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Lessway et al.

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(54) **STEADY REST WITH PREDICTABLE MICRON-SIZED ADJUSTMENT**

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B23Q 3/06 (2006.01)
B24B 41/06 (2012.01)

(52) **U.S. Cl.**

CPC ***B23Q 1/76*** (2013.01); ***B23Q 3/06*** (2013.01); *B24B 41/065* (2013.01)

(58) **Field of Classification Search**

CPC B23Q 1/76; B23Q 1/763; B23Q 3/186; B23Q 3/06; B23Q 3/082; B25B 5/064; B25B 5/087; B24B 41/065

USPC 451/408, 406, 244, 407, 402, 49, 51

See application file for complete search history.

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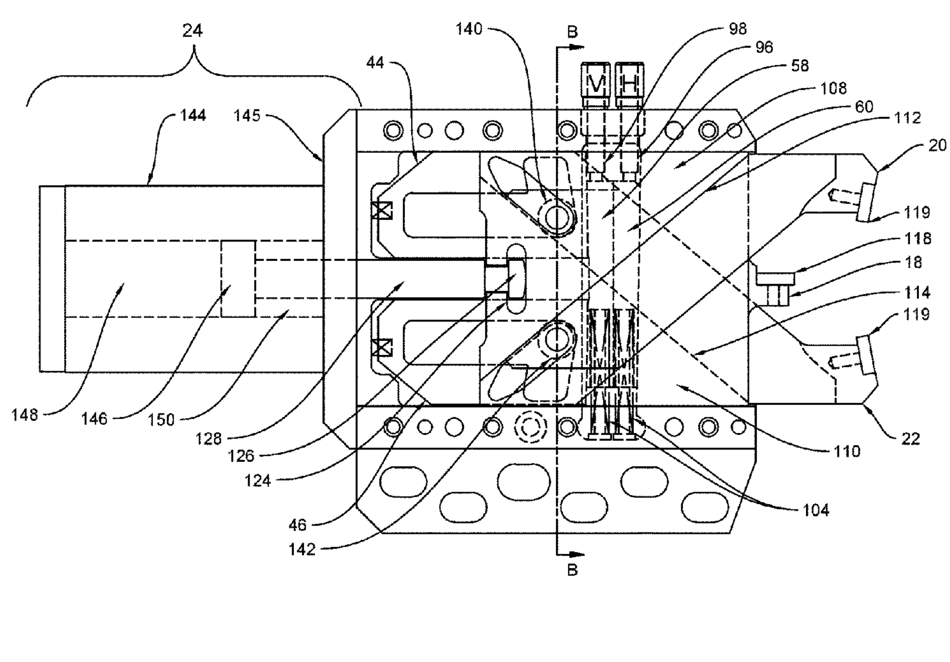
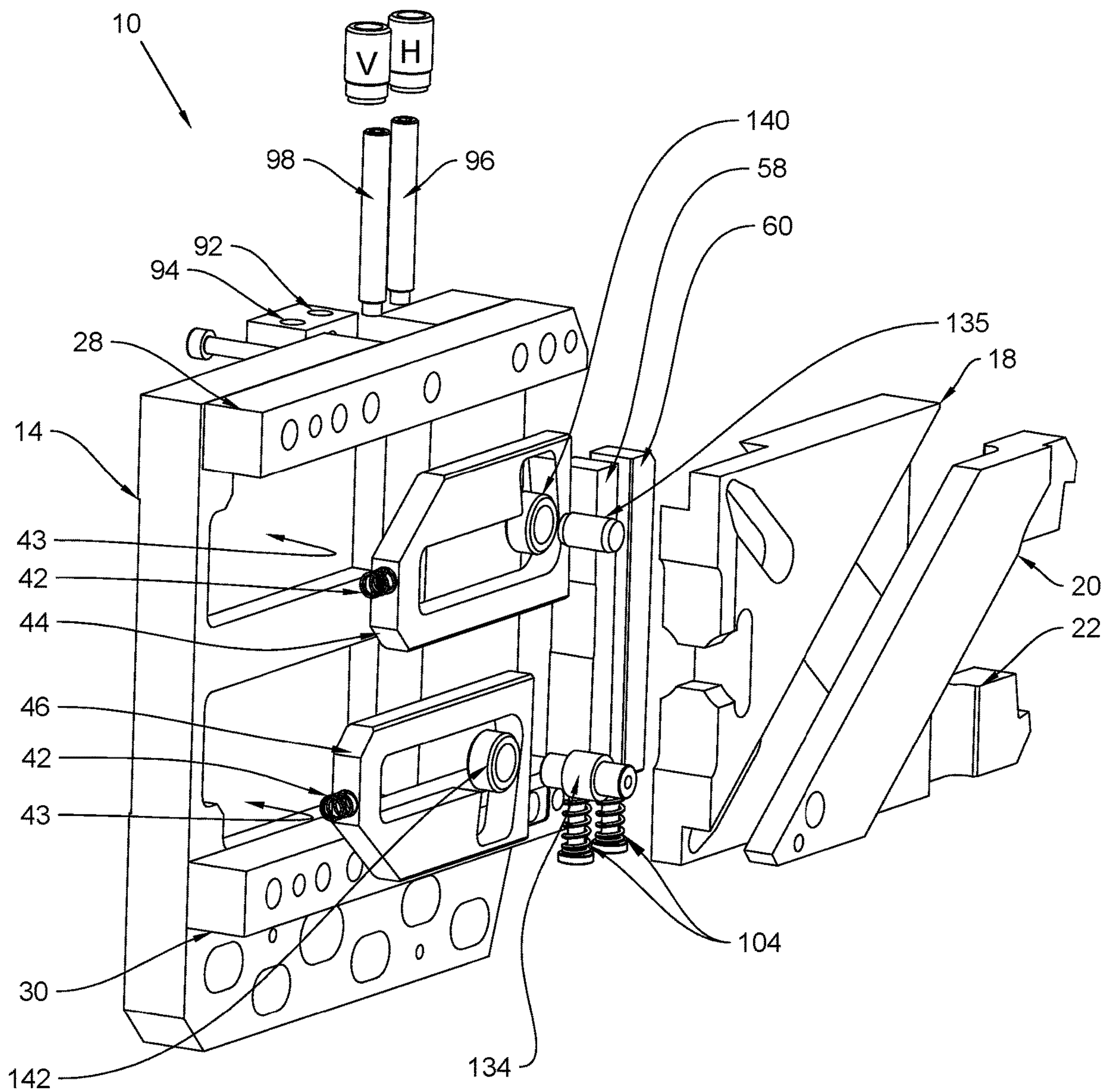
(57) **ABSTRACT**

A steady rest has working and right-hand cover plates and a central plate sandwiched there between. The working cover plate has upper and lower guide tracks and track engagement springs that are received within cavities. The central plate is movably disposed between the working and right-hand cover plates. The central plate slidably engages upper and lower gripping arms that are movable relative to the working cover plate between a clamped position and a retracted position. Tapered rails and rail engagement springs are disposed in a rail recess of the working cover plate. The rails are movable relative to each other to finely and precisely adjust a position at which the workpiece is clamped and moved horizontally or vertically when the gripping arms are in the clamped position. The track and rail engagement springs share common mechanical properties for ready interchange, thereby alleviating inventory concerns.

