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[Continued on next page]

(54) **Title**: SPRING ASSEMBLY AND METHOD

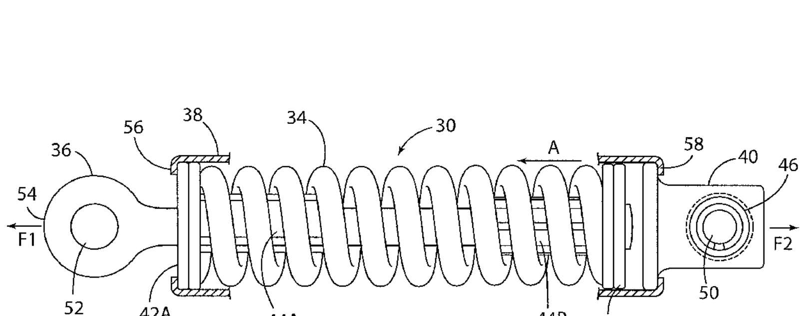

Fig. 5

(57) **Abstract**: A method of assembling a spring inside of a tube includes providing a coil spring and a tube having a first retaining structure at a first end of the tube. The method includes positioning a rod in the tube. The spring is positioned in the tube, and a second retaining structure is attached to the rod with the spring positioned between the first and second retaining structures. A force is applied to the spring, and the second retaining structure is fixed at a position wherein the spring provides a desired preload.

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SPRING ASSEMBLY AND METHOD

BACKGROUND

[0001] Various springs and spring assemblies have been developed for providing a resistance or assistance force for devices such as chair tilt mechanisms, height adjustment mechanisms for chairs and tables, door opening/closing mechanisms and other applications requiring an assistance or resistance force. Due to production tolerances and other such variables, the amount of force generated by a spring may vary from one spring to another. This can lead to inconsistent resistance forces assemblies such as office chairs, height adjustable tables, or other devices or products that utilize springs.

[0002] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each claim of this application.

[0003] Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

SUMMARY

[0004] One aspect of the present invention provides a method of assembling a spring assembly, the method comprising: providing a coil spring having first and second opposite spring ends and an axis; providing a tube having an interior space and a first retaining structure at a first end of the tube such that the coil spring transmits force to the tube upon insertion of the coil spring into a second end of the tube; providing an elongated rod having first and second rod ends; positioning the rod in the tube with the first rod end toward the first tube end and the second rod end toward the second tube end; positioning the spring in the tube with the first end of the coil spring engaging the first retaining structure; providing a second retaining structure; attaching the second retaining structure to the second end of the rod such that the second retaining structure

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moves with the rod, and wherein the coil spring is positioned at least partially inside the tube between the first and second retaining structures; axially compressing the coil spring; measuring an axial force acting on the coil spring as the coil spring is axially compressed utilizing an assembly tool having a force sensor; followed by fixing a stop on the second end of the tube such that the stop retains the second retaining structure at a position wherein the magnitude of the measured axial force acting on the coil spring is at a predefined magnitude or is within a predefined range; and removing the spring assembly from the assembly tool whereby the force sensor of the assembly tool is no longer capable of measuring an axial force acting on the coil spring.

[0005] Another aspect of the present invention provides a method of assembling a spring assembly, the method comprising: providing a coil spring having first and second opposite spring ends and an axis; providing a tube having an interior space and a first retaining structure at a first end of the tube such that the coil spring transmits force to the tube upon insertion of the coil spring into a second end of the tube; providing an elongated rod having first and second rod ends; positioning the rod in the tube with the first rod end toward the first tube end and the second rod end toward the second tube end; positioning the spring in the tube with the first end of the coil spring engaging the first retaining structure; providing a second retaining structure; attaching the second retaining structure to the second end of the rod such that the second retaining structure moves with the rod, and wherein the coil spring is positioned at least partially inside the tube between the first and second retaining structures; axially compressing the coil spring; measuring an axial force acting on the coil spring as the coil spring is axially compressed utilizing an assembly tool having a force sensor; followed by fixing a stop on the second end of the tube such that the stop retains the second retaining structure at a position wherein the magnitude of the measured axial force acting on the coil spring is at a predefined magnitude or is within a predefined range; removing the spring assembly from the assembly tool whereby the force sensor of the assembly tool is no longer capable of measuring an axial force acting on the coil spring; the tube defines an axis; and the stop comprises an integral flange that extends inwardly in a direction that is transverse to the axis of the tube, wherein the flange is formed at the second end of the tube.

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[0006] Yet another aspect of the present invention provides a method of fabricating a force-generating assembly, the method comprising: providing an enclosure and an actuator; positioning at least a portion of the actuator in the enclosure with a portion of the actuator extending outside the enclosure; providing a resilient member defining an axis; operably interconnecting the enclosure and the actuator utilizing the resilient member, such that the resilient member is capable of generating an axial resistance force tending to return the actuator and the enclosure to their assembled positions relative to one another; axially deforming the resilient member along the axis of the resilient member utilizing an axial applied force acting on the resilient member while measuring the axial applied force utilizing an assembly tool having a force sensor; and fixing the enclosure and actuator relative to one another whereby the resilient member provides a predefined axial preload force or an axial preload force falling within a predefined range.

[0007] Still another aspect of the present invention provides an energy mechanism, comprising: a spring generating a spring force upon deformation of the spring; an enclosure housing at least a portion of the spring therein; an actuator having a first portion disposed inside the enclosure and operably engaging the spring, and a second portion extending out of the enclosure to transmit a spring force outside the enclosure, the actuator being movable from an initial position wherein the spring is deformed an initial amount and generates an initial spring force acting on the actuator, to a second position wherein the spring is deformed a second amount and generates a second spring force; wherein the spring is supported in a partially stressed condition within the enclosure after being prestressed to deform the spring to the initial amount of deformation to generate the initial spring force, such that an applied force acting on the actuator must be at least as great as a predetermined initial force to shift the actuator from its initial position, wherein a portion of the enclosure is deformed to retain the spring in a preselected preload state, and wherein the initial position of the actuator is fixed such that the initial spring force cannot be altered.

