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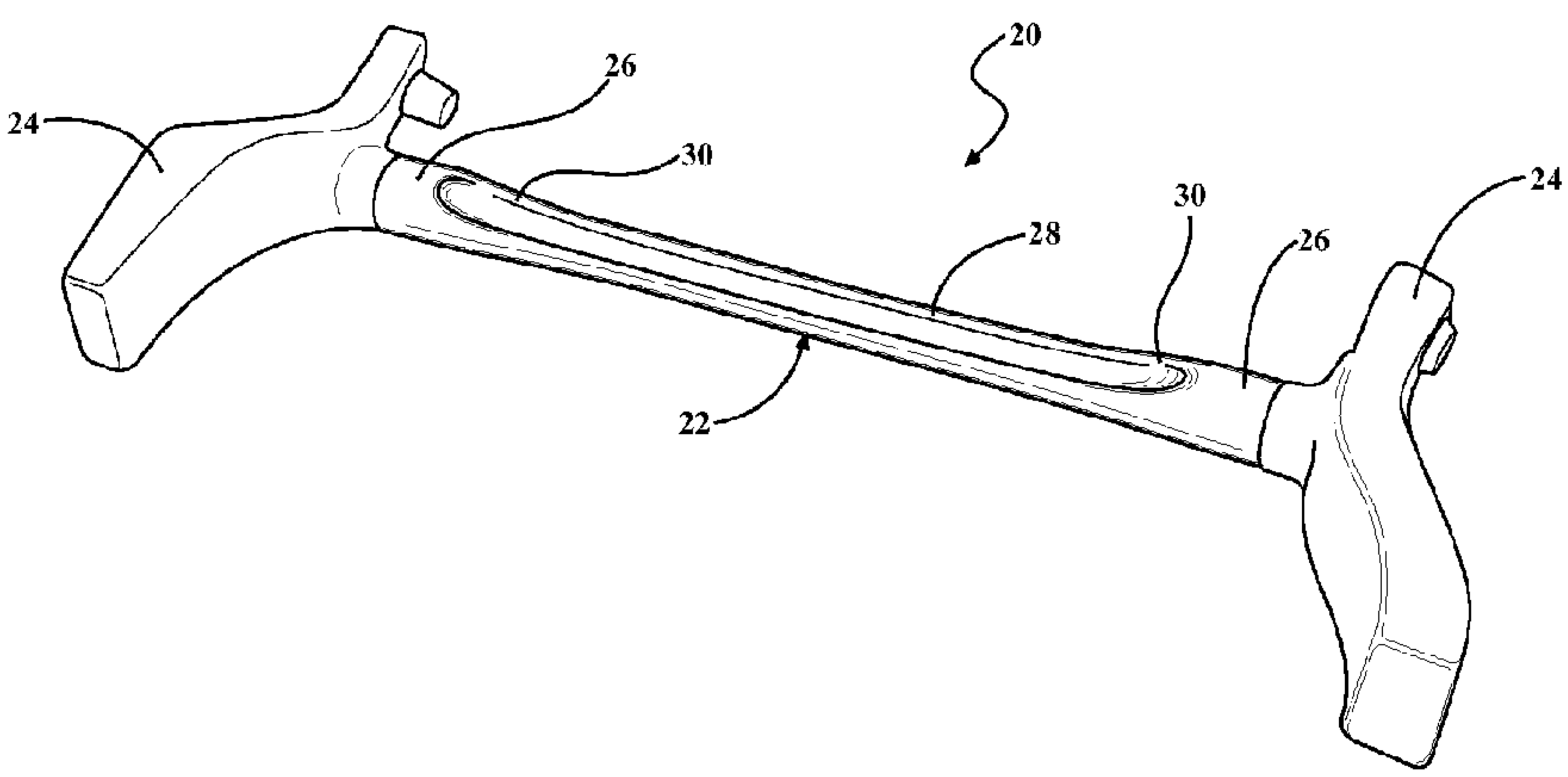

(57) Abrégé/Abstract:
A roll forming assembly for forming a transverse strut from a tube is provided. The roll forming assembly includes a heater, such as an induction heater, for heating a tube to a predetermined annealing temperature. Next, the tube is fed to a roll former, which includes a plurality of forming wheels to shape the tube into a transverse strut. Servo motors are operably coupled to the forming wheels for adjusting the positions of the forming wheels in a radial direction during the roll forming process to give the transverse strut a variable profile along its length. After the roll forming process is completed, the transverse strut is quenched so that its base material is given a predetermined microstructure.