13 Claims, 8 Drawing Sheets





10
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96
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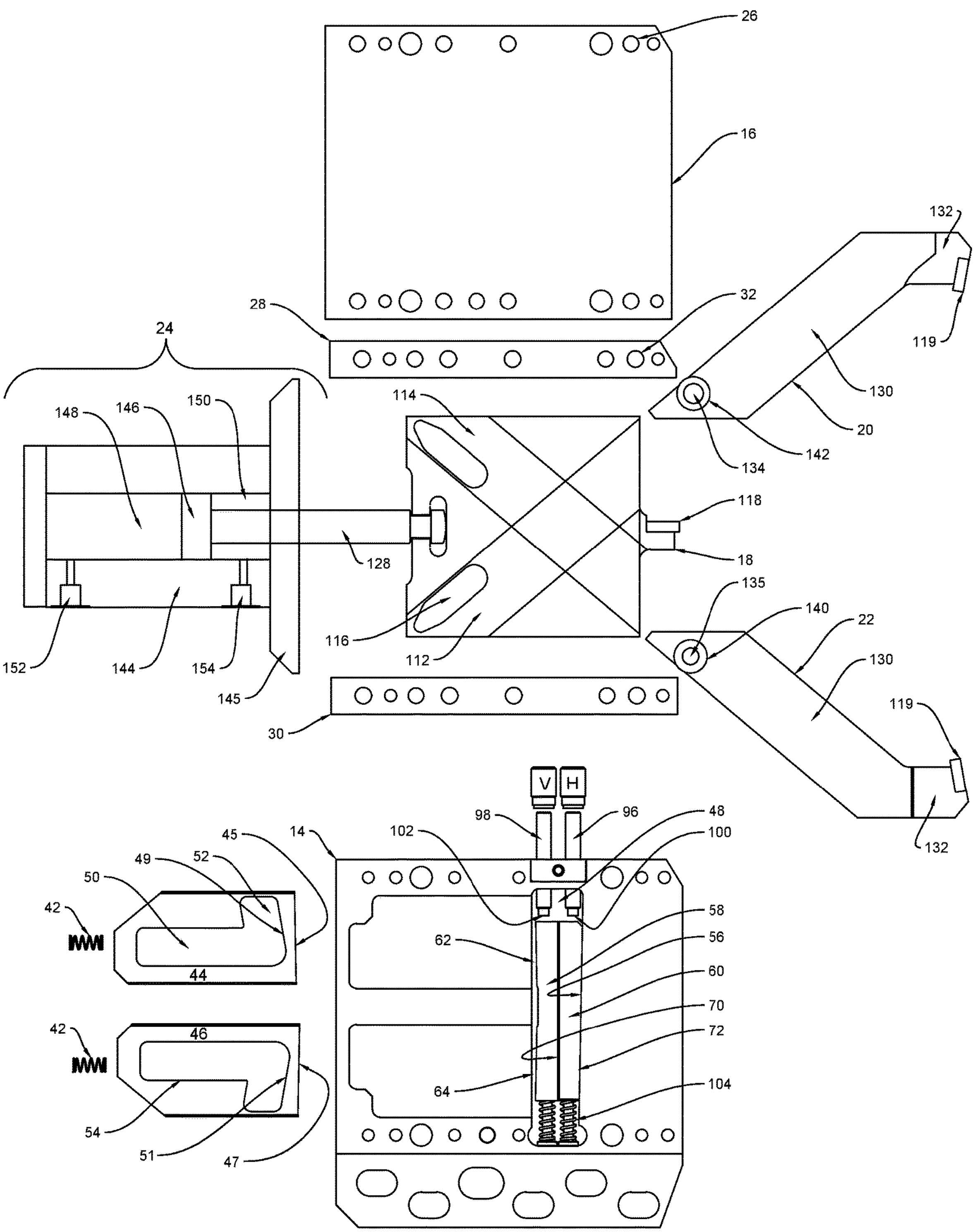
142
134

FIG 1



26
16
132
28
32
119
24
130
114
148
146
150
20
134
142
118
128
18
135
140
22
116
130
112
152
144
154
145
119
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V
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98
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48
102
100
14
45
52
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62
56
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44
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42
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104
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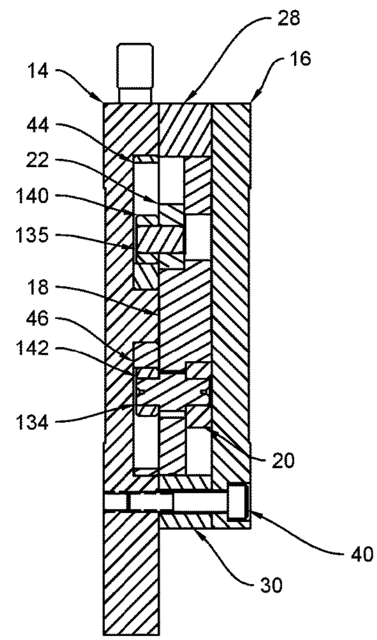
47

FIG 2


28
14
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44
22
140
135
18
46
142
134
20
40
30

