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PIN PULLER ASSEMBLY AND METHODS

Abstract

A pin puller assembly, a column assembly, and methods of assembling and operating a pin puller assembly. The pin puller assembly may be operable to pull a pin from a machine having a frame supporting the pin. The pin puller assembly may generally include a piston-cylinder unit; a pull rod positionable through a piston passage, the second rod end being connectable to the pin to be pulled; a reaction member engageable between the rod and the piston; and a column assembly positionable between the cylinder and the frame, the column assembly including a first column member connectable to the cylinder and having a first length along the axis, and a second column member releasably lockable to the first column member and having a second length along the axis. The reaction member may include a split reaction member assembly.

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Background/Summary

RELATED APPLICATIONS [0001] This application is the U.S. national stage application of International Application PCT/US2022/051434, filed Nov. 30, 2022, which international application was published on Jun. 8, 2023, as International Publication WO 2023/102067 in the English language. The International Application claims priority to U.S. Application No. 63/284,307, filed Nov. 30, 2021, and U.S. Application No. 63/337,587, filed May 2, 2022. The international application and US applications are all incorporated herein by reference, in entirety.

FIELD
[0002] The present disclosure relates to piston-cylinder units and, more particularly, to a pin puller.
SUMMARY
[0003] In general, heavy equipment (such as is found on construction sites, farms, and other locations) contains articulation points. At an articulation point, articulation is made possible by means of a pin that fits into a recess. Pins can be heavy and can rust. For these and other reasons, pins can be difficult to remove from recesses. New and improved mechanisms and/or methods of removing pins from recesses may be needed.
[0004] In one independent aspect, a pin puller assembly may be operable to pull a pin from a machine, the machine having a frame supporting the pin. The pin puller assembly may generally include a piston-cylinder unit including a cylinder having a first cylinder end and an opposite second cylinder end and defining an axis extending therebetween, the cylinder defining a chamber and having a port communicating with the chamber, and a piston defining an axial passage and having a piston end, the piston being movably supported by the cylinder, fluid passing through the port causing movement of the piston relative to the cylinder; a pull rod positionable through the passage and having a first rod end positioned proximate the first cylinder end and a second rod end positioned proximate the second cylinder end, the second rod end being connectable to the pin to be pulled; a reaction member engageable between the rod and the piston; and a column assembly positionable between the cylinder and the frame, the column assembly including a first column member connectable to the cylinder and having a first length along the axis, and a second column member releasably lockable to the first column member and having a second length along the axis.
[0005] In another independent aspect, a column assembly for use in a pin puller assembly may be provided. The column assembly may generally include a first column member connectable to the cylinder and having a first length along the axis, and a second column member releasably lockable to the first column member and having a second length along the axis.
[0006] In yet another independent aspect, a pin puller assembly may generally include a split reaction member assembly engageable between a pull rod and a piston of a piston-cylinder unit, the reaction member assembly including a first reaction member portion having a first inner surface, and a second reaction member portion having a second inner surface, the first inner surface and the

second inner surface cooperating to define an opening configured to receive the pull rod, the first reaction member portion and the second reaction member portion being relatively movable between an engaging position, in which the first inner surface and the second inner surface are engageable with the pull rod to fix the split reaction member assembly to the pull rod, and a disengaged position, in which the first inner surface and the second inner surface are disengageable from the pull rod.

[0007] In a further independent aspect, a method of assembling a pin puller assembly to pull a pin from a machine may be provided. The method may generally include positioning a pistoncylinder unit relative to the frame, the piston-cylinder unit including a cylinder having a cylinder end facing toward the frame and defining a chamber and a port communicating with the chamber, and a piston movably supported by the cylinder, the piston defining an axial passage and having a piston end opposite the cylinder end, fluid passing through the port causing movement of the piston relative to the cylinder; positioning a pull rod through the passage; engaging an end of the pull rod with the pin to be pulled; engaging a reaction member on the pull rod; positioning the reaction member on the pull rod against the piston end; installing a column assembly between the between the cylinder end and the frame, installing including positioning a first column member against the cylinder end, locking a second column member to an opposite end of the first column member, and engaging an end of the second column member against the frame.

[0008] In another independent aspect, a method of assembling a pin puller assembly may generally include positioning a piston-cylinder unit relative to the frame, the piston-cylinder unit including a cylinder having a cylinder end facing toward the frame and defining a chamber and a port communicating with the chamber, and a piston movably supported by the cylinder, the piston defining an axial passage and having a piston end opposite the cylinder end, fluid passing through the port causing movement of the piston relative to the cylinder; installing a column assembly between the between the cylinder end and the frame positioning a pull rod through the passage; engaging an end of the pull rod with the pin to be pulled; engaging a split reaction member assembly on the pull rod, engaging including moving a first reaction member having a first inner surface and a second reaction member portion having a second inner surface from a disengaged position, in which the first inner surface and the second inner surface are disengaged from the pull rod, into a locking position, in which the first inner surface and the second inner surface engage with the pull rod to fix the split reaction member assembly to the pull rod; and positioning the reaction member assembly locked on the pull rod against the piston end.

[0009] In yet another independent aspect, a pull rod assembly for a pin puller assembly may be operable to pull a pin from a machine, the machine having a frame supporting the pin. The pin puller assembly may generally include a piston-cylinder unit with a cylinder having a first cylinder end and an opposite second cylinder end and defining an axis extending therebetween, the cylinder defining a chamber and has a port communicating with the chamber, and a piston defining an axial passage and having a piston end, the piston being movably supported by the cylinder, fluid passing through the port causing movement of the piston relative to the cylinder, the pull rod being positionable through the passage, a reaction member is engageable between the pull rod and the piston, and a column assembly is positionable between the cylinder and the frame. The pull rod assembly may generally include a rod body having a first rod end positionable proximate the first cylinder end and a second rod end positionable proximate the second cylinder end, the second rod end being connectable to the pin to be pulled, a plurality of steps being defined on an outer surface of the body, the plurality of steps being spaced along a length of the body, each of the plurality of steps having an axial surface facing toward the second end, the axial surface extending substantially radially, and an opposite angled surface facing toward the first end.

[0010] In a further independent aspect, a split reaction member assembly for a pin puller assembly may be provided. The reaction member assembly may generally include a first reaction member portion having a first inner surface, and a second reaction member portion having a second inner

surface, the first inner surface and the second inner surface cooperating to define an opening configured to receive a pull rod, the first reaction member portion and the second reaction member portion may be relatively movable between an engaging position, in which the first inner surface and the second inner surface are engageable with the pull rod to fix the split reaction member assembly to the pull rod, and a disengaged position, in which the first inner surface and the second inner surface are disengageable from the pull rod, the first reaction member portion and the second reaction member portion being biased toward the engaging position.

[0011] In another independent aspect, a pin puller assembly operable to pull a pin from a machine may be provided. The pin puller assembly may generally include a piston-cylinder unit including a cylinder having a first cylinder end and an opposite second cylinder end and defining an axis extending therebetween, the cylinder defining a chamber and having a port communicating with the chamber, and a piston defining an axial passage and having a piston end, the piston being movably supported by the cylinder, fluid passing through the port causing movement of the piston relative to the cylinder; a pull rod assembly positionable through the passage, the pull rod assembly including a rod body having a first rod end positioned proximate the first cylinder end and a second rod end positioned proximate the second cylinder end, the second rod end being connectable to the pin to be pulled, the pull rod assembly having a first rod diameter proximate the first rod end and a second rod diameter proximate the second rod end, the second rod diameter being greater than the first rod diameter; a reaction member engageable between the rod body and the piston; a column positionable between the cylinder and the frame; and a base plate connectable between the second cylinder end and the column, the base plate defining an opening having an opening diameter, the opening diameter being greater than the first rod diameter to allow passage of the first rod end through the opening, the opening diameter being less than the second rod diameter to inhibit passage of the second rod end through the opening.

[0012] Other independent aspects of the disclosure may become apparent by consideration of the detailed description, claims and accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIGS. **1**A-**1**D illustrate a pin puller assembly and an exemplary process using the pin puller assembly to pull a pin from a machine.

[0014] FIGS. **2**A-**2**D illustrate a column assembly for use with the pin puller assembly of FIG. **1**.

[0015] FIGS. **3**A-**3**D illustrate an alternative construction of a column assembly for use with the pin puller assembly of FIG. **1**.

[0016] FIGS. **4**A-**4**E illustrate another alternative construction of a column assembly for use with the pin puller assembly of FIG. **1**.

[0017] FIGS. **5**A-**5**D illustrate yet another alternative construction of a column assembly for use with the pin puller assembly of FIG. **1**.

[0018] FIGS. **6**A-**6**E illustrate a further alternative construction of a column assembly for use with the pin puller assembly of FIG. **1**.

[0019] FIGS. **7**A-**7**K illustrate a split reaction member assembly for use with the pin puller assembly of FIG. **1** and an embodiment of a conical saddle.

[0020] FIGS. **8**A-**8**G illustrate an alternative construction of a split reaction member assembly for use with the pin puller assembly of FIG. **1**.

[0021] FIGS. **9**A-**9**G illustrate another alternative construction of a split reaction member assembly for use with the pin puller assembly of FIG. **1**.

[0022] FIGS. **10**A-**10**G illustrate yet another alternative split reaction member assembly for use with the pin puller assembly of FIG. **1**.

[0023] FIGS. **11**A-I IB illustrate an alternative construction of a reaction member for use with the pin puller assembly of FIG. **1**.
[0024] FIG. **12** is a perspective view of an alternative construction of a pin puller assembly including a pull rod, a reaction member, an adapter, and a barrel coupler.
[0025] FIG. **13** is a front view of the pin puller assembly of FIG. **12**.
[0026] FIG. **14** is a side view of the pin puller assembly of FIG. **12**.
[0027] FIG. **15** is a rear view of the pin puller assembly of FIG. **12**.
[0028] FIG. **16** is a side view of the pin puller assembly of FIG. **12**.
[0029] FIG. **17** is a top view of the pin puller assembly of FIG. **12**.
[0030] FIG. **18** is a cross-sectional side view of a segment of the pull rod shown in FIG. **12**.
[0031] FIG. **19** is a cross-sectional side view of a portion of the pin puller assembly of FIG. **12**.
[0032] FIG. **20** is a side view of a segment of the pull rod shown in FIG. **12**.
[0033] FIG. **21** is a cross-sectional side view of the pin puller assembly of FIG. **12**.
[0034] FIG. **22** is a side view of the pull rod shown in FIG. **12**.
[0035] FIG. **23** is a perspective view of another construction of a split reaction member for the pin puller assembly of FIG. **12**, illustrated with the reaction member in a closed position.
[0036] FIG. **24** is a perspective view of the reaction member of FIG. **23**, illustrated with the reaction member in an open position.
[0037] FIG. **25** is a cross-sectional view of a portion of the pin puller assembly of FIG. **12**.
[0038] FIG. **26** is a perspective view of an adapter for the pin puller assembly of FIG. **12**.
[0039] FIG. **27** is a perspective view of a barrel coupler for the pin puller assembly of FIG. **12**, illustrated with the barrel coupler in an open position.
[0040] FIG. **28** is a perspective view of the barrel coupler of FIG. **27**, illustrated with the barrel coupler in a closed position.
[0041] FIG. **29** is a perspective view of a coupling of the adapter and the pull rod for the pin puller assembly of FIG. **12**, illustrated with the barrel coupler partially cut away.
[0042] FIG. **30** is a perspective cross-sectional view of the pull rod and the reaction member for the pin puller assembly of FIG. **12**.
[0043] FIG. **31** is a perspective view of the pin puller assembly of FIG. **12**.
[0044] FIG. **32** is a perspective view of the pull rod and the reaction member for the pin puller assembly of FIG. **12**.
[0045] FIGS. **33**A-**33**D illustrate different constructions of a column assembly for a pin puller assembly.
[0046] FIG. **34** includes views of a column member, illustrating the locking members in more detail.
[0047] FIGS. **35**A-**35**F include views of the column members of a column assembly, illustrating relative orientations of the column members.
[0048] FIGS. **36**A-**36**C include views of the cylinder, the adapter plate and a column member, illustrating relative orientations of the components.
[0049] FIGS. **37**A-**37**D include views of a column assembly including a positive locking mechanism, illustrating engagement of the positive locking mechanism.
[0050] FIGS. **38**A-**38**B are enlarged side views of the positive locking mechanism shown in FIGS. **37**A-**37**D, illustrating the positions of the positive locking mechanism.
[0051] FIGS. **39**A-**39**F include views of an alternative construction of a positive locking mechanism, illustrating engagement of the positive locking mechanism.
[0052] FIG. **40** is a perspective view of another alternative construction of a positive locking mechanism.
[0053] FIG. **41** is a perspective view of a pin puller assembly and illustrating a guide member for the pull rod.

