US009182773B2

(12) **United States Patent**
Campean

(10) **Patent No.: US 9,182,773 B2**
(45) **Date of Patent: Nov. 10, 2015**

(54) **LOW PROFILE AUTO-LOCKING PINCH/TURN ADJUSTMENT KNOB**

(71) Applicant: **Leupold & Stevens, Inc.**, Beaverton, OR (US)

(72) Inventor: **Daniel I. Campean**, Portland, OR (US)

(73) Assignee: **Leupold & Stevens, Inc.**, Beaverton, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/153,949**

(22) Filed: **Jan. 13, 2014**

(65) **Prior Publication Data**

US 2014/0196351 A1 Jul. 17, 2014

Related U.S. Application Data

(60) Provisional application No. 61/752,418, filed on Jan. 14, 2013.

(51) **Int. Cl.**
F41G 1/38 (2006.01)
G05G 1/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G05G 1/082*** (2013.01); ***F41G 1/38*** (2013.01); *Y10T 74/20474* (2015.01)

(58) **Field of Classification Search**
CPC F41G 1/38; F41G 1/3935; G05G 1/082; Y10T 74/20474
USPC .... 42/119, 122, 125; 359/429, 426; 74/813 L, 504
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,344,973	A	6/1920	Bader
2,143,167	A	1/1939	Pechar
2,165,796	A	7/1939	Humeston
2,208,913	A	7/1940	Unertl
2,229,637	A	1/1941	Burton
2,336,107	A	12/1943	Litschert

(Continued)

FOREIGN PATENT DOCUMENTS

CN	2752794	Y	1/2006
DE	2 148 967		4/1973

(Continued)

OTHER PUBLICATIONS

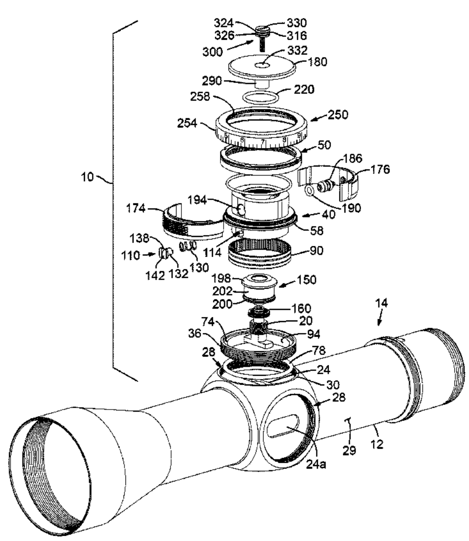
Notice of Allowance, U.S. Appl. No. 12/938,981, mailed Aug. 27, 2015, and Amendment and Response to Office Action (with Listing of Claims, as allowed), 16 pp.

Primary Examiner — Samir Abdosh
Assistant Examiner — John D Cooper
(74) *Attorney, Agent, or Firm* — Stoel Rives LLP

(57) **ABSTRACT**

A compact adjustment knob for an optical, mechanical, or electronic device includes a spindle supported on the device for rotation about an axis to control a setting of the device, and a releasable automatically locking lock mechanism supported on the spindle for rotation therewith. The lock mechanism includes at least one manually depressible button accessible on an outer surface of the adjustment knob and connected to an actuator shaft that extends inwardly through a drive hole in an outer side wall of the spindle so that a force manually applied to the button is transmitted by the actuator shaft to drive the lock mechanism and rotate the spindle. The lock mechanism may include a lock sleeve that is biased to a normally locked position and driven along the axis by the actuator shaft when the button is depressed.

15 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2,452,592	A	11/1948	Meyer
2,583,042	A	1/1952	Dayton
2,585,933	A	2/1952	Harvey
2,682,707	A	7/1954	Folke
2,913,826	A	11/1959	Petty
3,037,287	A	6/1962	Glatz et al.
3,058,391	A	10/1962	Leupold
3,161,716	A	12/1964	Burris et al.
3,206,238	A	9/1965	Speight et al.
3,222,987	A	12/1965	Wrigglesworth
3,280,463	A	10/1966	Stadler
3,297,389	A	1/1967	Gibson
3,471,932	A	10/1969	Luning
3,662,618	A	5/1972	Kroll et al.
3,707,204	A	12/1972	Dussardier
3,826,012	A	7/1974	Pachmayr
3,916,721	A	11/1975	Egger
3,990,155	A	11/1976	Akin, Jr. et al.
3,999,442	A	12/1976	Decker et al.
4,012,966	A	3/1977	Lieberman et al.
4,026,397	A	5/1977	Raus
4,038,757	A	8/1977	Hicks et al.
4,132,129	A	1/1979	Pratt
4,154,125	A	5/1979	Frank
4,200,355	A	4/1980	Williams, Jr.
4,201,096	A	5/1980	Morrison et al.
4,347,758	A	9/1982	Geil et al.
4,373,269	A	2/1983	Doliber et al.
4,389,791	A	6/1983	Ackerman
4,397,107	A	8/1983	Holden
4,408,842	A	10/1983	Gibson
4,457,076	A	7/1984	Heck
4,461,330	A	7/1984	Judkins
4,643,542	A	2/1987	Gibson
4,779,305	A	10/1988	Gorsek
4,955,253	A	9/1990	Sakai et al.
4,982,502	A	1/1991	Weyrauch
5,020,389	A	6/1991	Sigler
5,083,477	A	1/1992	Geil
5,121,653	A	6/1992	Sigler
5,152,187	A	10/1992	LaFemina
5,329,829	A	7/1994	Sell
5,363,559	A	11/1994	McCarty
5,433,010	A	7/1995	Bell
5,499,456	A	3/1996	Tomita
5,513,440	A	5/1996	Murg
5,586,569	A	12/1996	Hanning et al.
5,615,487	A	4/1997	Tomita
5,618,374	A	4/1997	Byerley
5,695,125	A	12/1997	Kumar
5,715,607	A	2/1998	Murg
5,745,287	A	4/1998	Sauter
5,771,595	A	6/1998	Bell
5,862,715	A	1/1999	Lemire
5,892,617	A	4/1999	Wallace
5,906,141	A	5/1999	Abdelmoula
5,930,934	A	8/1999	Fisher et al.
6,005,711	A	12/1999	Mai et al.
6,279,259	B1	8/2001	Otteman
6,351,907	B1	3/2002	Otteman
6,442,854	B1	9/2002	Liu et al.
6,508,144	B1	1/2003	Vendetti et al.
6,519,890	B1	2/2003	Otteman
6,588,125	B2	7/2003	Proctor, Sr.
6,643,970	B2	11/2003	Huber
6,691,447	B1	2/2004	Otteman
6,705,037	B2	3/2004	Van Kirk
6,721,095	B2	4/2004	Huber
6,772,550	B1	8/2004	Leatherwood
6,848,628	B2	2/2005	Walker
6,860,442	B2	3/2005	Datcuk, Jr.
6,862,832	B2	3/2005	Barrett
7,117,624	B2	10/2006	Kim
7,121,037	B2	10/2006	Penney
7,330,310	B2	2/2008	Hengst et al.
7,640,830	B2	1/2010	Bonis
8,006,429	B2	8/2011	Windauer
8,270,104	B2	9/2012	Windauer
2003/0140545	A1	7/2003	Huber
2004/0088898	A1	5/2004	Barrett
2006/0254115	A1	11/2006	Thomas et al.
2006/0268433	A1	11/2006	Thomas
2006/0278035	A1	12/2006	Casas
2007/0240356	A1	10/2007	Klepp et al.
2008/0066364	A1	3/2008	Klepp et al.
2008/0197642	A1	8/2008	Talpe
2008/0236018	A1 *	10/2008	Halverson 42/135
2009/0205461	A1	8/2009	Windauer
2011/0100152	A1 *	5/2011	Huynh 74/504
2013/0167425	A1	7/2013	Crispin
2013/0220060	A1	8/2013	Sano et al.