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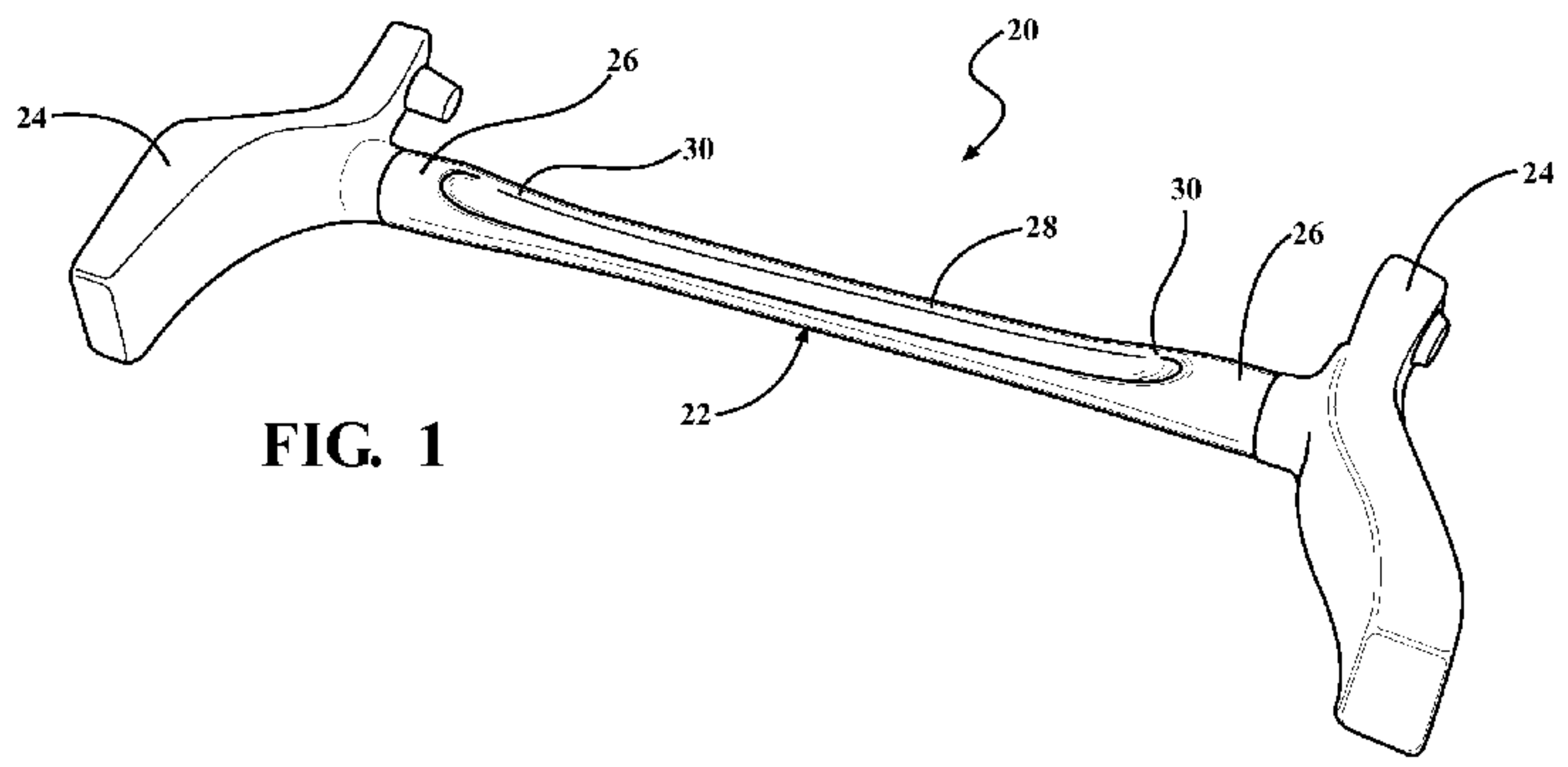

FIG. 1

(57) **Abstract**: A roll forming assembly for forming a transverse strut from a tube is provided. The roll forming assembly includes a heater, such as an induction heater, for heating a tube to a predetermined annealing temperature. Next, the tube is fed to a roll former, which includes a plurality of forming wheels to shape the tube into a transverse strut. Servo motors are operably coupled to the forming wheels for adjusting the positions of the forming wheels in a radial direction during the roll forming process to give the transverse strut a variable profile along its length. After the roll forming process is completed, the transverse strut is quenched so that its base material is given a predetermined microstructure.

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TRANSVERSE STRUT AND METHOD OF FORMING A TRANSVERSE STRUT

[0001]

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates generally to vehicle suspensions and, more particularly, to twist beam rear axles of vehicle suspensions.

2. Description of the Prior Art

[0003] Twist beam axle suspensions for motor vehicles typically include a transverse strut and a pair of control arms, each of which is operably coupled with one of the vehicle's wheels. In operation, the transverse strut provides roll stiffness to the vehicle's suspension by twisting as the two control arms move vertically relative to one another, such as while the vehicle is turning under speed. This has the effect of reducing roll of the vehicle body during cornering.

[0004] Transverse struts are typically shaped to provide the vehicle with a particular roll stiffness. One known way of shaping a transverse strut involves squashing a tube, either while cold or hot, with a special tool. However, this and other known ways to shape a transverse strut may be costly or may not be capable of shaping, traverse struts to very tight tolerances. Additionally, a different squashing tool may be required to form transverse struts having different shapes, sizes, or dimensions.

SUMMARY OF THE INVENTION

[0005] One aspect of the present invention provides for a roll tube forming assembly for forming a tube into a transverse strut. The forming assembly includes a heater for heating the tube to a predetermined temperature. The forming assembly also includes a roll former having a plurality of forming wheels for deforming the tube and an actuator operably coupled to at least one of the forming wheels. The actuator is configured to move the associated of the forming wheels in a radial direction to deform the tube into a transverse strut having a variable cross-section. The roll forming assembly is advantageous because, through simple adjustments in the movements of the actuators, it can be used to form transverse struts having different lengths, shapes, or dimensions. This is less costly and more efficient at forming different transverse struts than other known processes. Additionally, the roll forming assembly may form transverse struts having much tighter tolerances as compared to other known forming assemblies.

[0006] According to another aspect of the present invention, the roll forming assembly further includes a quenching bath for cooling the transverse strut after the roll forming. This, in combination with the heater for heating the tube before the roll-forming, allows for the transverse strut to be heat treated during the forming process. Thus, without any additional manufacturing structure or steps, the roll forming assembly can produce both a shaped and heat-treated transverse strut with little additional cost.

[0007] According to yet another aspect of the present invention, the actuator is operably coupled with the forming wheel or wheels through a ball screw connection. This provides for very precise control of the positioning of the forming wheel or wheels.

[0008] According to another aspect of the present invention, a method of forming a transverse strut from a tube is provided. The method includes the step of roll forming the tube with a plurality of forming wheels to shape the tube. During the roll forming step, the method includes adjusting the position of at least one of the forming wheels in a radial direction with an actuator to change the cross-sectional profile of the tube along its length to give the transverse strut a variable profile along its length.

[0009] According to yet another aspect of the present invention, the method includes the steps of heating the tube to a predetermined annealing temperature before the step of roll forming the tube and quenching the tube after the roll forming of the tube into the transverse strut. The heating of the tube before the roll forming improves the roll forming process, and the quenching heat treats the transverse strut very efficiently for very little or no additional costs. This is more efficient than other known processes for forming transverse struts, where the transverse strut is heated and quenched after the shaping process is complete.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] These and other features and advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0011] Figure 1 is a perspective and elevation view of an exemplary twist beam axle assembly;

[0012] Figure 2 is a perspective and elevation view of a transverse strut of the twist beam axle assembly of Figure 1;

[0013] Figure 3 is a schematic diagram of an exemplary hot tube roll forming assembly;

[0014] Figure 4 is a front view of an exemplary roll former including a plurality of forming wheels disengaged from a tube;

[0015] Figure 5 is a front view of the roll former of Figure 4 and with the forming wheels shaping the tube into a transverse strut; and

[0016] Figure 6 is a front view of an exemplary tube mover for guiding a tube through the hot tube roll forming assembly of Figure 3.