DETAILED DESCRIPTION

[0054] Before any independent embodiments are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The disclosure is capable of other independent embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.
[0055] Use of “including” and “comprising” and variations thereof as used herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Use of “consisting of” and variations thereof as used herein is meant to encompass only the items listed thereafter and equivalents thereof. Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings.
[0056] Relative terminology, such as, for example, “about”, “approximately”, “substantially”, etc., used in connection with a quantity or condition would be understood by those of ordinary skill to be inclusive of the stated value and has the meaning dictated by the context (for example, the term includes at least the degree of error associated with the measurement of, tolerances (e.g., manufacturing, assembly, use, etc.) associated with the particular value, etc.). Such terminology should also be considered as disclosing the range defined by the absolute values of the two endpoints. For example, the expression “from about 2 to about 4” also discloses the range “from 2 to 4”. The relative terminology may refer to plus or minus a percentage (e.g., 1%, 5%, 10% or more) of an indicated value.
[0057] Also, the functionality described herein as being performed by one component may be performed by multiple components in a distributed manner. Likewise, functionality performed by multiple components may be consolidated and performed by a single component. Similarly, a component described as performing particular functionality may also perform additional functionality not described herein. For example, a device or structure that is “configured” in a certain way is configured in at least that way but may also be configured in ways that are not listed.
[0058] The embodiment s) described below and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present disclosure. As such, it will be appreciated that variations and modifications to the elements and their configuration and/or arrangement exist within the spirit and scope of one or more independent aspects as described.
[0059] FIGS. **1**A-**1**D illustrate a pin puller assembly **10** configured to, from a machine M having a machine frame F, pull a pin P illustrated as having a pin flange PF. The pin puller assembly **10** includes a piston-cylinder unit **14**, a pull rod **18** connectable to the pin P and functioning as a pull stud, a reaction member **22** engageable with the pull rod **18**, and a loadbearing column assembly **26** positionable between the piston-cylinder unit **14** and the machine frame F.
[0060] The piston-cylinder unit **14** includes a cylinder **30** having a first cylinder end and a second cylinder end and defines an axis A extending therebetween. The cylinder **30** further defines a chamber **34** and a port **38** communicating with the chamber **34**. A piston **42** is movably supported by the cylinder **30** and has a piston end **46**. Fluid (e.g., hydraulic fluid) passing through the port **38** causes the movement of the piston **42** relative to the cylinder **30**.
[0061] The piston **42** is hollow and defines an axial passage **50** configured to receive the pull rod **18**. The pull rod **18** has a first rod end **54** positionable proximate the first cylinder end and a second rod end **58** positionable proximate the second cylinder end. The reaction member **22** is axially fastenable to the pull rod **18**. In the illustrated construction, the pull rod **18** is threaded **62**, and the reaction member **22** is a reaction nut having complementary threads **66**. The reaction member **22** engages against the piston end **46** to hold the pull rod **18** in position relative to the piston **42**. As shown in FIG. **1**, extension of the piston **42** causes the piston **42** to bear against the reaction member **22** and apply a force to the reaction member **22** along the longitudinal axis of the pull rod

18.
[0062] The illustrated column assembly **26** is positioned between the cylinder **30** and the machine frame F and includes a number of column members **70** (two shown). Each column member **70** has a cylinder end and an opposite frame end and defines a member length L (e.g., as illustrated, about 6.5 inches (in.)). Each column member **70** defines a mouth **72** configured to receive the pin flange PF as the pin P is pulled. The mouth **72** also facilitates installation of the column member **70** around the pull rod **18**. When assembled, the cylinder end of each column member **70** faces the cylinder **30**, and the frame end of the column member **70** faces the machine frame F. The column members **70** are arranged with the mouths **72** aligned.
[0063] While two column members **70***a*, **70***b* are shown, the column assembly **26** may include additional column members (not shown). Also, the illustrated column members **70** have the same member length. However, in other constructions (not shown), the column members **70** may have different member lengths.
[0064] In some aspects, the column members **70** are releasably lockable to each other in the column assembly **26** with a locking assembly **74**. Each column member **70** includes a first locking member **78** at one end (e.g., the frame end) and a second locking member **82** at the opposite end (e.g., the cylinder end). The first locking member **78** of one column member **70***a* is engageable with the second locking member **82** of the adjacent structure (e.g., the adjacent column member **70***b*) to releasably lock the structures together.
[0065] In illustrated constructions, one locking member (e.g., the first locking member **78**) includes a projection or a pin, and the other locking member (e.g., the second locking member **82**) is releasably lockable to the projection. The second locking member **82** includes a recess or a groove configured to receive the projection of the first locking member **78**. The locking members **78**, **82** are configured to toollessly lock the column members **70***a*, **70***b* as a column assembly **26**.
[0066] With continuing reference to FIGS. **1**A-**1**D, the pull rod **18** passes through the column assembly **26** to engage with the pin P to be removed from a recess in the machine frame F. As illustrated, the pull rod **18** engages with the pin P by threading into a threaded bore **90** in the pin P.
[0067] In other constructions (not shown), a threaded bore **90** may not be provided in the pin P, and, in such constructions, a nut, bolt, or other fastener (not shown) may be welded or otherwise fastened to an end of the pin P to provide structure with which the pull rod **18** is engageable. Other methods of engaging the pull rod **18** with the pin P may be provided, and, in such constructions (not shown), the pull rod **18** need not be threaded or threadedly engageable.
[0068] As shown in FIGS. **1**A-**1**D, one end of the column assembly **26** bears against the machine frame F, and the other end of the column assembly **26** bears against the cylinder **30**. The column assembly **26** transfers the aforementioned force to the machine frame F. The column assembly **26** includes an adapter plate **94** between the cylinder **30** and the first column member **70**. The adapter plate **94** connects and transfers force between the cylinder **30** and the column assembly **26**.
[0069] In the illustrated construction, the adapter plate **94** is fastened between the cylinder **30** and the column assembly **26**. The adapter plate **94** is connected to the cylinder **30** (e.g., by fasteners (as shown), welding, etc.). The illustrated adapter plate **94** includes a complementary locking member (e.g., the projection of the first locking member **78**) engageable with a locking member (e.g., the recess of the second locking member **82**) on the adjacent column member **70** to releasably lock the column member **70** to the adapter plate **94** and, therethrough, to the cylinder **30**.
[0070] In other constructions (not shown), the adapter plate **94** may be connected to only one or neither of the cylinder **30** and the column member **70**. In such constructions, the adapter plate **94** may be held in place by the compressive force of the pin puller assembly **10** on the pin P.
[0071] In some constructions (see FIGS. **1** and **7**-**10**), a concave conical saddle **98** is supported on the piston end **46** and mates with a conical protrusion, to be described below, on the reaction member **22**.
[0072] With continuing reference to FIG. **1**, a handle **102** is provided on the cylinder **30**, and one or

more clamps **106** may be provided on the cylinder **30** to be used as rigging points **110**. Rigging points **110** may be disposed on the column members **70** as well. The rigging points **110** may be used to support the pin puller assembly **10** (e.g., with ropes, chains, cables, etc. (not shown)) during transport, installation, use, etc.

[0073] Assembly and operation of the pin puller assembly is illustrated in FIG. **1**. As shown in FIG. **1**A, in Step **1**, the pin puller assembly **10** is assembled and connected to the pin P to be pulled. One or more column members **70** (functioning as column sections) are positioned between the cylinder **30** and the machine frame F. The first column member **70***a* is connected at the cylinder end to the cylinder **30** via the adapter plate **94**, and the frame end is positioned against the machine frame F. As mentioned above, to maintain the components of the pin puller assembly **10** in position the rigging positions **110** may be connected to supporting structure.

[0074] The pull rod **18** is inserted through the axial passage **50** (see, e.g., FIG. **19**) of the piston **42** and connected to (e.g., threaded into) the pin P to be pulled. The reaction member **22** is supported on the pull rod **18** proximate the piston end **46**. The reaction member **22** is threaded along the pull rod **18** into engagement with the piston end **46** or with the saddle **98**, if provided. A source of hydraulic fluid is connected to the cylinder **30**. The pin puller assembly **10** is ready to be operated to pull the pin P.

[0075] FIG. IB illustrates a stroke of the piston **42** (Step **2**). As fluid flows into the cylinder **30**, the piston **42** extends axially. As the piston **42** is extended, the pull rod **18** and pin P are moved axially as well. Engagement between the piston end **46** and the reaction member **22** causes the reaction member **22** to transfer the force that the hydraulic fluid applies to the piston **42** to the pull rod **18**. The column assembly **26** bears against the machine frame F to provide a reaction force against the cylinder **30**. To maintain the cylinder **30** in a stationary position, the column assembly **26** transfers the reaction force between the cylinder **30** and the column assembly **26** to the machine frame F.

[0076] In the illustrated construction, the stroke of the piston **42** (e.g., about 2 in. to about 4 in.) is shorter than length of the pin P (between about 10 in. to about 20 in.). In such case, the pin puller assembly **10** is adjusted to continue the pulling operation.

[0077] If the length of the assembled column member(s) **70** (again, the length of each column member is about 6.5 in.) is sufficient for another stroke of the piston **42**, the pin puller assembly **10** is reset. The reaction member **22** is disengaged from the piston **42**, and the piston **42** is retracted with hydraulic fluid exiting the cylinder **30**. The reaction member **22** is reengaged with the piston **42**, and hydraulic fluid is supplied to the cylinder **30** to extend the piston **42** and pull the pin P.

