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(54) **PNEUMATICALLY ACTUATED BELTLESS CONVEYOR**

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(60) Provisional application No. 60/195,929, filed on Apr. 10, 2000.

(51) **Int. Cl.**  
**B65G 25/04** (2006.01)

(52) **U.S. Cl.** ..... **198/750.7; 198/750.1; 198/955**

(58) **Field of Classification Search** ..... **198/750.7, 198/750.1, 750.5, 955**

See application file for complete search history.

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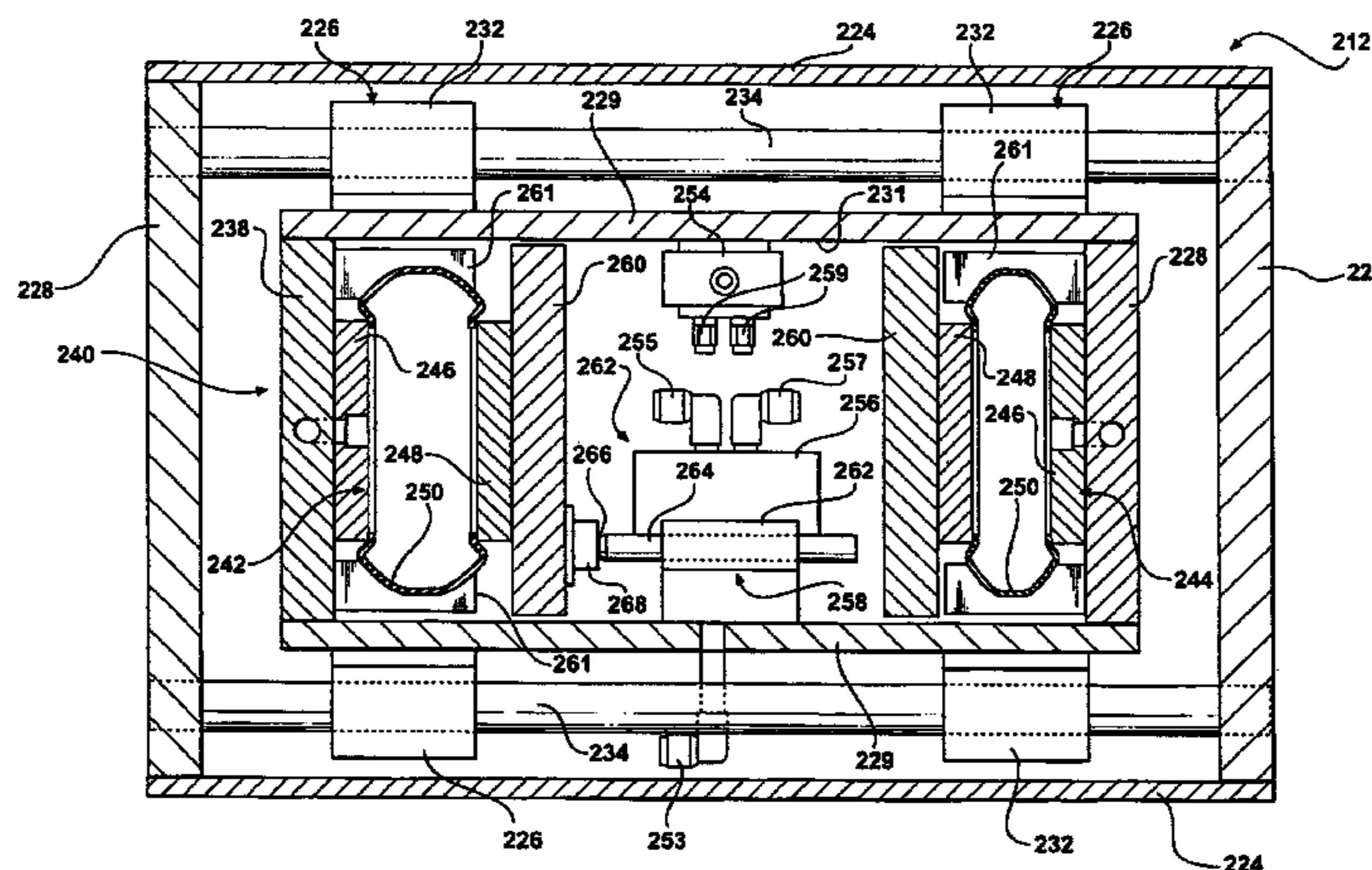
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(57) **ABSTRACT**

A pneumatically actuated, beltless conveyor assembly includes a housing, a drive system supported by the housing and at least one transport tray supported by the housing and operatively connected to the drive system. The drive system includes a seal-less pneumatic engine having at least one pair of opposed, pneumatic drive bellow assemblies. One of the drive bellow assemblies acts to drive the transport tray in one direction at a first predetermined speed to advance materials supported on the transport tray in the direction of the length of the tray. The other of the pair of drive bellow assemblies acts to drive the transport tray in a second direction opposite to the first direction and at a second, predetermined speed that is different from the first predetermined speed such that the transport tray moves relative to the material supported thereon.

