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McRoberts et al.

(54) HAND-HELD TOOLS AND COMPONENTS THEREOF

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(60) Provisional application No. 61/581,731, filed on Dec. 30, 2011, provisional application No. 61/646,594, filed on May 14, 2012.

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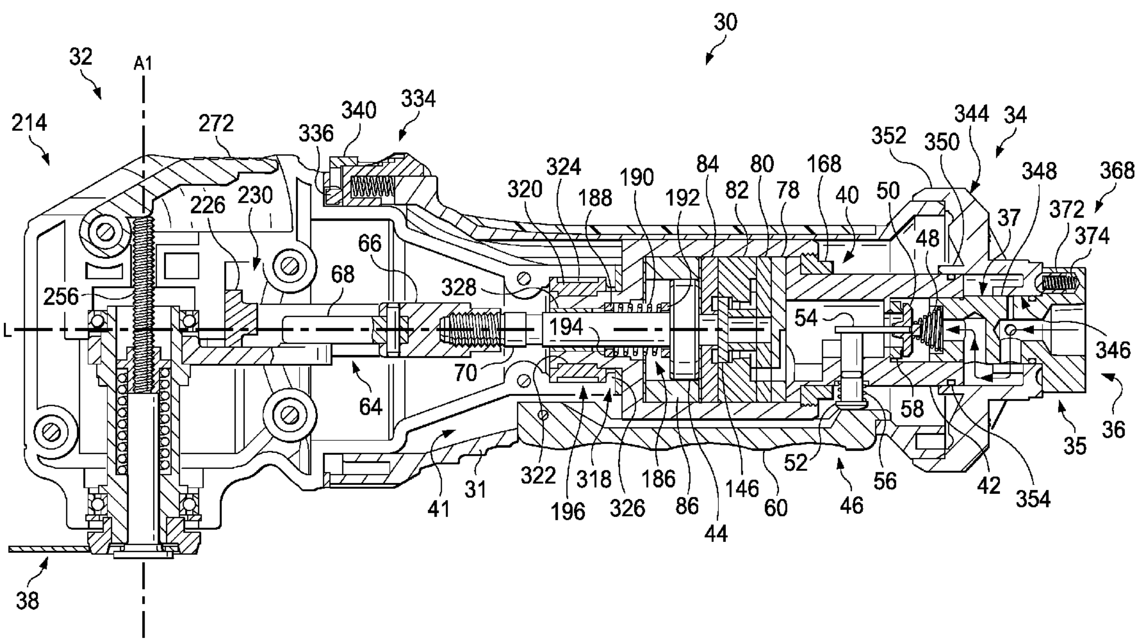
(52) **U.S. Cl.**

CPC . ***B25F 5/006*** (2013.01); ***B25F 5/00*** (2013.01); ***B23Q 5/06*** (2013.01)

USPC **173/162.2**; 173/213; 173/218

(57) **ABSTRACT**

A hand-held oscillating tool has a linear motor and an accessory attachment mechanism configured for releasable coupling to an accessory blade.



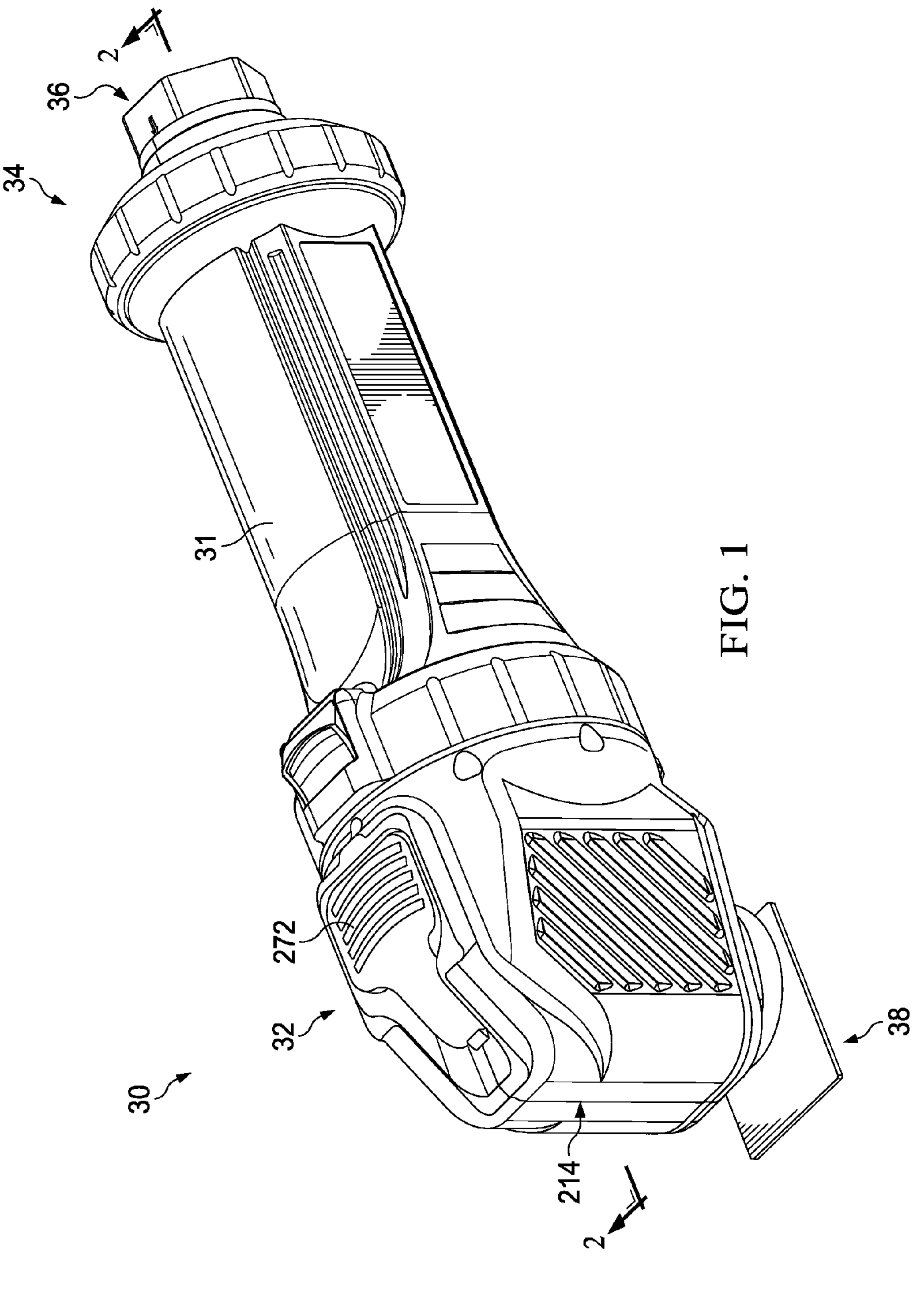


FIG. 1

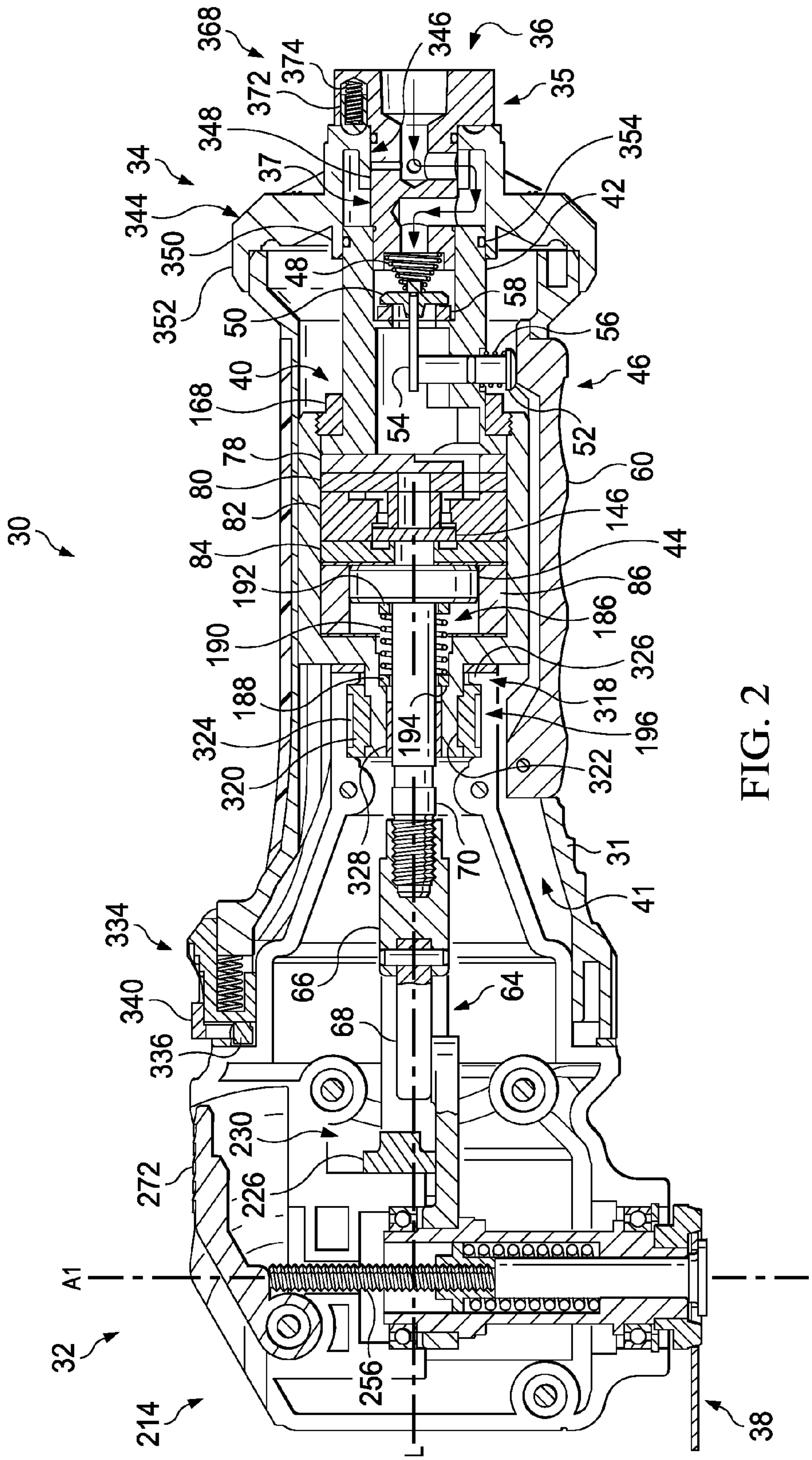

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FIG. 2

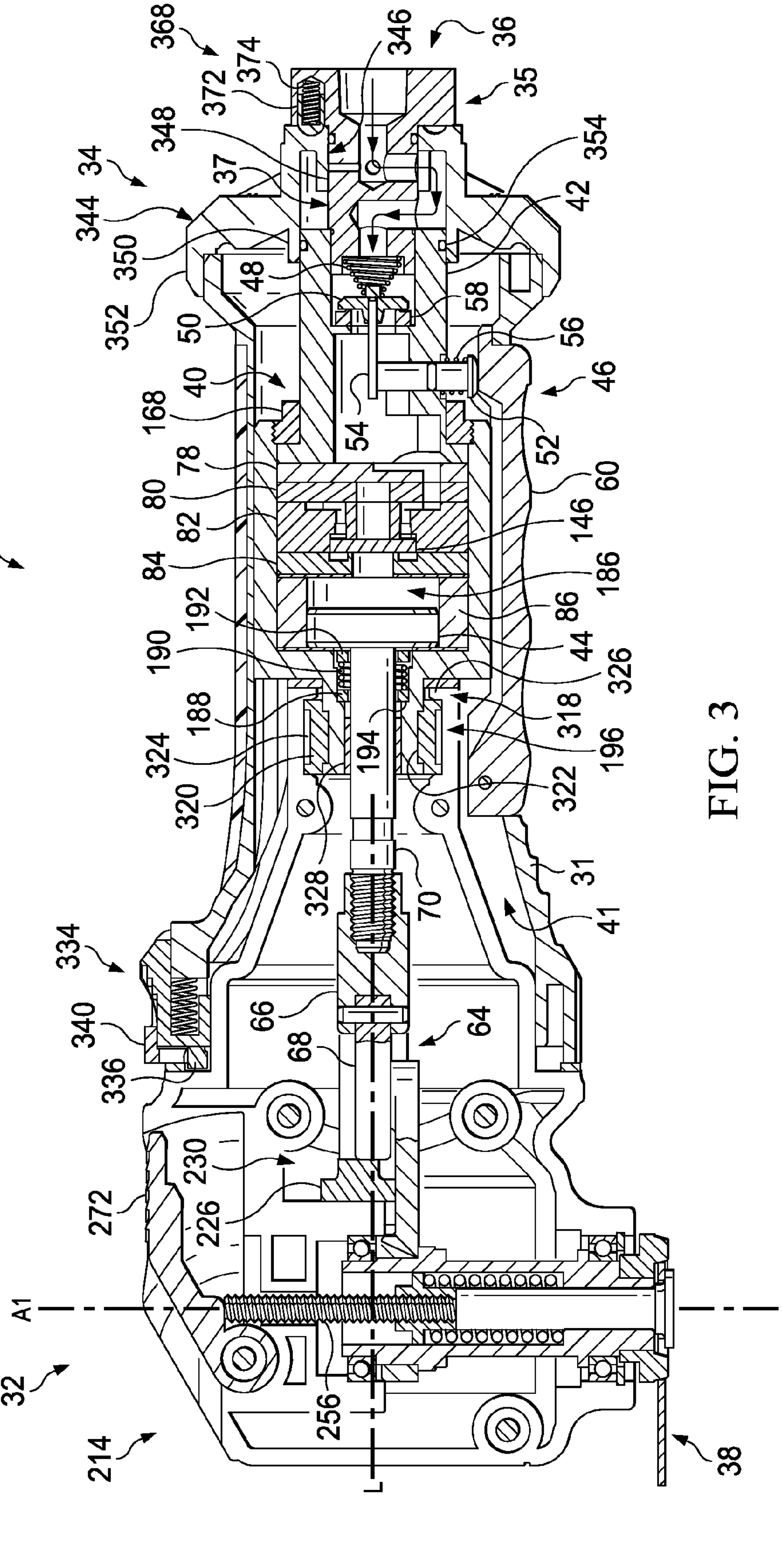
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FIG. 3

