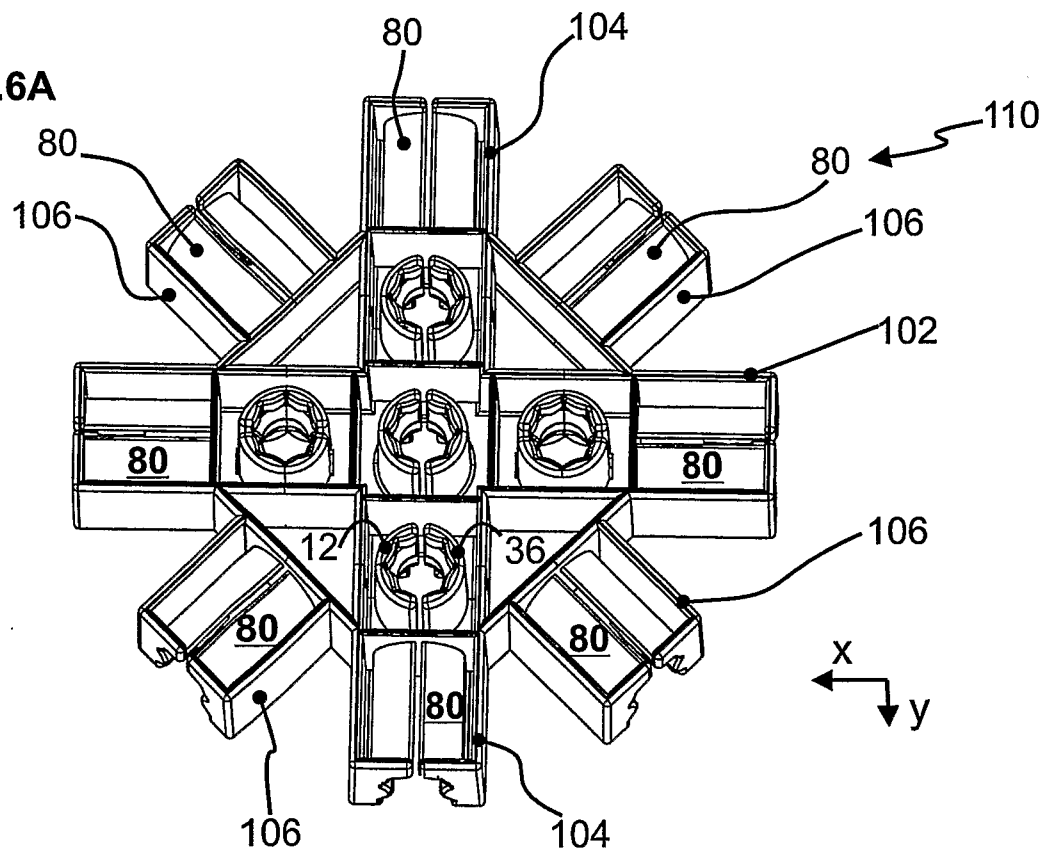
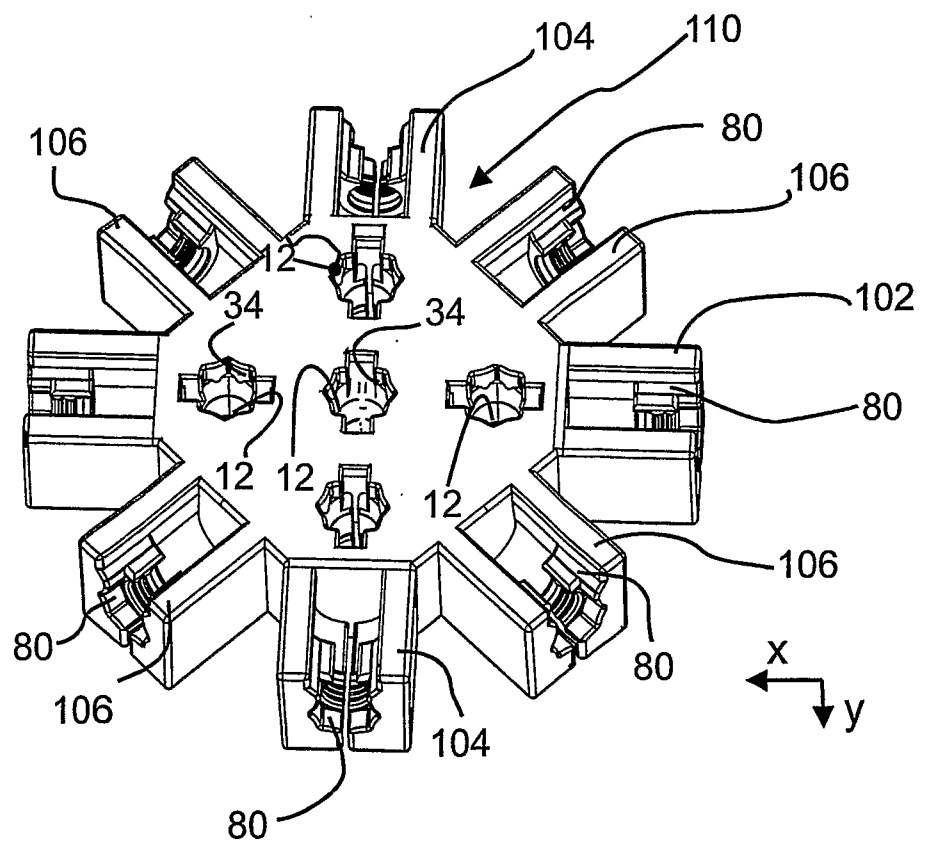


FIG.6B



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FIG.7A

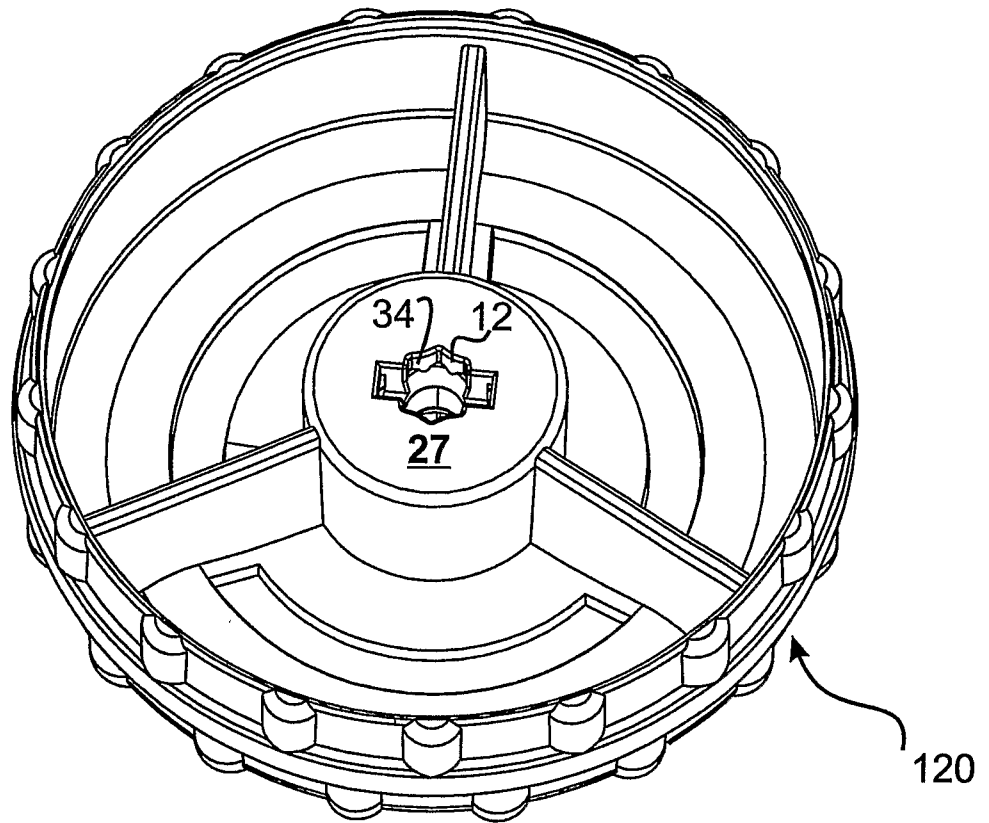
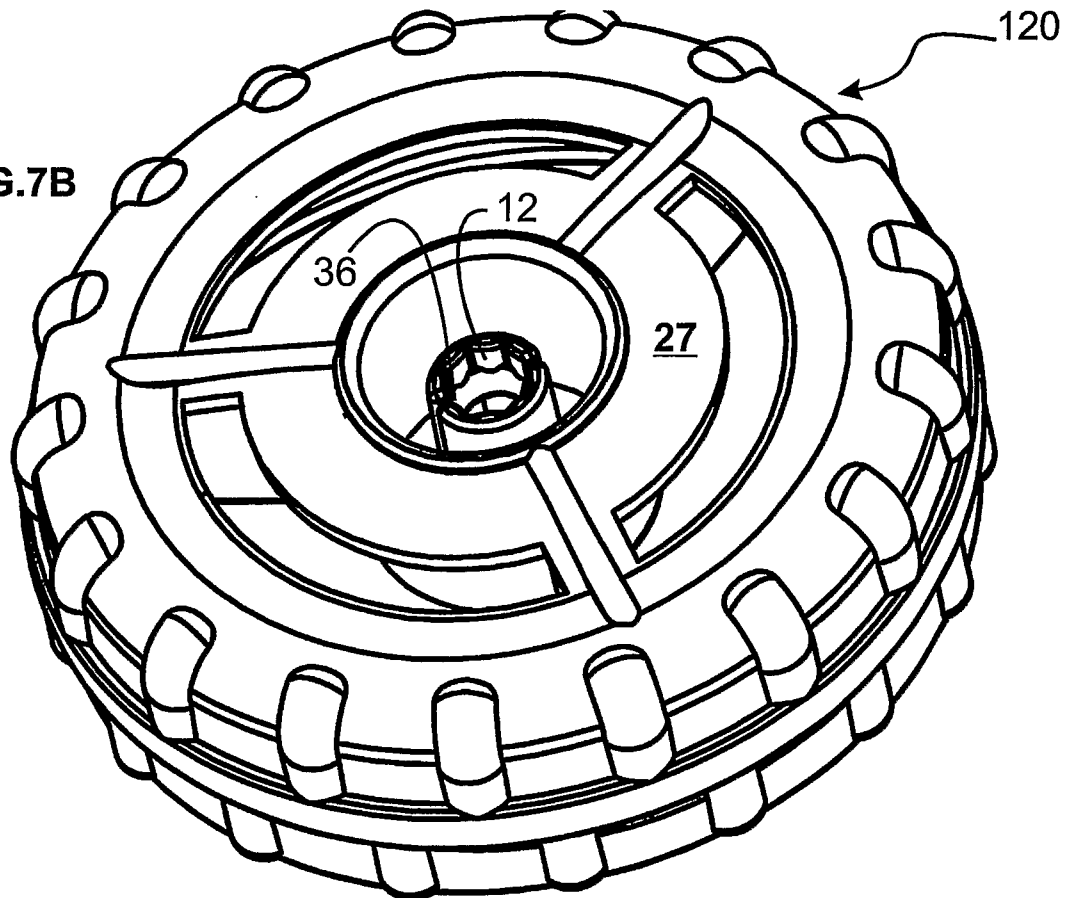


FIG.7B



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FIG.8A

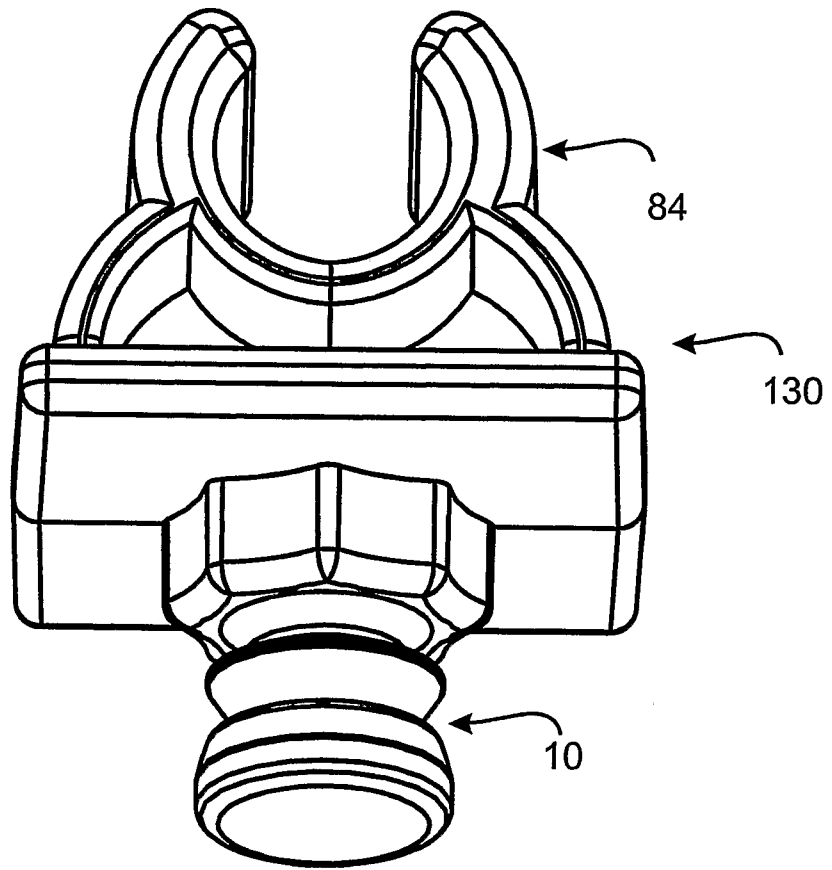
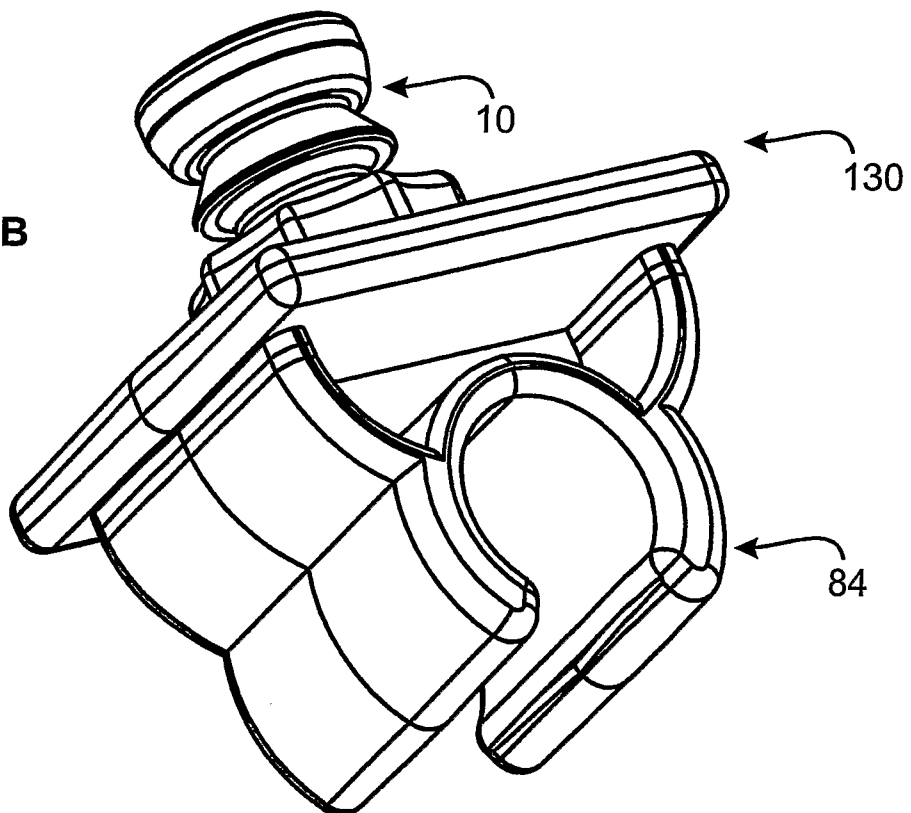


