



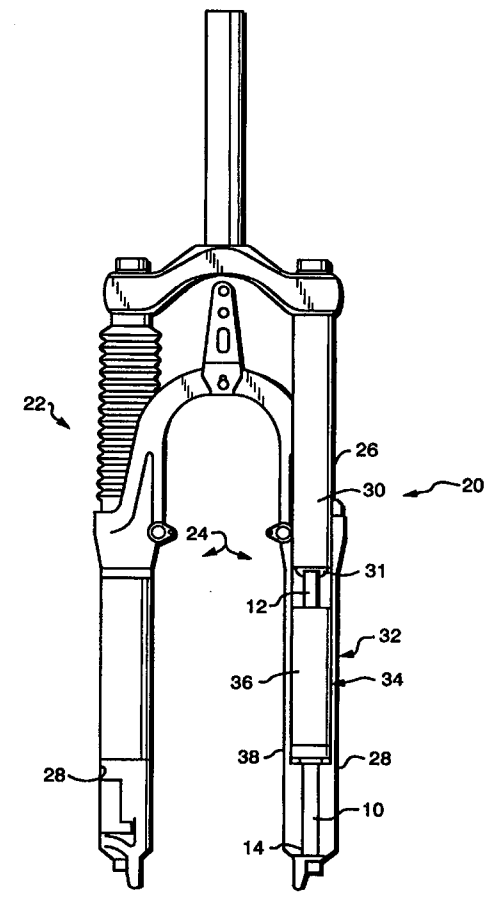
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<p>(21) International Application Number: PCT/US98/13196 (22) International Filing Date: 25 June 1998 (25.06.98) (30) Priority Data: 60/051,636 3 July 1997 (03.07.97) US 09/028,780 24 February 1998 (24.02.98) US (71) Applicant: ROCKSHOX, INC. [US/US]; 401 Charcot Avenue, San Jose, CA 95131 (US). (72) Inventor: BALDOMERO, Ricardo, R.; 10715 Vera Avenue, Felton, CA 95018 (US). (74) Agents: HANSEN, David, W. et al.; Skadden, Arps, Slate, Meagher &amp; Flom LLP, 919 Third Avenue, New York, NY 10022-3897 (US).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i></p>

(54) Title: PISTON ROD AND PISTON ASSEMBLY

(57) Abstract

A lightweight low cost damping assembly having a piston rod on which a piston is formed such that fastener elements are not needed to secure the piston onto the piston rod. Preferably, the piston rod is formed by chrome plating the exterior of a tubular steel rod except at a piston attachment portion. The piston attachment portion is specially shaped such that the piston may be formed thereon and coupled thereto by the inter-engaging of the piston with the shape of the piston attachment portion. Most preferably, the piston attachment portion is in the form of shallow grooves, knurls or dimples in the exterior of the piston rod and the piston is injection molded thereon. The material of the piston molds itself into the shape of the piston attachment portion, thereby resulting in a secure coupling between the piston and the piston rod.



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**PISTON ROD AND PISTON ASSEMBLY**CROSS-REFERENCE TO RELATED APPLICATION

5 The present application claims the benefit of the earlier filing date of U.S. provisional patent application Ser. No. 60/051,636, filed July 3, 1997.

BACKGROUND OF THE INVENTION

10 The present provisional patent application relates to the design and construction of piston rod and piston assemblies. More particularly, the present invention relates to an apparatus and method for manufacturing a lightweight, low cost damping assembly comprising a piston rod configured to have a damper piston injection molded directly thereon, for use in the damping system of high-performance suspension systems, particularly high-performance bicycle suspension systems.

15 A variety of systems utilize piston rods on which a piston assembly is mounted. A common use for a piston rod and piston assembly is in hydraulic damping systems having a damping fluid cartridge. The piston rod is passed through the damping cartridge such that the piston mounted thereon slides through the damping fluid in the cartridge to effectuate damping. Such hydraulic damping systems have been known to be incorporated into suspension systems, such as those used in the motorcycle and automotive fields, as well as in the field of bicycles. For example, U.S. Patent No. 5,456,480 to Turner et al. (the "'480 patent"), which patent has been assigned to the assignee of the present invention and is hereby incorporated by reference in its entirety, discloses a suspension system for use in a bicycle fork and having a damping system.