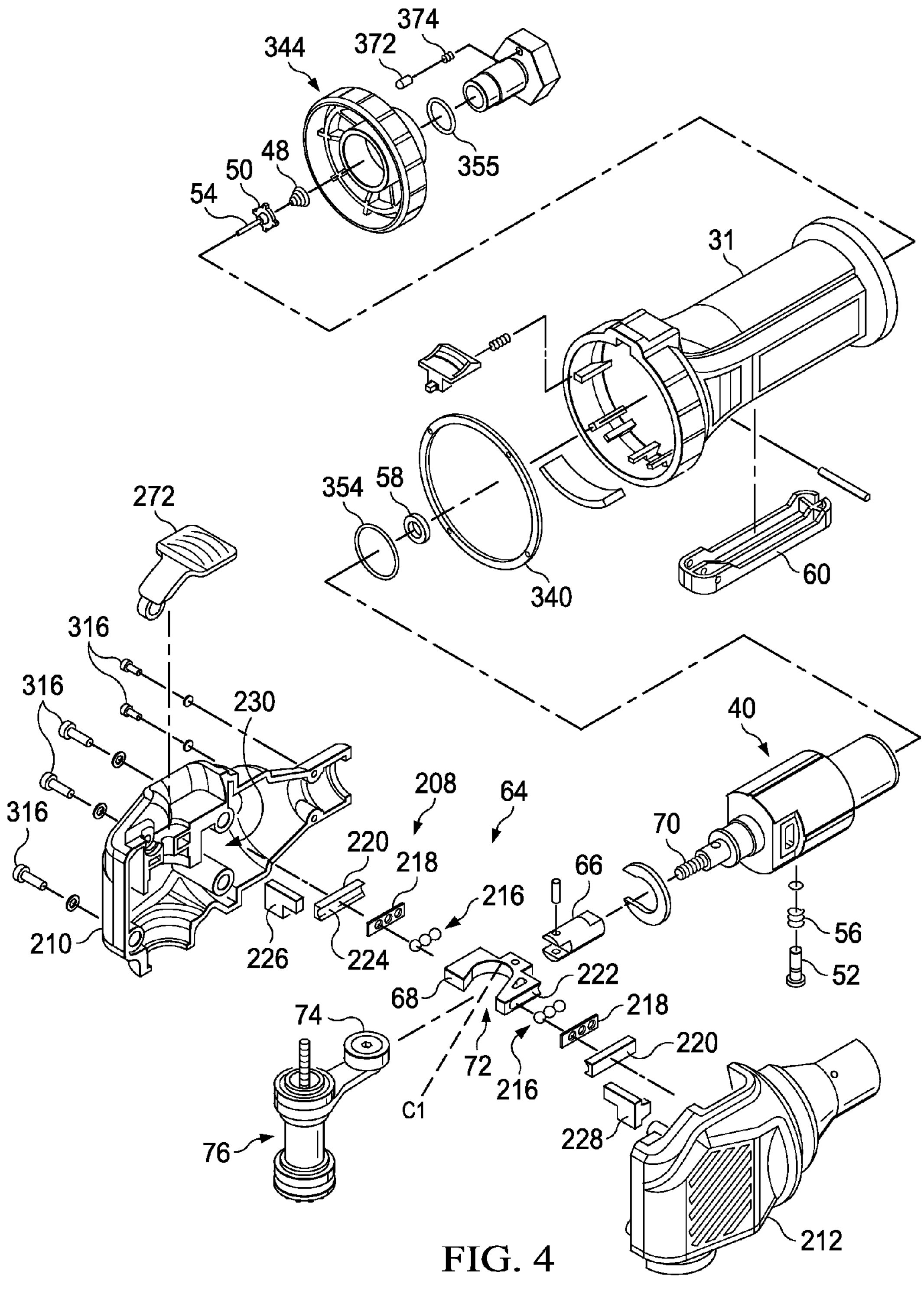
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FIG. 4

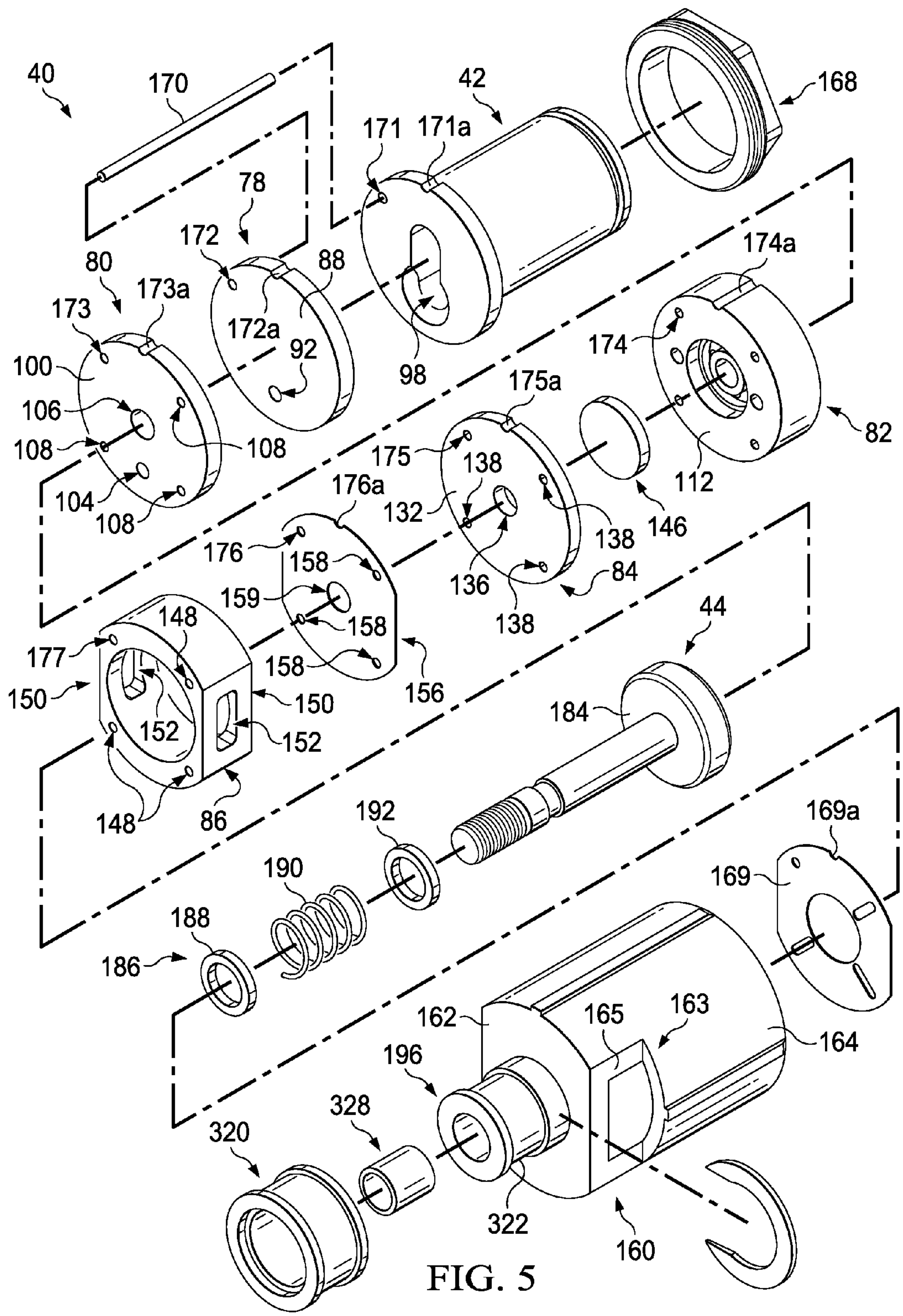
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FIG. 5

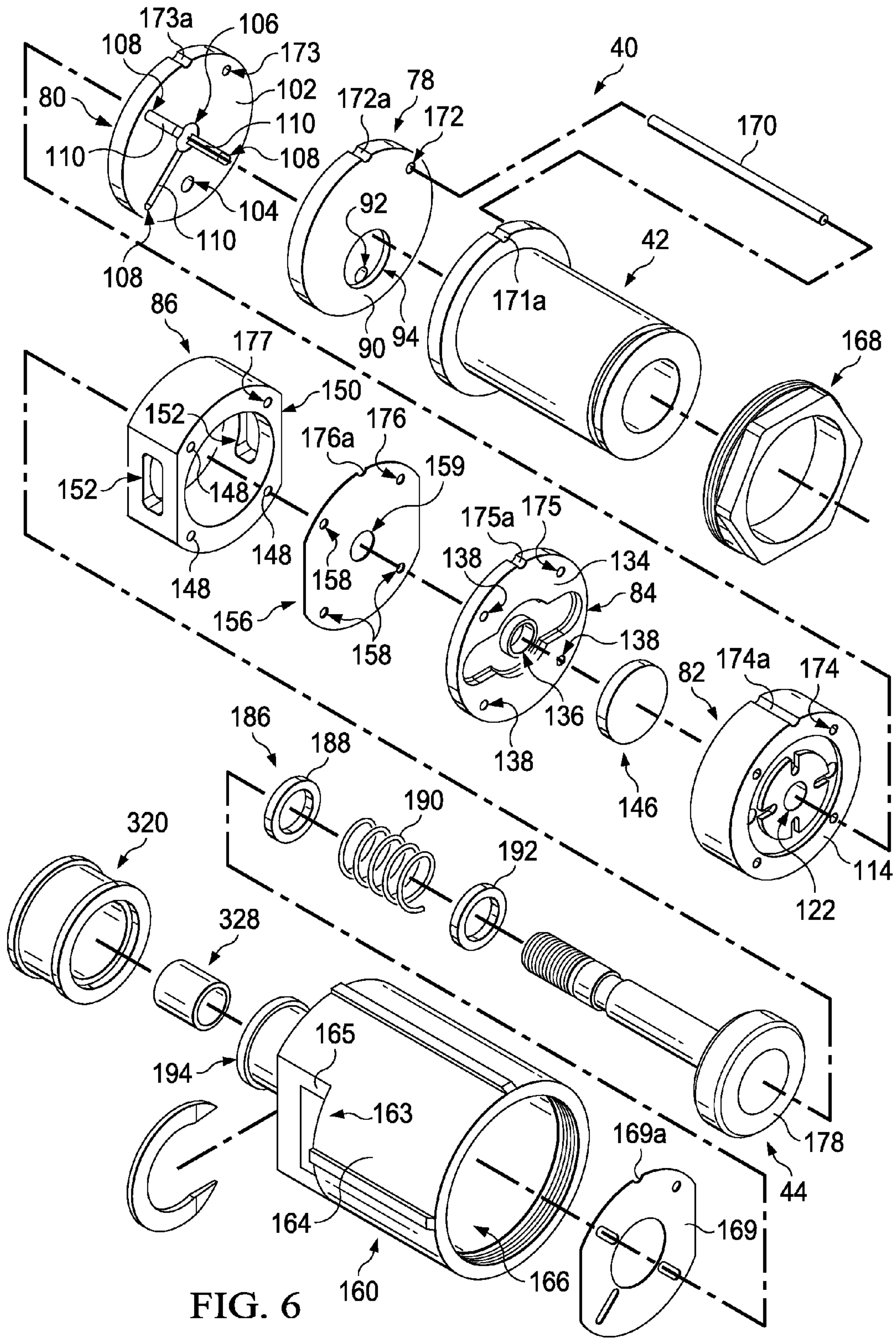
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FIG. 6

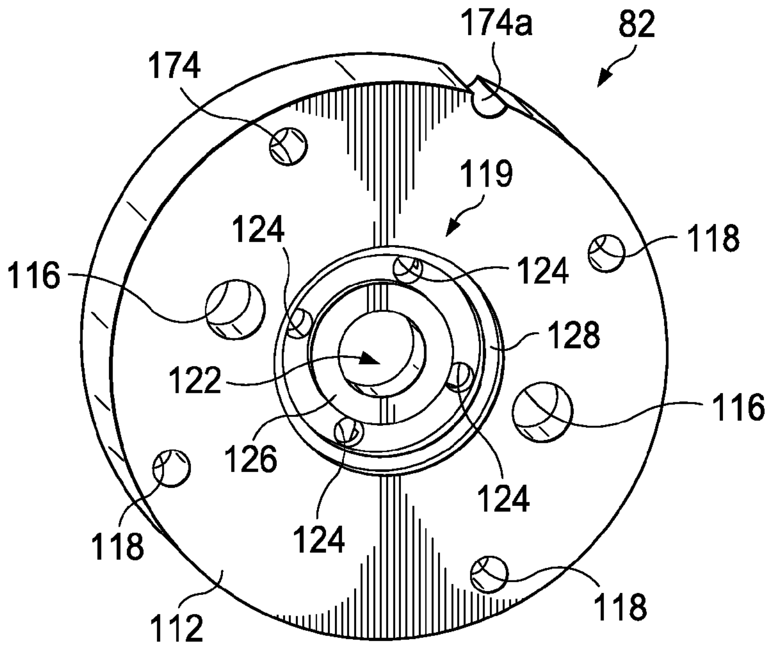
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FIG. 7

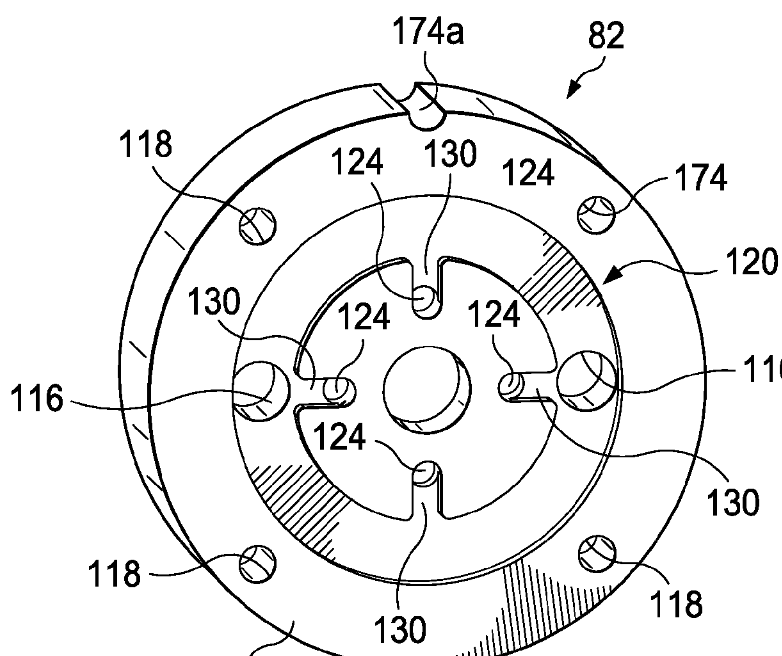
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FIG. 8

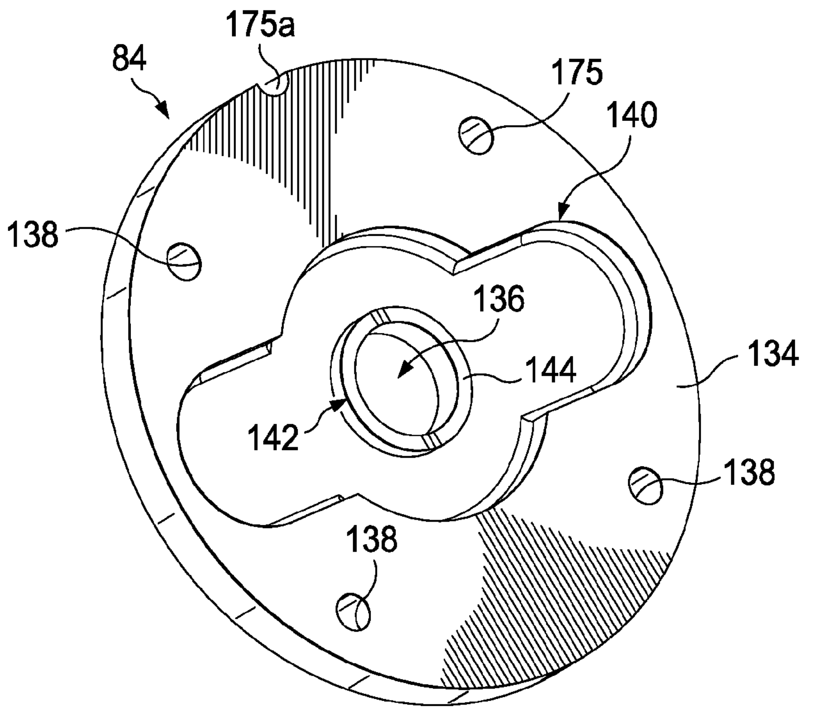
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FIG. 9

