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(54) **VEHICLE-STRAIGHTENING BENCH WITH TOWER LOCKING MECHANISM FOR MOVABLE CARRIAGES THAT MOUNT PULLING ASSEMBLIES**

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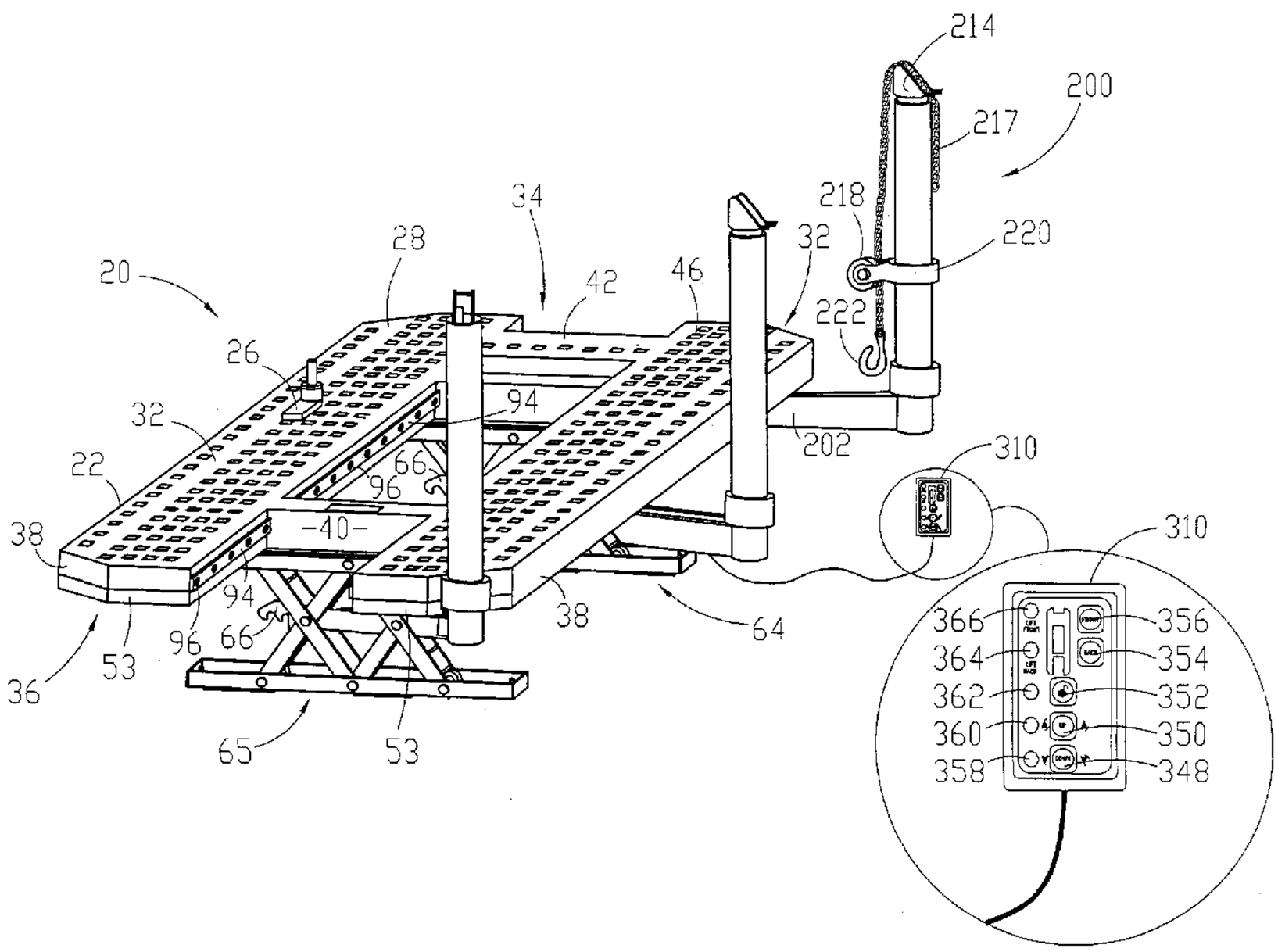
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(57) **ABSTRACT**

A vehicle-straightening bench (**20**) is utilized to apply pulling forces to a damaged vehicle chassis to restore the damaged chassis to an original configuration. The bench includes a vehicle platform (**22**) with a carriage track (**24**) having a plurality of carriage assemblies (**100**) movably received by the carriage track (**24**). Each carriage assembly (**100**) supports a pulling assembly (**200**) for applying the pulling forces. A trapezoidal carriage body (**102**) of the carriage assembly (**100**) rolls in the carriage track (**24**), and the carriage assembly also includes a tower positioning mechanism (**104**) to hold the pulling assemblies (**200**) in place while the carriage body (**102**) is are rolled on the track (**24**). The carriage assembly (**100**) also includes a locking mechanism (**106**) to lock them in place during a vehicle a pull. A force arm (**206**) is extended between the pulling mechanism (**200**) and the platform (**22**), so that the carriage assembly (**100**) is not the only force transmission path between the pulling assembly (**200**) and the bench (**20**). The automated control system (**300**) of the bench (**20**) utilizes two hydraulic pumps (**316,314**) to power front and back lifts (**65,64**), respectively. Only one of the pumps (**314**) is used by the pulling assemblies (**200**). A PLC (**308**) and a remote control (**310**) are used to control the bench (**20**).



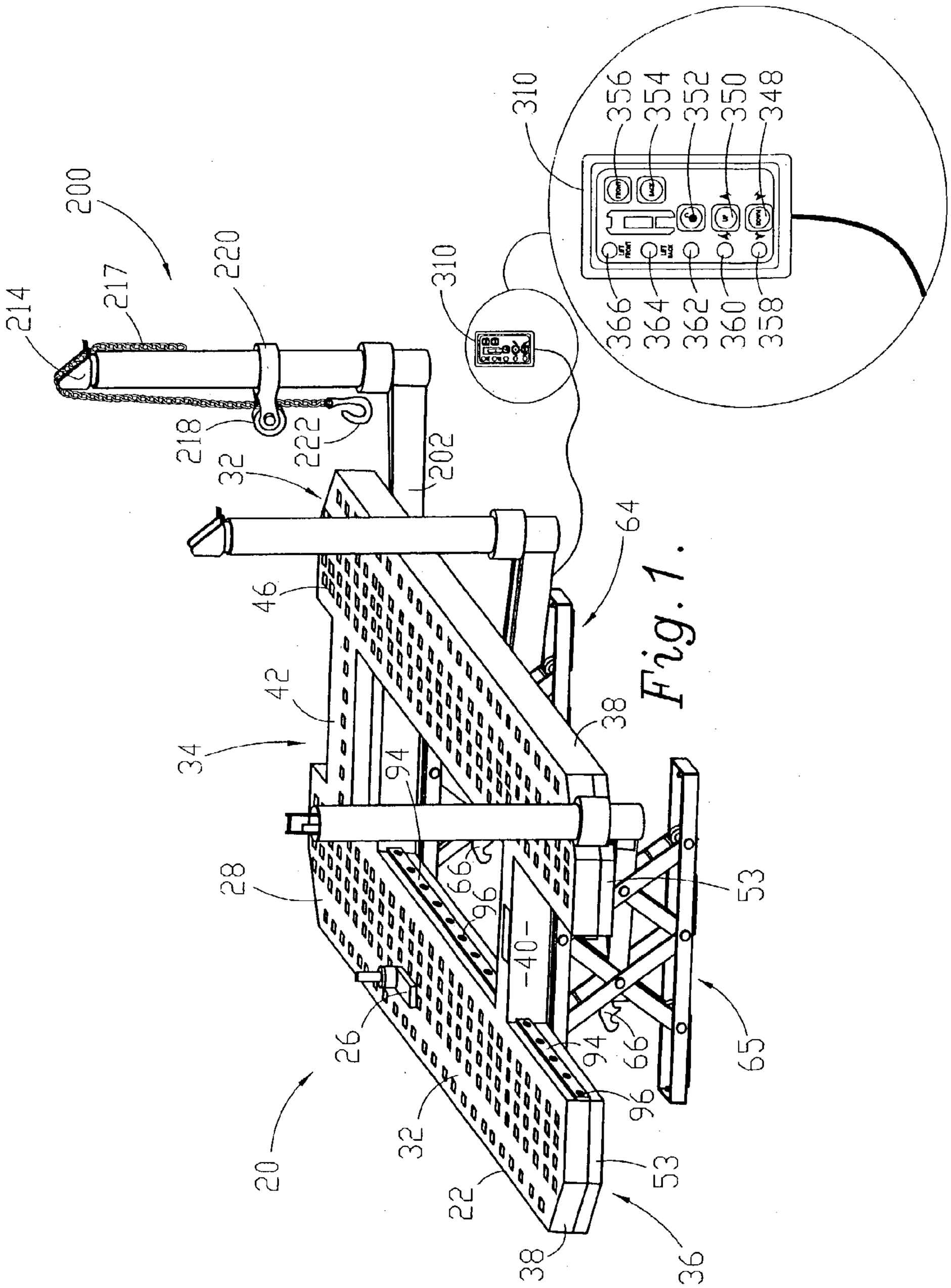

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Fig. 1.

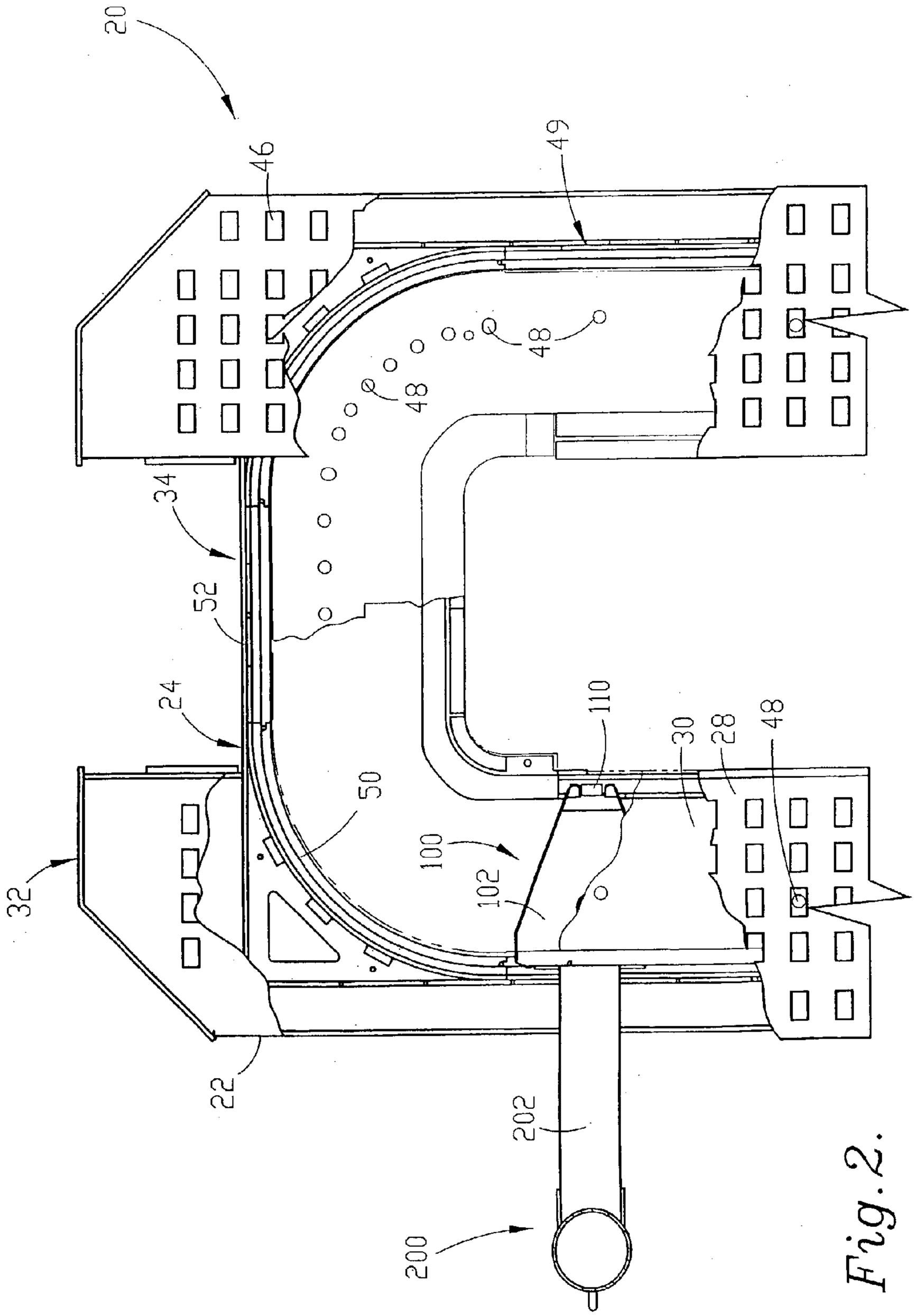


Fig. 2.

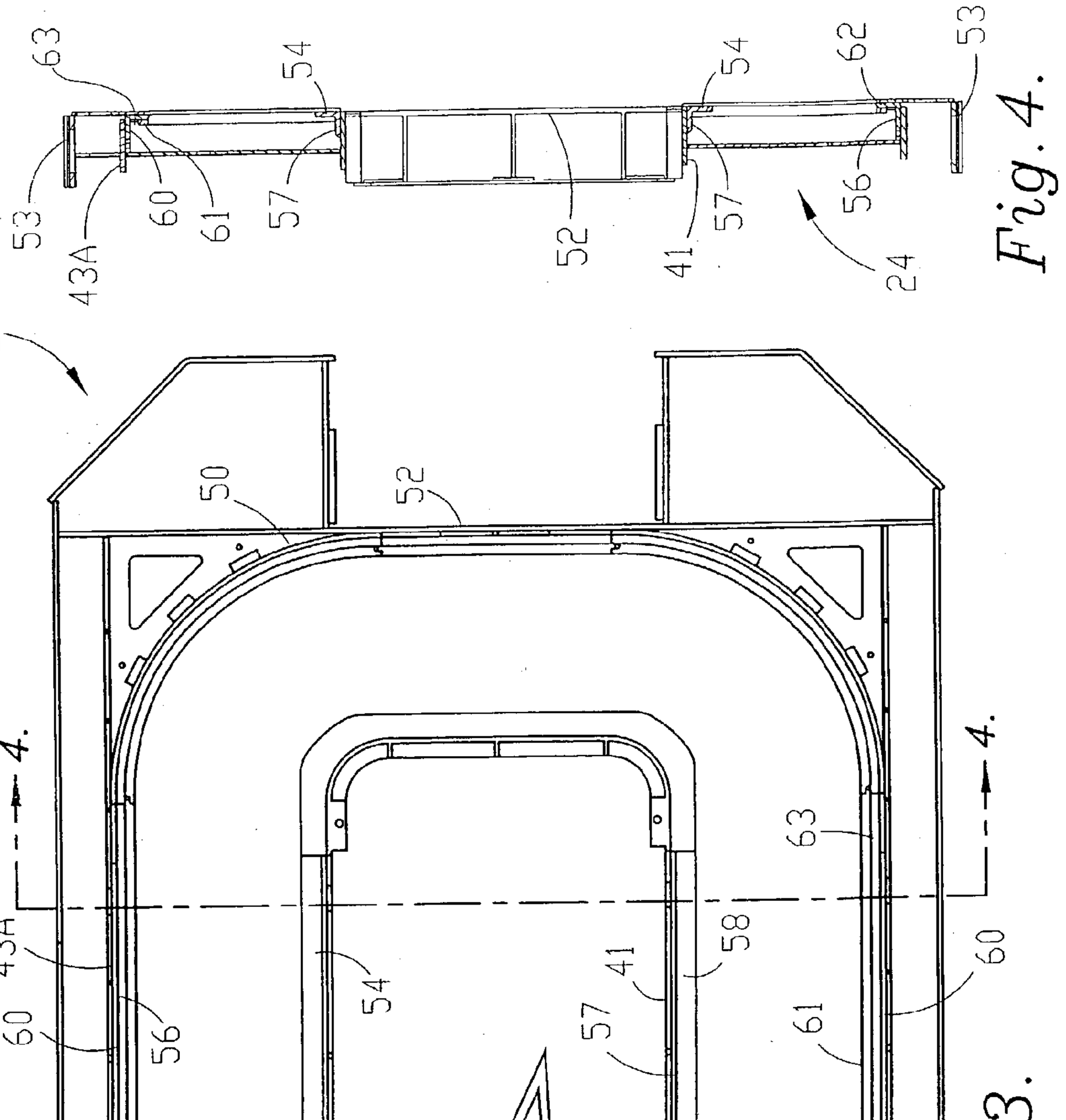

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Fig. 4.

