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(54) LOCKING CAP SYSTEM

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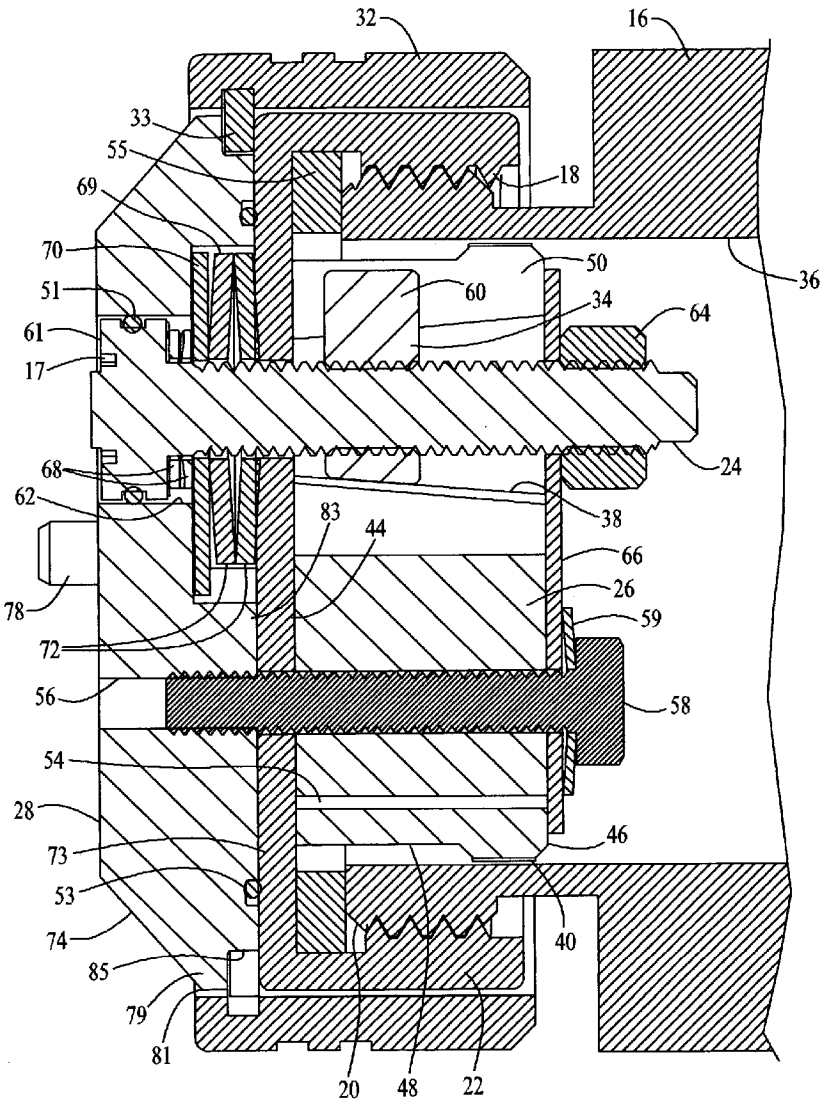
(57) ABSTRACT

A locking cap assembly is selectively locked into place within a tubular opening, such as the open end of a fire department connection. The locking cap assembly has an expandable element and a spreader element that is operatively connected to a locking bolt. As the locking bolt is rotated by a key, the spreader element is translated longitudinally through a tapered longitudinal bore in the expandable element, and the translation of the spreader element respectively expands and contracts the extendable element as the spreader element moves in the bore between first and second positions. The locking bolt includes a pair of cooperating lock washers having opposed cam surfaces, and a pair of opposed Bellville compression washers that apply axial pressure to the lock washers, allowing the locking bolt to be self locking during use for increased reliability and security.