20 25 30 35 The suspension bicycle fork of the '480 patent incorporates a replaceable damping cartridge unit. The cartridge unit is comprised of a cylindrical cartridge body filled with hydraulic oil. A piston rod, on which a piston assembly is mounted, is passed through the cartridge body so that the piston assembly is slidable within the cartridge body. The cartridge unit further has cartridge seals at both

ends, sealing the points at which the piston rod is passed through the cartridge body ends. The piston rod extends through the cartridge seals at both ends of the cartridge body, and the piston divides the cartridge into two chambers and engages the inner surface of the cartridge body to seal the first chamber from the second chamber. Ports extend through the piston as well as through the piston rod, so that upon movement of the piston in the cartridge body, hydraulic oil passes from one side of the piston to the other. The restriction of the passages determines the degree of resistance effected as the oil is forced through the passages, and thus determines the amount of damping achieved for a given piston speed.

As illustrated in the '480 patent, a bicycle suspension fork typically has a pair of telescoping struts, and the damping cartridge attaches to one of the struts. The piston rod and piston assembly attaches to the other strut so that when the struts are compressed or expanded, the movement of the oil from one side of the piston to the other creates damping.

For applications such as bicycles, weight is a major concern. Thus, piston rods such as the piston rod of the '480 patent, as well as those not used in cartridge-type systems, have typically been made from aluminum. Ideally, aluminum piston rods are machined to a fine surface finish, so that the movement of the rod against the damping system seals does not degrade the integrity of the cartridge seals. However, the cost of finely finishing aluminum shafts is high, and as a result, the aluminum shafts typically used in connection with damped suspension systems are unnecessarily abrasive. The natural result of this is that damping system seals degrade more rapidly than is desirable, leading to hydraulic fluid leakage and the need for servicing at unnecessarily short time intervals. It therefore would be desirable to provide a lightweight piston rod that has a finely finished exterior

surface, yet is also low in cost and has the requisite strength to endure compressive forces applied thereto.

In designs such as that illustrated in the '480 patent, the piston rod comprises two rod sections which are threaded together, securing the piston between them. In such a design, however, the wall of the piston rod must be of sufficient thickness to accommodate threads. Similarly, pistons have been attached to piston rods, for example, by using snap-rings positioned in grooves located on the outer surface of the piston rod on either side of the piston. However, this attachment mechanism requires that the wall of the piston rod be sufficiently thick to accommodate snap-ring grooves.

In order to permit passage of damping fluid through the piston rod, and also in order to reduce weight, piston rods typically are tubular. To reduce the weight of the piston rod even further, especially if a material stronger and heavier than aluminum is used, the walls must be as thin as possible. A common difficulty in providing for a light-weight tubular piston rod is that the thin walls cannot be provided with appropriate structural features, such as described above, for accommodating attachment mechanisms necessary for coupling the rod with other elements. If the walls are made thick enough to accommodate such attachment mechanisms, then the piston rod typically becomes unnecessarily heavy and costly to manufacture.

#### SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a lightweight and low cost piston rod having a sufficiently fine finish that reduces wear on the seals of the damping system in which the piston is used.

It is another object of the present invention to provide a piston rod that has the requisite strength for use in a suspension system, that is lightweight yet formed such that a piston may be securely mounted thereon.

The above and other advantages are realized in accordance with the principles of the present invention by

providing a thin-walled, preferably steel piston rod having a chrome-plated exterior providing a finely finished surface for sliding against the seals of a damping system, preferably but not necessarily including a damping cartridge, through which the piston rod is to be passed. A portion of the exterior of the piston rod is not provided with the chrome-plating, but instead is formed such that a piston may be mounted thereon without additional mechanical connection elements. In particular, the exterior of the unplated surface of the piston rod is preferably shaped such that a piston may be injection molded thereon for secure attachment thereto. For example, the unplated exterior may be provided with one or more holes or a series of shallow grooves in which the plastic of the piston may anchor itself.