DETAILED DESCRIPTION OF THE ENABLING EMBODIMENTS

[0017] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, an exemplary twist beam axle assembly **20** for use in an automobile and formed with a hot roll forming process is generally shown in Figure 1. The exemplary twist beam axle assembly **20** has a transverse strut **22** which extends along an axis **A** and a pair of longitudinally spaced control arms **24** which are attached to opposite ends of the traverse strut **22**. The control arms **24** are preferably welded to the opposite ends of the transverse strut **22** and could have any desirable size or shape depending upon the type of suspension system in the vehicle for which the twist beam axle assembly **20** is designed.

[0018] Referring now to Figure 2, the exemplary transverse strut **22** has a pair of end sections **26,** each of which has a substantially cylindrical profile. The exemplary transverse strut **22** also has a middle section **28** with an axially extending pocket which gives the middle section **28** a generally U-shaped profile. In between the middle section **28** and the sections **26**, the exemplary transverse strut **22** includes a pair of transition sections **30** which transition between the cylindrical and U-shaped profiles of the end sections **26** and the middle section **28** respectively. It should be appreciated that the end sections **26** could alternately have a non-cylindrical shape, and the middle section **28** could have a range of other non-circular profiles including, for example, a C-shape, a V-shape, or an Ω-shape. It should be appreciated that the shape, dimensions and material of the middle and transition sections **28, 30** of the transverse strut **22** influence the performance characteristics, such as the roll stiffness, of the vehicle's suspension.

[0019] Referring now to Figure 3, a hot tube roll forming assembly **32** for shaping stock tubes **42** into transverse struts (such as the transverse strut **22** shown in Figure 2 and discussed above) is generally shown. The exemplary hot roll forming assembly **32** includes a plurality of tube drivers **34**, a heater **36**, a roll former **38,** and a quenching bath **40**. The exemplary transverse strut **22** starts as a stock tube **42** having a diameter which is similar to the diameter of the cylindrical end sections **26** of the final transverse strut **22** to be produced. The tube **42** is preferably of one or more metals, such as various grades or alloys of steel, aluminum, iron, magnesium, etc. However, it should be appreciated that the tube **34** could be of any desirable type of formable material. During the roll forming process, the tube **42** is fed through the hot tube roll forming assembly **32** by the tube driver **34** or tube drivers **34**. In the exemplary embodiment, the hot tube roll forming assembly **32** includes a plurality of tube drivers **34**, which are positioned between the other components of the hot tube roll forming assembly **32**. However, the hot roll forming assembly could include any desirable number of tube drivers **34**. As shown in Figure 6, the exemplary tube drivers **34** include a plurality of driven rollers **35** for urging the tube **42** in the axial direction. However, each tube driver **34** could be any desirable type of machine or robot for controllably guiding tubes **42** through the hot roll forming assembly **32**.

[0020] Referring back to Figure 3, during operation of the hot tube roll forming assembly **32**, the tube **42** is fed by the tube driver **34** through or adjacent to the heater **36** which heats the tube **42** to a predetermined annealing temperature for easier shaping and for preventing cracks during the shaping process, which is discussed in further detail below. In the exemplary embodiment, the heater **36** is an induction heater **36** which is electrically connected to a power source **44**. The power source **44** is illustrated in the exemplary embodiment as being a battery. However, it should be appreciated that any desirable type of power source may be employed. When activated, the induction heater **36** heats the tube

42 through electromagnetic radiation, which has been found to be particularly efficient at heating metals and certain other materials to precise temperatures. However, it should be appreciated that any desirable type of heater or combination of heaters could be employed in the forming assembly **32** to heat the tube **42** to the predetermined annealing temperature.

[0021] After being heated to the predetermined annealing temperature, one of the tube drivers **34** feeds the tube **42** to the roll former **38**. As best shown in Figure 4, the exemplary roll former **38** includes a plurality of forming wheels **46, 48, 50** arranged in a pattern. More precisely, the exemplary roll former **38** has an upper forming wheel **46**, a lower forming wheel **48** and a pair of side forming wheels **50**. Each of the forming wheels **46, 48, 50** is straddled by a fork-shaped member **51** which is operably coupled to a servo motor **52** via a ball screw **53** type of connection including a threaded rod. However, it should be appreciated that the forming wheels **46, 48, 50** could be coupled with the servo motors **52** through any desirable type of connection. The servo motors **52** are in electrical communication with a controller **54** which is configured to precisely adjust the positions of the forming wheels **46**, **48**, **50** relative to one another and relative to the tube **42** being fed through the hot tube roll forming assembly **32**. In the exemplary embodiment, the controller **54** is shown as a desktop computer. However, it should be appreciated that any desirable type of controller could alternately be employed. In operation, the controller **54** activates the servo motors **52** to adjust the positions of the forming wheels **46**, **48**, **50** and urge them against the tube **42**. Electric servo motors **52** are preferred for controlling the positions of the forming wheels **46, 48, 50** because they are easily controlled and allow for quick and precise movements. However, it should be appreciated that any desirable type of actuators could be employed including, for example, hydraulic actuators or pneumatic actuators.