FOREIGN PATENT DOCUMENTS

DE	297 20 737	U1	2/1998
DE	299 03 989	U1	6/1999
DE	20301749	U1	4/2003
DE	102 22 528	A1	12/2003
DE	202006003770	U1	7/2006
GB	598306		2/1948
GB	708438		5/1954
GB	1102022		2/1968
GB	1214584		12/1970
GB	2213959	A	8/1989
JP	11-085290	A	3/1999
WO	WO 2006/060490	A2	6/2006
WO	WO 2006/109587	A1	10/2006

* cited by examiner

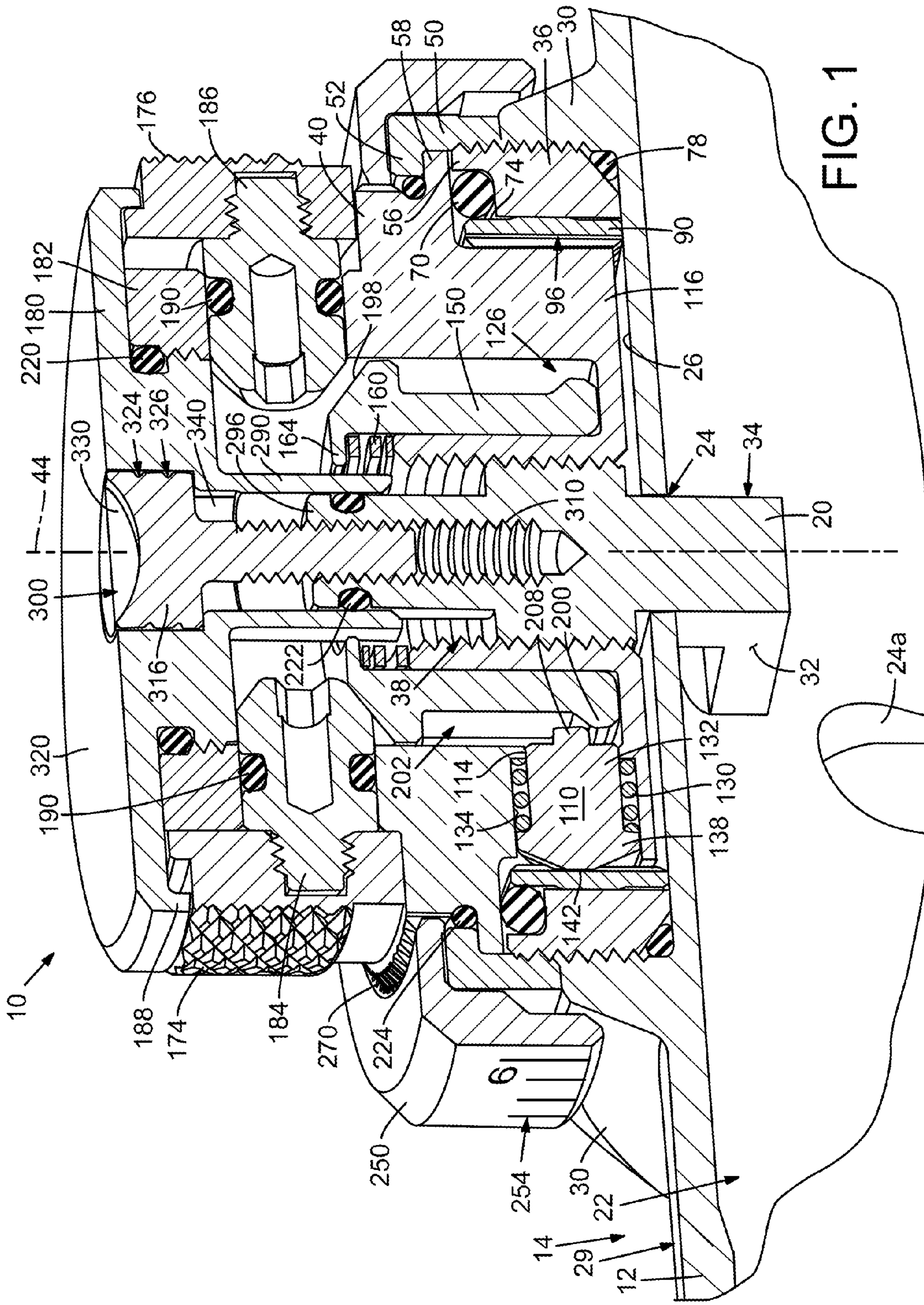

10
12
14
20
22
24
24a
26
29
30
32
34
36
38
40
44
50
52
56
58
70
74
78
90
96
110
114
116
126
130
132
134
138
142
150
160
164
174
176
180
182
184
186
188
190
198
200
202
208
220
222
224
250
254
270
290
296
300
310
316
320
324
326
330
340
9