FIG 3A

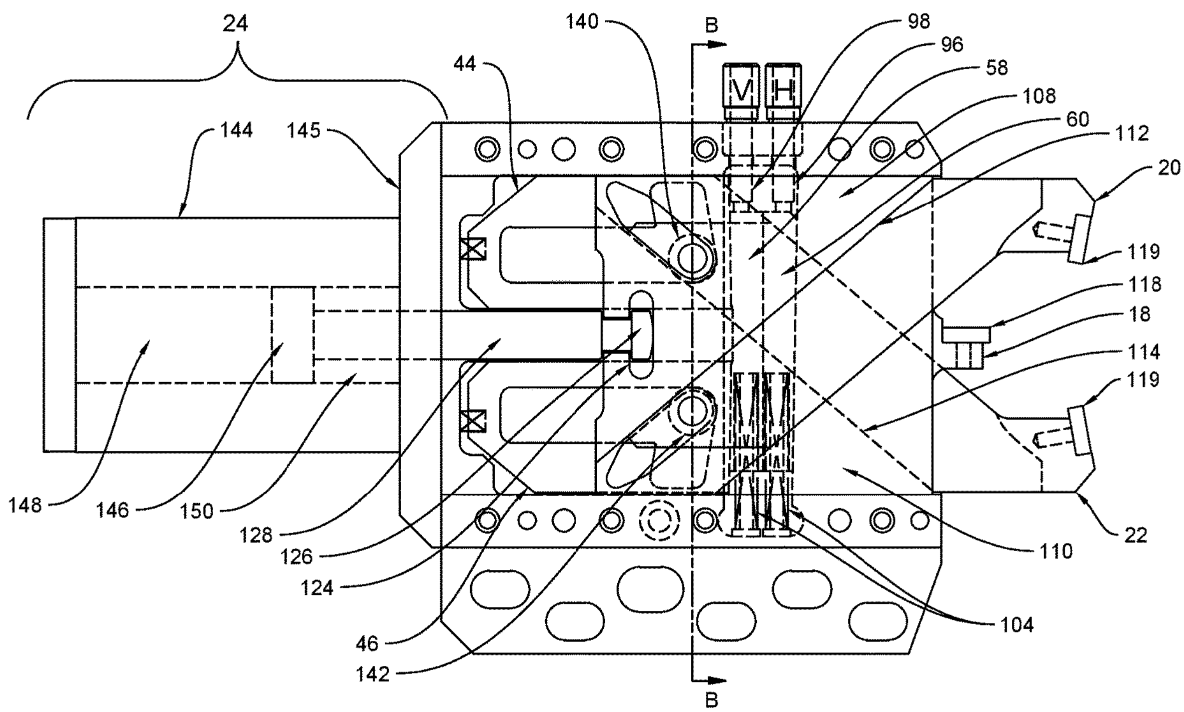

24
140
B
98
96
58
44
108
60
112
144
145
20
M
H
119
118
18
114
119
148
146
150
128
126
124
46
142
110
22
104
B

FIG 3B

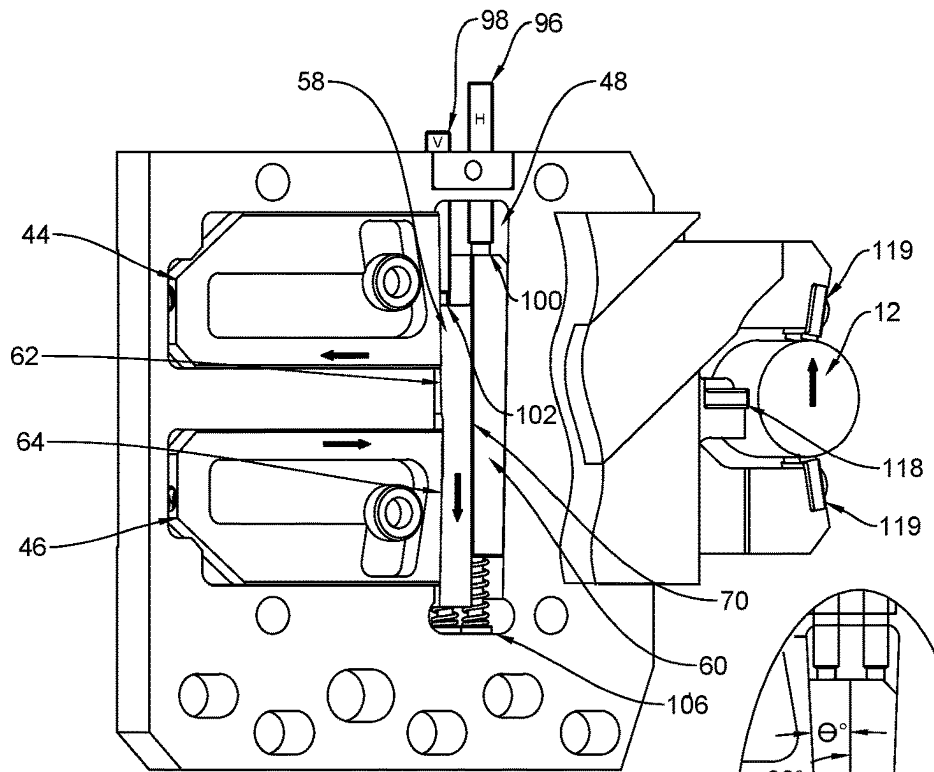


FIG 4A

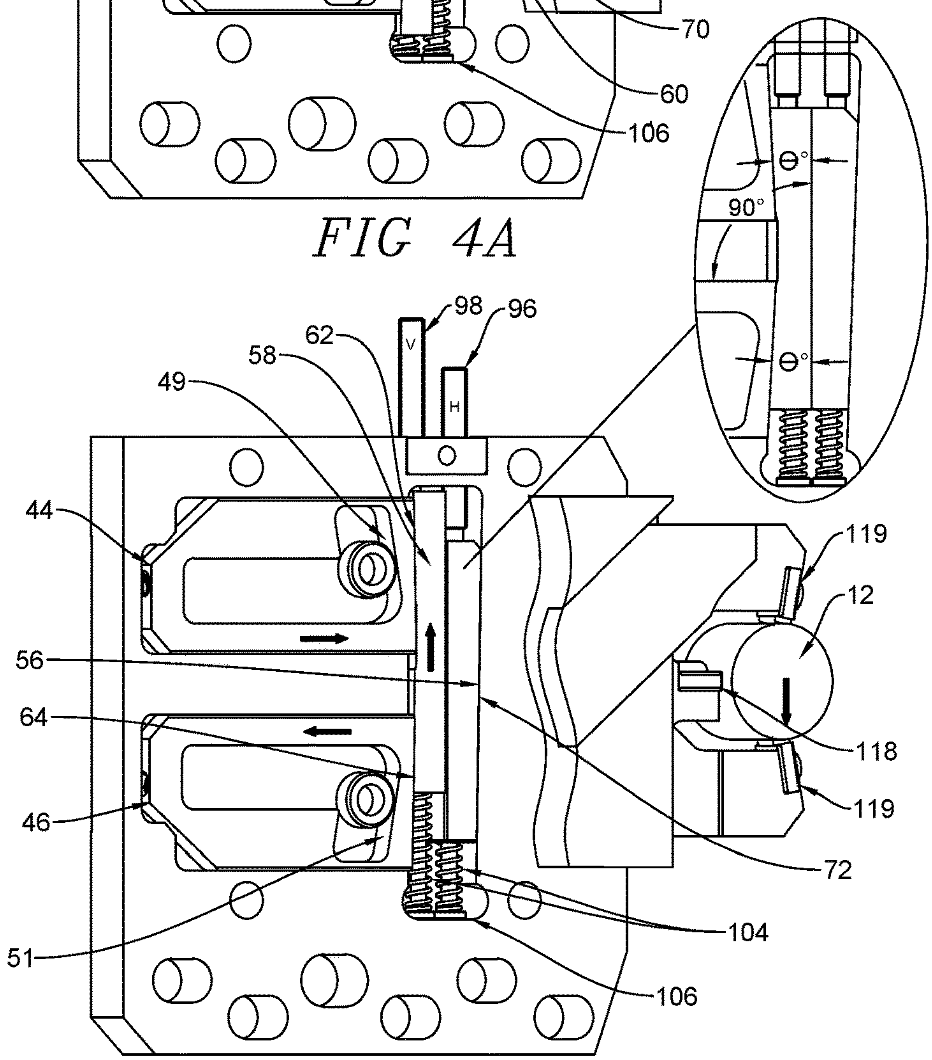


FIG 4B

VERTICAL ADJUSTMENT

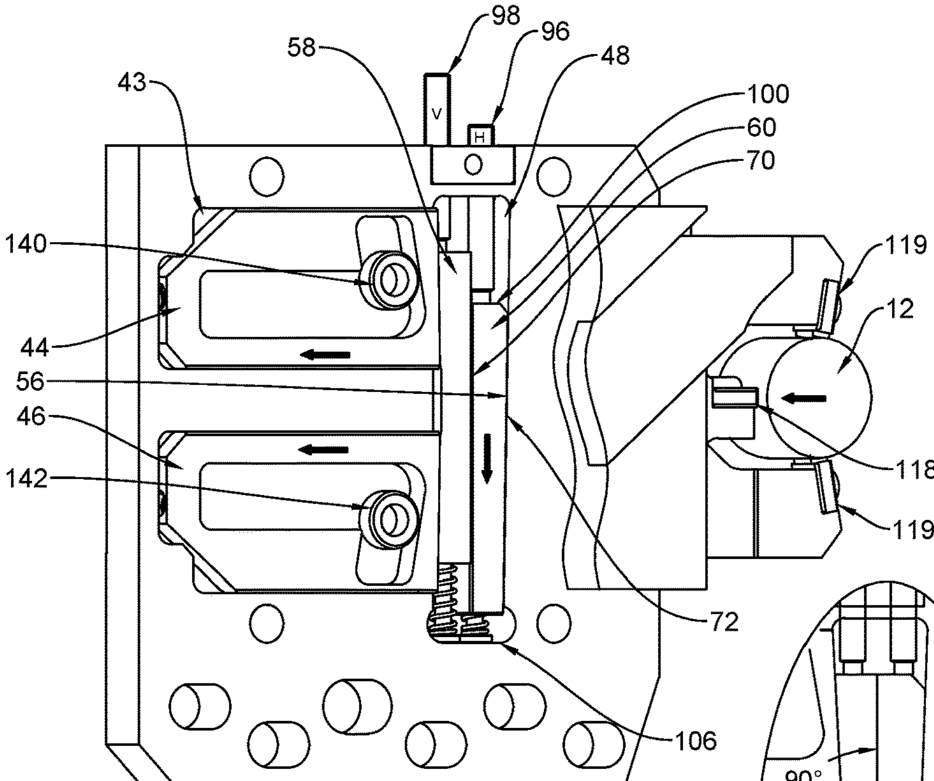