**10 Claims, 8 Drawing Sheets**



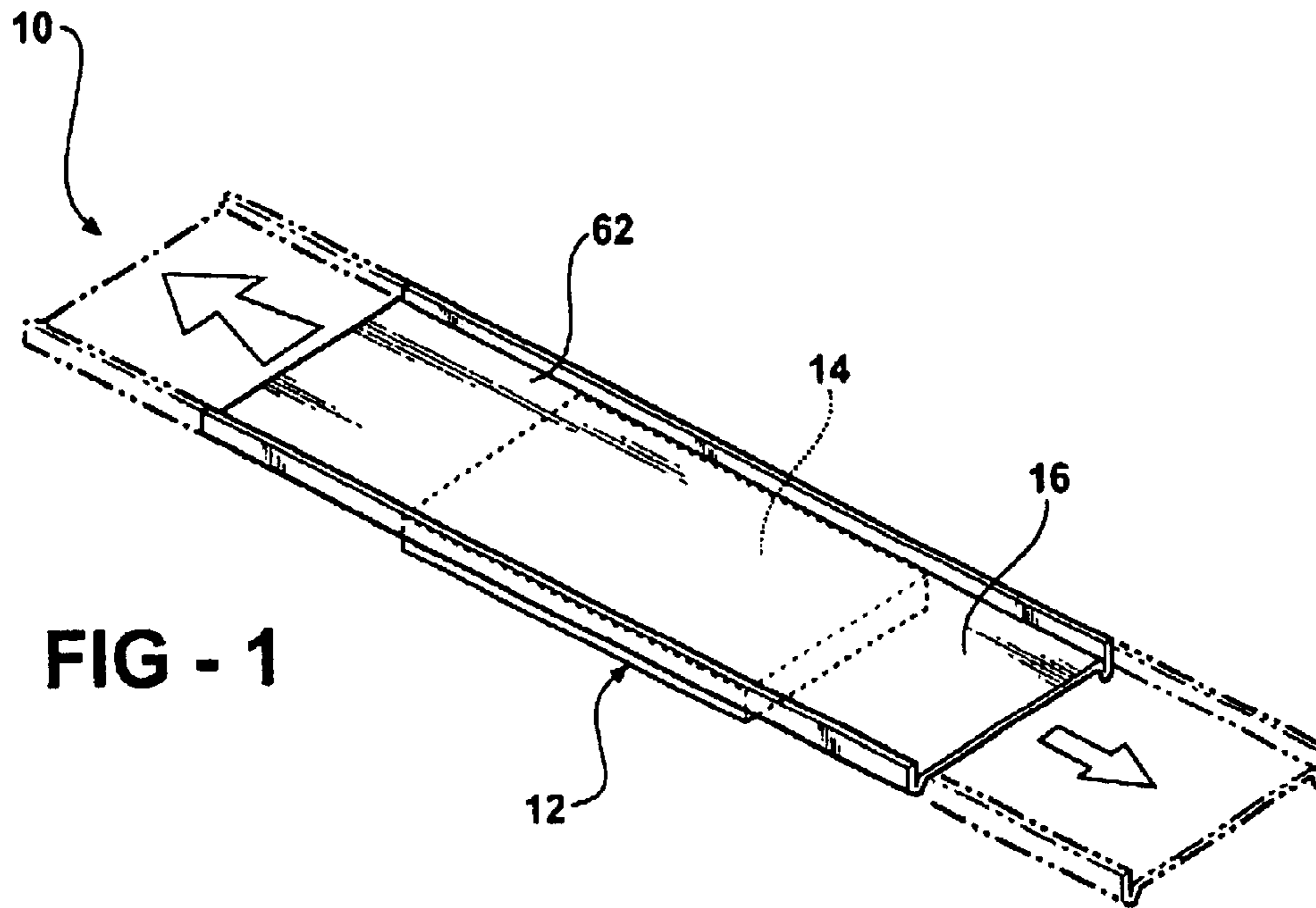


FIG - 1

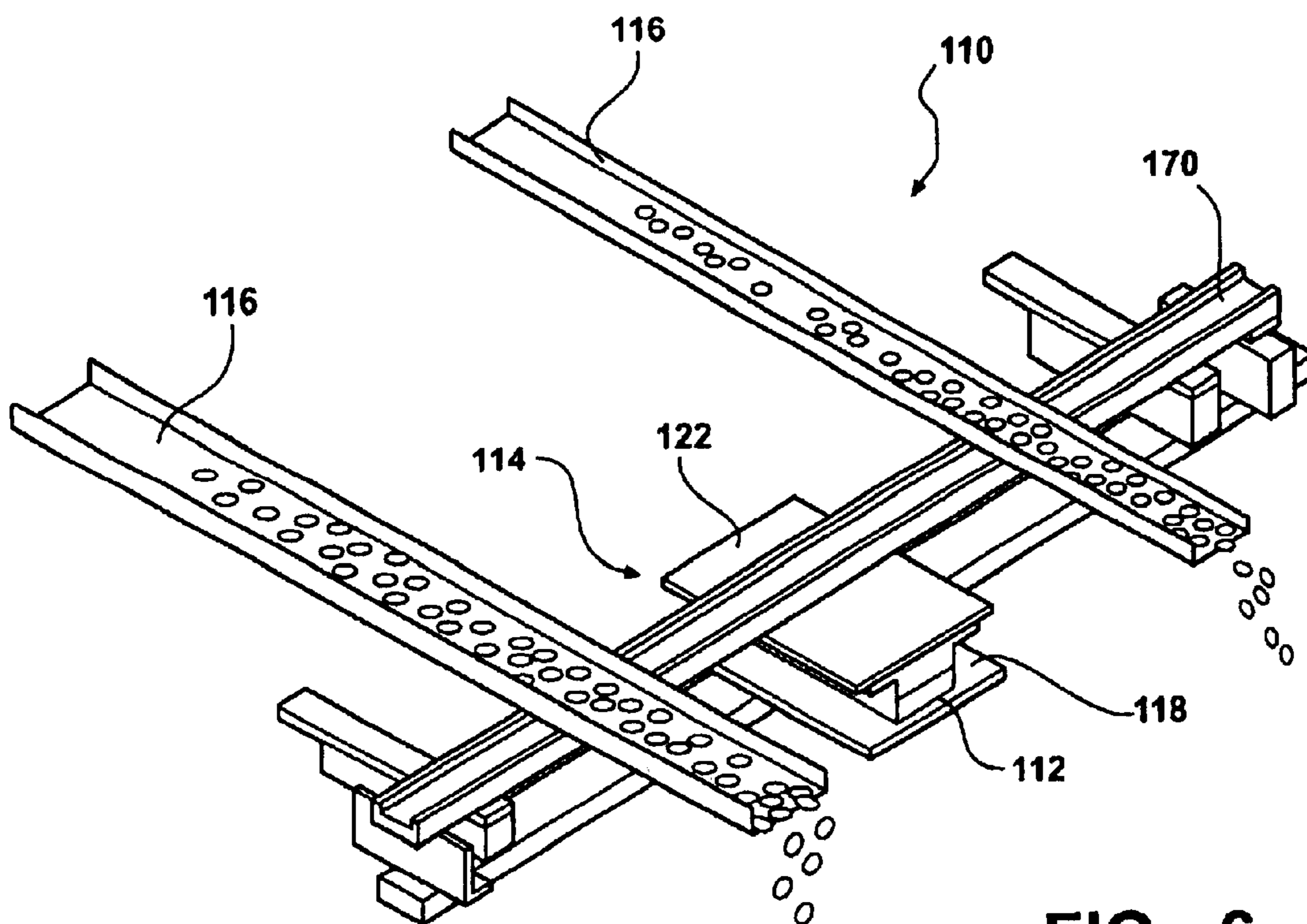
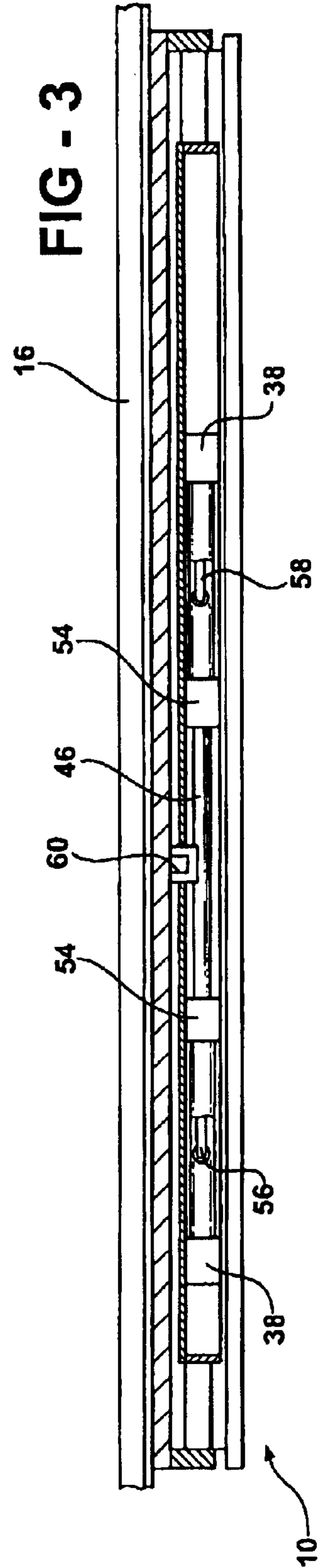
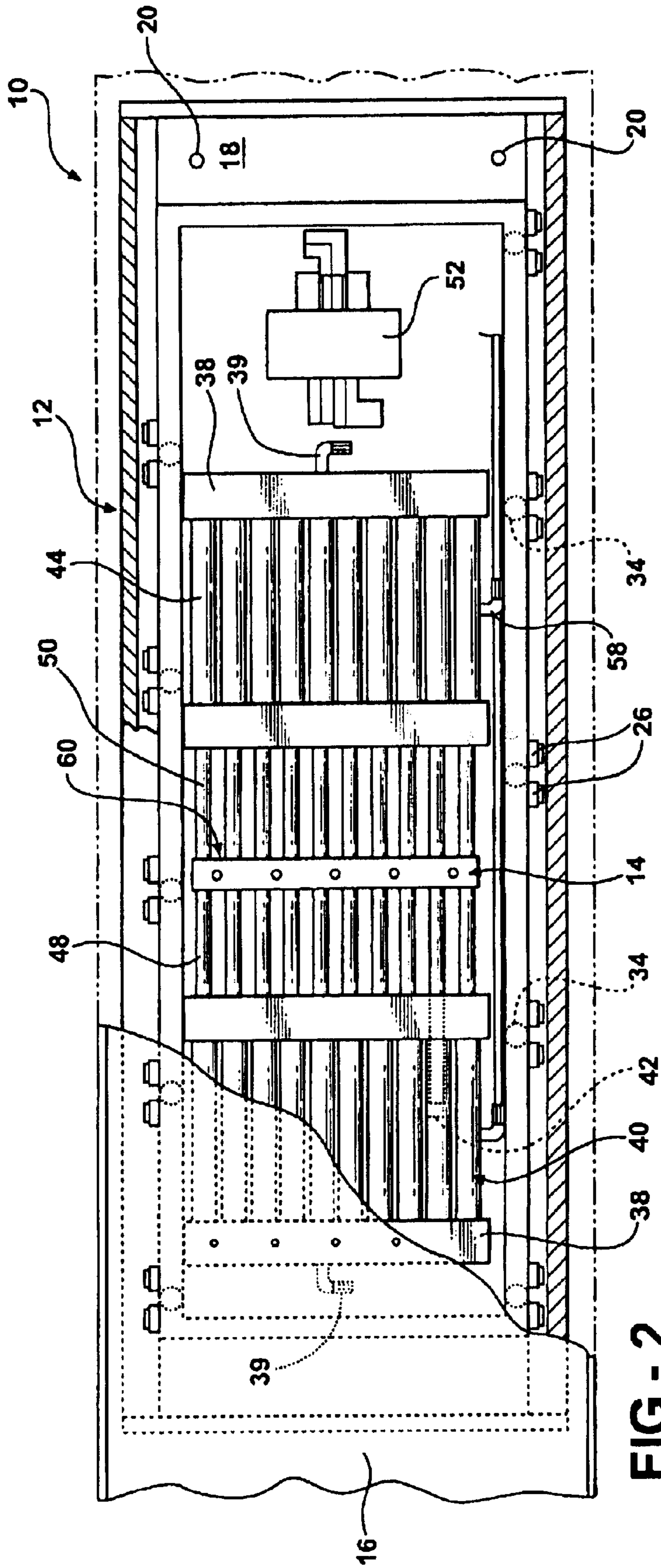