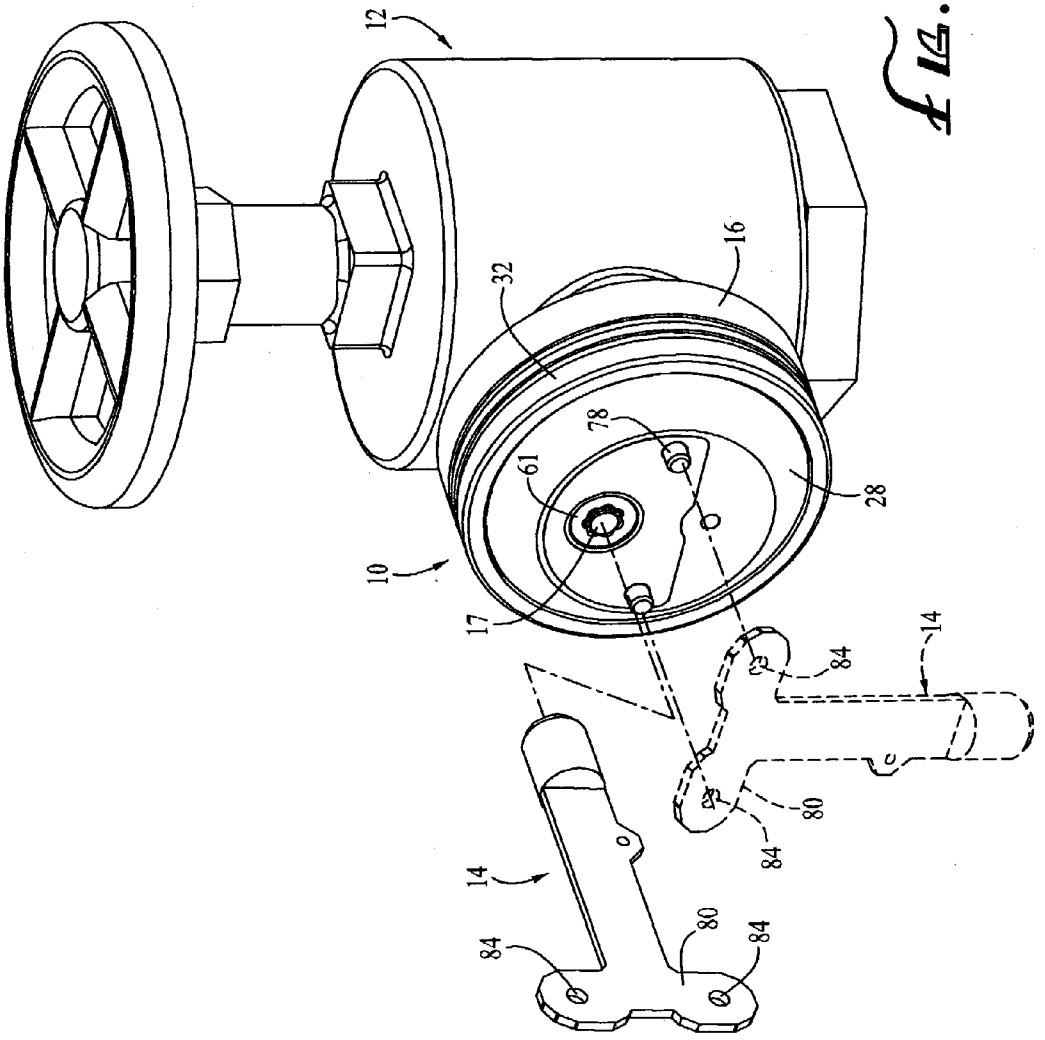


FIG. 1

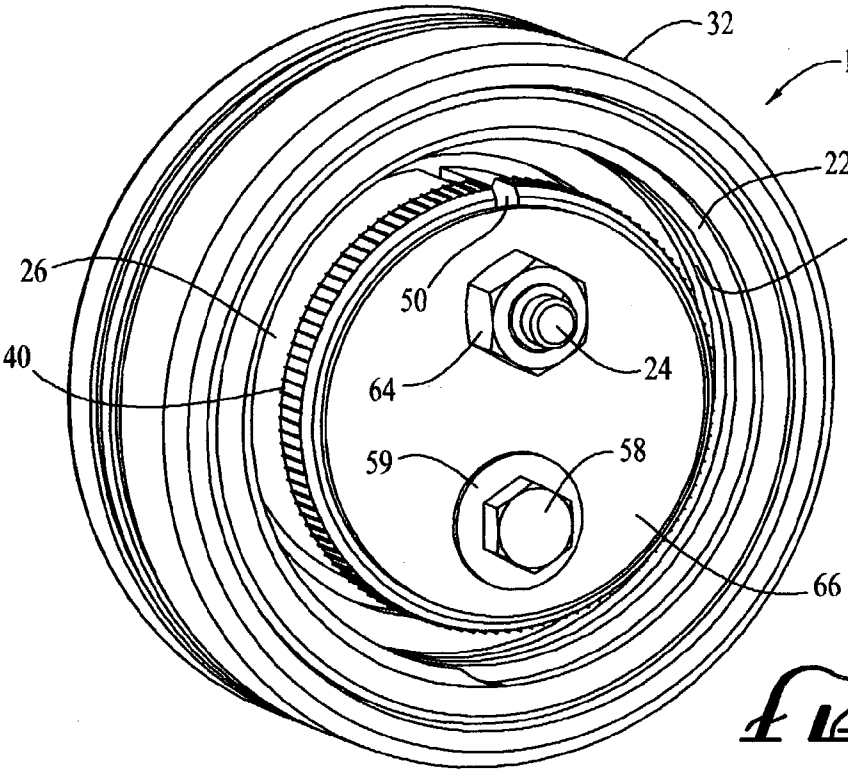


FIG. 2

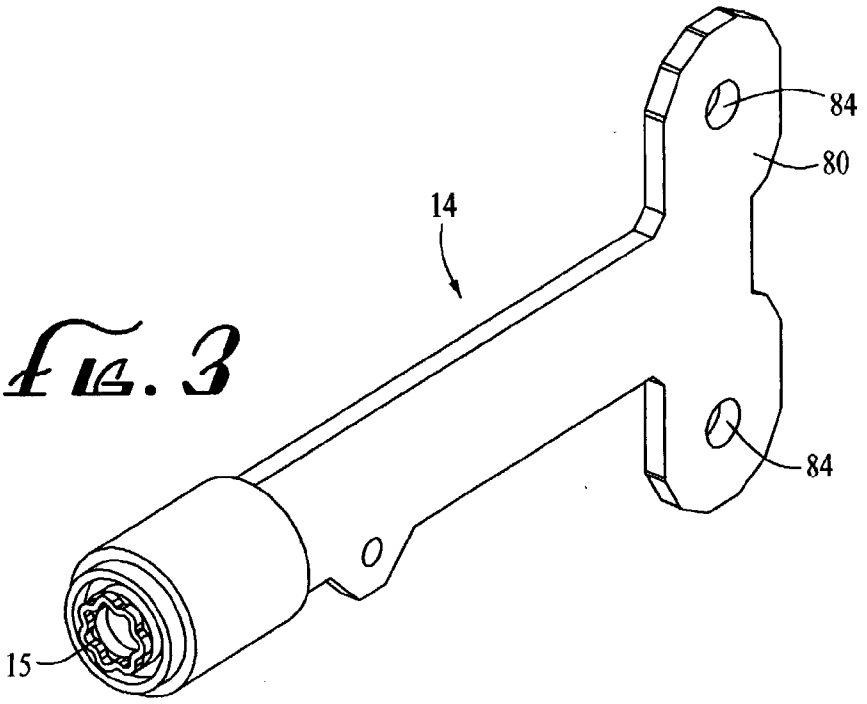


FIG. 3

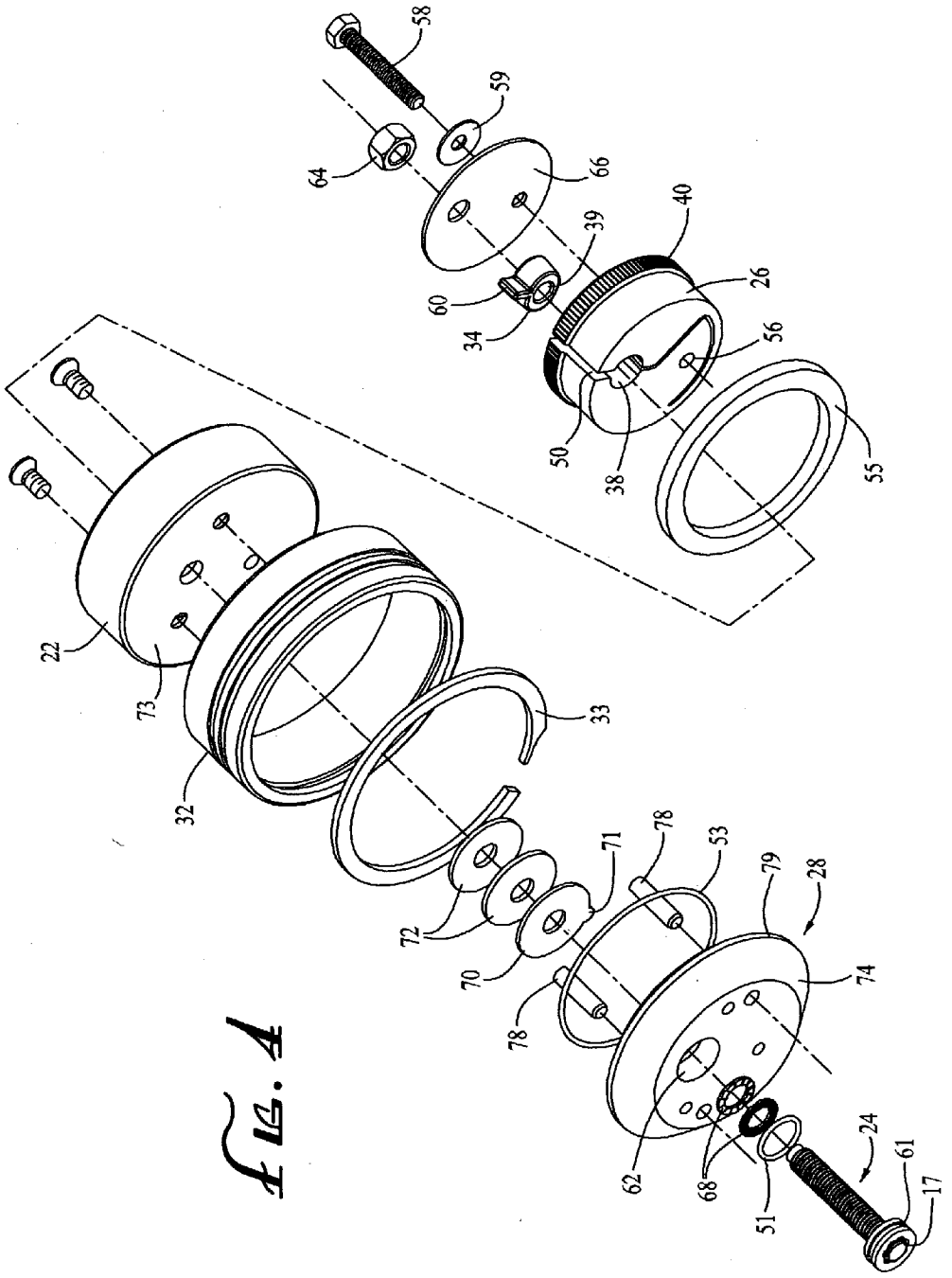

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FIG. 4

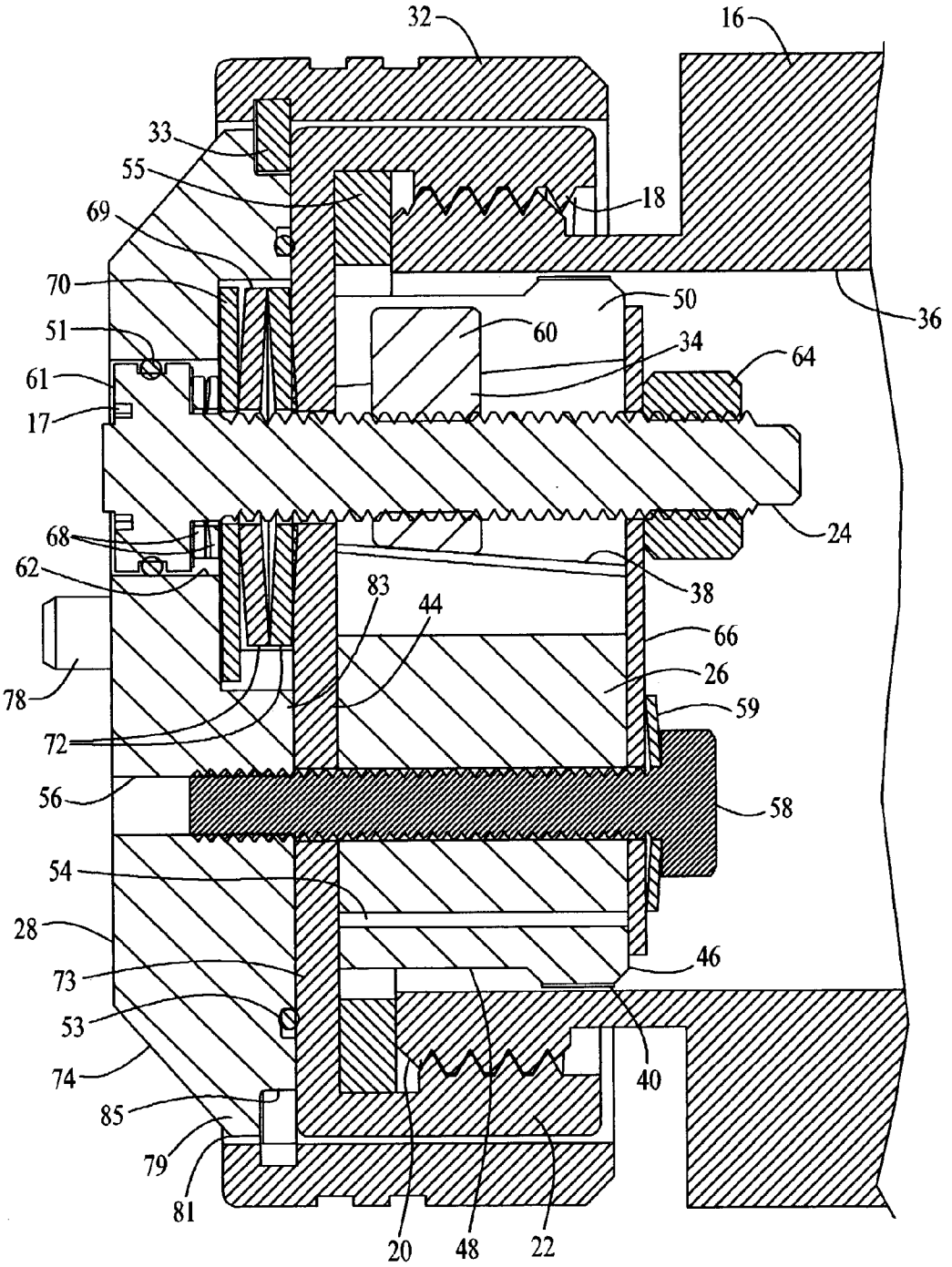
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FIG. 5