[0008] Yet another aspect of the present invention provides an energy mechanism, comprising: a spring; an enclosures housing the spring; an actuator movable between an initial position and at least one displaced position, the actuator extending to the coil spring to transmit a spring force outside of the enclosure; and the spring being supported in a preselected preloaded state within the enclosure after being preloaded to a

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predetermined spring force, such that an initial spring force required to move the actuator from the initial position correlates to the predetermined force amount, wherein a portion of the enclosure is deformed to retain the spring in the preselected preload state, and wherein the initial position of the actuator is fixed such that the initial spring force cannot be altered.

[0009] These and other features, advantages, and objects of the present invention will be further understood and appreciated by those skilled in the art by reference to the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1 is an isometric view of a chair including one or more spring assemblies according to the present invention;

[0011] Fig. 2 is a side elevational view of the chair of Fig. 1;

[0012] Fig. 3 is a schematic view of the linkage and springs of the chair of Fig. 1;

[0013] Fig. 4 is a partially fragmentary isometric view of a spring assembly according to the present invention;

[0014] Fig. 5 is a side elevational view of a spring assembly according to the present invention;

[0015] Fig. 5A is an exploded cross sectional view of the pin and retainer of Fig. 5;

[0016] Fig. 6 is an exploded isometric view of a spring assembly according to the present invention;

[0017] Fig. 7 is a cross-sectional view of a machine utilized to assemble the spring assembly according to the present invention;

[0018] Fig. 8 is a partially fragmentary view of a spring subassembly according to the present invention;

[0019] Fig. 9 is a partially fragmentary view of a spring assembly according to the present invention; and

[0020] Fig. 10 is a cross-sectional view of a spring assembly according to the present invention.

DETAILED DESCRIPTION

[0021] For purposes of description herein, the terms "upper," "lower," "right," "left," "rear," "front," "vertical," "horizontal," and derivatives thereof shall relate to the invention as oriented in Fig. 1. However, it is to be understood that the invention may assume various alternative orientations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

[0022] A chair 1 includes a back 2, a seat 3, armrests 4 and a base 5 with castors 6. With further reference to Figs. 2 and 4, chair 1 includes a four bar linkage comprising a base link 12 that is fixed to the chair base 5, a seat link 14, a control link 16, and a lower link 18. The links 12-16 are interconnected by first, second, third, and fourth pivots 21, 22, 23, and 24, respectively. A spring assembly 30 generates tension forces F1 and F2 acting on points 31 and 32 to thereby bias the four bar linkage 10 into an upright position as shown in Figs. 2 and 3. It will be understood that the spring and method of the present invention is not limited to coil springs, and also is not limited to spring assemblies generating a tension force.

[0023] With further reference to Figs. 4-6 and Figs. 9-10 spring assembly 30 includes a coil spring 34, an actuator or rod 36 having an opening 52 at end 54, a housing or enclosure 38, and an end plug or fitting 40. The spring assembly 30 also includes washers, 42A, 42B and bushings 44A, 44B. A pin 46 extends through an opening 50 in end plug or fitting 40, and a retainer 48 retains the pin 46 in the opening 50. Retainer 48 may comprise a C clip that is received in an annular grove, or it may comprise other suitable retaining devices to retain pin 46 in opening 50 of end plug 40. With reference to Fig. 5A, in a preferred embodiment, pin 46 includes a cylindrical portion 46A having a raised ring-like protrusion or ridge 46B and a slot 46C. Retainer 48 includes an annular ridge 48A that snaps over ridge 46B such that retainer 48 is retained on pin 46. Pin 46 and/or retainer 48 may comprise steel or other suitable material.

[0024] When assembled, pin 46 and opening 52 at end 54 of rod 36 are utilized to transmit forces through the spring assembly 30. When spring assembly 30 is assembled, end flanges 56 and 58 of housing 38 retain the spring 34 in a prestressed, compressed condition. As discussed in more detail below, the flange 58 is formed during assembly while measuring a force applied to rod 36 and end plug or fitting 40, such that the spring 34 has a predefined preload. Thus, the magnitude of tension forces F1 and F2 applied to rod 36 and end plug 40, respectively, must exceed a specified preload force amount before the rod 36 and end fitting 40 will move relative to one another from the initial position shown in Fig. 5. If tension forces F1 and F2 exceed the predefined preload force, coil spring 34 will compress further, resulting in movement of rod 36 in the direction of the arrow “A” (5) relative to end plug or fitting 40. The spring assembly 30 of the present invention can be assembled in a way that ensures that the actual tension forces F1 and F2 required to cause movement of rod 36 relative to fitting 40 fall within a predefined acceptable range.

[0025] With reference to Fig. 8, housing 38 is initially formed to include an inwardly-extending flange 56A at first end 62A of housing 38. Circular edge 66 at second end 62B of housing 38 is not initially formed to include a flange. During assembly, a first washer 42A is initially positioned in the inner space 60 of housing 38 in position against flange 56A at a first end 62A of housing 38, and a first bushing 44A and rod 36 are positioned as shown in Fig. 8. Rod 36 initially includes a reduced diameter end portion 64 that receives second washer 42B. A coil spring 34 is then positioned in housing 38, and a second bushing 44B and second washer 42B are then positioned in the interior space 60 with second washer 42B disposed on reduced diameter end portion 64 of rod 36. The edge 66 of housing 38 is initially not formed to include a flange, such that washers 42A and 42B, and bushings 44A and 44B can be inserted into interior space 60 of housing 38.

[0026] End 64 of rod 36 is then deformed utilizing a known radial riveting process or other suitable process to create an enlarged end portion 65 which securely retains the washer 42B on end 68 of rod 36. Enlarged end portion 65 is shown in dashed lines in Fig. 8, and in solid lines in Fig. 9. This forms a subassembly 30A as shown in Fig. 8.

[0027] Subassembly 30A is then positioned in a fixture 70 (Fig. 7). Fixture 70 includes first and second pins 72 and 74, respectively, that are received in openings 50 and 52, respectively of spring subassembly 30A. An end plug or fitting 40 is positioned in second end 62B of housing 38. Pins 72 and 74 may be inserted utilizing pneumatic or hydraulic cylinders (not shown). Upper pin 72 fixes the plug 40 relative to upper plate 90 of fixture 70, and lower pin 74 fixes the rod 36 relative to a vertically adjustable cylinder 84. Cylinder 84 can be driven upwardly by threaded force adjustment device 86 by rotating a hand wheel 88. A load cell 82 is utilized to measure the force generated by coil spring 34 on pin 74 due to upward movement of cylinder 84. Although a threaded adjustment device 86 and hand wheel 88 are shown in the fixture 70, the force adjustment device utilized to compress coil spring 34 may comprise a hydraulic cylinder, an electrically-powered actuator, or other suitable powered device.