FIG.8B



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FIG.9A

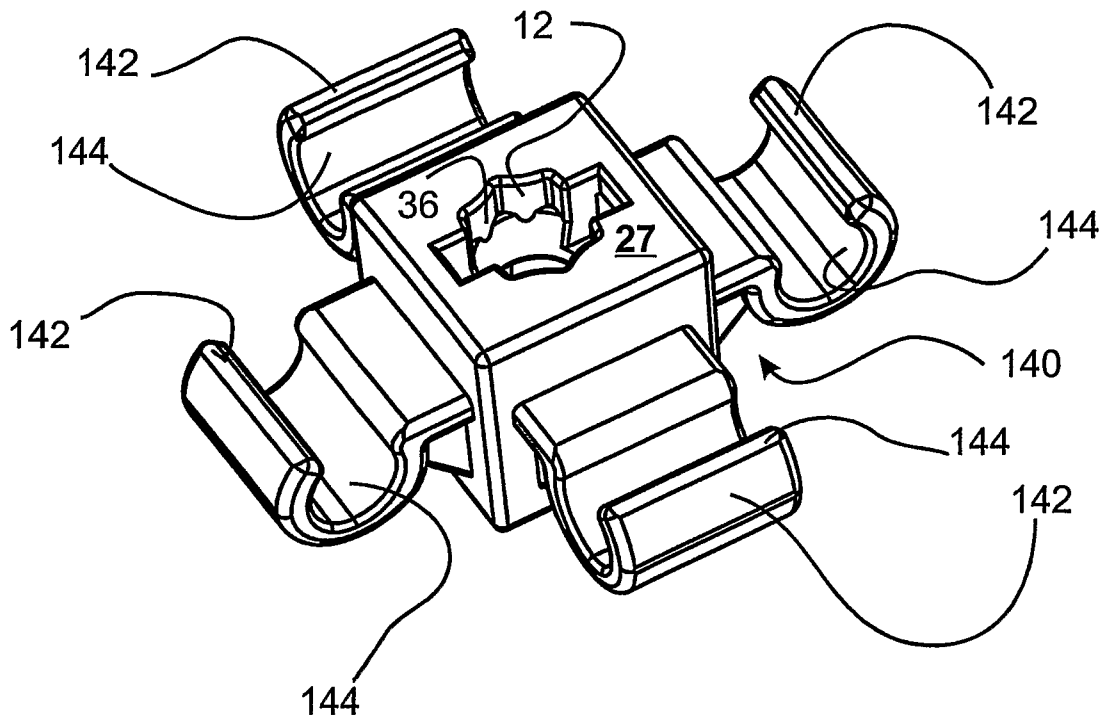
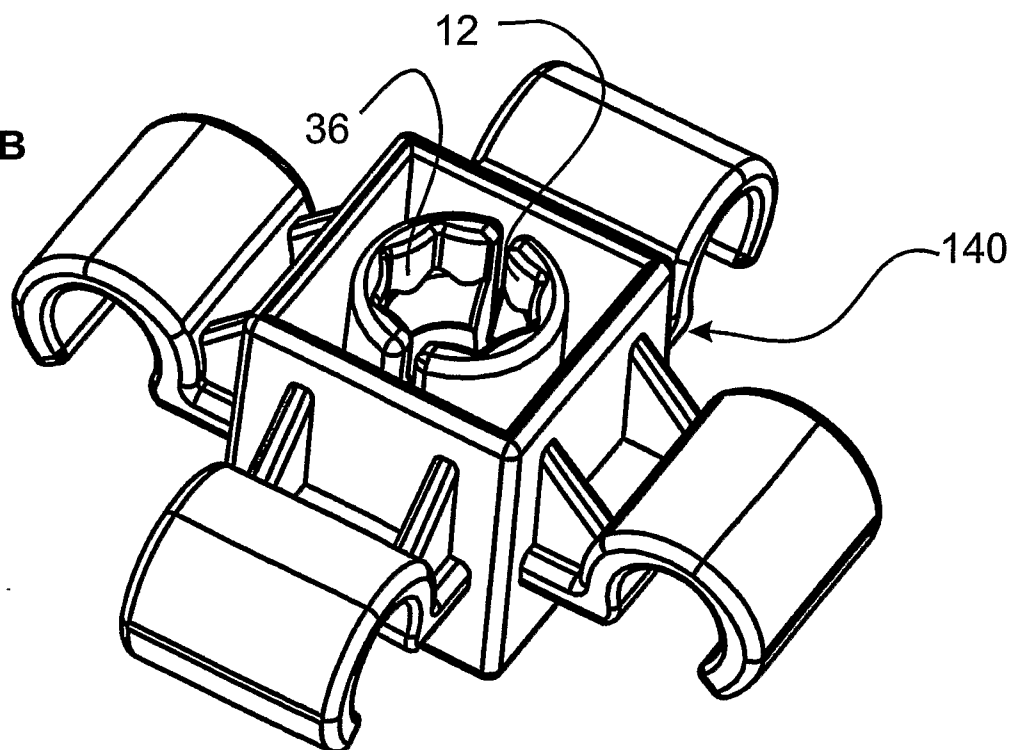


FIG.9B



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FIG.10A

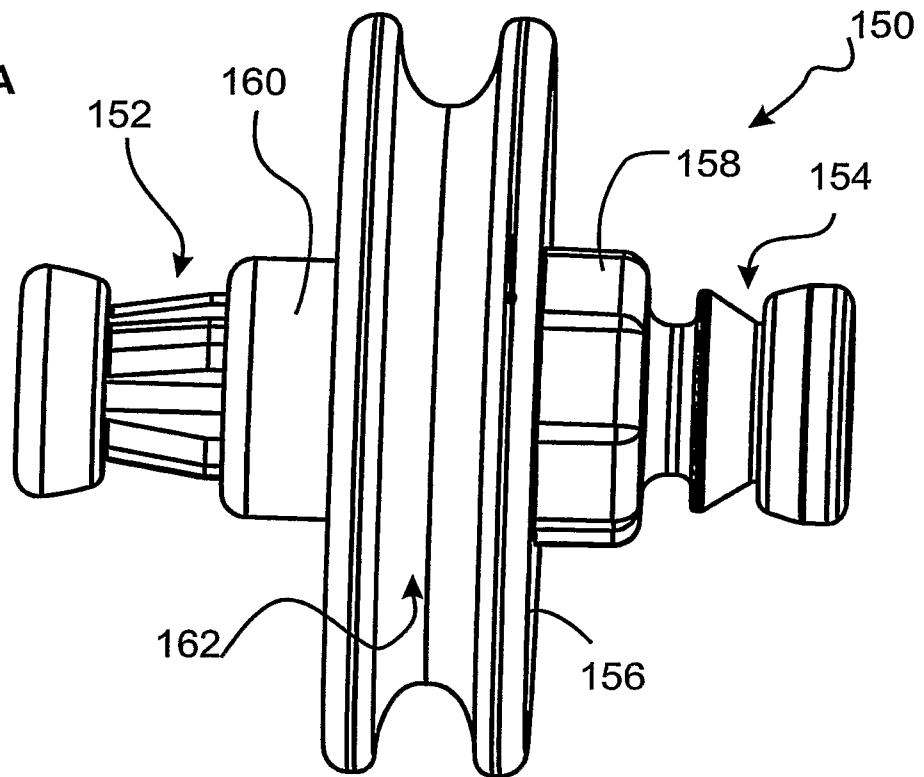
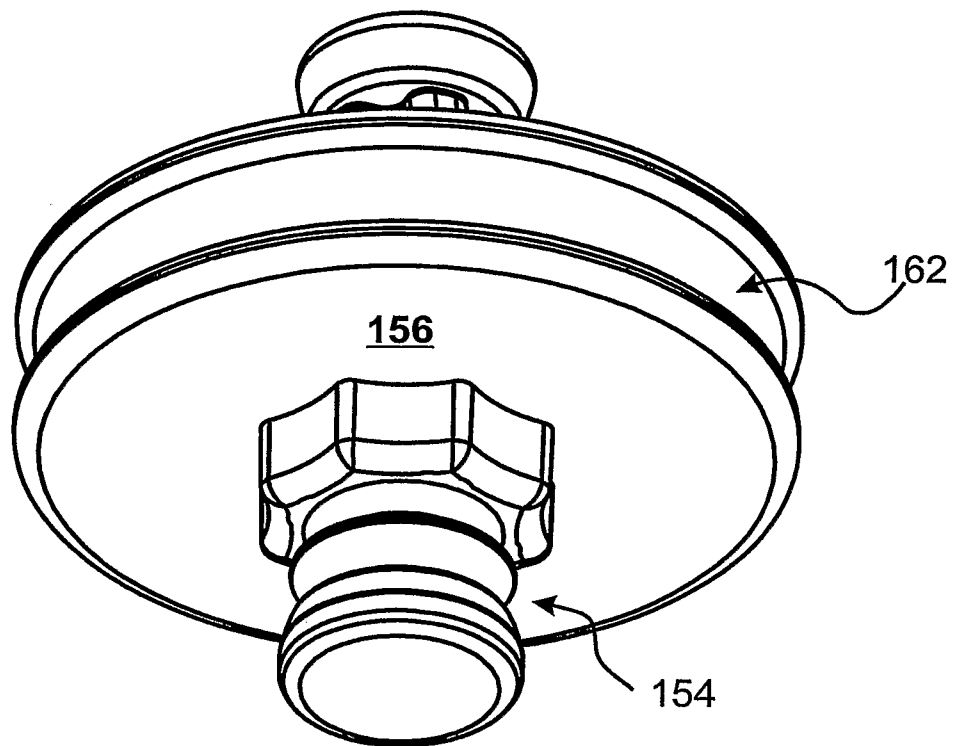


FIG.10B



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FIG.11A

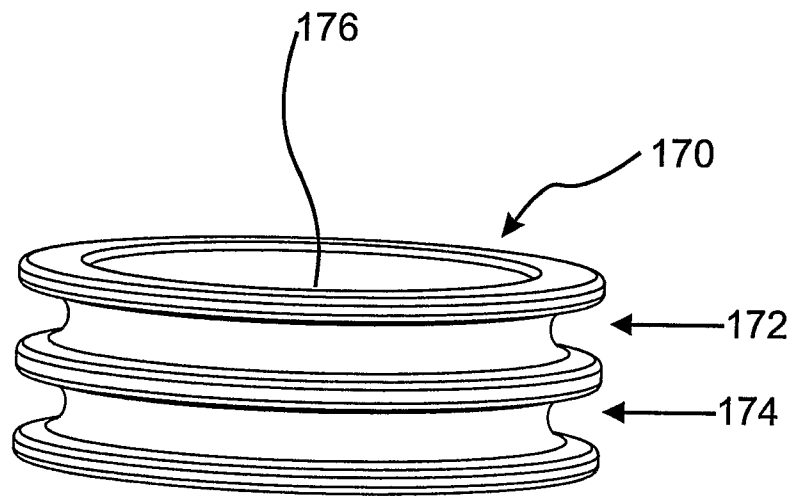
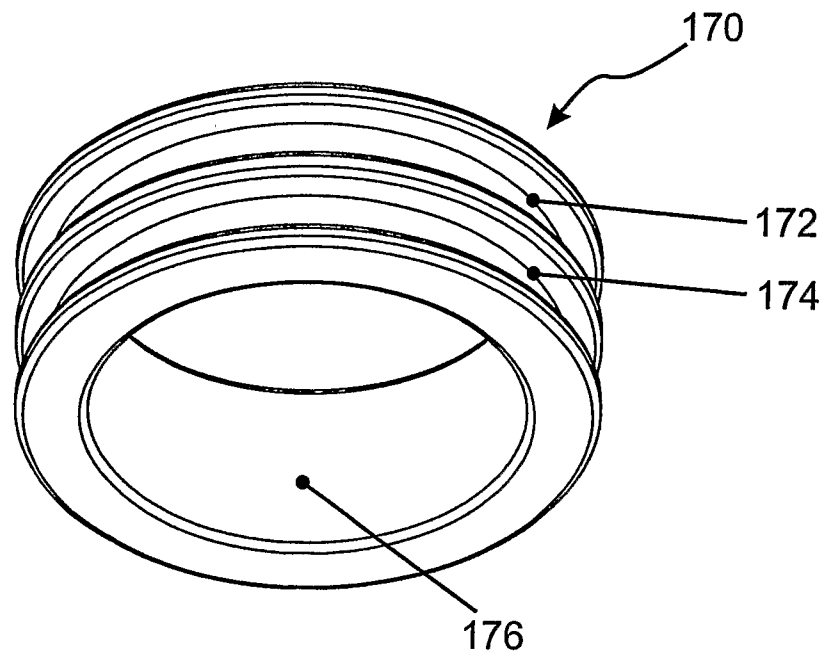


FIG.11B



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FIG.12A

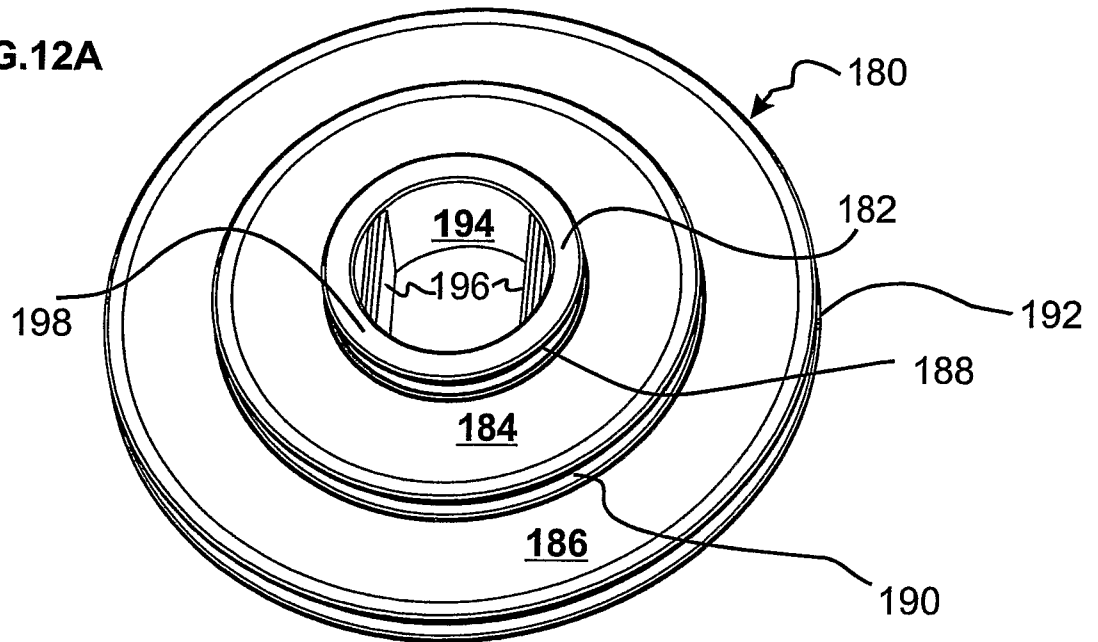
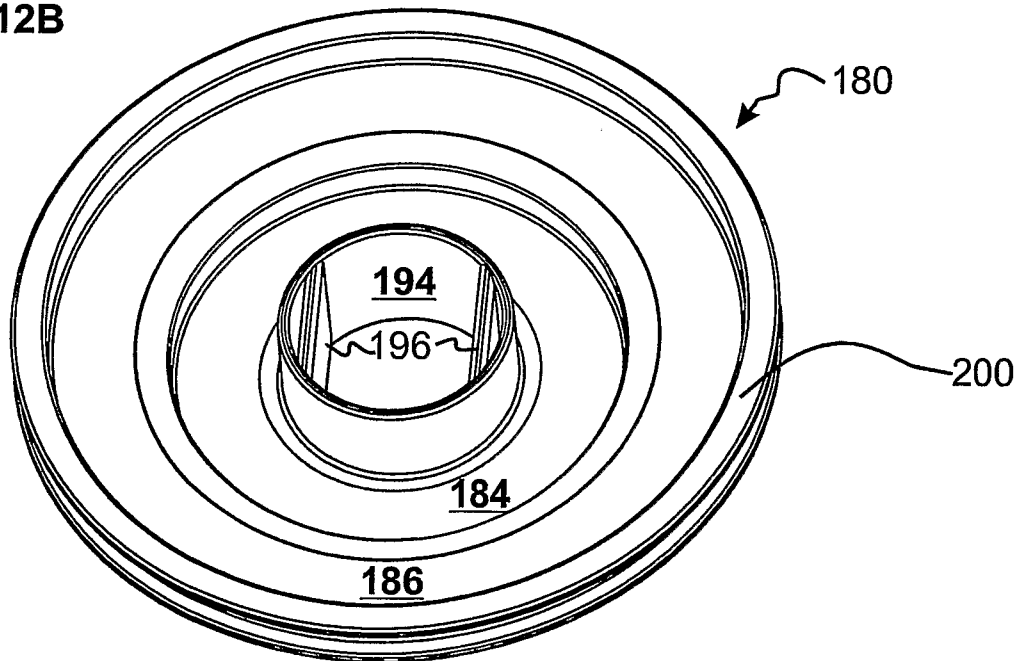