[0022] Referring now to Figure 4, in the exemplary embodiment, when the tube **42** is first inserted into the roll former **38**, the forming wheels **46, 48, 50** are spaced radially from the tube **42.** The tube **42** is then fed a predetermined axial distance corresponding to the length of the cylindrical end sections **26** of the transverse strut **22** to be formed. Next, as the tube **42** continues to be fed in the axial direction, the controller **54** (shown in Figure 3) operates the servo motors **52** to move each of the forming wheels **46, 48, 50** through a predetermined pattern with the forming wheels **46, 48, 50** engaging with the tube **42** to plastically deform the material of the tube **42** and shape it into a transverse strut **22**. For example, as shown Figure 5, the forming wheels **46, 48, 50** have moved to engage the transverse strut **22**, and the lower forming wheel **48** has been moved upwardly towards the upper forming wheel **46** to reduce the distance between the upper and lower forming wheels **46, 48** and give the middle section **28** of the transverse strut **22** the U-shaped profile described above. Controlled movements of the forming wheels **46, 48, 50** allow the roll former **38** to form both the transition sections **30** and the middle section **28** to very precise tolerances. For example, the exemplary roll former **38** has been found to be able to form transverse struts **22** to dimensions accurate to 0.1 mm. Additionally, the controller **54** may be programmed to operate the servo motors **52** to move the forming wheels **46, 48, 50** through different patterns thereby allowing for the formation of differently sized and shaped transverse struts **22** on the same hot tube roll forming assembly **32** with little or no adjustments to the other components of the hot tube roll forming assembly **32.** In other words, by reprogramming the controller **54**, the hot tube roll forming assembly **32** may be used to form transverse struts **22** which are optimized for the suspensions of different types of vehicles or to form transverse struts **22** which give the same vehicle suspension different performance characteristics. It should be appreciated that the hot tube roll forming assembly **32** could include more than one set of forming wheels **46**, **48**, **50**, if desired.

[0023] Referring back to Figure 3, the exemplary assembly additionally includes a quenching bath **40** for quenching the heated transverse strut **22** after the roll forming process is completed. The entire transverse strut **22** could be simultaneously quenched, or only specific portions of the transverse strut **22** could be quenched to give the transverse strut **22** variable material characteristics. The fluid in the quenching bath **40** is preferably water; however, it should be appreciated that any desirable type of fluid could be employed. Quenching of the transverse strut **22** allows for the properties of the material to be controlled and also provides oxidation resistance to the transverse strut **22**. As such, in addition to shaping the tube **42** into a transverse strut **22**, the hot tube roll forming assembly **32** also heat treats the material of the transverse strut **22** with little additional cost. This is beneficial because a separate heat treating process is not needed.

[0024] Referring once again to Figures 4 and 5, each of the forming wheels **46, 48, 50** of the roll former **38** has a specific profile for forming its respective surface of the transverse strut **22**. For example, in the exemplary embodiment, the upper forming wheel **46** has a generally concave shape, the lower forming wheel **48** has a generally convex shape and each of the side forming wheels **50** has a frustoconical shape. However, it should be appreciated that the forming wheels **46, 48, 50** could take a wide range of other shapes to form differently shaped transverse struts **22**. The forming wheels **46**, **48**, **50** could also be removable and interchangeable for forming differently shaped transverse struts. Additionally, although the exemplary roll former **38** has four wheels **46, 48, 50**, it should be appreciated that the roll former **38** could include any desirable number of forming wheels.

[0025] Another aspect of the present invention is a method of forming a transverse strut **22** for a twist beam axle assembly **20** from a tube **42**. An exemplary embodiment of the method includes the step of roll forming the tube **42** with a plurality of forming wheels **46, 48, 50** to shape the tube **42**. During the roll forming step, the method continues with adjusting the position of at least one of the forming wheels **46, 48, 50** in a radial direction to change the cross-sectional profile of the tube **42** to form a transverse strut **22** having a variable profile along its length. Preferably, at least one of the forming wheels **46, 48, 50** is adjusted from a first position spaced from another of the forming wheels **46, 48, 50** by a predetermined distance to a second position spaced from the other of the forming wheels **46, 48, 50** by a lesser distance to form a pocket in the transverse strut **22**. The adjustments of the forming wheel or forming wheels **46, 48, 50** could be through, for example, a ball screw connection between the actuator(s) and the forming wheel(s) **46, 48, 50**. The forming wheels **46, 48, 50** may have similar or different shapes and, preferably, at least one of the forming wheels is non-cylindrical. Preferably, the roll forming step forms a transverse strut **22** having a pair of end sections **26** with generally cylindrical shapes and a middle section **28** disposed between the end sections **26** with a pocket.

[0026] The method may additionally include the step of heating the tube **42** before the step of roll forming the tube **42** and may also include the step of quenching at least a portion of the transverse strut **22** to give the material of the transverse strut **22** a desired microstructure. The heating of the tube **42** could be with, for example, an induction heater **36**.

[0027] Obviously, many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the appended claims.

What is claimed is:

Claim 1. A roll forming assembly for forming a tube into a transverse strut, comprising:

a heater for heating the tube to a predetermined temperature;

a roll former including a plurality of forming wheels for deforming the tube, at least one of said forming wheels having a non-complementary shape to the tube for changing a cross-sectional shape of the tube along at least a portion of the length of the tube, and said plurality of forming wheels including two pairs of forming wheels with said forming wheels in each pair opposing one another;

an actuator operably coupled to at least one of said forming wheels of said roll former and configured to move the associated of said forming wheels in a radial direction to deform the tube into a transverse strut having a variable cross-sectional shape along the length of the transverse strut; and

one of said forming wheels in at least one of said pairs having a convex rolling surface and the other of said forming wheels in the respective pair having a concave rolling surface such that operation of said actuator results in a portion of the transverse strut having a double walled and U-shaped cross-sectional shape.

Claim 2. The roll forming assembly as set forth in claim 1 wherein at least one of said forming wheels is non-cylindrical.

Claim 3. The roll forming assembly as set forth in claim 1 further including a quenching bath for cooling the transverse strut after being shaped by said roll former.

Claim 4. The roll forming assembly as set forth in claim 1 wherein said heater is an induction heater.

Claim 5. The roll forming assembly as set forth in claim 1 wherein said plurality of forming wheels of roll former includes a top forming wheel, a bottom forming wheel, and a pair of side forming wheels.

Claim 6. The roll forming assembly as set forth in claim 1 wherein said actuator is operably coupled with said at least one forming wheel via at least one ball screw.

Claim 7. The roll forming assembly as set forth in claim 1 further including a controller configured to control said actuator to form transverse struts having different configurations.