FIG - 6





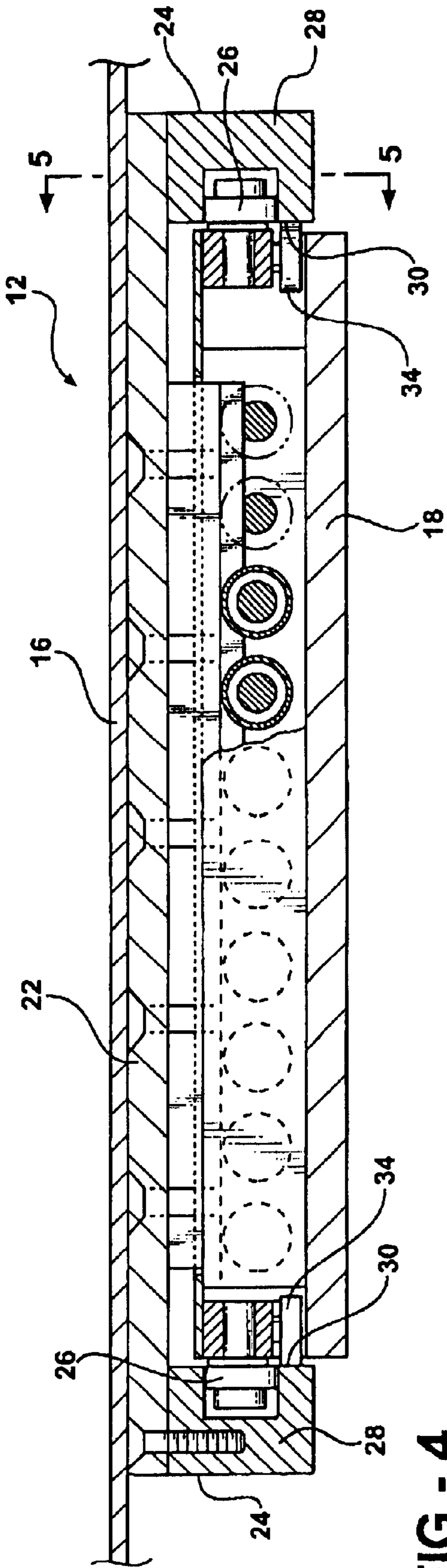


FIG - 4

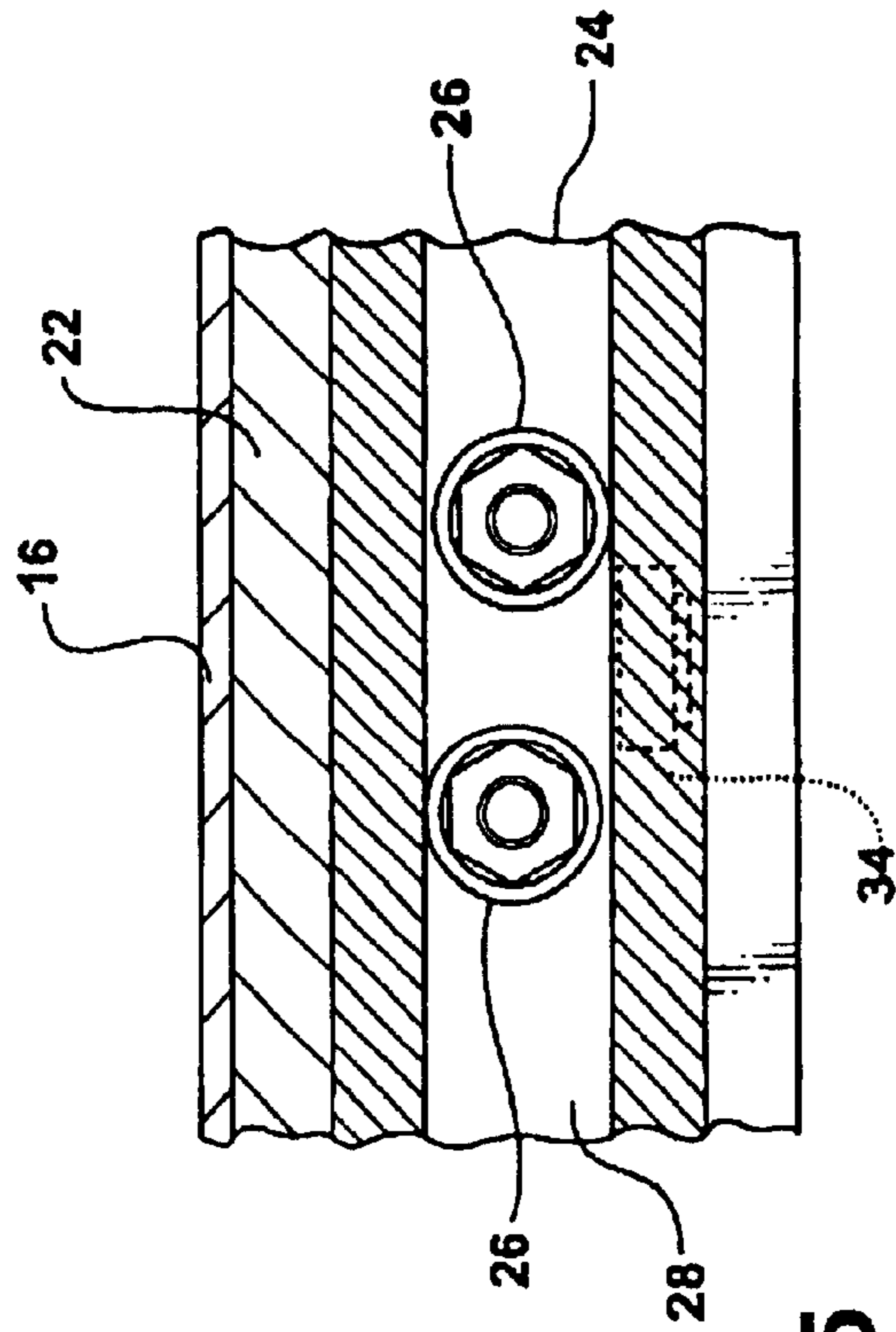


FIG - 5

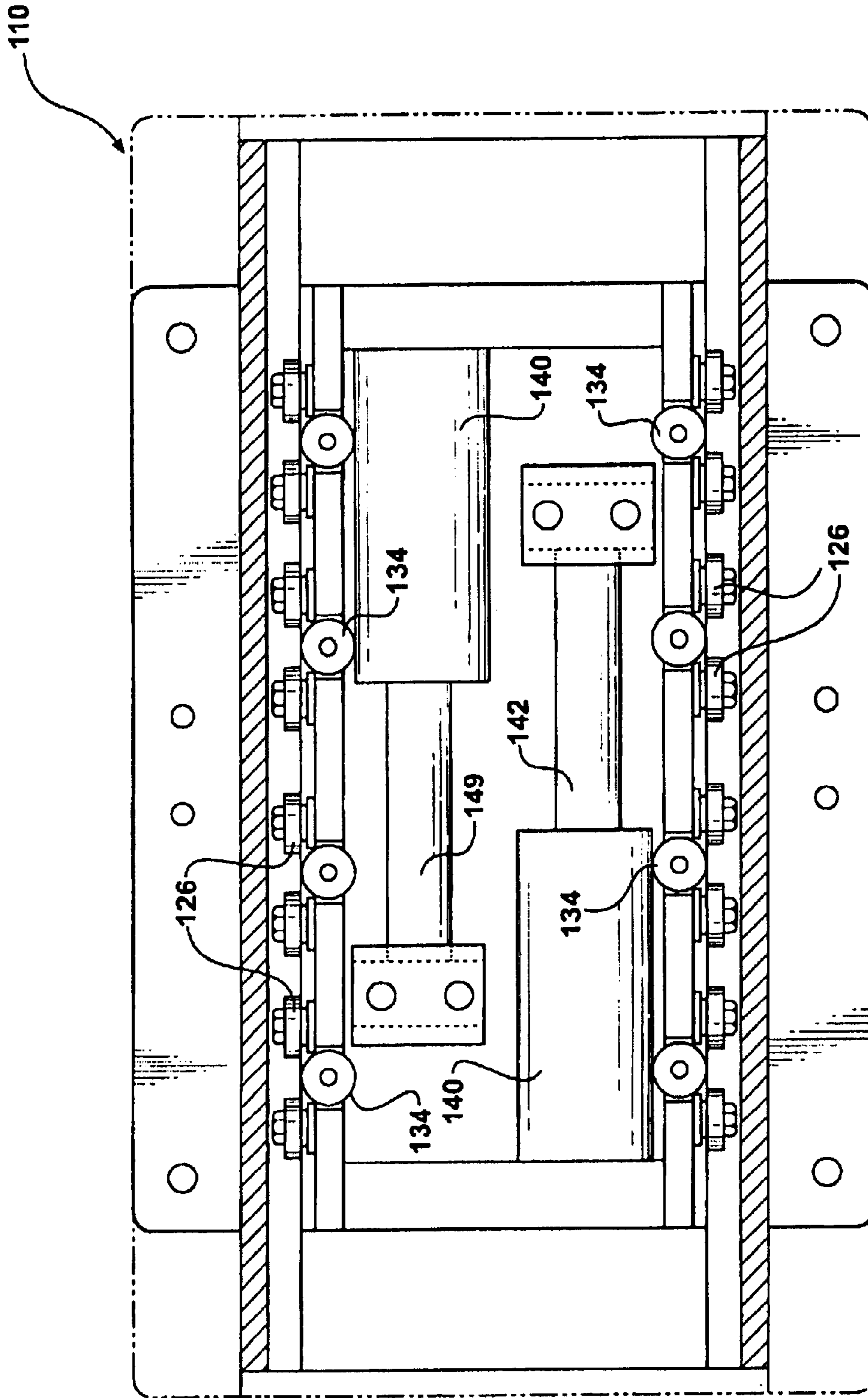
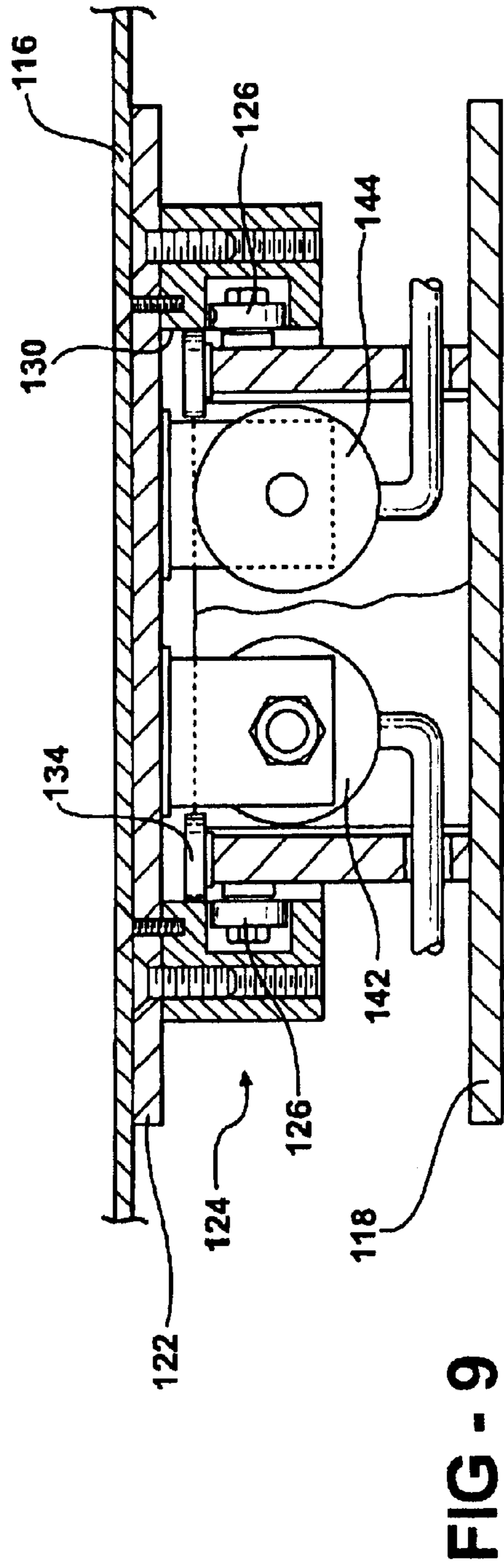
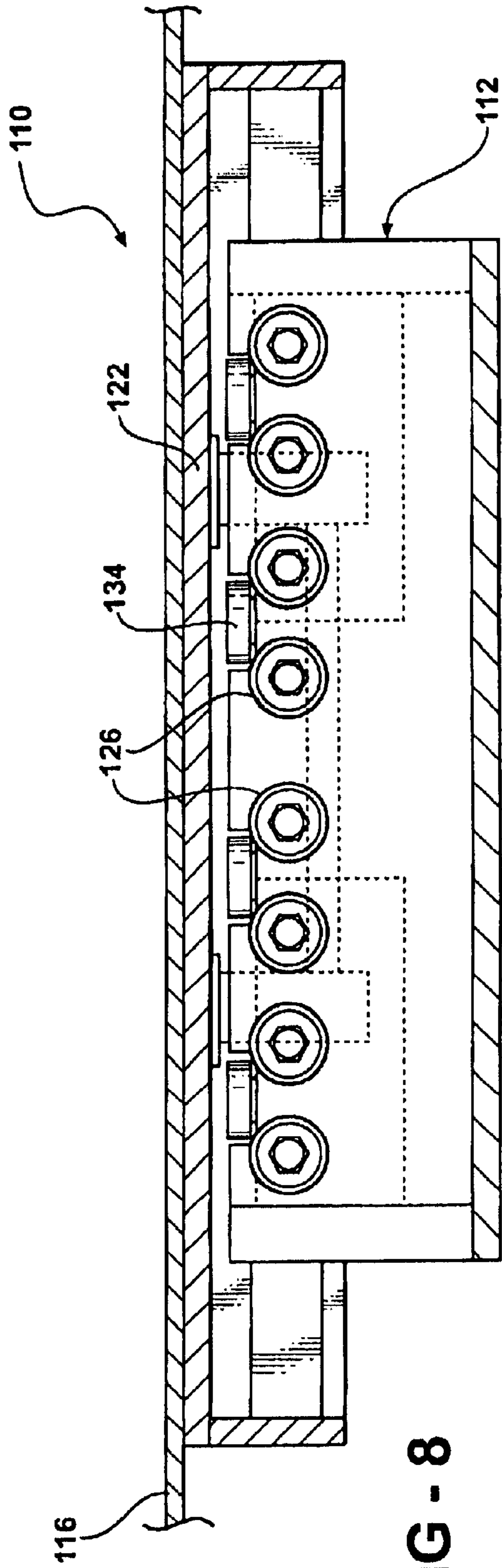


