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LOCKING PLIERS AND OTHER GRIPPING TOOLS

Abstract

A tool comprising an outer body with a first end and a second end, the outer body defining a longitudinal recess therein and having at least two connector link pivot points at the first end thereof, an inner body slidably received within the longitudinal recess of the outer body and having a core head extending out of the first end of the outer body, at least two jaws, each jaw having an inner pivot point and an outer pivot point, wherein the inner pivot point of each jaw pivotally connected to a corresponding core head pivot point on the core head, a connector link for each jaw, each connector link having a first end pivotally connected to the outer pivot point of the jaw and a second end pivotally connected to a corresponding connector link pivot point on the first end of the outer body, and an actuating assembly for moving the inner body relative to the outer body, whereby movement of the core head toward the outer body causes the jaws to move toward each other, and movement of the core head away from the outer body causes the jaws to move away from each other.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION [0001] This application is a continuation of the U.S. patent application Ser. No. 17/807,610, which claims the benefit of priority of U.S. Provisional Patent Application No. 63/202,625 filed Jun. 17, 2021, both of which are hereby incorporated herein by reference in their entirety.

TECHNICAL FIELD
[0002] The present disclosure relates to tools for gripping objects, such as locking pliers. Particular embodiments relate to locking pliers with a plurality of jaws adapted for gripping cylindrical objects from an axial direction.
BACKGROUND
[0003] Tradesmen, mechanics, technicians, and other individuals use a variety of manual hand tools on a daily basis. A very commonly used manual hand tool is locking pliers which is routinely referred to by its tradename Vise-Grips™. Since the original Peterson design (approx. 1934-1936), there have been a number of improvements in the functionality, ease of use, and versatility of Vise-Grips and similar tools. The last major modification by Peterson to the basic mechanism was the addition of a lock release lever, which was patented in 1957.
[0004] Such conventional tool designs are well suited for clamping onto a work-piece that fits into the plier's jaws at 90 degrees (perpendicular) to the plier's body. However, quite often the job requires one to grab and lock onto a work-piece axially (parallel to the plier body with the work-piece protruding outwards from the jaw tips). The need for axial gripping can be understood if one imagines holding a bolt or a shaft and trying to grind, cut, or drill. The action of removing a damaged fastener in a limited space or trying to align and insert an uncooperative pin into an object can also require axial gripping. However, when using conventional locking pliers to hold a workpiece in an axial position, when force is applied to the clamped workpiece, the workpiece tends to swing in a perpendicular direction relative to the jaw clamping force. This undesired workpiece movement is even more pronounced when the work-piece is cylindrical in shape. When conventional tools are used for axial gripping, they can damage not only the work-pieces but also the tools themselves, and possibly also result in personal injury. Such risks are often ignored, simply because there are no better tools available for the job at hand.
[0005] The inventors have determined a need for improved tools for gripping workpieces axially.
SUMMARY
[0006] One aspect of the present disclosure provides a tool comprising an outer body with a first end and a second end, the outer body defining a longitudinal recess therein and having at least two connector link pivot points at the first end thereof, an inner body slidably received within the longitudinal recess of the outer body and having a core head extending out of the first end of the outer body, at least two jaws, each jaw having an inner pivot point and an outer pivot point, wherein the inner pivot point of each jaw pivotally connected to a corresponding core head pivot point on the core head, a connector link for each jaw, each connector link having a first end pivotally connected to the outer pivot point of the jaw and a second end pivotally connected to a corresponding connector link pivot point on the first end of the outer body, and an actuating assembly for moving the inner body relative to the outer body, whereby movement of the core head

toward the outer body causes the jaws to move toward each other, and movement of the core head away from the outer body causes the jaws to move away from each other.
[0007] In some embodiments, the tool further comprises a compression spring placed within the longitudinal enclosure between the inner body and the second end of the outer body and an adjustment screw threadedly received the inner body and extending out from the second end of the outer body, and the actuating assembly comprises a handle assembly comprising a lever arm and a lock bar, each having a first end an a second end, wherein the lever arm has an intermediate pivot point between the first end and the second end thereof, with the first end of the lever arm connected to a handle pivot point on the outer body, the first end of the lock bar connected to the intermediate pivot point on the lever arm, and the second end of the lock bar configured to be received within a longitudinal slot in the inner body to engage a first end of the adjustment screw, whereby movement of the second end of the lever arm toward the second end of the outer body causes the core head to move toward the outer body and the jaws to move toward each other, and movement of the second end of the lever arm away from the second end of the outer body causes the core head to move away from the outer body and the jaws to move away from each other.
[0008] In some embodiments, the actuating assembly comprises first and second handle members pivotally connected to the inner body at first and second handle pivot points, and having angled portions extending forward from the handle pivot points in a crossing arrangement, and first and second handle connector links connected to corresponding handle pivot points on the outer body, whereby moving the first handle member toward the second handle member moves the core head toward the outer body.
[0009] In some embodiments, the actuating assembly comprises a robotic actuator.
[0010] In some embodiments, the tool comprises three, four, five, or more jaws.
[0011] In some embodiments, all of the jaws are pivotally connected to the core head and connector links by rivets.
[0012] In some embodiments, at least two of the jaws are pivotally connected to the core head and connector links by removable fasteners.
[0013] In some embodiments, at least one of the connector links comprises an adjustable length link.
[0014] Further aspects of the present disclosure and details of example embodiments are set forth below.