FIG.12B



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FIG.13A

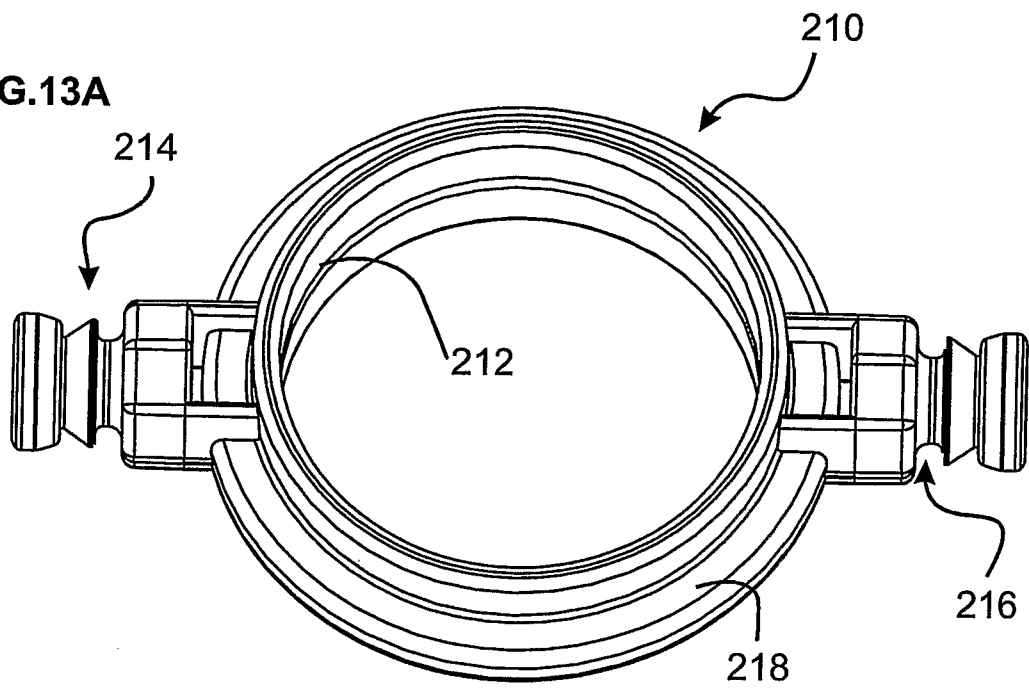
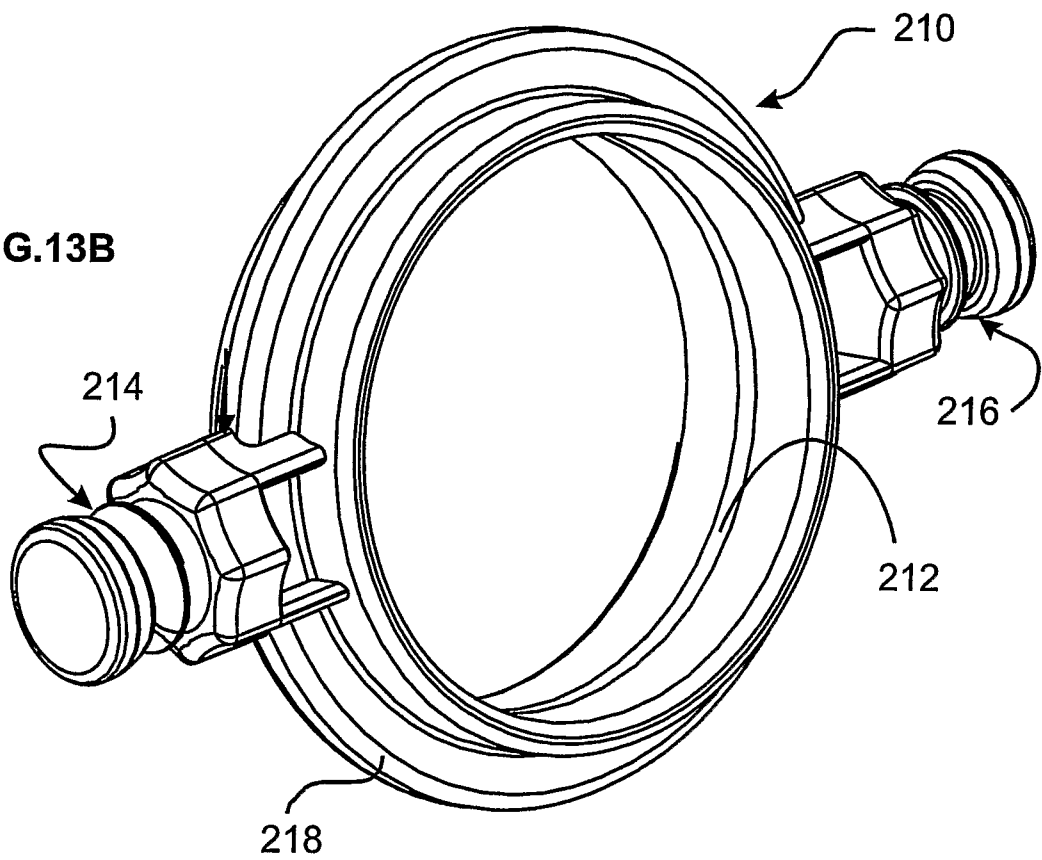


FIG.13B



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FIG.14A

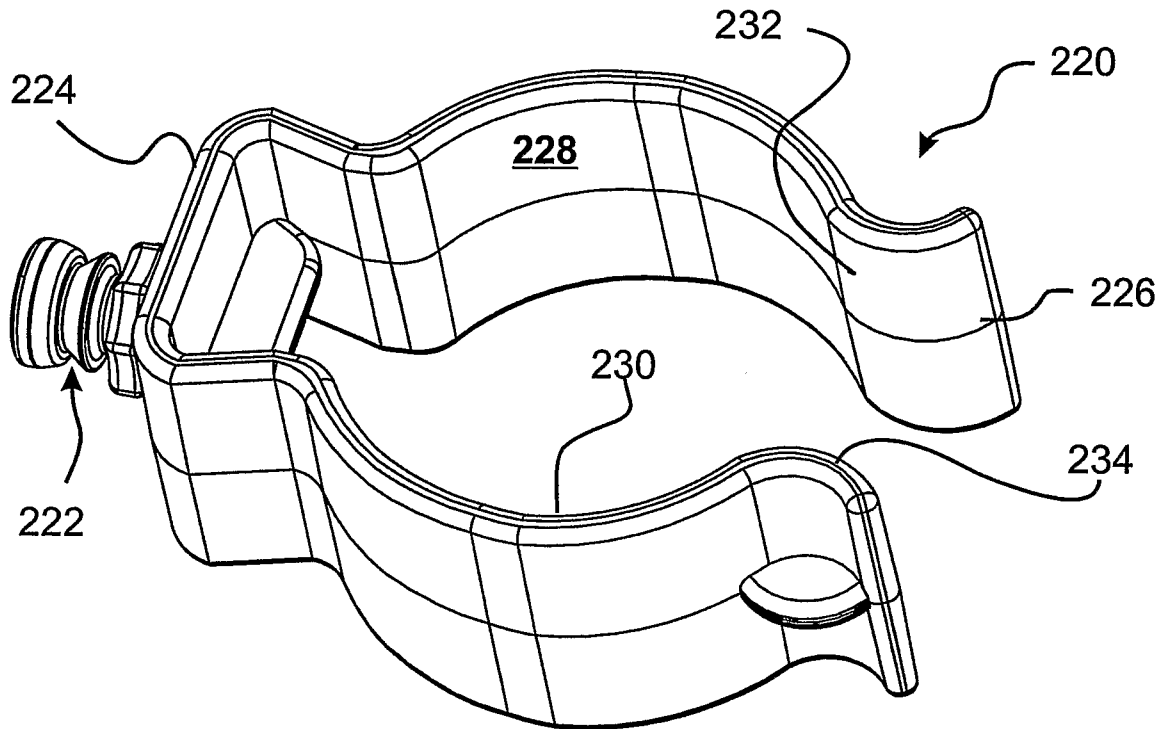
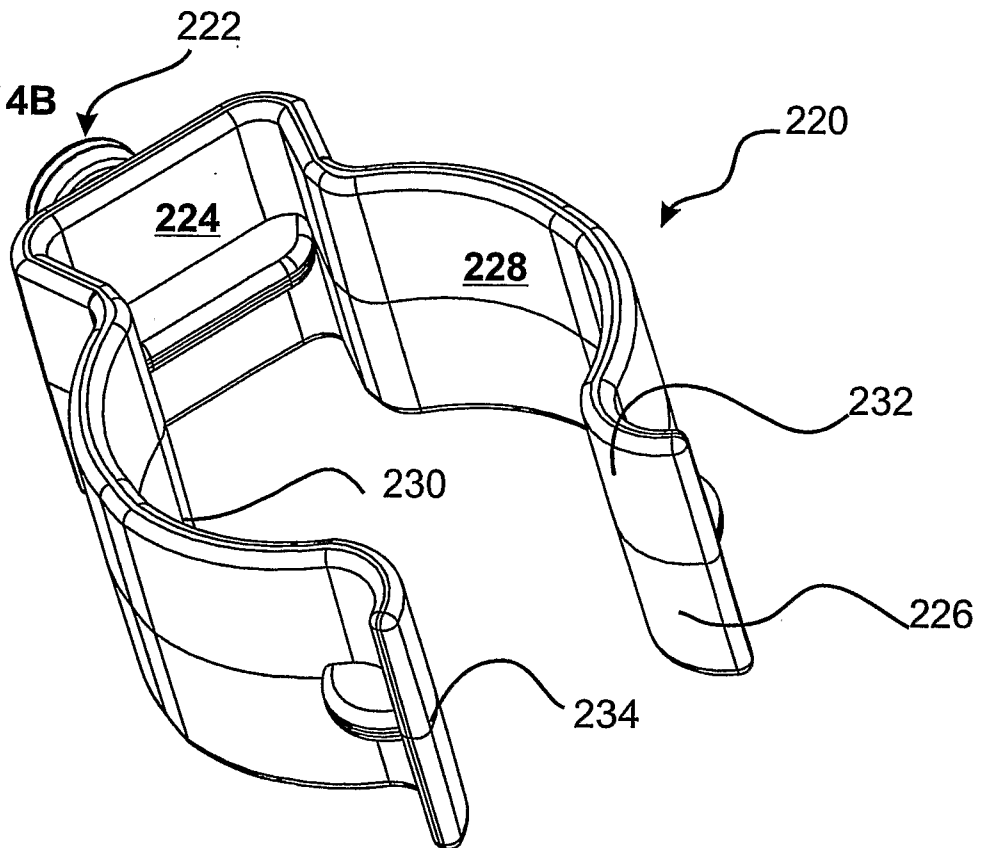


FIG.14B



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FIG.13C

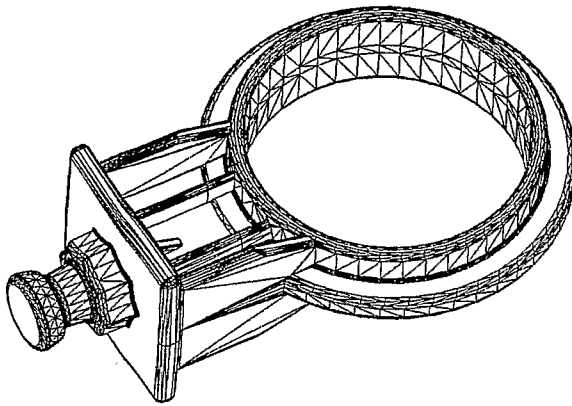


FIG.13D

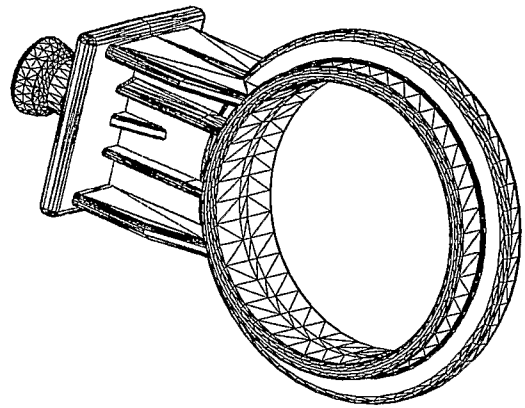


FIG.15C

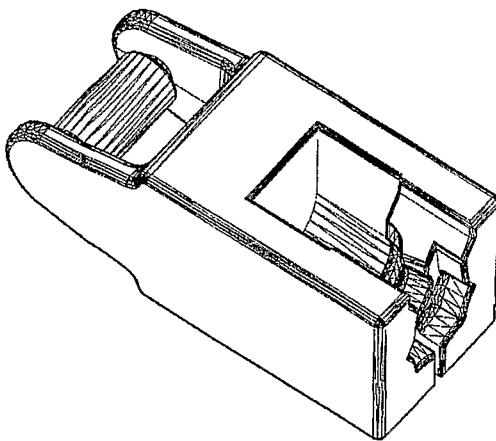


FIG.15D

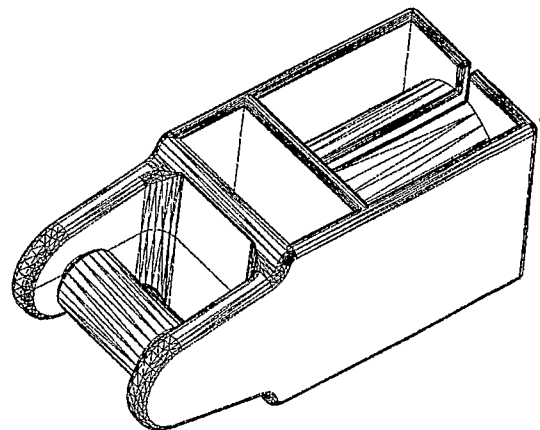


FIG.16C

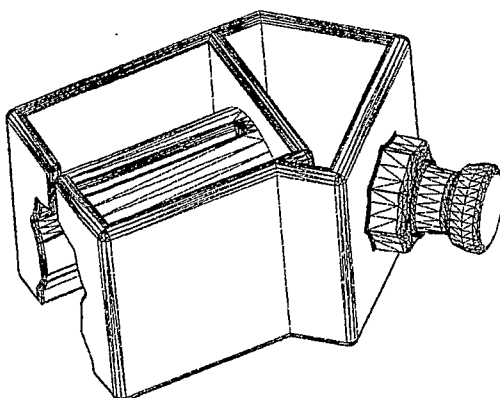
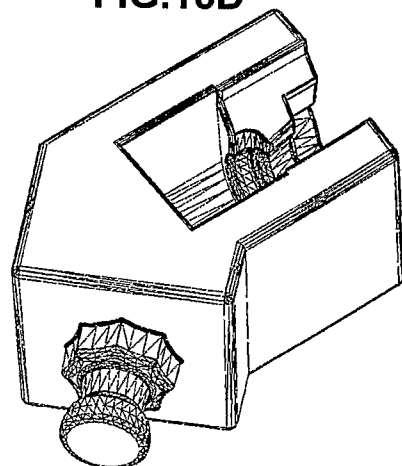