FIG - 7





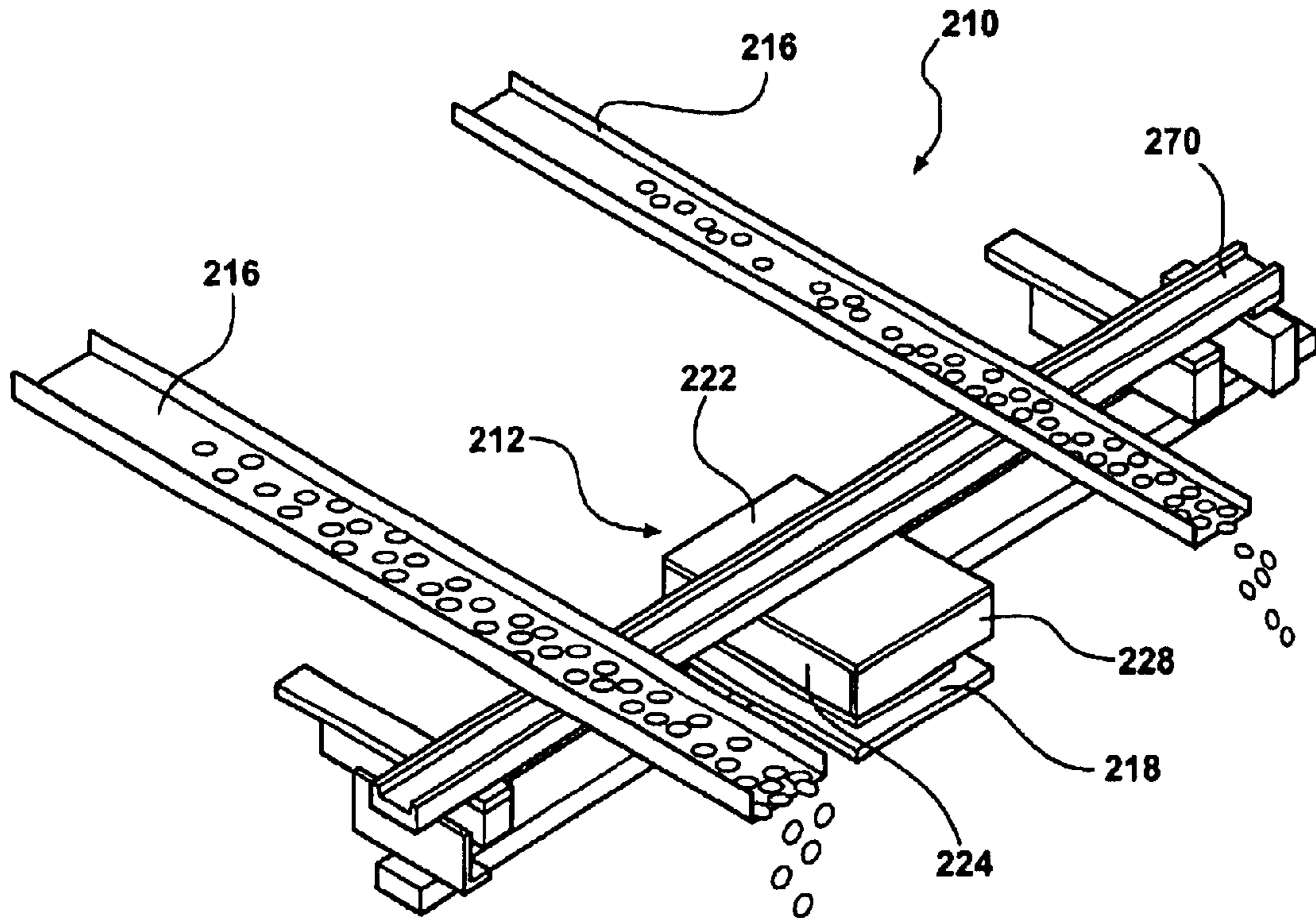


FIG - 10

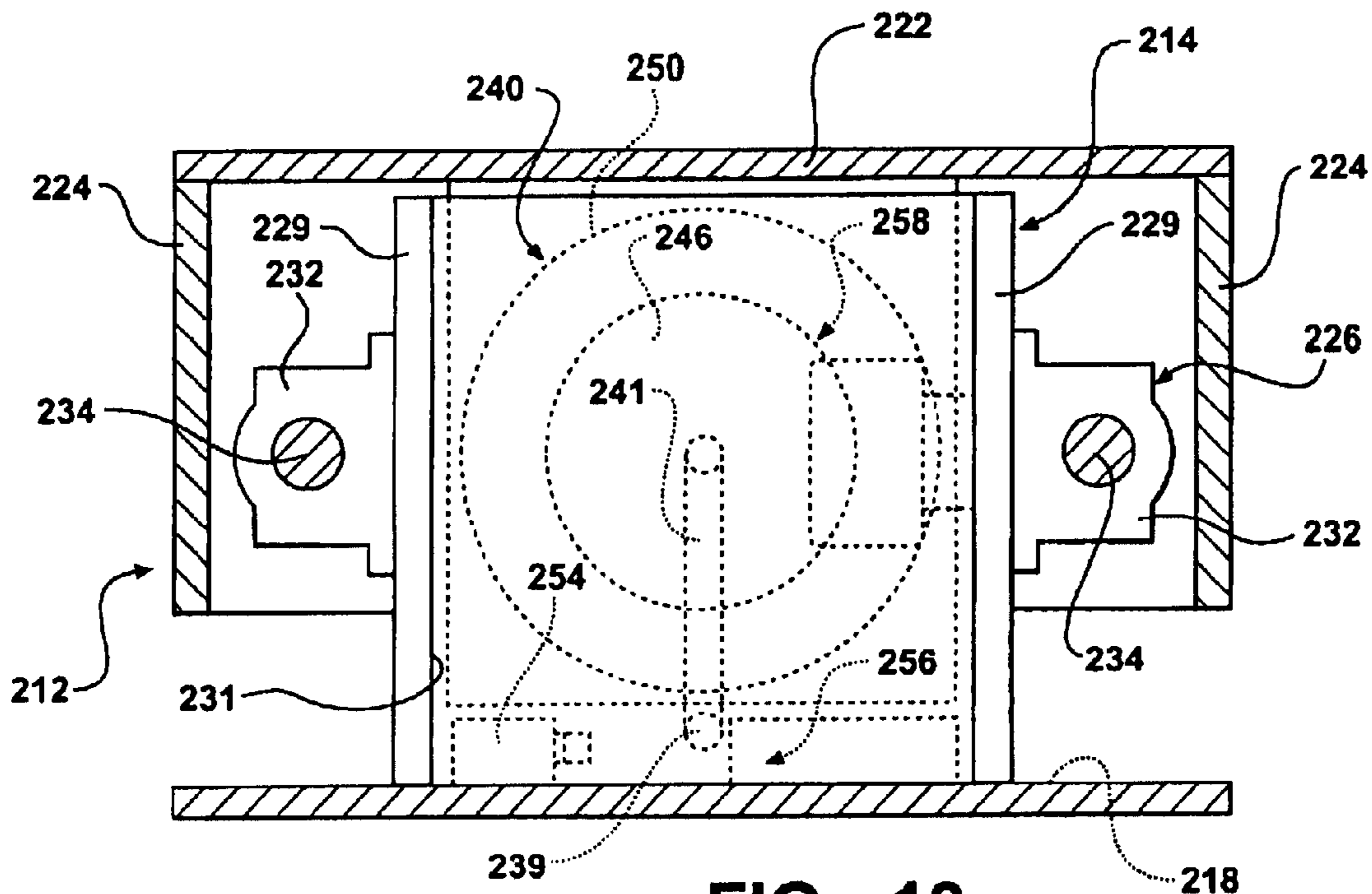


FIG - 13





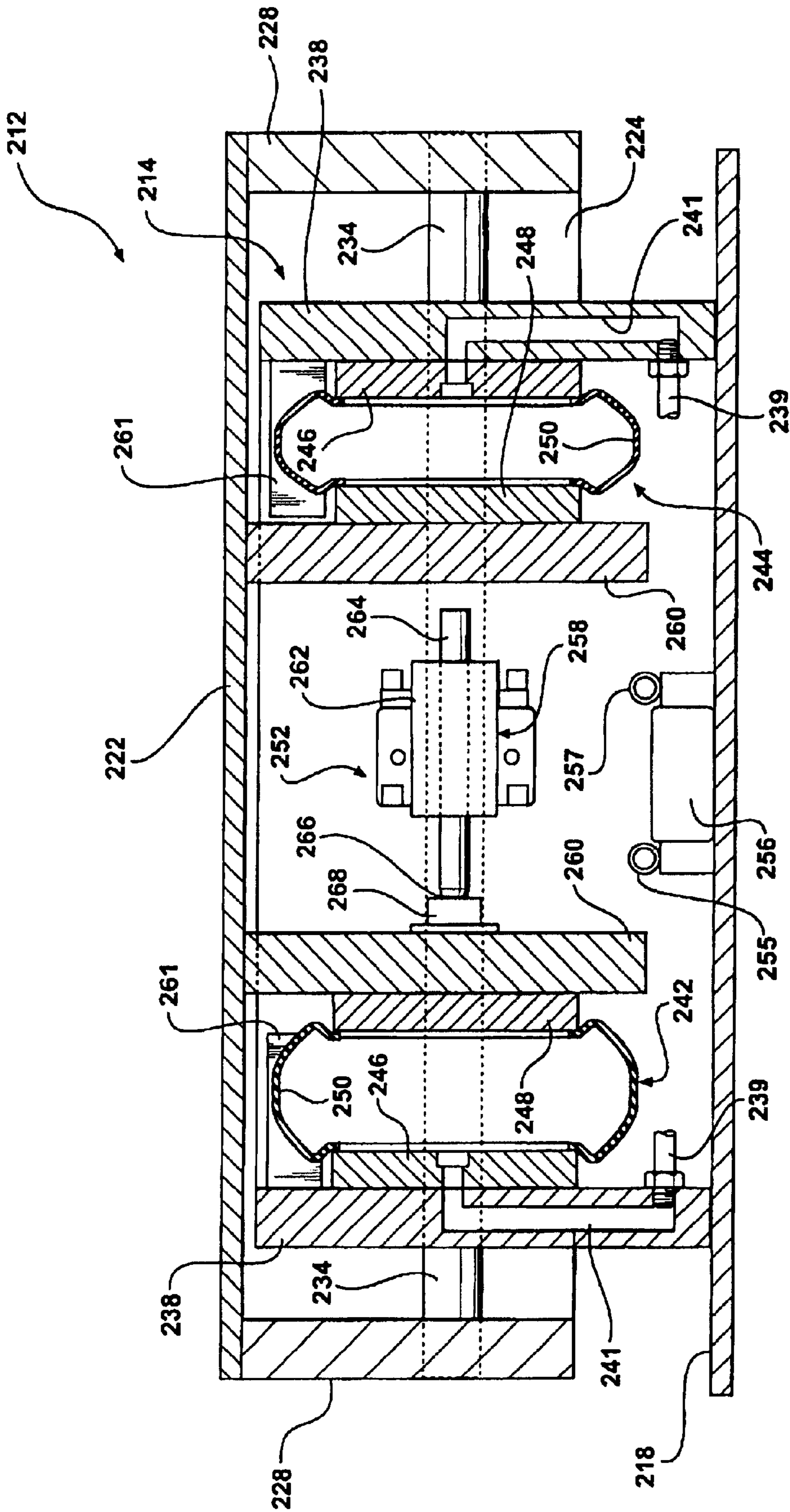


FIG - 12



**PNEUMATICALLY ACTUATED BELTLESS  
CONVEYOR**

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.**

This application is a continuation-in-part of U.S. Ser. No. 10/256,665 filed Sep. 27, 2002 *which is a continuation of Application No. PCT/US01/11783, filed Apr. 10, 2001* and claims the benefit of U.S. Provisional Application No. 60/195,929, filed Apr. 10, 2000 [and PCT which is a CIP of Application No. PCT/US01/11783, filed Apr. 10, 2001].

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed toward beltless conveyors and, more specifically, to a pneumatically actuated beltless conveyor.

2. Description of the Related Art

Conveyors are well known material handling devices that have application in a wide variety of environments for transporting objects from one place to another. For example, one type of conveyor employs a belt formed into an endless loop which is entrained about at least a pair of rollers spaced apart from one another and usually located at the opposed marginal ends of the conveyor. The rollers have sprockets at either end thereof. The spaced rollers are interconnected by a pair of chains entrained about the sprockets at either end of the rollers. An electric or hydraulic motor is usually employed to power the sprockets and continuously moves the belt over a substantial length of the conveyor between the rollers. In this way, objects may be transported by the conveyor over its length.

Conveyors find application in manufacturing environments. For example, in metal stamping operations, conveyors are employed to move parts between successive presses or from a press into a bin. In addition, conveyors are used for inspecting, transporting and assembly situations and can assist in maximizing production by removing parts, slugs or other scrap and materials from under low clearance areas like punch press dies and permitting continuous operation of the press. However, belted conveyors suffer from the disadvantage that the belts are often cut by the sharp edges of the metal parts formed in stamping operations. The useful life of the belts are reduced and the belts must be replaced more frequently. Frequent belt replacement increases the maintenance costs of the stamping operation. Further, stamped parts and other debris may pass through the damaged belts and jam or foul the inner workings of the conveyor drive system.