Claim 8. A method of forming a transverse strut from a tube, comprising the steps of:

roll forming the tube with two pairs of opposing forming wheels to shape the tube, wherein at least one of the forming wheels has a non-complementary shape to the tube, and wherein one of the forming wheels in at least one of the pairs has a convex rolling surface and the other of the forming wheels in the respective pair has a concave rolling surface; and

adjusting the position of at least one of the forming wheels in a radial direction with an actuator during the roll forming of the tube to change the cross-sectional shape of the tube along a length of the tube to give the transverse strut a variable profile along the length and wherein the concave and convex rolling surfaces of one of the pairs of forming wheels deforms a portion of the transverse strut into a double walled and U-shaped cross-sectional shape.

Claim 9. The method of forming a transverse strut as set forth in claim 8 further including the step of heating the tube to a predetermined temperature before the step of roll forming the tube.

Claim 10. The method of forming a transverse strut as set forth in claim 9 further including the step of quenching the transverse strut after the step of roll forming the tube.

Claim 11. The method of forming a transverse strut as set forth in claim 8 wherein the adjusting step is further defined as adjusting the position of at least one roll forming wheel to from a first position spaced from another of the forming wheels by a predetermined distance to a second position being spaced from the other of the forming wheels by a lesser distance to form a pocket in the transverse strut.

Claim 12. The method of forming a transverse strut as set forth in claim 8 wherein the actuator adjusts the position of at least one of the forming wheels via a ball screw connection.

Claim 13. The method of forming a transverse strut as set forth in claim 12 further including the step of heating the tube with an induction heater.

Claim 14. The method of forming a transverse strut as set forth in claim 8 wherein at least one of the forming wheels has a non-cylindrical shape.

Claim 15. The method of forming a transverse strut as set forth in claim 8 wherein the roll forming step forms a transverse strut having a pair of end sections having generally cylindrical shapes and a pocket disposed between said end sections.

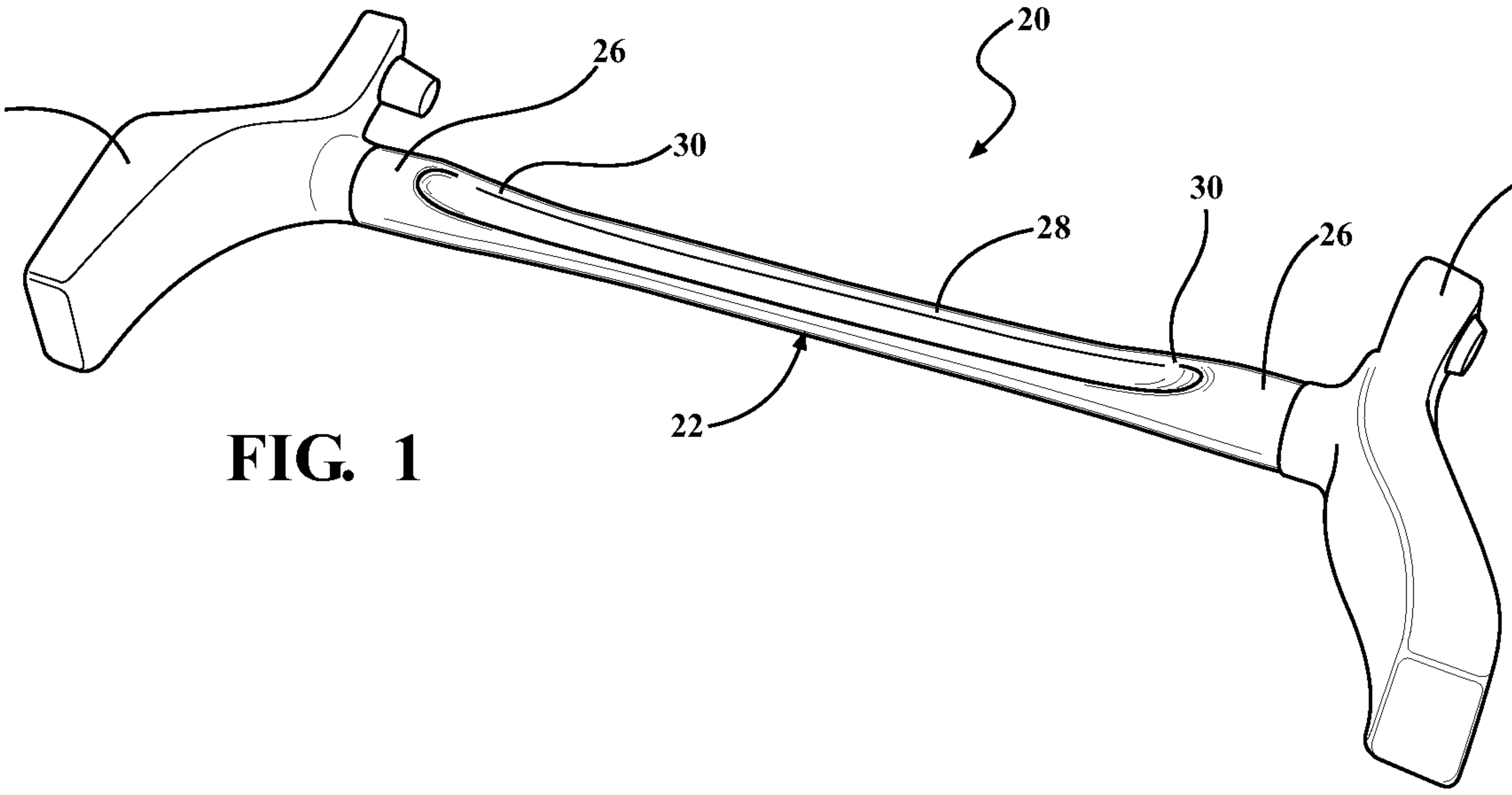
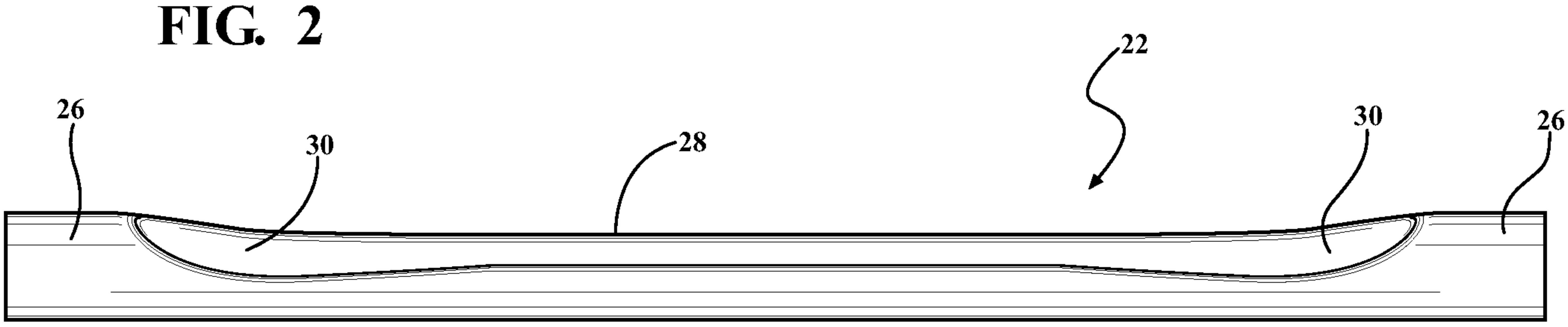