FIG.16D



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FIG.15A

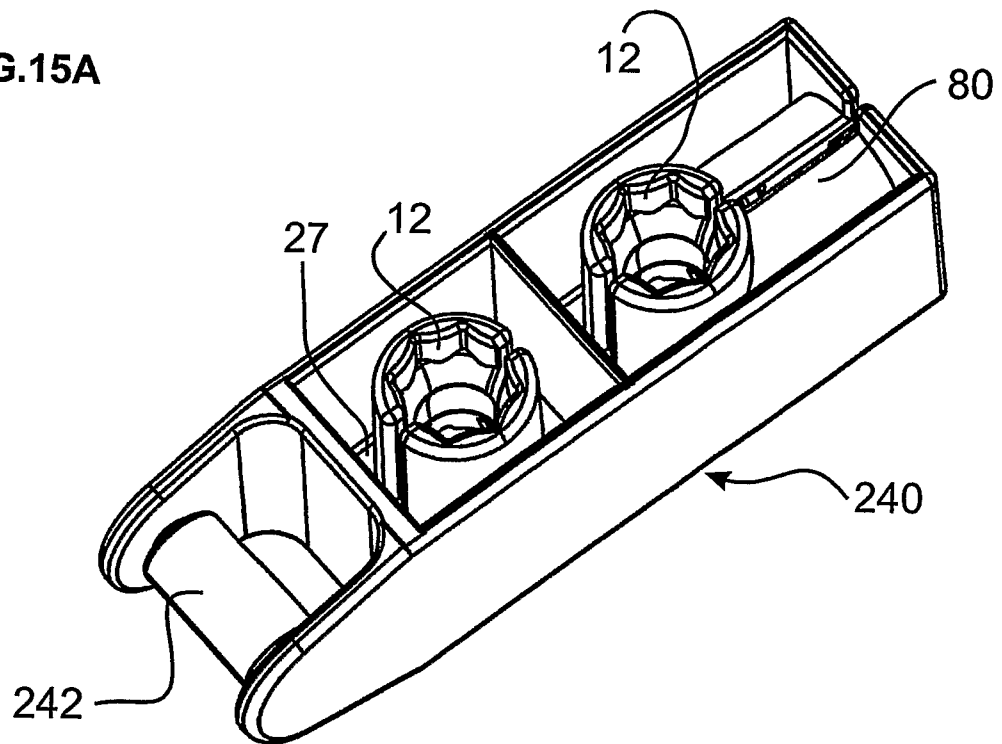
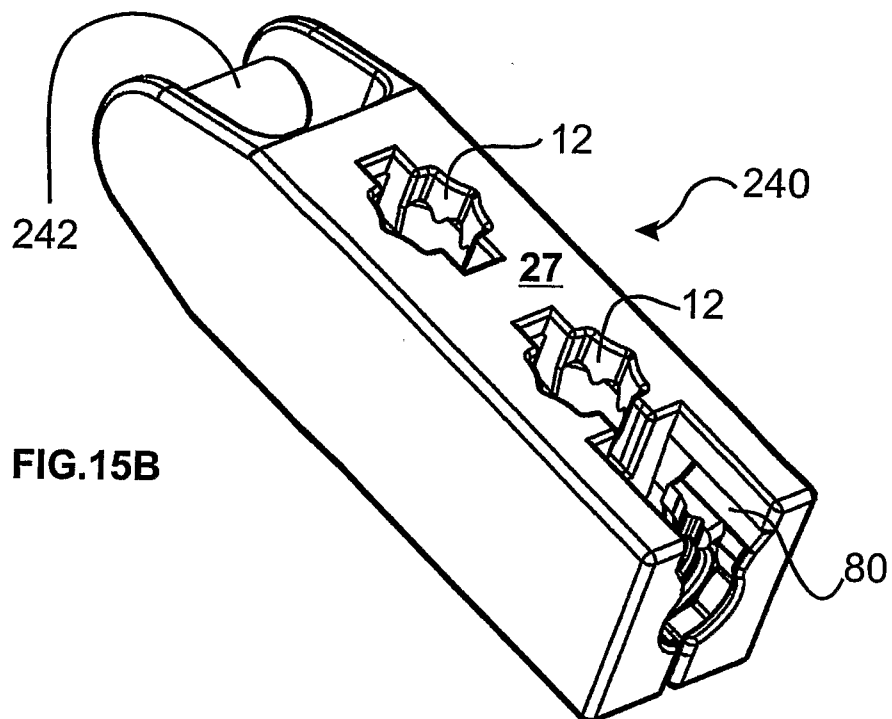


FIG.15B



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FIG.16A

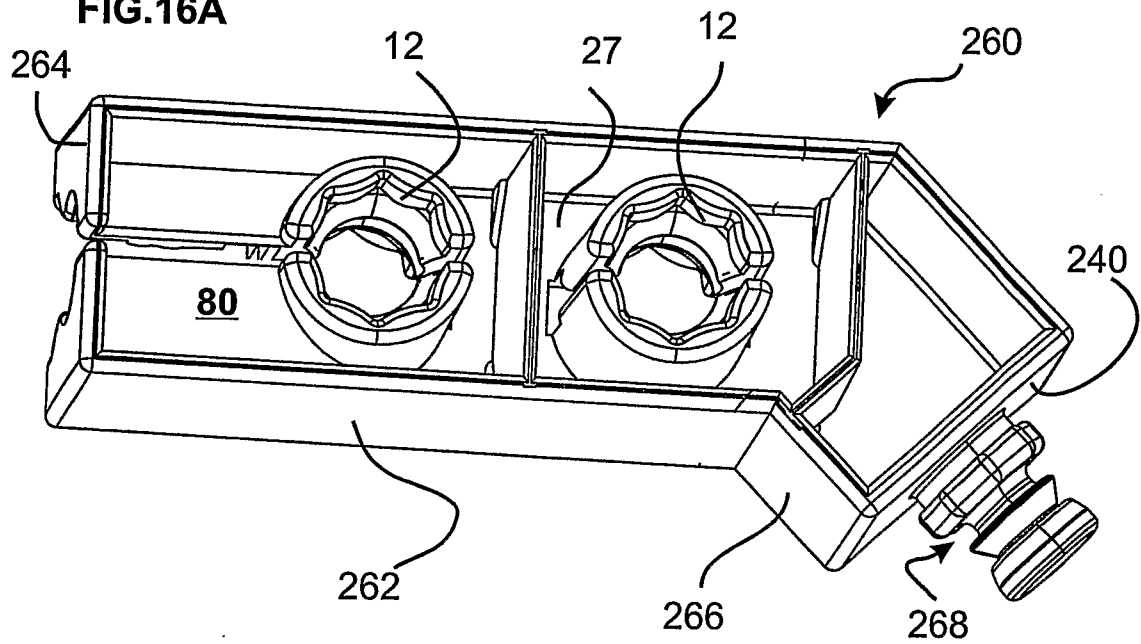
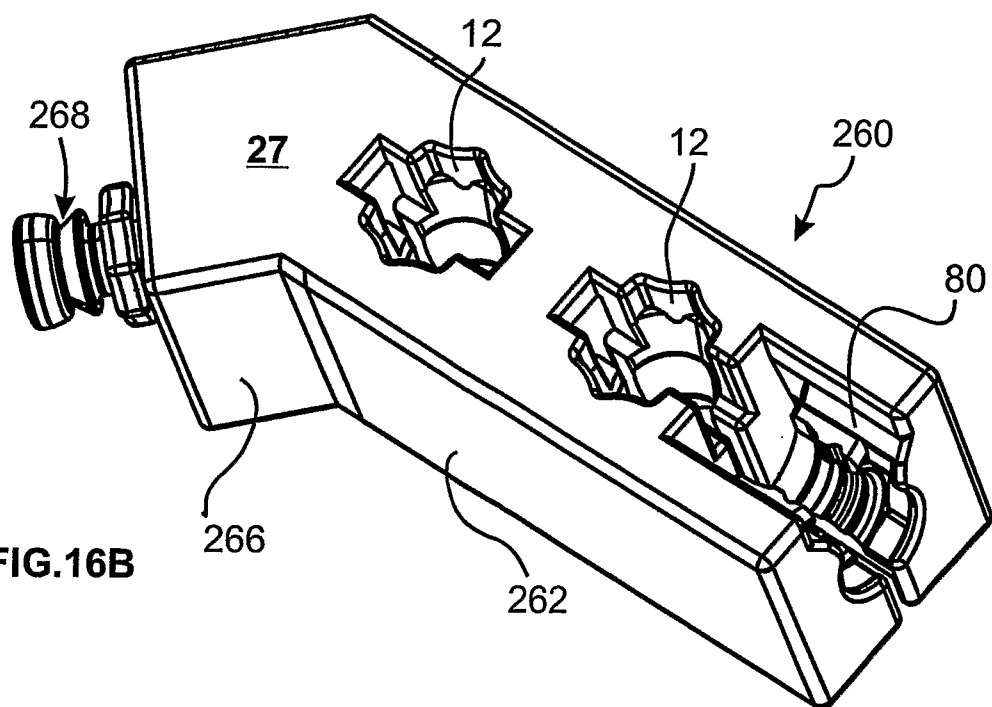


FIG.16B



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FIG.17A

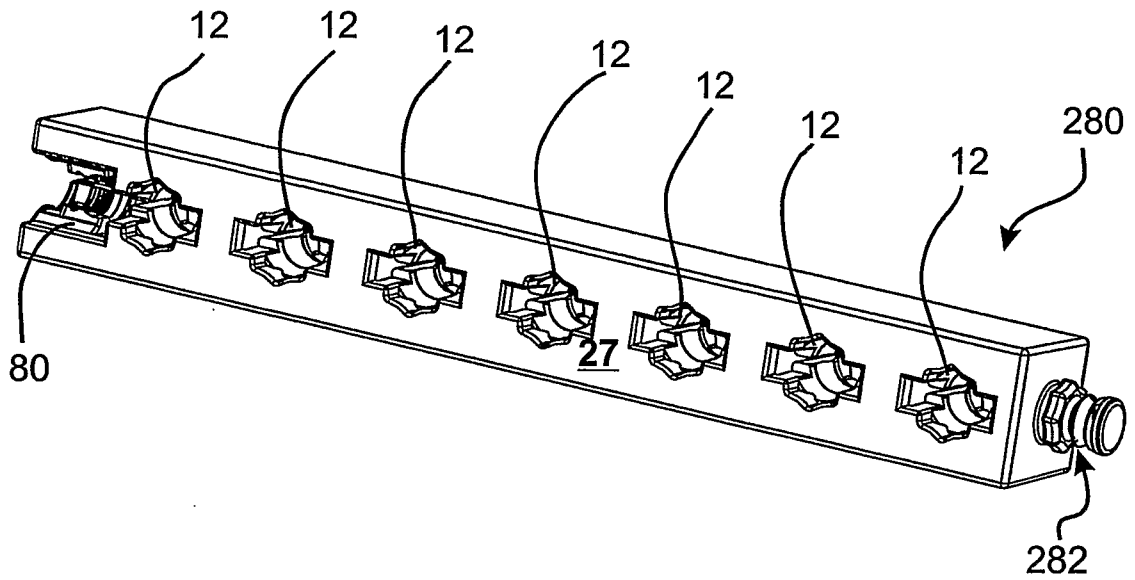
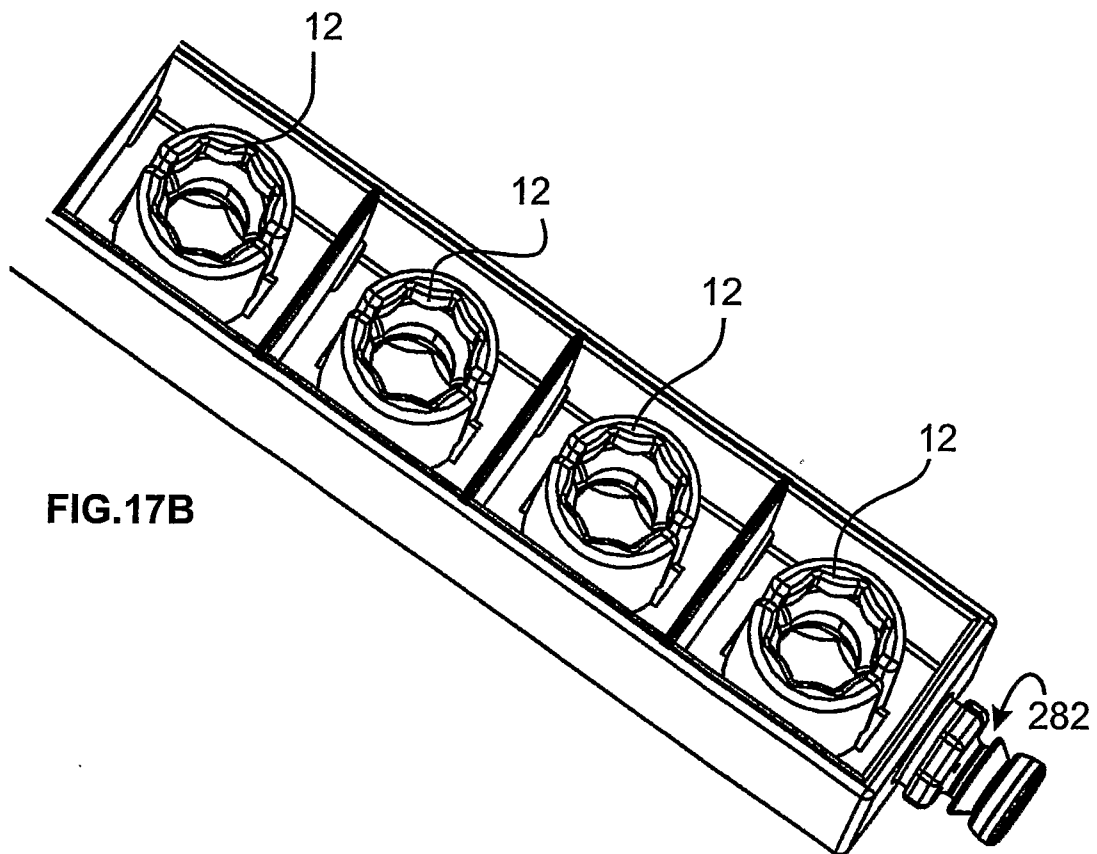