Description

DRAWINGS
[0015] The following figures set forth embodiments in which like reference numerals denote like parts. Embodiments are illustrated by way of example and not by way of limitation in the accompanying figures.
[0016] FIG. **1** shows a locking pliers with three jaws according to one embodiment of the present disclosure.
[0017] FIG. **1**A shows a locking pliers with three jaws according to another embodiment of the present disclosure.
[0018] FIG. **1**B is an enlarged view of the jaws of the locking pliers of FIG. **1**A.
[0019] FIG. **1**C is an enlarged view of a rear portion of the locking pliers of FIG. **1**A.
[0020] FIG. **1**D shows a rear end view of the locking pliers of FIG. **1**A.
[0021] FIG. **2** shows the locking pliers of FIG. **1** in a fully closed position.
[0022] FIG. **3** shows the locking pliers of FIG. **1** in a fully open position.
[0023] FIG. **4** shows the outer and inner bodies of the locking pliers of FIG. **1** in isolation.
[0024] FIG. **5** shows the handle assembly of the locking pliers of FIG. **1** in isolation.

[0025] FIG. **6** shows the interaction between the handle assembly and the outer and inner bodies of the locking pliers of FIG. **1**.
[0026] FIG. **7** shows a locking pliers with four jaws according to one embodiment of the present disclosure.
[0027] FIG. **8** shows a locking pliers with two jaws according to one embodiment of the present disclosure.
[0028] FIG. **9** shows a locking pliers with five jaws according to one embodiment of the present disclosure.
[0029] FIG. **10** shows a locking pliers with four jaws, wherein two of the jaws have adjustable links, according to one embodiment of the present disclosure.
[0030] FIG. **11** shows one of the jaws of the locking pliers of FIG. **1** in isolation, as well as a floating jaw and a long-nosed jaw according to other embodiments of the present disclosure.
[0031] FIG. **11**A shows the jaws of FIG. **11** from another angle.
[0032] FIG. **11**B shows two views from different angles of an example jaw with a compound curved gripping surface according to another embodiment of the present disclosure.
[0033] FIG. **12** shows a locking pliers with three floating jaws according to one embodiment of the present disclosure.
[0034] FIG. **13** shows a locking pliers with three long-nosed jaws according to one embodiment of the present disclosure.
[0035] FIG. **14** shows a portion of a locking pliers with an adjustment locking plate according to one embodiment of the present disclosure.
[0036] FIG. **15**A shows the locking pliers of FIG. **14** with the adjustment locking plate in an unlocked position.
[0037] FIG. **15**B shows the locking pliers of FIG. **14** with the adjustment locking plate in a locked position.
[0038] FIG. **16** shows a locking pliers with three jaws configured for outward gripping according to one embodiment of the present disclosure.
[0039] FIG. **17** shows a locking pliers with three jaws configured for inner diameter and outer diameter pulling according to one embodiment of the present disclosure.
[0040] FIG. **18** shows a locking pliers with two “snap ring” jaws according to one embodiment of the present disclosure.
[0041] FIG. **19** shows an extended reach locking pliers with four jaws according to one embodiment of the present disclosure.
[0042] FIG. **20** shows an angled extended reach locking pliers with four jaws according to one embodiment of the present disclosure.
[0043] FIG. **21** illustrates the internal components of the angled portion of the angled extended reach locking pliers of FIG. **20**.
[0044] FIG. **22** shows a non-locking pliers with four jaws in an open position according to one embodiment of the present disclosure.
[0045] FIG. **23** shows the non-locking pliers of FIG. **22** in a closed position.
[0046] FIG. **24** shows a robotic end effector with four jaws according to one embodiment of the present disclosure.
[0047] FIG. **25** shows the end effector of FIG. **24** with a cover installed thereon.

DETAILED DESCRIPTION

[0048] The following describes various examples of tools such as locking and non-locking pliers particularly suited for engaging workpieces such as pipes, bolts, or other cylindrical objects from an axial direction (parallel to the plier body with the workpiece protruding outwards from the jaw tips). As described below, tools according to embodiments of the present disclosure may also be utilized for engaging a variety of other types of workpieces, and engaging workpieces in other ways.