[0078] If the length of the assembled column member(s) is not sufficient for another piston stroke, as shown in FIG. **1**C (Step **3**), the pin puller assembly **10** is reset, and another column member **70***b* is added. Again, the reaction member **22** is disengaged from the piston **42**, and the piston **42** is retracted. The additional column member **70***b* is added to the column assembly **26** to increase the length of the column assembly **26**. The column member **70***b* is installed around the pull rod **18**, with the pull rod **18** being received through the mouth **72**. The column member **70***b* is locked to the column member **70***a* with the locking assembly **74**. The frame end of the column member **70***b* is positioned against the machine frame F. As necessary, the reaction member **22** is threaded along the pull rod **18** into engagement with the piston end **46** or with the saddle **98**, if provided. The pin puller assembly **10** is ready to continue to pull the pin P.

[0079] FIG. **1**D illustrates a subsequent stroke of the piston **42** (Step **4**). As fluid flows into the cylinder **30**, the piston **42** again extends axially. As the piston **42** is extended, the pull rod **18** and pin P are again moved axially as well. If the movement of the pin P is less than the length of the pin P, steps **3**-**4** are again repeated as necessary until the pin P is removed from the machine frame F. The necessary number of column members (not shown) are added and locked to the lowermost column member **70** in subsequent steps. Once the pin P is removed from the machine frame F, the pin puller assembly **10** remains supported at the rigging points **110**.

[0080] In some constructions (see, e.g., FIGS. **34**-**36**, discussed below in more detail), the column

assembly **26** may be constructed so that the column members **70***a*, **70***b* are connectable in a limited number of relative orientations (e.g., in one orientation with the mouths **72** aligned in the locked position). The column assembly **26** may include an indication (not shown; e.g., markings, colors, etc.) to the operator of the correct orientation(s). In such constructions, the column assembly **26** may be connectable to the cylinder **30** and/or to the adapter plate **94** in the same limited number of orientations or in a different number of orientations (see, e.g., FIGS. **36**A-**36**C, discussed below in more detail; in four orientations with the mouths **72** aligned in four directions relative to the cylinder **30** (for example, in FIGS. **1**A-**1**D, facing into or out of the page, to the left or to the right).
[0081] Alternatively or additionally, the locking assembly **74** may be constructed (see FIGS. **34**-**36**) so that the column members **70***a*, **70***b* are connectable in a limited number of relative orientations (e.g., in one orientation with the mouths **72** aligned in the locked position). The size, shape, relative position of the locking members **78**, **82** may allow engagement of the locking assembly **74** in selected orientations (e.g., the orientation with the mouths **72** aligned in the locked position) and inhibit engagement in other orientations (e.g., with the mouths **72** out of alignment in the locked position). In such constructions, the locking assembly **74** may be constructed so that the column members **70***a*, **70***b* are connectable to the cylinder **30** and/or to the adapter plate **94** in the same limited number of orientations or in a different number of orientations (see, e.g., FIGS. **36**A-**36**C; four orientations)
[0082] For example (see FIGS. **34**-**36**), the locking projections **78** may have different sizes (e.g., different angular extents) to only be received in the associated recess **82** having a corresponding angular extent. As another example (not shown), the locking members **78**, **82** may be non-uniformly positioned about the circumference of the column members **70***a*, **70***b* so that the locking members **78**, **82** are engageable in selected orientations (e.g., the orientation with the mouths **72** aligned in the locked position) and are not engageable in other orientations (e.g., with the mouths **72** out of alignment in the locked position).
[0083] FIGS. **2**A-**2**D illustrate in more detail one construction of a column assembly **114**. The illustrated column assembly **114** includes a number of column members **118** (two shown).
[0084] Each column member **118** has a column member body **122** with first and second locking members operable to toollessly lock one column member **118***a* to an adjacent column member **118***b* or to a plate member **124** (and therethrough to the cylinder **30**). The body **122** has a load-bearing column wall **126** defining a slot or mouth **130** (e.g., to fit around the pull rod **18** during installation, for receiving the pin flange PF during pin removal).
[0085] Each column member **118** includes at least one first locking member (e.g., two projections **134**, as illustrated) and a corresponding number of second locking members (e.g., two recesses **138**). The locking members **134**, **138** are spaced about the circumference of the wall **126** (e.g., by about 180° in the illustrated construction) on opposite sides of the mouth **130**. In the illustrated construction, the locking members **134**, **138** are formed as a part of the wall **126** (e.g., machined, laser cut, etc. into the material of the wall **126**).
[0086] In other constructions, each column member **118** may include only one of each locking member **134**, **138** (not shown) or more than two of each locking members (see, e.g., FIGS. **3**-**4** and **6**). In some constructions (not shown), the locking member **134** and/or **138** may be separate from and connected to the wall **126** of the column member **118**.
[0087] To assemble, each projection **134** is aligned with and enters an open end of a corresponding recess **138**. As the column member **118***a* is twisted relative to the adjacent column member **118***b* or to the plate member **124**, the projection **134** moves along the groove portion of the recess **138** until reaching a closed end of the recess **138** (e.g., after being pivoted between about 30° to about 60° (45° as shown)). At that point, the column member **118***a* is toollessly connected to the adjacent structure (e.g., the adjacent column member **118***b* or the plate member **124**). When connected, the mouth **130** of each column member **118** is aligned (e.g., for receiving the pin flange PF), and the column assembly **114** provides a solid loadbearing support between the cylinder **30** and the

machine frame F.
[0088] FIGS. **3**A-**3**D illustrate another embodiment of a column assembly **142**. The illustrated column assembly **142** includes a number of column members **146** (two shown).
[0089] Each column member **146** has a cylinder body **150** with a load-bearing wall **154** defining a slot or mouth **158**. In the illustrated construction, the toolless locking members (the projections **162** and the recesses **166** (three of each shown)) are provided on structure separate from and connected to the wall **154**. The locking members **162**, **166** are spaced apart about the circumference of the column member **146** (e.g., by about 120°).
[0090] The recesses **166** are provided by a ring assembly, including rings **170**, **174**, **178**, connected to one end of the wall **154** (e.g., on the cylinder end). The upper first ring **170** defines the open end of each recess **166** and an upper surface of the groove portion of the recess **166**. The intermediate second ring **174** defines the groove portion and the closed end of each recess **166**. The lower third ring **178** provides the lower wall of the groove portion of each recess **166**. A fourth ring **182** is connected to the frame end of the wall **154** and provides the projections **162**. In the illustrated construction, the rings **170**, **174**, **178**, **182** are fastened to the wall **154** by fasteners **186** but may be connected by other means (e.g., welding).
[0091] As illustrated, the locking members **162**, **166** are engaged by first aligning each projection **162** with the open end of the associated recess **166**. The column member **146***a* is first moved axially relative to the adjacent structure (e.g., the adjacent column member **146***b*, the adapter plate **94**) so that the projections **162** engage the recesses **166**. The column member **146***a* is then pivoted, and each projection **162** moves along the groove portion until the closed end of the associated recess **166** (e.g., by pivoting movement of about 20° to about 45° (about 30°, as shown)).
[0092] In other constructions (not shown), one of the locking members (e.g., the recesses **166**) may be provided on separate structure (e.g., the ring assembly) connected to the wall **154** while the other locking members (e.g., the projections **162**) may be provided on the structure of the wall **154**.
[0093] Cutouts **190** are provided on the cylinder body **150**, and rigging points **194** (e.g., eyebolts) are mounted in the cutouts **190**. The rigging points **194** may be used for supporting the column assembly **142** and the pin puller assembly **10** before, during, or after use.
[0094] FIGS. **4**A-**4**E illustrate another construction of a column assembly **198**. The column assembly **198** includes a number of column members **202** (two shown).
[0095] Each column member **202** has a cylinder body **206** with a load-bearing wall **210** defining a slot or mouth **214**. In the illustrated construction, the toolless locking members (the projections **218** and the recesses **222** (three of each shown)) are provided on structure separate from and connected to the wall **226**. The locking members **218**, **222** are spaced apart about the circumference of the column member **202** (e.g., by about 90°).
[0096] The recesses **222** are provided by a crown or ring **226** mounted (e.g., welded) to an upper cylinder end **230** of the body **206**. The projections **218** are provided by rolled pins **234** supported proximate a lower frame end **238** of the body **206** (e.g., received through openings in the wall **210**). The pins **234** of a first column member **202***a* mate with the recesses **222** of a second column member **202***b* to lock the column members **202***a*, **202***b* and thereby form the column assembly **198**.
[0097] As illustrated, the locking members **218**, **222** are engaged by first aligning each projection **218** with the open end of the associated recess **222**. The column member **202***a* is moved axially and pivoted relative to the adjacent structure (e.g., the adjacent column member **202***b*, the plate member (not shown)) so that the projections **218** engage the recesses **222**. The column member **202***a* is then pivoted, and each projection **218** moves along the groove portion until the closed end of the associated recess **222** (e.g., by pivoting movement of about 15° to about 35° (about 30°, as shown)).
[0098] Cutouts **242** are provided on the sides of the wall **210** to accommodate rigging points **246** (e.g., eyebolts). The rigging points **246** may be used for supporting the column assembly **198** and the pin puller assembly **10** before, during, or after use.

[0099] FIGS. **5**A-**5**D illustrate another construction of a column assembly **250**. The column assembly **250** includes a number of column members **254** (two shown).
[0100] Each column member **254** includes a cylinder body **258** with a load-bearing wall **262** defining a slot or mouth **264**. At the cylinder end, the wall **262** defines an annular groove **266** and, at the frame end, has an annular projection **270**. The projection **270** on the column member **254***a* (or on the adapter plate **274**) sits in the groove **266** of the adjacent column member **254***b*. In other constructions (not shown), a separate wall defining the groove **266** may be fixed to the wall **262**.
[0101] In the illustrated construction, the toolless locking members are provided by a latch assembly **278** (two shown) separate from and connected to the wall **262**. The latch assemblies **278** are spaced apart about the circumference of the column member **254** (e.g., by about 180°).
[0102] Each locking projection is provided by a shouldered pin **282** threaded into the wall **262** proximate the frame end (or into the adapter plate **274**). Each locking recess **284** is provided by a draw strap or latch member **286**. Each latch member **286** also defines an oblong opening **288** receiving a U-shaped mount **290** fixed to the wall **262** by fasteners **294**. Each latch member **286** pivots on the mount **290** and positions the locking recess **284** proximate the cylinder end to receive the associated pin **282** of the adjacent column member **254** (or of the adapter plate **274**). Each latch member **286** is flexible (e.g., formed of rubber) to stretch over and receive the wide head of the associated pin **282** in the locking position.
[0103] Further, there are cutouts **302** on the wall **262** at which rigging points **306** (e.g., eyebolts) are mounted to the wall **262**. Axial flats **308** extending from each cutout **302** provide a location to mount the latch assemblies **278**.
[0104] FIGS. **6**A-**6**E illustrate another construction of a column assembly **310**. The column assembly **310** includes a number of column members **314** (two shown).
[0105] Each column member **314** includes a cylinder side ring **318** and a frame side ring **322** and a number of support posts **326** (four shown) disposed between the rings **318**, **322**. The illustrated cylindrical posts **326** are mounted to the rings **318**, **322** by means of fasteners **330**. Each ring **318**, **322** is generally C-shaped so that the assembled column member **314** defines a slot or mouth **334**.
[0106] The toolless locking members **336**, **338** are provided on the rings **318**, **322**, respectively. The first locking members are provided by a number of shouldered pins **336** (three shown) threaded to the cylinder side ring **318**. The second locking members are provided a corresponding number of slots or recesses **338** (also three shown) defined in the frame side ring **322**. Each recess **338** has an enlarged open end sized to receive the head of the associated pin **336** and a narrow groove portion sized to inhibit axial removal of the pin **336**.
[0107] To assemble the column assembly **310**, each column member **314** is first assembled. The number of posts **326** are fastened between the rings **318**, **322**. Each post **326** has the same length to provide a length of the column member **314** (e.g., as illustrated, about 6.5 in.).
[0108] A column member **314***a* is locked to an adjacent structure (e.g., an adjacent column member **314***b*, an adapter plate **340**) by engaging the locking members **336**, **338**. Each pin **336** is aligned with and axially inserted into the open end of the associated recess **338**. The column member **314***a* is then pivoted relative to the adjacent structure (e.g., an adjacent column member **314***b*, an adapter plate **340**) so that each pin moves along the narrow portion to the closed end of the associated recess **338** (e.g., between about 5° and about 15° (about 10°, as shown)). In this position, each pin **336** may be tightened against the surface of the ring **322** to further lock the position of the column member **314***a* relative to the adjacent structure (e.g., an adjacent column member **314***b*, an adapter plate **340**). Also, a retainer member (not shown; e.g., a keeper pin) may be installed (e.g., inserted into aligned slots in the rings **318**, **322** to inhibit untwisting of the column member **314***a* and the adjacent structure.
[0109] During operation of the pin puller assembly **10** with the column assembly **310**, for an initial pulling operation, a column member **314***a* with posts **326** having a first length may be used. After the piston **42** reaches its maximum stroke, additionally or alternatively to adding another column