[0028] Once a predetermined or predefined force is generated as measured by load cell 82, a forming tool 92 is shifted downwardly into position adjacent second end 62B of housing 38 utilizing a hydraulic cylinder 80 or other suitable powered actuator. The forming tool 92 then forms edge 66 (Fig. 8) into flanges 56B (Fig. 9) to retain plug 40 at a position wherein the coil spring 32 is preloaded at the desired level. This process thereby sets the preload force at a desired, predefined level or to a predefined range that includes acceptable tolerance variations. The final spring assembly 30 (Figs. 9 and 10) is then removed from fixture 70.

[0029] Referring again to Fig. 1, chair assembly 1 includes two spring assemblies 30. Because the spring assemblies 30 are consistent with respect to the preload or initial force required to initially extend the spring assemblies 30, a plurality of chairs 1 can be manufactured and the springs 30 do not need to be adjusted at the time of assembly of the chair 1. Furthermore, each chair 1 assembled will have substantially the same tilt characteristics with respect to the amount of force required to tilt the chair back.

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CLAIMS

1. A method of assembling a spring assembly, the method comprising:

providing a coil spring having first and second opposite spring ends and an axis;

providing a tube having an interior space and a first retaining structure at a first end of the tube such that the coil spring transmits force to the tube upon insertion of the coil spring into a second end of the tube;

providing an elongated rod having first and second rod ends;

positioning the rod in the tube with the first rod end toward the first tube end and the second rod end toward the second tube end;

positioning the spring in the tube with the first end of the coil spring engaging the first retaining structure;

providing a second retaining structure;

attaching the second retaining structure to the second end of the rod such that the second retaining structure moves with the rod, and wherein the coil spring is positioned at least partially inside the tube between the first and second retaining structures;

axially compressing the coil spring;

measuring an axial force acting on the coil spring as the coil spring is axially compressed utilizing an assembly tool having a force sensor;

followed by fixing a stop on the second end of the tube such that the stop retains the second retaining structure at a position wherein the magnitude of the measured axial force acting on the coil spring is at a predefined magnitude or is within a predefined range; and

removing the spring assembly from the assembly tool whereby the force sensor of the assembly tool is no longer capable of measuring an axial force acting on the coil spring.

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2. The method of claim 1, including:

placing the tube in a fixture;

placing the elongated rod in a fixture; wherein the elongated rod has an annular surface;

positioning the second retaining structure on the rod in contact with the annular surface; and

deforming a portion of the elongated rod to fix the second retaining structure on the elongated rod such that a position of the second retaining structure on the elongated rod cannot be adjusted.

3. A method of assembling a spring assembly, the method comprising:

providing a coil spring having first and second opposite spring ends and an axis;

providing a tube having an interior space and a first retaining structure at a first end of the tube such that the coil spring transmits force to the tube upon insertion of the coil spring into a second end of the tube;

providing an elongated rod having first and second rod ends;

positioning the rod in the tube with the first rod end toward the first tube end and the second rod end toward the second tube end;

positioning the spring in the tube with the first end of the coil spring engaging the first retaining structure;

providing a second retaining structure;

attaching the second retaining structure to the second end of the rod such that the second retaining structure moves with the rod, and wherein the coil spring is positioned at least partially inside the tube between the first and second retaining structures;

axially compressing the coil spring;

measuring an axial force acting on the coil spring as the coil spring is axially compressed utilizing an assembly tool having a force sensor;

followed by fixing a stop on the second end of the tube such that the stop retains the second retaining structure at a position wherein the magnitude of the measured axial force acting on the coil spring is at a predefined magnitude or is within a predefined range;

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removing the spring assembly from the assembly tool whereby the force sensor of the assembly tool is no longer capable of measuring an axial force acting on the coil spring;

the tube defines an axis; and

the stop comprises an integral flange that extends inwardly in a direction that is transverse to the axis of the tube, wherein the flange is formed at the second end of the tube.

4. The method of claim 3, wherein:

the annular flange is formed on the second end of the tube by bending portions of the tube after the second retaining structure is attached to the elongated rod.

5. The method of claim 4, wherein:

the tube includes an inwardly-extending flange at the first end defining the first retaining structure at the time the tube is placed in the fixture;

the rod includes a ring structure having a transverse opening therethrough at the first end of the rod; and

positioning the rod in the tube includes positioning the ring structure outside of the first end of the tube adjacent the inwardly-extending flange.

6. The method of claim 5, including:

positioning an inner portion of an end plug inside the tube before forming the annular flange, whereby an outer portion of the end plug having a transverse opening therethrough is positioned outside the tube after forming the annular flange and the inner portion bears against the annular flange.

7. The method of claim 6, wherein:

the coil spring is deformed utilizing a linear powered actuator.

8. The method of claim 6, wherein:

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the second end of the tube is deformed to form the stop while the coil spring is compressed to thereby retain a portion of the end plug inside the tube.

9. The method of claim 8, wherein:

the stop comprises a flange formed by a forming tool.

10. A method of fabricating a force-generating assembly, the method comprising:

providing an enclosure and an actuator;

positioning at least a portion of the actuator in the enclosure with a portion of the actuator extending outside the enclosure;

providing a resilient member defining an axis;

operably interconnecting the enclosure and the actuator utilizing the resilient member, such that the resilient member is capable of generating an axial resistance force tending to return the actuator and the enclosure to their assembled positions relative to one another;

axially deforming the resilient member along the axis of the resilient member utilizing an axial applied force acting on the resilient member while measuring the axial applied force utilizing an assembly tool having a force sensor; and

fixing the enclosure and actuator relative to one another whereby the resilient member provides a predefined axial preload force or an axial preload force falling within a predefined range.

11. The method of claim 10, wherein:

the resilient member comprises a spring.

12. The method of claim 11, wherein:

the spring comprises a coil spring having first and second opposite ends.