[0049] For simplicity and clarity of illustration, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. Numerous details are set forth to provide an understanding of the examples described herein. The examples may be practiced without these details. In other instances, well-known methods, procedures, and components are not described in detail to avoid obscuring the examples described. The description is not to be considered as limited to the scope of the examples described herein.

[0050] FIGS. **1** to **6** show details of an example three-jawed locking pliers **100** according to one embodiment of the present disclosure. The pliers **100** comprise an outer body **102** with an inner body **110** slidably received therein. The outer body **102** has a plurality (three in the illustrated example) of connector link pivot points **104** at a first or "forward" end thereof. The first end of the inner body **110** extends out from the first end of the outer body **102**, and has a core head **111** thereon defining a plurality (three in the illustrated example) of core head pivot points **112**. The inner body **110** is retained in the outer body **102**, and their relative motion is constrained, by a slot pin **105** extending laterally through the outer body **102** which is received in a core slot **115** (see FIG. **4**) through the inner body **110**, such that the length of the core slot **115** determines the range of relative longitudinal motion between the outer body **102** and inner body **110**. As discussed below, the relative movement of the inner body **110** with respect to the outer body **102** is constrained such that the core head **111** will never contact the first end of the outer body **102**.

[0051] A jaw **120** is connected to each core head pivot point **112**. Each jaw **120** has an inner pivot point **122**, which is pivotally connected (e.g. by a rivet) to the core head pivot point **112**, and an outer pivot point **124**, which is pivotally connected (e.g. by a rivet) to the first end of a connector link **126**. The second end of the connector link **126** is pivotally connected (e.g. by a rivet) to a corresponding one of the jaw pivot points **104** on the outer body **102**. The jaw outer pivot point **124** acts as a semi-stationary pivot point around which the jaw **106** rotates as it is activated to grab or release a work-piece, and the connector link **126** compensates for the arc of movement of the jaw outer pivot point **124** when the jaw inner pivot point **122** moves "forwards" (i.e. away from the outer body **102**) or "backwards" (i.e. toward the outer body **102**) when triggered by movement of the core head **111**. Thus the position of all the jaws **120** is controlled by the movement of the inner body **110** in and out of the outer body **102**, whereby movement of the core head **111** towards the outer body **102** causes the jaws **120** to move towards each other, and movement of the core head **111** away from the outer body **102** causes the jaws **120** to move away from each other.

[0052] An adjustment screw **108** is threadedly received in the second end of the inner body **110**, and extends out of the second end of the outer body **102** through an opening in an end wall **103**. A compression spring **106** is positioned over the adjustment screw **108** between the end wall **103** and the inner body **110** for biasing the inner body **110** "forwardly" (i.e. to extend the core head **111** away from the first end of the outer body **102**, urging the jaws **120** open). The inner body **110** has a longitudinal slot **107** therein for receiving a lock bar **136** of a handle assembly **130**, and the second end of the lock bar **136** abuts the first end of the adjustment screw **108**. Accordingly, by adjusting the adjustment screw **108**, the user can adjust the relative longitudinal position of the inner body **110** with respect to the outer body, and thus the relative spacing between the jaws **120**. As noted above, the relative movement of the inner body **110** with respect to the outer body **102** is constrained such that the core head **111** will never contact the first end of the outer body **102**, and consequently when the tool is in the closed position and the adjustment screw **108** is adjusted to minimize jaw spacing (jaws adjusted for less than minimum size workpiece), all clamping pressure will be on the jaw tips against each other when there is no workpiece in the jaws. This arrangement also ensures the tool operation will continue be the same when the jaw tips start to wear with time.

[0053] The handle assembly **130** comprises a lever arm **132** pivotally attached (e.g. by a rivet) at a first end thereof to a suitable attachment point on the outer body **102**. In the illustrated example, the lever arm **132** is attached to one of the connector link pivot points **104** on the outer body **102**, but the lever arm **132** could be attached to other locations on the outer body **102** in different

embodiments. The lock bar **136** is pivotally attached (e.g. by a rivet) to the lever arm **132** near the first end of the lever arm **132**, and a release arm **134** is pivotally attached (e.g. by a rivet) to the lever arm **132** rearward of the lock bar **136**, with the first end of the release arm **134** positioned between the lever arm **132** and the lock bar **136** and the second end of the release arm **134** positioned next to the second end of the lever arm **132**. In some embodiments, a small spring **133** (see FIG. **1**D) is provided between the lever arm **132** and release arm **134**. In some embodiments, small spacers are provided on either side of the lock bar **136** to ensure that the lock bar **136** is centered in the inside cavity of the lever arm **132**. These spacers may or may not be required in all embodiments.