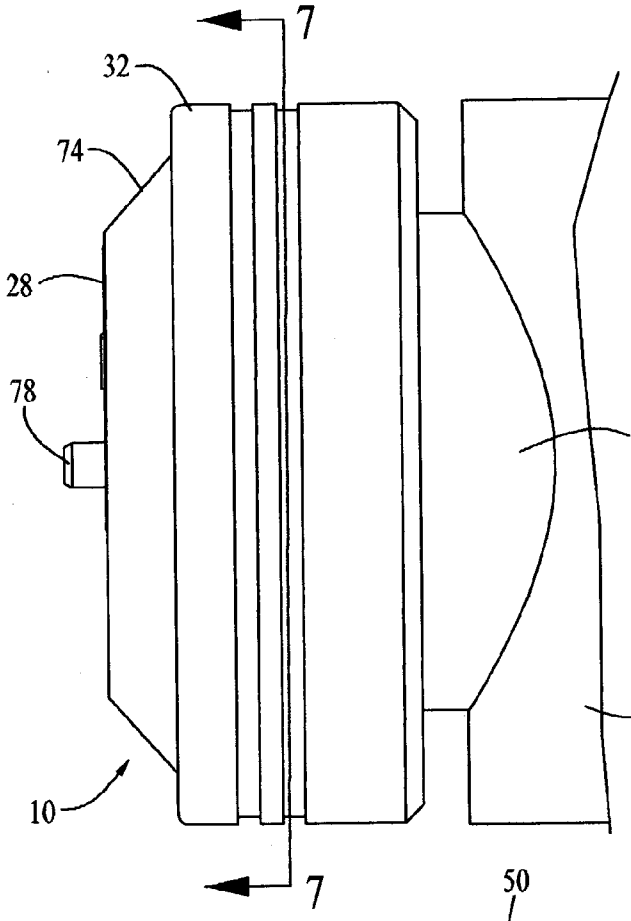

FIG. 6

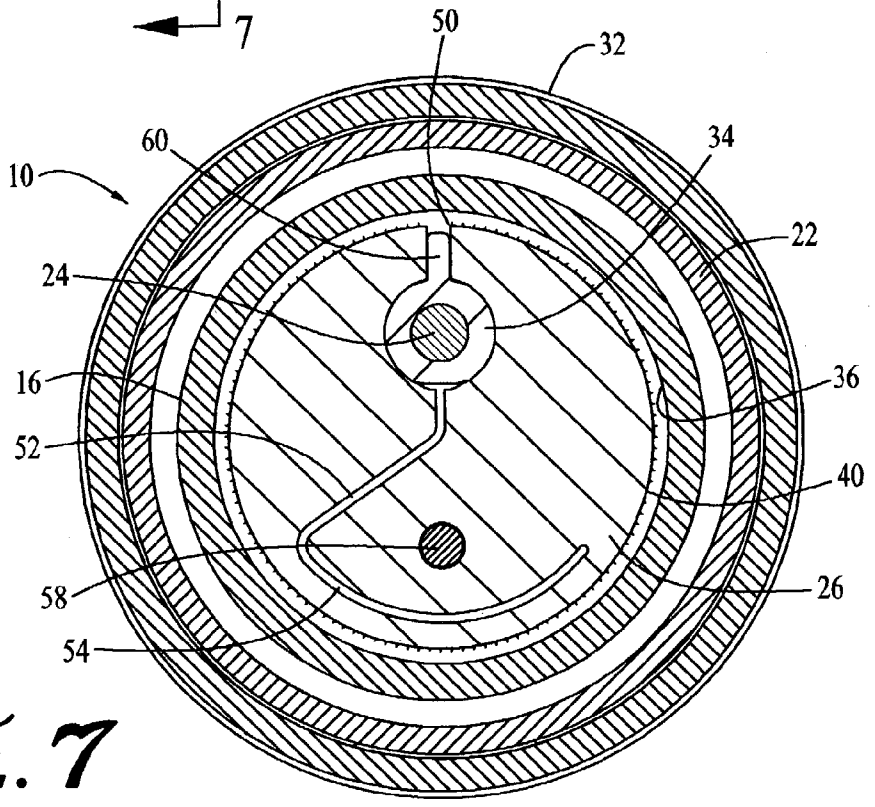

FIG. 7

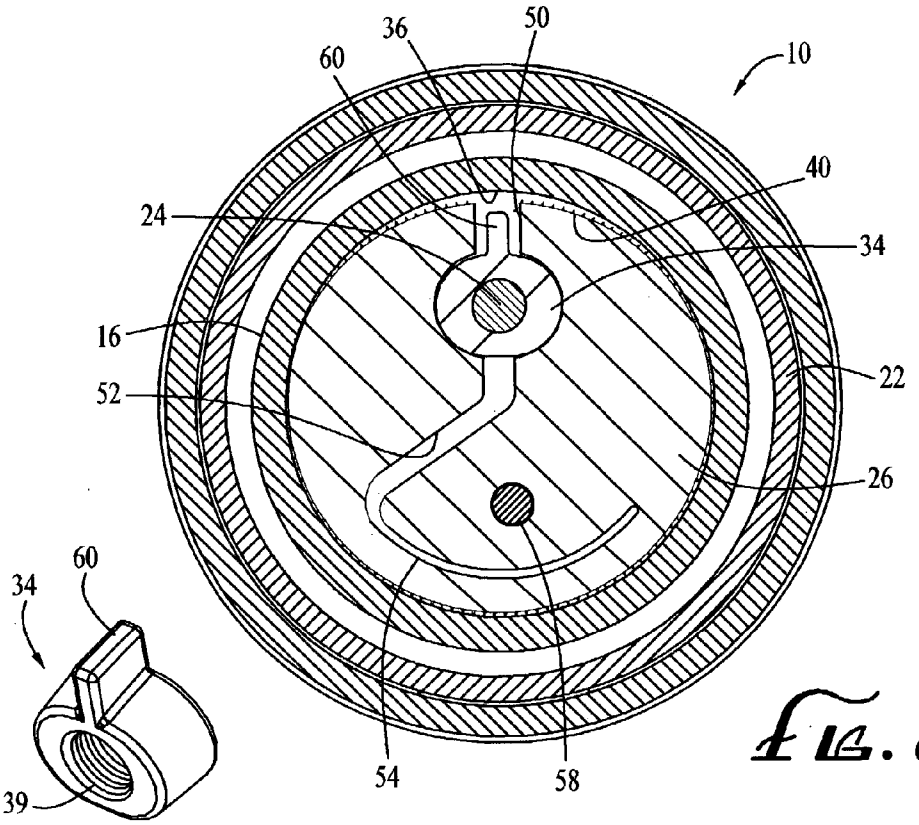

FIG. 8

FIG. 11

Fig.10

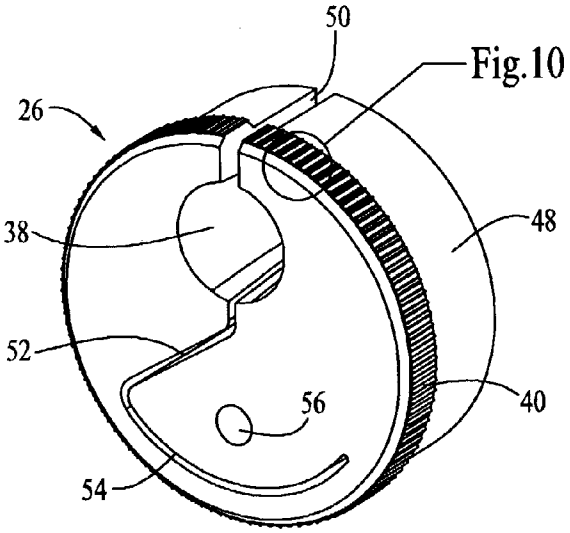

FIG. 9

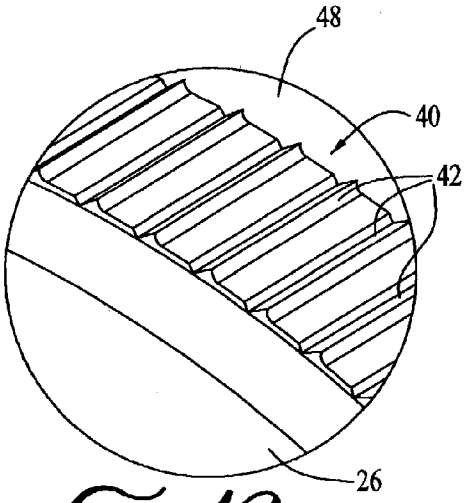

FIG. 10

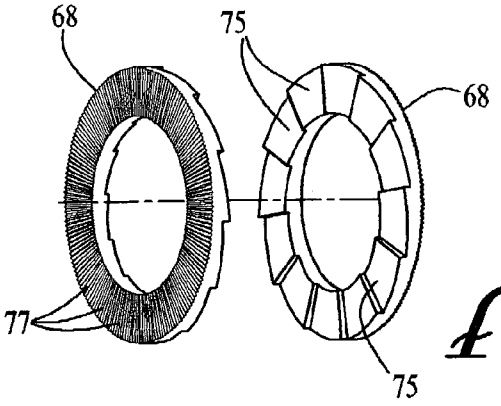
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FIG. 12

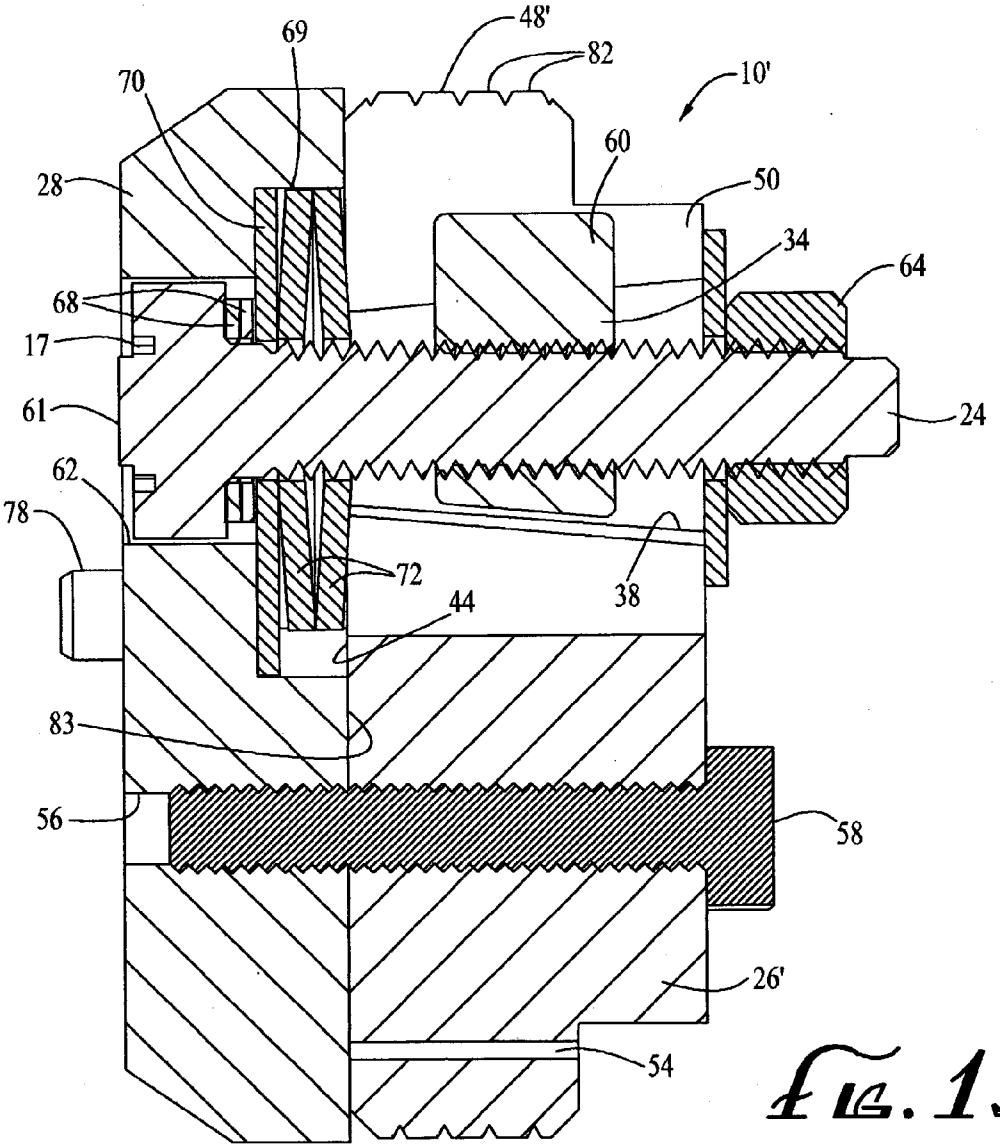
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FIG. 13

LOCKING CAP SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] The present invention generally relates to a locking cap and key combination for open ends of plumbing components and, more specifically, to a protective locking cap and key combination for threaded openings in couplings, fixtures and the like, such as fire retardant sprinkler systems utilizing charging pipes.

[0005] 2. Description of the Related Art

[0006] In fire department connections, such as hydrants, pipes of all sorts and protection systems that include automatic sprinkler systems having multiple sprinkler heads, the standing water supply is often not sufficient to maintain optimum operating water pressure for many reasons including when there are several sprinkler heads in simultaneous operation. Therefore, local laws and ordinances, as well as the National Fire Protection Association Code require a connection through which a fire department can hook up a hose, for example, to draw water or pump water into the sprinkler system in order to charge or recharge the sprinkler system. Where such fire department connections are provided, upon arrival of fire department personnel, a hose hook up, such as an auxiliary source of water from a fire truck pump, may be connected to a connection located inside or outside a building. Such hose connections come in different configurations and may have external or internal threads sized and dimensioned to match the external or internal threads of various hoses of local fire departments.

[0007] The above-described systems, as well as other fire department connections on, near, or in buildings, are equipped with plugs or caps. Furthermore, because the hose connections are many times in public locations which may be unsecured, the plugs or caps must be used to reduce the likelihood that anyone will accidentally or deliberately damage or remove the connections, or otherwise render the connections unusable. Thus, the plugs or caps cover the inlet to the connections to prevent accidental or malicious damage or introduction of trash or other debris. Such damage, trash or debris might render the connection inoperative when it is most needed.