FIG 5A

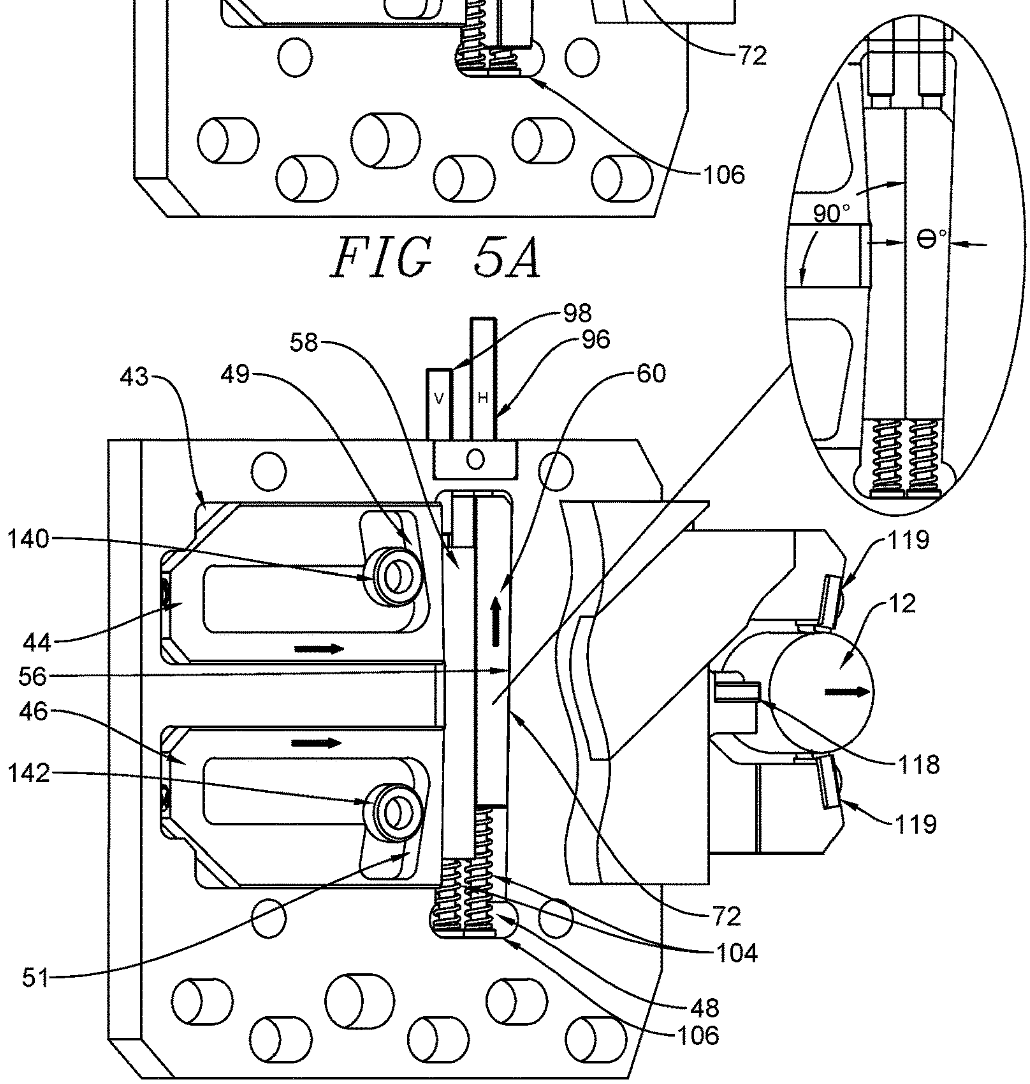


FIG 5B

HORIZONTAL ADJUSTMENT

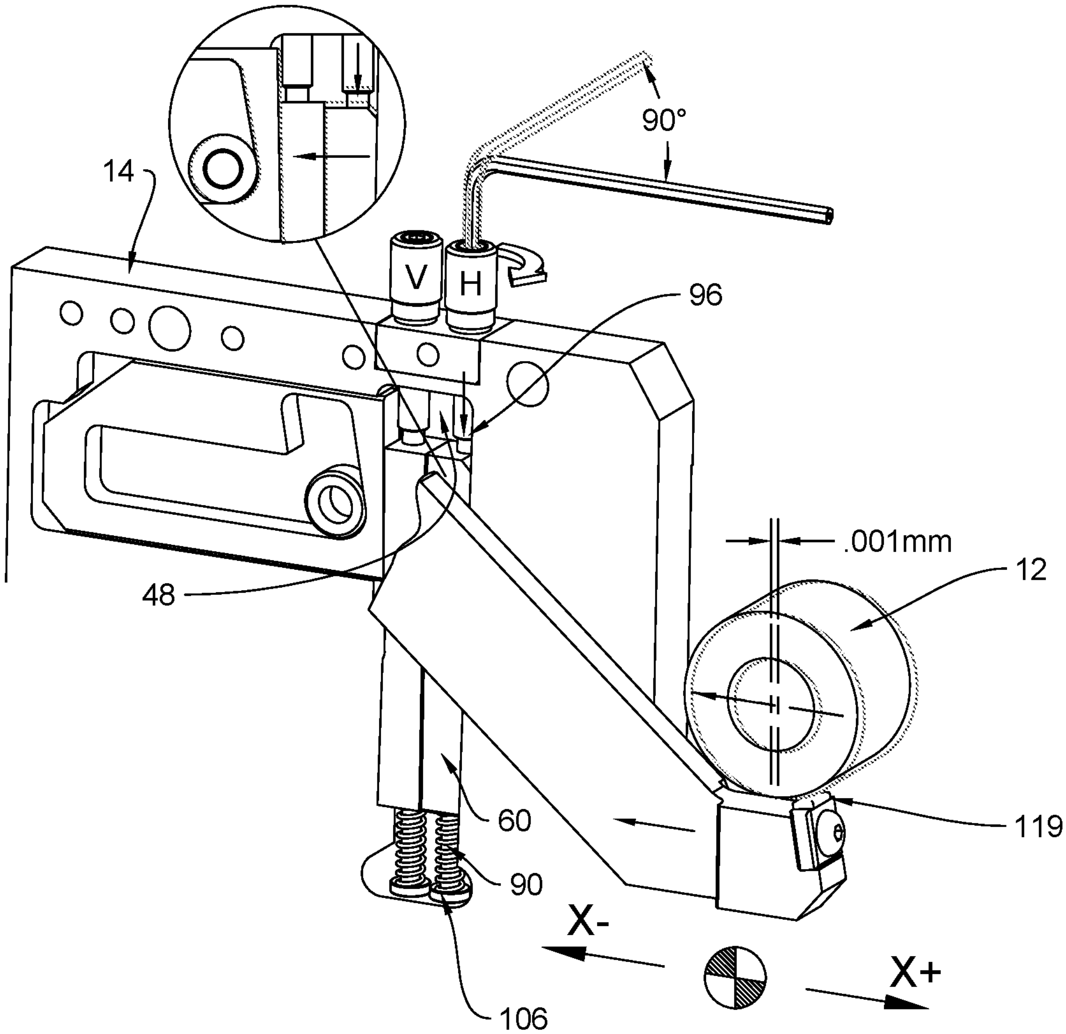
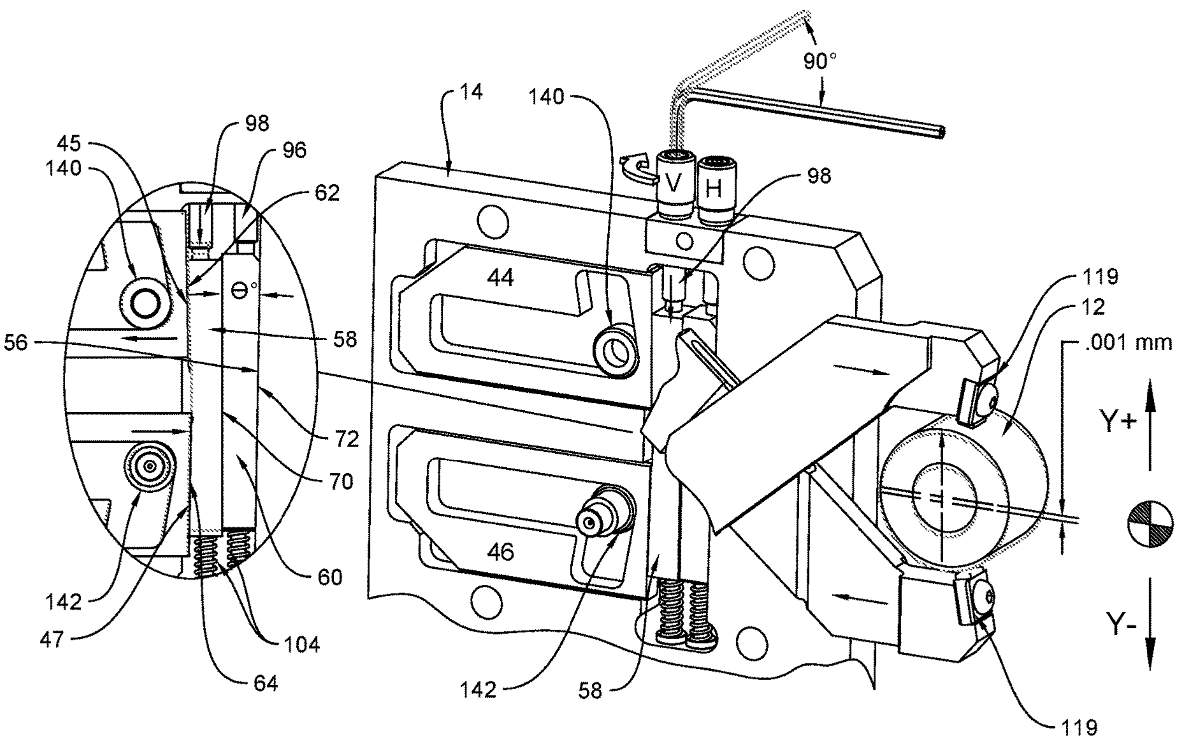


FIG 6


14
140
90°
V
H
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96
62
44
119
12
.001 mm
56
58
θ°
Y+
72
70
46
60
142
Y-
47
104
64
142
58
119