In part to avoid these problems, beltless conveyors are often employed in certain manufacturing operations. One type of beltless conveyor known in the related art employs magnets to move ferromagnetic parts along the length of the conveyor. Metal parts are supported on a stainless steel or other non-magnetic slide surface. A plurality of strong magnets are movably supported at spaced increments beneath the non-magnetic slide surface along the length of the conveyor. The magnets cause the metal parts to be moved along the slide surface of the conveyor. Beltless magnetic conveyors obviously do not suffer from cuts or worn belts and thus have been adopted in numerous manufacturing environments. Water-tight beltless magnetic conveyors have even been submerged in coolant used in drilling, boring or other metal cutting operations. The magnetic conveyors clean the used

coolant of metal or ferromagnetic contaminants so that the coolant may be recycled.

While magnetic conveyors have overcome significant problems associated with the belted conveyors of the related art, disadvantages still exist. Drive systems in both belted and magnetic beltless conveyors employ expensive and complex components. The complexity and expense of such drive systems has become a major factor in limiting the use of conveyors in industry today. Further, as the drive systems have become more complex, the risk that any given component may break, jam or fail has also increased. Conveyors presently employed in the related art are heavy pieces of machinery which are not often portable. In fact, after two to three years, magnetic conveyors are often discarded rather than reused in a different manufacturing line.

Thus, there remains a need in the art for a conveyor that is not susceptible to external damage from including, but not limited to, sharp edges of metal stampings, turnings, chips or parts, which at the same time, does not require a relatively complex drive system that is susceptible to internal damage caused by a failure of complex components. Further, there remains a need in the art for such a conveyor that presents a thin profile, is lightweight and that is also cost-effective.

Partly in response to this need, pneumatically actuated conveyors, commonly referred to as transporters, were developed in the related art. The pneumatic engines are typically mounted to a steel tray designed to convey or transport parts. When compressed air is fed into the transporter, reciprocating forward and reversing motion is created. A critical aspect of this conveying method is the control of the forward and reversing speed and motion cycle. Attaching a tray to this device allows materials to slide along the length of the tray parallel to the forward/reversing direction. This method of conveying materials provides a very cost competitive alternative to belted and magnetic beltless conveyors.