13. The method of claim 12, wherein:

the enclosure comprises a tubular member defining first and second opposite ends and an interior space, the method further including:

positioning at least a portion of the coil spring in the interior space.

14. The method of claim 13, wherein:

the actuator comprises an elongated rod member having first and second opposite ends; and wherein:

operably interconnecting the enclosure and the actuator includes positioning at least a portion of the elongated rod member in the interior space.

15. The method of claim 14, wherein:

fixing the enclosure and the actuator relative to one another includes securing a flange member to the second end of the elongated rod member, and wherein the flange member is configured to engage the second end of the coil spring.

16. The method of claim 10, wherein:

fixing the enclosure and the actuator relative to one another includes providing first and second stops on first and second ends of the tubular member in a manner that prevents expansion of the resilient member.

17. The method of claim 10, wherein:

the enclosure defines opposite ends that engage opposite ends of the resilient member and prevent expansion of the resilient member.

18. An energy mechanism, comprising:

a spring generating a spring force upon deformation of the spring;

an enclosure housing at least a portion of the spring therein;

an actuator having a first portion disposed inside the enclosure and operably engaging the spring, and a second portion extending out of the enclosure to transmit a spring force outside the enclosure, the actuator being movable from an initial position wherein the spring is deformed an initial amount and generates an initial spring force acting on the actuator, to a second position wherein the spring is deformed a second amount and generates a second spring force;

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wherein the spring is supported in a partially stressed condition within the enclosure after being prestressed to deform the spring to the initial amount of deformation to generate the initial spring force, such that an applied force acting on the actuator must be at least as great as a predetermined initial force to shift the actuator from its initial position,

wherein a portion of the enclosure is deformed to retain the spring in a preselected preload state, and

wherein the initial position of the actuator is fixed such that the initial spring force cannot be altered.

19. The energy mechanism of claim 18, wherein:

the enclosure comprises a tubular member having generally cylindrical inner and outer surfaces.

20. The energy mechanism of claim 18 or claim 19, wherein:

the enclosure comprises a tubular member having first and second opposite ends, the first end being at least partially closed by a spring-engaging structure; and

the actuator includes an elongated rod having a spring-engaging flange at an inner end of the actuator, and wherein the spring is disposed between the spring-engaging structure and the spring-engaging flange.

21. The energy mechanism of any one of claims 18-20, wherein:

the spring-engaging flange comprises a washer having a central opening that fixedly receives an end portion of the elongated rod.

22. An energy mechanism, comprising:

a spring;

an enclosures housing the spring;

an actuator movable between an initial position and at least one displaced position, the actuator extending to the coil spring to transmit a spring force outside of the enclosure; and

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the spring being supported in a preselected preloaded state within the enclosure after being preloaded to a predetermined spring force, such that an initial spring force required to move the actuator from the initial position correlates to the predetermined force amount,

wherein a portion of the enclosure is deformed to retain the spring in the preselected preload state, and

wherein the initial position of the actuator is fixed such that the initial spring force cannot be altered.

23. The energy mechanism of claim 22, wherein:

the spring is retained at the initial position unless a force exceeding the initial spring force is applied to the actuator.

24. The energy mechanism of claim 22 or 23, wherein:

the enclosure is deformed to retain the actuator at the initial position.