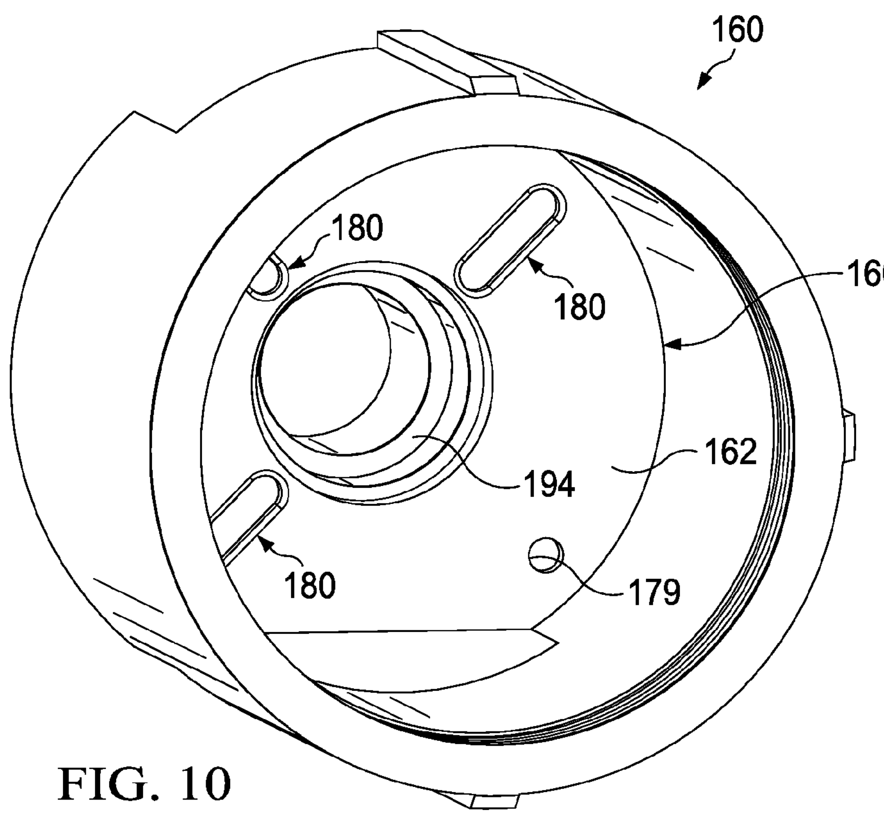
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FIG. 10

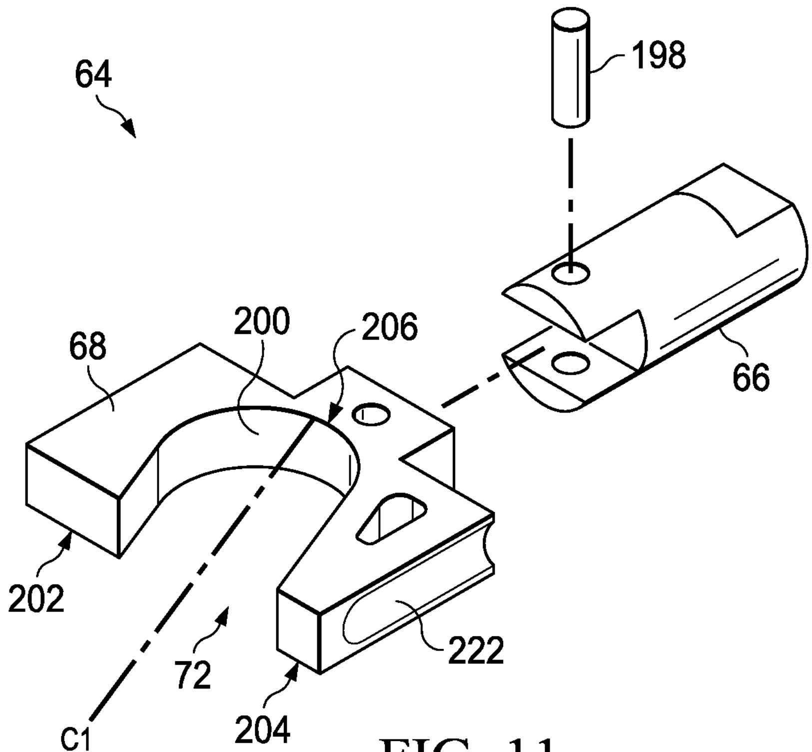

FIG. 11

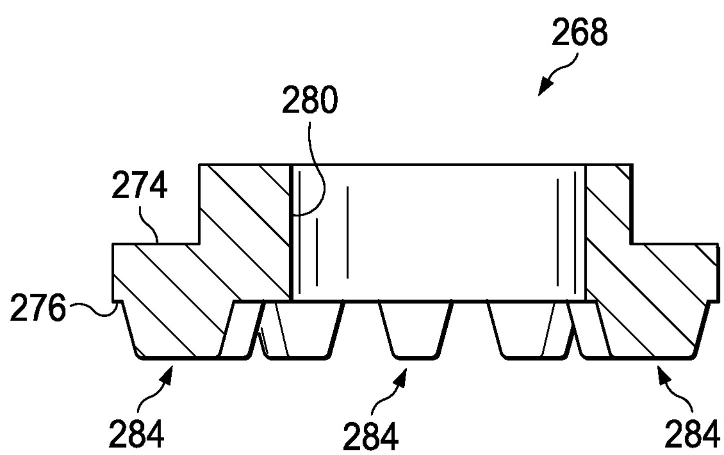

FIG. 13

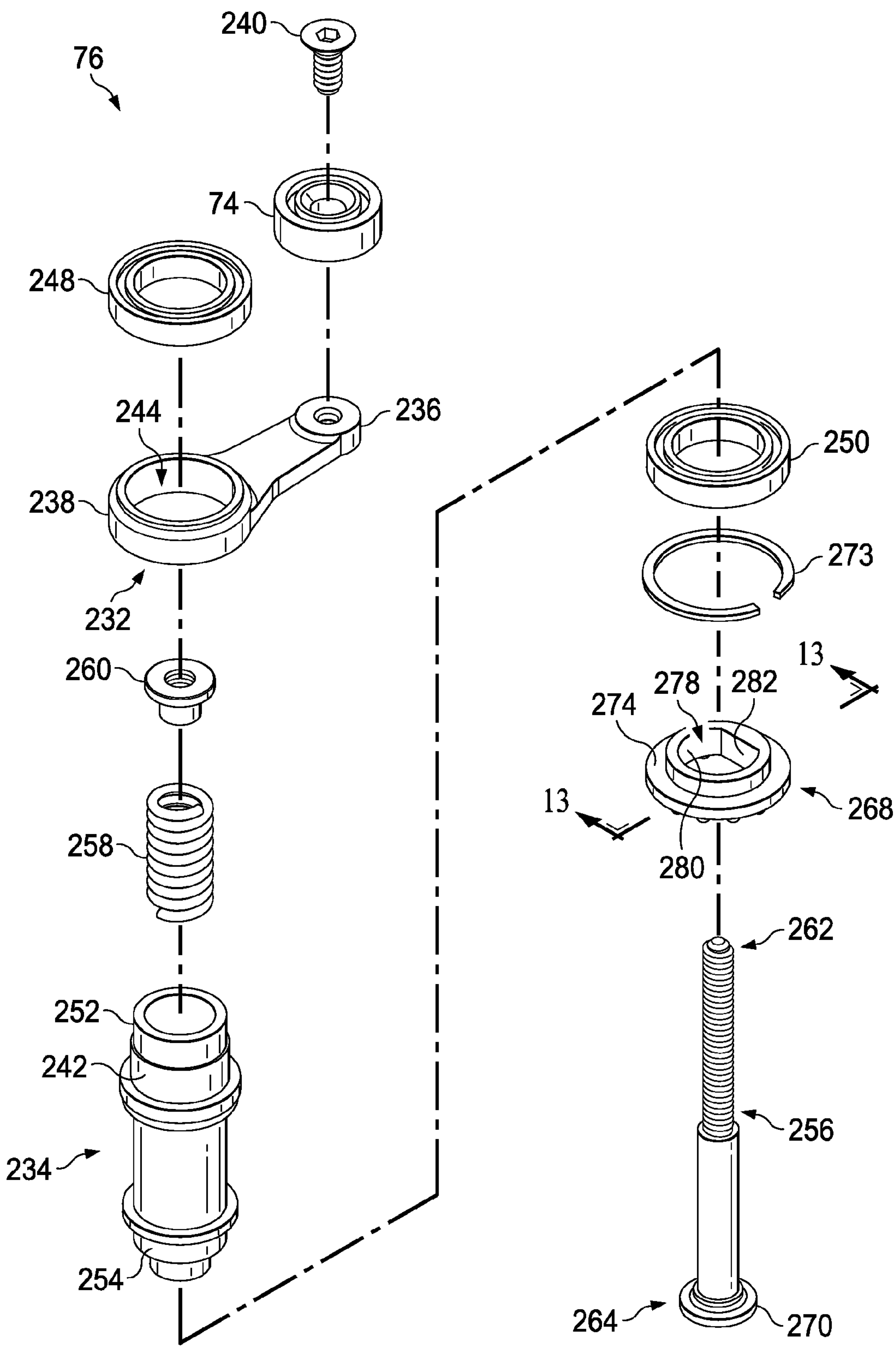
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FIG. 12

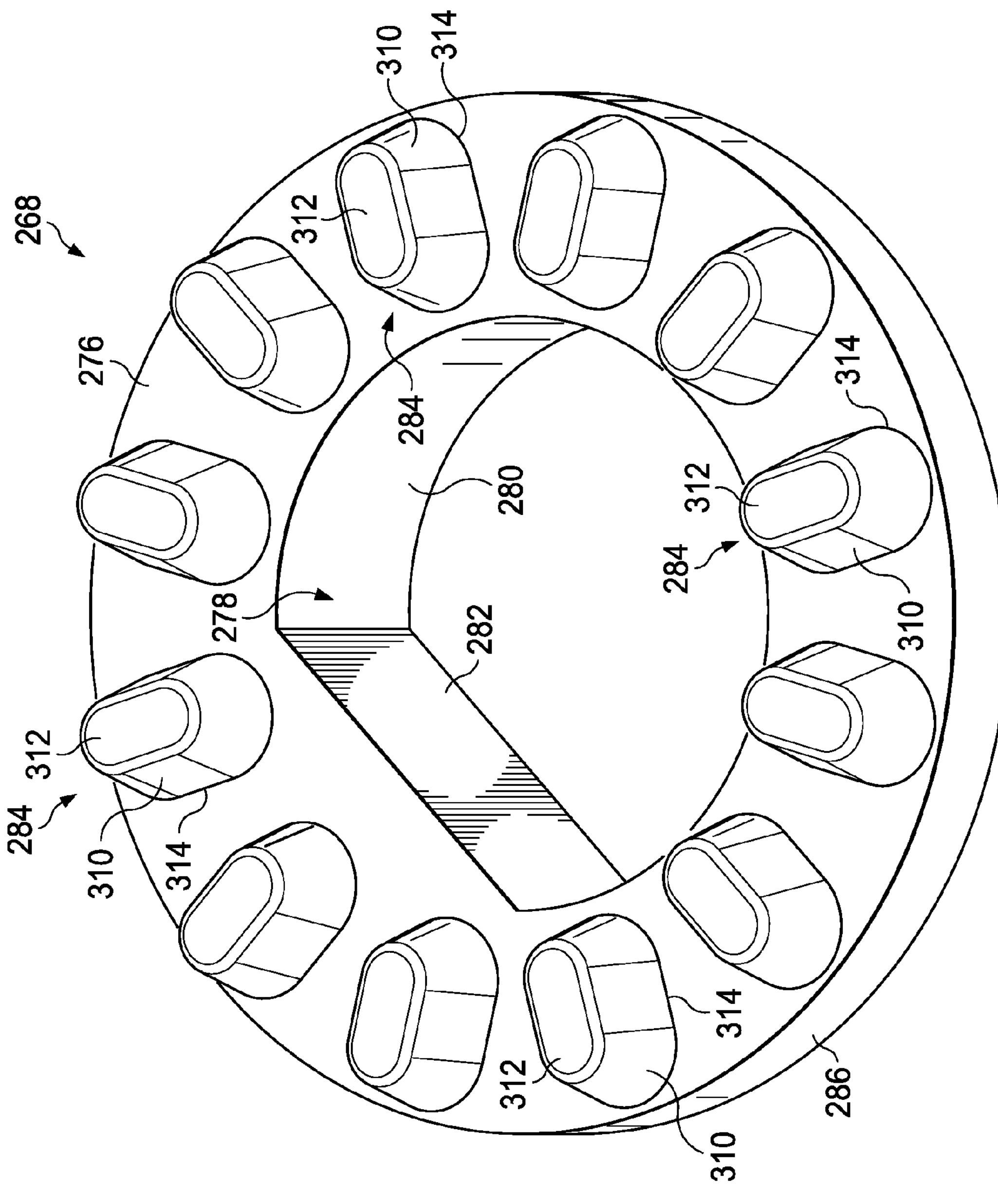

FIG. 14

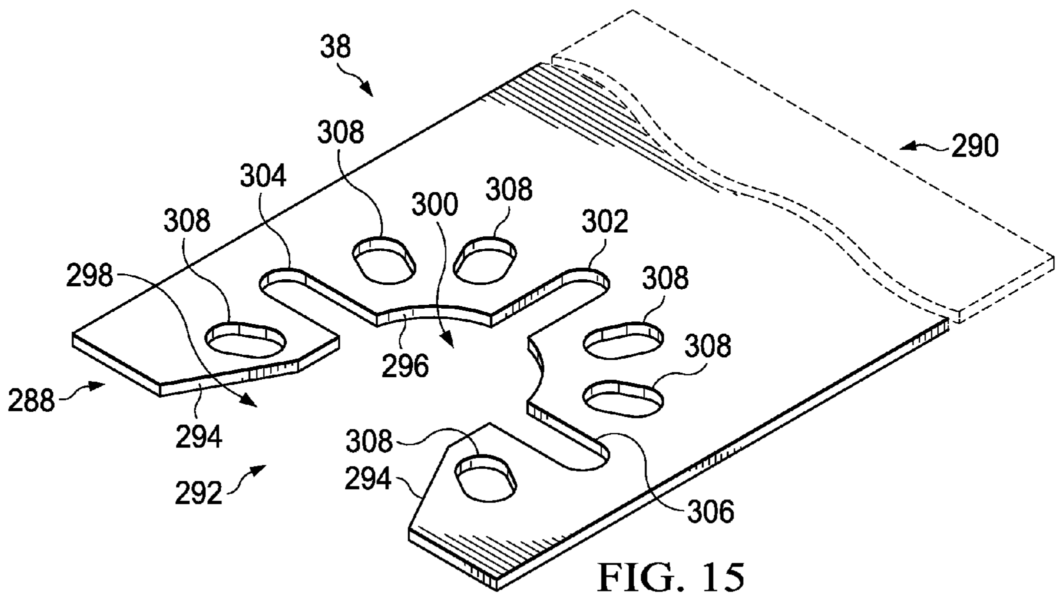
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FIG. 15