The above and other objects, features, and advantages of the present invention will be readily apparent from the following detailed description of the invention taken in conjunction with the accompanying drawings wherein like reference characters represent like elements, the scope of the invention being set out in the appended claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is an elevational view, partly in section, of a bicycle suspension fork having a damping cartridge incorporating a preferred embodiment of the piston rod and piston assembly of the present invention;

FIG. 2 is a perspective view of a preferred embodiment of the piston rod and piston assembly of the present invention;

FIG. 3 is an elevational view of a preferred embodiment of the piston rod of the present invention; and

FIG. 4 is an enlarged isolated view of the piston attachment portion of the piston rod of FIG. 3.

#### DETAILED DESCRIPTION OF THE INVENTION

In accordance with the principles of the present invention, a lightweight yet strong piston rod 10 (FIGS. 1-4)

having first and second ends 12, 14 is provided for use in a suspension system. Preferably, piston rod 10 is formed as a tubular rod with a sufficiently thin wall such that the piston rod has sufficient strength to withstand compression forces exerted on the suspension system with which it is used, yet is sufficiently lightweight for effective use in a suspension system in which weight reduction is essential for optimum use. A preferred material that is strong enough to be used in a thin-walled tubular piston rod is steel. The thin-walled steel piston rod of the preferred embodiment of the present invention can be made to weigh as little as or less than the weight of an aluminum piston rod that performs the same functions. Preferably, the wall thickness of a steel piston rod 10 is approximately 0.0275 inches (0.6985 mm).

A typical use of piston rod 10 is in bicycle suspension system 20 of bicycle fork 22 shown in FIG. 1. Fork 22 comprises two telescoping struts 24 each having an inner tube 26 telescopingly received within an outer tube 28. It will be appreciated that the inner tube need not be the upper tube, as shown in FIG. 1, but, instead, may be the lower tube. Suspension system 20 preferably includes a biasing element 30 positioned within inner tube 26 (although it is within the scope of the present invention to instead provide biasing element 30 in the outer tube 28, or external to and between inner tube 26 and outer tube 28) and supported by piston rod 10. Preferably, a flange or other support element 31 is provided on first end 12 of piston rod 10 to support biasing element 30. Second end 14 of piston rod 10 may be coupled to the outer tube 28 as described in further detail below. Compression of fork 22 causes inner tubes 26 to telescopingly slide into outer tubes 28. As a result, biasing element 30 is compressed against flange 31 on first end 12 of piston rod 10. As will be understood by one of ordinary skill in the art, piston rod 10, as positioned within fork 22, must therefore be sufficiently strong to endure the compressive forces exerted on fork 22. The formation of piston rod 10 from a thin-walled chromed-

steel in accordance with the principles of the present invention provides the requisite strength for such use of piston rod 10.

As illustrated in FIG. 1, a damping system 32 preferably having at least one damping cartridge 34 may be provided in at least one of struts 24 of fork 22. Ends 36, 38 of damping cartridge 34 are typically sealed in order to retain damping fluid or gas therein. Piston rod 10 has a piston assembly 40 mounted thereon, as shown in FIG. 2, and is passed through the seals on ends 36, 38 of damping cartridge 34 (or, where a damping cartridge is not used, through at least one seal sealing the end of damping system 32) to effectuate the damping function of damping system 32. Accordingly, a high-quality finely finished surface is typically desirable on the exterior of piston rod 10 to reduce wear of the seals of damping cartridge 34 resulting from the sliding of piston rod 10 therethrough during use of fork 22. In a preferred embodiment, thin-walled steel piston rod 10 is provided with a chrome-plated exterior. The finish achieved by chrome-plating the steel piston rod 10 improves the life of the seals. Thus, damping cartridge 34 is far less likely to leak, and will require less servicing during use of the bicycle with which it is used.