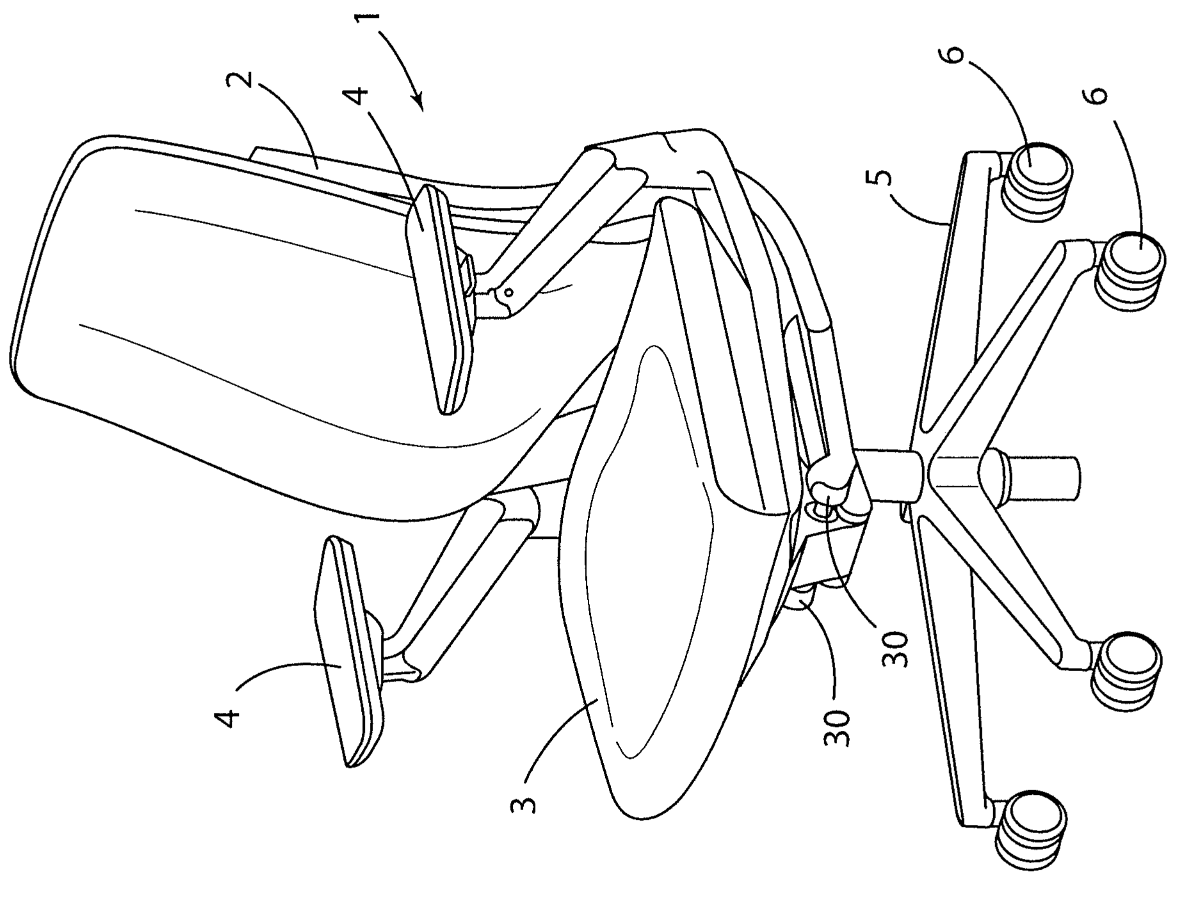


Fig. 1

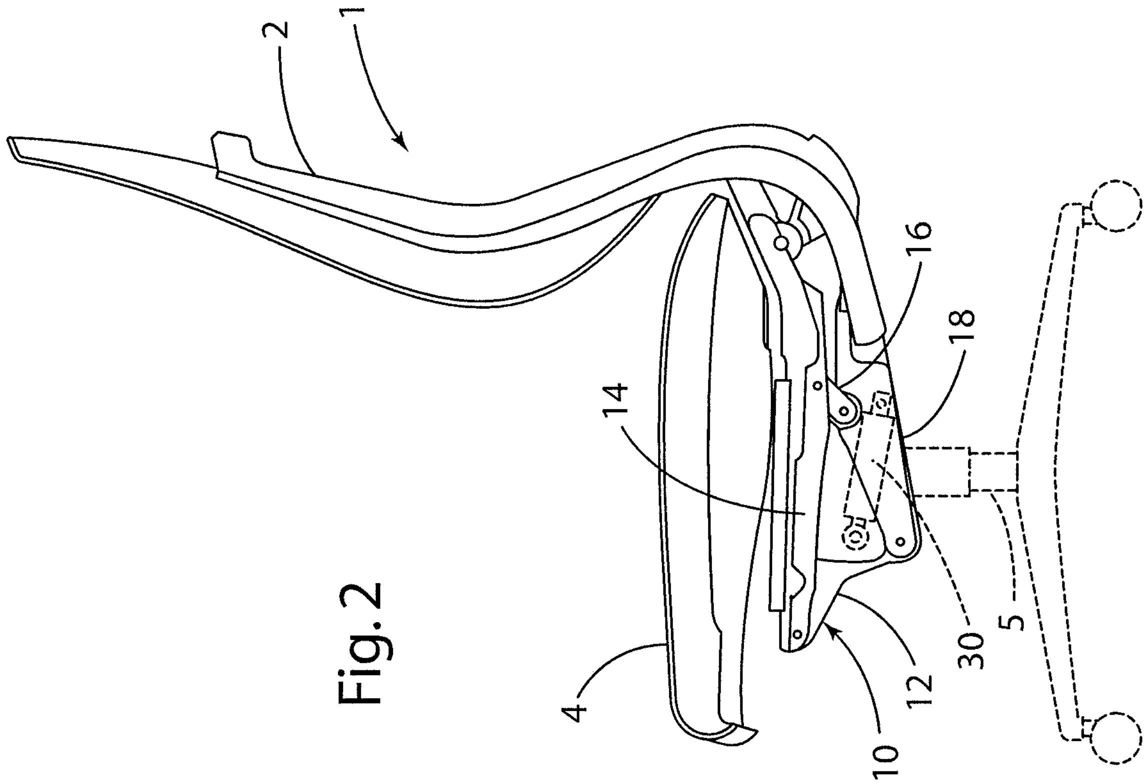


Fig. 2

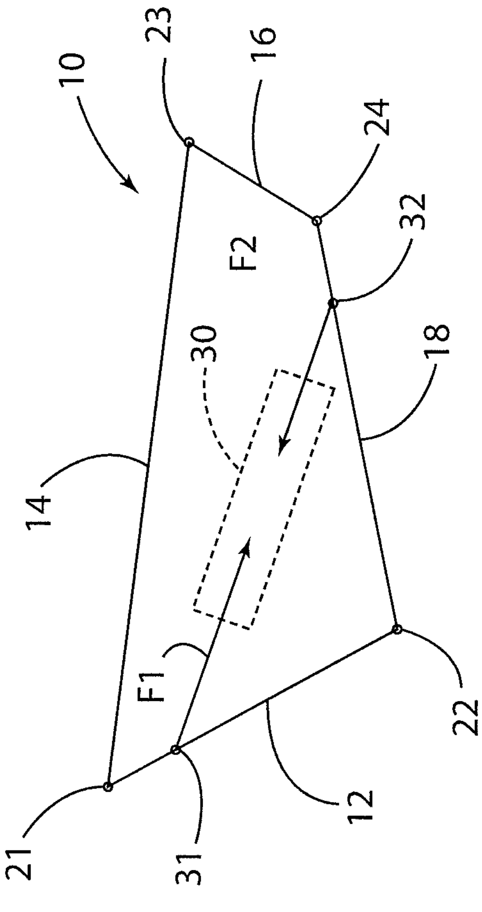


Fig. 3

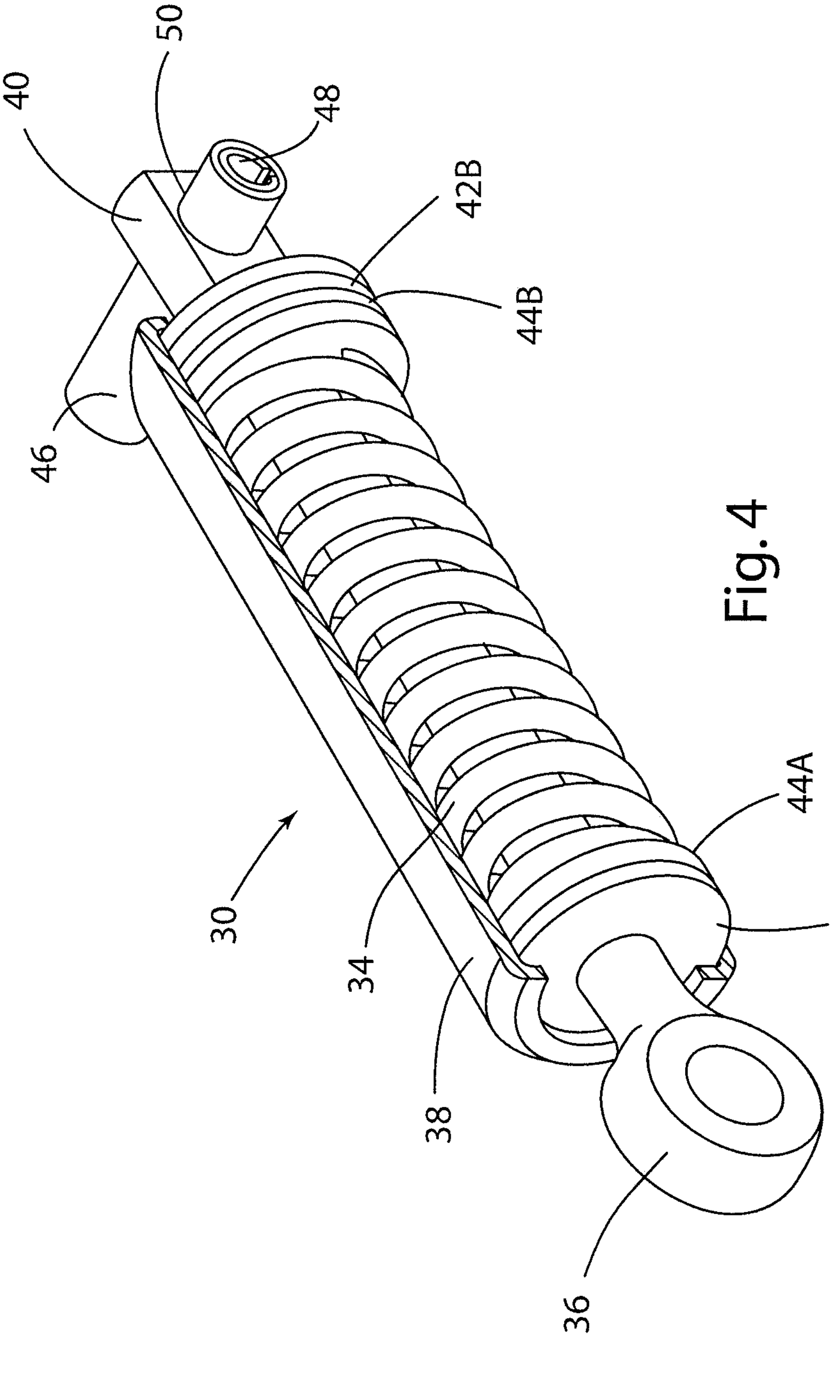