FIG.17B



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FIG.17C

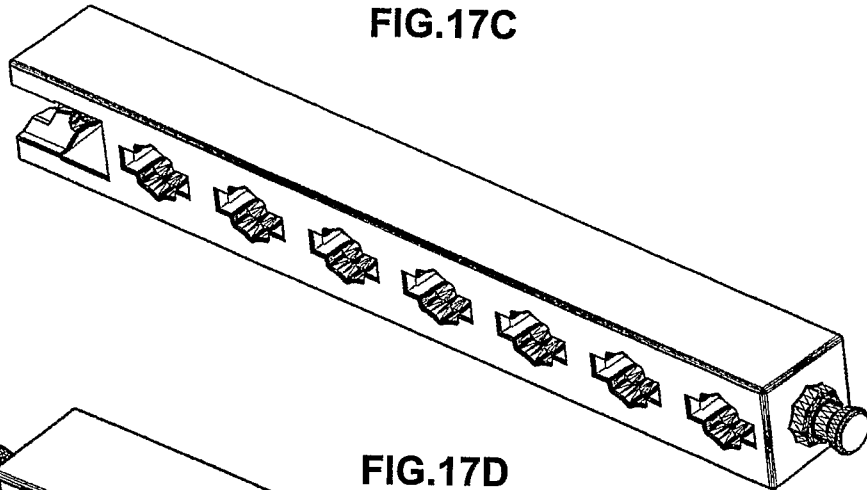


FIG.17D

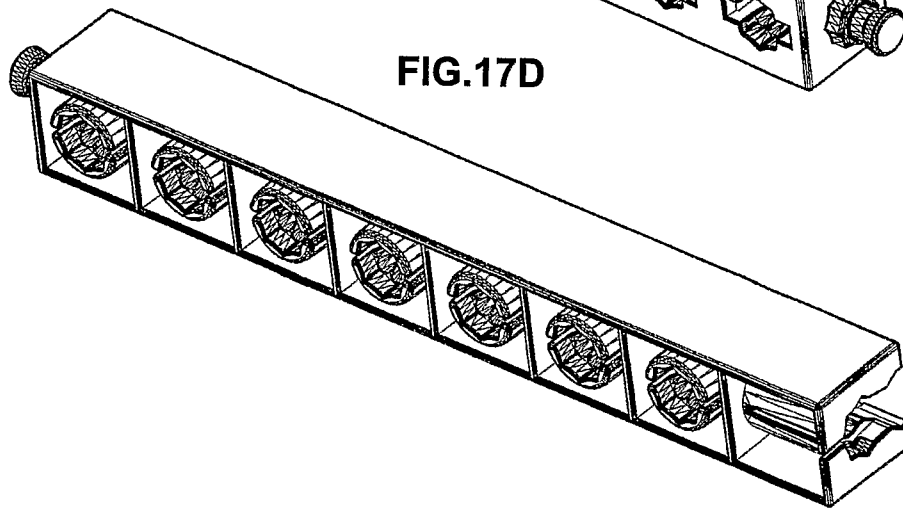


FIG.17E

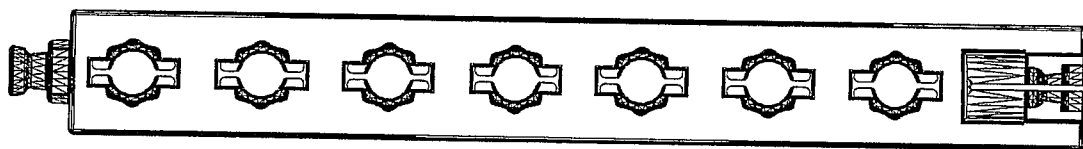
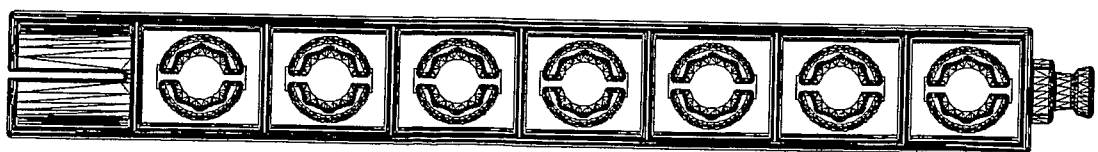


FIG.17F



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FIG.18A

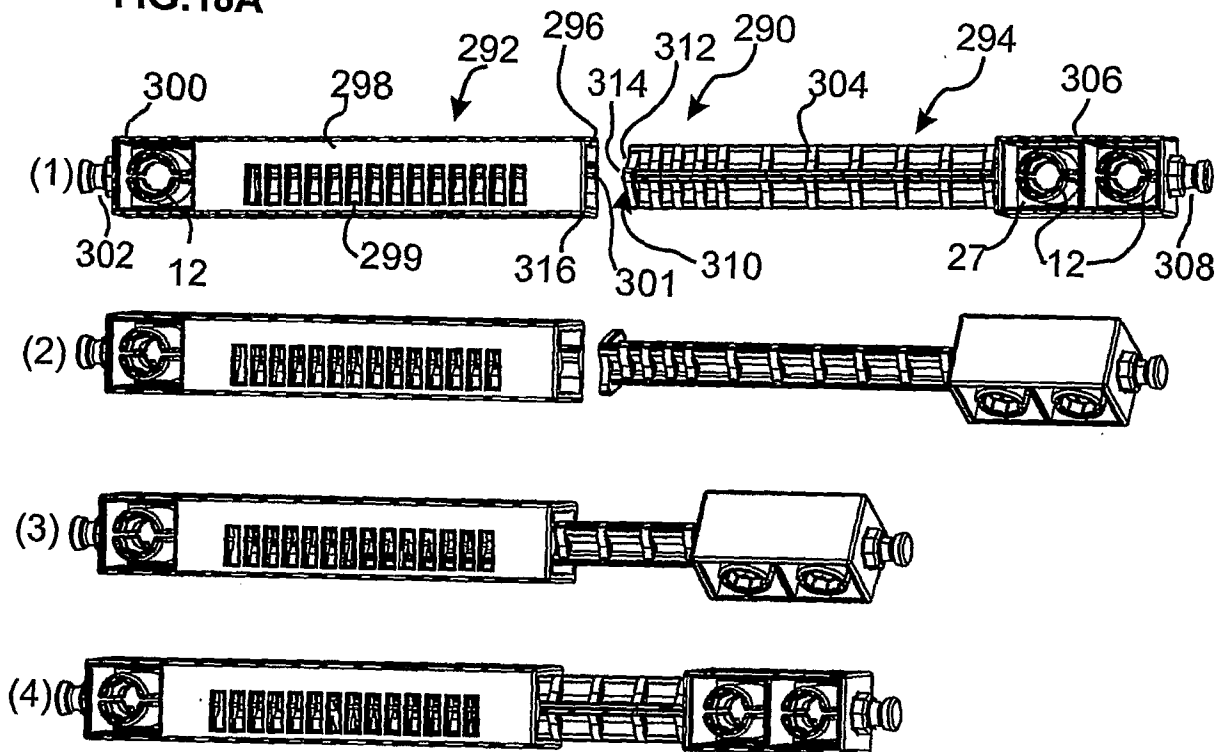
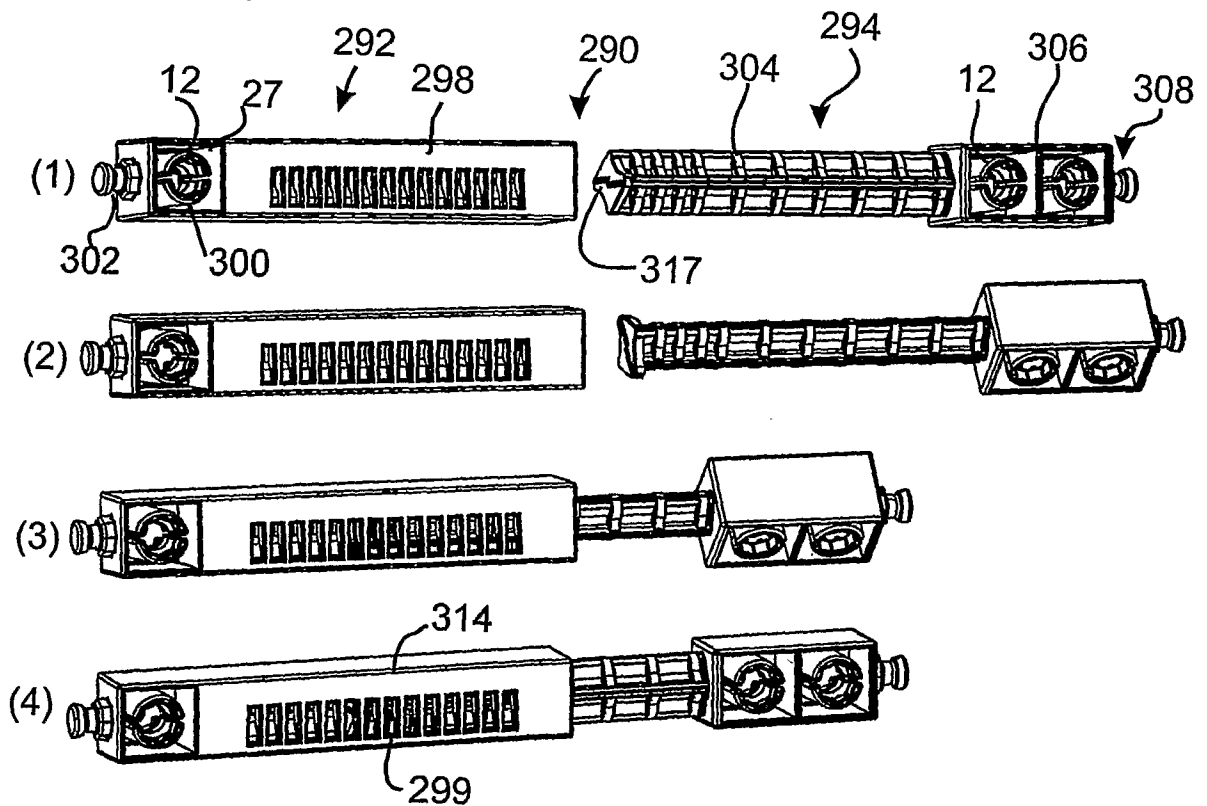


FIG.18B



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FIG.18C

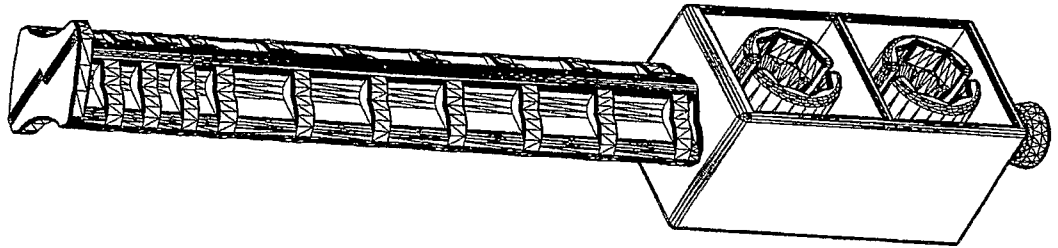


FIG.18D

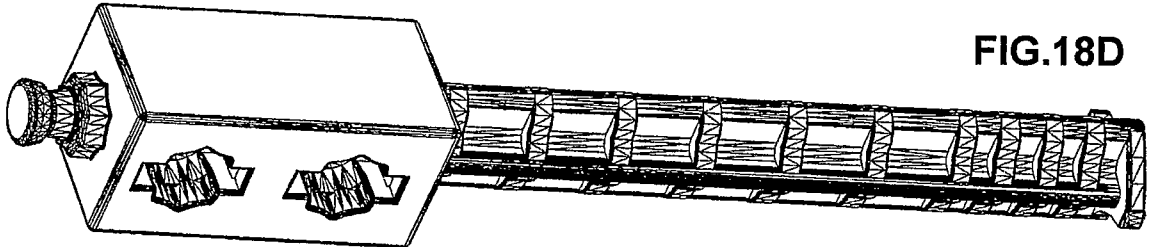


FIG.18E

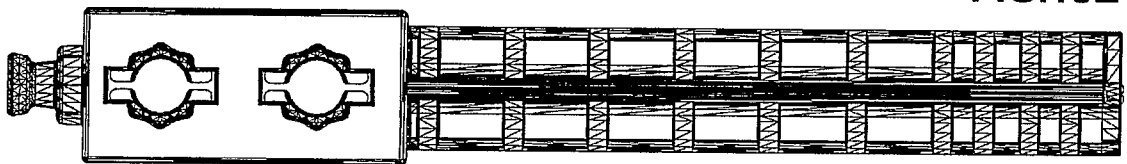


FIG.18F

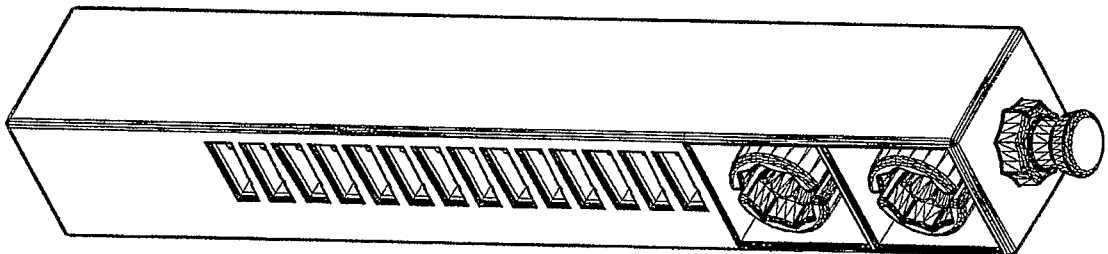


FIG.18G

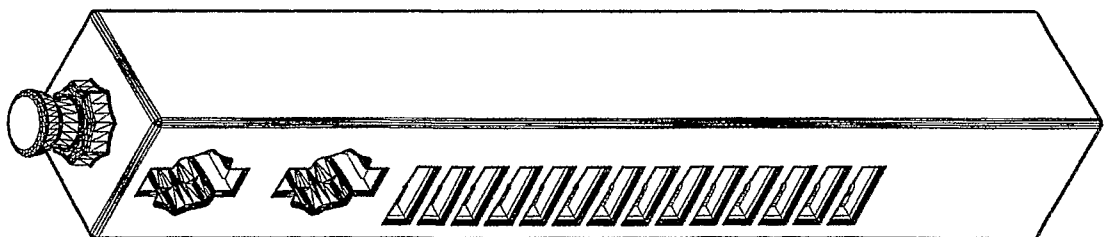
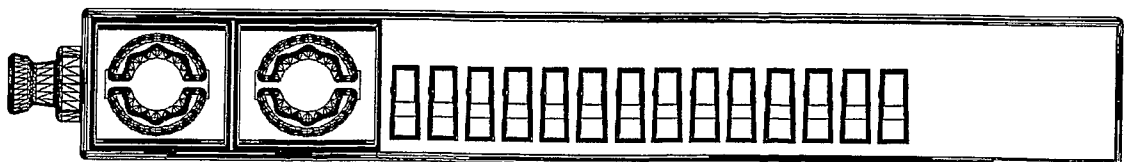