As described above, piston rod 10 is preferably hollow to reduce weight. Additionally, when piston assembly 40 is provided on piston rod 10 such that the combined piston and rod assembly is used in a damping system such as system 32 of FIG. 1, piston assembly 40 divides the interior of damping cartridge 34 into two chambers. In order to permit damping fluid to pass from one chamber to another and thereby damp the system, at least one through-hole fluidly connecting the chambers must be provided within at least one, and preferably both, of piston rod 10 and piston assembly 40. When through-holes are provided in piston rod 10, piston rod 10 is typically hollow from end 12 to end 14. However, as described



above, the walls of piston rod 10 should be as thin as possible to reduce the weight of the system.

The thin walls of piston rod 10 must nonetheless permit attachment of piston assembly 40 thereto. In a preferred embodiment, as illustrated in FIG. 2, at least plastic piston 42 of piston assembly 40 is injection-molded directly onto piston attachment piston 44 of piston rod 10, shown in FIGS. 3 and 4. Although nylon 6,6 has been found to work well for the injection-molding of the piston, any type of plastic or other moldable material may be used.

As described above, piston rod 10 is preferably chrome-plated. However, to facilitate attachment of piston 42 to the exterior of piston rod 10, piston attachment portion 44 is not chrome-plated.

A variety of securing devices may be used to ensure that piston 42 is fixed in place on the piston rod 10, such as a knurled-type surface, a series of dimples or holes in piston rod 10, or a roll-crimped or machined groove or other type of groove in piston rod 10. Preferably, however, piston attachment portion 44 of piston rod 10 includes one or more shallow grooves, and more preferably still, includes a continuous, shallow spiral groove as shown in FIGS. 2 and 3. Such grooves provide ample surface area with which the plastic of piston 42 may anchor itself to rod 10, thus preventing piston 42 from traveling toward the first 12 or second 14 end of piston rod 10. In addition, the spiral geometry of the grooves prevents piston 42 from rotating on piston rod 10. The absence of chrome plating on piston attachment 44 portion of piston rod 40 also helps to prevent movement of piston 42 with respect to piston rod 10.

Thus, the injection-molded design of the present piston rod 10 and piston assembly 40 eliminates the need for spring-clip grooves or other fastener connections for attaching piston assembly 40 to piston rod 10, thereby reducing the number of parts required in, and the complexity of, the assembly. In addition, as a result of using shallow spiral grooves

to secure an injection-molded piston to piston rod 10, piston rod 10 may be constructed of thin tubing, preferably thin steel tubing, as described above.

In accordance with a preferred embodiment, the piston rod 10 and piston assembly 40 of the present invention are used in a damping system 32 of a bicycle suspension rod 22 as shown in FIG. 1, as described above. Preferably, cartridge body 34 of damping system 32 is secured within inner tube 26, while first end 14 of piston rod 10 is secured to outer tube 28.

Because the walls of piston rod 10 are preferably very thin such that they cannot support a thread, an alternative means is required to secure piston rod 10 to the outer tube 28. In the preferred embodiment of the present invention, an insert 50 couples second end 14 of piston rod 10 to the bottom end of outer tube 28. Insert 50 is crimpable on a first end 52 and configured for operative connection (such as by threaded connection) to the outer tube 28 on a second end 54. The first end 52 of insert 50 is placed into and securely crimped within second end 14 of piston rod 10 such that insert 50 and piston rod 10 are securely coupled together. The crimping may be accomplished using a roll-crimping or other crimping process, but is preferably accomplished using a crimping process that effects a connection between insert 50 and piston rod 10 such that piston rod 10 cannot rotate relative to insert 50. Such a connection may be achieved, for example, using a roll-crimping device or a three-jaw crimping tool that crimps the rod and insert at three locations spaced apart by about 120 degrees. Alternatively, although perhaps not as preferable, insert 50 may be configured at first end 52 to be press-fit into second end 14 of piston rod 10.

In a preferred embodiment of the present invention, second end 54 of insert 50 has an internally threaded bore 56 so that a bolt may be passed through an opening in the bottom of outer tube 28 to secure piston rod 10 to the outer tube 28. The outer surface 58 of second end 54 of insert 50 is to be

seated in a tapered bore in outer tube 28. To prevent insert 50 from rotating relative to tapered bore, as may occur when the bolt passing through the lower end of outer tube 28 is threaded into or out of insert 50, the outer surface 58 of second end 54 of insert 50 may be knurled or splined. Knurling or splining outer surface 58 of second end 54 of insert 50 enables insert 50 to cut its own seat into the tapered bore of outer tube 28 as insert 50 is bolted to the outer tube 28.