[0054] As best seen in FIGS. **5** and **6**, the first end of the lock bar **136** extends slightly past the pivot point where the lock bar **136** is attached to the lever arm **132** so as to serve as a stop when the first end of the lock bar **136** contacts the lever arm **132**, limiting the opening angle therebetween. The lock bar **136** has a rounded bump thereon shaped such that when the lever arm **132**/release arm **134** contacts the bump the user may continue to continue to exert force on the lever arm **132** to place the tool **100** into an "overlock" state wherein the jaws remain closed against the opening force applied by the spring **106** even when the user is not applying any force to the lever arm **132**. The adjustment screw **108** has a shoulder machined on the first end, such that when installed in the internal thread of the inner body **110**, there is a tubular empty space between the inner diameter of the internal thread and the outer diameter of the first end of the screw **108**, to capture the small tail on the second end of the lock bar **136** (best seen in FIGS. **5** and **6**), preventing the lock bar **136** from lifting out of the longitudinal slot **107** of the inner body **110**. The lever arm **132** has a limited opening angle in relation to the outer body **102** when the tool is in a "fully open" position. This opening angle is determined by the combination of length of the first end of the lock bar which extends past its pivot point attachment to the lever arm **132**, the second end of the lock bar **136** which is secured in the tubular space formed by the first end of the adjustment screw **108**. This limiting of the opening angle of the handle has both functional and ergonomic advantages.

[0055] The release arm **134** and lock bar **136** may, for example, have the same basic design and functionality as corresponding components of conventional locking pliers. Similar to conventional locking plier mechanisms, pressing the second end of the release arm **134** toward the second end of the lever arm **132** causes the first end of the release arm **134** to push on the bump of the lock bar **136** to help break and release the overlock pressure between the lever arm **132** and the lock bar **136** when the tool is locked onto a workpiece and the mechanism is in the overlock state.

[0056] Unlike conventional locking plier mechanisms, the relationship between the outer body **102**, the inner body **110**, the core head **111** and the compression spring **106** of tool **100** are configured such that the handle/lock bar assembly can remain in the overlock state without actually having a workpiece clamped in the jaws **120**. Unlike conventional locking pliers, the spring **106** applies enough pressure on the overlock mechanism to keep the overlock function engaged by default. This feature allows tool **100**, and similarly constructed tools according to other embodiments, to be used for various "third hand" operations.

[0057] Many jobs require a workpiece to be held in place to allow the user to use both of their hands. Conventionally, bench vises have been used but they are often not the right solution. Some other tools called "third hands" are available which can be used to hold workpieces, but such solutions requires one to own or possess a separate tool to hold the workpiece in place. However, tools of the type disclosed herein allow a user to keep the overlock state engaged thereby providing the functionality of a third hand tool. The adjustment screw **108** allows the user to grab and hold any suitable workpiece with a reasonable holding force. It is pertinent to note that the holding force does not compare to the clamping power available when the handle assembly **130** is used to hold the workpiece, but the holding force is more than sufficient to grab workpieces for most third hand purposes.

[0058] In some embodiments, a bench stand **116** can be added to provide the user with another

option to hold the workpiece in place on a surface. The stand **116** may optionally have a fold-down mechanism to allow the user to stow it inside when not being used. For example, in the illustrated example, the stand is pivotally attached to the outer body **102** by the slot pin **105**.

[0059] As noted above, locking pliers **100** of the type disclosed herein are particularly suited for gripping workpieces axially. Because the tool's primary function is to hold workpieces axially, users can be expected to apply rotational torque to the tool in order to apply torque to the work-piece. For this reason, in some embodiments the handle assembly **130** is designed to partially engage into the outer body **102** when the tool is in the closed and locked position. For example, as best seen in FIG. **2**, the edges of the lever arm **132** are sized to fit just inside the edges of the outer body **102** and around the inner body **110**. This interlocking engagement greatly reduces undue stress on various tool pivot rivet points and other components.

[0060] FIG. **1**A shows another example three-jawed locking pliers **1000** according to another embodiment of the present disclosure. The pliers **1000** are substantially similar to pliers **100** shown in FIG. **1**, and as such the construction and operation of pliers **1000** will not be described in detail, other than to highlight certain features of pliers **1000** that differ from pliers **100**. For example, pliers **1000** include a pair of stops **117** on the outer surface of the body **102** to limit forward rotation of the stand **116**. The connector links **126** of pliers **1000** are also shorter, thicker and stronger than in pliers **100**, and similarly the jaws **120**D of pliers have thicker bodies than jaws **120**. As best seen in FIG. **1**B, each jaw **120**D has a “compound-curved” gripping surface **125**D on an inner surface thereof, and a compound curve and groove **127** on the outer surface thereof. The compound-curved gripping surface **125**D (which similar to surface **125**C described below with reference to FIG. **11**B) includes a first gripping portion along most of its length with lateral serrations, and a second gripping portion with a curved inner surface and longitudinal serrations at the tip of the jaw **120**D, providing for stable outer-diameter-gripping of a wide range of workpieces with differing diameters. The grooves **127** on the outer surfaces of jaws **120**D allow pliers **1000** to also be used for inner-diameter-gripping for a wide range of diameters.