FIG. 1

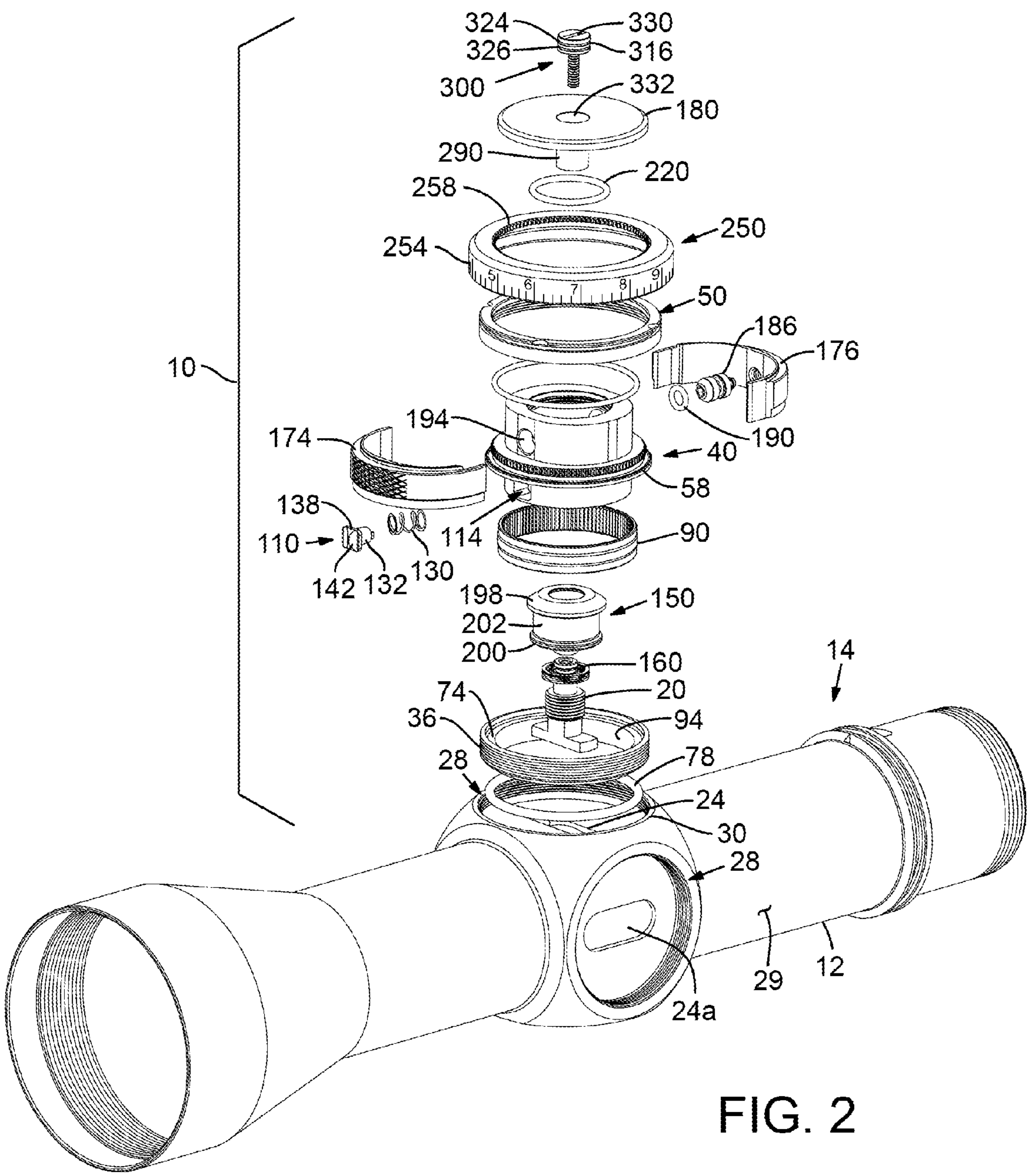

324
330
326
316
300
332
180
290
220
258
250
254
5
6
7
8
9
50
186
176
10
194
190
174
40
58
138
114
90
110
142
132
130
198
150
202
200
160
14
20
74
94
36
78
28
24
30
28
24a
29
12