While the foregoing description and drawings represent the preferred embodiments of the present invention, it will be understood that various additions, modifications and substitutions may be made therein without departing from the spirit and scope of the present invention as defined in the accompanying exemplary claim. In particular, it will be clear to those skilled in the art that the present invention may be embodied in other specific forms, structures, arrangements, proportions, and with other elements, materials, and components, without departing from the spirit or essential characteristics thereof. One skilled in the art will further appreciate that the invention may be used with many modifications of structure, arrangement, proportions, materials, and components and otherwise, used in the practice of the invention, which are particularly adapted to specific environments and operative requirements without departing from the principles of the present invention. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and not limited to the foregoing description.

What is claimed is:

- 1           1.    A piston rod and piston assembly comprising:  
2                    a piston assembly including a piston formed  
3           from a moldable material; and  
4                    a thin-walled tubular piston rod having an  
5           exterior surface with a piston attachment portion shaped to  
6           receive said piston, said piston being molded on said piston  
7           rod such that fastener connection elements are not needed to  
8           couple said piston to said piston rod.
- 1           2.    A piston rod and piston assembly as in claim 1,  
2           wherein said piston attachment portion of said piston rod  
3           includes at least one groove for receiving said piston during  
4           molding of said piston on said piston rod.
- 1           3.    A piston rod and piston assembly as in claim 1,  
2           wherein said piston attachment portion of said piston rod  
3           includes at least one knurl for receiving said piston during  
4           molding of said piston on said piston rod.
- 1           4.    A piston rod and piston assembly as in claim 1,  
2           wherein said piston attachment portion of said piston rod  
3           includes dimples for receiving said piston during molding of  
4           said piston on said piston rod.
- 1           5.    A piston rod and piston assembly as in claim 1,  
2           wherein said exterior surface of said piston rod is chrome  
3           plated.
- 1           6.    A piston rod and piston assembly as in claim 5,  
2           wherein said piston rod is formed of steel.
- 1           7.    A piston rod and piston assembly as in claim 5,  
2           wherein said piston is formed of plastic injection molded onto  
3           said piston attachment portion of said piston rod.

1           8. A piston rod and piston assembly as in claim 7,  
2 wherein said plastic is nylon 6,6.

1           9. A piston rod and piston assembly as in claim 1,  
2 wherein holes are formed through said piston rod on each side  
3 of said piston, thereby forming a fluid passage from a first  
4 side of said piston, through said piston rod, and to a second  
5 side of said piston.

1           10. A piston rod for use in a suspension system of  
2 a bicycle suspension fork, said piston rod being a thin-walled  
3 tubular chromed steel rod.

1           11. A piston rod as in claim 10, wherein said wall  
2 of said piston rod is approximately 0.0275 inches.

1           12. A piston rod as in claim 10, wherein said  
2 piston rod has an exterior surface with a piston attachment  
3 portion, said exterior surface being plated with chrome except  
4 at said piston attachment portion.

1           13. A piston rod as in claim 12, further comprising  
2 a piston formed on said piston attachment portion.

1           14. A piston rod as in claim 13, wherein said  
2 piston is molded on said piston attachment portion such that  
3 fastener connection elements are not needed to couple said  
4 piston to said piston rod.

1           15. A piston rod as in claim 13, wherein holes are  
2 formed through said piston rod on each side of said piston,  
3 thereby forming a fluid passage from a first side of said  
4 piston, through said piston rod, and to a second side of said  
5 piston such that said piston rod is usable in a damping system  
6 of the bicycle suspension fork.

1           16. A piston rod as in claim 10, wherein said  
2 piston rod has a first end and a second end, said piston rod  
3 further comprising an insert positioned within and coupled to  
4 said second end of said piston rod, said insert coupling said  
5 piston rod to the bicycle suspension fork.

1           17. A piston rod as in claim 16, wherein said  
2 insert and said second end of said piston rod are crimped  
3 together.