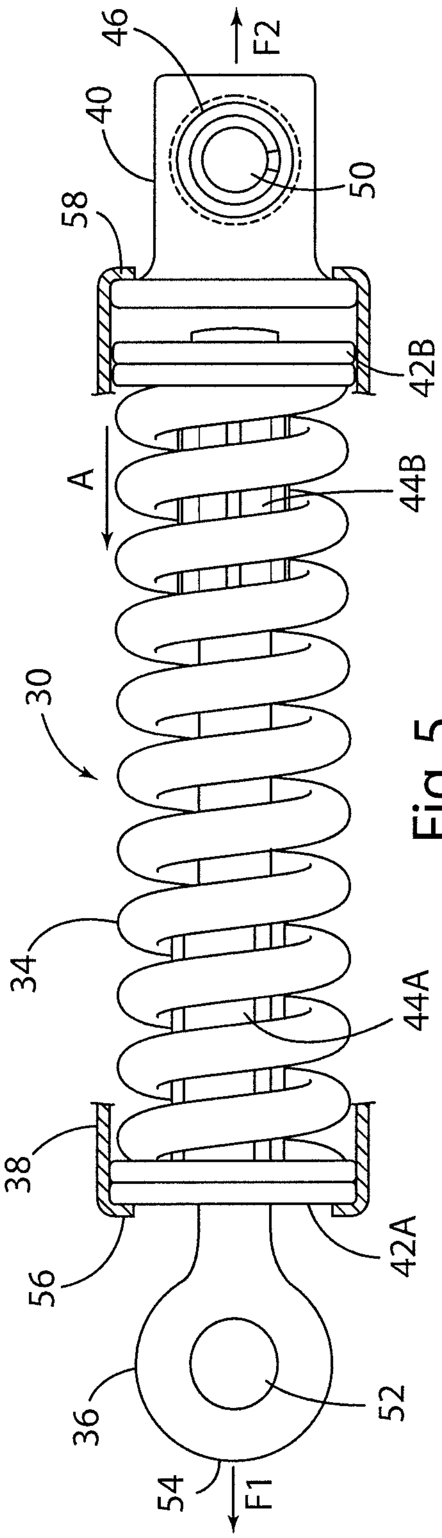


Fig. 4



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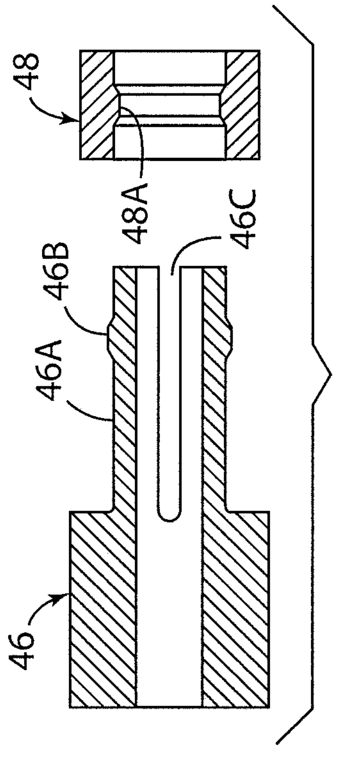
54
F1