[0008] Many types of caps or plugs have heretofore been provided for use on hydrants, standpipes, and the like to cover the threaded connections and protect the integrity and operability of the systems to which the connections are attached.

[0009] Common devices for use on connections include metal or plastic caps or plugs screwed onto external or internal threads of a pipe connection by special tools, and which can only be removed by use of the special tools. Other devices include key operated locks for locking cap. While it is advantageous to prevent vandals and the like from removing the locking cap, the locking caps are configured with a unique locking mechanism which allows the fire department, or other authorized personnel, to use a single key to unlock every locking cap.

SUMMARY OF THE INVENTION

[0010] Accordingly, a locking cap assembly is desired for a standpipe that can be securely mounted so that it is not easily removed by unauthorized personnel. Additionally, such a locking cap desirably is quickly removed by authorized personnel under time pressures and mental anxiety. Moreover, such a locking cap assembly should be relatively impervious to climatic elements such that deterioration over time is reduced.

[0011] Thus, the present invention provides a locking cap assembly operable by a special key to prevent removal without substantial destruction thereof, but which is not susceptible to inadvertent breakage. Moreover, the locking cap assembly is easily removed at the appropriate time by authorized personnel utilizing a specially designed mating key arrangement. Furthermore, another aspect of the present invention provides a novel lockable cap and plug design which is easily and economically fabricated, and which is easily attached to secure a fire department connection.

[0012] One feature of the present invention is the universal nature of the key and locking cap assembly. While it is advantageous to prevent vandals and the like from removing the locking cap assembly, the locking cap assembly is configured with a unique locking mechanism which allows the fire department, or other authorized personnel, to use a single key to unlock every locking cap assembly within their jurisdiction. This capability may prove important during crisis situations requiring rapid response. Specifically, the use of a single key eliminates the need to rifle through a variety of keys to find the proper key to remove a specific locking cap assembly. Additionally, locking cap assemblies according to the present invention may be serialized to allow a fire department or other entity to track their location in the event of a lost, stolen or otherwise transferred locking cap assembly.