1           18. A piston rod as in claim 16, wherein said  
2 insert includes a knurled outer surface enabling said insert  
3 to cut a seat in the bicycle suspension fork and thereby  
4 secure said piston rod to the bicycle suspension fork.

1           19. A method of forming a piston rod for use in a  
2 bicycle suspension fork, said method comprising the steps of:  
3                providing a thin-walled tubular piston rod; and  
4                forming a piston on said piston rod such that  
5 fastener connection elements are not needed to couple said  
6 piston to said piston rod.

1           20. A method as in claim 19, wherein:  
2                said tubular rod is plated with chrome except  
3 at a piston attachment portion; and  
4                said piston is coupled to said piston attach-  
5 ment portion on said tubular rod.

1           21. A method as in claim 20, wherein said piston is  
2 injection molded onto said piston attachment portion.

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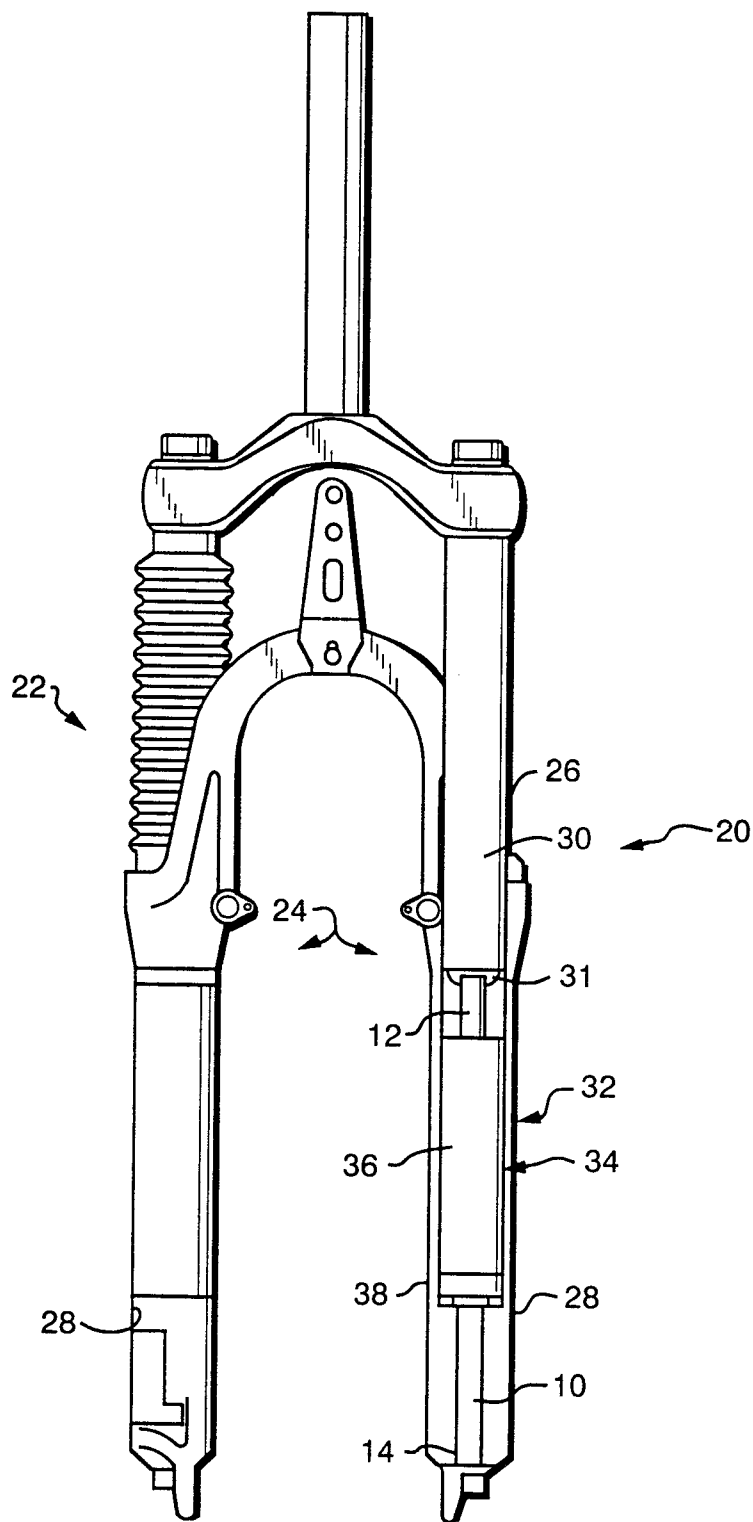