Fig. 5



48
48A
46C
46B
46A
46

Fig. 5A

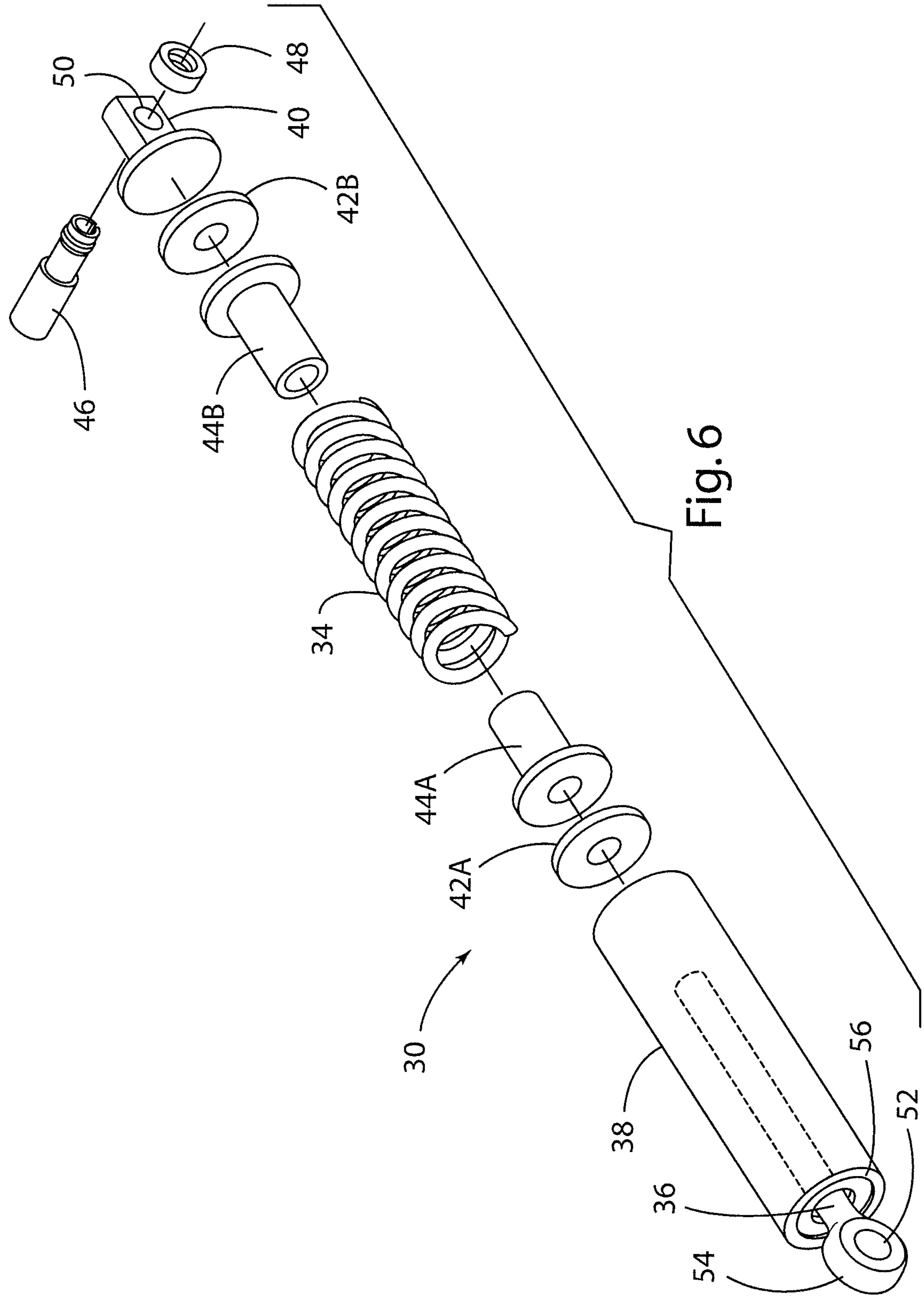


Fig. 6

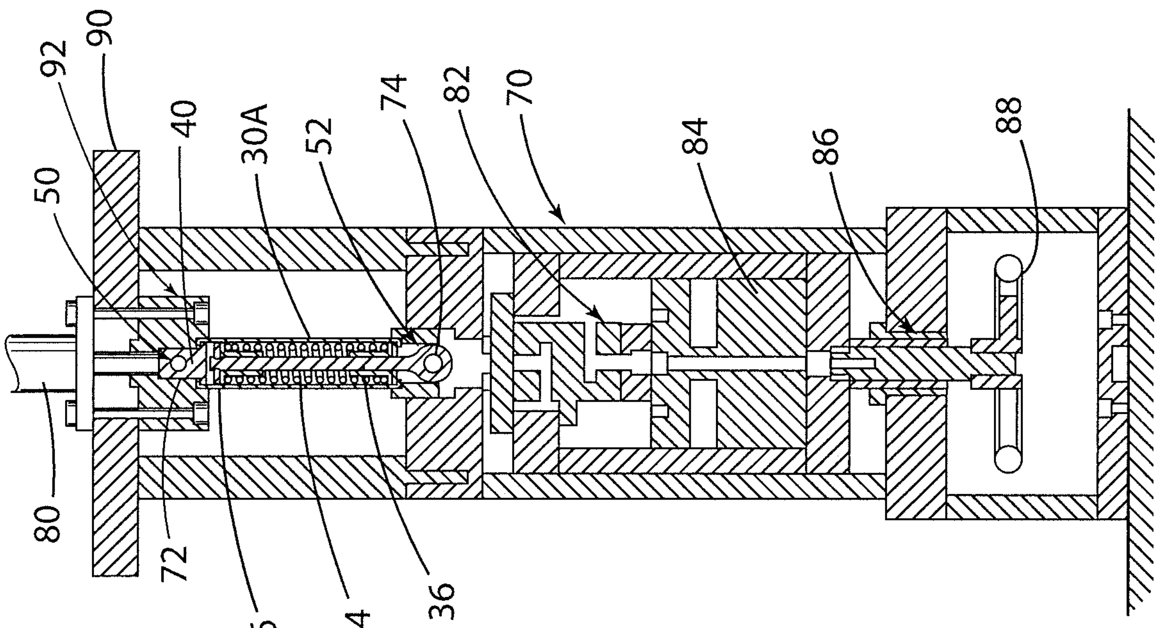


Fig. 7

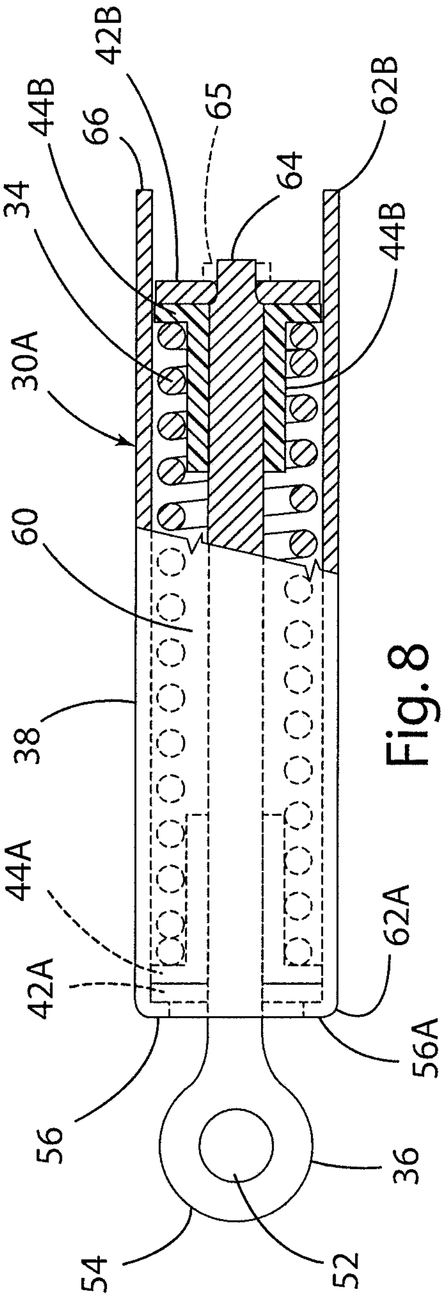
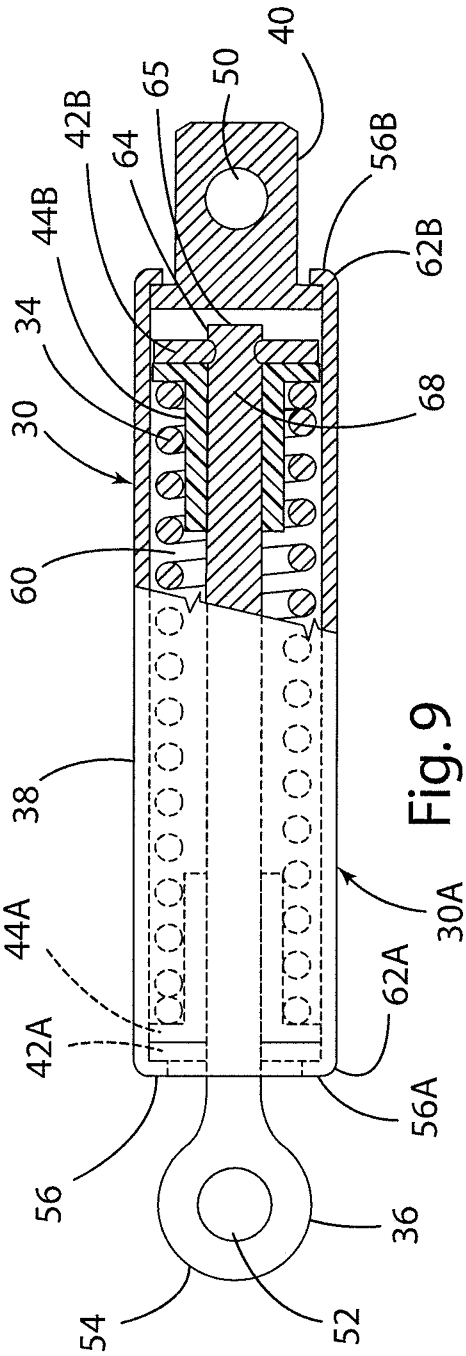

66
44B
42B
65
64
62B
34
44B
30A
60
38
44A
42A
62A
56A
56
36
54
52