FIG 7

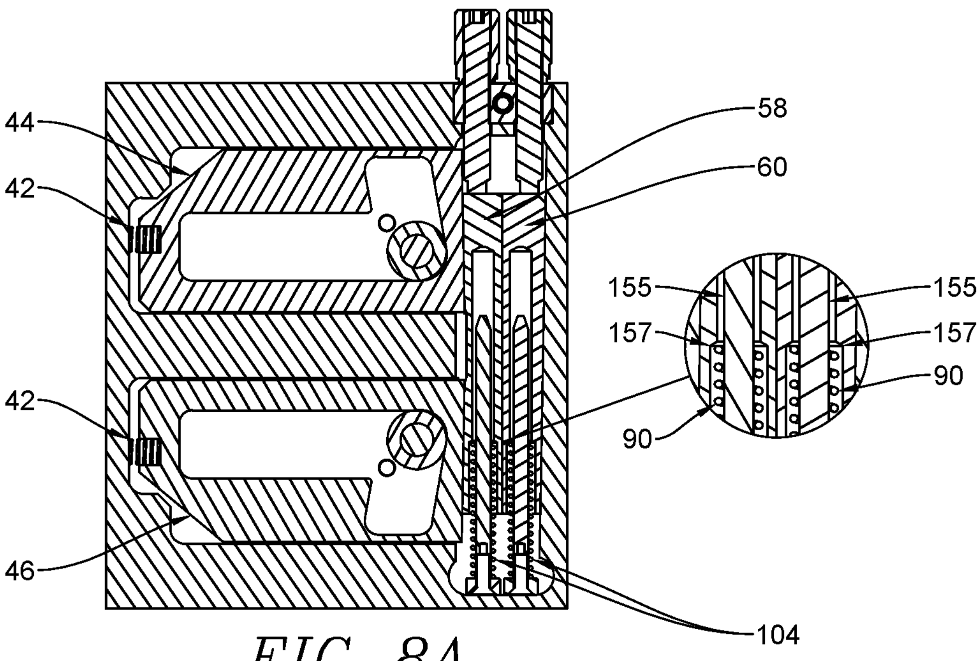
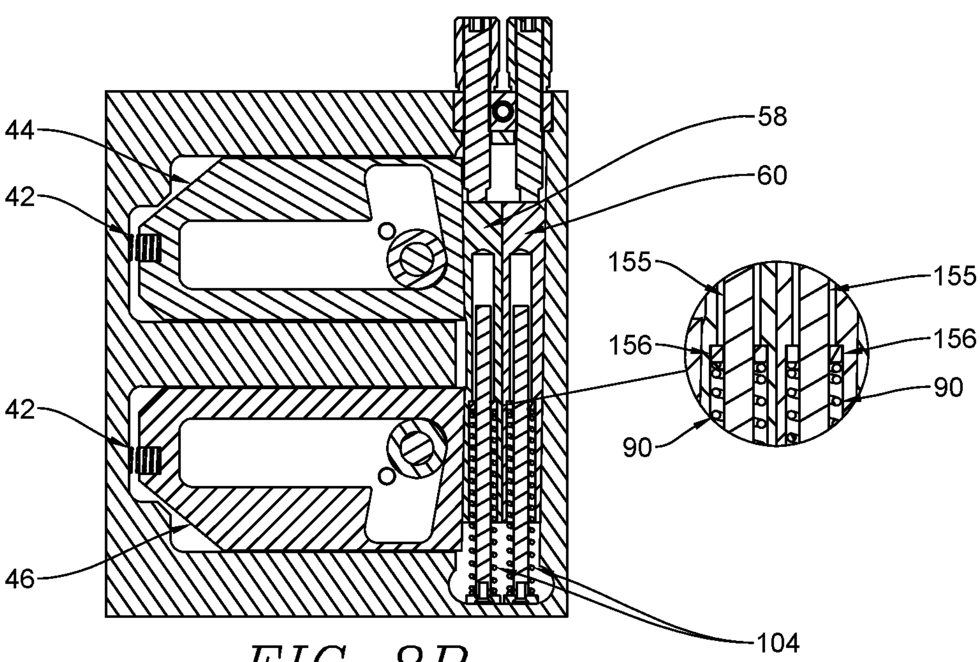

44
42
42
46
58
60
155
157
90
155
157
90
104

FIG 8A


44
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46
58
60
155
156
90
155
156
90
104

FIG 8B

STEADY REST WITH PREDICTABLE MICRON-SIZED ADJUSTMENT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of and is a continuation-in-part of U.S. Ser. No. 17/680,891, filed on Feb. 25, 2022, now U.S. Pat. No. 12,350,784 issued Jul. 8, 2025, which is incorporated by reference herein.

TECHNICAL FIELD

The present disclosure relates to a finely adjustable steady rest system for positioning a workpiece that is rotationally symmetrical.

BACKGROUND

An adjustable steady rest system is commonly used for securing a workpiece during machining operations such as but not limited to grinding, turning, milling, and boring. In such systems, gripping arms secure the workpiece while a cutting tool, such as an abrasive wheel, blade, or bit removes material from the workpiece. Known steady rests have a mechanism for adjusting the position or location of the gripping arms and thus the workpiece to enhance the accuracy of the machining operations.

Today's machines often demand high tolerances. Such challenges are often presented in high production volumes. Desirably, adverse workpiece conditions such as out-of-roundness and lobing should be avoided.

End users expect adjustment mechanisms to be accurate, capable of fine adjustment, repeatable, and reliable. Reducing the number of parts, particularly the number of moving parts, is advantageous. This may increase the reliability of the mechanism and reduce the likelihood of moving parts coming into contact with contaminants. Furthermore, reducing the number of parts may reduce tool manufacturing costs and complexity.

Against this background, it would be desirable to offer a refined adjustment system that enables a higher precision in repeatable adjustment with a minimal number of parts that are required to bring about such an adjustment.

Ideally, such a system would be designed to facilitate the task of repairing with minimal downtime.

Such adjustment mechanisms have a number of parts that should ideally cooperate so that none of them stick or unnecessarily interfere with each other when guided movement is called for in the adjustment process. It would be desirable to anticipate the potential for such unwanted interference by providing ameliorating design changes. For example, it would be desirable to eliminate any potential for a spring to become "pinched" between adjacent parts of the adjustment mechanism. Another example relates to situations where a part receives another moving part. Ideally, the interface between the two parts should be contoured so that there is no unwanted binding interference therebetween. Such factors assume importance when the two parts cooperate under the influence of high-engagement forces.

To facilitate replacement and repair, it would be helpful to have all springs in an adjustment mechanism with the same dimensions and share common mechanical properties so that they can be readily interchangeable.

Ideally, the springs should not be exposed to unnecessary compression in a single or repeated use because such exposure may lead to a spring losing at least some of its rebounding properties.

Thus, it would be desirable to have a mechanism that would permit a more precise adjustment system that accommodates design criteria such as those described above.

Among the references considered in preparing this application are U.S. Pat. Nos. 9,174,317, and 8,955,419. Those references are incorporated here by reference, to the extent that they are not inconsistent with the disclosure herein.

SUMMARY

Several embodiments of the disclosed steady rest adjustment mechanisms have a number of parts that cooperate so that none of them stick or unnecessarily interfere with each other when guided movement is called for in the adjustment process. In such embodiments, any potential for a spring to become "pinched" between adjacent parts of the adjustment mechanism is eliminated.

The present disclosure also addresses situations where a part receives another moving part. So that there is no unwanted binding interference therebetween, mating surfaces that define the interface between the two parts are contoured. Such factors assume importance when the two parts cooperate under the influence of high-engagement forces.

In one embodiment, the present disclosure provides a steady rest system for precisely locating a workpiece that is rotated and subjected to forces exerted by one or more machine tools in a direction inclined (e.g., orthogonal) to an axis of workpiece rotation. One steady rest has a working cover plate (as further described below) and a right-hand cover plate (when viewed from the rear). Between these plates is a central plate (which moves in parallel with an X- or horizontal axis). The working cover plate has a pair of recesses that receive two guide tracks which ultimately influence and enable finely tuned displacement of upper and lower gripping arms that secure and displace a workpiece.

Within the guide tracks, roller guides move in a defined, precise and predictable manner.

The central plate slidably engages the upper and lower gripping arms. The gripping arms are movable between a closed clamped position and an open retracted position to releasably secure the workpiece. In the closed clamped position, the workpiece can be minutely re-positioned horizontally and vertically.

Fine, predictable, and precise horizontal and vertical adjustments of the gripped workpiece are enabled.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings described herein are for illustrative purposes of selected embodiments and not all possible implementations. They are not intended to limit the scope of the present disclosure.