Fig. 3.

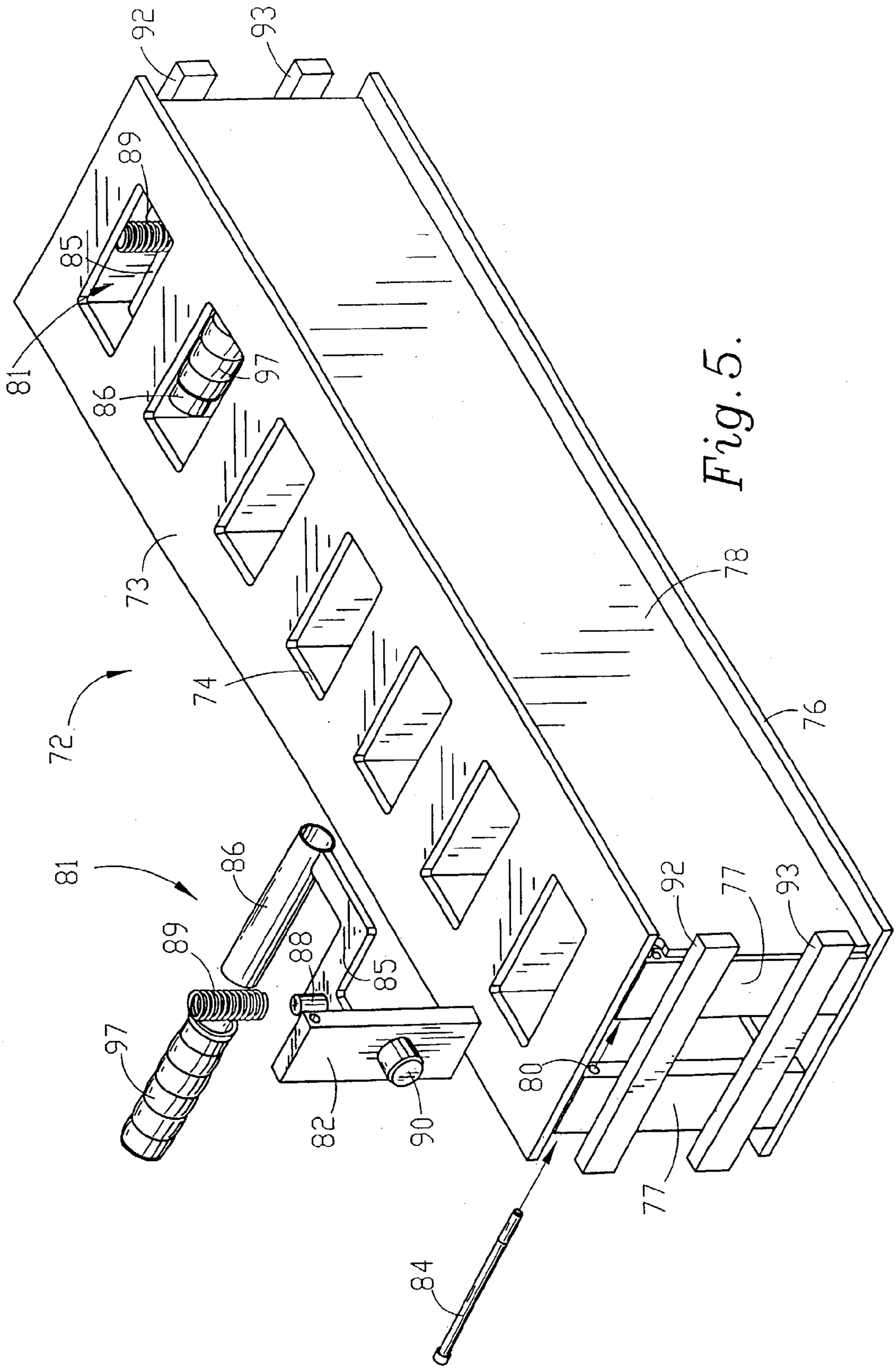

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Fig. 5.

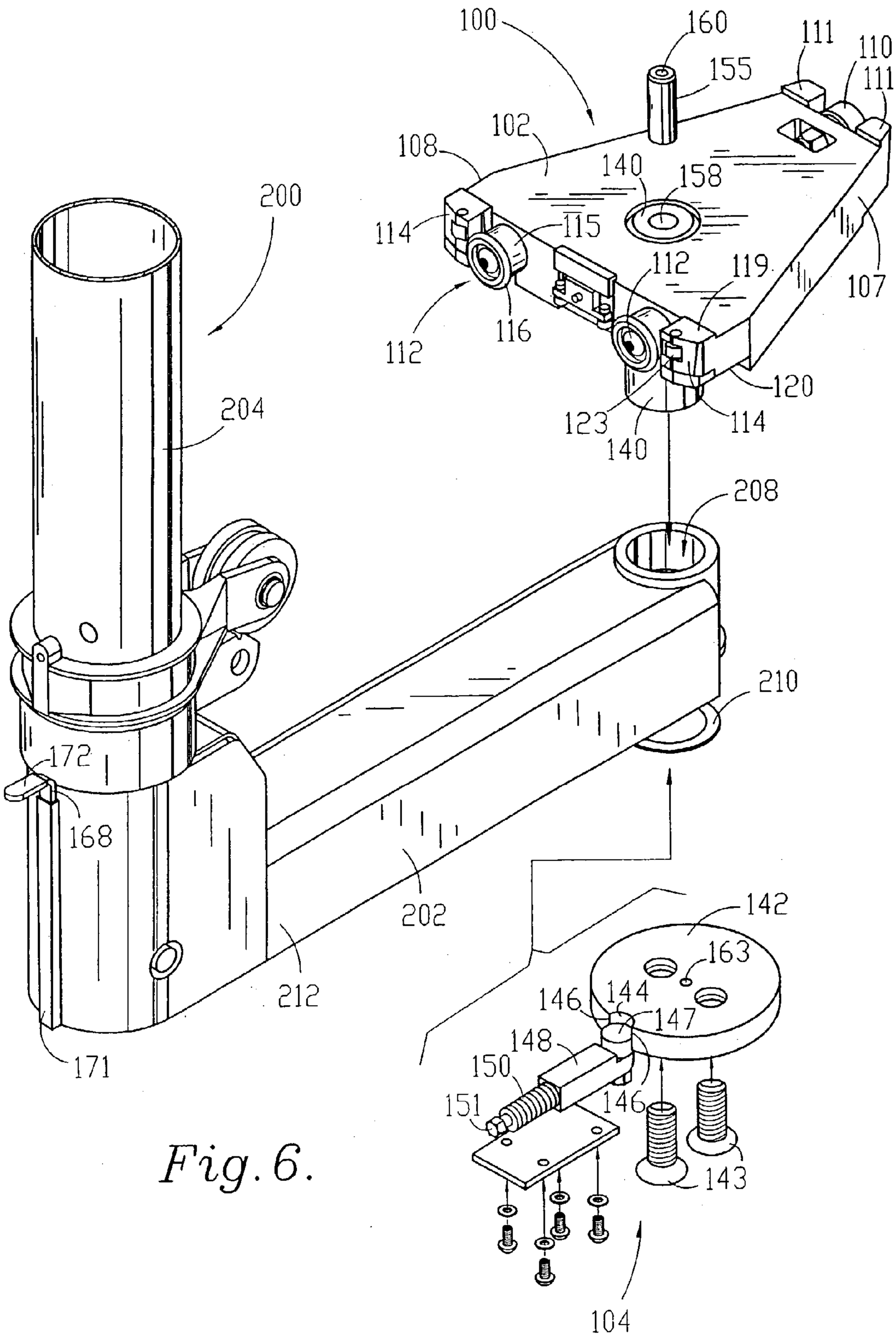

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Fig. 6.

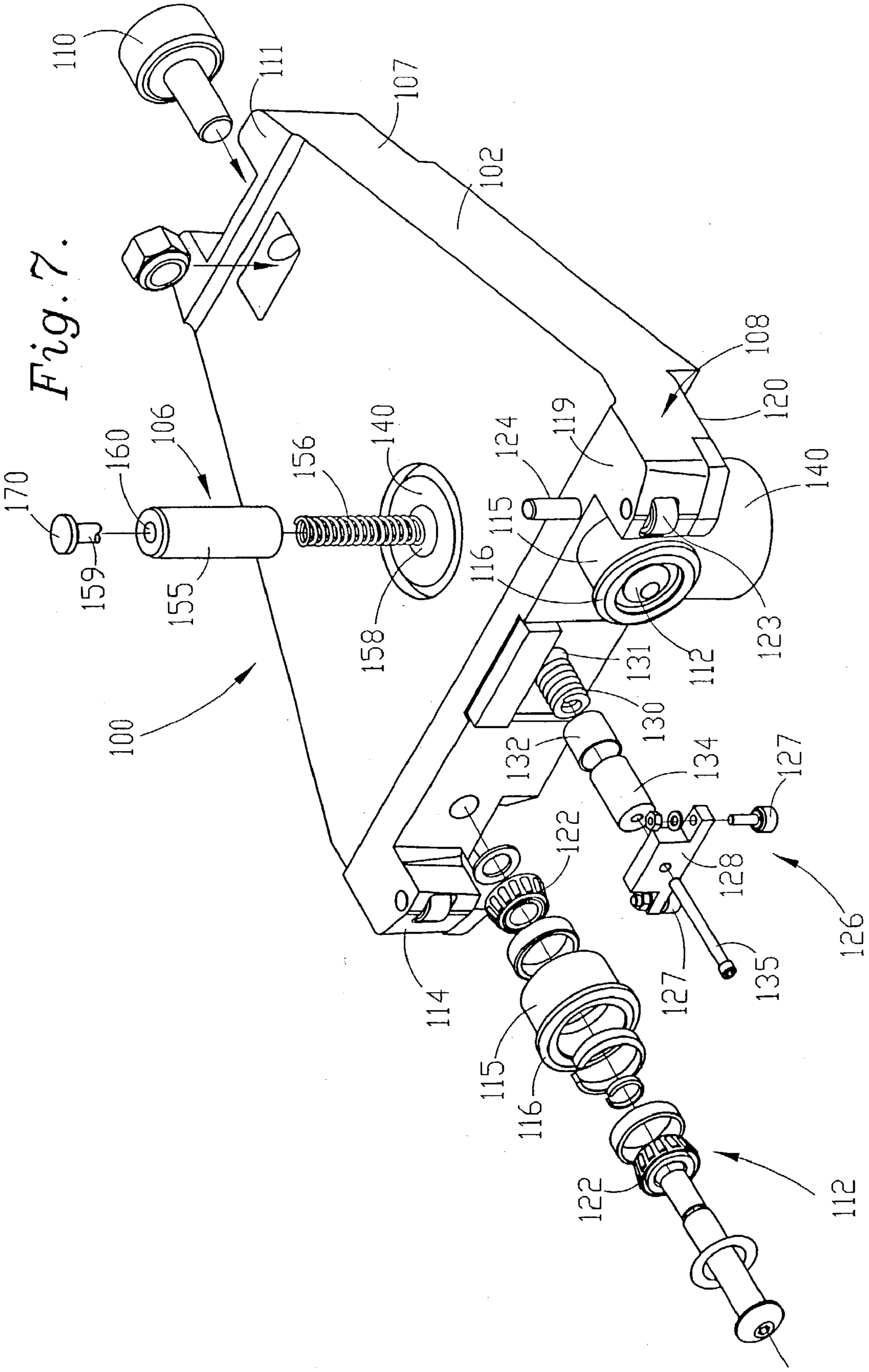

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Fig. 7.

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Fig. 12.

Fig. 8.

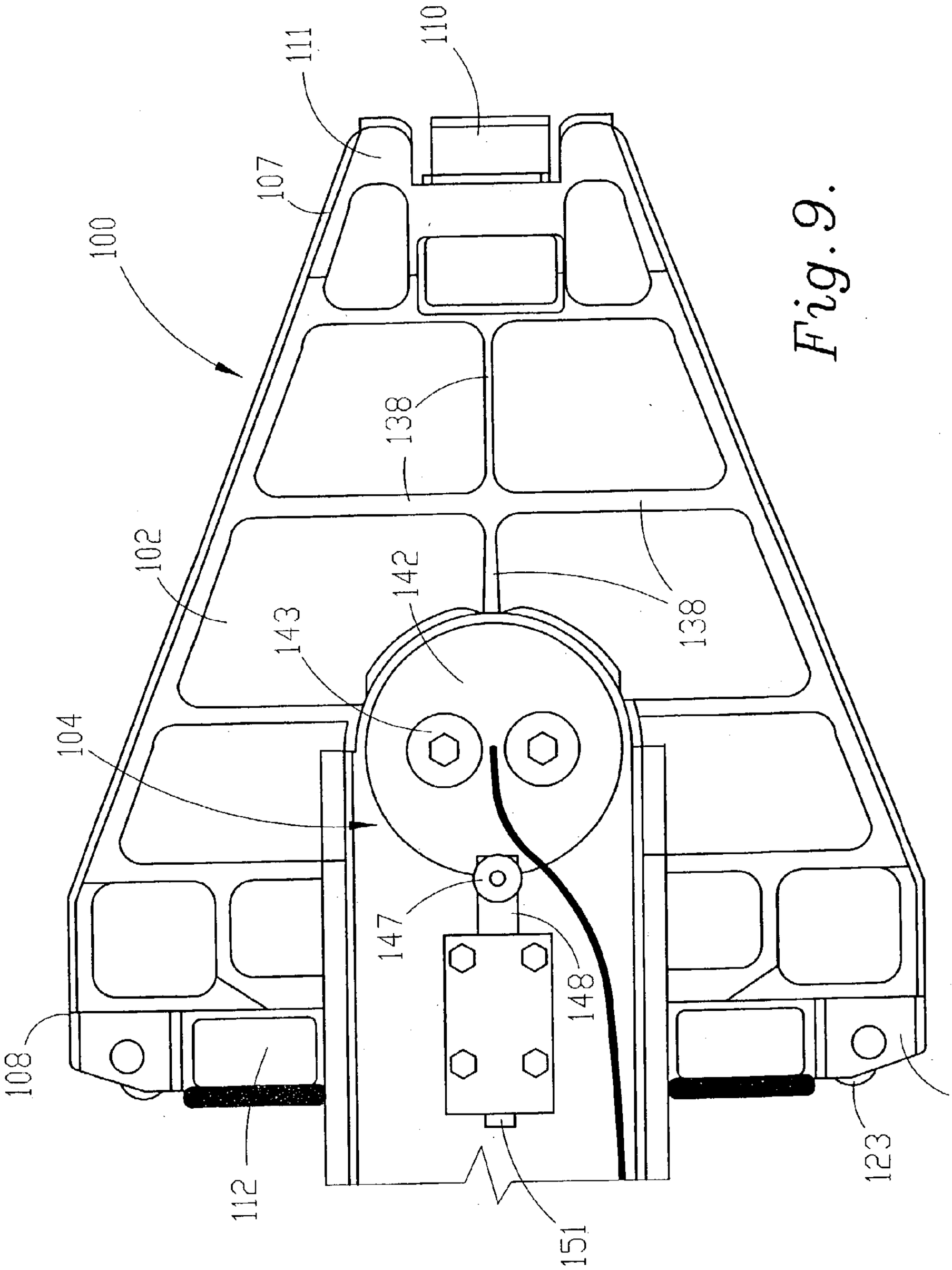

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Fig. 9.