[0013] One aspect of the present invention involves a locking cap assembly for an externally threaded pipe end. The locking cap assembly includes a faceplate and an expandable plug element. The faceplate has a front face and a rear face, while the plug element has a front surface, a rear surface and a peripheral surface. An interstitial expansion slot extends longitudinally between the front surface and the rear surface of the plug element, and it extends radially from approximately the center of the plug element to the peripheral surface. The interstitial expansion slot is intersected by a tapered longitudinal bore. The plug element is sized and configured to be received by the pipe end. The bore receives a locking mechanism comprising a longitudinally translatable spreader element that is operable to spread the plug element. The spreader element is longitudinally translatable within the bore between a first position and a second position to expand the plug element. In a preferred embodiment, the spreader element is a taper nut that is threaded on a locking bolt extending through the bore. At least one surface of the taper nut or the bore is tapered to enable the taper nut and the bore to cooperate to expand and contract the plug element as the taper nut is moved within the bore by the rotation of the locking bolt.

[0014] Another aspect of the present invention involves a locking cap assembly for a tubular opening. The locking cap assembly generally comprises a cap body having an expandable element and a spreader element or taper nut. The expandable element and the taper nut include sloping engagement portions such that relative axial movement of the expandable element and the spreader element results in radial displacement of at least a portion of the expandable element. The radial displacement of the portion of the expandable element urges the expandable element into a frictional and/or mechanical interlock with an inner surface of the opening.

[0015] Yet another aspect of the present invention involves a locking cap assembly for a pipe end generally comprising a faceplate secured to a plug portion. The faceplate includes a front face and at least two pins projecting from the front face. The faceplate also has a back face and is connected to the plug portion such that the back face of the faceplate is proximate a surface of the plug portion. At least a portion of the plug portion is capable of selective expansion and contraction to create a frictional interlock between the locking cap assembly and the pipe end.

[0016] Another aspect of the present invention involves a locking cap assembly for an open end of a tubular structure. The locking cap assembly generally comprises a radially expandable plug element and a locking bolt. The locking bolt has a first end and a second end with the first end of the locking bolt having a keyed socket configuration and cooperating control washers. The second end of the bolt extends through the expandable plug element into the tubular structure. The locking bolt is rotatable relative to the expandable plug element, and it is operatively connected to a spreader element that, in turn, operates to selectively expand and contract the plug element. Specifically, the rotation of the locking bolt in a first direction operates the spreader element so as to effect a generally outward movement (expansion) of the radially expandable plug element, while rotation of the locking bolt in the opposite direction operates the spreader element so as to effect a generally inward movement (contraction) of the radially expandable plug element.

[0017] A particular advantage of the present invention is that the locking action is enhanced by a pair of specially-configured lock washers that are carried on the locking bolt, and by a pair of Bellville washers, likewise carried on the bolt, that apply an axial compression force to the lock washers through a pressure plate located on the bolt between the Bellville washers and the lock washers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other features, aspects and advantages will now be described with reference to drawings of a particular preferred embodiment which is intended to illustrate and not to limit the present invention and in which:

[0019] **FIG. 1** is a perspective illustration of an exemplary fire department connection having a locking cap assembly in accordance with a preferred embodiment of the present invention;

[0020] **FIG. 2** is a rear perspective view of a locking cap assembly in accordance with a preferred embodiment of the present invention;

[0021] **FIG. 3** is a perspective view of a key in accordance with the present invention.

[0022] **FIG. 4** is an exploded perspective view of a preferred embodiment of the locking cap assembly of the present invention;

[0023] **FIG. 5** is a cross sectional view of the locking cap assembly of **FIG. 4** mounted on a fire department connection;

[0024] **FIG. 6** is a partial side elevational view of the locking cap assembly mounted on a fire department connection;

[0025] **FIG. 7** is a cross-sectional view taken along line **7-7** of **FIG. 6**, with the locking cap assembly in the open or unlocked position;

[0026] **FIG. 8** is a cross-sectional view similar to **FIG. 7**, with the locking cap assembly in the closed or locked position;

[0027] **FIG. 9** is a rear perspective view of the expandable element of the locking element of the locking cap assembly;

[0028] **FIG. 10** is an enlarged perspective view of the novel knurl or toothed portion on the expandable element shown in **FIG. 9**;

[0029] **FIG. 11** is a perspective view of a taper nut of the present invention;

[0030] **FIG. 12** is a perspective view of a pair of lock washers as used with the locking bolt of the present invention; and

[0031] **FIG. 13** is a cross sectional view of a second preferred embodiment of a locking cap assembly of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] The following description is provided to enable any person skilled in the art to make and use the invention, and it sets forth best modes contemplated by the inventors of carrying out their invention. Various modifications, however, will remain readily apparent to those skilled in the art, since the generic principles of the present invention have been defined herein specifically to provide for a novel and improved locking cap assembly for a fire department connection.

[0033] Referring now to FIGS. **1-12** of the drawings, there is shown a locking cap assembly **10** attached to an open pipe end **16** (**FIG. 5**) of a fire department connection **12**. The open pipe end **16** may have external or internal threads for attaching fire hose or the like. The locking cap assembly **10** is secured to the pipe end **16** in engagement with the threads on the pipe end. The locking cap assembly **10** is operated by a special key **14** with an end having a patterned projection **15** (**FIG. 3**) that fits into a specially-configured socket or receptacle **17** that is exposed through a faceplate **28**, as described below. Thus, the cap assembly **10** can be removed only by authorized personnel to protect the fire department connection opening **16**, or other similar openings, from intentional or accidental damage or the introduction of debris.

[0034] It is understood, however, that a locking cap assembly having features, aspects and advantages in accordance with the present invention may also find utility in a variety

of other contexts. For instance, but without limitation, the locking cap assembly **10** may protect valves, pipes, connections, fittings and various other components having an open end subject to tampering or unauthorized access. Such components may be used in industries such as, for example but without limitation, those related to petrochemicals, chemicals, pharmaceuticals, and food or dairy processing. For instance, a locking cap assembly, in accordance with the present invention, may provide a way of securing an open pipe end in a petroleum line that may reduce or eliminate unauthorized access to such an opening **16**.

[**0035**] Referring now to **FIGS. 1, 2, 4** and **5**, a locking cap assembly **10**, in accordance with a preferred embodiment of the invention, is shown inserted into an open end **16** of an outlet pipe, valve, connection, fitting or other similar component. The locking cap assembly **10** is preferably rotated into its place via threads **18**, **20** formed externally of the open end **16** and internally of a cap member **22**. Notably, as will be discussed below, the locking cap assembly **10** fits over and extends within the open end **16**. Once the cap assembly **10** is in place, the key **14** (**FIGS. 1 and 3**) is used to lock the locking cap assembly **10** in position, as described below. Various locking mechanisms may be used; however, a presently preferred expanding positive axial friction interlock will be described in detail below. When access to the open end **16** is desired or required, the key **14** is used to quickly unlock the locking cap assembly **10** for easy removal.

[**0036**] The locking cap assembly **10** provides a selectively lockable closure for the open end **16** of a fire department connection **12**. A locking bolt **24**, described in detail below, has an outer end terminating in the socket or receptacle **17** into which the key **14** fits. Thus, the patterned projection **15** of the key **14** and the mating socket **17** of the locking bolt **24** are desirably formed with as a mating lug and socket type combination.

[**0037**] The locking cap assembly **10** generally comprises the cap member **22**, an expandable plug element **26**, and the faceplate **28**. Both the cap member **22** and the expandable plug element **26** of the locking cap assembly **10** are sized and dimensioned for insertion into the open end **16**. The cap member **22** desirably has internal threads **20** along a portion thereof, although other non-threaded configurations may also have features in accordance with the present invention. An annular cover or housing **32** surrounds the exterior of the cap member **22**, and is secured to the faceplate **28** and the cap member **22** by means of a snap-ring **33** captured between the faceplate **28** and the cap member **22**.

[**0038**] The cap assembly **10**, as shown in **FIGS. 1, 2** and **4-12**, has a locking mechanism generally comprising the locking bolt **24**, the expandable plug element **26**, and an expander element that is preferably in the form of a taper nut **34** that is threaded onto the locking bolt **24**. These elements cooperate to selectively urge the expandable plug element **26** outwardly into abutment with an inner wall **36** of the open end **16**, and to allow the plug element to contract so as to disengage from the inner wall **36**. Specifically, the taper nut **34** is threaded onto the locking bolt **24**, which, in turn, extends through a longitudinal bore **38** formed in the expandable plug element **26**. The taper nut **34** is constrained from rotation relative to the axis of the bore **38** by means to be described below. Thus, as the locking bolt **24** is rotated, the taper nut **34** is translated longitudinally within the bore **38**. Because of a cooperative taper between the taper nut **34** and the bore **38**, the longitudinal translation of the taper nut **34** in the bore **38** causes the expandable plug element **26** either to expand outwardly or to contract inwardly. More specifically, the expandable plug element **26** is resiliently expanded outwardly from a nonbiased, unexpanded position by the forward (i.e., toward the faceplate **28**) movement of the taper nut **34** in the longitudinal bore **38** formed in the expandable plug element **26**. Likewise, the expandable plug element **26** is allowed to resiliently contract inwardly (i.e., resiliently return to its natural, unexpanded configuration) as the taper nut **34** moves rearward (i.e., away from the faceplate **28**) within the bore **38**.