FIG. 2

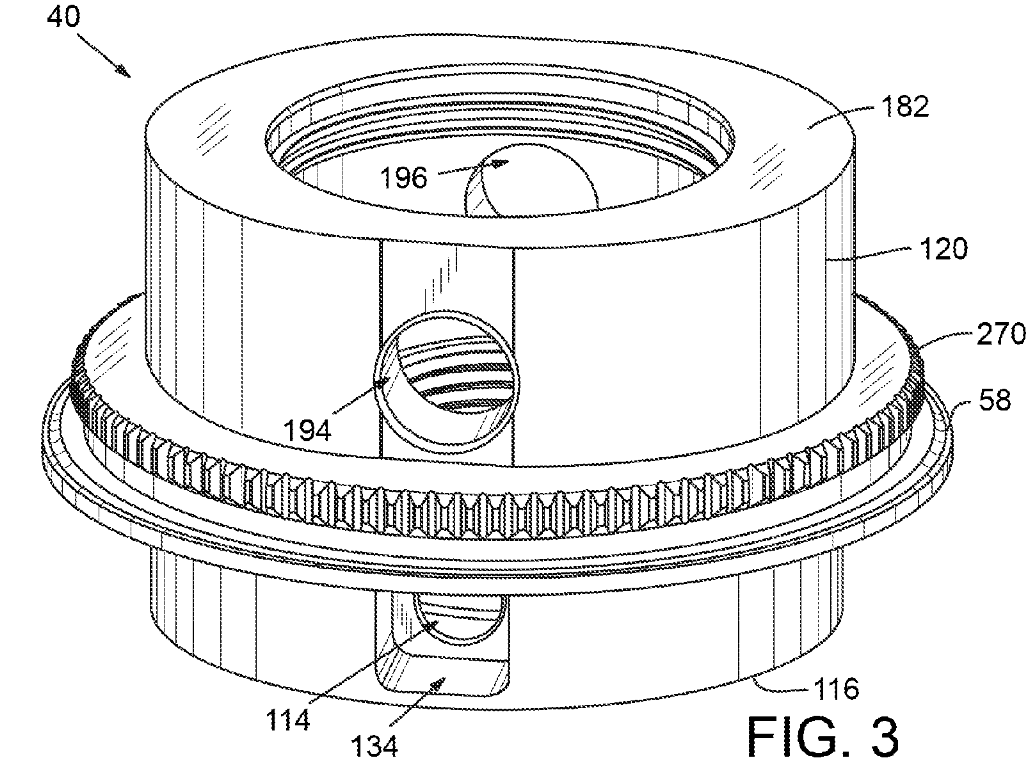

40
182
196
120
270
58
194
116
114
134

FIG. 3

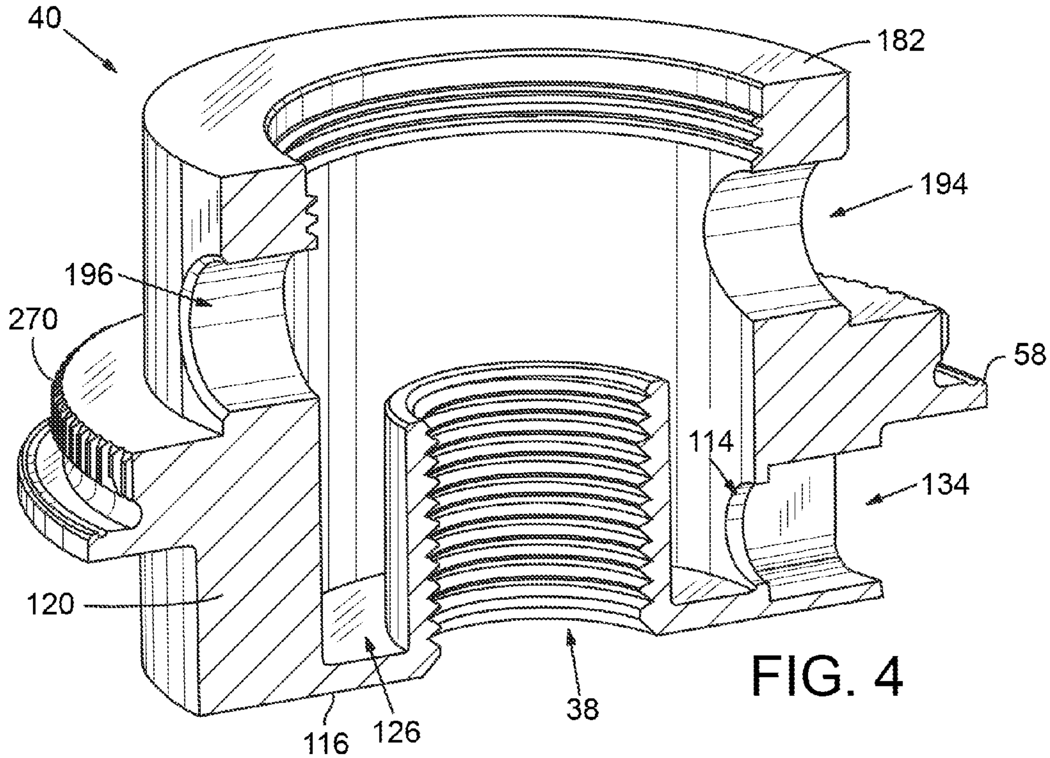

40
182
194
196
270
58
114
134
120
116
126
38

FIG. 4

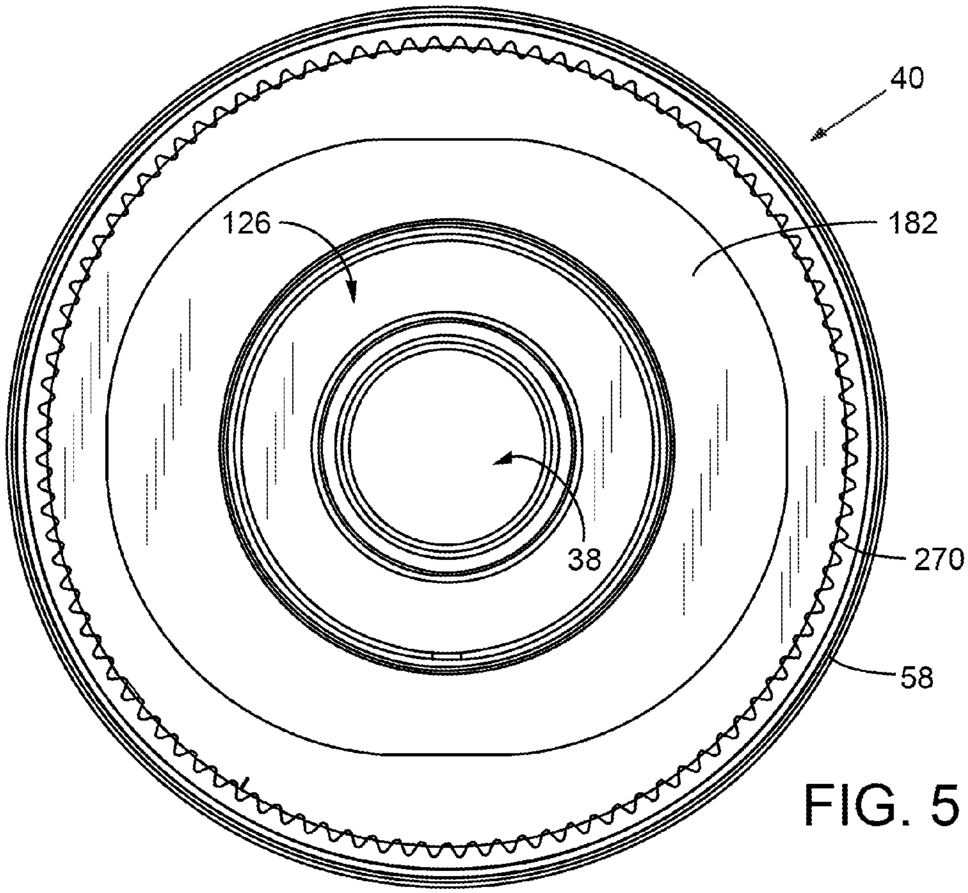


FIG. 5

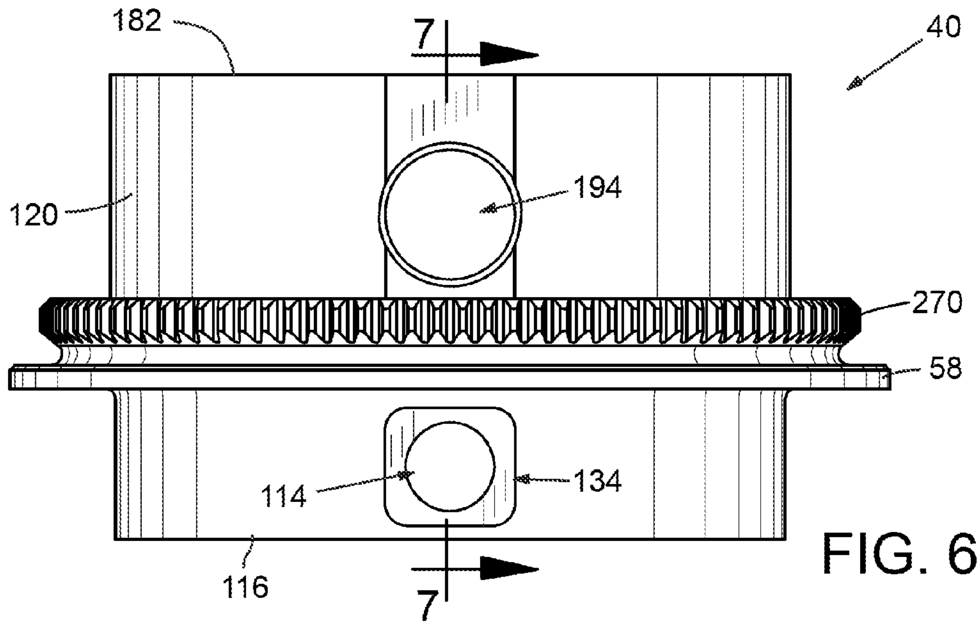


FIG. 6

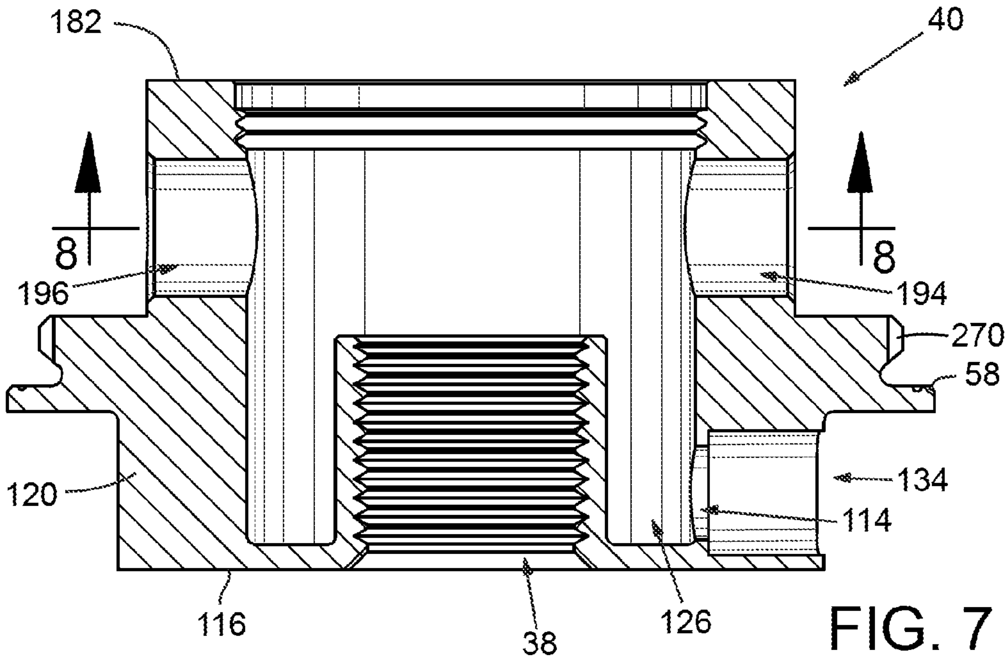


FIG. 7

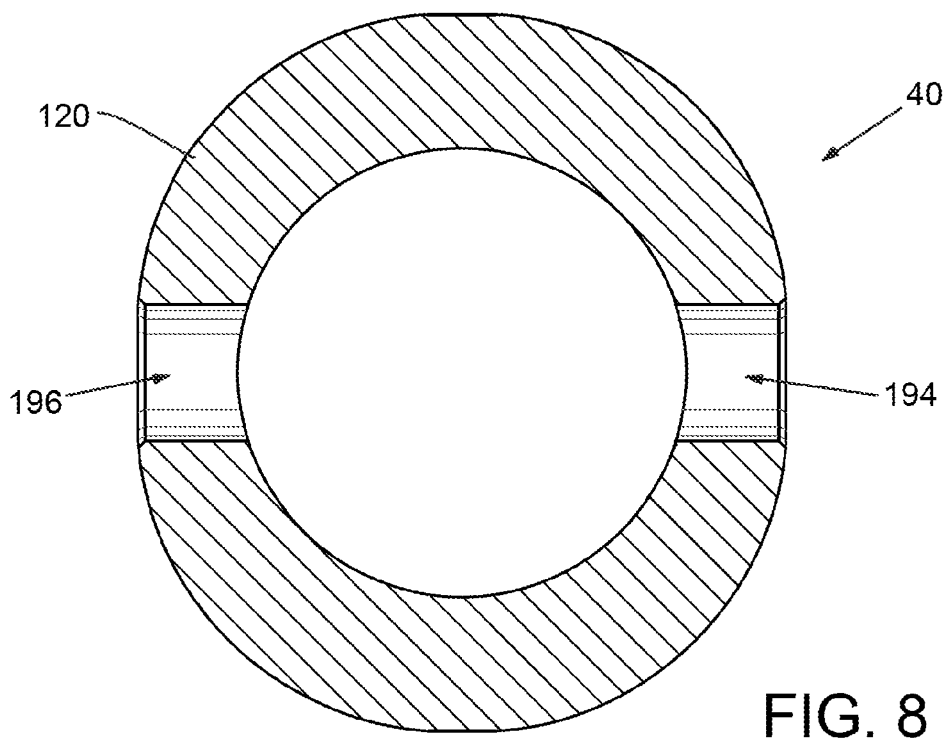


FIG. 8

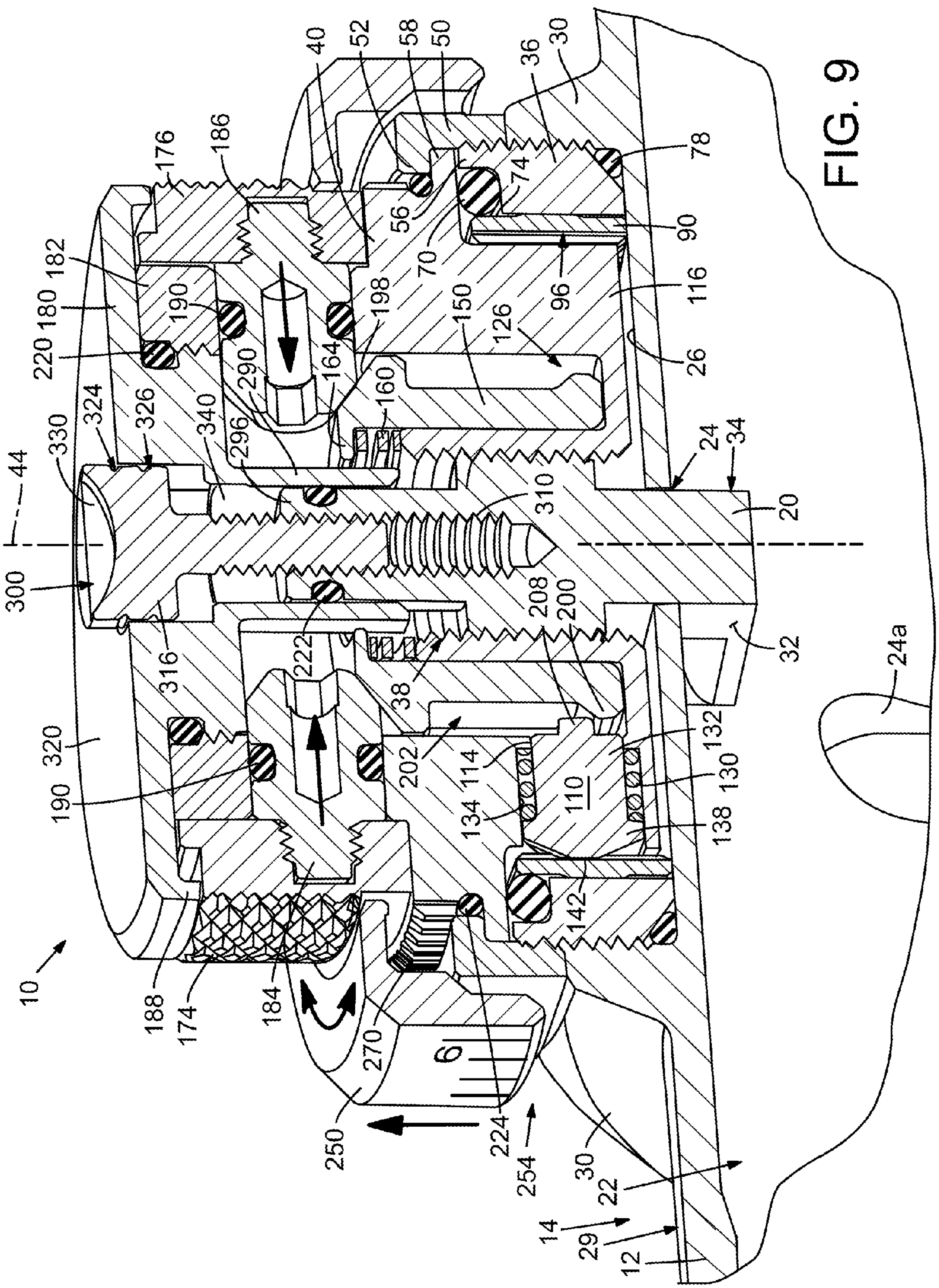

10
12
14
20
22
24
24a
26
29
30
32
34
36
38
40
44
50
52
56
58
70
74
78
90
96
110
114
116
126
130
132
134
138
142
150
160
164
174
176
180
182
184
186
188
190
198
200
202
208
220
222
224
250
254
270
290
296
300
310
316
320
324
326
330
340

FIG. 9

LOW PROFILE AUTO-LOCKING PINCH/TURN ADJUSTMENT KNOB

RELATED APPLICATION

This application claims priority to and the benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application No. 61/752,418, filed Jan. 14, 2013, which is incorporated herein by reference.

TECHNICAL FIELD

The field of the present disclosure relates to automatically locking (auto-locking) rotatable adjustment knobs used to adjust a setting of a device such as a riflescope or other optical device, an electronic device, or a mechanical device.

BACKGROUND

Rotatable adjustment knobs or control knobs are commonly utilized to adjust settings of optical, mechanical, and electrical devices. Riflescopes and similar weapon aiming devices commonly include a pair of orthogonally mounted rotatable adjustment knobs, also known as turret knobs or simply turrets, which are used for adjusting elevation and windage settings affecting the respective vertical and horizontal aim of the riflescope, and thus of the weapon to which the riflescope is attached. Rotating adjustment knobs are also commonly used on riflescopes and other optical devices for adjusting focus, reticle illumination intensity, display settings, display illumination, and other settings of the device. Rotating adjustment knobs are also used on various other optical, electronic, and mechanical devices, such as spotting scopes, binoculars, microscopes, stereos and radios, appliances, automobile controls, and measurement instruments, for example.