member **314***b*, posts **326** with an increased length (e.g., twice the first length) may be substituted into the column member **314***a* so that the pin puller assembly **10** may continue the pulling operation.

[0110] The open areas between the rings **318**, **322** and the posts **326** may provide rigging points for the column assembly **310**.

[0111] In some constructions, the separate locking arrangements (e.g., those shown in FIGS. **3**-**6**) may be added to existing column assemblies (not shown) which are not lockable. The locking arrangements may be provided separately as a kit and retrofitted to the column members of such existing column assemblies. Alternatively, the existing column members may be modified (e.g., machined) to provide the locking arrangement shown in FIG. **2**.

[0112] The retainer member (keeper pin) described above for the column assembly **310** may be provided in the other constructions of the locking column assemblies **26**, **114**, **142**, **198**, **250**.

[0113] In some constructions (see, e.g., FIG. **11**), the reaction member **22** is a unitary nut threadedly engaging the threaded pull rod **18**. In other constructions and for some aspects (see, e.g., FIGS. **1** and **7**-**10**), the reaction member **22** includes a split reaction member assembly selectively engageable along the pull rod **22**. In such constructions, the split reaction member assembly is also threaded to thread along the pull rod **18**. The split reaction member assembly may allow rapid application to and adjustment along the pull rod **18** even with damaged threads. The split reaction member assembly may provide coarse and fine positional adjustment along the length of the pull rod **18**.

[0114] FIGS. **7**A-**7**G illustrate one construction of a split reaction member assembly **342**. In the illustrated construction, the split reaction member assembly **342** includes a quick fastening Split Nut®, model EAJ #QFN, sold by Enerpac, as a component of the EAJ-Series Aquajack® Subsea Tensioner.

[0115] The illustrated reaction member assembly **342** includes first and second nut halves **346**, **350** positionable to cooperate and define a threaded bore **354** therebetween. The threaded bore **354** is configured to threadably attach to the pull rod **18**. First and second fasteners **358**, **362** selectively hold the two nut halves **346**, **350** together.

[0116] The nut halves **346**, **350** have two positions: a locked position, in which the nut halves **346**, **350** are compressed and held together such that the threaded bore **354** will threadably engage the pull rod **18**, and an unlocked position, in which the halves **346**, **350** are spaced apart such that the threaded bore **354** does not threadably engage the pull rod **18**. Each fastener **358**, **362** is fixed at one end to one nut half (e.g., the nut half **346**), and the other nut half (e.g., the nut half **350**) is slidable along the fasteners **358**, **362** between the locked and unlocked positions.

[0117] In the illustrated construction, the halves **346**, **350** are biased apart toward the unlocked condition by a biasing arrangement (e.g., a spring (not shown) positioned around each fastener **358**, **362** and between the nut halves **346**, **350**). An actuator button **366** supported on the sliding nut half (e.g., on the nut half **350**) selectively engages one fastener (e.g., the fastener **358**) to hold the nut halves **346**, **350** in position. When the actuator button **366** is actuated (e.g., depressed), the actuator button **366** disengages the fastener **358**, and the springs bias the nut halves **346**, **350** apart toward the unlocked position.

[0118] In the unlocked position, the inner diameter of the threaded bore **354** of the reaction member **342** is greater than the maximum diameter of the pull rod **18** at the outside of its threads. Accordingly, in the unlocked position, the reaction member assembly **342** may be moved axially along the pull rod **18** without engagement of the threaded bore **354** with the threaded pull rod **18** to a selected axial position on the pull rod **18**. This provides coarse adjustment of the axial position of the reaction member assembly **342** on the pull rod **18**.

[0119] When the reaction member assembly **342** has reached the selected axial position on the pull rod **18**, the reaction member assembly **342** may be locked in place by compressing the two nut halves **346**, **350** together into the locked position such that the threaded bore **354** of the reaction

member **342** threadably engages the threads of the pull rod **18**. In the locked position, the actuator button **366** engages an annular groove in the fastener **358** to hold the nut halves **346**, **350** together. As the nut halves **346**, **350** move toward the locked position, the actuator button **366** slides along the fastener **358** so that the actuator button **366** does not need to be actuated during locking of the reaction member assembly **342**.

[0120] To allow for locking operation of the reaction member assembly **342**, the reaction member assembly **342** is positioned out of engagement with the piston end **46** and locked. In the locked position, the reaction member assembly **342** is rotatable relative to and moves axially along the pull rod **18** due to threaded engagement with the threaded bore **354**.

[0121] The nut halves **346**, **350** cooperate to provide a conical protrusion **370** engageable with the conical recess of the saddle **98** on the piston **42**. Mating of the conical protrusion **370** on the nut halves **346**, **350** with the conical saddle **98** causes the nut halves **346**, **350** to be forced together as the piston **42** applies pulling force to the pull rod **18**. The force of the piston **42** has an axial component transferred along the pull rod **18** to the pin P to be pulled and a radial component to further compress the nut halves **346**, **350** together to inhibit the reaction member assembly **342** from disengaging the pull rod **18** (e.g., potentially causing the pulling operation to be interrupted, damaging the threads on the pull rod **18**, etc.).

[0122] While not described below in detail, in the constructions illustrated in FIGS. **8**-**10**, the split reaction member assemblies provide a similar conical protrusion mateable with the conical saddle **98** on the piston **42**.

[0123] Threading the reaction member assembly **342** axially along the pull rod **18** while in the locked position provides a close engagement of the conical protrusion **370** with the conical saddle **98**. This close engagement will minimize the portion of the stroke of the piston **42** required to tighten the piston end **46** against the reaction member **342** and thereby maximize the portion stroke of the piston **42** used to pull the pin P.

[0124] FIGS. **8**A-**8**G illustrate another construction of a split reaction member assembly **374**.

[0125] The reaction member assembly **374** includes first and second nut halves **378**, **382** positionable to cooperate and define a threaded bore **386** therebetween configured to threadably attach to the pull rod **18**. In the illustrated construction, the nut halves **378**, **382** are pivotable between the locked and unlocked positions (described above).

[0126] Each nut half **378**, **382** includes two pairs of ears **390**, **394** and **398**, **402**, respectively. The nut halves **378**, **382** are releasably coupled at one end by a clamping pin **406** pivotably supported on a stationary pivot pin **410**. The pivot pin **410** positioned in a hole **414** defined in the first pair of ears **390** of the first nut half **378**, and, in the locked position, the clamping pin **406** is selectively engageable between the pair of ears **398** on the second nut half **382**. At the opposite end, the nut halves **378**, **382** are pivotably coupled to a plate **418** by pins **422**, **426** respectively coupled to the pairs of ears **394**, **402** on the nut halves **378**, **382**.

[0127] To move to the unlocked position, the clamping pin **406** is loosened and pivoted out of engagement between the pair of ears **398**. With the clamping pin **406** disengaged from the nut half **382**, the nut halves **378**, **382** are pivotable away from each other about the pins **422**, **426**. The threaded bore **386** is disengaged from the pull rod **18**, and the reaction member assembly **374** may be positioned at a selected location along the pull rod **18**.

[0128] Once in the selected position, the nut halves **378**, **382** are moved together so that the threaded bore **386** engages the pull rod **18**. The clamping pin **406** is engaged between the pair of ears **398** on the nut half **382** and threadedly tightened to clamp the reaction member assembly on the pull rod **18**.

[0129] As mentioned above, to allow for locking operation of the reaction member assembly **374**, the reaction member assembly **374** is positioned out of engagement with the piston end **46** and locked. In the locked position, the reaction member assembly **374** is threaded along the pull rod **18** into engagement with the saddle **98** on the piston **42** to mate a conical protrusion **428** on the nut