[**0039**] The expandable plug element **26** of the locking cap assembly **10** may have many shapes and configurations. For instance, the expandable plug element **26** may be conical, rectangular, spherical, hemispherical or tubular in nature. However, in the presently preferred embodiment, the expandable plug element **26** is substantially cylindrical. The cylindrical configuration advantageously increases the contact surface area between the expandable plug element **26** and the inner wall **36** of the open end **16**, as compared to most other configurations. Specifically, as the expandable plug element **26** is displaced outwardly into contact with the inner wall **36** of the open end **16**, the contact surface area is increased due to the arcuate exterior surface defined by the cylindrical configuration.

[**0040**] As best shown in **FIGS. 2, 4, 5** and **7-10**, at least a portion of the outside diameter of the expandable plug element **26** has a peripheral surface **48** that includes a knurled or toothed portion **40** formed thereon. As best shown in **FIGS. 9 and 10**, this knurled portion **40** includes pointed or sharpened teeth **42**, which are formed or machined in a saw-toothed configuration, such that when they come into contact with a surface, such as the inner wall **36**, they will restrict rotational movement in a counter-clockwise direction, by continually digging deeper into the inner wall **36** as more torque is applied.

[**0041**] The expandable plug element **26** may be formed of any suitable material utilizing any number of well known machining techniques, including but not limited to milling, drilling, turning and the like. Additionally, the expandable plug element **26** may be forged, molded, or cast depending upon the characteristics of the material selected for use. The selection of the material used desirably accounts for the material properties and attempts to reduce corrosion. As will be recognized, the material selected for use may be a high strength polymer or metal, for instance. It is understood that corrosion in metal-on-metal contacts may be reduced by the use of a protective, corrosion-resistant metal coating, such as zinc, tin, lead, nickel, or copper, by producing a coating of oxide, phosphate, or a similar coating on any iron and/or steel surfaces, or by utilizing protective paints to render the metal surface passive. In the presently preferred embodiment, the expandable plug element **26** is made from stainless steel for added strength.

[**0042**] The expandable plug element **26** generally has a front surface **44**, a rear surface **46** (see **FIG. 5**), and a peripheral surface **48** having the knurl **40** thereon. The expandable plug element **26** may be sized and configured for easy insertion into the opening **16** that is to be capped. The

expandable plug element **26** preferably has a major outside diameter, in its relaxed or contracted state, that is advantageously slightly smaller than the inside diameter of the open pipe end **16** into which it is to be inserted. This allows the expandable plug element **26** to be inserted into open pipe end **16** as the cap member **22** is threaded onto the exterior of the open pipe end **16** by means of the threads **18**, **20** (see **FIG. 5**).

[**0043**] The peripheral surface **48**, including the knurled portion **40**, may be of any desired length from the front surface **44** to the rear surface **46**. As is known, the threads **18**, **20** of the cap **22** and the fire department connection **12** may be of any suitable size and configuration. Advantageously, the threads would be configured according to local fire department specifications. Additionally, as is known, at least three threaded turns are desired; however, any number of threads **18** acceptable for the specific application may be provided on the cap member **22**. Moreover, depending upon the application, more than one set of threads may also be used. For instance, two half turn threads may provide about the same holding force as a single thread, but will require only a half turn to remove the locking cap assembly **10**.

[**0044**] The expandable plug element **26** is sized and dimensioned to allow the locking cap assembly **10** to be fully tightened into position without harming the open pipe end **16**. In one embodiment, the overall length (or thickness) of the expandable plug element **26** is between about 0.75 in. and about 1.25 in. More preferably, the overall length is about 1.00 in.

[**0045**] The threads **18** on the cap member **22** are preferably matched to the external threads **20** of the open pipe end **16**. Such a configuration reinforces the external threads **20** of the open pipe end **16** such that the threads **20** are less likely to be deformed or damaged when the locking cap assembly **10** is locked into position. Additionally, when the locking cap assembly **10** is locked into place, the open pipe end **16** is reinforced and internally supported by the material forming the locking cap assembly **10**, such that the open end **16** is unlikely to be deformed if dealt blows by a pipe wrench or the like. Moreover, the intermeshed threads **18**, **20** maintain the threads **18** of the open pipe end **16** substantially clear once the locking cap assembly **10** is removed, such that the open pipe end **16** is maintained in better working condition (i.e., less corrosion and debris as compared to standard or missing caps or covers).

[**0046**] The expandable plug element **26** has a longitudinally extending interstitial expansion slot **50** extending radially outwardly from approximately the center of the plug element **26** to its peripheral surface **48**. As shown, the interstitial slot **50** extends through the longitudinal axis of the expandable plug element **26**, although it may be offset to either side. The interstitial expansion slot **50** is intersected by the tapered longitudinal bore **38**. The radially inner end of the interstitial expansion slot **50** connects with a radially inner end of a first relief slot **52** that extends radially outwardly from the center of the plug element **26**, but not all the way to the peripheral surface **48** of the plug element **26**. The first relief slot **52** advantageously forms an obtuse angle with the interstitial expansion slot **50**. The radially outer end of the first relief slot **52** connects with a first end of a second relief slot **54** that extends in a circumferential direction to a second end. The second relief slot **54** advantageously subtends an arc of between about 45° and about 90°. The slots **50**, **52**, and **54** may be formed by any suitable process, such as machining, drilling, electrochemical machining, etc. The relief slots **52**, **54** allow the material of the expandable plug element **26** to flex without exceeding its elastic limit. For instance, the expandable plug element **26** preferably provides a hard peripheral surface **48** with the knurled portion **40** that is displaced outwardly in an elastic deformation of the expandable plug element **26**, so that the teeth **42** are wedged against the inner wall surface **36** of the pipe opening **16** into which the locking cap assembly **10** is inserted. Due to the elastic springing action of the plug element **26** and the knurled portion **40** in its hard peripheral surface, the expandable plug portion **26** provides an advantageously non-deforming locking element. Accordingly, the width and length of the relief slots **52**, **54** are partially dependent upon the modulus of the material selected for the expandable plug element **26**. Additionally, the juncture between the relief slots **52**, **54** is preferably arcuate, as is at least one of the slots (i.e., the second relief slot **54**) for better distribution of the bending stresses throughout the material of the expandable plug element **26**.

[**0047**] As best illustrated in **FIGS. 4 and 5**, the cap assembly **10** includes O-ring seals **51**, **53** in the faceplate **28**, and a sealing ring **55** between the cap member **22** and the expandable plug element **26**. A continuous passage **56**, at least a portion of which is internally threaded, is provided through the expandable plug element **26**, the cap member **22**, and the faceplate **28**. The passage **56** receives a threaded fastener **58**, such as a bolt, to connect the expandable plug element **26** to the cap member **22** and the faceplate **28**. The fastener or bolt **58** may be used with an optional washer **59**. The passage **56** allows the threaded fastener or bolt **58** to pass through the plug element **26**, and to fasten the cap **22** and the faceplate **28** to the expandable plug element **26**. The outermost end of the passage **56** (i.e., the empty portion in the faceplate **28**) may the optionally be filled with epoxy or the like (not shown) to seal the passage **56** for protection from the elements and tampering. Moreover, if the faceplate **28** is directly attached to the cap member **22** and/or the expandable plug element **26** in another manner (e.g., welded in a manner that still allows the expandable plug element **26** to flex) the passage **56** may be omitted.

[**0048**] The tapered bore **38** provides a channel in which the taper nut **34** travels. The closer to the peripheral surface **48** (i.e., the circumference) that the tapered bore **38** is positioned a long the interstitial expansion slot **50**, the less leverage is required to spread the expandable plug element **26** by movement of the taper nut **34**. On the other hand, a sufficient thickness of material should remain between the tapered bore **38** and the peripheral surface **48** to reduce the likelihood of failure through the peripheral surface **48**. The maximum diameter of the tapered bore **38** desirably ranges from about 0.5 in. to about 0.75 in.