FIG. 1

FIG. 2



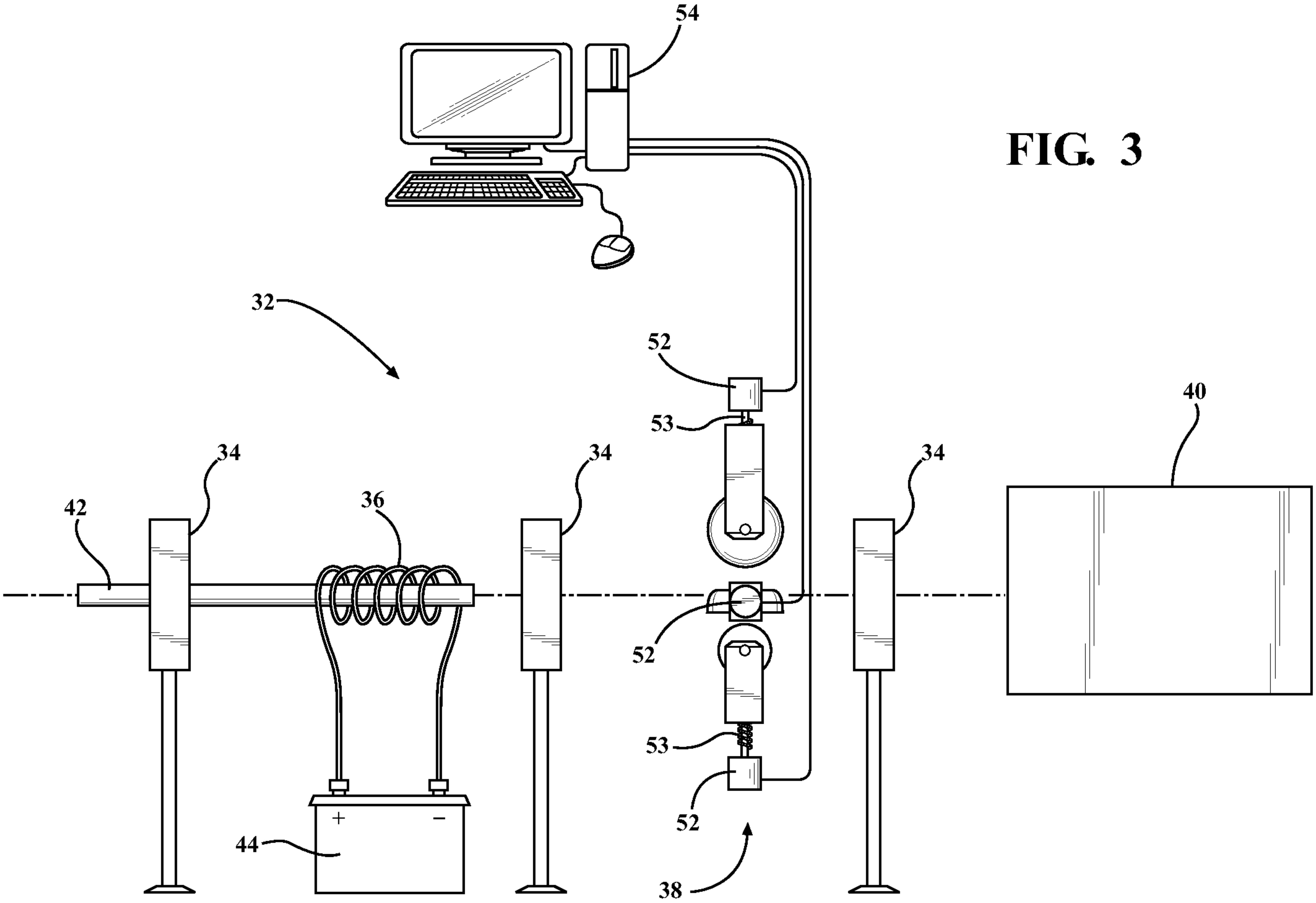


FIG. 3

FIG. 4

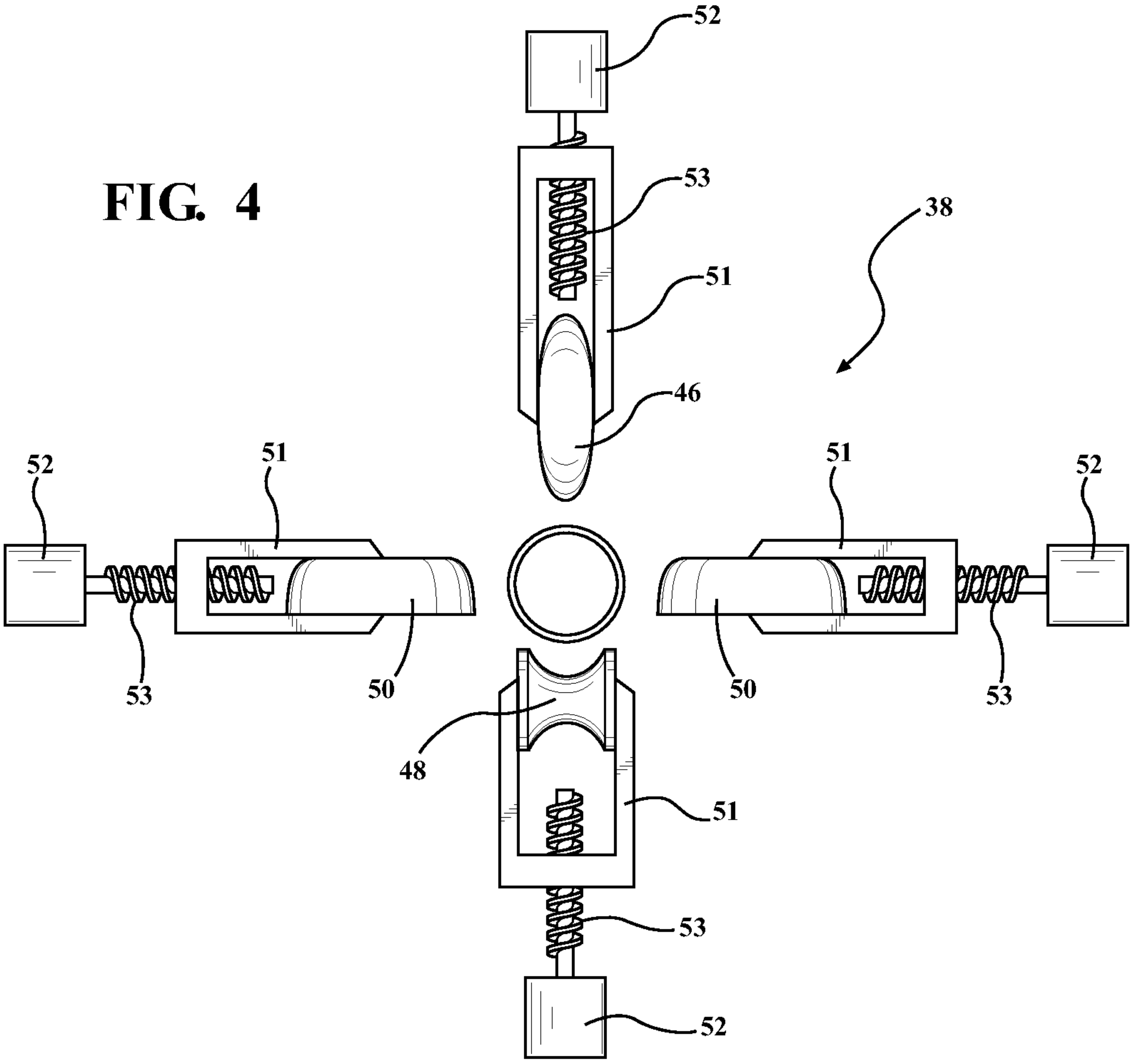