In some applications, it is advantageous for an adjustment knob to automatically lock in place to prevent inadvertent adjustment. U.S. Pat. No. 8,006,429, issued Aug. 30, 2011, describes various locking turret knobs for riflescopes, some of which are normally locked, but may be unlocked by applying a releasing force to the knob or a component thereof, then rotating the knob to make an adjustment. In some embodiments described in the '429 patent, when the manual force is removed a spring or other biasing device of the knob automatically returns the locking mechanism to its normally locked state, preventing inadvertent rotation of the adjustment knob, for example during transit or other handling.

Patent Application Publication No. US 2011/0100152 A1 describes an auto-locking adjustment mechanism including a pair of buttons on opposite sides that are manually depressed with a pinching action to release the locking mechanism and allow the knob to be rotated for adjustment of a setting of a riflescope or other device. When force is released from the buttons, the device automatically locks. Hence, the adjustment mechanism is sometimes referred to as a pinch-and-turn adjustment knob or a pinch/turn knob. The buttons are carried by a knob body that is installed over and frictionally secured to a threaded spindle of the device by a pair of set screws. The knob carries an indicator ring marked to provide a visual indication of the rotational position of the knob relative to the riflescope. The zero position of the knob can be adjusted relative to the spindle by loosening the set screws, rotating the knob until a zero marking on the indicator ring is aligned as desired relative to the riflescope main tube, then re-tightening the set screws. Each of the buttons carries an actuator shaft that extends radially through a bore in the side of the knob body and operatively engages a linkage within the mechanism that is driven in an axial direction when the buttons are depressed to release the locking mechanism, allowing the knob body and spindle to be rotated together to drive a threaded adjustment screw plunger or another type of adjustment device.

The present inventor has recognized a need for an improved auto-locking pinch/turn adjustment knob.