halves **378**, **382** with the conical saddle **98**.
[0130] FIGS. **9**A-**9**G illustrate another construction of a split reaction member assembly **430**.
[0131] The reaction member assembly **430** includes first and second nut halves **434**, **438** positionable to cooperate and define a threaded bore **442** therebetween configured to threadably attach to the pull rod **18**. In the illustrated construction, the nut halves **434**, **438** are pivotable between the locked and unlocked positions (described above).
[0132] The nut halves **434**, **438** include two pairs of ears **446**, **450** and **454**, **458**, respectively. The nut halves **434**, **438** are releasably coupled at one end by a clamping mechanism **462** pivotably connected to both nut halves **434**, **438**. The clamping mechanism **462** includes an arm member **466** coupled at one end to an arm pin **470** between the pair of ears **446** of the first nut half **434** and a lever member **474** coupled to a lever pin **478** between the pair of ears **454** of the second nut half **438**. At its opposite end, the arm member **466** is coupled by a connector pin **482** to a cam portion of the lever member **474**.
[0133] Similar to the reaction member assembly **374** described above and shown in FIGS. **8**A-**8**G, at the opposite end, the nut halves **434**, **438** are pivotably coupled to a plate **486** by first and second pins **490**, **494** respectively received by the pairs of ears **450**, **458** of the nut halves **434**, **438**.
[0134] To move to the unlocked position, the clamping mechanism **462** is released by pivoting the free end of the lever member **474** away from the second nut half **438**. The force applied by the clamping mechanism **462** on the nut halves **434**, **438** is reduced, allowing the nut halves **434**, **438** to spread apart and the threaded bore **442** to disengage the pull rod **18**. In the unlocked position, the reaction member assembly **430** may be positioned at a selected location along the pull rod **18**.
[0135] Once in the selected position, the clamping mechanism **462** is activated by moving the free end of the lever member **474** toward the second nut half **438**. The clamping mechanism **462** draws the nut halves **434**, **438** together so that the threaded bore **442** engages the pull rod **18**. The lever member **474** is pivoted over center to retain the clamping mechanism **462** in the locked position.
[0136] As mentioned above, to allow for locking operation of the reaction member assembly **430**, the reaction member assembly **430** is positioned out of engagement with the piston end **46** and locked. In the locked position, the reaction member assembly **430** is threaded along the pull rod **18** into engagement with the saddle **98** on the piston **42** to mate a conical protrusion **498** on the nut halves **434**, **438** with the conical saddle **98**.
[0137] FIGS. **10**A-**10**G illustrate another construction of a split reaction member assembly **500**.
[0138] The reaction member assembly **500** includes first and second nut halves **502**, **506** positionable to cooperate and define a threaded bore **510** therebetween configured to threadably attach to the pull rod **18**. In the illustrated construction, the nut halves **502**, **506** are pivotable between the locked and unlocked positions (described above).
[0139] The nut halves **502**, **506** include two pairs of ears **514**, **518** and **522**, **526**, respectively. The nut halves **502**, **506** are releasably coupled at one end by a clamping mechanism **534**. The clamping mechanism **534** is similar to the clamping mechanism **462** described above and illustrated in FIGS. **9**A-**9**G; however, in the illustrated construction, the clamping mechanism **534** selectively disengages the first nut half **502** to allow the nut halves to move further apart in the unlocked position and to radially engage and disengage the pull rod **18**.
[0140] The illustrated clamping mechanism **534** includes an arm member **538** with a protrusion **542** on each side selectively received in a notch **546** in each of the pair of ears **514** of the first nut half **502**. A lever member **550** is coupled to a lever pin **554** between the pair of ears **522** of the second nut half **506**. At its opposite end, the arm member **538** is coupled by a connector pin **558** to a cam portion of the lever member **550**. With the arm protrusion **542** received in the notches **546**, the lever member **550** may be pivotably clamped against the second nut half **506**, thereby clamping the nut halves **502**, **506** together
[0141] Similar to the reaction member assemblies **374**, **430** described above and shown in FIGS. **8**A-**9**G, at the opposite end, the nut halves **502**, **506** are pivotably coupled to a plate **560** by first

and second pins **562**, **566** respectively received by the pairs of ears **518**, **526** of the nut halves **502**, **506**.

[0142] To move to the unlocked position, the clamping mechanism **534** is released by pivoting the free end of the lever member **550** away from the second nut half **506**. The force applied by the clamping mechanism **534** on the nut halves **502**, **506** is reduced, allowing the arm member **538** to disengage the first nut half **502**. The nut halves **502**, **506** can be spread apart so that the threaded bore **510** disengages the pull rod **18**. In the unlocked position, the reaction member assembly **500** may be positioned at a selected location along the pull rod **18**.

[0143] Once in the selected position, the arm member **538** is engaged with the first nut half **502**, with the arm protrusion **542** engaging the notches **546** in the pair of ears **514** on the first nut half **502**. The clamping mechanism **534** is then activated by moving the free end of the lever member **550** toward the second nut half **506**. The clamping mechanism **534** draws the nut halves **502**, **506** together so that the threaded bore **510** engages the pull rod **18**. The lever member **550** is pivoted over center to retain the clamping mechanism **534** in the locked position.

[0144] As mentioned above, to allow for locking operation of the reaction member assembly **500**, the reaction member assembly **500** is positioned out of engagement with the piston end **46** and locked. In the locked position, the reaction member assembly **500** is threaded along the pull rod **18** into engagement with the saddle **98** on the piston **42** to mate a conical protrusion **568** on the nut halves **502**, **506** with the conical saddle **98**.

[0145] FIGS. **11**A-I IB illustrate a construction of a unitary reaction nut **570**.

[0146] The reaction nut **570** includes inner and outer rings **574**, **578** connected by support spokes **582**. Slots **586** are defined between the rings **547**, **578** and the support spokes **582**. The inner ring **574** defines a threaded bore **590** threadedly engageable with the pull rod **18**. The illustrated reaction nut **570** is positioned in a selected position along the pull rod **18** by rotating and threading the reaction nut **570** along the pull rod **18**.

[0147] Because the reaction nut **570** has a large outside diameter compared to its inside diameter and because the outer ring **578** has a substantial amount of mass, the moment of inertia of the reaction nut **570** about the longitudinal axis of the pull rod **18** is larger than with a typical hex nut (not shown). As a result, the reaction nut **570** creates a flywheel effect when rotated quickly by an operator, causing the reaction nut **570** to move quickly along the axis of the pull rod **18** and to continue rotating for a relatively long time. The reaction nut **570** may save the operator time and effort compared to threading a typical hex nut, having an associated relatively low moment of inertia (when compared to the reaction nut **570** of FIG. **11**), along the pull rod **18**.

[0148] FIGS. **12-17** illustrate an alternative construction of a pin puller assembly **610** operable to pull a pin P from a machine M having a frame F. The pin puller assembly **610** is similar to the pin puller assembly **10** described above and shown in FIGS. **1**A-**1**D. Certain common elements between the pin puller assembly **10** and the pin puller assembly **610** are identified in this paragraph and have the same reference number plus “600.” The pin puller assembly **610** includes a pull rod assembly including a pull rod **618**. The pin puller assembly **610** further includes a reaction member **622**, a piston-cylinder unit **614**, and a load-bearing column assembly **626**.

[0149] Pulling the pin P requires the application of a force to the pin P, and the pull rod **618** is configured to withstand a greater tension force than the force required to pull the pin P. As described below, the pull rod **618** (and the reaction member **622**) are constructed so that the pull rod **622** cannot be substituted with a lower grade threaded rod that is not constructed for the given pin pulling force.

[0150] With reference to FIGS. **18-20**, the pull rod **618** has a rod end **662** proximate to the pin P and an opposite rod end **664** positioned distal from the pin P, with a rod body **665** disposed therebetween. The pull rod **618** defines a longitudinal axis **668** and, as illustrated, has a circumferential sawtooth profile **670** along at least a portion of an outer surface of the rod body **665**.

[0151] The sawtooth profile **670** includes a plurality of annular pulling steps or sawtooth pulling rings **680** encircling and spaced along the length of the sawtooth portion of the rod body **665** disposed toward the rod end **664**. In the illustrated construction, a plurality of annular coupling steps or sawtooth coupling rings **682** are disposed proximate the rod end **662**. The illustrated rings **680**, **682** are not connected to each other. In other words, the rings **680**, **682** do not comprise threads. An annular recess or depression **690** is provided between adjacent rings **680**, **682**. In the illustrated construction, the pull rod **618** has the sawtooth profile cut into the outer surface of a round bar which may provide increased strength.
[0152] Each illustrated pulling ring **680** has an annular axial surface or a flat face **700**, an angled surface or an angled face **710**, and a circumferential surface or outer face **720**. The flat face **700** extends substantially radially with respect to the axis **670**. The outer face **720** is a circumferential surface connecting the flat face **700** of a pulling ring **680** to the associated angled face **710** of that pulling ring **680**.
[0153] The flat face **700** of each pulling ring **680** is substantially perpendicular to the axis **668** and is a force-receiving surface. For each pulling ring **680**, the flat face **700** of the ring **680** faces toward the rod end **662**, in other words, towards the pin P. The angled face **710** of each pulling ring **680** is at an angle (e.g., between about 30° and about 60° (about 45° as shown) relative to the axis **668**. For each pulling ring **680**, the angled face **710** of the ring **680** faces toward the rod end **664**, in other words, away from the pin P. The outer face **720** is oriented substantial parallel to the axis **668**. The orientation of the pulling rings **680** is configured to receive pulling force from the reaction member **622**
[0154] In the illustrated construction, the sawtooth profile **670** of the pulling rings **680** extends between about 25% and about 90% of the length of the pull rod **618** (e.g., about 75% as shown). It should be understood that, in other constructions, the sawtooth profile **670** may extend less than 25% or greater than 90% of the length of the pull rod **618**.
[0155] As shown in FIG. **29**, the illustrated rod end **662** includes a plurality of coupling steps or sawtooth coupling rings **682**. The coupling rings **682** differ from the pulling rings **680** in that the coupling rings **682** are oriented in the opposite direction compared to the pulling rings **680**. More specifically, for each coupling ring **682**, a flat face **684** of the ring **682** faces toward the rod end **664**, in other words, away from the pin P. An angled face **686** of each coupling ring **682** is at an angle (e.g., between about 30° and about 60° (about 45° as shown) relative to the axis **668**. For each coupling ring **682**, the angled face **686** of the coupling ring **682** faces toward the rod end **662**, in other words, towards from the pin P. The orientation of the coupling rings **682** is configured to transmit force to a barrel coupler **900**, described below.
[0156] With reference to FIG. **31**, the pull rod **618** includes an annular ridge **730** positioned towards the rod end **662** encircling (completely (as shown) or partially) the pull rod **618**. The ridge **730** is positioned between the pin P and the piston-cylinder unit **614** when the pin puller assembly **610** is in a pin pulling configuration. The pull rod **618** has a first rod diameter proximate the rod end **664** and a larger second rod diameter proximate the rod end **662** (e.g., closer to the pin P). For example, the ridge **730** has an outside diameter **740** providing the larger rod diameter.
[0157] With reference to FIGS. **23-24**, a reaction member **622** is a split reaction member assembly having a number of reaction member portions (two shown). In the illustrated construction, the portions are substantially identical, have a substantially equal size and, in other words, are reaction member halves **760***a*, **760***b*. The inner surfaces of the halves **760***a*, **760***b* cooperate to define an opening **762** to receive the pull rod **618**.
[0158] In the illustrated construction, the reaction member **622** is constructed as a quick ratchet clasp. The reaction member **622** is adjustable between a closed, engaging position (shown in FIG. **24**), in which the inner surfaces are engageable with the pull rod **618**, and an open, disengaged position (shown in FIG. **25**), in which the inner surfaces are disengageable from the pull rod **618**. Movement of the reaction member **622** relative to the pull rod **618** in one direction along the axis

668 (e.g., toward the pin P) causes adjustment of the reaction member **622** from the closed position toward the open position.

[0159] Pins **770** connect and guide movement of the halves **760***a*, **760***b* between the open and closed positions. Each pin **770** is received in a guide bore **775***a*, **775***b* defined in each half **760***a*, **760***b*. The halves **760***a*, **760***b* are biased toward one position (the closed position in the illustrated construction). The reaction member **622** includes at least one biasing member (e.g., a spring **780** (two shown)). Each spring **780** is supported on a pin **770** and acts to bias the halves **760***a*, **760***b* towards each other (towards the closed, engaging position).

[0160] The inner surfaces of the halves **760***a*, **760***b* cooperate to define an opening **762** having a plurality of inwardly-facing pulling steps or sawtooth pulling rings **790** (three shown). Each pulling ring **790** has an annular axial retaining surface connected to an annular angled opening surface, and internal annular grooves **800** are between adjacent pulling rings **790**.