FIG. 5

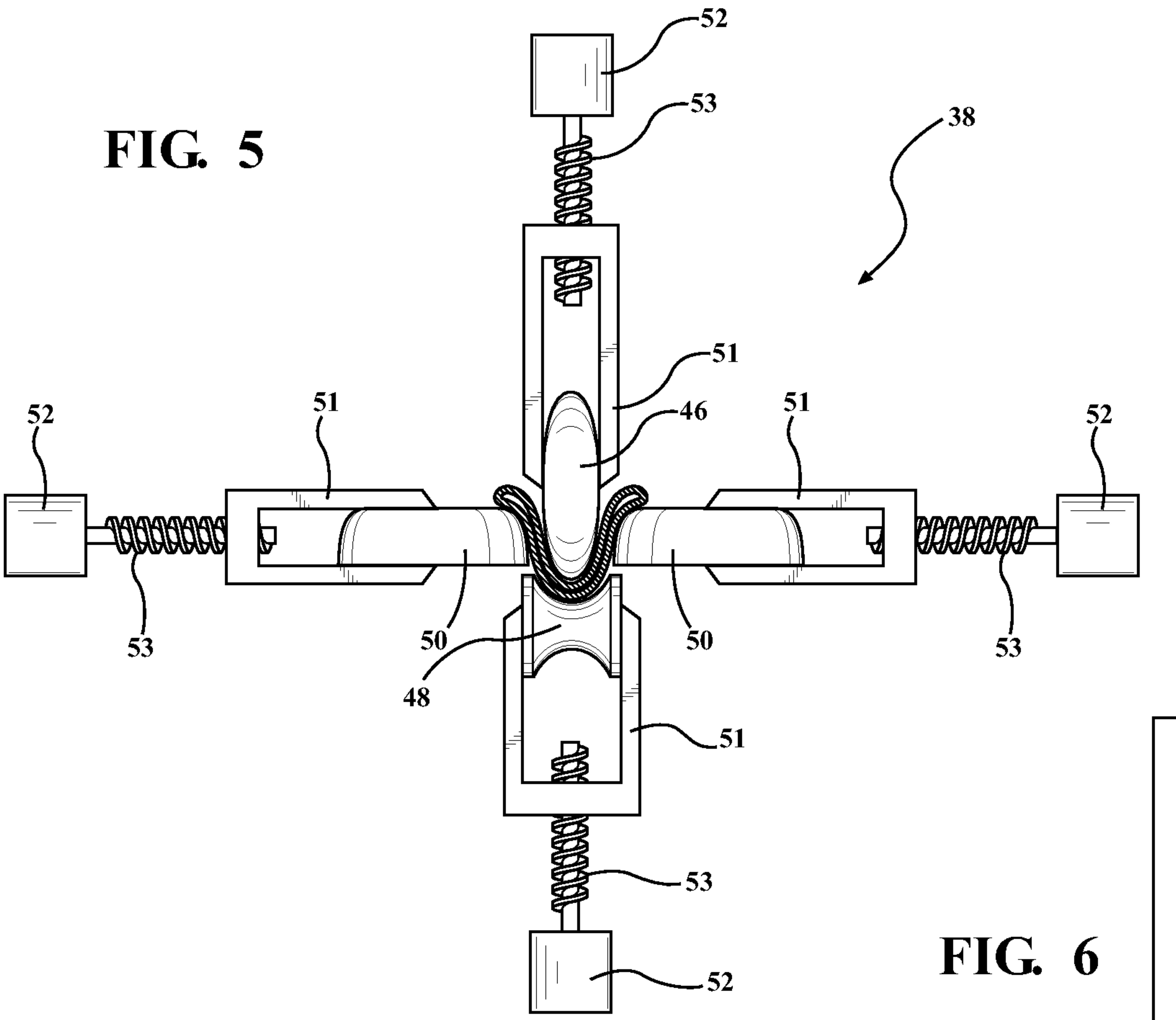
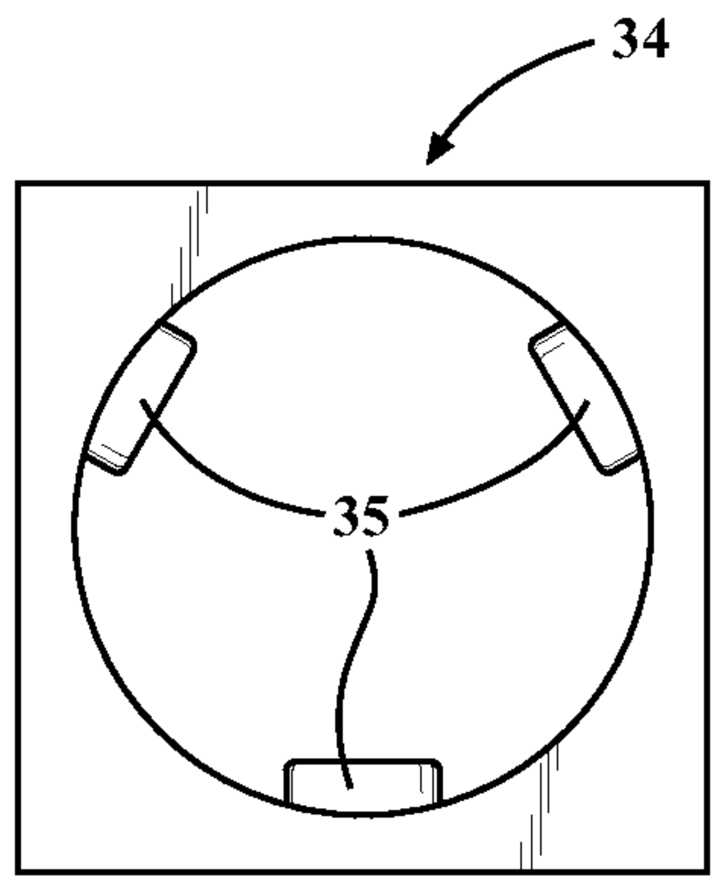