FIG. **1** is a perspective, exploded view of part of an adjustable steady rest system with a right-hand cover plate removed for clarity;

FIG. **2** is a laid-open, exploded view of the steady rest system; in FIG. **3**B;

FIG. **3**A is a vertical, sectional view of the steady rest system along the line B-B in FIG. **3**B;

FIG. **3**B is a vertical, sectional view of the steady rest system with the right-hand cover plate removed;

FIGS. **4**A and **4**B illustrate various components in vertical adjustment modes;

FIGS. **5**A and **5**B illustrate various components in horizontal adjustment modes;

FIG. **6** further illustrates horizontal displacement of a clamped workpiece in response to turning an adjustment screw;

FIG. **7** further illustrates vertical displacement of a clamped workpiece in response to turning another adjustment screw; and

FIG. **8**A is an earlier steady rest design. FIG. **8**B is its revision. In FIG. **8**A the relationship between the rail pin **155** and vertical rail **58** or horizontal rail **60** would allow a condition in which the rail engagement spring **90** could become seized in the rail spring pocket **157**. To solve this condition, a rail washer **156** is added (FIG. **8**B). This eliminates the rail spring pocket **157** and changes the relationship between the rail pin **155** and vertical rail **58** or horizontal rail **60**. Additionally, springs **104** are now characterized by a higher spring force.

Corresponding reference numerals indicate corresponding parts throughout the several drawings.

DETAILED DESCRIPTION

Representative embodiments and enhancements to earlier steady rests will now be described more fully with reference to the accompanying drawings.

Components of a Representative Steady Rest System

With reference to FIGS. **1**-**8**B, in one embodiment, an adjustable steady rest system (hereinafter "steady rest") **10** is provided that is adapted to clamp and if desired, finely adjust the position of a workpiece during a machining operation (e.g., grinding or turning) by horizontal or vertical displacement or both horizontal and vertical displacement. In one embodiment, the steady rest **10** preferably includes a working cover plate **14**, a right-hand cover plate **16** (from the perspective of FIG. **3**A), and a central plate **18** that is slidingly positioned between them.

The steady rest **10** is adapted to cause gripping and displacement of the workpiece **12** vertically (FIGS. **4**A, **4**B and **7**), or horizontally (FIGS. **5**A, **5**B and **6**).

Upper and lower gripping arms **20**, **22** (FIG. **1**) and a cylinder/piston actuation mechanism **24** (FIG. **2**) are provided. As will be described in more detail below, the actuation mechanism **24** is operable to move the central plate **18** and the gripping arms **20**, **22** between a clamped position, in which the steady rest **10** grips the workpiece **12**, and a retracted position, in which the workpiece **12** is released and the gripping arms **20**, **22** are retracted into the steady rest **10**.

As depicted in FIG. **2**, the working cover plate **14** is a generally solid, flat plate having a plurality of threaded and unthreaded mounting apertures **32** (FIG. **2**). Upper and lower slide plates **28**, **30** (FIG. **1**) are mounted (directly or indirectly) to the working cover plate **14**. The central plate **18** is adapted to move between and be guided by slide plates **28**, **30**. The upper and lower slide plates **28**, **30** include threaded and/or unthreaded apertures **32** aligned with the apertures **26** in the working cover plate **14**.

The right-hand cover plate **16** (FIG. **3**A) has apertures that are aligned with the apertures **32** of slide plates **28**, and **30** and with the apertures **26** of the working cover plate **14**. Bolts **40** or other fasteners are received in some or all of the apertures to fixedly secure the working and right-hand cover plates **14**, and **16** to each other and to slide plates **28**, and **30**. The central plate **18** is sandwiched there between (as shown in FIGS. **1** and **3**) and is movable horizontally between the slide plates **28**, **30**.

The working and right-hand cover plates **14**, **16** and slide plates **28**, **30** cooperate to define cavities **43** in which guide tracks **44**, and **46** are movably received. The guide tracks **44**, **46** are adapted to move horizontally under the influence of fortified track engagement springs **42** (FIG. **1**). Track engagement springs **42** are selected to withstand repeated compression and rebound. For ease of maintenance, such springs preferably conform with other springs to be discussed below.

As shown in FIGS. **1**-**2**, the working cover plate **14** accommodates the upper and lower guide tracks **44**, **46** that are received in the cavities **43** (FIG. **1**). Each of the guide tracks **44**, **46** preferably includes an elongated leg **50** and a relatively shorter leg **52** (FIG. **2**). The legs **50** of the upper and lower guide tracks **44**, **46** preferably extend parallel to each other and parallel to a longitudinal axis –X (FIG. **6**). Each of the shorter legs **52** extends from an end of a corresponding one of the longer legs **50** in a direction that is laterally outward and away from the workpiece **12** (i.e., an acute angle is formed between the longer and shorter legs **50**, **52**).

To displace the gripping arms **20**, **22** and thus a clamped workpiece **12** in precise, predictable and finely metered amounts, a number of components cooperate to displace a workpiece vertically (FIGS. **4**A, **4**B and **7**) and horizontally (FIGS. **5**A, **5**B and **6**).

Shaped rails **58**, **60** (FIG. **1**) respectively cooperate to finely displace a workpiece **12** vertically and horizontally with predictable precision in a manner to be described. These rails are slidingly movable within a rail recess **48** independently of each other (e.g., FIGS. **2**-**7**). The vertical rail **58** has a flat face **70** (enlargement, FIG. **7**) that abuts the horizontal rail **60** and an opposing face with inclined sections **62**, **64** that meet on opposing sides of a flat middle section.

The working cover plate **14** has threaded apertures **92**, **94** (FIG. **1**) that extend preferably perpendicularly to the longitudinal axis X-X and communicate with the rail recess **48** (FIG. **2**). Adjustment screws or rods **96**, **98** (FIGS. **2**, **6**-**7**) threadedly engage the threaded apertures **92**, **94**, respectively, and extend into the rail recess **48**. Preferably, about 100 threads per inch are provided to enable finely-tuned adjustments to be made. An end **102** of the upper or vertical adjustment rod **98** abuts an end of the rail **58** which ultimately adjusts the workpiece position minutely vertically ("vertical rail **58**"). An end **100** of the lower or horizontal adjustment rod **96** abuts an end of the rail **60** (FIG. **5**A), which ultimately finely tunes the workpiece position minutely horizontally ("horizontal rail" **60**).

Akin to the track engagement springs associated with the upper and lower guide tracks **44**, **46**, rail engagement springs **104** (FIG. **2**) are positioned between a lower wall **106** of the rail recess **48** and a corresponding one of the vertical and horizontal rails **58**, **60** (FIGS. **4**A, **4**B, **5**A and **5**B). Preferably all engagement springs share common mechanical characteristics in order to facilitate maintenance and interchangeability. Common characteristics eliminate inventory problems associated with stocking differently-sized springs.

Rail engagement springs **104** (FIG. **4**B) bias the rails **58**, **60** into contact with the axial ends **100**, **102** of the adjustment rods **96**, **98**. In this manner, the rails **58**, **60** move toward and away from the lower wall **106** (in the directions shown in FIGS. **4**-**5**) as the adjustment rods **96**, **98** are moved along the threaded apertures **92**, **94** into and out of the rail recess **48**.

Threadedly adjusting the position of the horizontal adjustment rod **96** (FIGS. **5**A, **5**B and **6**) causes the horizontal rail **60** to slide in relation to a wall of the rail recess **48**. There is a relative angle (theta) between the wall and side **72** of the horizontal rail **60** (FIG. **5**A and enlargement, FIG. **5**B). Thus, a wedge-like effect is created in which movement of the horizontal rail **60** along wall **56** causes corresponding movement of the vertical rail **58** toward or away from the wall **56** in a direction along or parallel to the longitudinal X-axis.

Threadedly adjusting the position of the vertical adjustment rod **98** (FIGS. **4**A, **4**B and **7**) causes the vertical rail **58** to slide in relation to the wall **70** of the horizontal rail **60**. There is a relative angle (theta) between the walls **62**, **64** of the vertical rail **58** and walls **45**, **47** of the guide tracks **44**, **46** (enlargement, FIG. **4**B). Thus, movement of the vertical rail **58** along the wall **70** causes opposing movement of the guide tracks **44**, **46** toward and away from the wall **70** in a direction along or parallel to the vertical Y-axis.

Cross channels **112**, **114** (FIGS. **2**, **3**A and **3**B) formed in the central plate **18** slidingly receive the gripping arms **20**, **22**. The upper channel **112** receives the upper arm **20**. The lower channel **114** receives the lower arm **22**. A slot **116** extends into the upper channel **112**. A longitudinal axis of the slot **116** extends parallel to a longitudinal axis of the upper channel **112**. Similarly for a slot provided in the lower channel **114**. The upper and lower channels **112**, **114** are angled relative to the longitudinal axes and to each other. The upper and lower channels **112**, **114** cross each other to form a generally X-shaped pattern. The channels **112**, **114** are configured so that the upper and lower gripping arms **20**, **22** may move without interfering with each other.