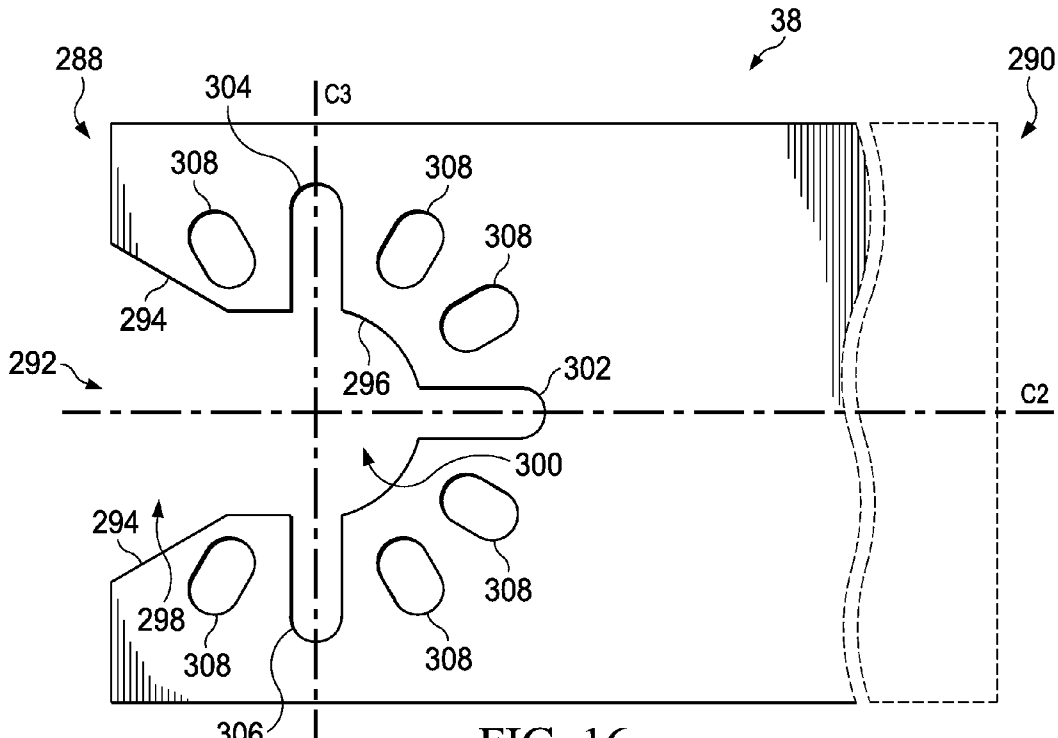
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FIG. 16

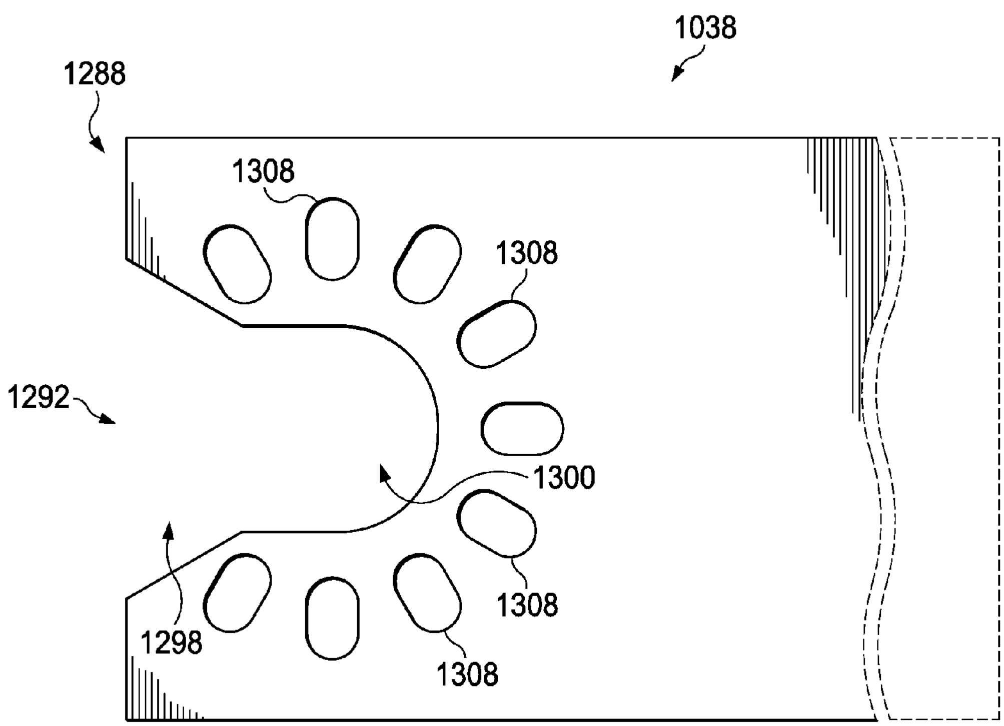

FIG. 17

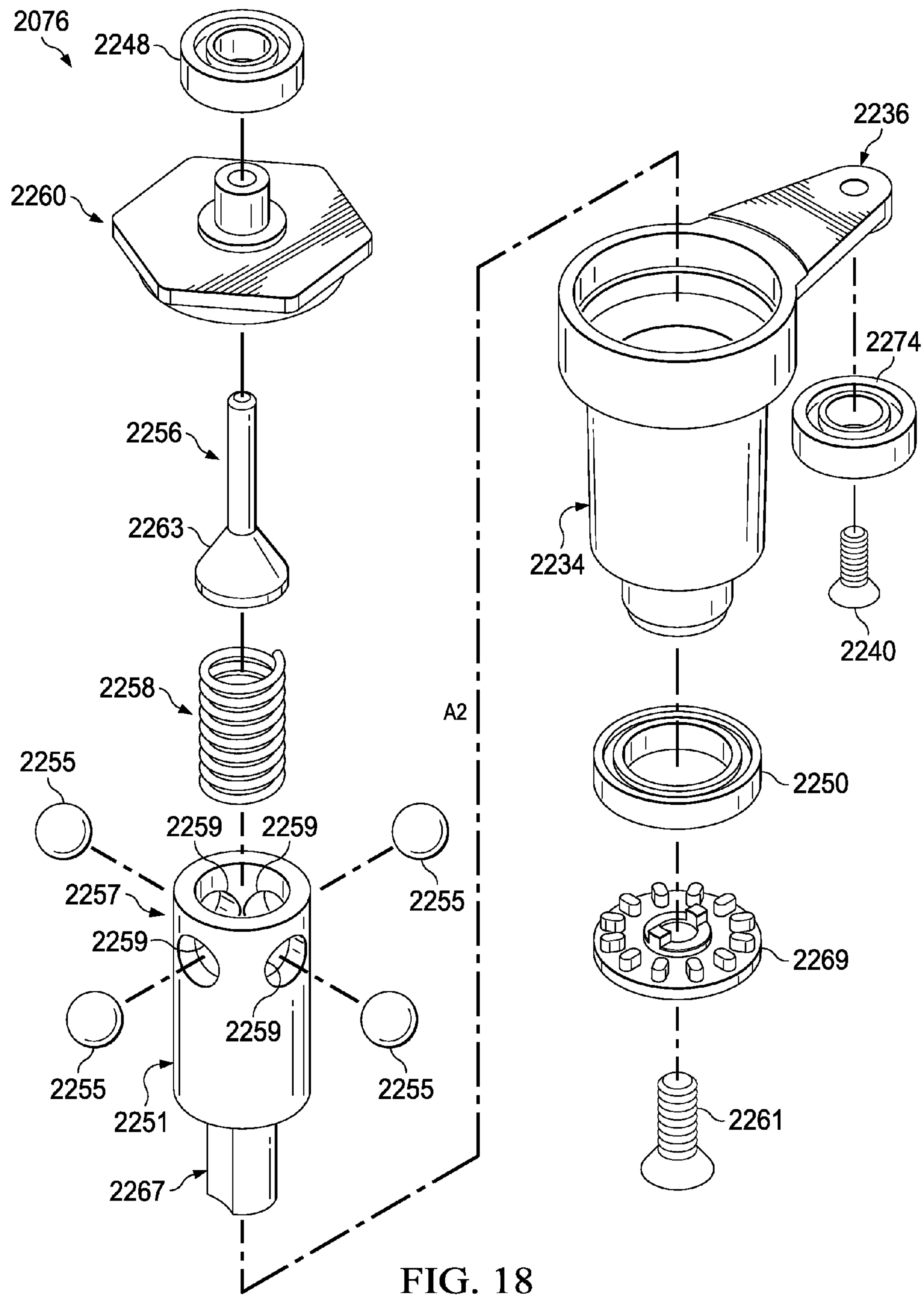
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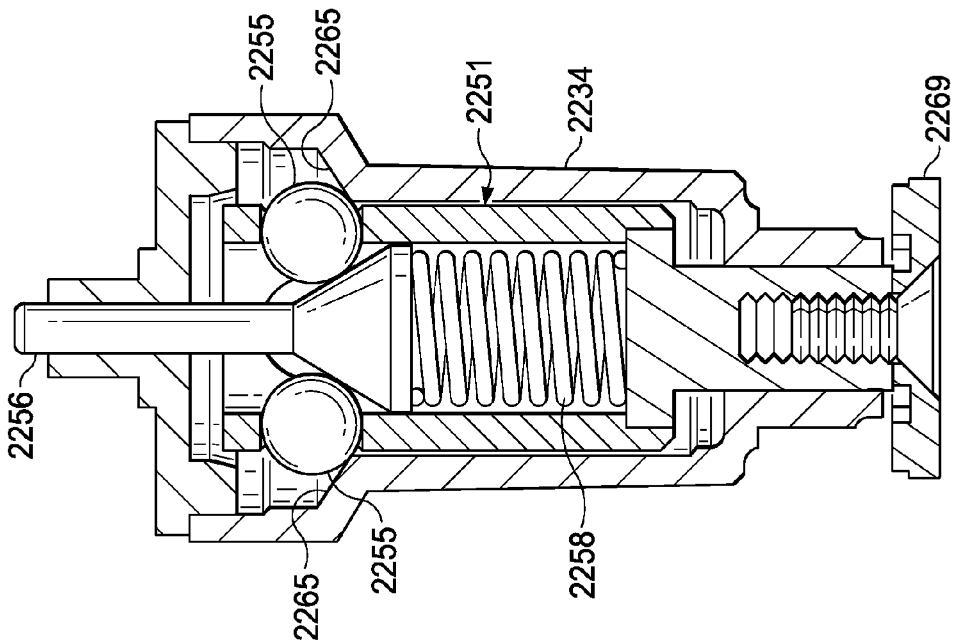
FIG. 18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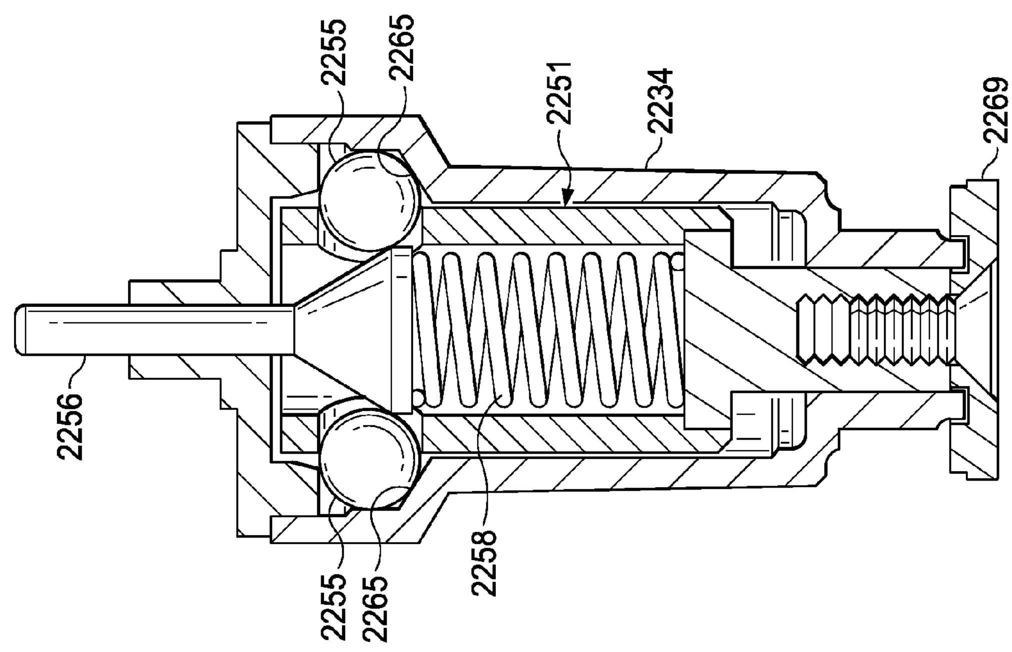
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FIG. 19

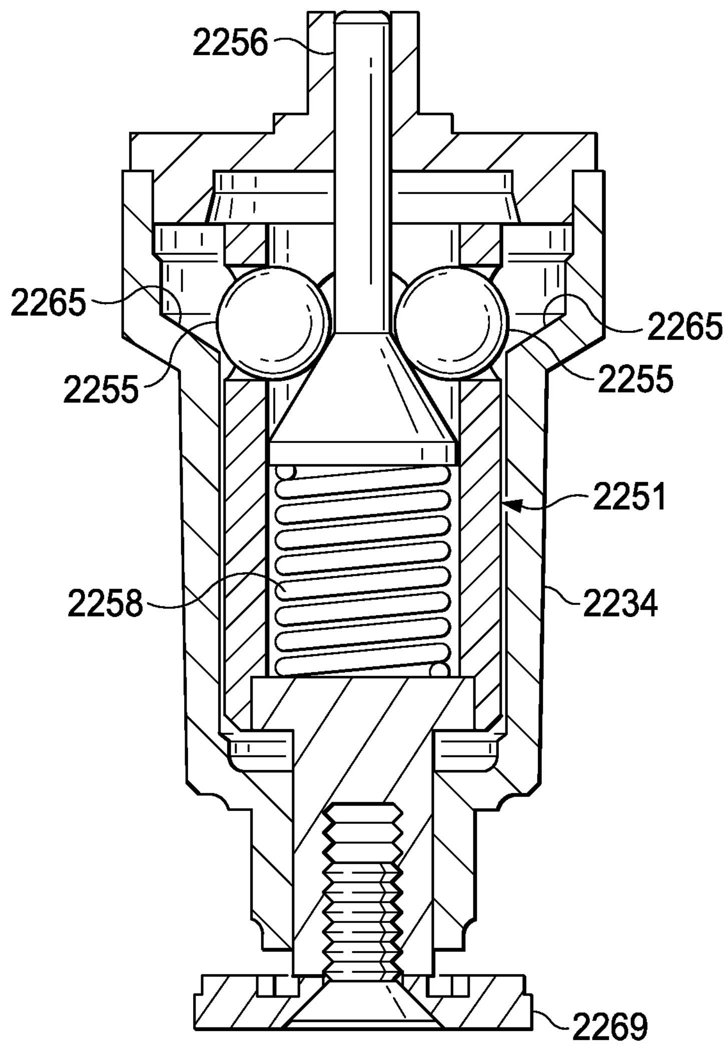

FIG. 21

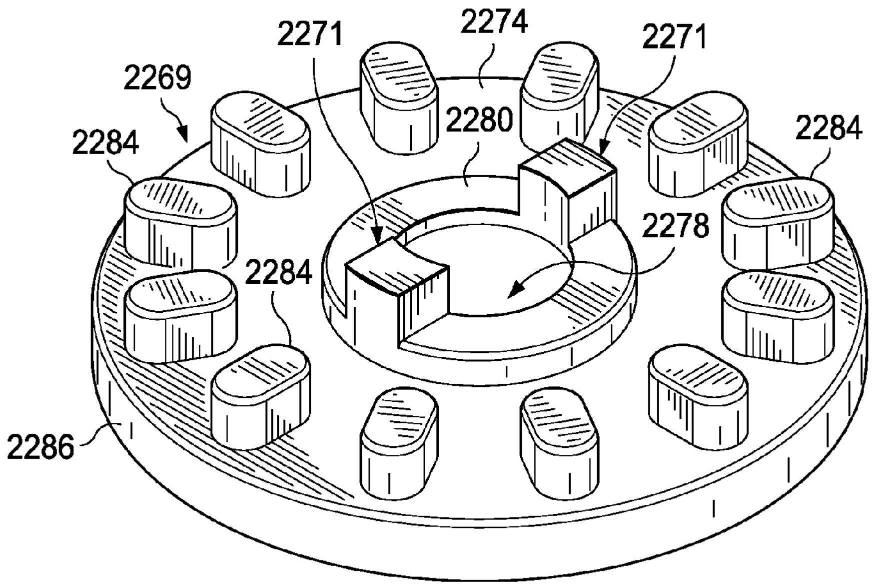
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FIG. 22