Transporters are very portable, lightweight, small in size and affordable. Trays attached to the transporter can be designed to fit a number of application requirements at a very inexpensive cost. This enables a single transporter to fit a variety of applications, as needs change by simply changing the tray attached to the transporter in applications such as tool changes on a metal stamping press.

Transporters presently employed in the related art utilize compressed air and air seals to operate the pneumatic engine movement. Control of the air in the transporter engine is critical to its effective conveying capability. If the air seal becomes worn or damaged, the transporter will fail to convey materials on the tray. Due to this disadvantage, transporters presently employed in the related art are sold with replacement seal kits to maintain the proper control of forward and reversing speed and motion cycle. Replacing seals requires downtime of production process machinery and man-hour labor costs. These costs can often exceed the original cost of the transporter the first time a seal kit is required.

Thus, there continues to be a need in the art for a pneumatically actuated beltless conveyor which presents a thin profile, is lightweight, which does not require the replacement of its engine seals, but which is long lasting as well as cost-effective.

SUMMARY OF THE INVENTION

The present invention overcomes these disadvantages in the related art in a pneumatically actuated, beltless conveyor assembly including a housing, a drive system supported by the housing and a transport tray also operatively supported



by the housing. The drive system includes a seal-less pneumatic engine having at least one pair of opposed pneumatic drive bellow assemblies. One of the pair of pneumatic drive bellow assemblies acts to drive the transport tray in one direction at a first predetermined speed in such a way that the materials supported on the transport tray are moved or advanced in the direction of the length of the tray. The other one of the pair of pneumatic drive bellow assemblies acts to drive the transport tray in a second direction that is opposite to the first direction and does so at a second, predetermined speed that is different than the first predetermined speed such that the transport tray moves relative to the material supported thereon.

In this way, materials such as metal stampings, chips, turning as well as parts are advanced over the length of the conveyor until they are discharged. The repeated, rectilinear movement of the drive system, but at different forward and reverse speeds, moves material in the direction of the conveyor. No sprockets are required which greatly reduces the thickness of the conveyor. There is no heavy motor nor motor mounts required to drive the conveyor. In addition, the conveyor of the present invention is lightweight, thin, relatively inexpensive and is robust and efficient in operation.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a perspective view of one embodiment of the pneumatically actuated beltless conveyor of the present invention;

FIG. 2 is a partially cut-away top view of one embodiment of the pneumatically actuated beltless conveyor of the present invention;

FIG. 3 is a cross-sectional side view of one embodiment of the pneumatically actuated beltless conveyor of the present invention;

FIG. 4 is a cross-sectional end view of the pneumatically actuated beltless conveyor illustrated in FIG. 3;

FIG. 5 is a partial cross-sectional side view taken substantially along lines 5—5 of FIG. 4;

FIG. 6 is a perspective view of an alternate embodiment of the pneumatically actuated beltless conveyor of the present invention;

FIG. 7 is a top view of an alternate embodiment of the pneumatically actuated beltless conveyor of the present invention illustrating the drive system;

FIG. 8 is a cross-sectional side view of the pneumatically actuated beltless conveyor illustrated in FIG. 7;

FIG. 9 is a cross-sectional end view of the pneumatically actuated beltless conveyor illustrated in FIG. 8;

FIG. 10 is a perspective view of still another embodiment of the pneumatically actuated beltless conveyor of the present invention;

FIG. 11 is a cross-sectional top view of the pneumatically actuated beltless conveyor illustrated in FIG. 10;

FIG. 12 is a cross-sectional side view of the pneumatically actuated beltless conveyor illustrated in FIG. 10; and

FIG. 13 is a cross-sectional end view of the pneumatically actuated beltless conveyor illustrated in FIG. 10.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

One embodiment of the pneumatically actuated beltless conveyor of the present invention is generally indicated at 10

in FIGS. 1 through 5, where like numerals are used to designate like structure throughout the drawings. The conveyor 10 may be employed in any number of applications and neither the preceding discussion nor the description of the invention which follows should be interpreted as limiting the present use of the invention.

Referring now to FIG. 1, the conveyor 10 of the present invention includes a housing, generally indicated at 12 and a drive system, generally indicated at 14 which is supported by the housing 12. As best shown in FIGS. 1—3, a transport tray, also known as a rigidized shaker pan, generally indicated at 16, is operatively supported by the housing 12 as will be described in greater detail below. The drive system 14 includes a seal-less pneumatic engine which acts to impart repeated, rectilinear movement to the transport tray 16 so as to advance materials supported by the tray 16 in the direction of its longitudinal length. As best shown in FIG. 2, the housing 12 includes a bottom mount plate 18 which includes suitable apertures 20 and other structure (not shown) adapted to mount the conveyor assembly 10 into a press or any other environment in which the conveyor may be employed. In addition, the apertures 20 may be used to mount the drive system 14 within the housing 12.

As best shown in FIGS. 4 and 5, a slider top plate 22 is movably supported relative to the bottom mount plate 18. To this end, the slider top plate 22 includes a pair of depending side tracks, generally indicated at 24 extending along a portion of the longitudinal length of the slider top plate 22. Each side track 24 is adapted to cooperate with a plurality of bearing clusters, generally indicated at 26, which support the slider top plate 22 relative to the bottom plate 18. More specifically, in the preferred embodiment illustrated in FIGS. 4 and 5, the side tracks 24 define a U-shaped track 28 and a rail 30. Each bearing cluster 26 includes one or more bearings 32 which are rotatable about a horizontal axis and received within the U-shaped tracks 28. The bearings 32 facilitate smooth movement of the slider top plate 22 without deviation in a direction transverse to the horizontal plane containing the axis of rotation of the bearings 32. Each bearing cluster 26 also includes one or more bearings 34 that are rotatable about a vertical axis and that rotatably engage the rail 30. The bearings 34 facilitate smooth movement of the slider top plate 22 without deviation in a direction transverse to the horizontal plane containing the axis of rotation of the bearings. Thus, the bearing clusters 26 cooperate with corresponding structure on the slider top plate 22 to ensure smooth, repeatable, rectilinear motion of the slider top plate 22 relative to the bottom plate 14.

One embodiment of the drive system 14 is generally illustrated in FIGS. 2—3. The drive system 14 of the present invention is, in essence, a seal-less, pneumatic engine which eliminates the need to replace seals which frequently wear out in other conveyors known in the related art. To this end, the drive system 14 includes a pair of end manifolds 38 and a plurality of cylinders 40 extending therebetween. Each end manifold 38 includes an air inlet 39 which is operatively connected to a source of pressurized air (not shown but commonly known in the art). Within each cylinder 40 there is supported a pair of bi-directional pistons 42, 44 and a push rod 46 extending therebetween. A push rod guide 48, 50, which in the preferred embodiment may take the form a round Delrin ball, extends between the pistons 42, 44 and the push rods 46, respectively. A control valve 52 is employed to sequentially cycle pressurized air against alternating pistons 42, 44, so as to reciprocally move the pistons 42, 44 within the cylinders 40. Furthermore, the pressure applied to the pistons 42, 44 is controlled so that the movement in one



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direction, such as the direction of part movement on the conveyor **10**, is relatively slow and so that movement in the opposite direction is relatively fast. A pair of center manifolds **54** span the transverse width of the plurality of cylinders **40** and are located between the pair of pistons **42, 44** to vent cylinder air to the atmosphere. However, those having ordinary skill in the art will appreciate that the relative speeds (faster in one direction, slower in the opposite direction) selected for forward and rearward movement of the transport tray **16** may be reversed and still cause the material or part supported on the transport tray **16** to move in the direction of the conveyor **10**. This is achieved due to the inertia of the material or part that tends to cause movement in the direction of the conveyor even as the direction of movement of the transport tray **16** is reversed.

At least one of the cylinders **40** includes a pair of stroke control orifices **56, 58** disposed spaced relative to one another in the direction of the longitudinal length of the conveyor. Movement of a piston **42** past an associated orifice **56** signals the control valve **52** to reverse direction of the pressurized air to the opposite end manifold **38**. This, in turn, reverses the direction of the movement of the pistons **42, 44**. The similar, but opposite effect results when the piston **44** moves past the associated orifice **58**. Thus, the drive system **14** of the present invention includes a seal-less pneumatic engine having a series of bi-directional pistons **42, 44** which are movable simultaneously within a plurality of adjacent cylinders **40**, all of which are supported in a common plane.

The drive system **14** further includes a free-floating drive dog assembly, generally indicated at **60** in FIGS. **2** and **3**. The drive dog assembly **60** includes fingers (not shown) which fit around ring grooves (also not shown) formed in the push rods **46** associated with the pistons **42, 44**. The drive dog **60** is self-aligning and acts as a flexible link which interconnects the pneumatic engine to the transport tray **16** via the slider top plate **22**. This flexible link acts to isolate the push rods **46** from vibrations which could otherwise be transmitted to the engine thereby causing stress and possibly premature failure.

The rhythmic, repeating, rectilinear movement of the engine is imparted to the transport tray **16** which is supported for movement with the slider top plate **22**. The transport tray **16** may define any geometric shape and can be fabricated in a number of ways to fit the particular applications at hand. As illustrated in FIG. **1**, the transport tray **16** has an elongated, rectangular shape with a pair of upstanding flanges **62** extending for a substantial portion of its longitudinal length.