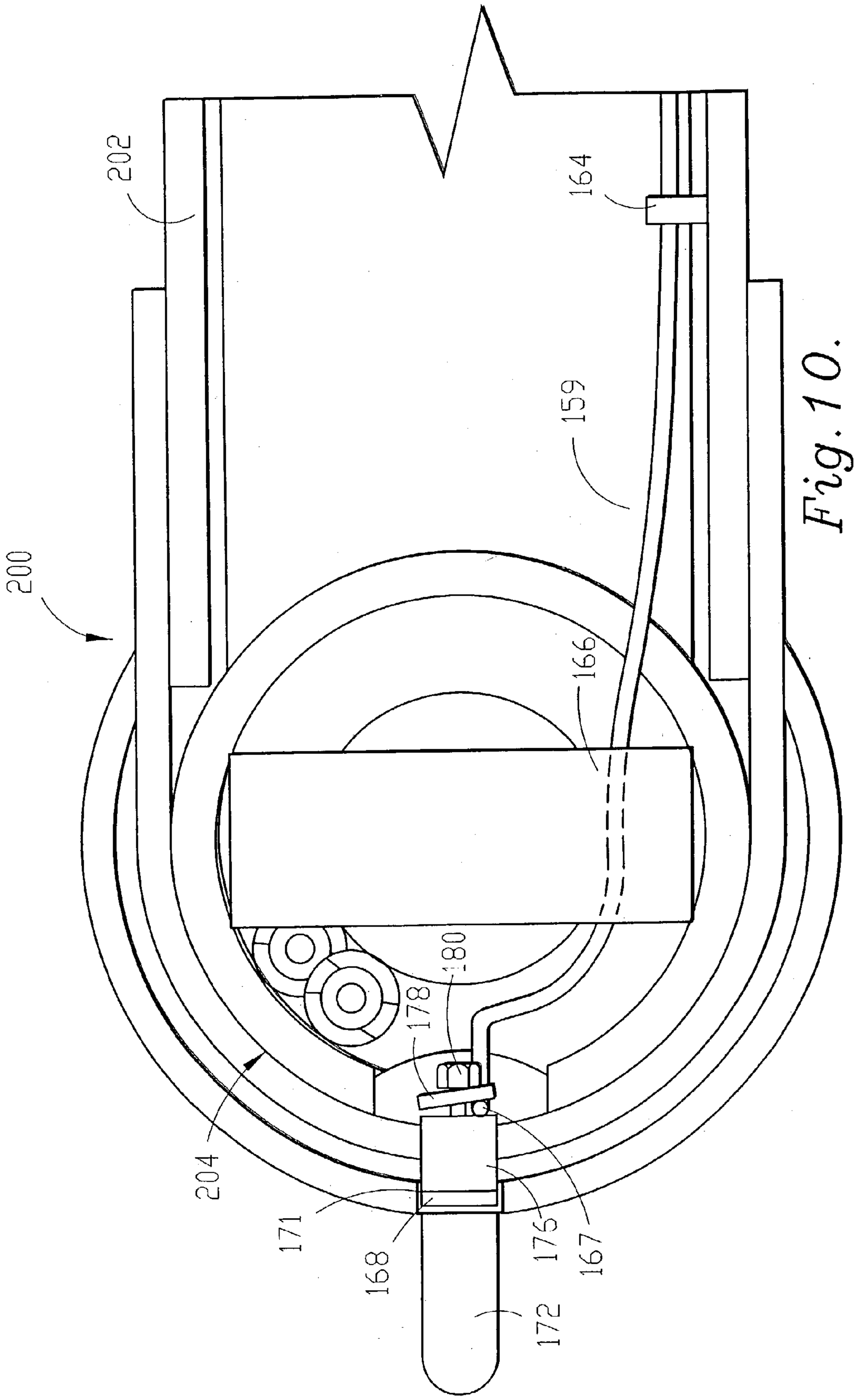


Fig. 10.

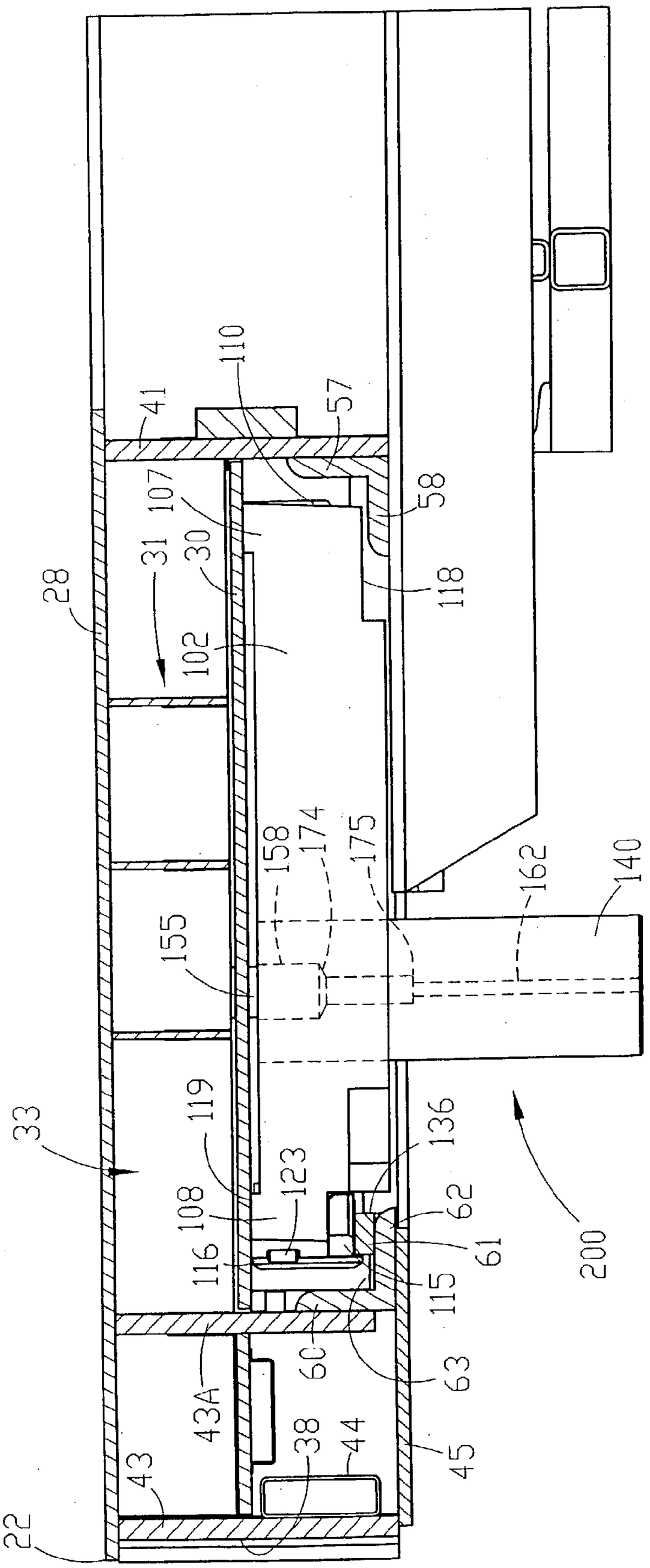

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Fig. 11.

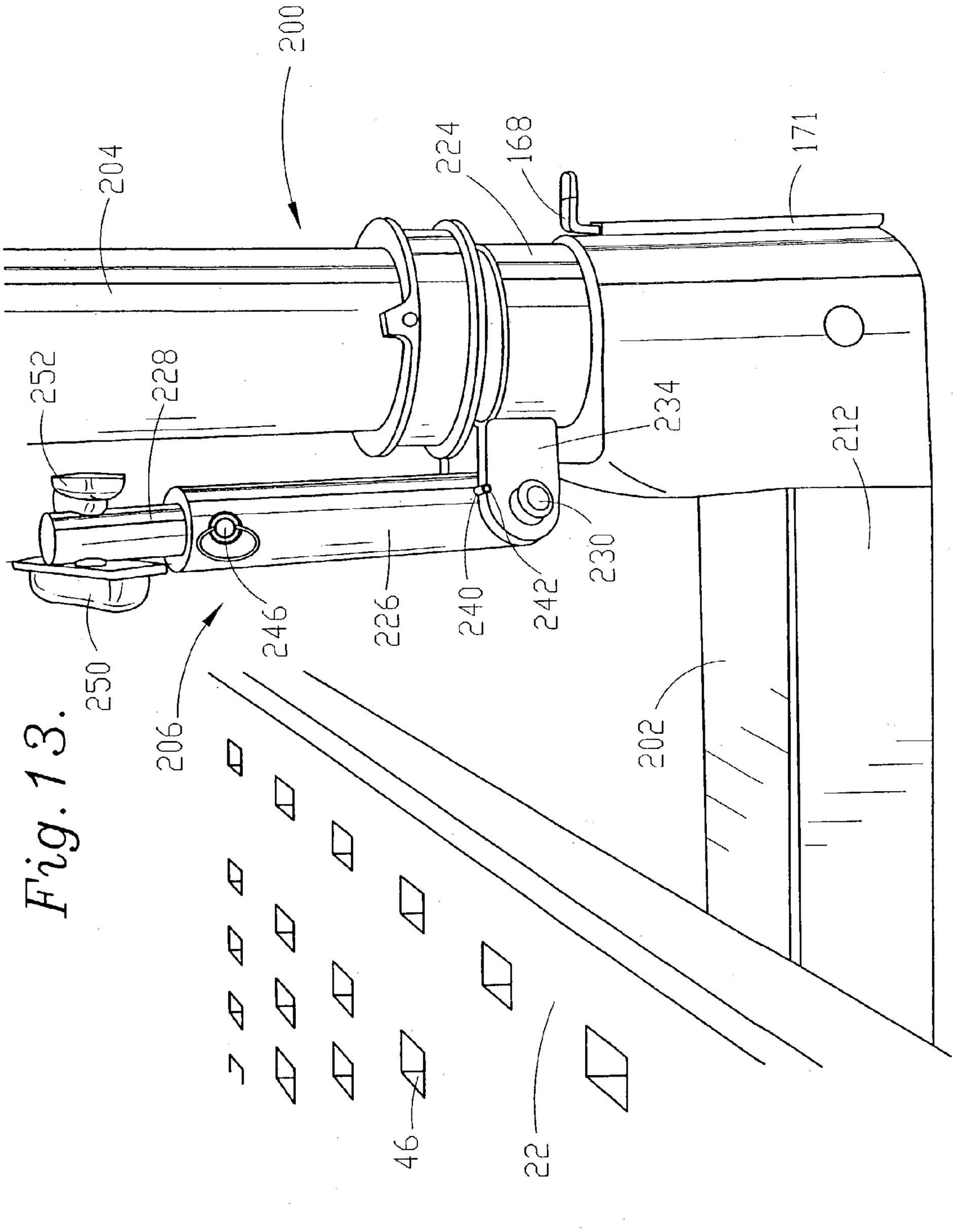


Fig. 13.

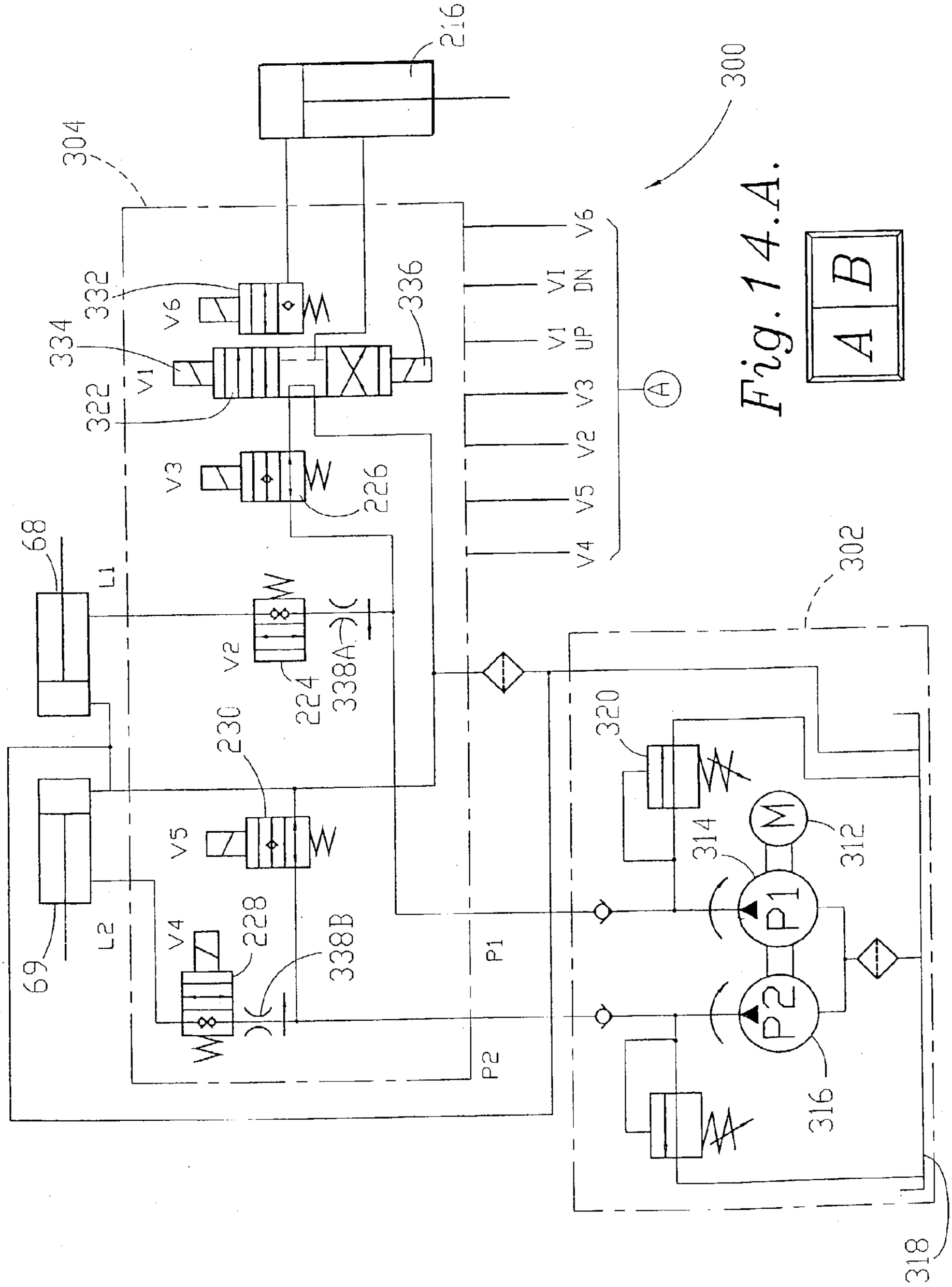

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V1 UP
V3
V2
V5
V4
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V6
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V3
226
68
L1
V2
224
338A
230
320
302
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Fig. 14.A.