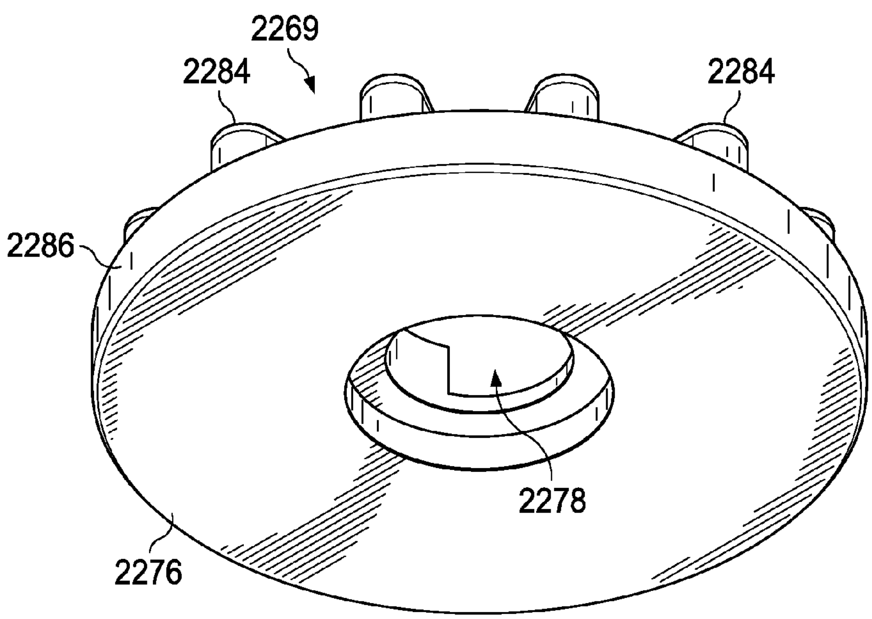
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FIG. 23

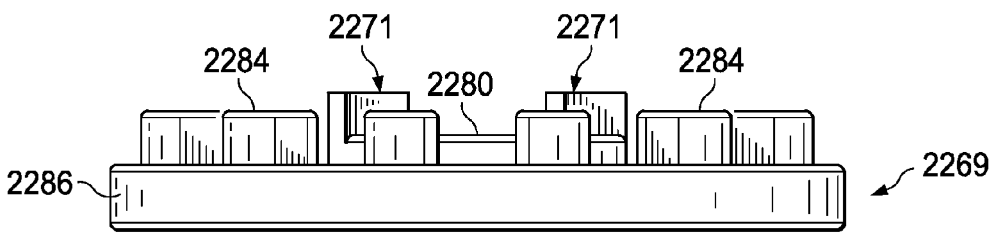
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FIG. 24

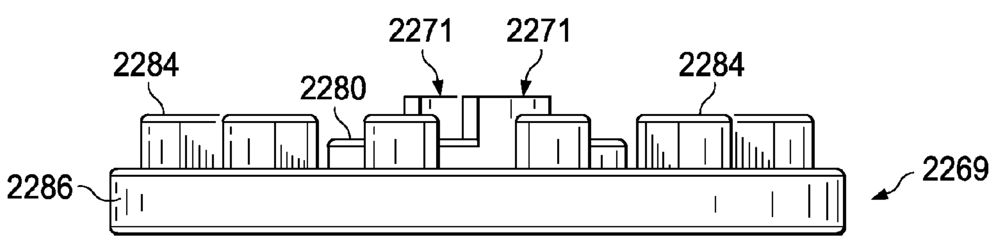
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FIG. 25

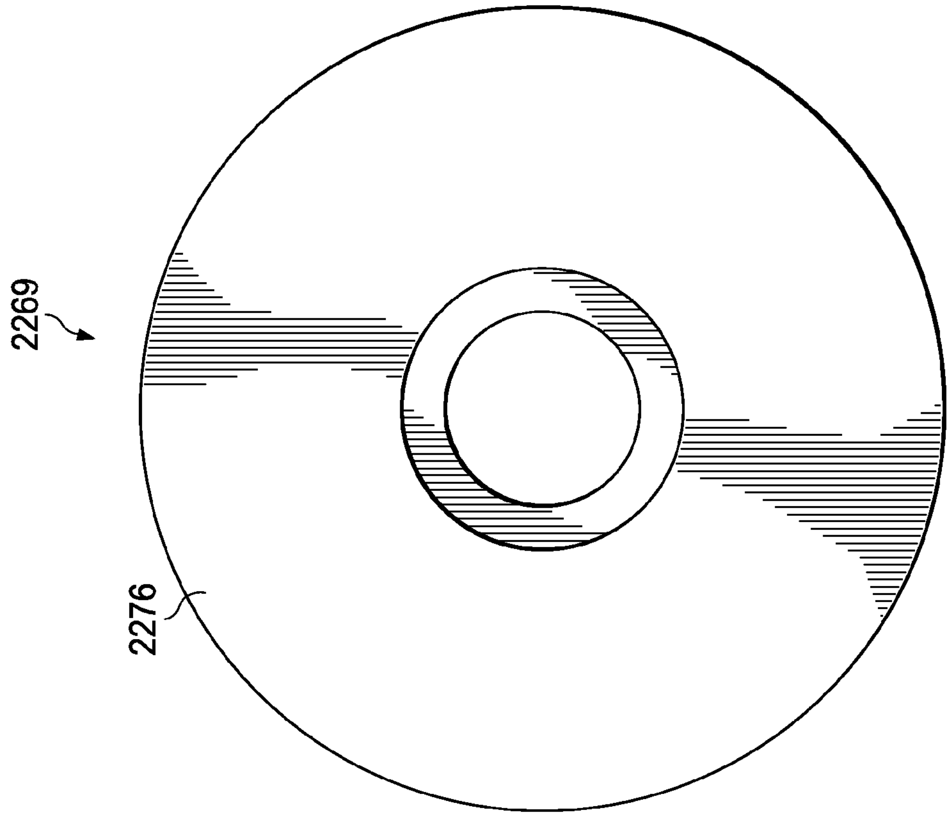

FIG. 27

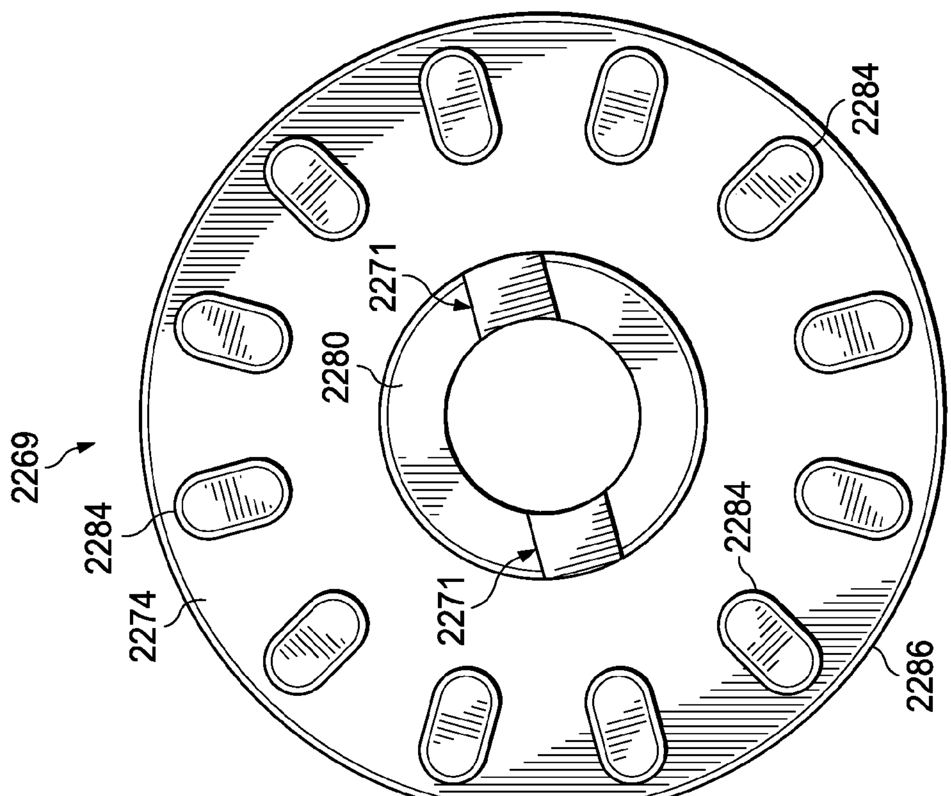

FIG. 26

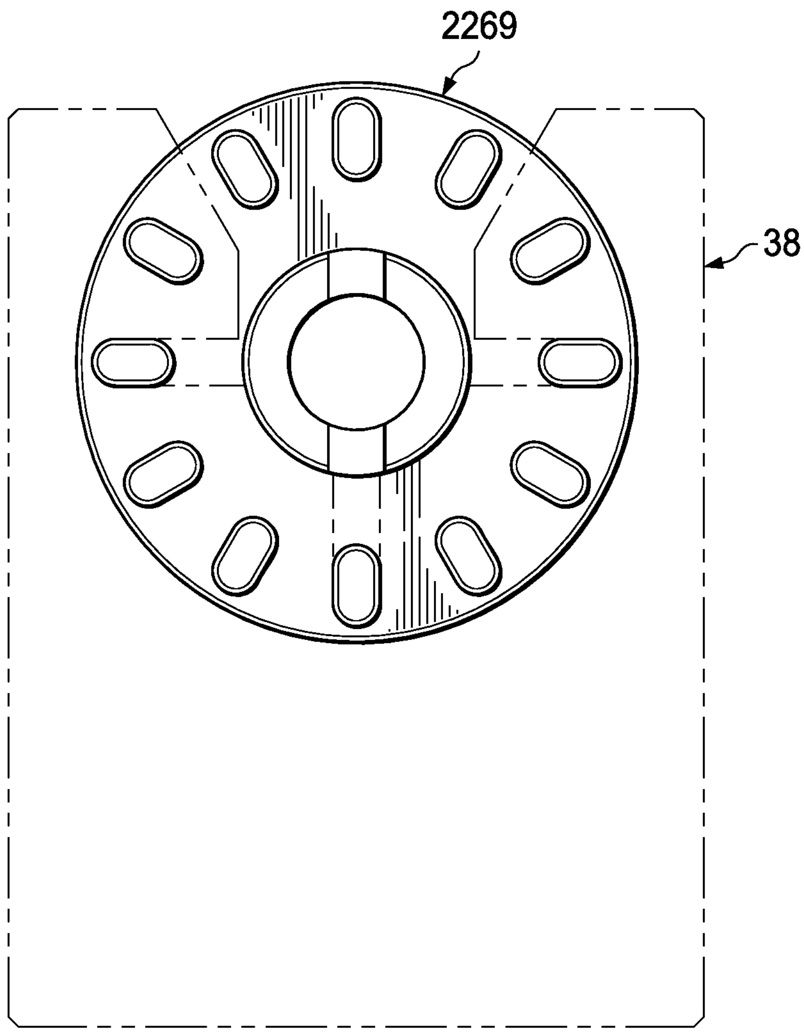

FIG. 28

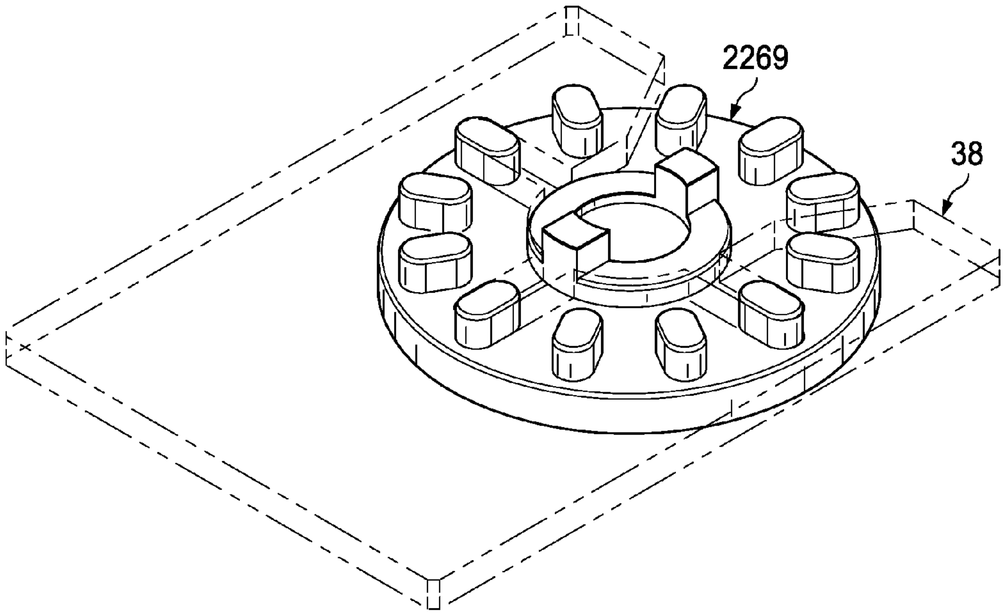

FIG. 29

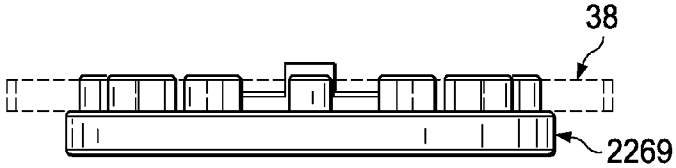

FIG. 30

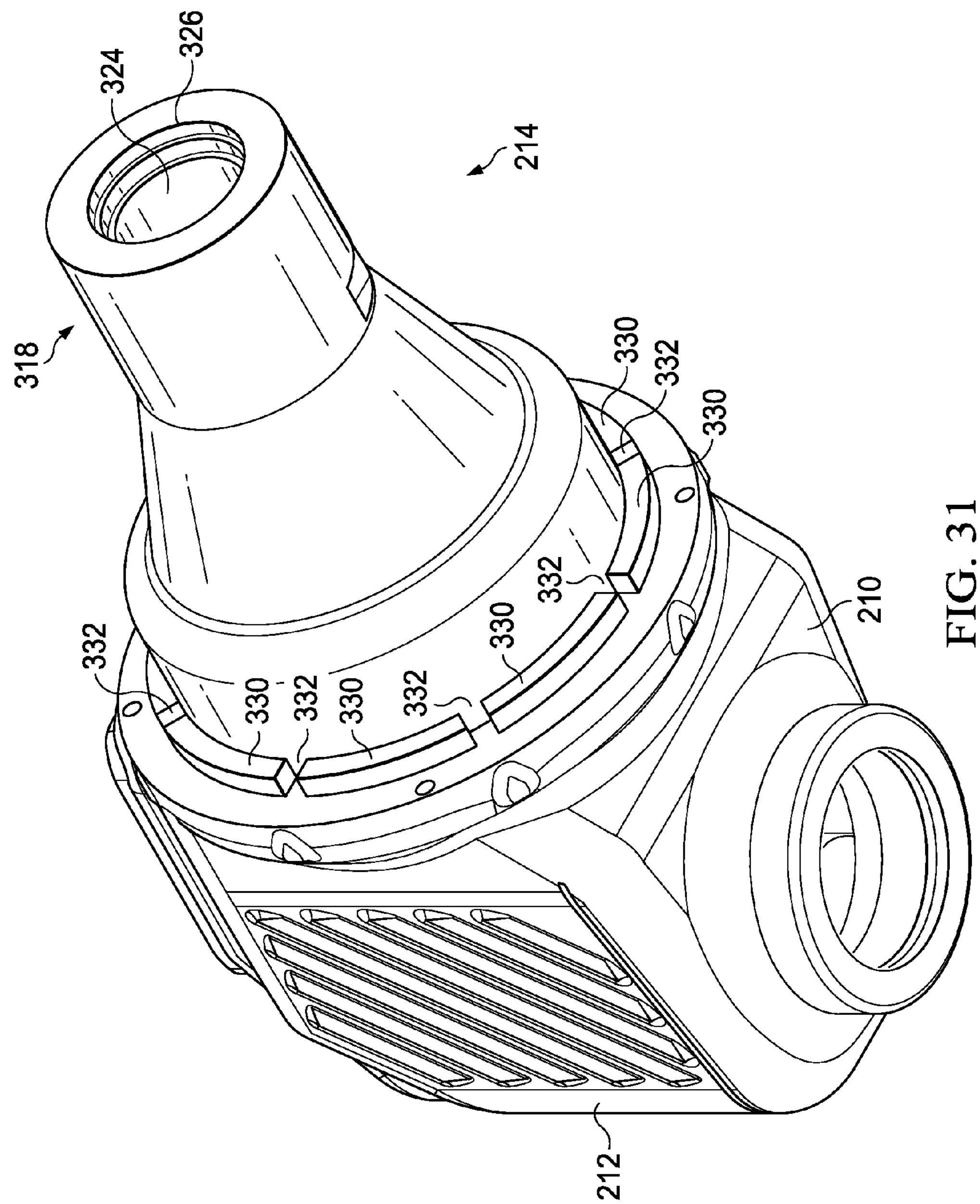
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FIG. 31