SUMMARY

An adjustment knob for adjusting an optical, mechanical, or electronic device, includes a spindle supported on the device for rotation about an axis and a releasable lock mechanism supported on the spindle for rotation therewith. The spindle is operatively associated with an adjustment mechanism that controls a setting of the device. The lock mechanism includes a button that is manually depressible in a generally radial direction from a radially outward locked position at which the lock mechanism constrains the spindle to prevent it from rotating relative to the device, to a radially inward unlocked position that releases the lock mechanism and allows the spindle to be rotated. The lock mechanism also includes an actuator shaft connected to the button and extending radially inward through a drive hole in an outer side wall of the spindle. A force applied to the button drives the lock mechanism and is transmitted to the spindle via the actuator shafts to rotate the spindle. A hermetic seal may be provided between the actuator shaft and the drive hole, which also provides a sliding interface therebetween. The spindle and its outer side wall, including the drive hole, are preferably formed in a monolithic structure for rigidity and sealing purposes, among others. Accordingly, the spindle may be driven for rotation by forces transmitted directly from the button to the spindle primarily via engagement of the actuator shaft in the drive hole.

The lock mechanism may include a lock sleeve having a tapered surface that is contacted by the actuator shaft and thereby driven along the axis by the actuator shaft when the button is depressed. The lock sleeve may be positioned in an annular groove of the spindle and is preferably biased in the axial direction toward the locked position by a spring that is operably interposed between the lock sleeve and the spindle and concentric with the axis. The lock sleeve is driven in opposition to the spring force toward the unlocked position by depressing the button. The spring preferably has sufficient biasing force to return the lock sleeve and the button to the locked position when external force is released from the button. The lock mechanism may further include a lock pin carried by the spindle, which is contacted by the lock sleeve and driven radially outward by movement of the lock sleeve and into engagement with a catch when the lock sleeve is in the locked position.

The adjustment mechanism may include a threaded adjustment plunger such as an adjustment screw threaded into the spindle and constrained to prevent it from rotating about the axis, or may include a different kind of adjustment mechanism, such as an orbital pin, crown gear arrangement, spiral cam mechanism, etc. The lock sleeve may encircle the threaded adjustment plunger or screw.

The adjustment knob may further comprise a revolution indicator pin attached to the adjustment screw for movement therewith along the axis and visible from outside of the adjustment knob to provide a visual indication of the number of revolutions that the spindle is turned relative to an initial zero position.

The adjustment knob may also include a second lock-release button and second actuator shaft supported on the outer side wall of the spindle opposite the button so that the button and the second button may be pinched toward each other by a user to unlock the lock mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric cross sectional view of an auto-locking adjustment knob shown installed on a riflescope illustrated in partial cross section;

FIG. **2** is an exploded assembly view showing the adjustment knob and a riflescope housing of FIG. **1**;

FIG. **3** is an enlarged isometric view of a spindle of the adjustment knob of FIG. **1**;

FIG. **4** is an isometric cross sectional view of the spindle of FIG. **3**;

FIG. **5** is top view of the spindle of FIG. **3**;

FIG. **6** is a side view of the spindle of FIGS. **3** and **5**;

FIG. **7** is a cross sectional view taken along lines **7-7** of FIG. **6**;

FIG. **8** is a cross sectional view taken along lines **8-8** of FIG. **7**; and

FIG. **9** is an auxiliary view of the adjustment knob of FIG. **1**, illustrating a process for manually re-positioning or re-zeroing an indicator ring of the adjustment knob.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1**. is an isometric cross sectional view of an auto-locking pinch/turn adjustment knob **10** in accordance with a presently preferred embodiment, illustrated as an elevation control knob mounted on a housing (main tube **12**) of a riflescope **14**. Riflescope **14** is merely exemplary of a type of optical aiming device with which adjustment knob **10** may be utilized. Other devices with which adjustment knob **10** may be used are noted elsewhere herein.

With reference to FIG. **1**, adjustment knob **10** includes a threaded adjustment plunger in the form of an adjustment screw **20** extending into an interior **22** of riflescope **14** via a slot **24** (best shown in FIG. **2** along with a similar second slot **24*a*** for a windage adjustment screw). Slot **24** is formed in a floor **26** of a turret seat **28** (FIG. **2**) that is formed on a lateral outer surface **29** of main tube **12**. Flats **32**, **34** on the sides of an inner end of adjustment screw **20** prevent adjustment screw **20** from rotating relative to main tube **12**. Turret seat **28** includes a threaded mounting boss **30** into which a threaded adapter ring **36** is fitted. Adjustment screw **20** is threaded into a threaded bore **38** of a spindle **40** that is retained in turret seat **28** for rotation about an axis **44** of adjustment knob **10** as further described below. When spindle **40** is rotated, the rotatably constrained adjustment screw **20** is driven along axis **44** to adjust a setting of riflescope **14**, for example by bearing against and moving an erector lens holder tube (not shown) that may be disposed within and pivotably mounted to main tube **12**, and spring-biased to press against the inner end of adjustment screw **20**. In an alternative embodiment (not illustrated), instead of adjustment screw **20**, the threaded adjustment plunger may comprise an internally threaded post or standoff having a threaded end portion for mounting to an externally threaded portion of a spindle.

A retainer nut **50** having an inwardly extending lip **52** is threaded onto an axially outer end **56** of adapter ring **36** that extends beyond mounting boss **30** to retain spindle **40** in turret seat **28**. A flange **58** of spindle **40** is captured between lip **52** and the axially outer end **56** of adapter ring **36**. Retainer nut **50** is sized to provide clearance around flange **58**, allowing smooth rotation of spindle **40**. An o-ring **70** or sliding gasket made of a resilient material is positioned in a groove or step **74** formed in outer end **56** of adapter ring **36** and is sized to project beyond outer end **56** to provide a bearing surface for spindle **40**, while also providing a hermetic seal between spindle **40** and adapter ring **36**. A second sealing gasket or o-ring **78** is positioned between adapter ring **36** and turret seat **28**. In the embodiment illustrated, adapter ring **36** is provided on a standard mounting boss **30** design (which may fit many different styles of adjustment knobs) to retrofit the mounting boss **30** for the particular mounting requirements of adjustment knob **20**. In other embodiments (not shown), adapter ring **36** may be omitted, and retainer nut **50** may be threaded directly onto main tube **12**.

Although the preferred embodiment is described herein as an adjustment screw device for a riflescope, embodiments of the pinch/turn adjustment knob described herein may be utilized with adjustment mechanisms other than adjustment screws, such as other mechanical devices, electrical controls, and other mechanisms. For example, instead of a threaded adjustment plunger, the adjustment mechanism may comprise an eccentric pin or spiral cam mechanism of the kind described in U.S. Pat. No. 6,351,907, issued Mar. 5, 2002, a crown gear mechanism, taut-band mechanism, or other mechanical device. Alternatively, the adjustment knob may rotate an electrical control comprising a rheostat or an arrangement of electrical contact pads that are selectively brought into contact with electrical contacts depending on the position of the control knob.

Turning back to the preferred embodiment of FIG. **1**, a detent ring **90** is press-fit or cemented to an inner face **94** (FIG. **2**) of adapter ring **36** and bears a series of catch structures, for example evenly spaced alternating axially extending ridges and grooves (detent grooves **96**), formed along an inner surface of detent ring **90**. In an alternative embodiment (not illustrated), detent ring **90** may be omitted in favor of detent grooves **96** or other catch structures formed directly in the surface of adapter ring **36** or, if adapter ring **36** is omitted as suggested above, in an inner circumferential surface of mounting boss **30**. A lock pin **110** is slidably mounted in a radial bore **114** formed in spindle **40** near its base **116**. FIGS. **3** and **4** are respective isometric and cross sectional views of spindle **40** showing detail of bore **114** and other aspects of spindle **40**. FIGS. **5-8** illustrate additional views of spindle **40**. With reference to FIGS. **1**, **3**, and **4-8**, bore **114** extends through an outer wall **120** of spindle **40** into an annular groove **126** (FIG. **4**) that is coaxially aligned with spindle **40** (on axis **44**). Spindle **40** and its outer side wall **120**, including bore **114**, annular groove **126**, drive holes **194**, **196**, and other features illustrated in FIGS. **5-8**, are preferably formed in a monolithic structure to provide rigidity or improved sealing, or for other reasons. A coil spring **130** encircling a neck portion **132** of lock pin **110** is captured in a pocket **134** leading to bore **114**, and is compressed to bear against a head **138** of lock pin **110** and a bottom of the pocket **134** to urge lock pin **110** radially outward against detent ring **90** and into detent grooves **96**.