An alternate embodiment of the present invention is illustrated in FIGS. **6-9** where like numerals increased by a factor of 100, are used to designate like structure. Thus, as with the conveyor **10** illustrated in FIGS. **1-5**, the conveyor **110** illustrated in FIGS. **6-9** includes a housing **112**, a drive system, generally indicated at **114** that is supported by the housing **112** and a transport tray, generally indicated at **116** that is operatively supported by the housing **112** for repeated, rectilinear, rhythmic motion as described above. However, and as best shown in FIG. **6**, the conveyor **110** includes a pair of transport trays **116** which are mounted to a cross-member **170** that, in turn, is mounted to the slider top plate **122**. The cross-member may be an extrusion or any other suitable device for supporting one or more transport trays. In addition and as best shown in FIGS. **7** and **9**, the drive system **114** employs a pair of staggered cylinders **140** within which are supported a pair of staggered pistons **142, 144**. The use of staggered piston/cylinder arrangement facilitates a shorter length of the drive system **114**. The

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larger pistons/cylinders when compared with those employed with the drive system **114** allow for greater power even though only a pair of pistons is employed. Each piston **142, 144** is used to power the unit in only one direction. Thus, the pistons **142, 144** are powered in opposed directions. Furthermore, the push rods employed in the drive system **114** of the conveyor **110** are directly connected to the slider top plate **122**.

The conveyor **110** enjoys all of the advantages as described in connection with the conveyor **10** and is illustrated to show the acceptable variations of the present invention within the scope of the description set forth herein.

Another, alternate embodiment of the present invention is illustrated in FIGS. **10-13**, where like numbers increased by a factor of 200 are used to designate like structure with respect to the embodiment illustrated in FIGS. **1-5**. Thus, as with the conveyor **10** illustrated in FIGS. **1-5**, the conveyor **210** illustrated in FIGS. **10-13** may be employed in any number of applications and neither the preceding discussion nor the description of the invention that follows should be interpreted as limiting the present use of the invention.

Referring specifically to FIG. **10**, the conveyor **210** of the present invention includes a housing, generally indicated at **212**, and a drive system, generally indicated at **214**, that is supported by the housing **212**. A transport tray, also known as a rigidized shaker pan, is generally indicated at **216**. Like the embodiment illustrated in FIG. **6**, the conveyor **210** may include a pair of transport trays **216** that are mounted to a cross member **270** that, in turn, is mounted to the top plate **222** of the housing **212**. The transport tray **216** may define any geometric shape and can be fabricated in a number of ways to fit the particular application at hand. As illustrated in FIG. **10**, the transport tray **216** has an elongated, rectangular shape with a pair of upstanding flanges **262** extending for a substantial portion of its longitudinal length. The cross member may be an extrusion or any other suitable device for supporting one or more transport trays **216**. As best shown in FIGS. **12** and **13**, the housing **212** includes a bottom plate **218** and a top plate **222** that is operatively connected to the drive system **214** as will be explained in greater detail below. The transport tray **216** is operatively connected to the top plate **222** so as to be moved in repeated rectilinear fashion by the drive system **214**. The housing further includes a pair of drive side plates **224** that depend from the top plate **222** and that extend along at least a portion of the longitudinal length of the top plate **222**. In the preferred embodiment, the drive plates **224** extend for the entire length of the top plate **222**. In addition, a pair of drive end plates **228** also depend from the top plate **222** and extend between the drive side plates **224**.

Like the other embodiments disclosed herein, the drive system **214** includes a seal-less pneumatic engine, generally indicated at **240** that eliminates the need to replace seals that frequently wear out in other conveyors known in the related art. To this end, the seal-less pneumatic engine **240** includes at least one pair of opposed pneumatic drive bellow assemblies **242, 244**. One of the pair of pneumatic drive bellow assemblies **242, 244** acts to drive the transport tray **216** in one direction at a first, predetermined speed in such a way that the material supported on the transport tray **216** is advanced in a direction of the length of the tray. The other of the pair of pneumatic drive bellow assemblies **242, 244** acts to drive the transport tray **216** in a second direction, opposite to the first direction and at a second predetermined speed that is different from the first predetermined speed such that the transport tray **216** moves relative to the material supported thereon. Thus, the drive bellow assemblies may move the transport tray **216** faster in one direction and slower in



the opposite direction to induce movement of material or parts supported on the transport tray **216** in the direction of the conveyor **210**. While only a pair of pneumatic drive bellow assemblies is illustrated in these figures, those having ordinary skill in the art will appreciate that any number of such assemblies may be employed as dictated by other design considerations. In addition, like the operation of the embodiments described in connection with FIGS. 1–9, those having ordinary skill in the art will appreciate that the relative speeds (faster in one direction and slower in the opposite direction) selected for forward and rearward movement of the transport tray **216** may be reversed and still cause the material on part supported on the transport tray **216** to move in the direction of the conveyor **210**. This is achieved due to the inertia of the material or part that tends to cause movement in the direction of the conveyor even as the direction of movement of the transport tray **216** is reversed.

The drive system **214** also includes a pair of end manifolds **238**. Each manifold **238** includes an air inlet **239** that is operatively connected to a source of pressurized air (FIGS. 12 and 13). Delivery passages **241** that are operatively connected to the air inlet **239** are formed through the manifolds **238** for this purpose. The pair of end manifolds **238** provide fluid communication between the source of pressurized air and the pair of pneumatic drive bellow assemblies **242, 244** as will be described in greater detail below.

As best shown in FIGS. 11 and 13, the housing **214** includes a pair of inner side plates **229** that are fixedly mounted to the bottom plate **218**. The manifolds **238** are also supported on the bottom plate **218**. The pair of inner side plates **229** extend between the pair of manifolds **238** such that, together with the manifolds, the inner side plates **229** act to define an enclosure **231**. The seal-less pneumatic engine **240** is supported by the housing **212** within this enclosure **231**. The housing **212** further includes at least one linear bearing assembly, generally indicated at **226**, that is operatively supported by the housing **212** and acts to support the top plate **222** in such a way as to provide repeatable, smooth rectilinear movement relative to the bottom plate **218**. More specifically, in the preferred embodiment illustrated in these figures, two pair of linear bearing assemblies **226** are supported by the housing **212** in spaced relationship with respect to one another on either side of the pneumatic engine **240**. To this end, each linear bearing assembly **226** includes a bearing housing **232** that is fixedly mounted to the inner side plates **229** of the housing **212**. A shaft **234** is moveably supported for rectilinear movement relative to the bearing housing **232**. Furthermore, each shaft **234** extends between the pair of drive end plates **228** to which they are operatively connected.

Each of the drive bellow assemblies **242, 244** includes a fixed plate **246** that is operatively mounted to the housing **212**. In the embodiment illustrated in FIGS. 10–13, each fixed plate **246** is mounted to an associated manifold **238** via fasteners or any other suitable means. In addition, the pneumatic drive bellow assemblies **242, 244** include a moveable plate **248** that is operatively connected to the transport tray **216**. An annular, flexible membrane **250** extends between the fixed and moveable plates **246, 248**. The delivery passages **241** also extend through each of the fixed plates **246**. Thus, the flexible membrane **250** is in fluid communication with the source of pressurized air through the manifolds **238** so as to expand and contract. The expanding and contracting action of the moveable membrane imparts repeated rectilinear movement to the transport tray **216** through the moveable plates **248**. To this end, the drive system **214** further includes a pair of drive dogs **260**. Each of the pair of drive

dogs **260** is associated with a corresponding one of the pair of pneumatic drive bellow assemblies **242, 244**. More specifically, each of the pair of drive dogs **260** is operatively connected to a corresponding one of the moveable plates **248** of an associated drive bellow assemblies **242, 244** as well as with the top plate **222** of the housing **212** via fasteners or any other suitable means commonly known in the art. Thus, the pair of drive dogs **260** act to operatively interconnect their associated pneumatic drive bellow assemblies **242, 244** to the transport tray **216**. The conveyor assembly **210** may also include a plurality of bumper mechanisms or stops **261** that are disposed between the fixed manifolds **238** and the drive dogs **260**. In the preferred embodiment, two or more bumpers **261** may be employed in connection with each bellows assembly **242, 244**. The bumpers **261** act to limit the distance traveled by the drive dogs **260** in the direction that the flexible membranes **250** contract.

The drive system **214** further includes a control valve assembly **252** that operates to sequentially cycle pressurized air to alternating ones of the pair of opposed pneumatic bellow assemblies **242, 244** through the air delivery passages **241** formed in the manifold **238** and fixed plates **246**. The sequentially delivered, alternating pressurized air acts on the flexible membranes **250** in such a way that the membranes **250** expand and contract so as to induce repeated, rectilinear movement of the moveable plates **248**. To this end, the control valve assembly **252** includes a pneumatic valve **256** and a pneumatic switch **258**. As best shown in FIG. 11, an air inlet **253** provides fluid communication between the pneumatic valve **256** and a source of pressurized air. The pneumatic valve **256** also includes a pair of outlets **255, 257** that provide fluid communication between the pneumatic valve **256** and the flexible membranes **250** of each drive bellows assembly **242, 244**, respectively, via the manifold inlet **239** and delivery passages **241** extending therein.

The pneumatic switch **258** is operable to send signals to the pneumatic valve **256** to change the delivery path of pressurized air from one pneumatic drive bellow assemblies **242** to the other **244**. In addition, this arrangement is further operable to change the delivery path from the drive bellow assembly **244** back to the other **242**. The pneumatic switch **258** includes a housing **262** that is in fluid communication with the pneumatic valve **256** via any suitable means such as conduits or tubing. A shaft **264** is moveably supported by the switch housing **262** and extends for a predetermined length that is shorter than the distance between the drive dogs **260**. The shaft **264** is responsive to actuation of at least one of the pair of pneumatic drive bellow assemblies **242, 244** so that it moves relative to the housing **262**. In the embodiment illustrated in these figures, the shaft **264** is responsive to the bellows assembly **242**. Movement of the shaft **264** relative to the housing **262** initiates a pneumatic signal from the switch **258** to the pneumatic valve **256**. This signal causes the control valve to change the flow path of pneumatic pressure between the drive bellow assemblies **242, 244**.