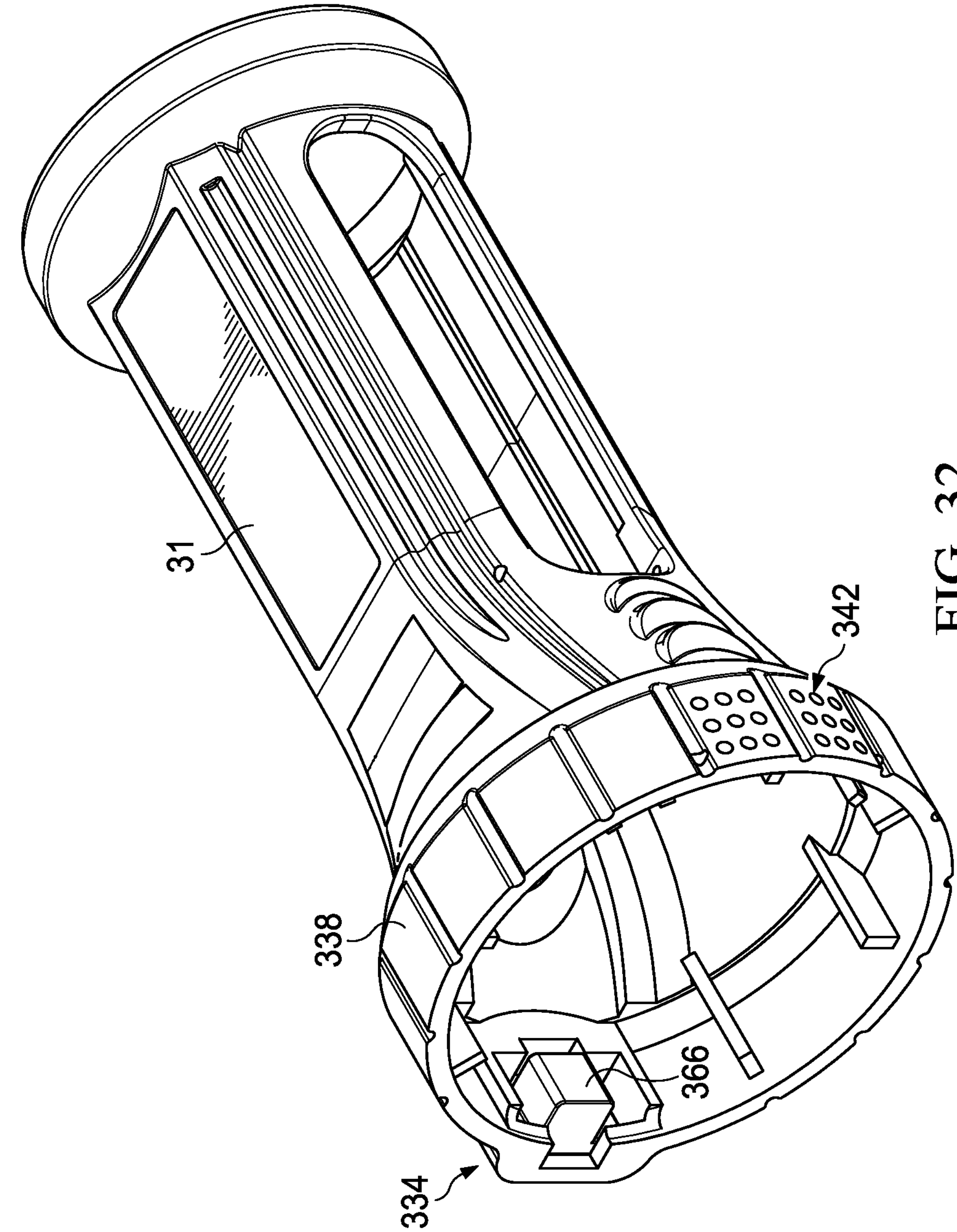

FIG. 32

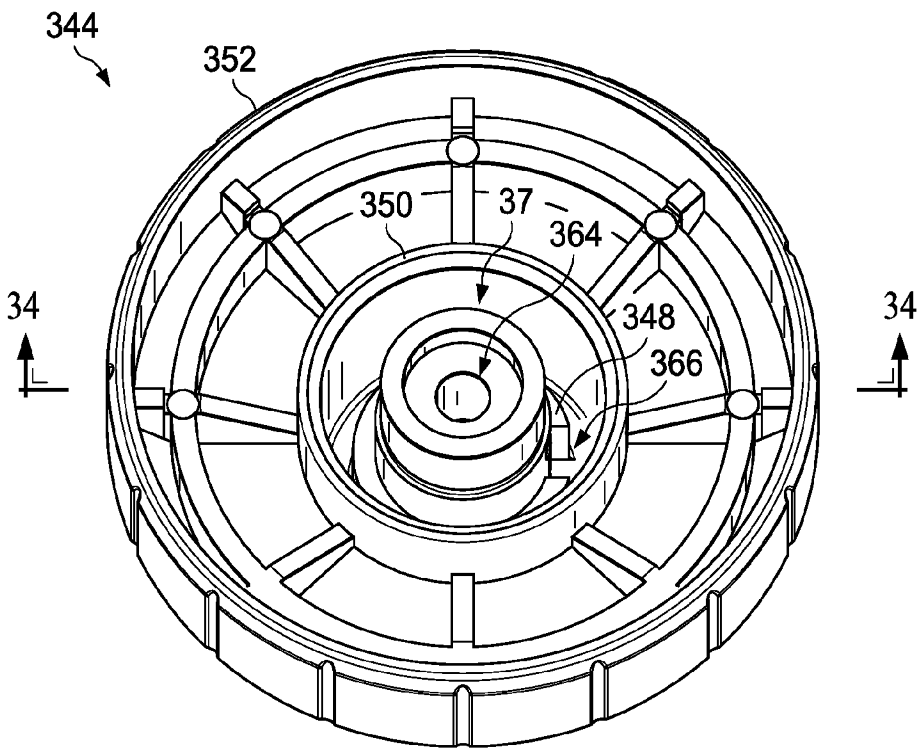
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FIG. 33

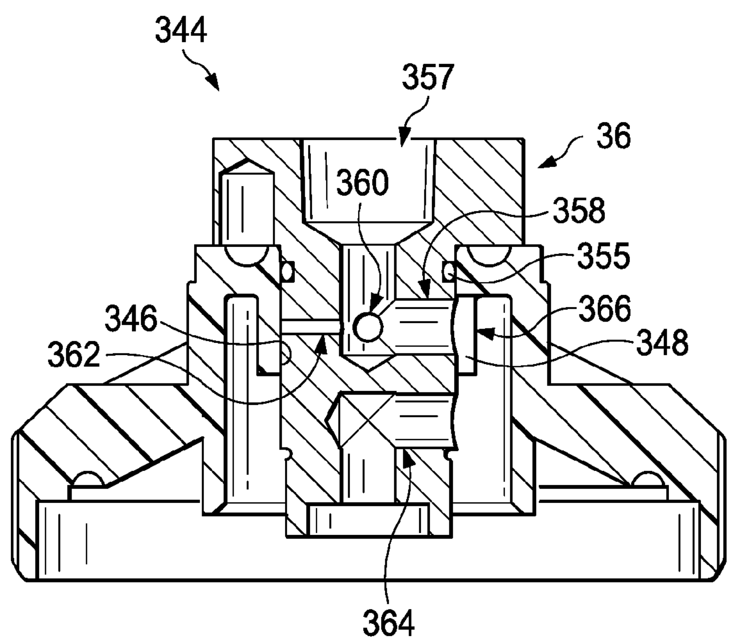
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FIG. 34