[**0049**] The tapered bore **38**, because it provides a channel for the taper nut **34**, has a cooperatively-tapered internal diameter that may be tapered in either longitudinal direction, but preferably with the larger diameter at the rear surface **44**. It should be appreciated, however, that the taper nut **34** could travel in a non-tapered channel and achieve a similar effect or vice versa. In other words, the wide end of the tapered bore **38** can be arranged at either the front surface **44** or the rear surface **46** of the expandable plug element **26**. However

configured, the arrangement of the components preferably results in a loosening counterclockwise rotation of the locking bolt **24** and a tightening clockwise rotation of the locking bolt **24**, such that the locking cap assembly **10** substantially conforms to standardized fastening arrangements. The tapers of the bore **38** and/or the nut **34** are desirably configured to allow the necessary outward expansion with the amount of travel provided for the taper nut **34**. In other words, the taper desirably allows the necessary expansion of the expandable plug element **26** when the nut **34** is translated from a first position to a second position within the bore **38**.

[**0050**] With continued reference now to **FIG. 5**, the taper nut **34** and the locking bolt **24** will now be described in detail. As described above, the taper nut **34** translates within the tapered bore **38** under the control of the locking bolt **24** to effect expansion and contraction of the expandable plug element **26**. This controlled translation affords positive control of the expansion and contraction of the expandable plug element **26**. Accordingly, preferred materials for the taper nut **34** are generally those that will not substantially gall or corrode within the tapered bore **38**. The presently preferred material for the taper nut **34** is a hard, polished metal, such as an investment cast **316** stainless steel.

[**0051**] The taper nut **34** advantageously has a tapered or sloping surface, or a flat surface that cooperates with the tapered or sloping surface of the tapered bore **38**. As described above, the interacting surfaces of the nut **34** and bore **38** result in the expansion or contraction of the expandable plug element **26** about the interstitial expansion slot **50** when the locking bolt **24** is rotated.

[**0052**] The taper nut **34** is translated longitudinally within the tapered bore **38** by the rotation of the locking bolt **24**. The taper nut **34** preferably has a threaded-through hole **39**, and a blade-like lateral extension **60** that is captured in and that rides in the expansion slot **50**. The extension **60** can freely travel longitudinally within the interstitial slot **50** while also constraining the taper nut **34** against rotation within the bore **38** relative to the expandable plug element **26**. The extension **60** may be any suitable size or shape consistent with the configuration and dimensions of the interstitial expansion slot **50** in which it fits.

[**0053**] The through hole **39** of the taper nut **34** is sized to be threaded onto the threaded shank of the locking bolt **24**. The pitch of the threads in the taper nut hole **39** and on the locking bolt shank may be between about 32 threads per inch and about 13 threads per inch, but the presently preferred pitch is about 16 threads per inch. At this pitch, when combined with the preferred inclination angles, the locking cap assembly **10** may advantageously be locked into an open pipe end **16** with two or more turns (preferably about three turns) of the locking bolt **24**.

[**0054**] With continued reference to **FIG. 5**, the locking bolt **24** has a head **61** that is received in an opening **62** in the front of the faceplate **28**, while the threaded shank of the locking bolt **24** extends through the faceplate **28**, the cap **22**, the tapered bore **38**, the threaded through hole **39** of the taper nut **34**, and a securing nut **64** that secures the locking bolt **24** to a back plate **66** on the rear (inner) surface of the expandable plug element **26**. The exposed outer surface of the bolt head **61** is formed with the above-described receptacle or socket **17** that mates with the patterned projection **15** on the key **14**. A washer (not shown) may optionally be employed between the securing nut **64** and the back plate **66**.

[**0055**] The locking bolt **24** and the taper nut **34** are parts of a locking mechanism for the locking cap assembly **10** that will now be described in detail, with particular reference to **FIG. 5**. Contained within the opening **62** in the faceplate **28**, and seated behind the bolt head **61**, are two co-engaged, complementary lock washers **68**. The two lock washers **68**, as described below, are preferably of the type marketed under the trademark Nord-Lock®D. An enlarged-diameter cut-out on the back side of the faceplate **28** communicates with the opening **62** and is dimensioned to receive a compression mechanism. In a preferred embodiment, the compression mechanism comprises a pressure plate **70** having a tab **71** (**FIG. 4**) to prevent rotation, and a compression element configured and located so as to apply pressure to the pressure plate **70**. In a preferred embodiment, the compression element comprises two opposing compression washers **72**, of the type commonly called "Bellville washers". The pressure plate **70** provides a surface against which the lock washers **68** are seated. The opposing Bellville washers **72** are seated between the pressure plate **70** and a forward end plate **73** of the cap member **22**. It will be appreciated that other types of compression elements, such as, for example, a coil spring, may be adapted for use in the present invention.

[**0056**] As the locking bolt **24** is turned clockwise, the taper nut **34**, being restrained against rotation by the engagement of the taper nut flag **60** in the interstitial expansion slot **50**, is drawn forward on the locking bolt **24** within the tapered bore **38**, or toward the cap member **22** and the faceplate **28**, and it thereby expands the expandable plug element **26**, in the manner described above, inside the open pipe end **16**. The locking bolt **24** gets harder to turn as the knurled teeth **42** of the expandable plug element **26** dig into the interior wall surface **36** of the open pipe end **16**, as shown in **FIG. 8**. Moreover, as the lock bolt **24** is turned clockwise, it begins to compress the Bellville washers **72**. As the Bellville washers **72** are compressed, they apply an axial compression against the lock washers **68** through the pressure plate **70**. This is considered the locked condition, illustrated in **FIG. 8**.

[**0057**] As best shown in **FIG. 12**, each lock washer **68** has one side with an array of inclined cams **75** arranged circumferentially. Each of the cams **75** preferably has a greater rise than the pitch of the threads of the locking bolt **24**. On the opposite side, each lock washer **68** has an array of radial teeth **77**. The lock washers **68** are installed as a mating pair, cam face to cam face. When the locking bolt **24** is tightened, the radial teeth **77** of the rearward lock washer **68** grip the pressure plate **70**, while the teeth **77** of the forward lock washer **68** engage the underside of the head **61** of the locking bolt **24**. Therefore, the radial teeth **77** lock the lock washers **68** in place, allowing movement only across the faces of the cams **75**. The axial compression created by the Bellville washers **72** makes the locking bolt **24** self-locking, which greatly improves the vandal resistance of the locking cap **10**. Specifically, jarring, prying or pounding the lock bolt **24** may tend to move the bolt **24** and the taper nut **34** forward in the bore **38**, thereby loosening the plug element **26** and/or allowing the loosening of the bolt **24** with a reduced amount of torque. The Bellville washers **72** apply an axial force against the pressure plate **70** that is transferred to the locking

bolt **24** and the taper nut **34**, thereby taking up any small axial or longitudinal movements of the taper nut **34** within the taper bore **38** that may result from such pounding, prying, or jarring. Furthermore, the axial pressure or compression applied by the Bellville washers **72** against the pressure plate **70** is transferred to the lock washers **68**, thereby keeping them tightly co-engaged as described above, thereby further inhibiting any inadvertent or unauthorized loosening of the locking bolt **24**. Thus, to unlock the cap assembly **10**, an increased amount of torque is required to turn the locking bolt **24** to overcome the camming action of the lock washers **68**.

[**0058**] With reference now to **FIGS. 4 and 5**, the faceplate **28**, in addition to being decorative and capable of receiving various finishes and colors, protects the inner workings of the locking cap assembly **10**. The faceplate **28** generally has a front surface and a back surface. In some configurations, the faceplate **28** may have an exposed side surface when installed. For instance, the faceplate **28** may take on any of a variety of shapes, including, but not limited to, conical, cylindrical, spherical, hemispherical, or any of a number of more complex configurations. In the illustrated embodiment, the faceplate **28** has a chamfered exposed side surface **74**, providing the faceplate **28** with the configuration of a truncated right frusticone extending from a short cylindrical base **79** having an annular peripheral surface **81**. The peripheral surface **81** of the base **79** is covered by the housing **32**. The base **79** has a bottom (rearward-facing) surface **83** that forms the back face of the faceplate **28**, and it is formed with an annular peripheral groove **85** that receives and holds the ring **33**. The chamfered side surface **74** of the presently preferred faceplate **28** allows the exposed thickness of the faceplate **28** to be greater than the cylindrical base **79**.

[**0059**] The faceplate **28** also has preferably two pins **78** (or at least one such pin **78**) that extend forward from the front surface of the faceplate **28**. The pin or pins **78** allow gloved personnel to effectively grip the locking cap assembly **10** to remove the locking cap assembly in all weather conditions and during extreme heat such as that encountered during fires. Additionally, where the locking cap **10** has been painted over or corroded, the pins **78** allow a specially designed key handle **80** with apertures **84** dimensioned and located to receive the pins **78** (see **FIG. 3**), to engage the faceplate **28** so as to provide additional leverage to initiate its rotation.