FIG. **2** shows how the outer end **142** of head **138** is wedge-shaped to allow it to ride over the ridges and grooves **96** (FIG. **1**) of detent ring **90** during rotation of adjustment knob **10** to provide tactile and/or auditory feedback of clicks indicating a predetermined amount of adjustment. In one embodiment, detent ring **90** includes one hundred (**100**) regularly spaced detent grooves **96** circumscribing detent ring **90**, and the pitch of adjustment screw **20** is selected so that each click represents approximately 0.1 milliradian (mils) of elevation or windage adjustment. In other embodiments a greater or lesser number of detent grooves **96** may be provided and the pitch of adjustment screw **20** may be different.

With reference again to FIG. **1**, an annular lock sleeve **150** surrounds adjustment screw **20** and is retained in annular groove **126** of spindle **40** in operative engagement with lock pin **110**. A lock spring **160** captured between an inner lip **164** of lock sleeve **150** and spindle **40** is operably interposed therebetween to urge spindle **40** axially outward along axis **44**. A pair of release buttons **174**, **176** are supported adjacent opposite sides of spindle **40** where they are exposed and can be manipulated and operated from outside adjustment knob **10** by grasping or pressing them via a user's fingers. Release buttons **174**, **176** are retained on spindle **40** by a cap **180** that is threadably secured to spindle **40** over an axially outer end **182** thereof. First and second actuator shafts **184**, **186** are mounted to and extend radially inward from buttons **174**, **176** through drive holes **194**, **196** (FIG. **3**) formed in outer wall **120** of spindle **40**. A skirt portion **188** of cap **180** extends axially from a peripheral edge of cap **180** to retain buttons **174**, **176**. Actuator shafts **184**, **186** are each fitted with o-rings **190**, providing a hermetic seal and sliding interface between actuator shafts **184**, **186** and drive holes **194**, **196**. Actuator shafts **184**, **186** have radiused tips that engage a tapered shoulder surface **198** of lock sleeve **150** when release buttons **174**, **176** are depressed. First release button **174** and actuator shaft **184** are shown in FIG. **1** in their depressed (unlocked) position, whereat the inner end of actuator shaft **184** bears against shoulder surface **198** to drive lock sleeve **150** axially inward to its unlocked position in opposition to the biasing force of lock spring **160**. In the unlocked position, a foot portion **200** of lock sleeve **150** is moved axially inward and a channel **202** on an outer surface of lock sleeve **150** between foot portion **200** and shoulder surface **198** is aligned with a heel **208** of lock pin **110**, providing clearance that allows lock pin **110** to reciprocate within bore **114** for providing tactile and audible feedback to the user as adjustment knob **10** is turned.

In an alternative embodiment (not illustrated), the lock sleeve **150** may instead be biased in an inward direction, and configured and interfaced with the actuator shafts **184**, **186** and lock pin **110** so that when the release buttons are depressed the actuator shafts drive the lock sleeve in an axially outward direction to unlock the adjustment knob.

Second release button **176** and actuator shaft **186** are shown in FIG. **1** in the locked (undepressed) position (although the lock sleeve **150** is shown in the unlocked position by virtue of the first release button **174** being depressed). When manual pinching force is removed from both release buttons **174** and **176** they return to the locked position by virtue of the biasing force provided by lock spring **160** driving lock sleeve **150** axially outward. In the locked condition, the foot portion **200** of lock sleeve **150** presses against heel **208** of lock pin **110** to drive lock pin **110** radially outward and securely seat outer end **142** in one of the detent grooves **96**, which locks adjustment knob **10** to prevent it from being inadvertently rotated about axis **44**.

O-rings **74**, **78**, **190**, and additional seals or o-rings **220**, **222**, are provided at interfaces between parts of adjustment knob **10** to hermetically seal main tube **12** and retain a dry gas charge therein to prevent weather-induced condensation on internal optical elements (not shown) of riflescope **14**. A further o-ring **224** is provided along an outer surface of flange **58** of spindle **40** to help center spindle **40** on axis **44**, and to prevent dust and grit from migrating into the sliding bearing between flange **58**, retainer nut **50**, and adapter ring **36**.

The design of adjustment knob **10** is greatly simplified relative to the device disclosed in US 2011/0100152, reducing component cost and assembly expense, and further providing certain advantages. The shape of lock sleeve **150** enables it to extend into annular groove **126** in spindle **40** and directly engage lock pin **110**, thereby eliminating a lock pin linkage of prior designs. The shape of lock sleeve **150** also enables the use of concentric lock spring **160**, which provides a centered biasing force that may be sufficient for returning release buttons **174**, **176** to the locked position, thereby eliminating the need for separate button return springs of prior designs. Alternatively, a second return spring or set of springs (not illustrated) may be provided to act directly on buttons **174**, **176** and/or actuator shafts **184**. For example, a leaf spring or spring loop may be interposed between the tips of actuator shafts **184**, **186** and extend around a stem **290** of cap **180** where there is space for the leaf spring or loop spring to flex when buttons **174**, **176** are depressed.

Extending the actuator shafts **184**, **186** through drive holes **194**, **196** in spindle **40** eliminates the need for a separate button-carrying knob body of prior designs and the frictional connection between the button-carrying knob body and the spindle provided by a set screw of prior designs. Instead, the actuator shafts **184**, **186** and buttons **174**, **176** are carried by drive holes **194**, **196** of spindle **40**, and directly drive spindle **40** for rotation about axis **44** without the need for a frictional connection that the inventors have found prone to slippage. Several of the above-described differences also cooperate to provide an adjustment knob **10** having an overall height above floor **26** of turret seat **28** (or above the lateral outer surface **29** of main tube **12**) that is approximately half that of prior designs. In some embodiments, adjustment knob **10** has an overall height H above floor **26** in the range of approximately 0.55 inch to approximately 0.7 inch (approximately 14 to 18 mm). In other embodiments, adjustment knob **10** may have a height H in the range of 0.5 to 0.8 inch (12.7 to 20.3 mm), or in the range of 0.5 to 0.9 inch (12.7 to 22.9 mm), or in the range of 0.5 to 1.0 inch (12.7 to 25.4 mm). This low-profile design is advantageous for use with riflescopes, as it avoids obscuring the shooter's view past the outside of the riflescope and may facilitate the use of auxiliary aiming devices such as reflex sights that may be mounted alongside or closely above riflescope **14**.

With reference to FIGS. **1**, **2**, and **9**, an indicator ring **250** bearing a scale **254** or other indicia marked along an outer circumferential surface thereof is installed around adjustment knob **10** and over retainer nut **50**. Indicator ring **250** includes a set of splines formed along an inner shoulder opening **258** (FIG. **2**) of indicator ring **250**. The splines of indicator ring **250** are sized to mesh with splines **270** (FIG. **3**) formed around outer wall **120** of spindle **40** adjacent and axially outward of flange **58** so that indicator ring **250** rotates with spindle **40** relative to main tube **12**. A fiduciary mark (not shown) on the outside of mounting boss **30** is visually referenced by a user to read the rotational position of adjustment knob **10** from scale **254**.