[0061] As best seen in FIG. **1**C, pliers **1000** include a locking plate **140**A which is similar to and functions in substantially the same way as locking plate **140** described below with reference to FIGS. **14**, **15**A and **15**B, except that locking plate **140**A has a tab extending out of the bottom of the outer body **102** that a user can use to engage locking plate **140**A with a groove in the adjustment screw **108**. Also the adjustment screw **108** has a hexagonal key slot **109** formed in the rear end thereof. As best seen in FIG. **1**A, pliers **100** also include a bushing **141** at the rear end of spring **106** for improved interaction between the locking mechanism for the adjustment screw.

[0062] With reference to FIGS. **1**A and **1**D, the construction of the links **126** and the relative positions of the pivot points **104**, **112**/**122** and **124** of pliers **1000** have been adjusted (in comparison to pliers **100** to maximize rotational contact areas, increase load bearing wall thicknesses, and also to minimize the space needed for operation of the clamping mechanism. For example, circle C in FIG. **1**D illustrates how much clearance would be needed for the linkage and jaw head area of pliers **1000** of FIG. **1**A. Also visible in FIG. **1**D is a spring **133** between the lever arm **132** and release arm **134** to provide improved operation and user experience when using pliers **1000**.

[0063] In the example pliers **100** and **1000** shown in FIGS. **1**-**6** and FIGS. **1**A-**1**D the tools are equipped with three jaws. However, in other implementations, tools according to other embodiments of the present disclosure may be equipped with different numbers of jaws. For example, FIG. **7** shows a locking pliers **100**A with four jaws according to one embodiment of the present disclosure, FIG. **8** shows a locking pliers **100**B with two jaws according to one embodiment of the present disclosure, and FIG. **9** shows a locking pliers **100**C with two jaws according to one embodiment of the present disclosure. As one of skill in the art will appreciate, other than the shape of the core head **111** and the configuration of the jaw pivot points **104** being adapted to receive a different number of jaws, pliers **100**A, **100**B and **100**C are substantially similar to pliers **100** of

FIGS. **1**-**6** (just with one or two more or one fewer jaw **120**, connector link **126** and associated pivot points). Accordingly, locking pliers according to the present disclosure can include any desired number of jaws.

[0064] In some situations, workpieces of different shapes and having different cross sections may need to be gripped axially. In some embodiments, tools according to the present disclosure may have one or more jaws connected to the outer body by an adjustable link, such that a user can readily configure the tool for gripping a workpiece of any shape. For example, FIG. **10** shows a locking pliers **100**D with four jaws, wherein two of the jaws have adjustable links **127**. Each adjustable link **127** comprises a thumbscrew **128** which allows the user to adjust the relative position of the jaw connected thereto.

[0065] In order to maximize radial clamping forces when gripping axially, some embodiments of the present disclosure comprise specialized jaws configured for gripping workpieces with circular cross-sections. The jaws may also themselves have different configurations, depending on the intended use of the tool. FIG. **11** shows one of the jaws **120** of the locking pliers of FIG. **1** in isolation, as well as a floating jaw **120**A and a long-nosed jaw **120**B. FIG. **11**A shows the jaws **120**, **120**A and **120**B of FIG. **11** from another angle. As best seen in FIG. **11**, the jaws **120**, **120**A and **120**B each has a curved and serrated gripping surface **125**, **125**A, **125**B. FIG. **11**B shows another example jaw **120**C with a "compound-curved" gripping surface **125**C. Gripping surface **125**C has a flat portion, and a curved portion with a radius of curvature that varies from the tip towards the inner portion of the jaw, which facilitates gripping a wide range of round fastener head bottom circumferences of different diameters directly at the fastener head mounting surface.

[0066] As one of skill in the art will appreciate, other types of jaws are also possible. For example, FIG. **12** shows an example locking pliers **100**E with three floating jaws, and FIG. **13** shows a locking pliers **100**F with three long-nosed jaws. In the locking pliers **100**E of FIG. **12**, the floating gripping surfaces **125**A are pivotally attached to the ends of the jaws **120**A, and designed to be self-adjusting and self-aligning to the workpiece radial surface, such that the grip available on the workpiece remains strong regardless of the workpiece dimensions.