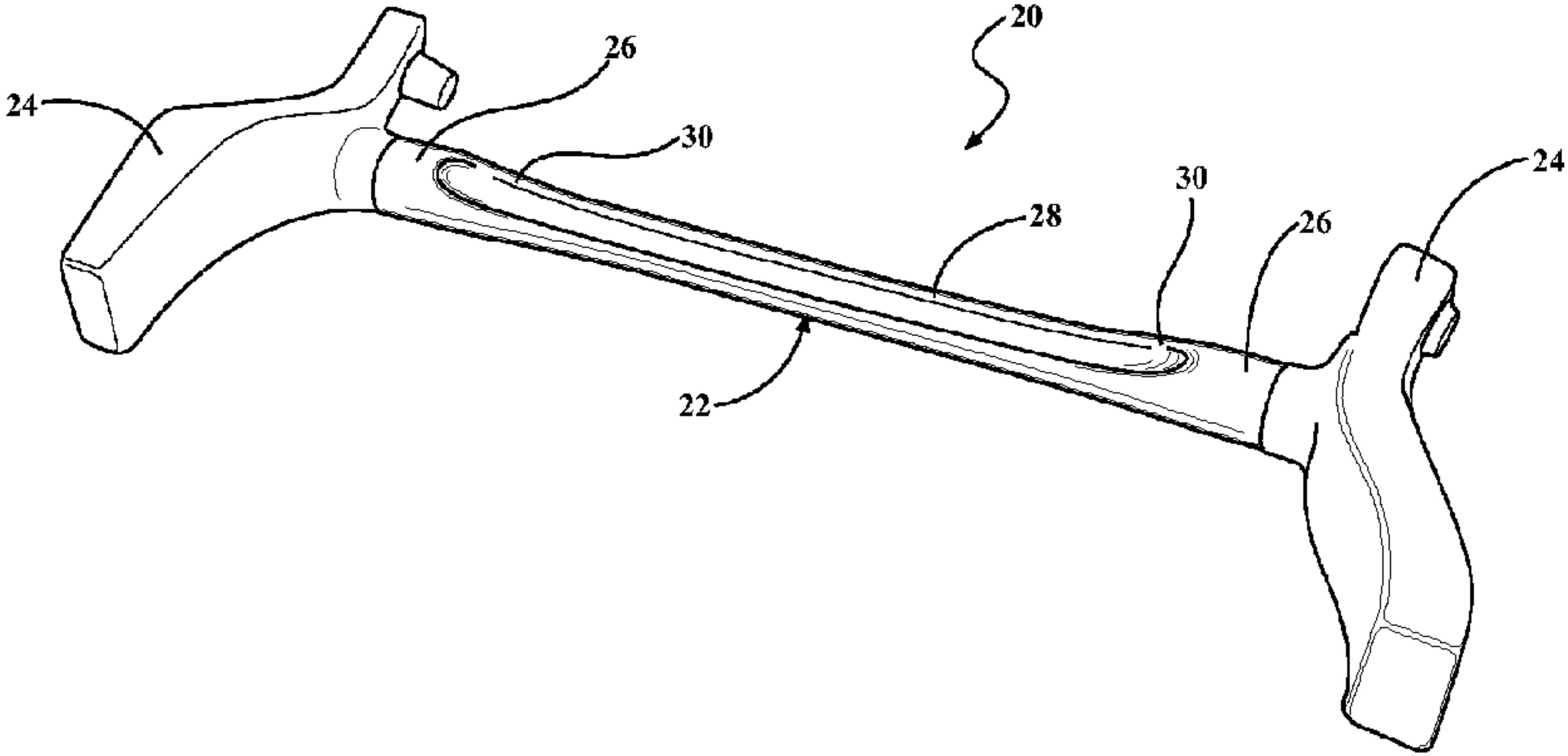


FIG. 6

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