FIG.18H



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FIG.18I

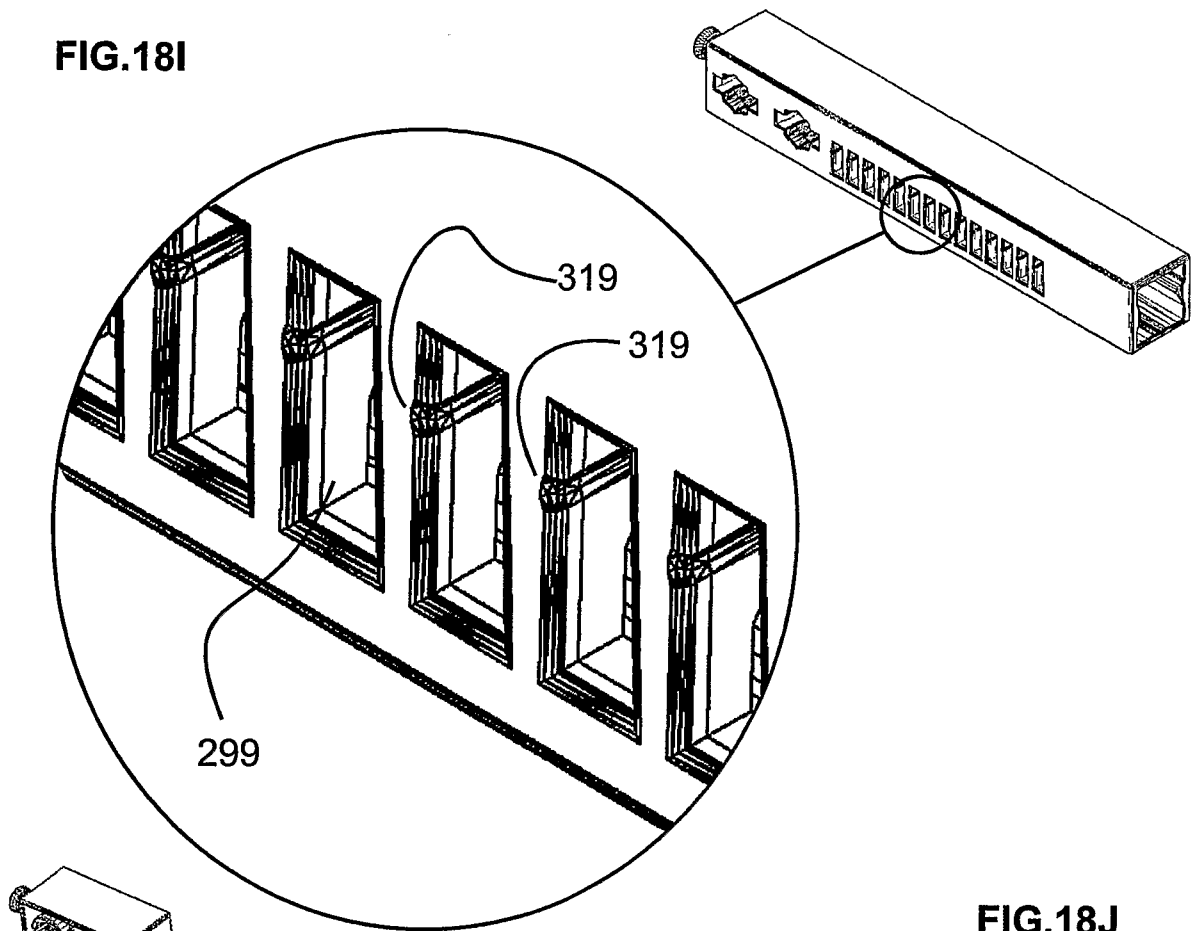
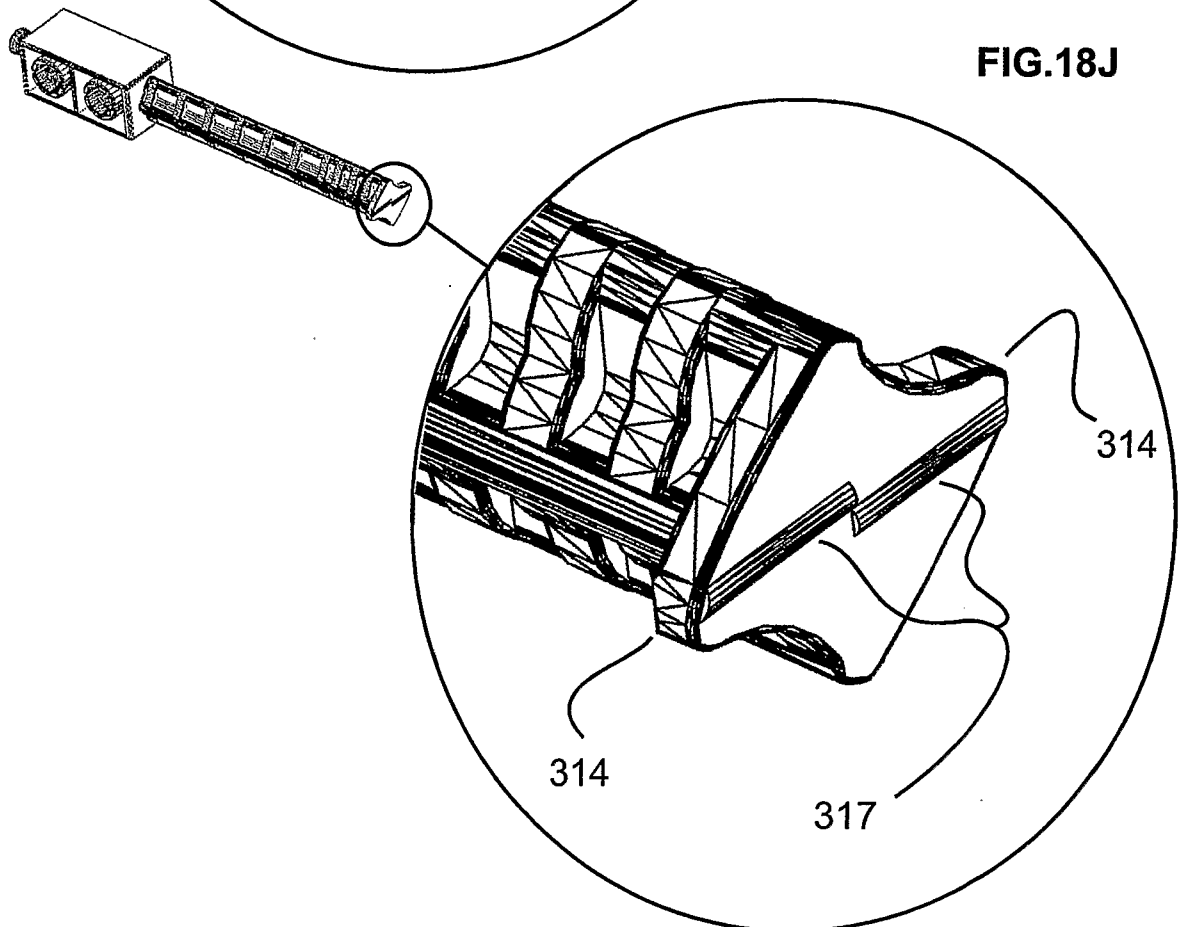


FIG.18J



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FIG.19A

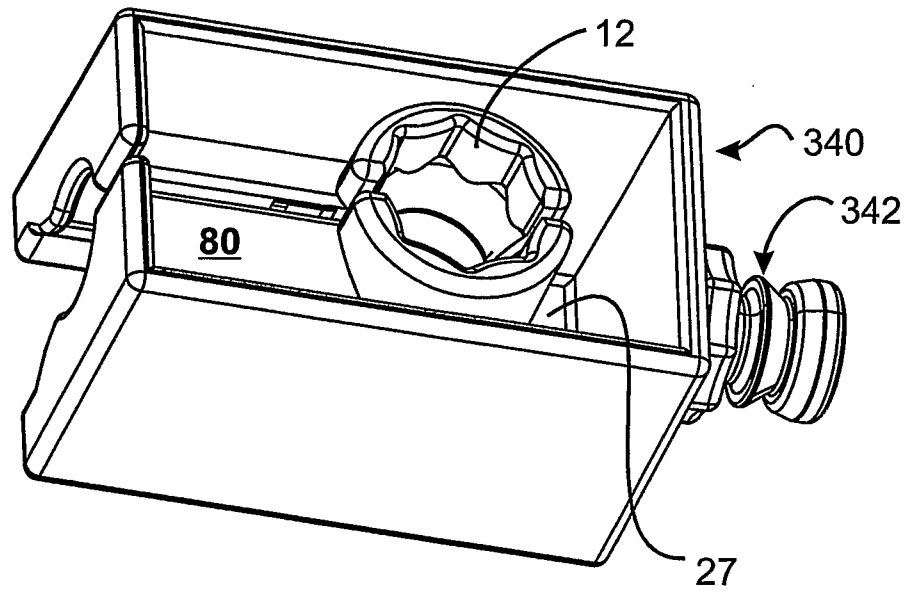
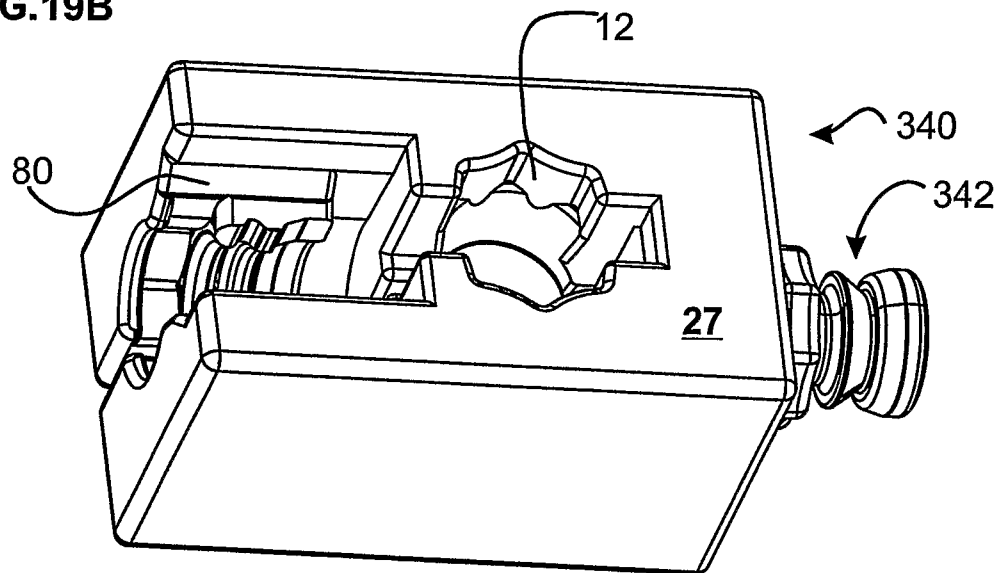


FIG.19B



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FIG.20A

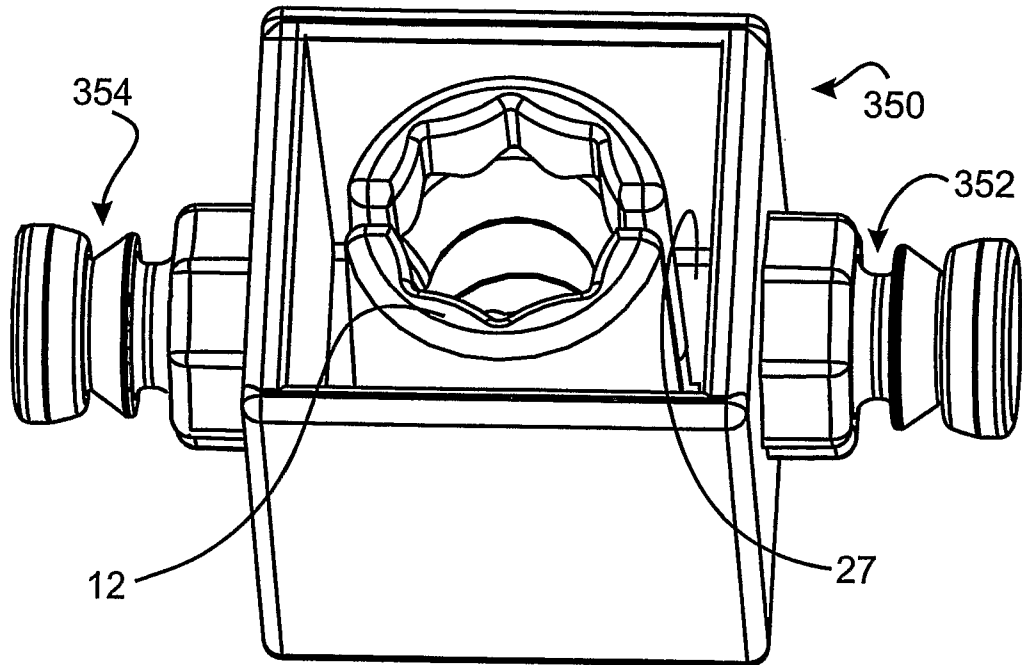
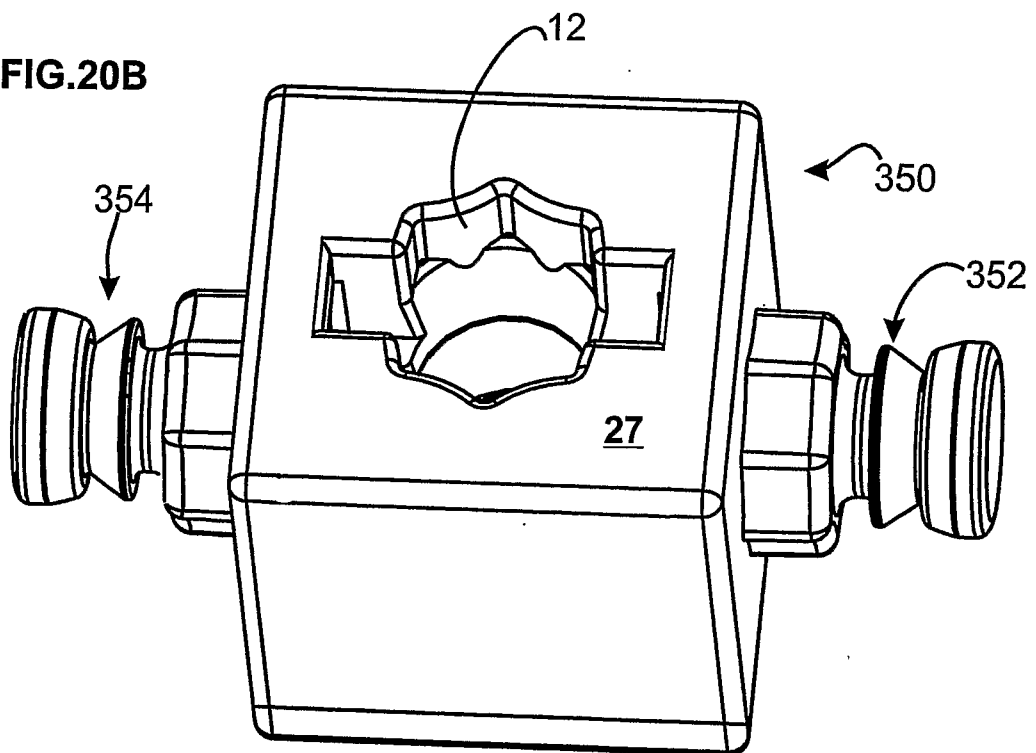