A | B

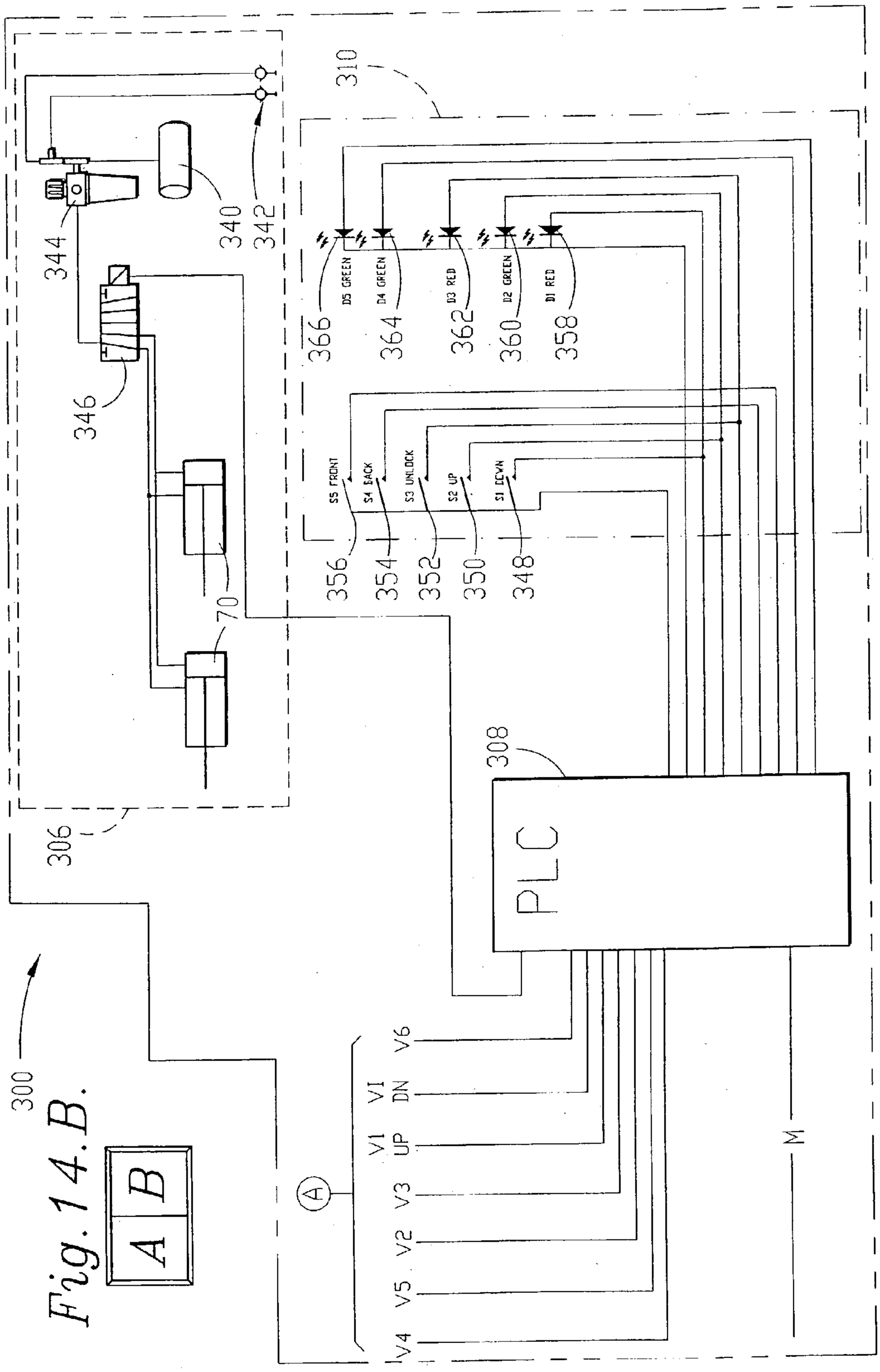
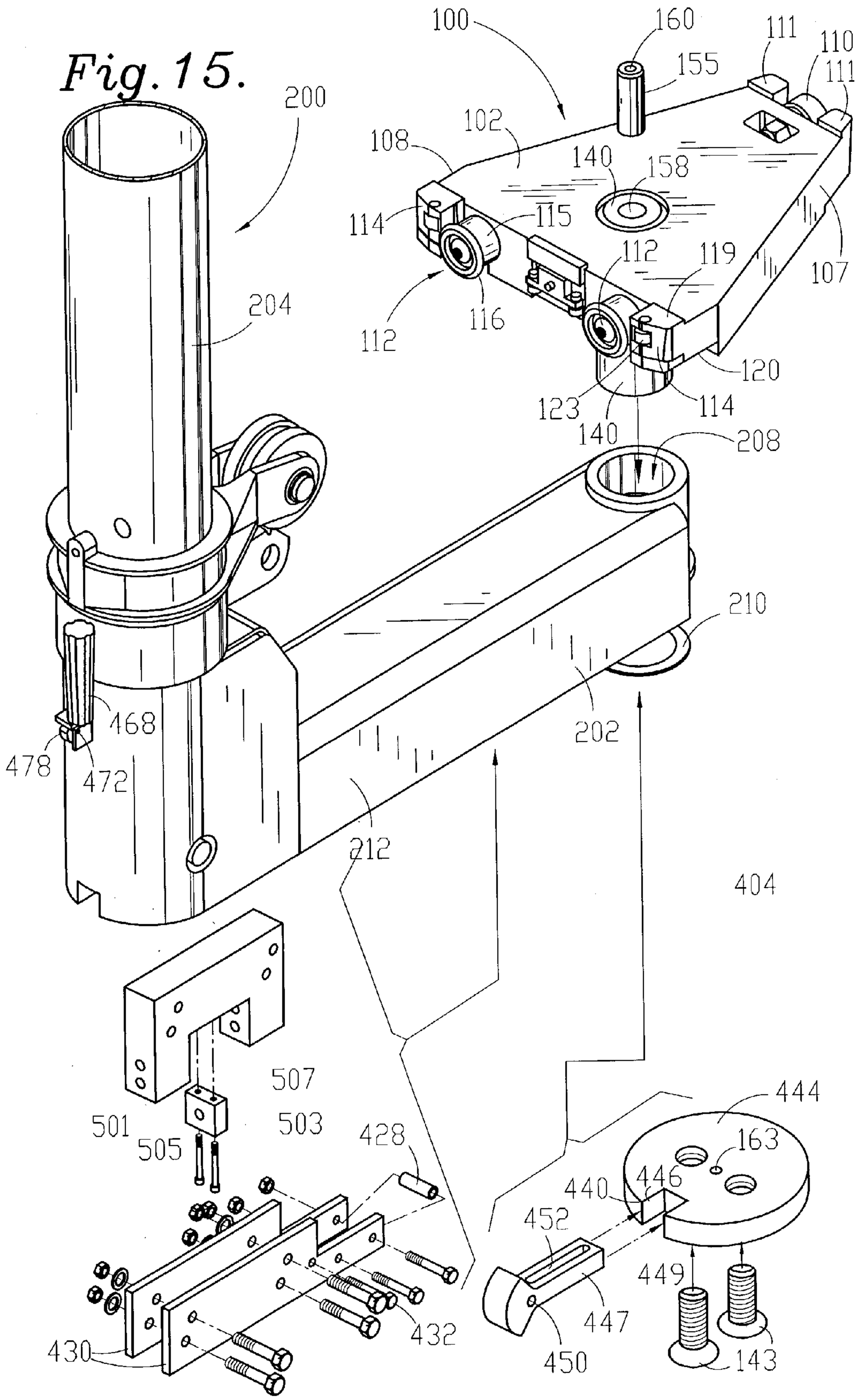

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D5 GREEN
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D3 RED
D2 GREEN
D1 RED
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350
348
S5 FRONT
S4 BACK
S3 UNLOCK
S2 UP
S1 DOWN
308
PLC
V6
V1
DN
V1
UP
V3
V2
V5
V4
A
M

Fig. 14. B.

A	B

Fig. 15.


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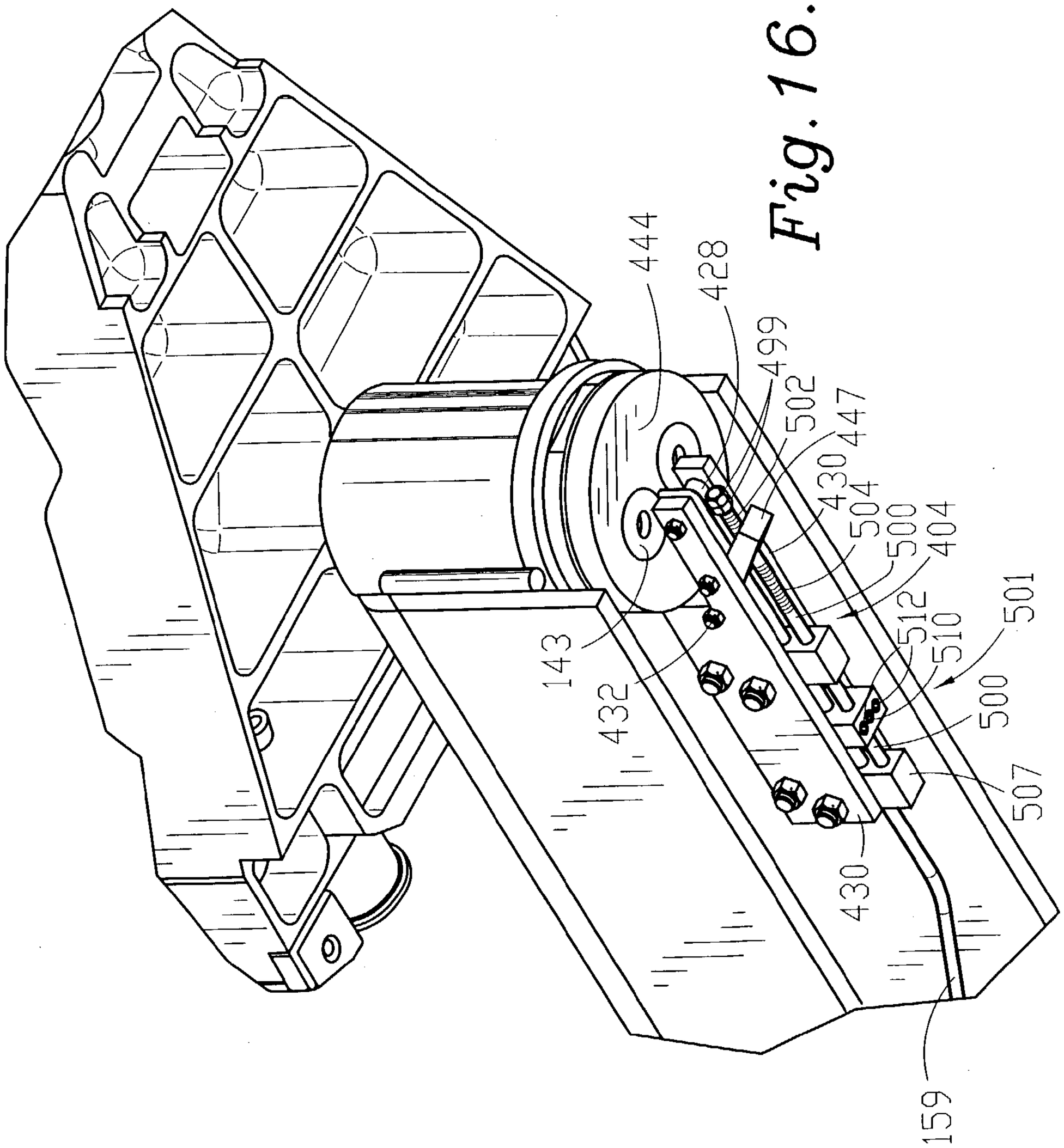

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Fig. 16.