The shaft **264** is operatively connected to its associated drive bellow assembly in such a way that it automatically accommodates wear and change in stroke length of the bellow assembly. More specifically, the shaft **264** includes at least one arcuate end **266**. A magnet **268** is operatively mounted to the drive bellow assembly **242**. In the preferred embodiment, the magnet **268** is mounted to the drive dog **260** which, in turn, is mounted to the moveable plate **248**. The arcuate end **266** of the shaft **264** is attracted to the magnet **268**. This establishes a magnetic connection between the shaft **264** and the drive bellow assembly **242**. This connection also automatically accommodates for changes in the



operating parameters of the bellows assembly due to wear or any number of other factors. Thus, the connection between the pneumatic switch and the drive bellow assemblies is sufficiently flexible so that this feature improves the operational life span of the conveyor assembly **210** of the present invention.

A pneumatic exhaust valve **254** is in fluid communication with each one of the pair of pneumatic drive bellow assemblies **242, 244** via exhaust ports **259**. The pneumatic exhaust valve **254** is employed to vent pneumatic pressure from the drive bellow assemblies to the atmosphere. More specifically, the exhaust valve **254** acts to vent pneumatic pressure from the flexible membranes **250** to atmosphere.

In its operative mode, a source of pressurized air is provided to the pneumatic valve **256** via the inlet **253**. Depending on the signals provided by the pneumatic switch **258**, pressurized air is alternately supplied to one **242** or the other **244** of the pneumatic drive bellow assemblies via the inlet **239** to the air delivery passages **241** extending through the manifold **238** and fixed plates **246**. Pressurized air delivered to the bellow assemblies in this fashion causes the annular, flexible membranes **250** to expand thereby moving its associated drive dog **260** in one linear direction. This movement is translated to the transport tray **216** via the top plate **222** via any cross member **270**, if one is employed. When the bellows assembly **242** expands, the opposed bellow assembly **244** contracts as illustrated in FIGS. **11** and **12**. Air is exhausted from the annular flexible membrane **250** of the bellows assembly **244** via the exhaust valve **254**. When the bellow assembly **242** expands, the shaft **264** of the pneumatic switch **258** is moved linearly relative to its housing **262**. At the point when the bellows assembly **242** has reached its fully extended position, the shaft **264** triggers a pneumatic signal that is delivered to the pneumatic valve **256**. In response to this signal, the pneumatic valve **256** reverses the direction of pressurized air from the bellows assembly **242** to the bellows assembly **244**. When this occurs, the flexible membrane **250** of the bellows assembly **244** expands in a direction opposite to that imparted by the bellows assembly **242**. At the same time, the pressurized air found within the flexible membrane **250** of the bellows assembly **242** is exhausted through the exhaust valve **254**. In this way, rhythmic, repeating, rectilinear movement is imparted to the transport tray **216**.

The pneumatically actuated beltless conveyor **10, 110, 210** of the present invention is inexpensive, lightweight and designed to handle small parts and materials such as metal stamping, chips and turnings. The transport tray **16, 116, 216** is moved in a repeated, rectilinear, rhythmic motion relatively slowly forward and then quickly backwards or quickly forward and then slowly backward. In either case, this movement advances the material on the transport tray **16, 116, 216** in the direction of the forward movement of the transport tray. The pneumatically actuated beltless conveyor **10, 110, 210** of the present invention employs a seal-less engine for its drive system **14, 114, 214** thereby eliminating the need for replacement seals. The pneumatically actuated conveyor requires approximately 50–150 psi air supply to operate and includes an external regulator as well as a filter assembly for removing contaminate from the air supply. The present invention is easily and quickly mounted in a number of different applications and includes an adjustable speed control. It is lightweight and is easily moved from one location to another.

The invention has been described in an illustrative manner. It is to be understood that the terminology which has been used is intended to be in the nature of words of descrip-

tion rather than of limitation. Those having ordinary skill in the art will appreciate that many modifications and variations of the invention are possible in light of the above teachings. Therefore, within the scope of the appended claim, the invention may be practiced other than as specifically described.

We claim:

**1.** A pneumatically actuated, beltless conveyor assembly comprising:

a housing, a drive system supported by said housing, and at least one transport tray supported by said housing and operatively connected to said drive system;

said drive system including a seal-less pneumatic engine including at least one pair of opposed pneumatic drive bellow assemblies, wherein one of said pair of pneumatic drive bellow assemblies acts to drive said transport tray in one direction at a first predetermined speed to advance materials supported on said transport tray in the direction of the length of said tray and the other of said pair of pneumatic drive bellow assemblies acts to drive said transport tray in a second direction opposite to said first direction at a second predetermined speed that is different from the first predetermined speed such that the transport tray moves relative to the material supported thereon.

**2.** A pneumatically actuated beltless conveyor assembly as set forth in claim **1** wherein said drive system further includes a pair of end manifolds, each manifold includes an air inlet that is operatively connected to a source of pressurized air, said pair of end manifolds providing fluid communication between the source of pressurized air and said pair of pneumatic drive bellow assemblies.

**3.** A pneumatically actuated beltless conveyor assembly as set forth in claim **2** wherein each of said pneumatic drive bellow assemblies includes a fixed plate operatively mounted to said housing, a moveable plate operatively connected to said transport tray and a flexible membrane extending therebetween, said flexible membrane being in fluid communication with said source of pressurized air through said manifolds to expand and contract thereby imparting repeated rectilinear movement to said transport tray through said moveable plate.

**4.** A pneumatically actuated beltless conveyor assembly as set forth in claim **3** wherein said drive system further includes a control valve assembly that operates to sequentially cycle pressurized air to alternating ones of said pair of opposed pneumatic bellow assemblies to act on said flexible membranes so as to induce repeated, rectilinear movement of said moveable plates.

**5.** A pneumatically actuated beltless conveyor assembly as set forth in claim **4** wherein said control valve assembly includes a pneumatic valve and a pneumatic switch, said pneumatic switch being operable to send signals to said pneumatic valve to change the delivery path of pressurized air from one pneumatic drive bellow assembly to the other.

**[6.** A pneumatically actuated beltless conveyor assembly as set forth in claim **5** wherein said pneumatic switch includes a housing in fluid communication with said pneumatic valve and a shaft moveably supported by said switch housing, said shaft responsive to actuation of at least one of said pair of pneumatic drive bellow assemblies to move relative to said housing so as to initiate a pneumatic signal from said switch to said pneumatic valve to change the flow path of pneumatic pressure between said drive bellow assemblies.]

**[7.** A pneumatically actuated beltless conveyor assembly as set forth in claim **6** wherein said shaft includes at least one



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arcuate end, a magnet operatively mounted to at least one of said pneumatic drive bellow assemblies, said shaft operatively connected in an articulating manner to said pneumatic drive bellows assembly through said magnet at said arcuate end so as to provide automatic adjustment between said shaft and said pneumatic drive bellows assembly.]

8. A pneumatically actuated beltless conveyor assembly as set forth in claim 2 wherein said housing includes a bottom plate, a top plate operatively connected to said drive system, said transport tray operatively connected to said top plate so as to be moved in repeated rectilinear fashion by said drive system.

9. A pneumatically actuated beltless conveyor assembly as set forth in claim 8 wherein said housing further includes at least one linear bearing assembly operatively supported by said housing and acting to support said top plate in such a way so as to provide repeatable, smooth rectilinear movement relative to said bottom plate.

[10. A pneumatically actuated beltless conveyor assembly as set forth in claim 9 herein said housing further includes a pair of drive side plates depending from said top plate and extending along at least a portion of the longitudinal length of said top plate and a pair of drive end plates depending from said top plate and extending between said drive side plates, said linear bearing assembly including a bearing housing fixedly mounted to said housing and a shaft moveably supported for rectilinear movement relative to said bearing housing and extending between said pair of drive end plates.]

11. A pneumatically actuated beltless conveyor assembly as set forth in claim [10] 9 further including a pair of linear

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bearing assemblies supported by said housing in spaced relationship with respect to one another on either side of said pneumatic engine.

12. A pneumatically actuated beltless conveyor assembly as set forth in claim 8 herein said housing includes a pair of inner side plates fixedly mounted to said bottom plate, said pair of manifolds supported on said bottom plate, said pair of inner side plates extending between said pair of manifolds such that said manifolds and said inner side plates act to define an enclosure with said seal-less pneumatic engine disposed within said enclosure.

13. A pneumatically actuated beltless conveyor assembly as set forth in claim 1 further including a pneumatic exhaust valve in fluid communication with each one of said pair of pneumatic drive bellow assemblies to vent pneumatic pressure from said drive bellow assemblies.

[14. A pneumatically actuated beltless conveyor assembly as set forth in claim 1 wherein said drive system further includes a pair of drive dogs, each one of said pair of drive dogs being associated with a corresponding one of said pair of pneumatic drive bellow assemblies, said pair of drive dogs acting to operatively interconnect said associated pneumatic drive bellow assemblies to said transport tray.]

[15. A pneumatically actuated beltless conveyor assembly as set forth in claim 14 herein each of said pair of drive dogs is operatively connected to a corresponding one of said moveable plates of an associated drive bellows assembly.]

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