FIG.20B



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FIG.21A

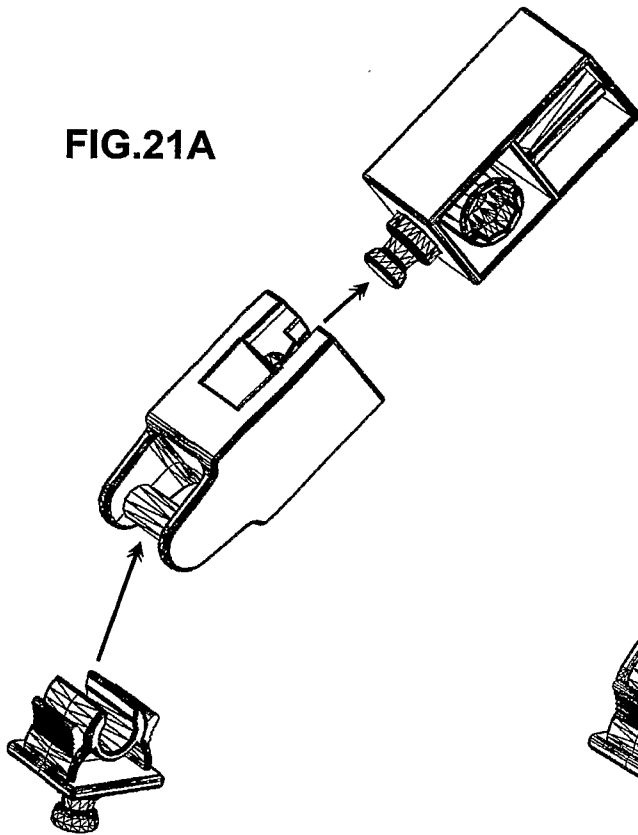


FIG.21B

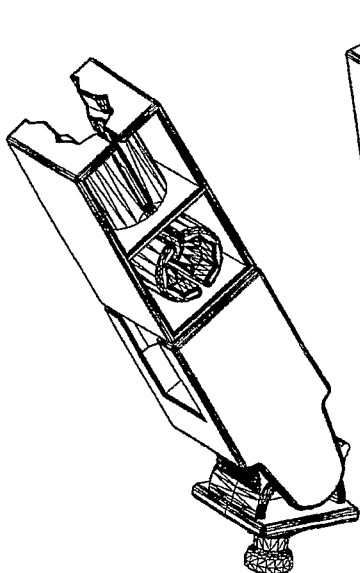
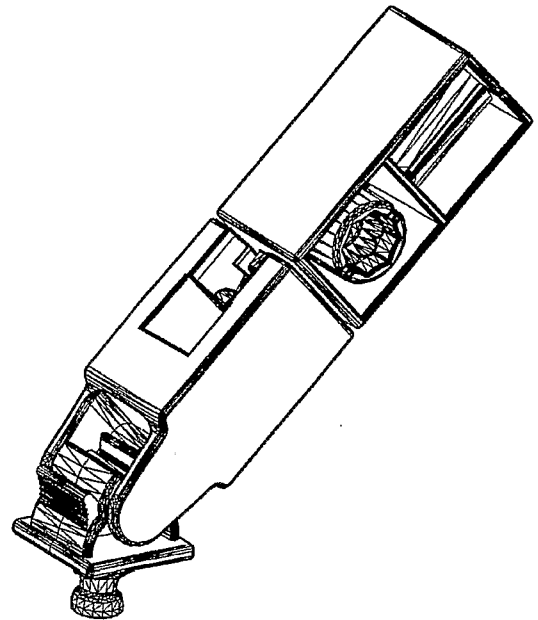


FIG.21C

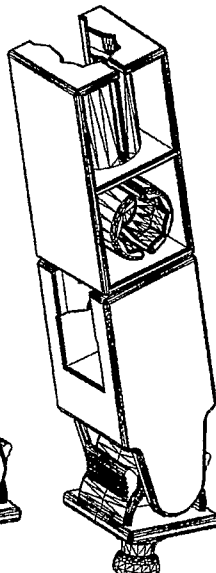


FIG.21D

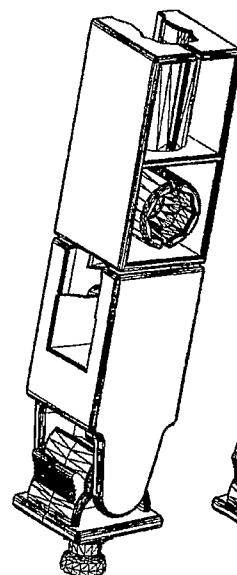


FIG.21E

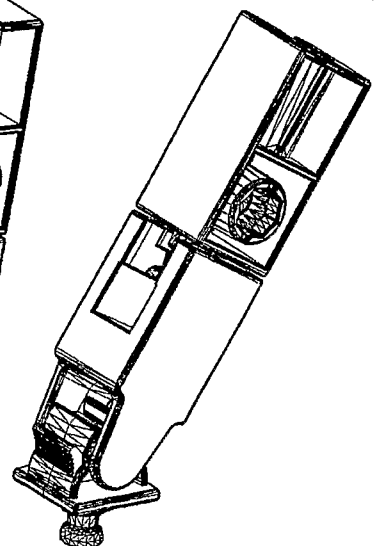


FIG.21F

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FIG.22A FIG.22B FIG.22C FIG.22D FIG.22E FIG.22F

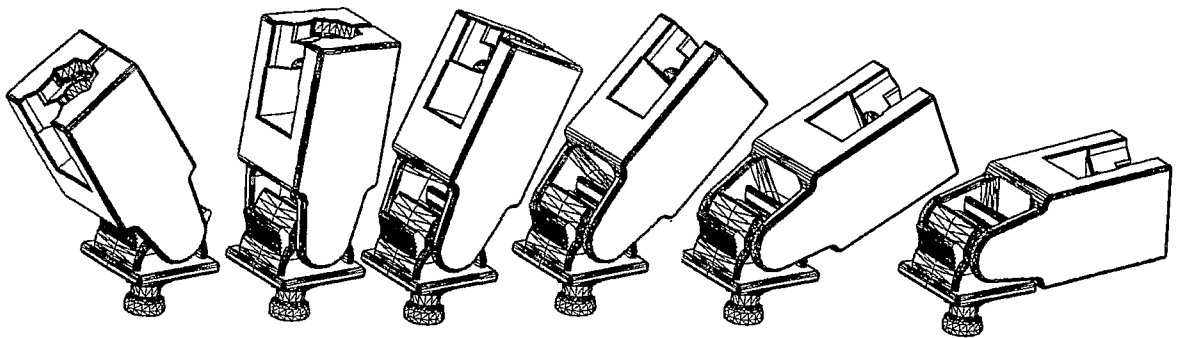


FIG.23A

FIG.23B

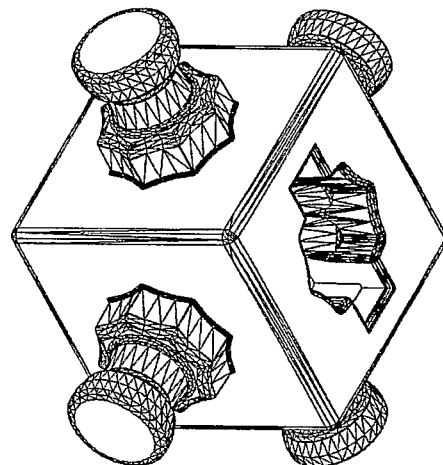
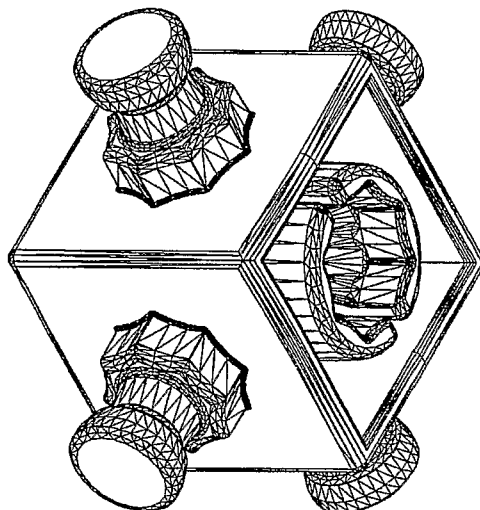


FIG.23C

FIG.23D

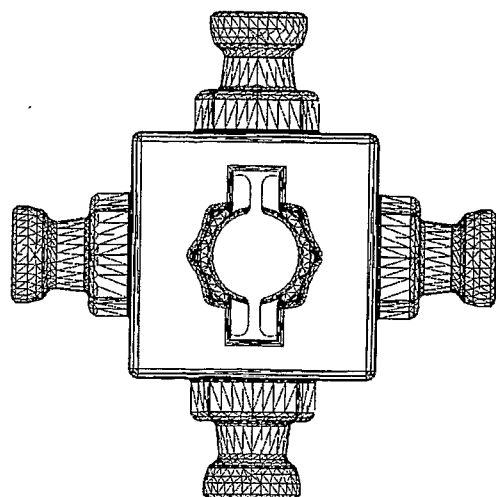
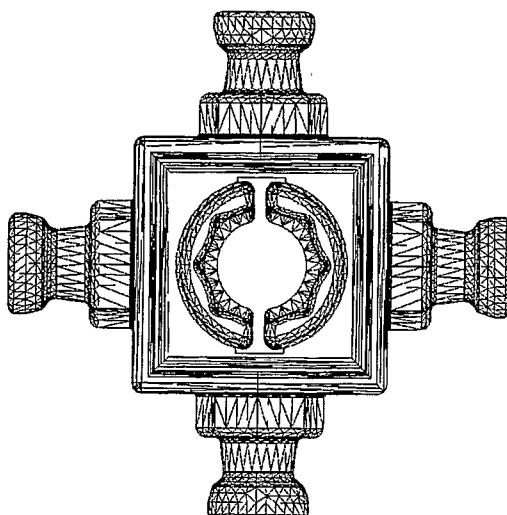


FIG.24A

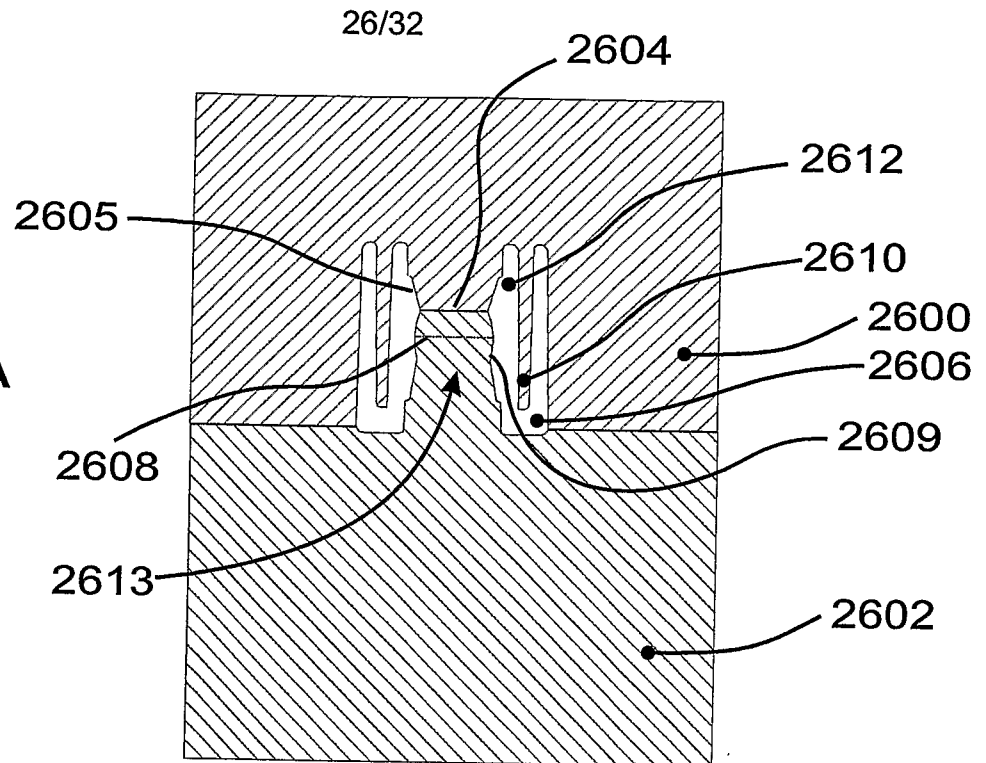
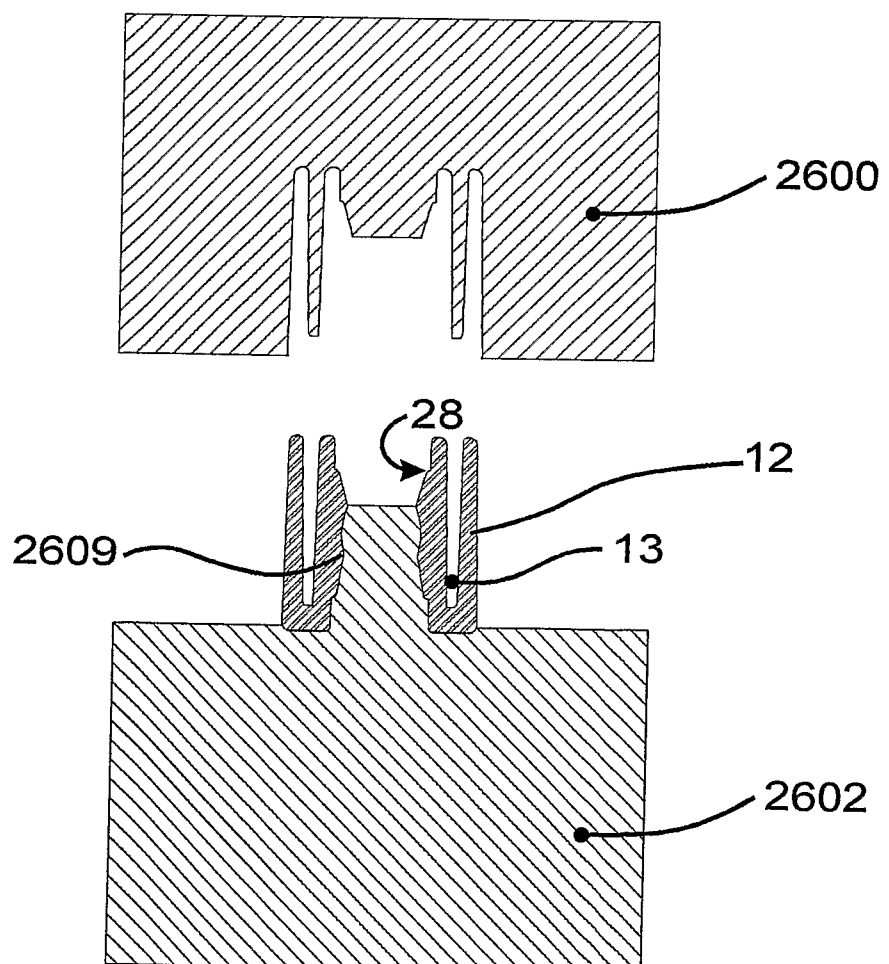