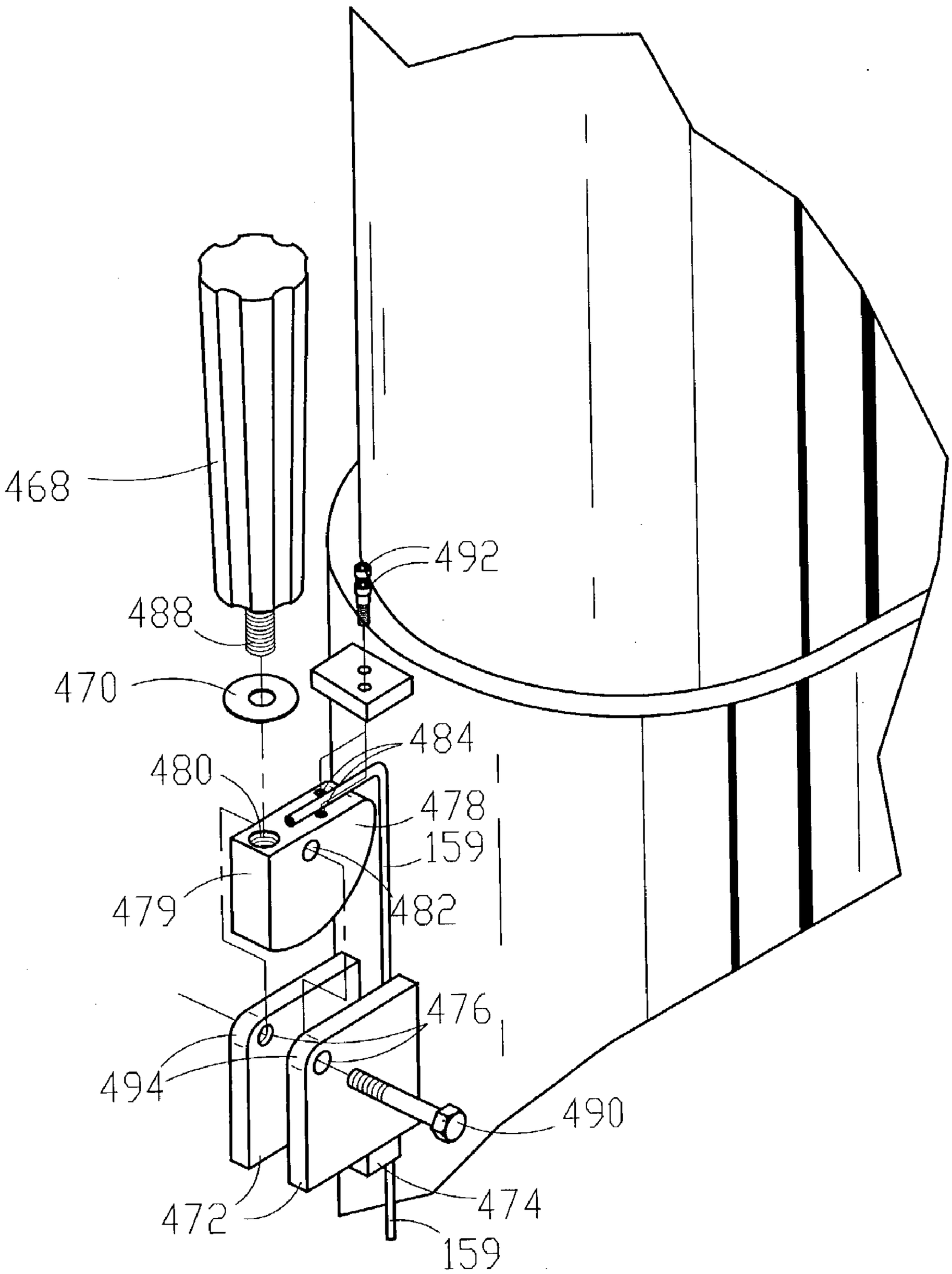


Fig. 17.

VEHICLE-STRAIGHTENING BENCH WITH TOWER LOCKING MECHANISM FOR MOVABLE CARRIAGES THAT MOUNT PULLING ASSEMBLIES

FIELD OF THE INVENTION

[0001] This invention relates to apparatus used to straighten vehicle chassis of automobiles, vans, SUV's, trucks and other vehicles and, more particularly, to vehicle-straightening benches having platforms for supporting and anchoring vehicles while pulling assemblies apply forces at desired locations and in desired directions thereby restoring the vehicle chassis to original configurations.

BACKGROUND OF THE INVENTION

[0002] Occasionally, vehicles are involved in collisions, and before they can reenter meaningful service, the vehicle chassis must be returned, as nearly as possible, to their original configurations. This is frequently accomplished with straightening benches. A typical straightening bench includes a platform for supporting and anchoring a vehicle chassis while forces are applied to the chassis by pulling assemblies. The pulling assemblies utilize hydraulically powered telescoping towers with chains that attach to desired locations on the vehicle chassis. To hold them in place, the pulling assemblies are secured to the bottom of the platform while force is applied to the chassis. In many designs the pulling assemblies are permanently mounted to the bottom side of the platform. With the pulling assemblies mounted on the platform, the large hydraulic pulling forces exerted by the towers create even larger moments and forces where the pulling assemblies are mounted to the platform. Thus, the pulling assembly mounts must be excessively over designed and occasionally fail rendering the pulling assembly inoperable. Further, the pulling assembly mounts unduly limit the possible positions of the pulling assemblies and hence restrict an operator's ability to apply force in any desired direction.

[0003] Many straightening benches utilize platforms, which can be raised and lowered with hydraulic lifts. Typically, the same hydraulic pump is used to power both the platform lift and the pulling assemblies. However, there are competing hydraulic design criteria for the lifts and the pulling assemblies. For the lifts, it is desirable to have a high volume pump, so that the lift does not operate too slowly, but the high-force pulls need more control requiring a low volume pump. More simply put, the lift should operate relatively fast and the towers of the pulling assemblies should operate relatively slow. To date, no satisfactory solution has been presented for these competing hydraulic design criteria. Additionally, prior straightening benches have lacked sufficient automation of locking mechanisms, and operators have been required to manually release valves and lock mechanism, which places the operators dangerously close to the straightening bench.

BRIEF SUMMARY OF THE INVENTION

[0004] There is therefore provided in the practice of the invention a novel vehicle-straightening bench which provides increased versatility, improved force control, and enhanced safety, for straightening vehicle chassis by the measured application of hydraulic force to the vehicle chassis. The vehicle straightening bench broadly includes a vehicle platform operable to support a vehicle chassis and an anchor attachable to the platform for securing the vehicle chassis to the platform. A pulling tower is provided to apply force to the vehicle chassis. A carriage assembly is moveably received by a carriage track, which is mounted on the platform, and the pulling tower is mounted on the carriage assembly.

[0005] In a preferred embodiment, the pulling tower is pivotally mounted on the carriage assembly, and the carriage assembly includes a tower positioning mechanism. The tower positioning mechanism engages a tower arm which extends between the pulling tower and the carriage assembly to mount the pulling tower to the carriage assembly. The positioning mechanism holds the pulling tower in a transport position substantially perpendicular to the bench while the pulling tower and carriage assembly are moved along the carriage track. The preferred positioning mechanism includes a pawl follower fixedly mounted on the tower arm and a notch plate mounted on the carriage assembly. The notch plate defines a notch, which receives the pawl follower, so that the pulling tower is substantially perpendicular to the bench when the pawl follower is received in the notch. A pawl biasing member, which is preferably a pawl spring, engages the pawl follower and forces it toward the notch plate and into the notch to hold the pulling tower in the transport position.

[0006] Preferably, the carriage assembly includes a carriage body defining a lock pin opening and further comprises a locking mechanism having a lock pin moveably received in the lock pin opening. A lock pin biasing member, preferably a compression spring, also received in the lock pin opening, engages the lock pin to bias the lock pin into an extended locking position. Once the lock pin is in the locking position, which locks the carriage assembly in place relative to the vehicle platform and carriage track, an operator applying a force will overcome the pawl biasing member thereby forcing the pawl out of the notch and pivoting the pulling tower relative to the carriage assembly. Preferably, the lock pin is coaxial with the pivot axis of the pulling tower. The locking mechanism also includes a release handle operative to release the lock pin when moved vertically downward.

[0007] A preferred carriage assembly includes a generally trapezoidal carriage body having a inwardly facing narrow end and an outwardly facing wide end. A single inner wheel is mounted on the narrow end of the carriage body for engaging the platform adjacent an inner rail of the carriage track. Two outer wheels are supported on an outer rail of the carriage track. The outer wheels preferably include circumferential ridges, which engage a wheel slot defined by the outer rail. Further, a guide is forced against the outer rail by a guide spring, and a pair of guide rollers are positioned adjacent the outer wheels. Preferably, the carriage assembly alone supports the pulling tower above the ground surface.

[0008] In another aspect of the invention, the bench utilizes a force arm which has one end substantially fixed to the pulling tower and a free end capable of pivoting in three dimensions relative to the pulling tower. The force arm is preferably telescoping and includes a pivoting anchoring foot configured for insertion in anchoring apertures defined in the platform. The pivoting anchoring foot rotates to lock

in the platform anchoring apertures. The force arm provides additional support to the pulling tower and carriage assembly when hydraulic force is applied to the vehicle chassis by the pulling tower.

[0009] In still another aspect of the invention, the vehicle-straightening bench utilizes a moveable crossmember extended between inner sides of opposed legs of the vehicle-straightening bench. Opposite ends of the crossmember slideably engage slide tracks formed on the inner sides of the opposed legs of the bench. Two position locks are located at the ends of the crossmember and are operable to lock the crossmember in a selected position on the bench. The slide tracks define lock openings and each position lock includes a pivotally mounted lock rod. A rod biasing member forces the lock rods into the lock openings defined in the leg tracks to hold the crossmember in position.

[0010] In still another aspect of the present invention, the vehicle-straightening bench preferably includes a hydraulic control circuit. In a preferred embodiment of the bench having front and rear lifts, the hydraulic control circuit includes front and rear sets of lift control valves operative to actuate the front and rear lifts independently and/or simultaneously. A tower control valve is also provided which in conjunction with the front and rear lift control valves is operable to permit actuation of the pulling tower only when the lift control valves are closed. The bench also preferably includes a pneumatic control circuit with first and second pneumatic cylinders operable to move first and second lift latches which engage the lifts to lock them in desired positions. A remote control is provided to operate both the pneumatic and hydraulic control circuits. The control system utilizes a programmable logic controller to transmit instructions to the respective valves and cylinders.

[0011] Accordingly, it is an object of the present invention to provide an improved vehicle-straightening bench for straightening vehicle chassis.

[0012] It is another object of the present invention to provide an improved carriage assembly for movement and increased positioning versatility of pulling towers around a vehicle-straightening bench.

[0013] It is still another object of the present invention to provide an improved vehicle straightening bench control circuit for remote actuation of valves and cylinders.

[0014] It is a further object of the present invention to provide an improved pulling assembly having an additional force transmission path between a pulling tower and a vehicle platform of a vehicle-straightening bench.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] These and other inventive features, advantages, and objects will appear from the following Detailed Description when considered in connection with the accompanying drawings in which similar reference characters denote similar elements throughout the several views and wherein:

[0016] **FIG. 1** is a perspective view of a vehicle-straightening bench according to the present invention and including a plurality of carriage assemblies (hidden) and pulling assemblies;

[0017] **FIG. 2** is a top view of the bench of **FIG. 1** having sections broken away to reveal a lower deck, a carriage track, and a carriage assembly;

[0018] **FIG. 3** is a top view of the carriage track shown in **FIG. 2**;

[0019] **FIG. 4** is an end view of the carriage track shown in **FIG. 2**;

[0020] **FIG. 5** is a perspective view of a movable crossmember with position locks for use with the bench of **FIG. 1**;

[0021] **FIG. 6** is a fragmentary perspective view of one of the pulling assemblies of **FIG. 1** having a corresponding carriage assembly, illustrated in **FIG. 2**, exploded away from the pulling assembly;

[0022] **FIG. 7** is a partially exploded perspective view of a portion of the carriage assembly of **FIG. 2**;

[0023] **FIG. 8** is a bottom elevational view of one of the pulling assemblies of **FIG. 1** assembled to a corresponding carriage assembly of **FIG. 2**;

[0024] **FIG. 9** is a fragmentary enlarged bottom view of the carriage assembly of **FIG. 8**;

[0025] **FIG. 10** is a fragmentary enlarged bottom view of the pulling assembly of **FIG. 8**;

[0026] **FIG. 11** is a fragmentary vertical cross-sectional view of a platform of the bench of **FIG. 1** having one of the carriage assemblies illustrated in **FIG. 2** received in the carriage track under the platform;

[0027] **FIG. 12** is an exploded perspective view of a force arm of the pulling assembly;

[0028] **FIG. 13** is a fragmentary perspective view of the bench of **FIG. 1** illustrating the force arm of **FIG. 12**;

[0029] **FIGS. 14A & B** illustrate a control system schematic for the bench of **FIG. 1**;

[0030] **FIG. 15** is a fragmentary perspective view of one of the pulling assemblies of **FIG. 1** having a corresponding carriage assembly, illustrated in **FIG. 2**, exploded away from the pulling assembly, with an alternative cam detent positioning mechanism;

[0031] **FIG. 16** is a fragmentary enlarged bottom view of the carriage assembly of **FIG. 8** with an alternative cam detent positioning mechanism; and

[0032] **FIG. 17** is an exploded view of an alternative release handle on a tower of one of the pulling assemblies of **FIG. 1**.

DETAILED DESCRIPTION

[0033] Referring to the drawings in greater detail, **FIGS. 1 and 2** show a vehicle straightening bench **20** constructed in accordance with a preferred embodiment of the present invention. The bench **20** broadly includes a vehicle platform **22** providing a carriage track **24**, a plurality of carriage assemblies **100** movably received by the carriage track **24**, and a plurality of pulling assemblies **200** are movably mounted to the platform **22** by the carriage assemblies **100**. Further, the pulling assemblies **200** can pivot on the carriage assemblies **100**. The bench **20** is provided with an automated control system **300** (**FIG. 14**) enabling remote operation of the bench power system **302** and safety mechanisms. The vehicle platform **22** is operable to support a vehicle chassis (not shown), and a plurality of anchors **26** (one shown),

which can be positioned at different locations on the platform **22**, attach to the vehicle chassis at selected locations holding it in a substantially fixed position relative to the platform **22**. While the vehicle chassis is secured, the pulling assemblies **200** are moved to desired locations around the bench **20** and locked in position. The pulling assemblies **200** then apply force to the vehicle chassis at desired locations and in desired directions. The carriage assemblies **100** are substantially identical and the pulling assemblies **200** are substantially identical, and they will be described in the singular at times for clarity with the understanding that the description applies to all of the respective assemblies.

[**0034**] Referring additionally to **FIG. 11**, the vehicle platform **22** is substantially rigid and includes an upper deck **28** defining a top of the platform and a lower deck **30** defining a bottom of the platform. The upper and lower decks **28**, **30** are joined by a plurality of rigid webs, generally designated **31**, which spaces the decks **28**, **30** apart to define an internal platform cavity **33**. The upper and lower decks **28**, **30** form legs **32** which extend over a desired length from the front **34** to the rear **36** of the of the bench **20** and define the sides **38** of the platform **22**. The platform legs **32** are joined by a perpendicular rear cross beam **40** and a perpendicular front cross beam **42**, which also serves to provide at least part of a protective housing for the bench control system **300** and power system **302**. The upper and lower decks **28**, **30** are also joined by an inner side wall plate **41** and outer wall plates **43**. The wall plates **41**, **43** extend below the lower deck **30** and hence below the bottom of the platform to define a track mounting area below the bottom of the platform. An outer bottom plate **45** extends across the gap between the outer wall plates **43**. A hollow rectangular tube **44** is mounted between the outer wall plates **45** and functions as a conduit for hydraulic hoses (not shown) and other supply and power lines as required.

[**0035**] The upper deck **28** defines a plurality of anchoring apertures **46** spaced apart and positioned between the webs **31**. The anchoring apertures **46** are preferably rectangular and are configured to receive components of the anchors **26**. The lower deck **30** defines a plurality of lock pin apertures **48**, which are substantially uniformly spaced along straight lines in the legs **32**. In the front corners of the platform **22**, the lock pin apertures **48** are more closely spaced and extend around a radius, which follows an arc of the carriage track **24** in the front platform corners.