[**0060**] Turning now to **FIG. 13**, there shown is a second embodiment of the invention **10'** for use with an internally-threaded open pipe end (not shown). The locking cap assembly **10'** comprises substantially the same elements as the previously-described locking cap assembly **10**, except for the lack of the cap member **22** and the outside housing **32**. Additionally, the locking cap assembly **10'** includes an expandable plug portion **26'** having a peripheral surface **48'** with external threads **82** formed on it. The peripheral surface **48'** may be stepped. The threads **82** engage with internal threads (not shown) in the open pipe end to hold the cap assembly **10'** securely in place, as will be described below. Furthermore, since the rear face **83** of the faceplate **28** and the front surface **44** of the expandable plug portion **26'** are in direct, contacting engagement, the rear-most one of the pair of opposing Bellville washers **72** will be in direct contact with the plug portion front surface **44**, and depending on the size of the tapered bore **38** at the front surface, a portion of such a Bellville washer may extend into the tapered bore **38**.

[**0061**] The operation of the locking bolt **24** and expansion of the expandable plug portion **26'** will be similar to that of the embodiment described above. However, instead of being in contact with a smooth inner wall, the exterior threads **82** will contact the internal threads (not shown) in the open pipe end. Specifically, the plug portion **26'** is threaded into the open pipe end in its normal or contracted configuration. The locking bolt **24** is then rotated, as described above, to move the taper nut **34** forward in the tapered bore **38** to expand the expandable plug portion **26'**. As a result of this expansion, the external threads **82** of the plug portion **26'** are jammed into the internal threads of the open pipe end, making it extremely difficult to rotate the expandable plug portion **26'**, and hence the cap assembly **10'**, relative to the pipe end.

[**0062**] As will be apparent to those of ordinary skill in the art, various other configurations of locking cap assemblies are possible which use the broad concept of a locking cap assembly that is secured to a pipe end using a key and lock actuator member. Accordingly although the present invention has been described in terms of a certain preferred embodiment, other embodiments apparent to those of ordinary skill in the art, including embodiments that do not provide all of the benefits, aspects and features set forth herein, are also considered to be within the scope of the present invention. Thus, the scope of the present invention is intended to be defined only by the claims that follow.

What is claimed is:

1. A locking cap assembly for an open pipe end having an interior wall surface, the assembly comprising:

an expandable plug element having a front surface, a rear surface and a peripheral surface, the expandable plug element having an unexpanded outside diameter that is sized to fit into the open pipe end;

a faceplate attached to the plug element and covering the front surface of the plug element, the faceplate having an exposed front surface;

a longitudinal bore extending through the expandable plug element;

a locking bolt having a bolt head exposed through the front surface of the faceplate, and a shank extending through the faceplate and through the bore;

a spreader element operatively connected to the shank of the locking bolt within the bore, whereby the rotation of the locking bolt in a first direction translates the spreader element longitudinally within the bore from a first position to a second position, and whereby the translation of the spreader element in the bore from the first position to the second position expands the expandable plug element into a locking engagement against the interior wall surface of the open pipe end;

a pressure plate carried on the locking bolt between the bolt head and the front surface of the plug element;

pair of co-engaged complementary lock washers carried on the locking bolt between the pressure plate and the bolt head; and

a compression element carried on the locking bolt between the pressure plate and the front surface of the plug element, the compression element being configured and located so as to apply axial pressure against the lock washers and the bolt head through the pressure plate.

2. The locking cap assembly of claim 1, wherein the compression element comprises a pair of compression washers.

3. The locking cap assembly of claim 1, wherein the shank of the locking bolt is threaded, and wherein the spreader element includes a taper nut threaded onto the shank.

4. The locking cap assembly of claim 1, wherein the plug element includes an expansion slot extending longitudinally through the plug element, and radially inwardly from the periphery of the plug element so as to intersect the bore.

5. The locking cap assembly of claim 1, wherein the spreader element is constrained from rotation with the bolt.

6. The locking cap assembly of claim 1, wherein the plug element cooperatively engages the spreader element so as to constrain the spreader element from rotation with the bolt.

7. The locking cap assembly of claim 4, wherein the shank of the locking bolt is threaded, and wherein the spreader element comprises:

a taper nut that is threaded onto the shank of the bolt; and

a lateral extension on the taper nut that is captured in the expansion slot.

8. The locking cap assembly of claim 1, comprising a cap member having internal threads, wherein the cap member is held between the rear face of the faceplate and the front surface of the expandable plug element.

9. The locking cap assembly of claim 2, wherein the pair of compression washers comprises an opposing pair of Bellville washers.

10. The locking cap assembly of claim 1, wherein the expandable plug element includes a peripheral surface with a knurled portion, and wherein the knurled portion includes a pattern of saw tooth-shaped teeth that are configured to dig into the interior wall surface of the open pipe end when the expandable plug element is expanded to bring the knurled portion into contact with the interior wall surface of the pipe end.

11. The locking cap assembly of claim 10, further comprising a cap member having internal threads; the cap member being held between the rear face of the face plate and the front surface of the expandable plug element.

12. The locking cap of claim 1, wherein the rear face of the faceplate and the front surface of the expandable plug element are secured together, and wherein the plug element includes a peripheral surface with external threads formed therein.

13. A locking cap assembly for an open pipe end having an interior wall surface, comprising:

a faceplate having a front face, a rear face and a peripheral edge;

an expandable plug element dimensioned for insertion into the open pipe end, the plug element having a front surface, a rear surface and a peripheral surface;

a slot formed in the expandable plug element and extending longitudinally between the front surface and the rear surface, and radially inwardly from the peripheral surface;

a tapered bore formed in the expandable plug element extending longitudinally between the front surface and the rear surface and intersecting the slot;

a taper nut held in the tapered bore and including a threaded opening and a lateral extension captured in the slot;

wherein the faceplate and the expandable plug element are secured together with a cylindrical cap member held between the rear face of the faceplate and the front surface of the plug element; and

wherein the cylindrical cap member has a side wall surrounding an end plate, and threads formed in the side wall;

a locking bolt having a head and a threaded shank; the head being seated in an opening formed through the faceplate and the threaded shank extending through the cylindrical cap member and the tapered bore and into the threaded opening of the taper nut for longitudinal translation of the taper nut between the front surface and the rear surface upon rotation of the locking bolt; and

a compression mechanism carried on the locking bolt in the opening in the faceplate, between the head of the locking bolt and the end plate, for self-locking of the locking bolt.

14. The locking cap assembly of claim 13 wherein the compression mechanism comprises:

a pair of co-engaged complementary lock washers having adjacent the bolt head; and

a pair of opposing compression washers between the lock washers and the end plate.

15. The locking cap assembly of claim 14, further comprising a pressure plate carried on the bolt shank between the pair of lock washers and the opposing pair of compression washers.

16. The locking cap assembly of claim 15, wherein the pressure plate is constrained from rotation relative to the bolt shank.

17. The locking cap assembly of claim 13, wherein the plug element includes a knurled portion formed on the peripheral surface, whereby, when the plug element is expanded by translation of the taper nut in the bore, the knurled portion is brought into contact with the interior wall surface of the pipe end.

18. The locking cap assembly of claim 17 wherein the knurled portion includes a plurality of saw tooth-shaped teeth configured for digging into the interior wall surface of the pipe end.

19. A locking cap assembly for an open pipe end having an interior wall surface, comprising:

a faceplate having a front face, a rear face and a peripheral edge;

an expandable plug element dimensioned for insertion into the open pipe end having a front surface, a rear surface and a peripheral surface;

a slot formed in the expandable plug element and extending longitudinally between the front surface and the rear surface, and radially inwardly from the peripheral surface;

a tapered longitudinal bore formed through the expandable plug, the bore extending longitudinally between the front surface and the rear surface and intersecting the slot;

a taper nut held in the bore for longitudinal translation therein between first and second positions, and including a threaded opening and a lateral extension captured in the slot;

the faceplate and the expandable plug element being secured together with the rear face of the faceplate and the front surface of the expandable plug element being held together;

a locking bolt having a head and a threaded shank; the head being held in an opening formed between the front face and the rear face of the faceplate, and the threaded shank extending through the tapered bore into the threaded opening of the taper nut for longitudinal translation of the taper nut between the front surface and the rear surface of the plug element in response to rotation of the locking bolt;

a pair of co-engaged complementary lock washers carried on the locking bolt shank in the opening in the faceplate, one of the lock washers being in contact with the head of the locking bolt; and

a compression element carried on the shank of the locking bolt between the lock washers and the front surface of the plug element, the compression element being located and configured to apply axial pressure against the lock washers.

20. The locking cap assembly of claim 19 wherein the each of the lock washers has a first surface with a circumferential array of inclined cams, and a second surface with an array of radial teeth, wherein the lock washers are arranged on the shank of the locking bolt with the cams on their respective first surfaces co-engaged.

21. The locking cap assembly of claim 19, wherein the compression element comprises an opposed pair of compression washers arranged between the lock washers and the front surface of the plug element.

22. The locking cap assembly of claim 20, further comprising a pressure plate held on the shank of the locking bolt between the pair of lock washers and the opposed pair of compression washers.

23. The locking cap assembly of claim 21, wherein the compression washers are Bellville washers.

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