[0161] The pulling rings **790** are configured to mate with the pulling rings **680** of the pull rod **618**. More specifically, the annular axial retaining surface of each ring **790** is complementary and bears against the flat face **700** of a ring **680** on the pull rod **618** to inhibit movement of the reaction member **622** relative to the pull rod **618** in the opposite direction (away from the pin P).

[0162] The annular angled opening surface of each ring **790** is complementary to and engageable with the angled face **710** of the ring **680**. During movement of the reaction member **622** relative to the pull rod **618** in the one direction (towards the pin P), the opening surface of each ring **790** rides along the angled face **710** of the ring **680** so that the halves **760***a*, **760***b* move towards the open position.

[0163] One or more connector members **810** (two shown) are supported on the reaction member **622** and are connectable to the piston end (to the saddle **98**) to connect the reaction member **622** to the piston. Each connector member **810** is positioned between the halves **760***a*, **760***b* and has a body **812** defining a bore **814** to receive a supporting pin **770**. A connector ear **816** extends outwardly from each body **812** and defines a mounting bore **818** to receive a fastener (not shown) to connect to the piston end or to the saddle **98**.

[0164] In the closed position, the halves **760***a*, **760***b* bear against the ears **810**. When connected to the piston end or the saddle **98**, the connector members **810** allow for some axial movement of the reaction member **622** away from the piston end/saddle **98** so that the reaction member **622** can open.

[0165] When the pin puller **600** is being reset (e.g., between pulling strokes), the piston is retracted into the cylinder relative to the pull rod **618** and the pin P. The reaction member **622**, connected to the piston end/saddle **98** moves with the piston. During this relative movement, the reaction member **622** unseats from the saddle **98**, and the angled surfaces of the rings **790**, **680** move along each other to open the reaction member **622** so that the reaction member **622** moves along the pull rod **618**. The biasing force of the spring **780** causes the halves **760***a*, **760***b* to move back to the closed position. The reaction member **622** ratchets open and is biased closed as it moves along the pull rod **618**.

[0166] As described previously, as shown in FIG. **25**, the pull rod **618** fits through an axial passage in the hollow piston of the piston-cylinder unit **614**. The pull rod **618** has a diameter **830**. The axial passage of the piston has a passage diameter **840**. A baseplate **850** is connected to the pin end of the piston-cylinder unit **614** and defines an opening **860** through which the pull rod **618** extends. The baseplate opening **860** has an opening diameter **870**. The diameter of at least one of the piston passage diameter **840** and the baseplate opening diameter **870** is sized to prevent that the rod end **662** from passing therethrough while allowing passage of the remainder of the pull rod **618** toward the rod end **664**.

[0167] As shown in FIG. **29**, the pull rod **618** is connectable to an adapter **820** to connect to the pin P to be pulled. With reference to FIG. **26**, the adapter **820** includes a locking segment **821**, a hex segment **822**, and a blank segment **823**. The blank segment **823** provides a pin end of the adapter

820, and the locking segment **821** provides a coupling end of the adapter **820**.
[0168] The locking segment **821** has a sawtooth profile of coupling steps or rings matching the pulling rings **680** and opposite to the coupling rings **682** of the pull rod **618**. In other words, each coupling ring on the adapter **820** has a flat face **700** toward the pin P an angled face **710** facing toward the pull rod **618** (and away from the pin P). A barrel coupler **900** is configured to couple the adapter **820** to the pull rod **618**.
[0169] In the illustrated embodiment of FIG. **26**, the blank segment **823** of the adapter **820** is not threaded, but rather is a blank to be machined to provide the desired threads to engage the pin P. A user may select the type of threads to be machined onto the blank segment **823** based on a type of threads of a threaded bore **824** in the pin P (see FIG. **25**). Accordingly, the adapter **820** is threaded into the pin P and coupled, through the barrel coupler **900**, to the pull rod **618** such that an axial force applied to the pull rod **618** is transmitted through the rod end **662**, through the coupler **900**, through the adapter **820**, and to the pin P to remove the pin P.
[0170] The hex segment **822** of the adapter **820** is shaped (e.g., in a hexagonal shape) for convenience in threading the adapter **820** and the pin P and may be formed with other shapes, for example, square. The hex segment **822** is located between the pin end and the coupling end of the adapter **820** and constructed as an annular collar. The annular collar or hex segment **822** has a collar diameter **825** and may be a 45 millimeter (mm) AF hex.
[0171] With reference to FIGS. **27-29**, the barrel coupler **900** is configured to couple the adapter **820** to the rod body **665**. The coupler **900** has body segments or halves **910***a*, **910***b* which are illustrated as being substantially identical. The halves **910***a*, **910***b* are movable between an open, release position (see FIG. **27**) and a closed, coupling position (see FIG. **28**). The halves **910***a*, **910***b* are coupled to pivot about an axis **940** and connected by a cam lever **920** and a latch **930**.
[0172] The coupler **900** has an inner surface having sawtooth coupling rings **950**, **980** configured to couple with the coupling rings **682** on the rod end **662** of the pull rod **618** and the coupling rings **680** in the locking segment **821** of the adapter **820**. As shown in FIG. **29**, a first portion **960** of the coupler **900** has sawtooth coupling rings **950** oriented in a first direction, and a second portion **970** of the coupler **900** has sawtooth coupling rings **980** oriented in the opposite second direction. In other words, the first portion **960** of the coupler **900** has coupling rings **950** configured to engage the coupling rings **682** on the pull rod **618**, and the second portion **970** has coupling rings **980** configured to engage the coupling rings on the adapter **820**. The two portions **960**, **970** are reversible and interchangeable. As best shown in FIG. **29**, both sets of coupling rings **950**, **980** (see also FIG. **27**) are oriented to transmit force from the pull rod **618** to the adapter **820**.
[0173] The coupler **900** is positionable in a release position (FIG. **27**), in which the adapter **820** and the pull rod **618** are relatively movable, and a coupling position (FIG. **28**), in which the coupler **900** connects the pull rod **618** and the adapter **820**. The halves **910***a*, **910***b* of the coupler **900** are relatively pivotable between the coupling and release positions. The latch **930** to releasably hold the halves **910***a*, **910***b* in the coupling position.
[0174] With reference to FIGS. **26-29** and **31**, the external diameter **740** of the ridge **730** may be larger than at least one of the piston axial passage diameter **840** and the baseplate opening diameter **870**. Additionally, the collar diameter **825** may be larger than at least one of the piston axial passage diameter **840** and the baseplate opening diameter **870**. The coupler **900** has an outer surface defining a coupler diameter **990**, which is larger than at least one of the piston passage diameter **840** and the baseplate opening diameter **870**.
[0175] In operation, with reference to FIGS. **30-32**, the pull rod **618** is inserted through an axial bore in a piston such that the rod end **664** protrudes beyond the piston-cylinder unit **614** and such that the rod end **662** is proximate to the pin P. The reaction member **622** is pulled over the rod end **664** and along a length of the pull rod **618** until the reaction member **622** approaches the piston-cylinder unit **614**. Alternatively, as the pull rod **618** is pushed through the axial passage of the piston and into the reaction member **622**, the reaction member **622** will automatically ratchet open

and closed.
[0176] Due to the sawtooth profile **670**, the reaction member **622** cannot thread along the length of the pull rod **618**. Rather, the reaction member **622** is ratcheted along the length of the pull rod **618**. Ratcheting the reaction member **622** along the pull rod **618** may save a user time and effort compared to threading along a pull rod. Because the reaction member **622** is biased to its closed position, once the reaction member **622** ratchets over one of the pulling rings **680** on the pull rod **618**, the reaction member **622** cannot be removed from the pull rod **618** without a user manually opening the reaction member **622** and sliding along the pull rod **618** in the opposite direction.
[0177] With reference to FIGS. **25** and **29**-**32**, the adapter **820** is connected to the pin P to be pulled (e.g., by threading into the threaded bore **824** of the pin P). Further, the rod end **662** of the pull rod **618** is coupled to the locking segment **821** of the adapter **820** by clamping the coupler **900** onto the adapter **820** and onto the rod end **662** of the pull rod **618**. The pin puller **600** is then operated to pull the pin P from the frame F, as described above.
[0178] With reference to FIG. **31**, during operation, the threads within the threaded bore **824** of the pin P, the adapter **820**, or another component might fail. In such a situation, the pull rod **618** may separate and tend to move forcefully away from the pin P and through the axial passage of the piston of the piston-cylinder unit **614**. Due to the larger diameter **990** of the coupler **900**, which is larger than at least one of the piston axial passage diameter **840** and the baseplate opening diameter **870**, the coupler **900** will contact and cannot pass through one of the baseplate **850** or the piston-cylinder unit **614**. Similarly, because of the larger diameter **740** of the ridge **730**, which is larger than at least one of the piston axial passage diameter **840** and the baseplate opening diameter **870**, the ridge **730** will contact and cannot pass through one of the baseplate **850** or the piston-cylinder unit **614**, preventing the pull rod **618** from moving out of the pin puller **600**.
[0179] In other constructions (not shown), one or more of the connections between the adapter **820**, the coupler **900**, and the pull rod **618** may be made with threaded connections, such as M30 thread.
[0180] FIGS. **33**A-**33**D illustrate additional embodiments of column assemblies **1004**, **1005**, each including a number (three shown) of column members **1008**, **1009**, respectively. The column assemblies **1004**, **1005** and associated column members **1008**, **1009** are constructed to, for example, have different load capacities to withstand a different compressive force during pin pulling. The illustrated column assembly **1004** and its column members **1008** have a first load capacity (e.g., up to about 60 tons (T)) while the illustrated column assembly **1005** and its column members **1009** have a different second load capacity (e.g., up to about 30T).
[0181] The column assemblies **1004**, **1005** and column members **1008**, **1009** are similar, and, for simplicity, only the column assembly **1004** and the column members **1008** will be described in detail. However, it should be understood that the description applies to the column assembly **1005** and column members **1009**.
[0182] Each column member **1008** includes one or more (three shown) mounting points **1009** to mount an eye or rigging point **1010** to its outer surface **1011**. Each illustrated mounting point **1009** includes a threaded hole or other attachment mechanism to receive and retain the rigging point **1010**. Each column member **1008** has a cylinder body **1012** with a load-bearing wall **1016** defining a slot or mouth **1020**.
[0183] The column members **1008** are releasably lockable to one another with a “toolless locking assembly” in a similar manner to the column members **146**, described above and shown in FIGS. **3**A-**3**D.
[0184] In the illustrated construction, each column member **1008** includes a number (three shown) of locking tabs or projections **1024** spaced apart about a circumference of the column member **1008** (e.g., by about 90° (as shown), by about 120° (in other embodiments)). With reference to FIG. **34**, each projection **1024***a*, **1024***b*, **1024***c* on one of the column members **1008** interfaces with one of a corresponding number (three shown) of locking recesses **1028** on another column member **1008**. As illustrated, the projections **1024***a*, **1024***b*, **1024***c* are positioned on a circular arc at one end **1029**

of the column member **1008**, and the recesses **1028***a*, **1028***b*, **1028***c* are positioned on a circular arc at the opposite end **1030** of the column member **1008**. In contrast to the column member **146** with separate structure providing its locking members **162**, **166**, each column member **1008** is formed as a single integral piece (e.g., via investment casting) including the locking projections **1024**, the recesses **1028**, the mounting point(s) **1009**.