[**0036**] Referring to **FIGS. 2, 3**, and **4**, the carriage track **24** extends along the length of the platform **22** and along both sides **38** of the platform. The carriage track **24** is generally mounted to the bottom platform underneath the legs **32** in the track mounting area. The track **24** includes long linear sections **49** positioned underneath the legs. At the front **34** corners of the platform, the carriage track **24** includes arcuate front corners **50** and a short linear section **52** extends across the front **34** of the platform **22**. Thus, the carriage track has a U-shaped configuration, opening toward the rear **36** of the bench. The long linear sections **49** terminate at the rear **36** of the platform and stop blocks **53** are positioned at the ends of the track **24** to keep the carriage assemblies from coming off the ends of the track. The stop blocks **53** (**FIG. 1**) are preferably attached to the lower deck **30** at the rear **36** of the legs **32**.

[**0037**] Referring additionally to **FIG. 11**, the carriage track **24** includes an inner rail **54** and an outer rail **56**. The inner rail **54** comprises a piece of angle iron attached to the inner wall plate **41** underneath the lower deck **30** inside the track mounting area defined below the bottom of the platform **22**. A vertical leg **57** of the inner rail **54** is attached to the inner wall plate **42**, and an inner rail horizontal leg **58** extends farther underneath the platform leg **32** toward the outer wall plates **43**. The outer rail **56** also comprises a piece of angle iron with an outer rail vertical leg **60** attached, preferably welded, on an inner one **43**A of the outer wall plates **43**. A wheel bar **61** is attached to the inner free end of the outer rail horizontal leg **62**. The wheel bar **61** preferably extends along the entire outer rail including the arcuate corners **50**, and therefore, defines a wheel slot **63** between the outer rail vertical leg **60** and the wheel bar **61** extending along the entire length of the outer rail **56** and track **24**. The outer bottom plate **45** is attached to the bottom of the outer rail horizontal leg **62**. The horizontal rail legs **58**, **62** are preferably coplanar and extend toward each other, and the vertical rail legs **57**, **60** are preferably parallel and extend upwardly toward the bottom of the platform **22**.

[**0038**] Referring to **FIGS. 1 and 14**, the platform **22** can preferably be raised and lowered with first and second hydraulic lifts **64**, **65**, which support the platform above the ground surface. The front lift **64** has a front lift cylinder **68** (shown schematically) and is aligned with the front crossbeam **42**, and the rear lift **65** has a rear lift cylinder **69** (shown schematically) and is aligned with the rear crossbeam **40**. Each lift includes a pneumatically released lift latch **66** operable to hold the lifts at a desired elevation. When the pneumatic cylinders **70** (shown schematically) are actuated, the latches **66** pivot from engaged positions, in which the latches **66** are operative to hold the lifts at desired elevations, to disengaged positions, which permit the lifts to lower. The lifts **64**, **65**, lift latches **66**, and operation thereof are fully described in U.S. patent application Ser. No. 09/973,586 filed on Oct. 9, 2001, which is fully incorporated herein by reference.

[**0039**] The bench **20** is also provided with a movable crossmember **72** illustrated in **FIG. 5**. The movable crossmember **72** includes an upper plate **73** defining additional anchoring apertures **74** and a lower plate **76** attached to the upper plate **73** with end plates **77** and side plates **78**. The end plates **77** are bifurcated to define a central opening, and the tops of the end plates have aligned pivot holes **80**. Position locks **81** are used at each end of the crossmember **72** to hold the crossmember in a desired location. The position locks **81** are substantially identical and will generally be described with reference to only one lock. The position lock **81** includes a pivot plate **82** pivotally mounted to the end plates **77** by a pivot pin **84** extending through the pivot holes **80**. A lever arm **85** extends inwardly from the pivot plate **82** and attaches a release handle **86** to the pivot plate **82**. The lever arm **85** also has an upwardly extending post **88** which receives a rod biasing member **89**, preferably a compression spring. A lock rod **90** extends outwardly from the pivot plate **82** in a direction substantially opposite to the lever arm **85**. If desired a grip enhancing and padding member **97** is placed over the release handle **86**.

[**0040**] Referring additionally to **FIG. 1**, pairs of upper and lower slide bars **92**, **93** are attached to the end plates **77** in a spaced, horizontal orientation. The slide bars **92**, **93** receive a slide track **94** between them. Opposing slide tracks **94** are attached to the inner wall plates **41** of the platform **22**

legs **32** and define a plurality of substantially equally spaced lock openings **96**, which are preferably cylindrical. The rod-biasing member **89** is engages the lever arm **85** and the upper plate **73**. Thus, the rod-biasing member **89** is compressed between the lever arm and the upper plate, and the post **88** holds the biasing member **89** in position. The rod biasing member **89** forces the pivot plate **82** against the slide bars **92**, **93**, so that the lock rod **90** extends between the bifurcated end plates **77** and the slide bars. The lock rod **90** has sufficient length to extend beyond the slide bars **92**, **93** and is configured for insertion in the lock openings **96**. When the lock rods **90** of the position locks **81** are aligned with the lock openings **96**, the rod biasing members **89** force the lock rods into the lock openings. When an operator pulls up on the handle **86**, the force of the rod biasing member **89** is overcome, and the pivot plates **82** pivot away from the slide bars retracting the lock rods **90** from the lock openings **96**. Once the lock rods **90** are retracted, the slide bars **92**, **93** are free to slide on the slide track **94**.

[**0041**] Referring to **FIGS. 6, 7**, and **11**, the carriage assembly **100** includes a carriage body **102**, a tower positioning mechanism **104**, and a locking mechanism **106**. The carriage body **102** has a generally trapezoidal perimeter with an inwardly facing narrow end **107** and an outwardly facing wide end **108**. The narrow end **107** rotatably mounts a cylindrical inner wheel **110** between protective fingers **111**. The inner wheel **110** is positioned high on the body **102** and extends a small distance above the fingers, so that has the carriage assembly rolls along the track **24**, the inner wheel rolls against the bottom of the platform **22**. More specifically, the inner wheel **110** rolls against the lower deck **30** as seen in **FIG. 11**. The wide end **108** rotatably mounts a pair of outer wheels **112** between an outer pair of protective fingers **114**. The outer wheels **112** extend a small distance below the outer protective fingers and roll on top of the wheel bar **61** of the outer rail **56** as the carriage assembly is moved along the track **24**. Because the carriage assembly **100** alone supports the pulling assembly **200** as it is moved, the weight of the pulling assembly tilts the carriage body and forces the inner wheel upward and the outer wheels downward.

[**0042**] As best illustrated in **FIG. 11**, when the pulling assemblies **200** are applying force to a vehicle chassis (a pull), this relationship is typically reversed, and a recessed bottom surface **118** of the narrow inner end **107** is forced against the inner rail horizontal leg **58**. Thus, the recessed bottom surface **118**, not the inner wheel **110** bears the load when the pulling assembly applies force. Similarly, a raised top surface **119** of the wide outer end **108** is forced against the lower deck **30** of the platform. Therefore, when the forces are greatest, which is during a pull, the carriage body **102** not the wheels **110**, **112** bears the load of the pull. When the carriage is rolling, the recessed bottom surface **118** of the narrow end **107** also provides clearance from the inner rail **54**, and the wide end **108** has a similar recessed surface **120**. While the wheels are positioned so that during a pull they typically are not exposed to force, there are certain pulls during which it is inevitable that some force will be transmitted to the wheels. To accommodate this force, the wheels are mounted with two tapered thrust bearings **122** (**FIG. 7**) placed in opposite orientations to bear load in either direction, and the wheels protrude only small distances beyond the protection of the carriage body.

[**0043**] Referring to **FIGS. 7 and 11**, the outer wheels **112** have an elongated cylindrical section **115** for rolling on the wheel bar **61**. The outer wheels **112** also include a circumferential ridge **116** spaced away from the carriage body **102**. The ridge **116** has a larger diameter than the cylindrical section **115**. The ridge **116** is received in the wheel slot **63** and engages the inner side of the wheel bar **61** to stabilize and secure the carriage assembly in the track **24**. To keep the carriage assembly from binding in the track **24** as it is moved around the corners **50**, two vertical axis rollers **123** are rotatably mounted by axles **124** on the outer surfaces of the protective fingers **114** of the wide end **108**. The rollers **123** protrude from the fingers **114** and engage and roll against the outer rail vertical leg **60** allowing the carriage assemblies to move smoothly around the corners **50** of the track. Because of the trapezoidal shape of the carriage bodies, several pulling assemblies **200** can be positioned in a corner with minimal spacing. Specifically, the narrow ends **107** of the carriage bodies allow the bodies **102** to move closer together even at the smaller radius of the inner rail **54**.

[**0044**] Referring to **FIG. 7**, the carriage body also has a guide assembly **126** centrally mounted on the wide end **108** of the carriage body **102**. The guide assembly **126** is positioned between the outer wheels **112** and includes two vertical axis guide rollers **127** mounted at opposite ends of an elongated guide bar **128**. A guide spring **130** is held in a guide aperture **131** formed in the wide end **108**. A guide collar **132** keeps the spring engaged with a guide plunger **134** that presses against the guide bar **128**. A tension control rod **135** threads into the base of the guide aperture **131** to hold the guide assembly **126** together and compress the guide spring **130**. The guide rollers **127** are aligned to engage the exposed side **136** of the wheel bar **61**. By threading the tension control rod **135** in and out, the positions of the guide rollers are adjusted relative to the wheel bar **61**. Preferably, the guide spring **130** is compressed, so that there is approximately 0.005 inch clearance between the guide rollers **127** and the wheel bar.

[**0045**] Referring additionally to **FIG. 11**, as the carriage assembly **100** and pulling assembly **200** are pushed along the track **24**, the carriage assembly tends to twist in the track. As the carriage assembly starts to twist, one of the guide rollers **127** engages the wheel bar **61** and rolls against its exposed side **136**. When the guide roller **127** contacts the wheel bar, the carriage assembly is forced toward a correct orientation in the track **24**. The force applied by the guide rollers is dampened by the guide spring **130** and guide collar **132**, which absorb the force and allow the guide bar **128** to twist a small amount. Thus, the guide assembly inhibits binding of the carriage assembly along the linear sections **49** of the carriage track **24**.

[**0046**] Referring to **FIGS. 7 and 9**, the carriage body **102** is substantially hollow with a plurality of frame members **138** extending across the body **102** making it more rigid. A pivot cylinder **140** is received in and is part of the carriage body. The pivot cylinder extends from the top of the body **102** and protrudes from the bottom of the carriage body **102** for pivotally mounting the pulling assembly **200** to the carriage assembly **100**.

[**0047**] The tower positioning mechanism **104** keeps the pulling assembly from pivoting when an operator pushes on the pulling assembly to position it. Referring to **FIGS. 6 and**

9, the positioning mechanism **104** includes a notch plate **142**. Two fasteners **143** join the notch plate **142** to the bottom of the pivot cylinder **140** thereby holding a tower arm **202** of the pulling assembly **200** on the pivot cylinder **140**. The notch plate **142** defines a notch **144** in its perimeter edge. The notch is approximately one-half of a circle, and preferably, the corners **146** of the notch are not rounded. A circular pawl follower **147** is attached to a pawl shaft **148**. The follower is sized to fit in the notch **144**, and the shaft **148** is slidably mounted on the tower arm **202**. The pawl is preferably free to rotate on the shaft **148**. A pawl biasing member **150**, preferably a pawl compression spring, engages the shaft **148** and forces the circular pawl **147** against the notch plate **142**. When the pawl **147** is aligned with the notch **144**, the pawl spring **150** biases the pawl into the notch. A mounting plate **152** and pawl fasteners **154** mount the pawl **147** and pawl spring **150** to the tower arm. A compression bolt **151** attaches the pawl spring to the pawl shaft, and the compression bolt **151** is operable to adjust the force with which the pawl **147** is pushed into the notch **144**. The tighter the bolt **151**, the greater the force. While several of the positioning mechanism components are mounted on the pulling assembly, they are still considered part of the carriage assembly for purposes of definition.

[**0048**] When the locking mechanism **106** locks the carriage assembly **100** in a selected location on the track **24**, an operator can force the pawl out of the notch **144** allowing the pulling assembly to pivot on the carriage assembly **100**. When the carriage assembly **100** is free to roll on the track, the force applied by the operator moves the pulling assembly and the carriage assembly. Thus, the force required to remove the pawl **147** out of the notch is greater than the force required to move the pulling and carriage assemblies. The substantially square corners **146** of the notch **144** contribute to this force differential. Therefore, when the locking mechanism **106** is not engaged, the operator can move the pulling assembly in its easiest transport position, which is substantially perpendicular to the platform. When the operator wants to pivot the pulling assembly, the locking mechanism is engaged allowing a higher force to be applied to the pulling assembly without moving it.

[**0049**] Referring to **FIGS. 7, 8**, and **11** the locking mechanism **106** includes a lock pin **155** and a lock pin biasing member **156**, preferably a lock spring in compression. The pivot cylinder **140** of the carriage body **102** defines a lock pin opening **158** in the top of the body, and the lock pin **155** and lock spring **156** are received in the lock pin opening **158**. Because the lock pin opening **158** is centrally positioned in the pivot cylinder **140**, the axis of the lock pin **155** is coaxial to the pivot axis of the pulling assembly **200**. The lock pin **155** is slidably received in the opening **158** and moves between an extended locking position and a retracted unlocked position. The lock pin opening **158** defines a lock pin shoulder **174** limiting how far the lock pin can retract into the carriage body. The lock pin opening **158** also defines a lock spring shoulder **175**, which positions the lock spring in the opening **158**. In the extended position, the lock pin **155** extends into a selected one of the lock pin apertures **48** (**FIG. 2**) of the lower deck **30**. An elongated release cable **159** is passed through an eyelet **160** in the top of the lock pin **155**, the center of the lock spring **156**, a small cable passage **162** through the pivot cylinder **140**, and a cable aperture **163** (**FIG. 6**) in the center of the circular notch plate **142**. The cable **159** extends along the tower arm **202** and is fastened to the arm **202** with cable guides **164**.

[**0050**] Referring additionally to **FIG. 10**, the cable **159** is then passed over a bottom inversion dowel **166**, and its free end **167** is clamped to a release handle **168** between a handle block **176** and cable pinch washer **178**. A cable pinch bolt **180** extends through the washer **178** and threads into the block **176** to pinch the free end **167** of the cable between the washer **178** and the block **176**. The first end of the cable **159** has a drum **170** (**FIG. 7**) that forms a T-end of the cable, and the T-end is too large to fit through the lock pin eyelet **160**. Thus, the cable **159** is in tension between the lock pin **155** and the release handle **168** thereby holding the lock spring **156** in compression. Referring to **FIGS. 6 and 10**, the release handle **168** is slidably received in a release channel **171** mounted on the outside of a pulling tower **204** of the pulling assembly **200** for easy operator access. The upper end of the release handle **168** has a handle flange **172** adapted to receive a substantial downward force from an operator's hand.

[**0051**] As an operator pushes downwardly on the handle flange **172** the tension cable **159** retracts the lock pin **155** and compressing the lock spring **156**. Because the cable passes over the inversion dowel **166**, it is an easily applied downward force, which disengages the locking mechanism **106**. The operator then maintains downward pressure on the release handle **168** until the pulling assembly is near a desired location. Then the handle **168** is released, and the top of the lock pin **155** slides against the lower deck **30** until it is aligned with the closest lock pin aperture **48**. Once aligned, the lock spring **156** forces the lock pin **155** into the lock pin aperture **48** defined in the lower deck **30** thereby locking the carriage assembly **100** in place relative to the track **24** and platform **22**.