Fig. 8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64
56B
44B
62B
34
68
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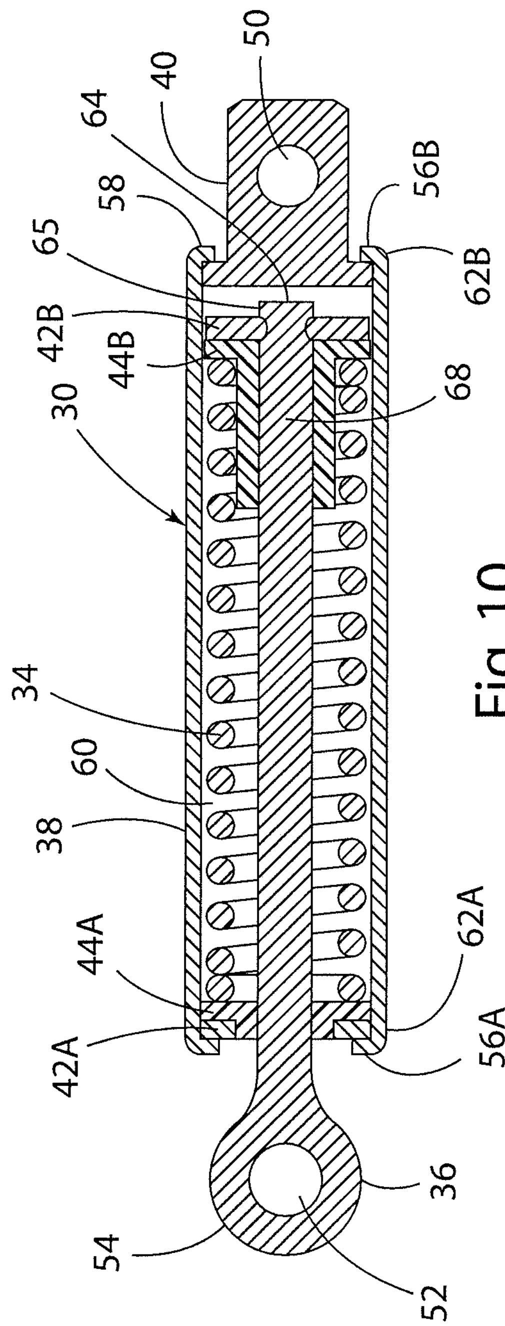
60
38
30A
44A
42A
62A
56A
56
36
54
52

Fig. 9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56B
58
65
62B
42B
44B
68
30
34
60
38
62A
44A
56A
42A
36
54
52

Fig. 10