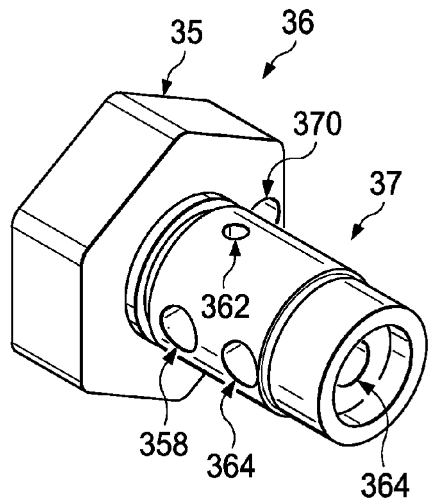

FIG. 35

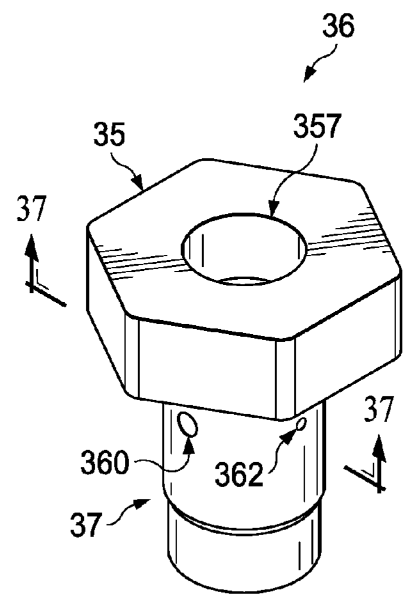

FIG. 36

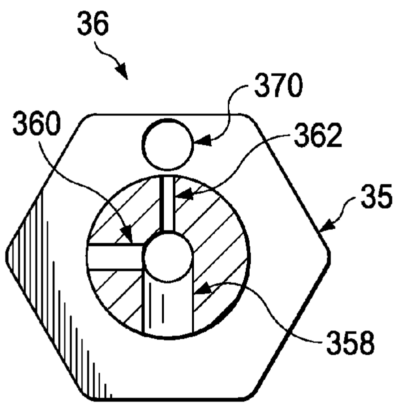

FIG. 37

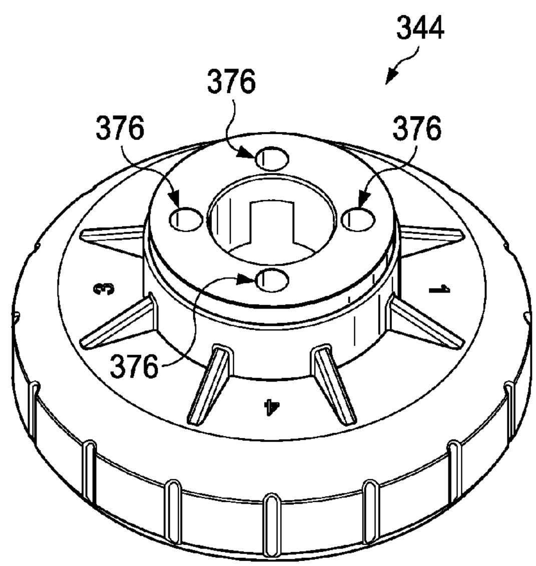

FIG. 38

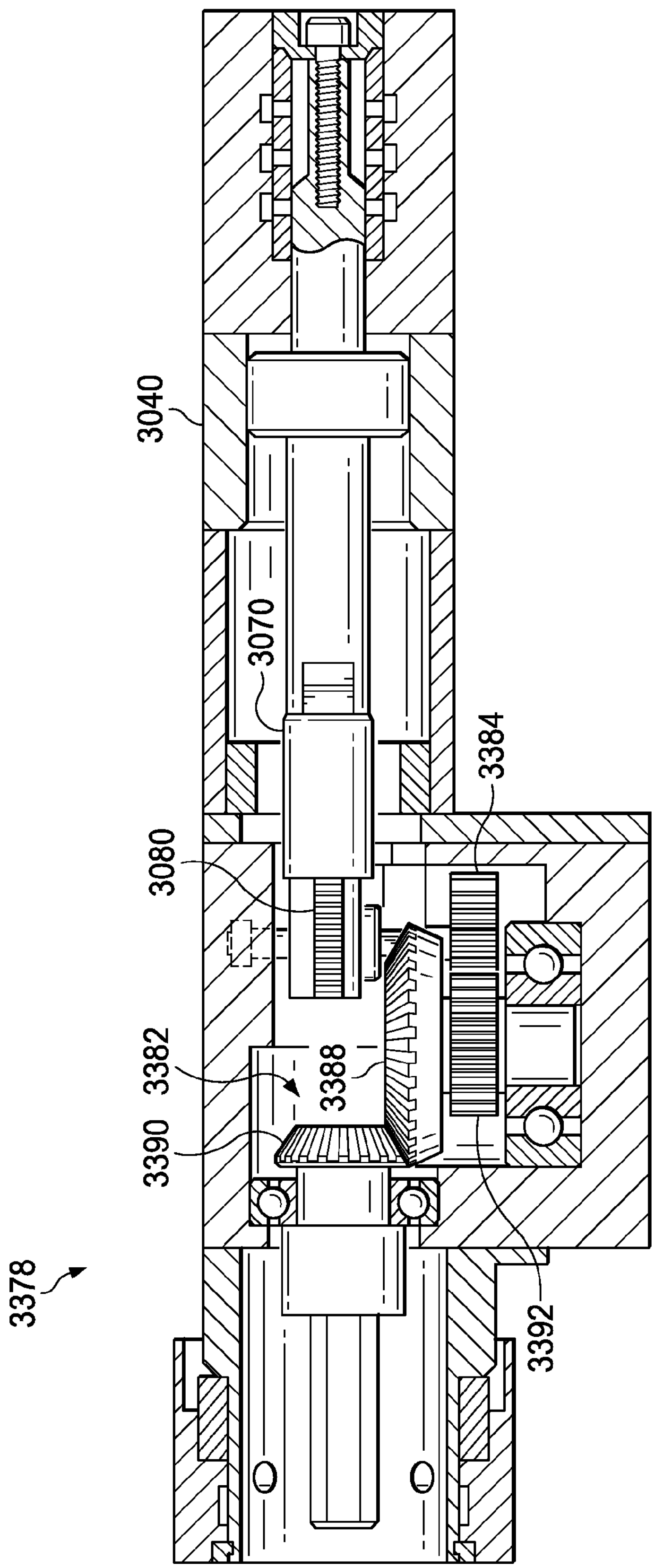

FIG. 39

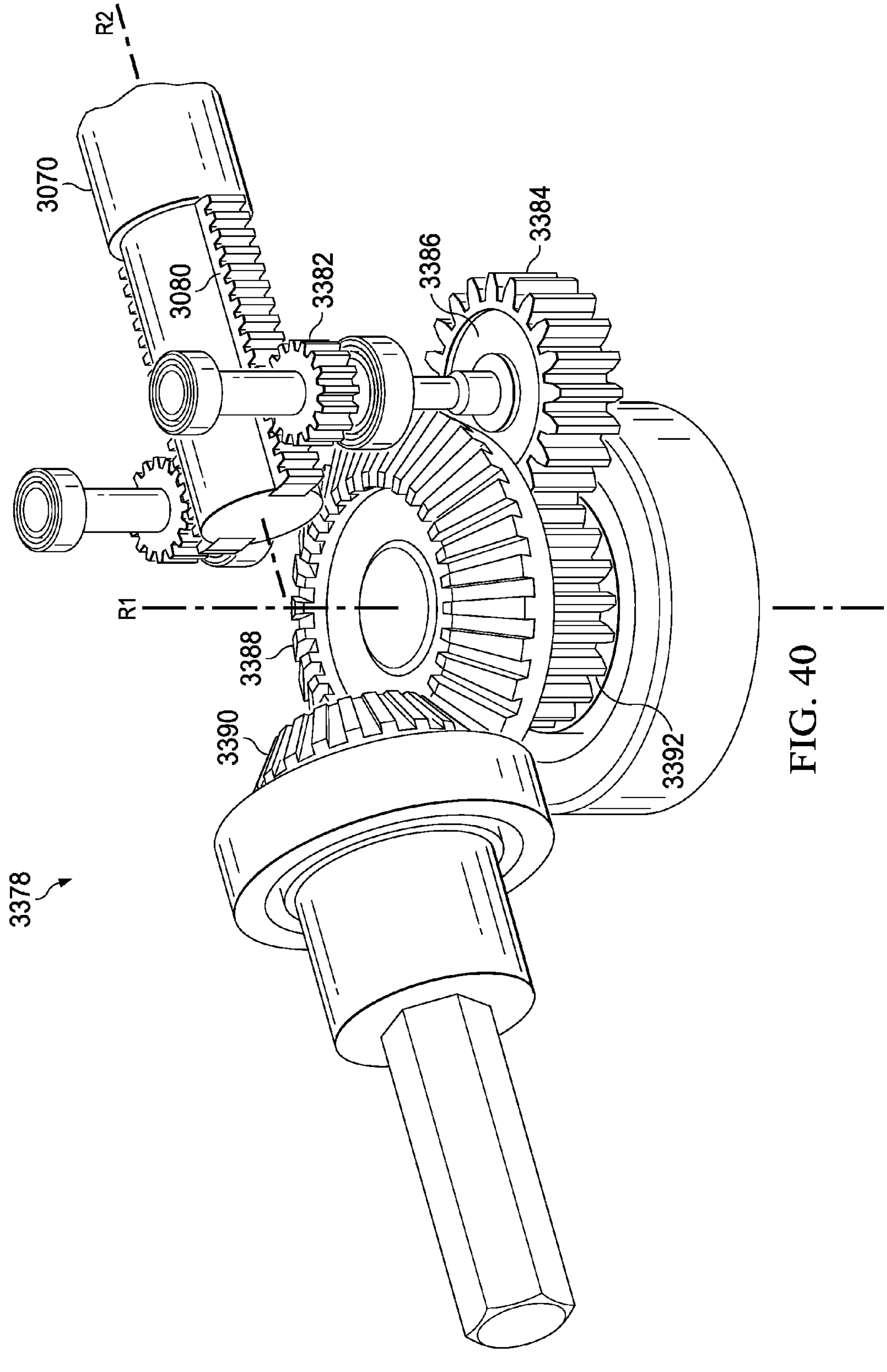

FIG. 40

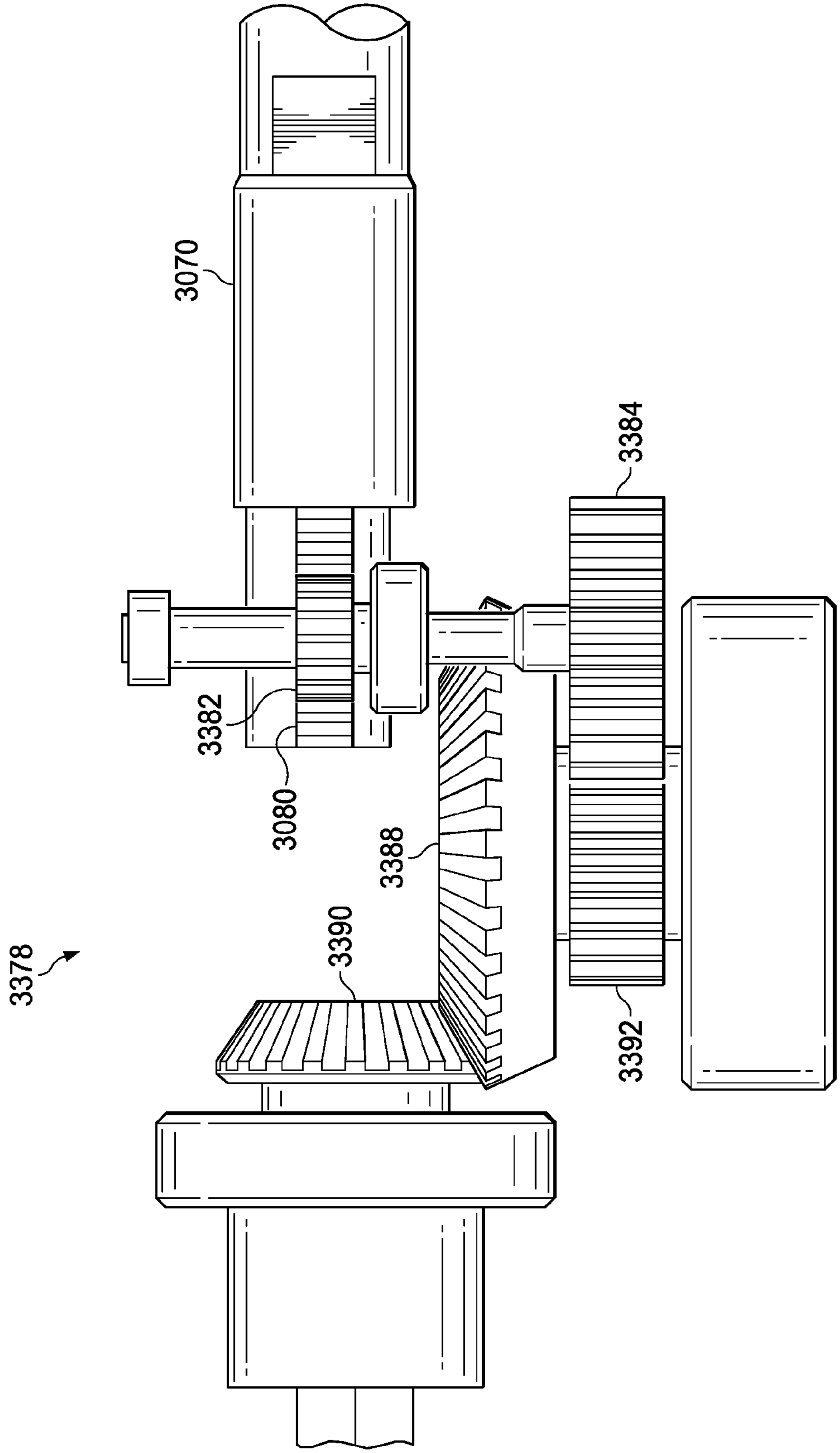

FIG. 41

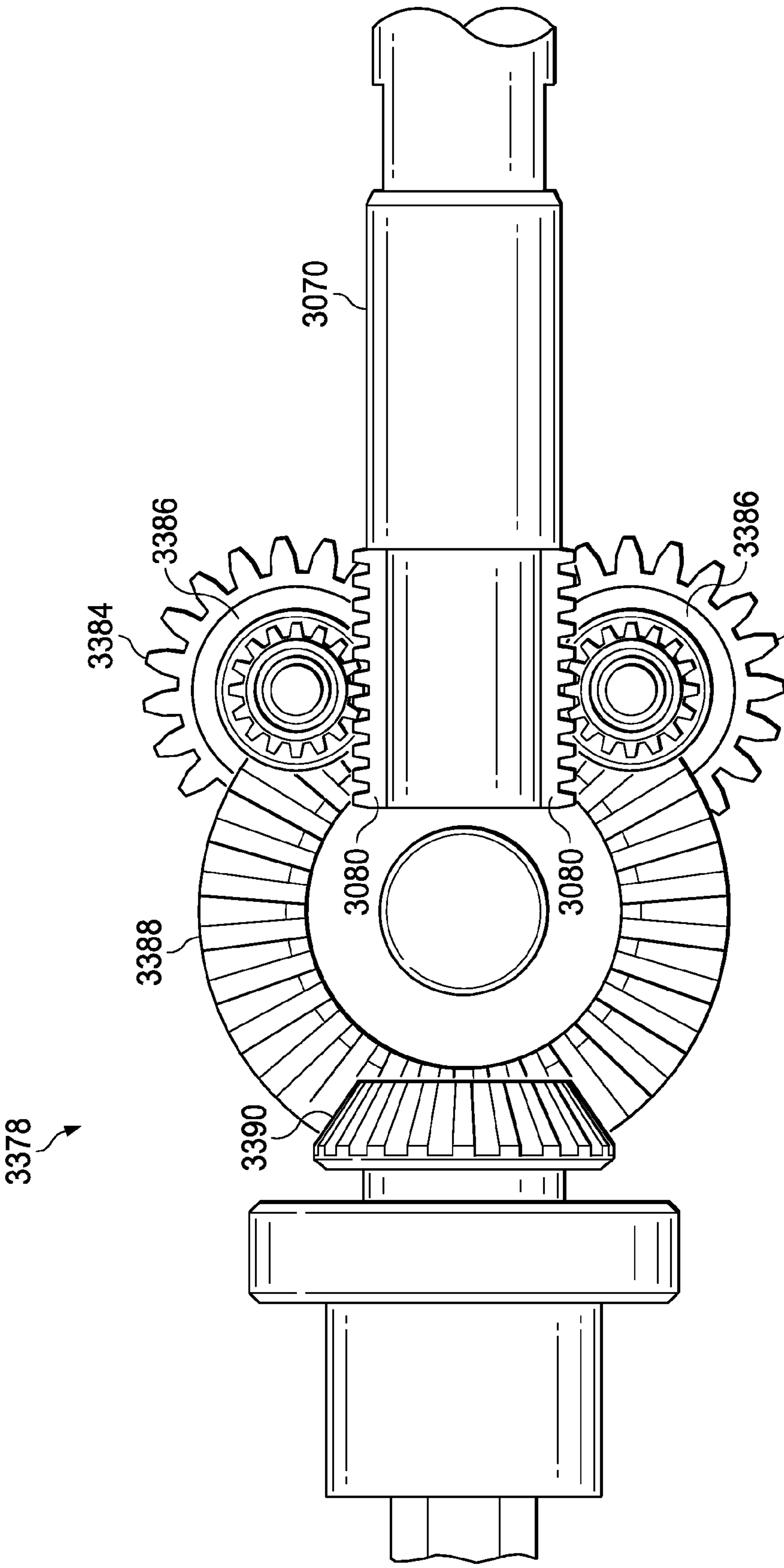

FIG. 42

HAND-HELD TOOLS AND COMPONENTS THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of U.S. Provisional Patent Application Ser. No. 61/581,731, "Pneumatic Tools, Components Thereof and Methods", filed Dec. 30, 2011, and Ser. No. 61/646,594, "Pneumatic Tools, Components Thereof and Methods", filed May 14, 2012, the entire disclosures of which are hereby expressly incorporated by reference herein.

TECHNICAL FIELD

[0002] This application relates generally to a hand-held oscillating tool and components thereof.

BACKGROUND

[0003] A hand-held oscillating tool has a motor and an accessory attachment mechanism for supporting an accessory blade. Operation of the hand-held oscillating tool can oscillate the accessory blade for use on a work surface.

SUMMARY

[0004] In accordance with one embodiment, a hand-held tool comprises a housing, a head assembly, an air inlet, a pneumatic linear motor, a transmission assembly, and at least one resilient member. The housing defines a motor compartment. The head assembly defines a head compartment. The air inlet is supported by the housing. The pneumatic linear motor is disposed at least partially within the motor compartment and comprises a piston. The piston comprises a shaft. The piston is configured for reciprocation between a forward position and a rearward position. The transmission assembly is coupled to the shaft and is disposed at least partially within at least one of the motor compartment and the head compartment. The at least one resilient member is disposed at least partially within the head compartment adjacent the transmission assembly and is configured for selective contact with one of the transmission assembly and the shaft when the piston is in one of its forward position and rearward position to facilitate dampening of the piston.

[0005] In accordance with another embodiment, a hand-held tool comprises a housing, a head assembly, a linear motor, and a transmission assembly. The housing defines a motor compartment. The head assembly is rotatably coupled with the housing and defines a head compartment. The linear motor is disposed at least partially within the motor compartment and comprises a piston. The piston comprises a shaft and is configured for reciprocation. The transmission assembly is coupled to the shaft and is disposed at least partially in at least one of the motor compartment and the head compartment. Each of the transmission assembly, the piston and the head assembly are rotatable together.

[0006] In accordance with yet another embodiment, a hand-held tool comprises a housing, a head assembly, an air inlet, a pneumatic linear motor, and a transmission assembly. The housing defines a motor compartment. The head assembly defines a head compartment. The air inlet is supported by the housing. The pneumatic linear motor is disposed at least partially within the air motor compartment and comprises a piston. The piston comprises a shaft. The piston is configured for reciprocation along a longitudinal axis. The transmission assembly is disposed at least partially in at least one of the motor compartment and the head compartment. The transmission assembly comprises a cam that defines a slot. A centerline bisects the slot and the slot is angled with respect to the longitudinal axis such that the centerline and the longitudinal axis form an acute angle.

[0007] In accordance with yet another embodiment, a hand-held tool comprises a housing, an air inlet, a pneumatic linear motor, and a transmission assembly. The housing defines a motor compartment. The air inlet is supported by the housing. The pneumatic linear motor is disposed at least partially within the air motor compartment and comprises a piston. The piston comprises a shaft. The piston is configured for reciprocation along a longitudinal axis. The transmission assembly is disposed at least partially in one of the motor compartment and the head compartment. The transmission assembly comprises a boss and a cam. The boss is coupled to the shaft of the piston. The cam is pivotally coupled with the boss and is configured to interact with a support a bearing of an accessory attachment mechanism to facilitate pivoting of the accessory attachment mechanism about a pivotal axis.