[0067] In some embodiments, a locking pliers according to the present disclosure may be configured such that a user can switch out one or more of the jaws with a different type or size of jaw. For example, in some embodiments, one or more of the jaws are pivotally connected to the core head and connector links by removable fasteners (such as, for example, shoulder bolts or shoulder screws). For example, with reference to FIG. **1**, replacing the rivets used at the core head/inner jaw pivot points **112**/**122** and outer jaw pivot points **124** with removable fasteners allows a user to reconfigure tool **100** by replacing the jaws **120** with any of jaws **120**A, **120**B or **120**C discussed above (or any of the additional types of jaws discussed below). In some embodiments one or more of the connector links may also be pivotally connected to the corresponding connector link pivot point on the outer body by a removable fastener, such that a user can replace one or more fixed length connector links with an adjustable length connector link.

[0068] In some embodiments, a locking pliers according to the present disclosure may be used to hold a work-piece from an inner dimension of a part. Instead of clamping inwards on the outer surface or edge of the workpiece, the pressure is reversed clamping outwards on the inner surface or edges of a workpiece. FIGS. **14**, **15**A and **15**B show a portion of a locking pliers with a locking plate **140** according to one embodiment of the present disclosure, which allows the adjustment screw **108** to be used to provide an outward gripping force on the jaws. When the locking plate **140** is in the unlocked position as shown in FIG. **15**A, the screw **108** (and thus the inner body **110**) is free to slide longitudinally with respect to the outer body **102** (within the constraints imposed by other components, such as the core slot **115** and/or handle assembly **130**), and the spring **106** applies forward force on the inner body **110** to bias the jaws to the open position. However, when the locking plate **140** is moved to the locked position shown in FIG. **15**B, the plate **140** engages a groove **142** in the shank of the adjustment screw **108**, such that the inner and outer bodies are

locked in place with respect to each other, and the adjustment screw can be turned to force the inner body **110** out the first end of the outer body **102**, and apply an outward gripping force to the jaws. The spring **106** still applies a biasing force on the inner body **110** (and thus the jaws), but a user can turn the screw **108** (counter-clockwise in the illustrated example) to add additional forward force to the inner body **110** (since the locking plate **140** is engaged by the groove **142** in the shank of screw **108**, and the locking plate **140** is held in place against the end wall **103** of the outer body **102**), subsequently adding additional outward force on the jaws. The holding force available for outward holding is same as when using the inward holding, third hand feature.

[0069] When a tool such as the example locking pliers described above is intended to be utilized for outwardly clamping an inner dimension (ID) of a workpiece, the tool may be configured with jaws configured to impart optimal outward holding force to the workpiece. For example, FIG. **16** shows a locking pliers **100**G with three jaws configured for outward gripping according to one embodiment of the present disclosure, wherein the jaws are similar to the long-nosed jaws shown in FIG. **13** but with exterior serrations on the jaws. The FIG. **16** embodiment provides a unique bidirectional “third hand” functionality integrated into locking pliers particularly adapted for axial gripping according to the above embodiments of the present disclosure.

[0070] In other embodiments, tools according to the present disclosure may be configured with other types of jaws for other tasks. For example, some embodiments provide a light duty puller tool which may be utilized to remove bearings, seals, bushings, or the like from some sort of housing or shaft. FIG. **17** shows an example locking pliers **100**H with three jaws configured for inner diameter and outer diameter pulling according to one embodiment of the present disclosure. FIG. **18** shows a locking pliers **100**I with two “snap ring” jaws according to one embodiment of the present disclosure. Other types of jaws configured for other tasks may also be incorporated into locking pliers according to embodiments of the present disclosure.

[0071] FIG. **19** shows an extended reach locking pliers **100**K with four jaws according to another embodiment of the present disclosure. Pliers **100**K of FIG. **19** may be substantially similar to pliers **100** of FIGS. **1-6**, except with elongated outer and inner bodies, and long-nosed jaws. FIG. **20** shows an angled extended reach locking pliers **100**J with four jaws according to one embodiment of the present disclosure. FIG. **21** illustrates the internal components of the angled portion of the angled extended reach locking pliers of FIG. **20**. In the angled extended reach pliers **100**J, the outer body comprises a corner portion with an angled linkage **103**J pivotally mounted therein, and the inner body **110**J is split into two parts, each of which is connected to the angled linkage **103**J by an inner body connector link **113**J. As one of skill in the art will appreciate, extended reach locking pliers, whether angled or not, may be configured with any number and types of jaws as described above.