A gripping finger **118** extends from the central plate **18** between the upper and lower channels **112**, **114** (FIG. **3**B). The gripping finger **118** cooperates with gripping fingers **119** of the upper and lower gripping arms **20**, **22** to grip and finely displace the workpiece **12** when the steady rest **10** is in the clamped position (FIGS. **4**-**7**).

Another end of the central plate **18** has a generally T-shaped aperture **124**. As shown in FIG. **3**B, the T-shaped aperture **124** receives a similarly shaped end **126** of a ramrod **128** of the actuation mechanism **24**.

Each of the upper and lower gripping arms **20**, **22** is preferably provided with an elongated upper portion **130** and a relatively shorter lower portion **132** (FIG. **2**). The upper and lower portions **130**, **132** preferably are angled relative to each other. The gripping fingers **119** extend toward each other from the lower portions **130**, **132**.

The upper portions **130** of the gripping arms **20**, **22** (FIG. **2**) include pins or roller guides **134**, **135** that protrude therefrom and extend into a corresponding one of the upper and lower guide tracks **44**, **46**. As shown in FIG. **2**, pin **134** of the upper gripping arm **20** extends through slot **116** and into the lower guide track **46**. In this way, an axial end of the pin **134** slidably engages the groove **54** of the lower guide track **46**. Pin **135** of the lower gripping arm **22** extends into the upper guide track **44**. An axial end of pin **135** slidably engages the groove **54** of the upper guide track **44**. The pins **134**, **135** have bushings **140**, **142** that are slidably received in the lower and upper guide tracks **46**, **44**, respectively (FIG. 3B).

Turning now to FIGS. **2** and **3**B, the actuation mechanism **24** includes a housing **144** with a chamber **148**, a piston **146** and a ramrod **128**. The housing **144** has a flange **145** that is bolted or otherwise mounted to the working cover plate **14** and/or the right-hand cover plate **16**. The housing **144** and the piston **146** define fluid chambers **148**, **150** in communication with upper and lower ports **152**, **154**, respectively (FIG. **2**). The piston **146** is attached to the ramrod **128** and separates the fluid chambers **148**, **150**. Ports **152**, **154** are in fluid communication with a source of working fluid (e.g., compressed air or preferably, hydraulic fluid). A fluid control device (not shown) is operable to control the flow of the working fluid in and out of ports **152**, **154** (FIG. **2**).

To move the piston **146** and ramrod **128** away from the workpiece **12**, the control device causes working fluid to flow into the fluid chamber **150** while evacuating fluid from the other fluid chamber **148**. To move the piston **146** and ramrod **128** toward the workpiece **12**, the control device causes working fluid to flow into fluid chamber **148** while evacuating fluid from the chamber **150**. Because the ramrod **128** is connected to the central plate **18**, movement of the piston **146** and ramrod **128** toward and away from the workpiece **12** causes corresponding movement of the central plate **18** toward and away from the workpiece **12**.

While the actuation mechanism **24** is described above as being a fluid-actuated device, it will be appreciated that any type of actuator could be used (e.g., an electric motor or another electromechanical device). Preferably the fluid is a liquid.

In conventional steady rests, threaded (tapped) holes are provided directly into the working and right-hand cover plates **14**, **16**. If the threads become damaged, the cover plates themselves often need to be replaced. Such an operation involves downtime and related cost. But with the steady rests systems disclosed herein, most repairs (if needed) are limited to the replacement of the horizontal and/or threaded adjustment rods **96**, **98** and associated locking nuts, the brass block in which receiving apertures are defined, roller bearings or bushings **140**, **142**, and seals in the cylinder **24**. Such steps are economically advantageous in comparison to prior approaches.

As described herein, the vertical threaded adjustment rod **98** lies on the left side (from the perspective of FIG. **1**). In alternative embodiments, the vertical threaded adjustment rod **98** and related components may lie on the right side.

Operation of a Representative Steady Rest System

(a) Clamping and Releasing the Workpiece

With continued reference to FIGS. **1**-**7**, the operation of a representative embodiment of a steady rest system **10** will now be discussed. As described above, the actuation mechanism **24** (FIG. **2**) is adapted to move the central plate **18** and the gripping arms **20**, **22** between a clamped position, in which the steady rest **10** grips the workpiece **12**, and a retracted position, in which the workpiece **12** is released and the gripping arms **20**, **22** are retracted into the steady rest **10**.

The steady rest **10** can be finely, precisely, and predictably adjusted to move the position of the workpiece **12** relative to the steady rest **10** when the workpiece **12** is in the clamped position (see FIGS. **4**-**7**). For example, a 90 degree turn of a vertical or horizontal adjustment rod **96**, **98** can displace a gripped workpiece by 1 micron while holding the workpiece **12** in place, despite forces exerted by machining operations and by the spinning mass of the workpiece. Such precision was not possible in conventional steady rests.

To move the steady rest **10** from the retracted position to the clamped position, working fluid is injected into chamber **148** of the actuation mechanism **24**, and working fluid (if present) is evacuated from chamber **150** (FIG. **2**). This causes the piston **146** and the ramrod **128** to move toward the workpiece **12** (i.e., to the right relative to the frame of reference of FIG. **3**B).

The central plate **18** moves with the ramrod **128** along the longitudinal X-axis relative to the working plate **14** and the right-hand plate **16** (FIG. **3**A). As the central plate **18** and gripping arms **20**, **22** move toward the clamped position, the pins **134**, **135**, and bushings **140**, **142** slide along the legs **50** of the corresponding guide tracks **44**, **46** (FIG. **3**B). Continued movement of the ramrod **128** and central plate **18** along the longitudinal X-axis toward the workpiece **12** causes the bushings **140**, **142** to come into contact with the surfaces **49**, **51** respectively, of the guide tracks **44**, **46** (FIG. **5**B).

Preferably, the rails **58**, **60** engage each other under the influence of a sliding interference fit. In one embodiment, there is about a 1-degree inclination of face **64** and surface **47** and face **62** and surface **45** (enlargement, FIG. **7**). Correspondingly there is about a 1-degree inclination between face **56** and surface **72**.

Once the bushings **142**, **140** are in contact with the guide tracks **44**, **46** and thus the surfaces **62**, **64** (FIGS. **4**A and **7**) of the vertical rail **58**, continued movement of the ramrod **128** and central plate **18** along the longitudinal X-axis toward the workpiece **12** causes the pins **134**, **135** (FIGS. **1**, **2**) and bushings **140**, **142** to slide laterally outwardly along the lower legs **52** of the guide tracks **44**, **46**. As the roller guides **134**, **135** and bushings **140**, **142** slide laterally outwardly along the lower legs **52** of the guide tracks **44**, **46**, the protruding ends (i.e., the lower portions **132**) of the gripping arms **20**, **22** move toward each other. The direction of movement of the protruding ends is in a direction perpendicular to the longitudinal X-axis. The gripping arms **20**, **22** slide in the channels **112**, **114**, respectively, relative to the central plate **18** until the gripping fingers **119** of the gripping arms **20**, **22** and the gripping finger **118** of the central plate **18** come into contact with and securely clamp the workpiece **12**.

To move the steady rest **10** from the clamped position to the retracted position (FIG. **7**), working fluid is injected into chamber **150** of the actuation mechanism **24**, and working fluid (if present) is evacuated from the other chamber **148**. This causes the piston **146**, the ramrod **128**, and the central plate **18** to move relative to the working and right-hand cover plates **14**, **16** away from the workpiece **12** after releasing it. Such movement reverses the movement of the gripping arms **20**, **22** described above.

(b) Displacing the Workpiece Horizontally and Vertically

Turning now to FIGS. **4-7**, the adjustment rods (fine screws, with about 100 threads per inch) **96**, **98** can be turned to finely shift the position in which the clamped workpiece **12** will be moved by the gripping fingers **118**, **119**.

As shown in FIG. **6**, to move the workpiece **12** horizontally toward the working and right-hand cover plates **14**, **16**, the user rotates the horizontal adjustment rod **96** in a direction that causes movement of the horizontal rail **60**. Such movement occurs within recess **48** in a direction perpendicular to the longitudinal X-axis. Rail engagement springs **90** urge the rails **96**, **98** upwardly.

There is a fine angle of inclination (theta, about 0.92 to 1.08 degrees, preferably 1.00 degree) between the horizontal rail **60** and the wall of recess **48**. As a result, a wedge effect is created that influences and constrains movement of the guide tracks **44**, **46** that abut the rail **58**.