FIG. 1

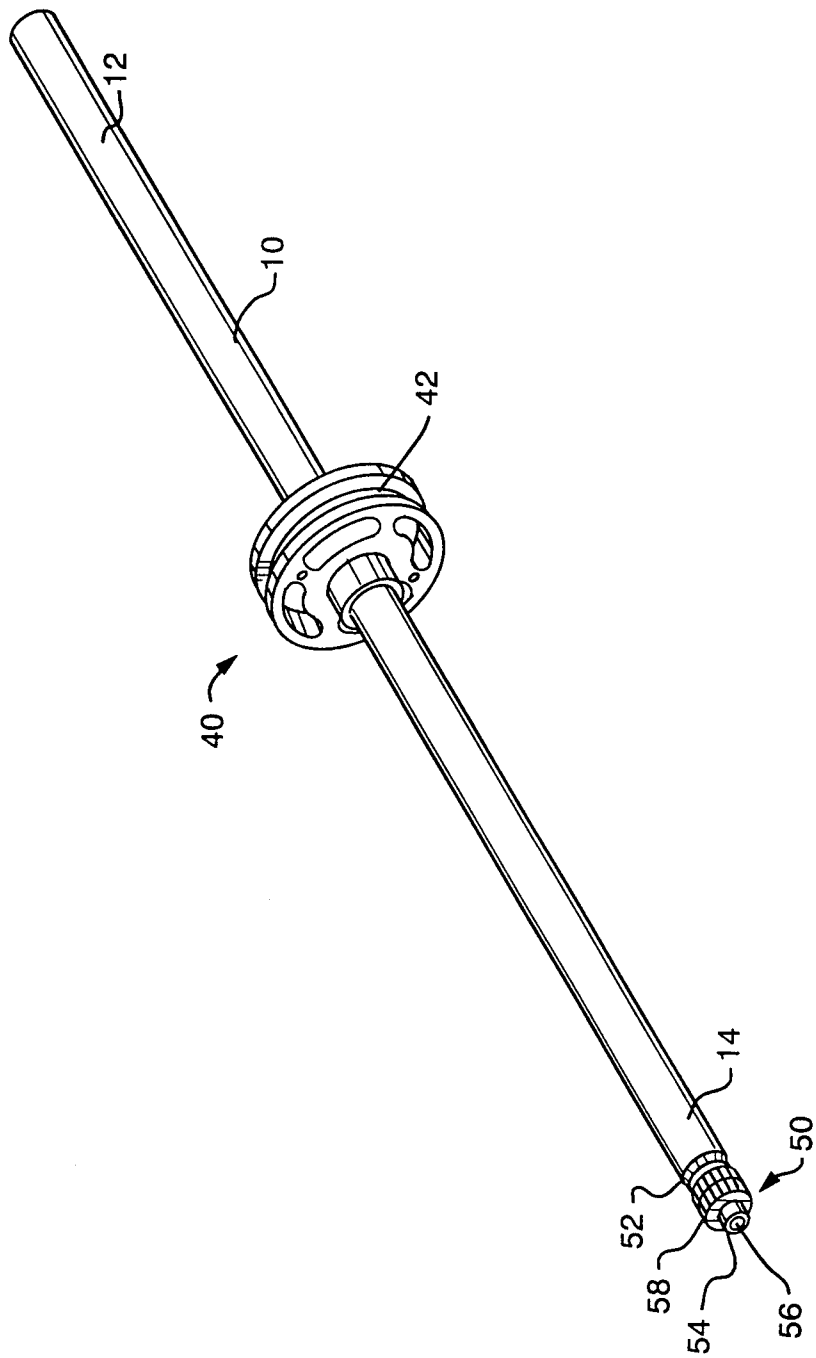


FIG. 2