[**0052**] Referring to **FIGS. 1 and 13**, the pulling assembly **200** includes a tower arm **202**, a pulling tower **204**, and a force arm **206**. Referring additionally to **FIG. 6**, the tower arm **202** is a substantially rigid member extending substantially horizontally between the pulling tower **204** and the carriage assembly **100**. The inner end of the tower arm provides a cylindrical opening **208**, which pivotally receives the pivot cylinder **140** of the carriage body **102**. The notch plate **142** and the notch plate fasteners **143** hold the tower arm on the pivot cylinder, and a circular bushing **210** is interposed between the notch plate and the tower arm to reduce friction and enhance relative rotation. The outer end **212** of the tower arm supports the pulling tower **204**.

[**0053**] The pulling tower **204** is preferably telescoping with an extendable head **214** that is powered by a hydraulic cylinder **216** (shown schematically in **FIG. 14**) housed inside the pulling tower. A chain **217** extends over and is secured by the head **214**. Typically, the chain **217** is threaded around a pulley **218**, which is pivotally mounted on the tower **204** by a pulley collar **220**. A connector **222**, such as a hook, is secured to the end of the chain, and is operable to attach to the vehicle chassis.

[**0054**] Referring to **FIGS. 12 and 13**, the force arm **206** is pivotally mounted on the pulling tower by a cylindrical force arm collar **224** rotatably received around the tower. The force arm **206** is preferably telescoping and has a proximal segment **226** and a distal segment **228**. Thus, the length of the force arm is adjustable. The proximal segment

226 is mounted on the arm collar **224** by a force arm axle **230** extending through slots **232** defined in mounting flanges **234** extending from the arm collar **224**. The arm axle **230** allows the force arm **206** to pivot up and down while the arm collar **224** permits horizontal motion. Therefore, the force arm moves in three dimensions. The arm axle **230** is held in place by a washer **236** and a split ring **238** at each end. The proximal segment **226** includes a storage dowel **240**, which preferably comprises an interference split ring dowel. When the force arm **206** is not in use, it is raised to a substantially vertical orientation; the arm axle **230** is raised in the flange slots **232**, and the ends of the storage dowel are rested in storage notches **242** formed in the top surfaces of the mounting flanges **234**.

[**0055**] The distal segment **228** has a smaller diameter and preferably slides inside the larger diameter proximal segment **226**. The distal segment **228** includes three length adjustment apertures **244** spaced along its length. A key pin **246** extends through a key pin aperture **248** in the proximal segment **226** and a selected one of the adjustment apertures **244** to attach the distal and proximal segments. The distal segment **228** pivotally holds an anchoring foot **250**, which is rotated with a top mounted, foot handle **252**. The anchoring foot **250** is configured for placement in either the anchoring apertures **46** (**FIG. 1**) of the platform upper deck **28** or the anchoring apertures **74** (**FIG. 5**) of the movable crossmember **72**.

[**0056**] After the carriage assembly **100** has been locked in a desired location, the pulling tower **204** is pivoted near a desired angle relative to the platform and vehicle chassis. Then the force arm **206** is removed from its vertical storage position (**FIG. 13**) and pivoted to an angle substantially in line with the chain **217** and the direction of the pull. Alternatively, the force arm can be pivoted to another desired angle and location. Then the anchoring foot **250** is rotated into alignment with the nearest anchoring aperture **46**, **74** and inserted into that aperture, so that shearing forces are applied to the deck plate and through a larger cross-section area made up of the combination of the areas of the lock pin **155** and the anchoring foot dowel **254**. Thus, the foot handle **252** and anchoring foot **250** lock the force arm in place. The force arm **206** substantially reduces the forces, such as the bending force, transmitted through the carriage assembly **100**. Thus, the force arm plays a substantial role in allowing application of pulling forces equal or greater than those applied by previous benches while providing a pulling assembly supported entirely by a movable carriage mounted to an elevated platform **22** of a vehicle-straightening bench **20**. Further, the force arm can be loaded in tension or compression, which allows pulling on both sides of the tower.

[**0057**] Referring to **FIGS. 14A and 14B**, the bench control system **300** includes a power system **302**, a hydraulic control circuit **304**, and a pneumatic control circuit **306**. The control system **300** utilizes a programmable logic controller (PLC) **308** and a remote control **310** seen schematically in **FIG. 14**B and illustrated in **FIG. 1**.

[**0058**] The power system **302** includes a motor **312**, a first or front/lift hydraulic pump **314**, and a second or rear hydraulic pump **316**. The pumps **314**, **316** are powered by the motor **312** and draw hydraulic fluid from a common reservoir **318**. A relief valve **320**, which preferably releases pressure at approximately 3800 pounds per square inch, is provided for each pump. The motor and pumps are controlled by the PLC **308**.

[**0059**] The hydraulic control circuit **304** includes six hydraulic valves **322-332**. Valve one (V**1**) **322** comprises a three position, four way, tandem center, spring to center, spool type, double solenoid valve in operative fluid communication with the front/lift pump **314** and the tower cylinders **216**. Thus, V**1** includes an up solenoid **334** and a down solenoid **336**. Valve six (V**6**) **332** comprises a two position, two way, normally closed, one way poppet solenoid valve also in operative fluid communication with the front/lift pump **314** and the tower cylinders **216**. When V**1** is off, ports A and B are blocked and pressure flows to the reservoir **318**. When the up solenoid is energized by the PLC, pressure flows to V**6** and then to port A while pressure from port B flows to the reservoir **318**. When the down solenoid **336** is activated, pressure flows to port B while pressure from port A flows to V**6** and hence to the reservoir if V**6** is on. When V**6** is on, pressure flows freely to and from port A to V**1**, and when V**6** is off, pressure is held in port A; and pressure continues to flow from V**1** to port A through V**6**. Thus, to retract the tower cylinders **216** and lower the towers **204**, V**6** is turned on and the V**1** down solenoid **336** is turned on. To raise the towers, the V**1** up solenoid **334** is turned on. Additionally, to raise the towers, valves three and five **226**, **230** must also be off, as described below. This assures that the lifts are at rest before the towers can be activated for a pull. If desired, the hydraulic cylinders are double acting cylinders.

[**0060**] Valve two (V**2**) **224** and valve four (V**4**) **228** are both two position, two way, normally closed, bi-directional poppet solenoid valves, and valve three (V**3**) **226** and valve five (V**5**) **230** are both two position, two way, normally open, one way poppet solenoid valves. V**2** and V**4** are provided with flow control orifices **338** to control the speeds of the lifts. V**2** and V**3** control the front lift **64** and front lift cylinder **68** and are in operative fluid communication with the front pump **314** and the front lift cylinder **68**. When V**2** is off, it holds pressure in port L**1** and blocks further pressure from entering port L**1**. When V**2** is on, it allows pressure to flow in and out of port L**1** and hence the front lift cylinder **68**. When V**3** is off, it allows pressure to flow to and from V**1**; this is why V**3** must be off to raise the towers. When V**3** is on it blocks flow to V**1** thereby forcing pressure to V**2**. Thus, to raise the front lift **64** with the front lift cylinder **68**, V**2** and V**3** must both be on. To lower the front lift, only V**2** is turned on.

[**0061**] V**4** and V**5** operate similar to V**2** and V**3**. V**4** and V**5** control the rear lift **65** and rear lift cylinder **69** and are in operative fluid communication with the rear pump **316** and the rear lift cylinder **69**. When V**4** is off, it holds pressure in port L**2** and blocks further pressure from entering port L**2**. When V**4** is on, it allows pressure to flow in and out of port L**2** and hence the rear lift cylinder **69**. When V**5** is off, it allows pressure from the rear pump to flow to the reservoir **318**. When V**5** is on it blocks flow to the reservoir thereby forcing pressure to V**4**. Thus, to raise the rear lift **65** with the rear lift cylinder **69**, V**4** and V**5** must both be on. To lower the front lift, only V**4** is turned on. Therefore, the lifts are independently controlled. The back sides of the lift cylinders **68**, **68** are used as reservoirs that are connected to the main reservoir **318**. Thus, when only V**4** and V**2** are turned on,

they allow the pressure to equalize and gravity lowers the lifts. Preferably, the orifice **338**A for the front lift is smaller than the orifice **338**B for the rear lift, so that the front lift lowers a little slower than the rear lift.

[**0062**] Using two pumps to independently control two lifts provides sufficient flow to raise and lower the lifts at acceptable speeds. Having only one of the pumps operate the pulling towers provides a small enough flow rate to move the tower cylinders **216** at a sufficiently slow rate for superior control of the pulls. Thus, the bench is safer and more exacting during pulls. Further, when only one pump is in use, the power system generates less heat and energy preserving the pump and extending the life of the hydraulic fluid.

[**0063**] The pneumatic control circuit **306** is provided with a pressure tank **340** which feeds air pressure to auxiliary tool connections **342** and a flow regulator and filter **344**. A pneumatic, **2** position, four way, bi-directional solenoid valve **346** controls air flow to the pneumatic cylinders **70**. When the pneumatic valve **346** is off, pressure is vented away from the cylinders **70** thereby retracting the cylinders and allowing the first and second lift latches **66** to remain in the respective first and second engaged positions. When the pneumatic valve **346** is on, pressure is applied to the cylinders **70** and the lift latches **66** are pivoted to their respective first and second disengaged positions.

[**0064**] The PLC **308** is operable to open and close the valves **322-332, 346** as described above based on the switch activation in the remote control **310**. The remote control includes five pressure switches **348-356** coded S**1** through S**5**. Each switch is provided with a corresponding light emitting diode (LED) **358-366** coded D**1** through D**5**. When unlock switch S**3352** is activated, D**3** LED **362** illuminates red and the PLC turns on the pneumatic valve **346** to unlock the lift latches **66**. Then the operator can select the front lift **64** by pressing front switch S**5356**, the rear lift **65** by pressing rear/back switch S**4354**, or both. When the S**5** and S**4** switches are pressed, LED D**5366** and LED D**4364**, respectively, are illuminated green. Then the operator can press down switch S**1348** to lower a selected lift or both lifts depending on which lifts are selected on the remote control **310**. Activation of the down switch SI activates LED D**1358** illuminated red while activated. The operator can also raise a selected lift or both lifts by pressing the up switch S**2350**, which causes LED D**2360** to illuminate while the lifts are being raised. To keep the lift latches **66** from interfering with the lift while it is being raised, the PLC **308** is programmed to prevent the lift latches **66** from being raised into the unlocked position during lifting. If both S**5** and S**4** are off and S**3** is locked, the towers can be raised and lowered by S**2** and SI, respectively. Thus, an operator can control all power components of the bench **20** from the remote control **310** making the bench safer than previous vehicle-straightening apparatus. Further, when no power component is active, there are no illuminated lights **358-366** on the remote control. Thus, a quick glance at the control **310** tells the operator if anything is active and needs to be shut down further increasing safety.

[**0065**] In operation, the front and rear lifts **64**, **65** are lowered and a vehicle is driven onto the platform **22**. The platform **22** is then raised to a comfortable working height by activation of the switches on the remote control **310** as described above. The anchors **26** are positioned and fixed to the platform **22** and the vehicle chassis. The locking mechanisms **106** of the carriage assemblies **100** are successively unlocked and the pulling towers **204** are moved to desired locations where the locking mechanisms are re-engaged to fix the carriage assemblies relative to the platform **22**. An operator then pivots the towers **204** to desired pull angles and anchors the force arms to the platform. The operator then remotely activates the towers **204** with the remote control **310**. The towers can be repositioned as many times as needed until the vehicle chassis is substantially restored to its original configuration.

[**0066**] In another embodiment, the vehicle straitening bench **20** has a tower positioning mechanism **404** with a modified notch plate **444**, as shown in **FIGS. 15 and 16**. The tower positioning mechanism **404** keeps the pulling assembly from pivoting when an operator pushes on the pulling assembly to position it at different locations around the bench **20**.

[**0067**] Referring to **FIG. 15**, the positioning mechanism **404** includes a notch plate **444** and a cam detent **447**. Two fasteners **143** join the notch plate **444** to the bottom of the pivot cylinder **140**, thereby holding the tower arm **202** of the pulling assembly **200** on the pivot cylinder **140**. The notch plate **444** defines a notch **446** in its perimeter edge. The notch is approximately rectangular, and preferably, the corners **440** of the notch are not rounded. The cam detent is sized to fit in the notch **446** and pivotally mounted on the tower arm **202** by two substanitally vertical mounting plates **430** and a fastener **432**. The mounting plates **430** are positioned on either side of the cam detent **447**, as shown in **FIG. 16**. The cam detent **447** pivots around the fastener **432** which extends through the mounting plates **430** and cylindrical aperture **450** in the cam detent. The cam detent **447** includes a semi-circular lock end **449** for engagement in the notch **446**.

[**0068**] The cable **159** (described above in association with the locking mechanism **106**) and a slide rod **500** operate to move the cam detent **447** from an engaged position, where the lock end **449** is in the notch **446**, to a disengaged position, where the lock end **449** is pivoted below and out of the notch, or vice versa. The cable **159** and slide rod **500** extend through a slot **452** in the cam detent **447**. The cable **159** runs from the lock pin **155** of the locking mechanism **106**, down the center of the pivot cylinder **140**, through the cable aperture **163** in the center of the circular notch plate **444**, over a roller **428** located under the notch plate, alongside and parallel to the rod **500**, to the release handle **468** located on the tower **204**.

[**0069**] Two springs are located around the slide rod **500**. The larger spring **504** is between the cam detent **447** and a cable mounting block **506**. The mounting block **506** has two guide legs **507** with lower rod apertures **520** and upper cable apertures **522** for receiving and guiding the rod **500** and cable **159** respectively. This spring **504** biases the cam detent in the disengaged position. The smaller spring **502** is between the cam detent and the notch plate **444**. The smaller spring **502** allows the rod to move an additional distance back toward the release handle **468**. The smaller spring is held on the rod **500** by fasteners **499**.

[**0070**] The cable is connected to the slide rod **500** by the cable clamp assembly **501**. The cable clamp assembly

includes a guide block **503**, a clamp plate **508**, a set-screw **510** and two fasteners **512**. The guide block has a central aperture **505** for receiving the slide rod **500** and a small aperture **514**, perpendicular to the central aperture **505**, for receiving the set-screw **510**. When the set-screw is tightened, the slide rod **500** is held in fixed relation to the guide block **503**. The clamp plate **508** attaches the cable to the guide block by pinching the cable between the clamp plate and the guide block. The two fasteners **512** connect the clamp plate to the guide block. When the fasteners are tightened, the cable is held between the clamp plate and the guide block, and the rod and cable are fixed relative to each other.

[**0071**] Referring to **FIGS. 15 and 17**, the cable **159** is connected to the release handle **468** on the tower **204**. The release handle **468** and the cable are both connected to a handle cam **478**. The release handle **468** is a generally cylindrical, tapered handle with a steel stud **488**. The handle tapers from the top end of the handle to the bottom end, where the handle is attached to the handle cam **478**. The release handle is fluted vertically. The steel stud **488** is threaded and received by an aperture **480** in the handle cam **478** that is also threaded. A washer **470** is placed between the handle **468** and the handle cam **478** when connecting the two structures.