Due to elimination of the adjustable frictional connection of prior designs between an outer knob body and a spindle, a different mode of re-zeroing adjustment knob **10** is provided in the present embodiment. The rotational position of indicator ring **250** is adjustable relative to spindle **40** for re-zeroing the indicator ring **250**, for example after sighting-in riflescope **14**. With particular reference to FIG. **9**, to adjust the position of indicator ring **250**, actuator buttons **274**, **276** (which serve as a latch for retaining indicator ring **250**) are depressed with one hand and indicator ring **250** is pulled axially outward around buttons **274**, **276** with the other hand, then indicator ring **250** is rotated relative to spindle **40** and replaced axially onto splines **270**. Indicator ring **250** may also be completely removed from adjustment knob **10** in the same two-handed manner by depressing buttons **274**, **276** and sliding indicator ring **250** over buttons **274**, **276**, and subsequently replaced with an indicator ring having a different scale, such as a scale calibrated for a particular type of weapon and/or ammunition. Further details of adjustable replaceable indicator rings similar to ring **250** are provided in U.S. patent application Ser. No. 13/683,985, filed Nov. 21, 2012, which is incorporated herein by reference.

Turning again to FIG. **1**, cap **180** includes a tubular central stem **290** extending axially inwardly around an outer end **296** of adjustment screw **20**. O-ring **222** is fitted in a circumferential groove around outer end **296** of screw **20** to achieve hermetic seal therebetween. O-ring **222** facilitates sliding movement of screw **20** relative to cap **180** as adjustment knob **10** is adjusted. An optional threaded revolution indicator pin **300** is threaded into a threaded bore **310** in the outer end of adjustment screw **20**. Revolution indicator pin **300** rides with adjustment screw **20** as adjustment knob **10** is adjusted so that a head **316** of revolution indicator pin **300** projects outwardly beyond an outer major surface **320** of cap **180** as adjustment screw **20** is adjusted. A pair of circumscribed indicator grooves **324**, **326** or markings on head **316** indicate the number of revolutions that adjustment knob **10** has been turned. For example, when adjustment knob **10** has been turned a full revolution to achieve 10 milliradians of angular aiming adjustment the outermost groove **324** is visible slightly above with the outer major surface **320** of cap **180**, as illustrated in FIG. **9**, and when adjustment knob **10** has been rotated two revolutions to achieve an angular aiming adjustment of 20 milliradians the second groove **326** is visible slightly above outer major surface **320**. Thus, visibility of none, one, or both of grooves **324**, **236** indicates the number of revolutions of adjustment knob **10**. In other embodiments (not illustrated), the revolution indicator pin **300** is omitted and the top of cap **180** is solid.

A slot **330** in the head of revolution indicator pin **300** is sized so that a tail of a cartridge or a small flathead screwdriver can be used to adjust a zero stop position by tightening revolution indicator pin **300** until head **316** is snugly seated in a counterbore **334** (FIG. **2**) of cap **180** in the zero position shown in FIG. **1**. The zero stop position enables adjustment knob **10** to be quickly returned to the zero position after an adjustment, without looking at revolution indicator pin **300**. Also, during sighting-in of a weapon and riflescope **14**, revolution indicator pin **300** may be loosened or removed to allow unrestricted travel of adjustment screw **20**. After the weapon and riflescope **14** have been sighted in, revolution indicator pin **300** is replaced and tightened to set the zero stop point of adjustment knob **10**. After subsequent adjustments of adjustment knob **10** (e.g., elevation adjustment for longer range shots), adjustment knob **10** can be quickly returned to the zero stop position merely by rotating adjustment knob **10** in the opposite direction until it stops against head **316** of revolution indicator pin **300**.

Completely removing revolution indicator pin **300** reveals a tool-receiving drive socket, such as a hex socket **340** within stem **290** that receives a tool (such as a hex key, not illustrated) for removing cap **180** and disassembling adjustment knob **10** for maintenance or replacement.

Except for o-rings **70**, **78**, **190**, **220**, **222**, and **224** and springs **130** and **160**, all components of adjustment knob **10** may be machined from solid aluminum, steel, or another metal. In some embodiments, lock sleeve **150**, actuator shafts **184**, **186**, lock pin **110**, and certain other friction and wear components may be polished and/or coated with a wear-resistant hard coating or made from a low-friction material for enhancing durability and reliability. Alternatively, some components may be made of plastic or another low-cost or low-friction material, albeit usually resulting in a less durable device.

It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

The invention claimed is:

1. An adjustment knob for adjusting an optical, mechanical, or electronic device, comprising:

a spindle supportable on the device for rotation about an axis, the spindle operatively associated with an adjustment mechanism that controls a setting of the device; and

a releasable lock mechanism supported on the spindle for rotation therewith, the lock mechanism including:

a button manually depressible in a generally radial direction from a radially outward locked position at which the lock mechanism constrains the spindle to prevent it from rotating relative to the device, to a radially inward unlocked position that releases the lock mechanism and allows the spindle to be rotated, and

an actuator shaft connected to the button and extending radially inward through a drive hole in an outer side wall of the spindle, the actuator shaft transmitting a force applied to the button to drive the lock mechanism and to rotate the spindle.

2. The adjustment knob of claim **1**, wherein the adjustment mechanism includes an adjustment plunger threaded to the spindle and constrained to prevent the adjustment plunger from rotating about the axis.

3. The adjustment knob of claim **2**, wherein the adjustment plunger is an adjustment screw, and further comprising a revolution indicator pin that is attached to the adjustment screw for movement therewith along the axis and visible from outside of the adjustment knob to provide a visual indication of the number of revolutions that the spindle is turned relative to an initial zero position.

4. The adjustment knob of claim **2**, wherein the lock mechanism includes a lock sleeve encircling the adjustment plunger and driven by the actuator shaft for movement along the axis in response to a user depressing the button, to thereby release the lock mechanism.

5. The adjustment knob of claim **1**, wherein the lock mechanism includes a lock sleeve that extends into an annular groove in the spindle.

6. The adjustment knob of claim **1**, wherein the lock mechanism includes a lock sleeve that is biased in the axial direction toward the locked position by a spring that is concentric with the axis, and the lock sleeve is driven in opposition to the spring toward the unlocked position by depressing the button, and wherein the spring provides sufficient biasing to return the lock sleeve and the button to the locked position when the force is released from the button.

7. The adjustment knob of claim **1**, wherein the lock mechanism includes a lock sleeve that is driven along the axis by the actuator shaft when the button is depressed.

8. The adjustment knob of claim **7**, wherein the lock mechanism further includes a lock pin carried by the spindle, and the lock sleeve contacts and drives the lock pin radially outward and into engagement with a catch when the lock sleeve is in the locked position.

9. The adjustment knob of claim **7**, wherein the actuator shaft contacts and slides against a tapered shoulder surface of the lock sleeve to drive the lock sleeve along the axis and release the lock mechanism.

10. The adjustment knob of claim **7**, further comprising a lock spring operably interposed between the lock sleeve and the spindle to bias the lock sleeve along the axis toward the locked position.

11. The adjustment knob of claim **1**, further comprising a hermetic seal between the actuator shaft and the drive hole that also provides a sliding interface therebetween.

12. The adjustment knob of claim **1**, wherein the spindle and its outer side wall, including the drive hole, are formed in a monolithic structure.

13. The adjustment knob of claim **1**, wherein the spindle is manually driven for rotation by forces transmitted from the button to the spindle primarily via engagement of the actuator shaft in the drive hole.

14. The adjustment knob of claim **1**, further comprising a second lock-release button supported on the outer side wall of the spindle opposite the button so that the button and the second button may be pinched toward each other by a user to unlock the lock mechanism, the second lock-release button connected to a second actuator shaft that extends radially inward through a second drive hole in the outer side wall of the spindle opposite the drive hole, the second actuator shaft transmitting a force applied to the second button to drive the lock mechanism and to rotate the spindle.

15. An optical aiming device including the adjustment knob of claim **1**.

* * * * *