FIG.24B



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FIG.25A

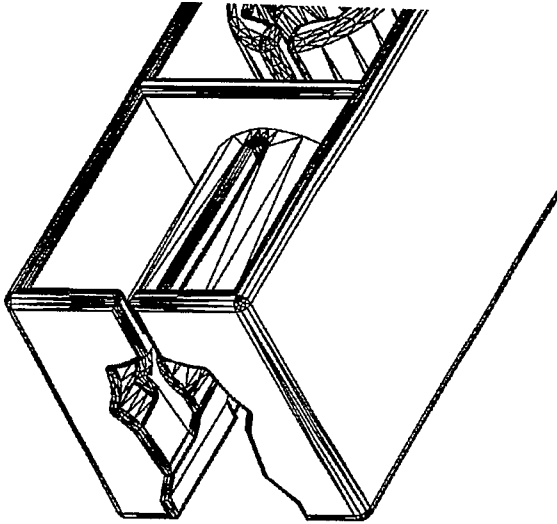


FIG.25B

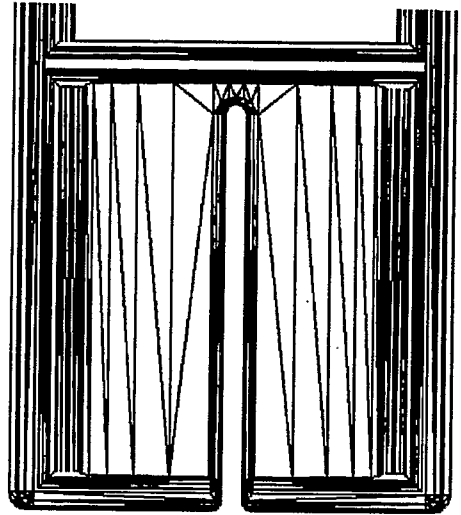


FIG.25C

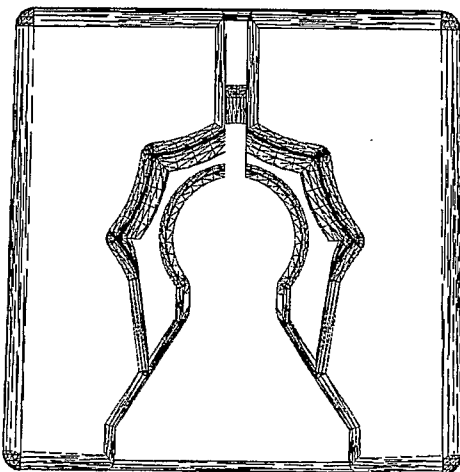
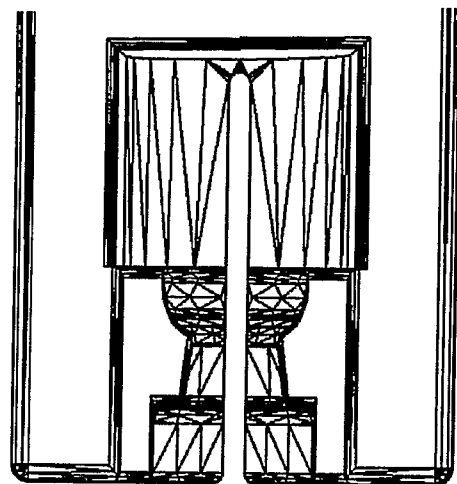


FIG.25D



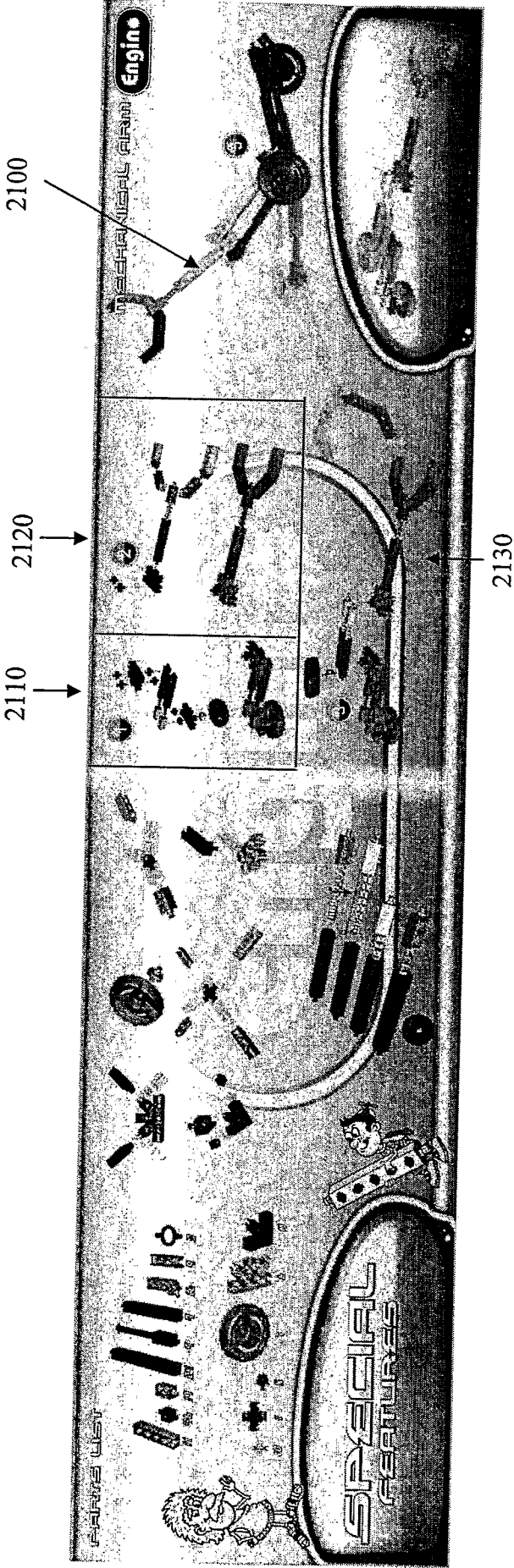


FIG. 26

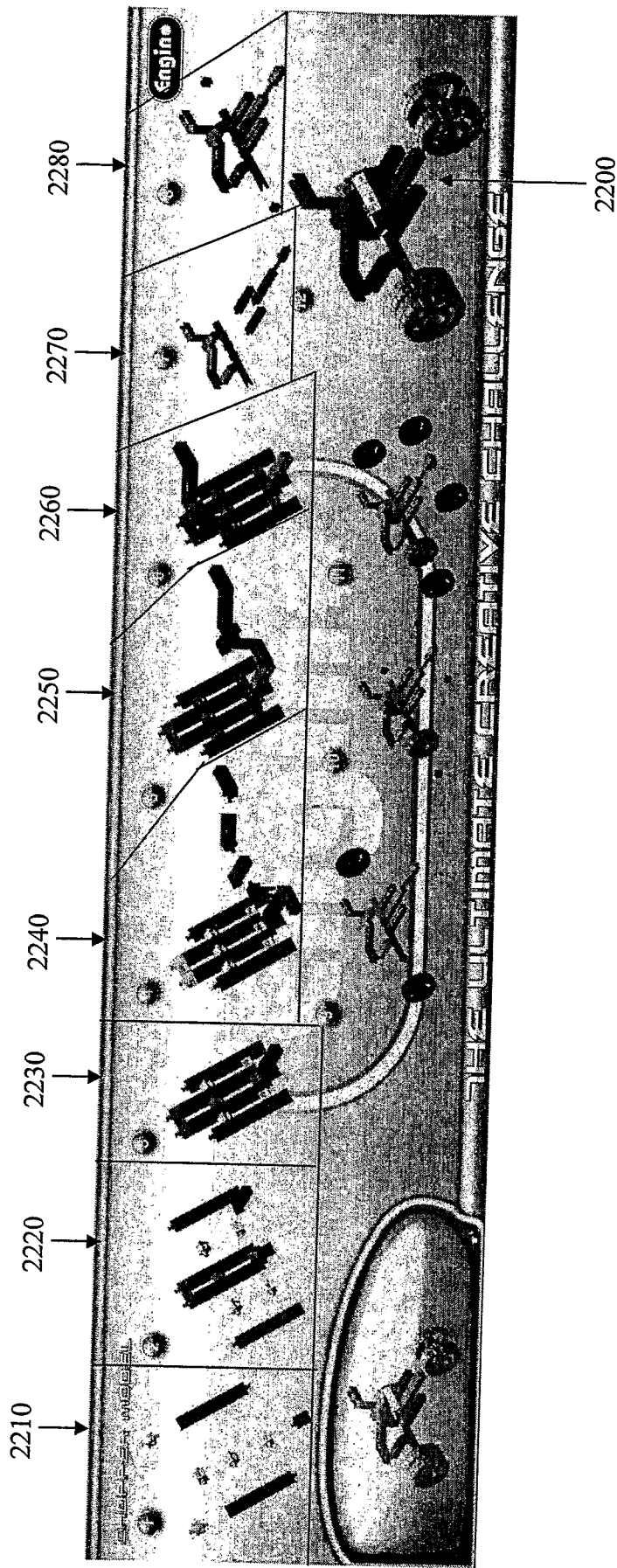
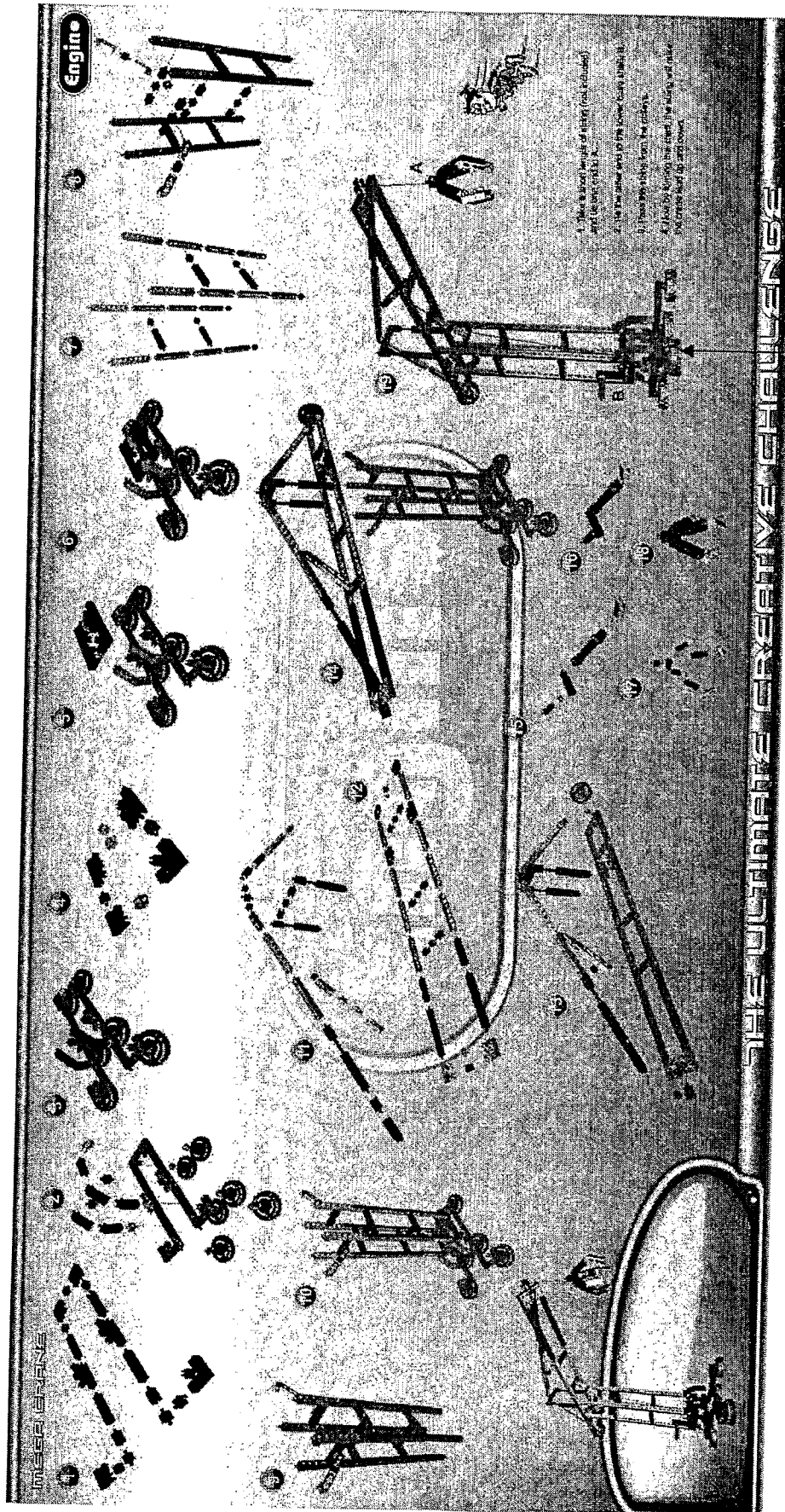


FIG. 27



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FIG. 28

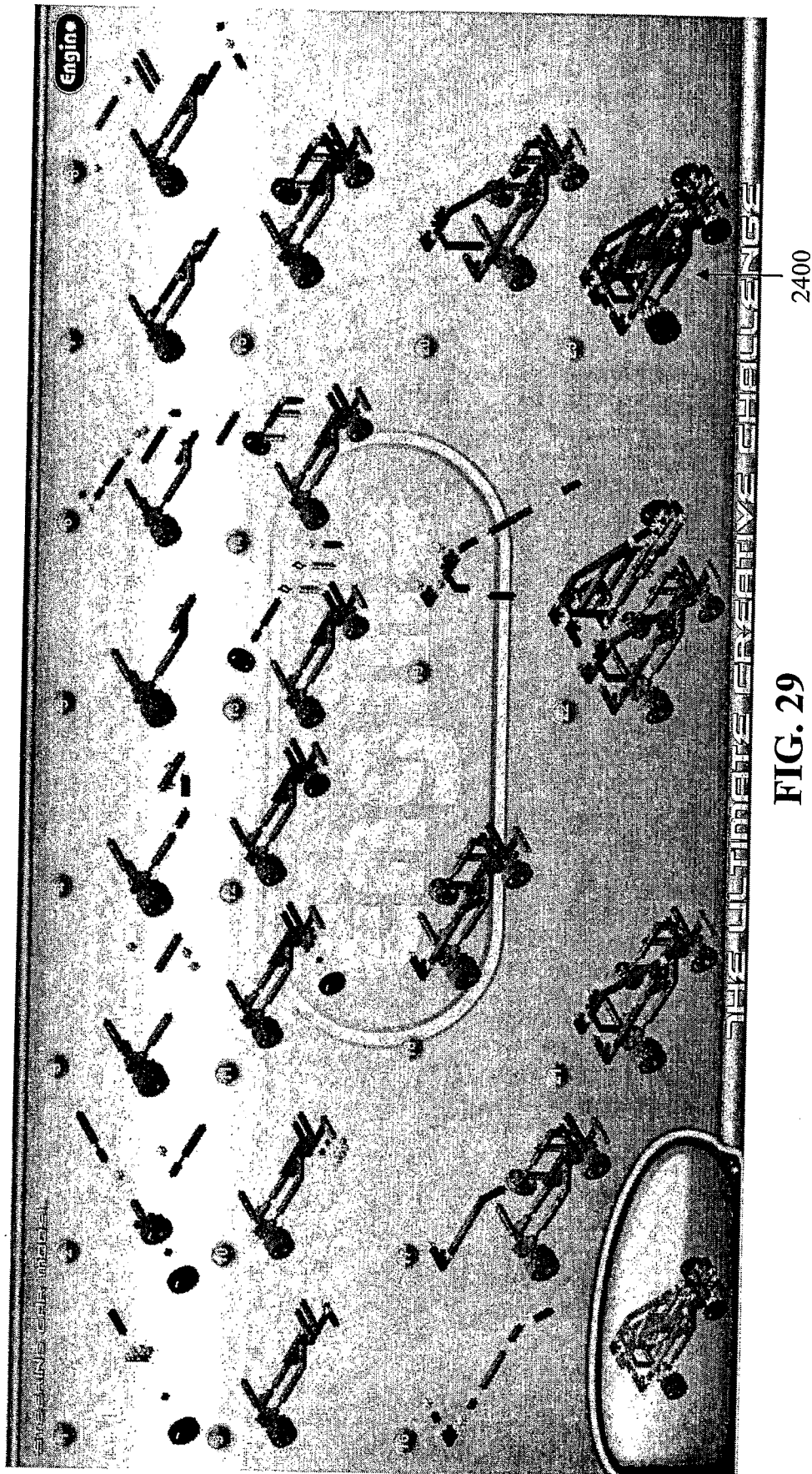


FIG. 29



FIG. 30