[0185] With continued reference to FIG. **34**, each recess **1028***a*, **1028***b*, **1028***c* includes an open portion **1032**, opening in a direction away from the first end **1029**, and an adjacent closed portion **1036**. In the illustrated construction, the closed portion **1036** is radially tapered.

[0186] Similarly, each projection **1024***a*, **1024***b*, **1024***c* has a radially tapered edge **1040**. The illustrated tapering of the recess(es) **1028** and/or of the project! on(s) **1024** causes the engagement between these components to become tighter when the column members **1008** are relatively pivoted toward the locking position. This structure may accommodate "looser" manufacturing tolerances between the components.

[0187] In other constructions (not shown), the recess(es) **1028** and/or the project! on(s) **1024** may additionally or alternatively have an axial taper to provide a tighter engagement in the axial direction.

[0188] With continued reference to FIG. **34** and with reference to FIG. **35**, one or more of the projections **1024***a*, **1024***b*, **1024***c* may be different than the other project! on(s) **1024***a*, **1024***b*, **1024***c*, and, likewise, one or more of the recesses **1028***a*, **1028***b*, **1028***c* may be different than the other recess(es) **1028***a*, **1028***b*, **1028***c*. With such a construction, the different project! on(s) **1024** may only be accommodated in the corresponding recess(es) **1028** and not in the other recess(es) **1028** to, as mentioned above, limit the possible relative orientations of the column members **1008**. This difference may be a difference in length, height, depth, another size or shape characteristic, or combinations thereof.

[0189] For reference, the projection **1024***b* opposite the mouth **1020** is a middle projection **1024***b* between the projections **1024***a*, **1024***c* adjacent the mouth **1020**. In the illustrated embodiment, the middle projection **1024***b* is larger (e.g., has a greater circumferential extent) than the projections **1024***a*, **1024***c*. The corresponding middle recess **1028***b* is also larger than the recesses **1028***a*, **1028***c* and can accommodate the larger middle projection **1024***b*. The larger projection **1024***b* cannot engage the other (smaller) recesses **1028***a*, **1028***c*, and, therefore, the column members **1008** can only be connected in the orientation with the projection **1024***b* engaging the recess **1028***b*. In this orientation (see FIG. **35**C), the mouths **1020** on the column members **1008** are aligned.

[0190] The structure of the larger locking projection **1024***b* will inhibit connection of the column members **1008** in orientations in which the mouths **1020** are misaligned (see FIG. **35**B). In other words, the middle projection **1024***b* functions as an orienting device or key to limit engagement of adjacent column members **1008** to only an orientation in which the mouths **1020** form a contiguous opening. FIG. **35**D illustrates the correct orientation ("V") and incorrect orientations ("X") of the column members **1008**.

[0191] In other embodiments, a different projection (e.g., the projection **1024***a* and/or **1024***c*) and a different associated recess (e.g., the recess **1028***a*, and/or **1028***c*) may be larger than the other(s) to provide the orienting device or key.

[0192] With reference to FIG. **35**A, two adjacent column members **1008** are engaged to form the column assembly **1004** by first aligning the projection **1024***a* with the recess **1028***a*, the projection **1024***b* with the recess **1028***b*, and the projection **1024***c* with the recess **1028***c*. Next, one column member **1008** is moved axially relative to the adjacent column member **1008** so that each projection **1024***a*, **1024***b*, **1024***c* engages the open portion **1032** of the associated recess **1028***a*, **1028***b*, **1028***c*, respectively. The column members **1008** are then relatively rotated, and each projection **1024***a*, **1024***b*, **1024***c* moves from the open portion **1032** to the closed end of the closed portion **1036** of the associated recess **1028***a*, **1028***b*, **1028***c* (e.g., by a pivoting or rotating movement of about 20° to about 45° (about 30°, as shown)). This process may be repeated with

additional column members **1008** to form a column assembly **1004** with more than two column members **1008**.

[0193] As shown in FIGS. **36**A-**36**C, an adapter plate **1044** is connected to the cylinder **30** (e.g., by fasteners (as shown), welding, etc.). The adapter plate **1044** may be similar to the adapter plate **94**, **124**, described above and shown in FIGS. **1**A-**1**D and **2**A-**2**D, respectively. The adapter plate **1044** is fastened between the cylinder **30** and the column assembly **1004** (e.g., the first or adjacent column member **1008**). The adapter plate **1044** connects and transfers force between the cylinder **30** and the column assembly **1004**.

[0194] The illustrated adapter plate **1044** includes a number (four shown) of locking members **1048**. The locking members **1048** are spaced about the circumference of the adapter plate **1044** (e.g., about 90 degrees). The locking members **1048** may be shaped similarly to the projections **1024** on the column members **1008** for engagement in the recesses **1028** on the adjacent column member **1008**.

[0195] In the illustrated construction, the locking projections **1048** are constructed to be engageable in each of the recesses **1028** so that the column assembly **1004** is connectable to the adapter plate **1044** and to the cylinder **30** in a number (e.g., four) of relative orientations. More specifically, the locking members **1048** are shaped and sized similarly to the projections **1024***a*, **1024***c*, but not the larger middle projection **1024***b*. In other words, the locking members **1048** are constructed so that each locking members **1048** may engage any of the recesses **1028***a*, **1028***b*, **1028***c*. As a result, a column member **1008** and the column assembly **1004** may engage the adapter plate **1044** and the cylinder **30** in any one of the possible orientations (e.g., four in the illustrated construction).

[0196] In other constructions (not shown), the adapter plate **1044** and the locking members **1048** may be constructed to limit the relative orientations of the column assembly **1004** and the cylinder **30**. In such constructions, one locking member **1048** may be larger than the others to only engage the larger recess **1028***b* on the column member **1008**.

[0197] In some constructions (see FIGS. **37**-**40**), the locking assembly may include a positive locking mechanism to selectively retain the column members **1008** in the locked condition and to inhibit unwanted unlocking of the column members **1008** (e.g., due to vibrations, impact, etc.). With reference to FIGS. **37**A-**37**D, the positive lock mechanism may include one or more movable pins **1052** (one shown). The illustrated pin **1052** is positioned on an outer periphery **1011** of the column member **1008** and communicates with one of the recesses **1028** (e.g., proximate the interface between the open portion **1032** and the closed portion **1036** of the recess **1028***b* in FIGS. **37**A-**37**C and/or the recess **1028***c* in FIG. **37**D). Once the locking member **1024** is positioned in the closed portion **1036** of the recess **1028**, the pin **1052** is inserted to block movement of the projection **1024** from the closed portion **1036** toward the open portion **1032**.

[0198] With reference to FIGS. **38**A-**38**B, the illustrated pin **1052** includes a head **1056** fixed to a shaft **1060**. A spring **1064** biases the pin **1052** relative to the column member **1008**. The pin **1052** is positionable between a locked position (see FIG. **38**A) and an unlocked position (see FIG. **38**B).

[0199] A detent mechanism (not shown) selectively holds the pin **1052** in a position (e.g., the locked position and/or the unlocked position) relative to the column member **1008**. The detent mechanism may be overcome when a user presses the head **1056** of the pin **1052**. When the pin **1052** is positioned in the unlocked position, pressing the head **1056** causes the pin **1052** to move to the locked position, and, when the spring pin **1052** is positioned in the locked position, pressing the head **1056** causes the pin **1052** to move to the unlocked position.

[0200] In operation, and with reference to FIGS. **37**A-**37**D, two column members **1008** are coupled as described above by inserting the projections **1024** of one column member **1008** into the respective open portions **1032** of the recesses **1028** of another column member **1008**, and relatively pivoting the column members **1008** so that the projections **1024** enter the closed portions **1036** of the recesses **1028**. The pin **1052** is then pressed to move it from the unlocked position (shown in FIG. **38**B) to the locked position (shown in FIG. **38**A) to block the open portion **1032** of the recess

1028 to inhibit the projections **1024** of the first column member **1008** from being removed from the recesses **1028** of the second column member **1008**. To decouple the column members **1008**, the pin **1052** is pressed again to move it from the locked position to the unlocked position, unblocking the open portion **1032** of the recess **1028**, thereby allowing movement of the projection **1024** to the open portion **1032** and the relative rotation of the column members **1008**.

[0201] With reference to FIGS. **39**A-**39**F, in another construction, a wing nut **1068** provides a positive lock mechanism functioning similarly to the pin **1052**. The wing nut **1068** includes a head **1072** fixed to a shaft **1076** surrounded by a spring **1080**. The illustrated wing nut **1068** is pivoted to move between a locked position (see FIG. **39**E) and an unlocked position (see FIG. **39**F). In other embodiments, the wing nut **1068** may slide in an axial direction of the shaft **1076** between the locked position and the unlocked position.

[0202] With reference to FIG. **40**, in another construction, a spring-loaded ball bearing mechanism **1084** provides a positive lock mechanism. The mechanism **1084** includes a ball bearing **1088** supported in a saddle **1092** and biased into a recess **1028** (e.g., the middle recess **1028***b*) by a spring **1096**. In some embodiments, the ball bearing **1088** may be received into a notch (not shown) in the associated projection **1024** (e.g., the middle projection **1024***b*). In other embodiments, the ball bearing **1088** may simply engage the projection **1024** to inhibit removal of the projection **1024** from the closed portion **1036** of the recess **1028**.

[0203] Movement of the projection **1024** toward the closed portion **1036** of the recess **1028** causes the mechanism **1084** to retract to the unlocked position. Once the projection **1024** passes into the closed portion **1036**, the spring **1096** causes the ball bearing **1088** to be extended into the locked position to inhibit removal of the projection **1024** from the closed portion **1032**. The biasing force of the spring **1096** is overcome by a sufficient force applied to relatively pivot the column members **1008** toward the unlocked position. In other constructions (not shown), an actuator may be provided to move the ball bearing **1088** at least to the unlocked position.

[0204] FIG. **41** illustrates a pin puller assembly **10** similar to that shown in FIGS. **1**A-**1**D and including a piston-cylinder unit **14**, a pull rod **18** connectable to a pin P to be pulled, a reaction member **22** engageable with the pull rod **18**, and a column assembly **1004** positionable between the piston-cylinder unit **14** and the machine frame F. The cylinder **30** has a first cylinder end **1100** and an opposite second cylinder end **1104**.

[0205] After the pin P is pulled, the end of the pull rod **18** with the pin P is unsupported by the frame F. The weight on the end of the pull rod **18** may cause the pull rod **18** to tilt relative to the piston **42** which may, for example, damage the threads or sawtooth profile on the pull rod **18**. To protect the pull rod **18**, in some embodiments, a guide member (see FIG. **41**) is positionable between the pull rod **18** and at least one of the column assembly **1004** and the piston-cylinder unit **14**.