[**0072**] The handle cam **478** is generally triangular in shape with a non-circular curved side for a hypotenuse, and a longer top leg/side **479**. The curved side is positioned facing the tower **204**. The handle cam has a top aperture **480** for receiving the steel stud **488** of the release handle **468**. The top of the handle cam also has two smaller apertures for attaching a handle plate **484**. One additional aperture **482** is located on the side of the handle cam for pivotally connecting the handle cam **478** to two mounting plates **472**.

[**0073**] The cable **159** is attached to the handle cam **478** by fastening the handle plate **484** to the top of the handle cam, to clamp it over the cable **159**. Two fasteners **492** are tightened to hold the cable **159** between the handle cam and handle plate.

[**0074**] The handle cam **478** is attached to the tower **204** by the handle mounting plates **472**. The plates are generally rectangular in shape with rounded corners **494**. The rounded corners **494** are located in the top corners of the plates **472**, farthest from the tower **204**. The rounded corners prevent the operator from injuring his or her hands when manually positioning the release handle **468**. The handle mounting plates **472** are welded to the tower **204**. The mounting plates **472** also have an aperture **476** for pivotally connecting the handle mounting plates with the handle cam **478**. A bolt **490** connects the handle cam to the mounting plates by extending through apertures **476** on the mounting plates and the aperture **482** on the handle cam **478**. The mounting plates are also positioned on either side of a handle mounting block **474**. The handle mounting block **474** is generally rectangular in shape and sits between the handle mounting plates **472**, near the lower edge of the mounting plates, against the tower **204**.

[**0075**] When the handle is manually moved by an operator from a vertical position to a horizontal position, the handle cam **478** rotates with the handle, the curved side sliding along the tower **204**. This pivoting motion of the handle cam pulls on the cable **159** attached to the handle cam **478**. When the cable **159** is pulled, the slide rod **500** is also moved in the same direction toward the handle. The movement of the slide rod changes the position of the cam detent **447**, overcoming the bias of the larger spring **504**, to engage the notch **446** of the notch plate **444**. Engaging the notch holds the tower arm **202** in a fixed position relative to the carriage assembly **100**. Until the cam detent is moved from the engaged position, the tower arm will not change position relative to the carriage assembly. The cam detent will only be disengaged when the release handle **468** is moved from the lowered horizontal position to the raised vertical position. The release handle **468** simultaneously controls the locking mechanism **106**, described in greater detail above.

[**0076**] When the locking mechanism **106** locks the carriage assembly **100** in a selected location on the track **24**, an operator can move the cam detent **447** down out of the notch **446** by moving the release handle **468** and releasing the cam detent. This action also moves the lock pin **155** up into its engaged position. Once the cam detent is released, the pulling assembly is allowed to pivot on the carriage assembly **100** but the carriage assembly cannot roll on the track. Alternatively, when the carriage assembly **100** is free to roll on the track, and the locking mechanism **106** is not engaged, the cam detent **447** is engaged to hold the pulling assembly in its easiest transport position, which is substantially perpendicular to the platform. When the operator wants to pivot the pulling assembly, the locking mechanism **106** is engaged and the cam detent **447** is disengaged, allowing the pulling assembly to pivot without changing the location of the pulling assembly on the track **24**. Because the large spring **504** biases the rod and detent in the disengaged position, the lock mechanism is biased into the locked position.

[**0077**] The vehicle-straitening bench **20** according to the present invention provides increased pulling versatility with enhanced safety. The bench **20** utilizes an additional force bearing member during pulls to further enhance safety and enable the increased versatility. Further, the bench use a PLC and a remote control to actuate power components thereby keeping operators at a safe distance from the power components.

[**0078**] Thus, a vehicle-straitening bench **20** is disclosed which utilizes movable carriage assemblies with pivotally mounted pulling towers to position the pulling towers at almost any position around a vehicle chassis to restore the chassis to an original configuration with remotely activated power components thereby enhancing efficiency and safety. While preferred embodiments and particular applications of this invention have been shown and described, it is apparent to those skilled in the art that many other modifications and applications of this invention are possible without departing from the inventive concepts herein. It is, therefore, to be understood that, within the scope of the appended claims, this invention may be practiced otherwise than as specifically described, and the invention is not to be restricted except in the spirit of the appended claims. Though some of the features of the invention may be claimed in dependency, each feature has merit if used independently.

What is claimed is:

1. A vehicle straightening bench for applying force to vehicle chassis and restoring vehicle chassis to desired configurations, the bench comprising:

a vehicle platform including a front, a rear, opposed sides corresponding to a length, a top, and a bottom, the vehicle platform being operable to support a vehicle chassis to be straightened;

at least one anchor attachable to the platform and operable to secure the vehicle chassis to the platform;

a carriage track mounted on the platform and extending along the length of the platform;

a carriage assembly movably received by the carriage track; and

a pulling tower pivotally mounted on the carriage assembly.

2. The bench according to claim 1 wherein the carriage assembly includes a tower positioning mechanism engaging a tower arm, extending between the pulling tower and the carriage assembly and mounting the pulling tower to the carriage assembly, the positioning mechanism being operable to lock the pulling tower in a transport position in which the tower arm is substantially perpendicular to the bench.

3. The bench according to claim 1 wherein the carriage assembly includes a tower positioning mechanism engaging a tower arm extending between the pulling tower and the carriage assembly and mounting the pulling tower to the carriage assembly, the positioning mechanism including a pawl follower slidably mounted on the tower arm and a notch plate mounted on the carriage assembly and defining a notch for receiving the pawl follower, so that the tower positioning mechanism holds the pulling tower in a transport position in which the tower arm is substantially perpendicular to the bench when the pawl follower is received in the notch.

4. The bench according to claim 3 wherein the positioning mechanism further includes a pawl biasing member engaging the pawl follower and forcing the pawl follower against the notch plate and biasing the pawl follower into the notch.

5. The bench according to claim 4 wherein the carriage assembly includes a carriage body defining a lock pin opening and a locking mechanism comprising a lock pin movably received in the lock pin opening, a lock pin biasing member received in the lock pin opening and engaging the lock pin to bias the lock pin into an extended locking position in which an operator applying force to the pulling tower can overcome the force of the pawl biasing member to pivot the pulling tower relative to the carriage assembly.

6. The bench according to claim 5 wherein the lock pin is coaxial with a pivot axis of the pulling tower.

7. The bench according to claim 1 wherein the carriage assembly includes a tower positioning mechanism engaging a tower arm extending between the pulling tower and the carriage assembly and mounting the pulling tower to the carriage assembly, the positioning mechanism including a cam detent pivotally mounted on the tower arm and a notch plate mounted on the carriage assembly and defining a notch for receiving the cam detent, so that the tower positioning mechanism locks the pulling tower in a transport position in which the tower arm is substantially perpendicular to the bench when the cam detent is received in the notch.

8. The bench according to claim 7 wherein the carriage assembly includes a carriage body defining a lock pin opening and a locking mechanism comprising a lock pin movably received in the lock pin opening, a lock pin biasing member received in the lock pin opening and engaging the lock pin to bias the lock pin into an extended locking position in which an operator applying force to the pulling tower pivot the pulling tower relative to the carriage assembly.

9. The bench according to claim 8 further comprising a dual action lever assembly operable to actuate both the tower positioning mechanism and the locking mechanism.

10. The bench according to claim 9 wherein the lever assembly comprises:

a dual action release handle assembly, positioned on the pulling tower, including a handle; and

a cable fastened to the release handle assembly and extending to the locking mechanism and the positioning mechanism, where the cable is operable to engage the locking mechanism while disengaging the positioning mechanism, and alternatively to disengage the locking mechanism while engaging the positioning mechanism.

11. The bench according to claim 10 wherein forcing the handle down retracts the lock pin into the lock pin opening and forces the cam detent into the notch of the notch plate.

12. The bench according to claim 11 further comprising a cam detent biasing member biasing the cam detent out of the notch.

13. The bench according to claim 12 wherein the cam detent biasing member comprises a compression spring positioned between the cam detent and a fastening block.

14. The bench according to claim 13 further comprising the cable extending from the release handle to the lock pin, and the cable slidably received through the fastening block and being attached to the cam detent.

15. The bench according to claim 1 wherein the carriage assembly includes a carriage body defining a lock pin opening and a locking mechanism comprising a lock pin movably received in the lock pin opening, a lock pin biasing member received in the lock pin opening and engaging the lock pin to bias the lock pin into an extended locking position.

16. The bench according to claim 15 wherein the platform comprises a bottom deck having the track mounted thereon and defining a plurality of pin lock apertures operable to receive the lock pin.

17. The bench according to claim 15 wherein the locking mechanism further comprises a release handle vertically, movably mounted on the pulling tower and an elongated release cable extending between the release handle and the lock pin whereby downward movement of the release handle overcomes the lock pin biasing member and forces the lock pin to a retracted position inside the lock pin opening of the carriage body.

18. The bench according to claim 15 wherein the lock pin biasing member comprises a compression spring.

19. A pulling assembly for use with a vehicle platform of a vehicle straightening bench, the pulling assembly comprising:

an elongated tower arm having a mounting end and a distal end opposite the mounting end;

a pulling tower attached to the distal end of the tower arm; and

a carriage assembly including a tower positioning mechanism, engaging the mounting end of the tower arm, extending between the pulling tower and the carriage

assembly and mounting the pulling tower to the carriage assembly, the positioning mechanism including a cam detent pivotally mounted on the tower arm and a notch plate mounted on the carriage assembly and defining a notch for receiving the cam detent, the tower positioning mechanism being operable to hold the pulling tower in a transport position in which the tower arm is substantially perpendicular to the bench when the cam detent is received in the notch.

20. The bench according to claim 19 wherein the carriage assembly includes a carriage body defining a lock pin opening and a locking mechanism comprising a lock pin movably received in the lock pin opening, a lock pin biasing member received in the lock pin opening and engaging the lock pin to bias the lock pin into an extended locking position in which an operator applying force to the pulling tower pivot the pulling tower relative to the carriage assembly.

21. The bench according to claim 20 further comprising a dual action lever assembly operable to actuate both the tower positioning mechanism and the locking mechanism.

22. The bench according to claim 21 wherein the lever assembly comprises:

a dual action release handle assembly, positioned on the pulling tower, including a handle; and

a cable fastened to the release handle assembly and extending to the locking mechanism and the positioning mechanism, where the cable is operable to engage the locking mechanism while disengaging the positioning mechanism, and alternatively to disengage the locking mechanism while engaging the positioning mechanism.

23. The bench according to claim 22 wherein forcing the handle down retracts the lock pin into the lock pin opening and forces the cam detent into the notch of the notch plate.

24. The bench according to claim 23 further comprising a cam detent biasing member biasing the cam detent out of the notch.

25. The pulling assembly according to claim 23 wherein the pulling tower comprises a telescoping pulling tower.

26. A vehicle straightening bench comprising for applying force to vehicle chassis and restore vehicle chassis to desired configurations, the bench comprising:

a vehicle platform including a front, a rear, opposed sides corresponding to a length, a top and a bottom, the vehicle platform being operable to support a vehicle chassis to be straightened, and the vehicle platform defining a plurality of anchoring apertures;

at least one anchor attachable to the platform and operable to secure the vehicle chassis to the platform;

a carriage track mounted on the platform and extending along the length of the platform;

a carriage assembly movably received by the carriage track, including a carriage body defining a lock pin opening;

an elongated tower arm having a mounting end attached to the carriage assembly and a distal end opposite the mounting end;

a pulling tower attached to the distal end of the tower arm;

a tower positioning mechanism connected to the tower arm and the carriage assembly, including a cam detent pivotally mounted to the tower arm and a notch plate mounted to the carriage assembly and defining a notch for receiving the cam detent, so that the tower positioning mechanism is operable to fix the pulling tower in a transport position relative to the bench; and

a locking mechanism including a lock pin movably received in the lock pin opening, a lock pin biasing member received in the lock pin opening and engaging the lock pin to bias the lock pin into an extended locking position in which an operator applying force to the pulling tower can pivot the pulling tower relative to the carriage assembly.

27. The bench according to claim 26 wherein the carriage assembly includes a carriage body defining a lock pin opening and a locking mechanism comprising a lock pin movably received in the lock pin opening, a lock pin biasing member received in the lock pin opening and engaging the lock pin to bias the lock pin into an extended locking position in which an operator applying force to the pulling tower pivot the pulling tower relative to the carriage assembly.

28. The bench according to claim 27 further comprising a dual action lever assembly operable to actuate both the tower positioning mechanism and the locking mechanism.

29. The bench according to claim 28 wherein the lever assembly comprises:

a dual action release handle assembly, positioned on the pulling tower, including a handle; and

a cable fastened to the release handle assembly and extending to the locking mechanism and the positioning mechanism, where the cable is operable to engage the locking mechanism while disengaging the positioning mechanism, and alternatively to disengage the locking mechanism while engaging the positioning mechanism.

30. The bench according to claim 29 wherein forcing the handle down retracts the lock pin into the lock pin opening and forces the cam detent into the notch of the notch plate.

31. The bench according to claim 30 further comprising a cam detent biasing member biasing the cam detent out of the notch.

32. The bench according to claim 31 wherein the cam detent biasing member comprises a compression spring positioned between the cam detent and a fastening block.

33. The bench according to claim 32 wherein the cable extends from the release handle to the lock pin, and the cable is slidably received through the fastening block attached to the cam detent.

34. A dual-action lever assembly for a pulling tower of a vehicle straightening bench with a positioning mechanism for retaining the pulling tower in a selected position around the perimeter of the straightening bench and a locking mechanism for retaining the pulling tower in a fixed, transport position in which the pulling tower is substantially perpendicular to the straightening, the lever assembly comprising:

a dual action release handle assembly, positioned on the pulling tower, including a handle; and

a cable fastened to the release handle assembly and extending to the locking mechanism and the position-

ing mechanism, where the cable is operable to engage the locking mechanism while disengaging the positioning mechanism, and alternatively to disengage the locking mechanism while engaging the positioning mechanism.

35. The lever according to claim 34 further comprising two handle biasing members operable to bias the handle in an upright position with positioning mechanism activated and locking mechanism deactivated.

36. The lever according to claim 35 wherein the positioning mechanism includes a lock pin received in a lock pin opening defined in a track around the perimeter of the bench and the locking mechanism includes a cam detent for engaging and disengaging from a notch in a notch plate.

37. The lever according to claim 34, wherein the cable is connected to the positioning mechanism by a cable-rod assembly, including:

a rod connected to the locking mechanism; and

a fastening block including an aperture for receiving the rod and a fastener for attaching the cable to the fastening block, operable to maintain the rod in fixed relation to the cable.

38. The lever according to claim 34, wherein the release handle assembly includes a cam, a cable, and a fastener plate comprising:

a plate with apertures for receiving threaded fasteners; and

a plurality of threaded fasteners for attaching the plate to the cam with the cable positioned between the cam and the cable fastener plate.

39. The lever according to claim 38 wherein forcing the handle down retracts the lock pin into the lock pin opening and forces the cam detent into the notch of the notch plate.

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