[0072] FIGS. **22** and **23** show a non-locking pliers **200** with four jaws according to another embodiment of the present disclosure. Pliers **200** comprise an outer body **202** having a plurality of jaw pivot points **204**, an inner body **210** slidably received therein having a core head **211** and a plurality of core head pivot points **121**, and four jaws **220** and associated connector links **226** substantially similar in operation to corresponding elements of pliers **100** of FIGS. **1-6** in that the inner body **210** moves in and out from the outer body **202** to open and close the jaws **220**. However, instead of a locking handle assembly, pliers **200** have a non-locking handle assembly **230** comprising first and second handle members **234** and **235** pivotally connected to the inner body **210** at first and second handle pivot points **214** and **215**. The handle members **234** and **235** have angled portions **236** and **237** extending forward from the handle pivot points **214** and **215** in a crossing arrangement. First and second handle connector links **238** and **239** are respectively connected to corresponding handle pivot points on the outer body (which, in the illustrate example are two opposed jaw pivot points **204** of the four-jawed pliers). Moving the first handle member **234** towards the second handle **235** member moves the core head **211** toward the outer body **202**, thus closing the jaws **220**. From the user's perspective, the inner body **210** and the core head **211**

are “stationary”, as the handle members **234** and **235** are pivotally connected to the inner body **210**. When the handles **234** and **235** are squeezed together, the outer body **202** (which may be in the form of a sliding collar in some embodiments) slides forward over the inner body **210** thereby operating the links and closing the jaws.

[0073] The jaw opening and closing mechanism disclosed herein may also be incorporated into other tools. For example, FIG. **24** shows a robotic end effector with four jaws according to one embodiment of the present disclosure, and FIG. **25** shows the end effector of FIG. **24** with a cover installed thereon. In the illustrated example, the robotic end effector comprises a UR5 robot wrist mount with a stepper motor driving a small ball screw/nut assembly. The ball nut is attached to the inner body which in this case is square (as in the non-locking pliers example) as opposed to being round in the locking plier examples. The linear inner body travel is controlled by the stepper motor and ball screw assembly then actuates the coordinated jaw movements as in other embodiments. Many stepper motor driver circuits and/or IC's already have motor current sensing and limiting systems integrated in them. These are normally used to protect both the motor and driver. Leveraging this existing current control provides the ability to program the amount of force the jaws can impart on the item being manipulated.

[0074] It will be appreciated that numerous specific details are set forth in order to provide a thorough understanding of the exemplary embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein may be practiced without these specific details. In other instances, well-known methods, procedures and components have not been described in detail so as not to obscure the embodiments described herein. Furthermore, this description is not to be considered as limiting the scope of the embodiments described herein in any way, but rather as merely describing implementation of the various example embodiments described herein.

[0075] The description provides many example embodiments of the inventive subject matter. Although each embodiment represents a single combination of inventive elements, the inventive subject matter is considered to include all possible combinations of the disclosed elements. Thus if one embodiment comprises elements A, B, and C, and a second embodiment comprises elements B and D, then the inventive subject matter is also considered to include other remaining combinations of A, B, C, or D, even if not explicitly disclosed.

[0076] As will be apparent to those skilled in the art in light of the foregoing disclosure, many alterations and modifications are possible to the methods and systems described herein. While a number of exemplary aspects and embodiments have been discussed above, those of skill in the art will recognize certain modifications, permutations, additions and sub-combinations thereof. It is therefore intended that the following appended claims and claims hereafter introduced are interpreted to include all such modifications, permutations, additions and sub-combinations as may reasonably be inferred by one skilled in the art. The scope of the claims should not be limited by the embodiments set forth in the examples, but should be given the broadest interpretation consistent with the foregoing disclosure.

[0077] The present disclosure may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive.

Claims

1. A tool comprising: an outer body with a first end and a second end, the outer body defining a longitudinal recess therein and having at least two connector link pivot points at the first end thereof; an inner body slidably received within the longitudinal recess of the outer body and having a core head extending out of the first end of the outer body, the core head having at least two core head pivot points thereon, wherein each core head pivot point is at a different position on the core

head; at least two jaws, each jaw having an inner pivot point and an outer pivot point, wherein the inner pivot point of each jaw is pivotally connected to a corresponding one of the core head pivot points; a connector link for each jaw, each connector link having a first end pivotally connected to the outer pivot point of the jaw and a second end pivotally connected to a corresponding connector link pivot point on the first end of the outer body; and an actuating assembly for moving the inner body relative to the outer body, whereby movement of the core head toward the outer body causes the jaws to move toward each other, and movement of the core head away from the outer body causes the jaws to move away from each other.