[0206] In the illustrated construction, the guide member includes a column sleeve **1108** positionable around the pull rod **18** and within the column assembly **1004** and at least one cylinder sleeve (two cylinder sleeves **1112**, **1116**) positionable around the pull rod **18** and a cylinder end (e.g., at each cylinder end **1100**, **1104**). During pin pulling, the illustrated spacer(s) or sleeve(s) **1108**, **1112**, **1116** may help to maintain alignment of the pull rod **18** in the piston **42** along a cylinder axis A even after the pin P has been pulled from the frame F. The sleeve(s) **1108**, **1112**, **1116** may be made of plastic or another suitable material and may be formed, for example, via a **3**D printing process.

[0207] The illustrated column sleeve **1108** defines a bore **1120** sized to receive the pull rod **18** with a minimal gap to support the pull rod **18** while not interfering with its axial movement. The column sleeve **1108** has an external surface **1124** sized to closely fit within and supportingly engage an inner surface of the column assembly **1004**. The gap(s) between the sleeve **1108** and the outer surface of the pull rod **18** and the inner surface of the column member **1008** may be less than about, for example, 5 mm, 2 mm, 1 mm, 0.5 mm, 0.1 mm, etc.

[0208] The column sleeve **1108** is slidable along the pull rod **18** to a desired position. Between strokes of the piston **42**, the column sleeve **1108** may be repositioned, for example, as column members **1008** are added to the column assembly **1004**. The illustrated column sleeve **1108** includes a number (three shown) of axial supports **1128**. The supports **1128** are spaced apart about the outer circumference of the column sleeve **1108** (e.g., by 120 degrees).
[0209] With continued reference to FIG. **41**, each cylinder sleeve **1112**, **1116** includes a large diameter portion **1132** and a small diameter portion **1136**. The first cylinder sleeve **1112** has a tapered portion **1138** connecting the large diameter portion **1132** and the small diameter portion **1136**. The portions **1132**, **1136** have concentric axes and define a bore **1140** passing therethrough. The bore **1140** is sized to receive the pull rod **18** with a minimal gap to support the pull rod **18** while not interfering with its axial movement. The outer diameter of the small diameter portion **1136** is sized to closely fit within and supportingly engage within the axial passage **50** (see FIG. **19**). The gap(s) between the sleeves **1112**, **1116** and the outer surface of the pull rod **18** and the inner surface of the passage **50** may be less than about, for example, 5 mm, 2 mm, 1 mm, 0.5 mm, 0.1 mm, etc.
[0210] It should be understood that features disclosed in one embodiment may be incorporated in other embodiments. For example, any of the disclosed lockable column assemblies illustrated, for example, in FIGS. **2**A-**6**E and **33**A-**35**D and any of the disclosed split reaction member assemblies (illustrated, for example, in FIGS. **1**A-**1**D and **7**A-**10**G) or the unitary reaction nut (illustrated, for example, in FIGS. **11**A-I IB) may be used together.
Similarly, the tapering locking members (the recess(es) and/or projection(s)), the orienting device/key, the positive locking mechanism, and/or the guide member may be incorporated with other column assemblies or pin pulling assemblies.
[0211] Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the invention as described above. The embodiment s) described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present disclosure. As such, it will be appreciated that variations and modifications to the elements and their configuration and/or arrangement exist within the spirit and scope of one or more independent aspects as described.
[0212] One or more independent features and/or independent advantages of the invention may be set forth in the claims.

Claims

1.-**80**. (canceled)
81. A pin puller assembly, the pin puller assembly being operable to pull a pin from a machine, the machine having a frame supporting the pin, the pin puller assembly comprising: a piston-cylinder unit including a cylinder having a first cylinder end and an opposite second cylinder end and defining an axis extending therebetween, the cylinder defining a chamber and having a port communicating with the chamber, and a piston defining an axial passage and having a piston end, the piston being movably supported by the cylinder, fluid passing through the port, causing movement of the piston relative to the cylinder; a pull rod positionable through the axial passage and having a first rod end positioned proximate the first cylinder end and a second rod end positioned proximate the second cylinder end, the second rod end being connectable to the pin to be pulled; a reaction member engageable between the pull rod and the piston; and a column assembly positionable between the cylinder and the frame, the column assembly including a first column member connectable to the cylinder and having a first length along the axis, and a second column member releasably lockable to the first column member and having a second length along the axis; wherein each of the first column member and the second column member has a cylinder

end positionable toward the cylinder and an opposite frame end positionable toward the frame, and wherein a first locking member is proximate the frame end of the first column member and a second locking member is proximate the cylinder end of the second column member, the second locking member being engageable with the first locking member to releasably lock the second column member to the first column member.

82. The pin puller assembly of claim 81, wherein one of the first locking member and the second locking member defines a recess and the other of the first locking member and the second locking member includes a projection engageable in the recess to releasably lock the second column member to the first column member.

83. The pin puller assembly of claim 82, wherein the recess is defined as an annular groove having an open end configured to receive the projection and a groove portion configured to retain the projection to releasably lock the second column member to the first column member.

84. The pin puller assembly of claim 83, wherein the open end is configured to be engaged by the projection through relative pivoting and/or axial movement of the first column member and the second column member.

85. The pin puller assembly of claim 82, wherein the column assembly further includes a separate member connected to one of the first column member and the second column member, the separate member defining the recess; wherein the separate member includes a plate connected to the one of the first column member and the second column member, the plate defining the recess; wherein the separate member includes movable latch member having a connection end connected to the one of the first column member and the second column member and a free end, the recess being defined proximate the free end; and wherein the movable latch member is pivotably connected at the connection end to the one of the first column member and the second column member, the movable latch member being pivoted to a locking position, in which the projection engages the recess, and an unlocking position, in which the projection is not engaged with the recess.

86. The pin puller assembly of claim 83, wherein the column assembly further includes plate connected to the first column member, the plate providing the first locking member; wherein the plate is a first plate, and wherein the column assembly further includes a second plate connected to the second column member, the second plate defining the second locking member.

87. The pin puller assembly of claim 83, wherein the column assembly further includes a separate member connected to one of the first column member and the second column member, the separate member providing the projection.

88. The pin puller assembly of claim 83, wherein the recess is a first recess and the projection is a first projection, wherein one of the first locking member and the second locking member defines a second recess and the other of the first locking member and the second locking member includes a second projection engageable in the second recess to releasably lock the second column member to the first column member.

89. The pin puller assembly of claim 88, wherein each of the first column member and the second column member has a sidewall defining an opening extending between the cylinder end and the frame end, wherein the first projection is engageable in the first recess and not the second recess to align the opening in sidewall of the first column member with the opening in the sidewall of the second column member when the second column member is locked to the first column member.

90. The pin puller assembly of claim 82, wherein at least one of the recess and the projection has a tapered surface engageable with the other of the recess and the projection during locking of the first column member and the second column member.

91. The pin puller assembly of claim 83, wherein the column assembly further includes a positive locking mechanism selectively engageable with the projection to inhibit unlocking of the first column member and the second column member.

92. The pin puller assembly of claim 81, further comprising an adapter plate connected between the cylinder and the first column member.

93. The pin puller assembly of claim 81, further comprising a saddle connectable to the piston end, the reaction member being configured to engage the saddle.
94. The pin puller assembly of claim 81, further comprising a guide member engageable between the pull rod and one of the piston-cylinder unit and the column assembly and configured to substantially align an axis of the pull rod with an axis of the axial passage.
95. The pin puller assembly of claim 94, wherein the guide member includes a sleeve positionable between the pull rod and one of the first column member and the second column member, the sleeve defining a bore receiving the pull rod and having an outer surface engaging an inner surface of the one of the first column member and the second column member.
96. The pin puller assembly of claim 95, wherein the guide member is a first guide member, and the sleeve is a first sleeve, and wherein the pin puller assembly further comprises a second guide member positionable between the pull rod and the piston-cylinder unit, the piston-cylinder unit having an end wall with a wall surface defining a wall opening, the pull rod extending through the wall opening, the second guide member including a second sleeve defining a second bore receiving the pull rod and having a second outer surface engaging the wall surface.
97. The pin puller assembly of claim 96, further comprising a third guide member positionable between the pull rod and the piston-cylinder unit, the end wall being a first end wall, the piston-cylinder unit having a second end wall opposite the first end wall, the second end wall having a second wall surface defining a second wall opening, the pull rod extending through the second wall opening, the third guide member including a third sleeve defining a third bore receiving the pull rod and having a third outer surface engaging the second wall surface.
98. The pin puller assembly of claim 94, wherein the guide member includes a sleeve positionable between the pull rod and the piston-cylinder unit, the piston-cylinder unit having an end wall with a wall surface defining a wall opening, the pull rod extending through the wall opening, the sleeve defining a bore receiving the pull rod and having an outer surface engaging the wall surface.
99. The pin puller assembly of claim 98, wherein the guide member is a first guide member, and the sleeve is a first sleeve, and wherein the pin puller assembly further comprises a second guide member positionable between the pull rod and the piston-cylinder unit, the end wall being a first end wall, the piston-cylinder unit having a second end wall opposite the first end wall, the second end wall having a second wall surface defining a second wall opening, the pull rod extending through the second wall opening, the second guide member including a second sleeve defining a second bore receiving the pull rod and having a second outer surface engaging the second wall surface.
100. A column assembly for use in a pin puller assembly, the pin puller assembly being operable to pull a pin from a machine, the machine having a frame supporting the pin, the pin puller assembly including a piston-cylinder unit including a cylinder having a first cylinder end and an opposite second cylinder end and defining an axis extending therebetween, the cylinder defining a chamber and having a port communicating with the chamber, and a piston defining an axial passage and having a piston end, the piston being movably supported by the cylinder, fluid passing through the port, causing movement of the piston relative to the cylinder, a pull rod positionable through the axial passage and having a first rod end positioned proximate the first cylinder end and a second rod end positioned proximate the second cylinder end, the second rod end being connectable to the pin to be pulled, and a reaction member engageable between the pull rod and the piston, the column assembly being positionable between the cylinder and the frame, the column assembly comprising: a first column member connectable to the cylinder and having a first length along the axis, and a second column member releasably lockable to the first column member and having a second length along the axis; wherein each of the first column member and the second column member has a cylinder end positionable toward the cylinder and an opposite frame end positionable toward the frame, and wherein a first locking member is proximate the frame end of the first column member and a second locking member is proximate the cylinder end of the second column member, the

second locking member being engageable with the first locking member to releasably lock the second column member to the first column member.

101. A method of assembling a pin puller assembly to pull a pin from a machine, the machine having a frame supporting the pin, the method comprising: positioning a piston-cylinder unit relative to the frame, the piston-cylinder unit including a cylinder having a cylinder end facing toward the frame and defining a chamber and a port communicating with the chamber, and a piston movably supported by the cylinder, the piston defining an axial passage and having a piston end opposite the cylinder end, fluid passing through the port causing movement of the piston relative to the cylinder; positioning a pull rod through the axial passage; engaging an end of the pull rod with the pin to be pulled; engaging a reaction member on the pull rod; positioning the reaction member on the pull rod against the piston end; installing a column assembly between the cylinder end and the frame, installing including positioning a first column member against the cylinder end, locking a second column member to an opposite end of the first column member, and engaging an end of the second column member against the frame.