By moving the horizontal guide rail **60** upwardly under the influence of an associated rail engagement spring **90** (FIGS. **5**B, **6**), the position along the guide tracks **44**, **46** at which the bushings **140**, **142** contact the guide tracks **44**, **46** also moves outwardly.

FIGS. **6-7** schematically illustrate how the rotation of one or both adjustment screws **96**, **98** move a clamped workpiece inwardly or outwardly (FIG. **6**) and/or upwardly and downwardly (FIG. **7**).

For example, to move the position in which the gripping fingers **118**, **119** precisely move the workpiece **12** in a vertical direction, the user rotates the adjustment rod **98**. In one case, a clockwise displacement of 90 degrees raises the workpiece **12** by 1 micron. Conversely, counterclockwise displacement lowers the workpiece by a corresponding amount.

It will be appreciated that intermediate adjustments may be made, and that displacement is not limited to 90-degree increments or decrements.

The steady rest **10** may be used to hold the workpiece **12** for a grinding operation. It will be appreciated, however, that the principles of the present disclosure may be applicable to steady rests configured for turning operations and/or other machining or manufacturing operations.

FIGS. **8**A-**8**B depict enhancements to an earlier design that was described in the parent patent application. FIG. **8**A is the original design and FIG. **8**B is its revision. In FIG. **8**A the relationship between the rail pin **155** and vertical rail **58** or horizontal rail **60** would allow a condition in which the rail engagement spring **90** could become seized in the rail spring pocket **157**. To solve this condition, a rail washer **156** was added (FIG. **8**B). This eliminated the rail spring pocket **157** and changed the relationship between the rail pin **155** and vertical rail **58** or horizontal rail **60**. Additionally, springs **104** are now characterized by a higher spring force.

The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

REFERENCE LIST

10 Steady rest system
12 Workpiece
14 Working cover plate
16 Right-hand cover plate
18 Central plate
20 Upper gripping arm
22 Lower gripping arm
24 Actuation mechanism
26 Apertures
28 Upper slide plate
30 Lower slide plate
32 Aperture
40 Bolt
42 Track engagement spring
43 Cavity
44 Upper guide track
45 Side wall of upper track
46 Lower guide track
47 Side wall of lower track
48 Rail recess
49 Inner wall of upper guide track
50 Elongated upper leg
51 Inner wall of lower guide track
52 Shorter lower leg
54 Groove
56 Upper wall
58 Vertical rail
60 Horizontal rail
62 Upper side of vertical rail

64 Lower side of vertical rail
70 Upper side of horizontal rail
72 Lower side of horizontal rail
90 Rail engagement spring
92 Threaded aperture
94 Threaded aperture
96 Horizontal threaded adjustment rod
98 Vertical threaded adjustment rod
100 Axial end of **96**
102 Axial end of **98**
104 Rail engagement springs
106 Second wall of **48**
108 First side of **18**
110 Second side of **18**
112 Upper cross channel
114 Lower cross channel
116 Slot
118 Gripping finger
119 Gripping finger arm
124 T-shaped aperture
126 T-shaped end of **128**
128 Ramrod of **24**
130 Elongated first portion of gripping arms
132 Shorter second portion of griping arms
134 Pin
135 Pin
140 Bushing
142 Bushing
144 Housing
145 Flange
146 Piston
148 First fluid chamber
150 Second fluid chamber
152 Port
154 Port
155 Rail Pin
156 Rail Washer
157 Rail Spring Pocket

What is claimed is:

1. A steady rest for gripping and finely positioning a workpiece, the steady rest comprising:

a working cover plate and a right-hand cover plate,

a central plate disposed between the working and right-hand cover plates, the central plate being adapted to move slidably therebetween, the central plate having an upper and a lower cross-channel for engaging upper and lower gripping arms, the gripping arms being movable relative to the working and right-hand cover plates between a clamped position and a retracted position, the working cover plate also having a rail recess and a pair of cavities that respectively receive upper and lower guide tracks and track engagement springs that bias the guide tracks within cavities;

a tapered horizontal rail situated in the rail recess, the tapered horizontal rail being adapted to cause displacement of the workpiece horizontally;

a vertical rail with a flat face that abuts the horizontal rail and an opposing face with inclined sections that meet on opposing sides of a flat middle section, the vertical rail being adapted to move the workpiece vertically, the vertical rail also being received in the rail recess,

the horizontal and vertical rails contacting the rail recess and each other while controlling location of the gripping arms, the horizontal and vertical rails being movable relative to each other under the guidance of rail pins that extend along channels defined within the horizontal and vertical rails and rail washers to avoid binding and to adjust a position relative to the working and right-hand cover plates at which the workpiece will be clamped when the upper and lower gripping arms are in the clamped position.

2. The steady rest of claim **1**, further comprising horizontal and vertical threaded adjustment rods threadedly received in apertures of the working cover plate and extending into the rail recess, the horizontal threaded adjustment rod abutting the horizontal rail and being rotatable to adjust a position of the horizontal rail, the vertical threaded adjustment rod abutting the vertical rail and being rotatable to adjust a position of the vertical rail.

3. The steady rest of claim **2**, further comprising rail engagement springs for biasing the horizontal and vertical rails into contact with an upper wall of the rail recess, the track engagement springs and the rail engagement springs having common mechanical properties.

4. The steady rest of claim **1**, wherein the inclined sections of the vertical rail have faces that are inclined to the flat face by an angle theta, where theta lies between 0.92 and 1.08 degrees.

5. The steady rest of claim **1**, wherein the horizontal rail includes a flat side that slidingly engages the vertical rail and an opposing side that slidingly engages a wall of the rail recess, wherein the flat side and the wall are inclined by an angle theta, where theta lies between 0.92 and 1.08 degrees.

6. The steady rest of claim **1**, wherein the upper and lower gripping arms include pins extending therefrom that are slidably received in the upper and lower guide tracks.

7. The steady rest of claim **6**, wherein the upper and lower guide tracks each have an elongated leg and a shorter leg extending therefrom.

8. The steady rest of claim **1**, further including an actuation mechanism with a housing having fluid chambers, a piston positioned between the chambers and a ramrod, the housing being secured to the working cover plate and/or the right-hand cover plate.

9. The steady rest of claim **8**, wherein the housing and the piston define fluid chambers in communication with upper and lower ports respectively, the ports being in fluid communication with a source of working fluid and a fluid control device that is operable to control a flow of the working fluid in and out of the ports.

10. The steady rest of claim **1**, wherein a 90 degree turn of a vertical or horizontal adjustment rod displaces the workpiece by 1 micron while holding the workpiece in place, despite forces exerted by machining operations and by the spinning mass of the workpiece.

11. A method of moving the steady rest of claim **1** from the retracted position to the clamped position, comprising the steps of

injecting a working fluid into a chamber of an actuation mechanism, thereby causing a piston to move toward the workpiece;

moving the central plate under the influence of the actuation mechanism along an axis relative to the working plate and the right-hand plate;

as the central plate and gripping arms move toward the clamped position, sliding pins and bushings along legs of corresponding guide tracks so that the bushings come into contact with surfaces of the guide tracks and so that the pins and bushings slide laterally outwardly along lower legs of the guide tracks, protruding ends of the gripping arms thereby moving toward each other to come into contact with and securely clamp the workpiece.

12. A method of moving a clamped workpiece horizontally using the steady rest of claim **1**, comprising the steps of

rotating a horizontal adjustment rod with a horizontal adjustment screw in a direction that causes movement of the horizontal rail under the influence of a rail engagement spring, such movement occurring under the constraint of an angle of inclination (theta, 0.92 to 1.08 degrees) between the horizontal rail and a wall of the rail recess so that a wedge effect influences and constrains movement of the guide tracks; and

moving the horizontal guide rail upwardly under the influence of the rail engagement spring so that a position along the guide tracks at which bushings contact the guide tracks also moves outwardly, thereby displacing the workpiece horizontally, so that rotation of the horizontal adjustment screw moves a clamped workpiece inwardly or outwardly.

13. A method of moving a clamped workpiece vertically using the steady rest of claim **1**, comprising the steps of

rotating a vertical adjustment screw in a direction that causes movement of the vertical rail, such movement occurring under the constraint of an angle of inclination (theta, 0.92 to 1.08 degrees) between the vertical rail and a wall of the rail recess so that a wedge effect influences and constrains movement of the guide tracks; and

moving the vertical rail upwardly so that a position along the guide tracks at which bushings contact the guide tracks also moves vertically, thereby displacing the workpiece vertically.

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