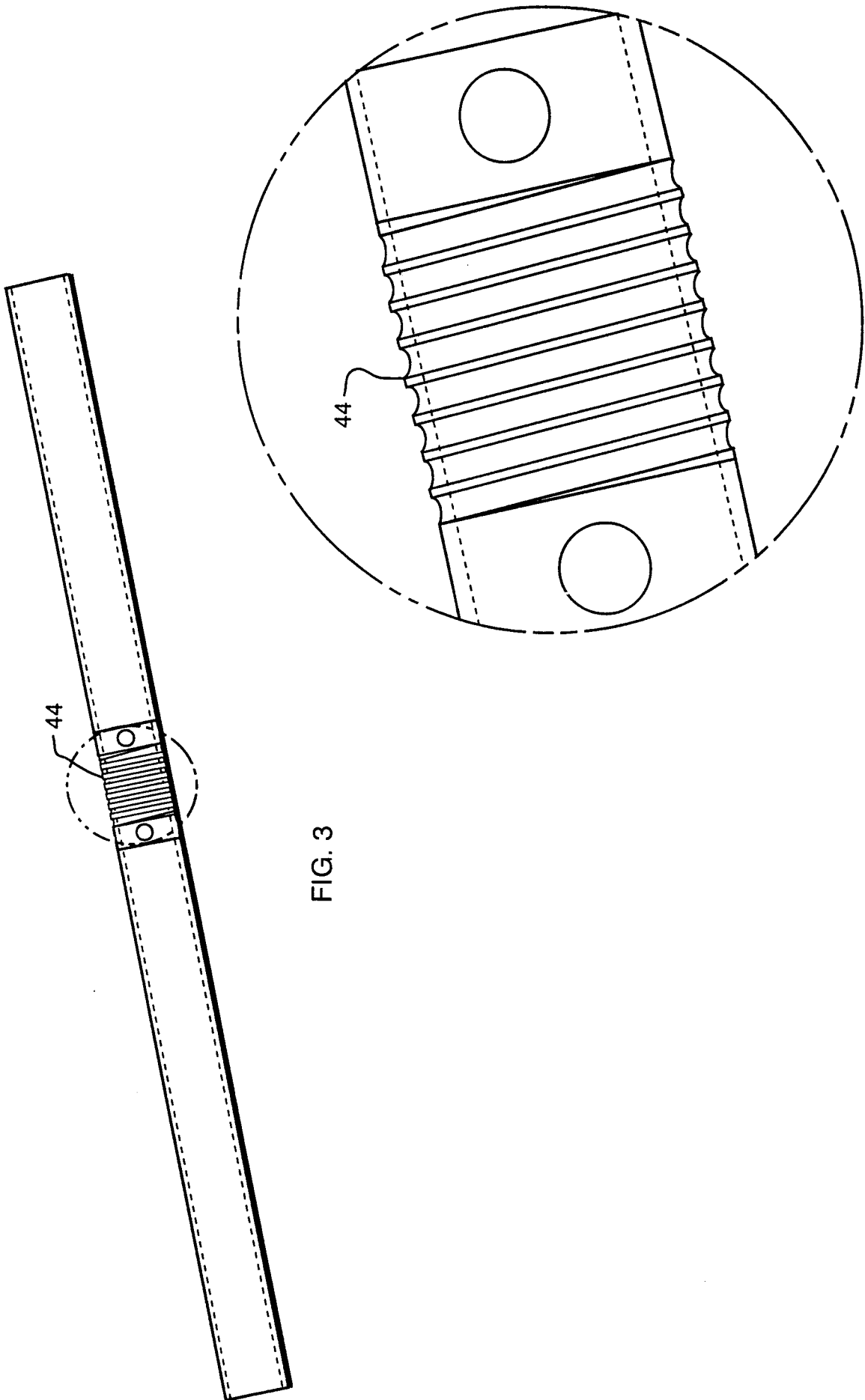


FIG. 3

FIG. 4