2. The tool of claim 1 further comprising: a compression spring placed within the longitudinal enclosure between the inner body and the second end of the outer body; and an adjustment screw threadedly received the inner body and extending out from the second end of the outer body; and wherein the actuating assembly comprises a handle assembly comprising a lever arm and a lock bar, each having a first end an a second end, wherein the lever arm has an intermediate pivot point between the first end and the second end thereof, with the first end of the lever arm connected to a handle pivot point on the outer body, the first end of the lock bar connected to the intermediate pivot point on the lever arm, and the second end of the lock bar configured to be received within a longitudinal slot in the inner body to engage a first end of the adjustment screw, whereby movement of the second end of the lever arm toward the second end of the outer body causes the core head to move toward the outer body and the jaws to move toward each other, and movement of the second end of the lever arm away from the second end of the outer body causes the core head to move away from the outer body and the jaws to move away from each other.

3. The tool of claim 1 wherein the actuating assembly comprises first and second handle members pivotally connected to the inner body at first and second handle pivot points, and having angled portions extending forward from the handle pivot points in a crossing arrangement, and first and second handle connector links connected to corresponding handle pivot points on the outer body, whereby moving the first handle member towards the second handle member moves the core head toward the outer body.

4. The tool of claim 1 wherein the actuating assembly comprises a robotic actuator.

5. The tool of claim 2 wherein the at least two jaws comprise at least three jaws.

6. The tool of claim 5 wherein all of the jaws are pivotally connected to the core head and connector links by rivets.

7. The tool of claim 5 wherein at least two of the jaws are pivotally connected to the core head and connector links by removable fasteners.

8. The tool of claim 5 wherein at least one of the connector links comprises an adjustable length link.

9. The tool of claim 1 wherein the at least two jaws comprise four jaws.

10. The tool of claim 1 wherein the at least two jaws comprise five or more jaws.

11. The tool of claim 2 further comprising a release arm pivotally attached to the lever arm rearward of the lock bar, with a first end of the release arm positioned between the lever arm and the lock bar and a second end of the release arm positioned next to the second end of the lever arm, wherein the tool may be placed in an overlock state by forcing the second end of the lever arm toward the second end of the outer body and the tool may be released from the overlock state by pressing the second end of the release bar toward the second end of the outer body.

12. The tool of claim 11 wherein the compression spring applies sufficient force on the inner body to maintain the tool in the overlock state regardless of whether the jaws are clamping a workpiece.

13. The tool of claim 11 further comprising a locking plate coupled to the outer body and configured for movement between an unlocked position and a locked position, wherein the locking plate is moveable into the locked position when the tool in in the overlock state, and when the locking plate is in the locked position the locking plate engages the adjustment screw to limit movement of the adjustment screw relative to the outer body, such that rotation of the adjustment

screw in a first sense moves the core head away from the outer body and forces the jaws outwardly, and rotation of the adjustment screw in a second sense moves the core head towards the outer body and forces the jaws inwardly.

14. The tool of claim 13 wherein the adjustment screw comprises a recess in a rear end thereof configured to receive an instrument for facilitating rotation of the adjustment screw.

15. The tool of claim 13 wherein the adjustment screw comprises a groove in a shank thereof, and wherein in the locked position the locking plate engages the groove in the adjustable screw.

16. The tool of claim 13 wherein the locking plate comprises a tab that is aligned with an aperture in a wall of the outer body, wherein while the locking plate is in the locked position, the tab is accessible through the slot and can be actuated to move the locking plate into the unlocked position.

17. The tool of claim 13 wherein each jaw comprises an exterior gripping surface.

18. The tool of claim 17 wherein the exterior gripping surface of each jaw comprises one or more grooves.

19. The tool of claim 17 wherein the exterior gripping surface comprises a serrated portion on an outer surface of each jaw.

20. The tool of claim 1 wherein each jaw comprises an interior gripping surface with at least one portion thereof being curved.

21. The tool of claim 1 wherein each jaw comprises an interior gripping surface with at least one portion thereof being serrated.

22. The tool of claim 1 wherein each jaw comprises a compound curved interior gripping surface.

23. The tool of claim 1 wherein each jaw comprises a floating gripping surface, wherein the floating gripping surface is pivotally connected to a corresponding grip pivot point on each jaw.

24. The tool of claim 23 wherein the grip pivot points are located at the tip of each of the jaws.

25. The tool of claim 23 wherein at least one portion of the floating gripping surface is curved.

26. The tool of claim 25 wherein at least one portion of the floating gripping surface is serrated.

27. The tool of claim 1 wherein each jaw comprises a long-nosed jaw.

28. The tool of claim 1 wherein each jaw comprises a T-shaped tip.

29. The tool according to claim 1 wherein the outer body comprises a corner portion with an angled linkage pivotally mounted therein, and wherein the inner body is split into a first portion within the longitudinal recess of the outer body prior to the angled linkage, and a second portion within the longitudinal recess of the outer body after the angled linkage, wherein the first portion and second portion of the inner body are each connected to the angled linkage by an inner body connector link.