[0008] In accordance with still another embodiment, an oscillating hand-held tool comprises a housing, a head assembly, a tool free attachment, and an accessory release handle. The housing defines a motor compartment. The head assembly is coupled with the housing and defines a head compartment. The tool free attachment assembly is pivotally supported by the head assembly and is at least partially disposed within the head compartment. The tool free attachment assembly comprises a sleeve, a plunger, a spring, and an accessory disk. The plunger is disposed at least partially within the sleeve and is movable between a clamping position and a depressed position. The spring is associated with the plunger and is configured to bias the plunger into the clamping position. The accessory disk is associated with the plunger and is configured to alternatively engage and release an accessory blade depending upon whether the plunger is in the clamping position and the depressed position, respectively. The accessory release handle is pivotally coupled with the head assembly and overlies the plunger. Depression of the accessory release handle facilitates movement of the plunger into the depressed position.

[0009] In accordance with still another embodiment, an oscillating hand-held tool comprises a housing, a head assembly, an accessory attachment mechanism, and an accessory disk. The housing defines a motor compartment. The head assembly is coupled with the housing and defines a head compartment. The accessory attachment mechanism is pivotally supported by the head assembly and is at least partially disposed within the head compartment. The accessory disk is associated with the accessory attachment mechanism and is configured to alternatively engage and release an accessory blade. The accessory disk defines a central aperture and comprises an inner edge, an outer edge, and a plurality of ovular protrusions. The inner edge borders the central aperture. The plurality of ovular protrusions is disposed circumferentially about the inner edge and is spaced substantially evenly from one another. Each of the ovular protrusions is generally frustoconically shaped.

[0010] In accordance with still another embodiment, an oscillating hand-held tool comprises a housing, a head assembly, a pneumatic linear motor, a trigger assembly, and an accessory attachment mechanism. The housing defines a motor compartment. The head assembly is coupled with the housing and defines a head compartment. The pneumatic linear motor is disposed at least partially within the motor compartment and defines at least one first exhaust port that is configured to permit passage of exhaust fluid during operation of the pneumatic linear motor. The trigger assembly is associated with the pneumatic linear motor and is configured for selective actuation to facilitate operation of the linear motor. The accessory attachment mechanism is coupled with the pneumatic linear motor and is pivotally supported by the head assembly. The accessory attachment mechanism is at least partially disposed within the head compartment and is configured to support an accessory blade. At least one of the housing and the head assembly defines at least one second exhaust port that is in fluid communication with said at least one first exhaust port. Said at least one second exhaust port is located along a lower portion of the oscillating hand-held tool. Said at least one second exhaust port is configured to direct the exhaust fluid from said at least one first exhaust port towards the accessory blade during operation of the linear motor.

[0011] In accordance with still another embodiment, a hand-held tool comprises a housing, a head assembly, an air inlet, a pneumatic linear motor, and a flow control collar. The housing defines a motor compartment. The head assembly defines a head compartment. The air inlet is supported by the housing. The air inlet defines an inlet passageway, a first port, a second port, and an outlet passageway. The first port is in fluid communication with the inlet passageway. The second port is in fluid communication with the inlet passageway. The outlet passageway is spaced from each of the inlet passageway, the first port, and the second port. The pneumatic linear motor is disposed at least partially within the air motor compartment and comprises a piston that is configured for reciprocation between one of a forward position and a rearward position. The flow control collar is rotatably coupled with the air inlet and is rotatable with respect to the air inlet between a first position and a second position. The outlet passageway is in fluid communication with the pneumatic linear motor. When the flow control collar is in the first position, the first port is in fluid communication with the outlet passageway and is configured to distribute pressurized fluid to the outlet passageway at a first fluid flow rate. When the flow control collar is in the second position, the second port is in fluid communication with the outlet passageway and is configured to distribute pressurized fluid to the outlet passageway at a second fluid flow rate. The first and second fluid flow rates are different.

[0012] In accordance with still another embodiment, a hand-held tool comprises a housing, an air inlet, and a pneumatic linear motor. The housing defines a motor compartment. The air inlet is supported by the housing. The pneumatic linear motor is disposed at least partially within the motor compartment and comprises a piston, an outer housing, and a return spring. The piston comprises a shaft and a front surface. The piston is configured to reciprocate in response to pressurized air between one of a forward position and a rearward position. The outer housing defines an interior and comprises a front collar that defines an interior front shoulder. The return spring assembly is disposed entirely within the interior of the outer housing and comprises a front washer, a rear washer, and a spring. The front washer abuts the interior front shoulder. The rear washer abuts the front surface of the piston. The spring is sandwiched between each of the front washer and the rear washer and is configured to bias the piston into a rearward position. The front washer, the rear washer and the spring are circumferentially disposed about the shaft of the piston.

[0013] In accordance with still another embodiment, an accessory blade for use with a motorized hand-held tool is provided. The accessory blade comprises a working end and a shank end. The shank end defines a main opening, a first slot, a second slot, a third slot, and a plurality of apertures. The main opening has a first angled edge and a second angled edge that cooperate with each other to define a v-shaped opening and respectively terminate at a generally U-shaped edge. The first slot is in communication with the main opening. The second slot is in communication with the main opening. The third slot is in communication with the main opening. The first, second, and third slots are distributed about a circumference of the main opening such that they are provided in a substantially T-shaped formation. At least two of the apertures are distributed between the first slot and the second slot. At least two of the other ones of the apertures are distributed between the first slot and the third slot. At least one of the other ones of the apertures is disposed between the first angled edge and the second slot. At least one other one of the apertures is disposed between the second angled edge and the third slot.

[0014] In accordance with still another embodiment, a hand-held tool comprises a housing, a head assembly, an air inlet, and a pneumatic linear motor. The housing defines a motor compartment. The head assembly defines a head compartment. The air inlet is supported by the housing. The pneumatic linear motor is disposed at least partially within the motor compartment. The pneumatic linear motor comprises a piston, a valve seat, a cylinder end plate, and a flapper. The piston comprises a shaft and is configured for reciprocation between one of a forward position and a rearward position. The valve seat defines a first set of passageways and a second set of passageways. The first and second passageways are in selective fluid communication with the air inlet. The flapper is sandwiched between the valve seat and the cylinder end plate. The flapper is configured for movement between a first position and a second position in response to pressurized fluid through the first set of passageways and the second set of passageways, respectively. The piston is configured to move to the forward position when the flapper is in the first position and to the rearward position when the flapper is in the second position.

[0015] In accordance with still another embodiment, a hand-held tool comprises a housing, a head assembly, an air inlet, a pneumatic linear motor, and a transmission assembly. The housing defines a motor compartment. The head assembly defines a head compartment. The air inlet is supported by the housing. The pneumatic linear motor is disposed at least partially within the air motor compartment and comprises a piston configured for reciprocation along a longitudinal axis. The piston comprises a shaft and the shaft comprises a first geared surface and a second geared surface. The respective first and second geared surfaces are disposed on substantially opposite sides of the shaft. The transmission assembly is disposed at least partially in at least one of the motor compartment and the head compartment. The transmission assembly comprises a first gear, a second gear, and a third gear. The first gear is intermeshed with the first geared surface. The second gear is intermeshed with the second geared surface. The third gear is associated with the first and second gears and is configured to rotate about a rotational axis in response to reciprocation of the piston along the longitudinal axis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] It is believed that certain embodiments will be better understood from the following description taken in conjunction with the accompanying drawings in which:

[0017] FIG. **1** is a front perspective view depicting a hand-held oscillating tool with an accessory blade in accordance with one embodiment;

[0018] FIG. **2** is a cross-sectional view taken along the line **2-2** in FIG. **1** and depicting the hand-held oscillating tool of FIG. **1**, wherein certain components of the hand-held pneumatic oscillating tool have been removed for clarity of illustration and wherein a piston and a flapper of a linear motor are shown in respective rearward positions;

[0019] FIG. **3** is a cross-sectional view similar to FIG. **2**, but with the piston and the flapper shown in respective forward positions;

[0020] FIG. **4** is a partially exploded front perspective view depicting parts of the hand-held pneumatic oscillating tool of FIG. **2**;

[0021] FIG. **5** is a further exploded front perspective view depicting some of the parts of FIG. **4**;

[0022] FIG. **6** is an exploded rear perspective view depicting the parts of FIG. **5**;

[0023] FIG. **7** is an enlarged front perspective view depicting one of the parts of FIG. **5**;

[0024] FIG. **8** is a rear perspective view depicting the part of FIG. **7**;

[0025] FIG. **9** is an enlarged rear perspective view depicting another one of the parts of FIG. **5**;

[0026] FIG. **10** is an enlarged rear perspective view depicting yet another one of the parts of FIG. **5**;

[0027] FIG. **11** is an exploded front perspective view depicting some of the parts of FIG. **4**;

[0028] FIG. **12** is a further exploded perspective view depicting some of the parts of FIG. **4** corresponding to a tool free attachment assembly, according to one embodiment;

[0029] FIG. **13** is a cross-sectional view taken along the line **13-13** in FIG. **12**;

[0030] FIG. **14** is an enlarged perspective view depicting the part of FIG. **13**;

[0031] FIG. **15** is a perspective view depicting the accessory blade of FIG. **1**;

[0032] FIG. **16** is a top plan view depicting the accessory blade of FIG. **15**;

[0033] FIG. **17** is a top plan view depicting an accessory blade, according to another embodiment;

[0034] FIG. **18** is an exploded perspective view of a tool free attachment assembly, according to another embodiment

[0035] FIGS. **19-21** are front sectional views depicting various operating states of the tool free attachment assembly of FIG. **18**;

[0036] FIGS. **22-23** are upper and lower perspective views depicting an accessory disk according to another embodiment;

[0037] FIGS. **24-25** are side elevational views depicting the accessory disk of FIG. **22**;

[0038] FIGS. **26-27** are upper and lower plan views depicting the accessory disk of FIG. **22**;

[0039] FIG. **28** is an upper plan view depicting the accessory disk of FIG. **22** in association with the accessory blade of FIG. **5** shown in dashed lines;

[0040] FIG. **29** is an upper perspective view depicting the arrangement of FIG. **28**;

[0041] FIG. **30** is a side elevational view depicting the accessory disk and the accessory blade of FIG. **28**;

[0042] FIG. **31** is a perspective view depicting some of the parts of FIG. **4** as assembled;

[0043] FIG. **32** is an enlarged perspective view depicting one of the parts of FIG. **4** as assembled;

[0044] FIG. **33** is an enlarged front perspective view depicting other parts of FIG. **4**;

[0045] FIG. **34** is a cross-sectional view taken along the line **34-34** in FIG. **33**.

[0046] FIG. **35** is an enlarged front perspective view depicting another part of FIG. **4**;

[0047] FIG. **36** is a rear perspective view depicting the part of FIG. **35**;

[0048] FIG. **37** is a cross-sectional view taken along the line **37-37** in FIG. **36**;

[0049] FIG. **38** is a rear perspective view depicting one of the parts of FIG. **33**;

[0050] FIG. **39** is a cross-sectional view depicting certain portions of a hand-held tool in accordance with another embodiment;

[0051] FIG. **40** is a perspective view depicting a transmission and a portion of a piston of a linear motor of the hand-held tool of FIG. **39**;

[0052] FIG. **41** is a side elevational view depicting the arrangement of FIG. **40**; and

[0053] FIG. **42** is a top plan view depicting the arrangement of FIG. **41**.

DETAILED DESCRIPTION

[0054] Embodiments are hereinafter described in detail in connection with the views and examples of FIGS. **1-42**, wherein like numbers indicate the same or corresponding elements throughout the views. According to one embodiment, as illustrated in FIGS. **1** and **2**, a hand-held pneumatic oscillating tool **30** (hereinafter "oscillating tool") is provided that can include a housing **31** and can extend between a front end **32** and a rear end **34**. As illustrated in FIG. **2**, an air inlet **36** can be disposed at the rear end **34** and supported by the housing **31** and can include a base portion **35** and a stem portion **37**. The base portion **35** of the air inlet **36** can be coupled with an air compressor (not shown) or another source of pressurized air or other fluid. The pressurized air can facilitate selective powering of the oscillating tool **30** which can actuate an accessory blade **38** such that the oscillating tool is operable as a hand-held cutting tool.

[0055] As illustrated in FIGS. **2-4**, the oscillating tool **30** can include a linear motor **40**. The linear motor **40** can be at least partially disposed within a motor compartment **41** defined by the housing **31**. The linear motor **40** can be in fluid communication with the air inlet **36** and can be selectively powered with pressurized air from the air inlet **36**. The linear motor **40** can include a piston **44** configured for reciprocation between one of a rearward position (FIG. **2**) and a forward position (FIG. **3**). In one embodiment, the piston **44** can be formed of a thermoplastic material in a unitary one-piece construction. In other embodiments, the piston **44** can be formed of a variety of other materials, such as metals, and/or can be overmolded, such as with a resilient coating for dampening of the piston **40**. As illustrated in FIGS. **2-3**, the stem portion **37** of the air inlet **36** can be coupled with a rear backing plate **42** of the linear motor **40**, such as through threaded engagement, compression fit, interference fit, or any of a variety of suitable alternative coupling arrangements. The oscillating tool **30** can include a trigger assembly **46** that can be selectively actuated to facilitate operation of the linear motor **40**.

[0056] The trigger assembly **46** can include a valve spring **48**, a valve overmold **50**, and a plunger **52**. The valve spring **48** can be seated in the stem portion **37** of the air inlet **36**, and one end of the valve overmold **50** can be coupled to the valve spring **48**. The other end of the valve overmold **50** can be coupled with a finger **54** that contacts the plunger **52**. The plunger **52** can be slidably coupled with the rear backing plate **42** and can be biased into a released position (shown in FIGS. **2** and **3**) by a spring **56**. When the plunger **52** in the released position, the valve overmold **50** can mate with a valve bushing **58** to substantially seal the rear backing plate **42** and prevent pressurized air from passing through to the rest of the linear motor **40**. When the plunger **52** is depressed (not shown), the valve overmold **50** is urged away from the valve bushing **58** enough to permit pressurized air to flow through the rear backing plate **42** and operate the piston **44** such that it reciprocates along a longitudinal axis L.

[0057] As illustrated in FIG. **2**, the oscillating tool **30** can include a trigger handle **60** associated with the plunger **52** and pivotally coupled to the housing **31** of the oscillating tool **30**. The trigger handle **60** can be arranged along a bottom of the oscillating tool **30** and can be configured for selective actuation by a user's hand when grasping the oscillating tool **30**. When the trigger handle **60** is depressed, the plunger **52** can be depressed to facilitate operation of the linear motor **40**. The trigger handle **60** can provide a mechanical advantage for actuating the plunger **52** and can also cooperate with adjacent portions of the housing **31** to substantially conceal the plunger **52** and provide an aesthetically pleasing appearance to the oscillating tool **30**.

[0058] Referring now to FIGS. **2-4**, the piston **44** can be coupled with a transmission assembly **64**. The transmission assembly **64** can include a cam boss **66** and a cam **68**. In one embodiment, the cam boss **66** can be threaded onto a shaft **70** of the piston **44**, or in other embodiments, can be coupled with the shaft **70** through welding, or fasteners or provided as a one-piece construction with a shaft of a piston, or any of a variety of other suitable arrangements. As illustrated in FIG. **4**, the cam **68** can define a slot **72** that is configured to receive a bearing **74** from a tool free attachment assembly **76**. A centerline C**1** is shown to bisect the slot **72**. The slot **72** can be angled such that the centerline C**1** is angled with respect to the longitudinal axis L. In some embodiments, the slot **72** can be angled such that the centerline C**1** is angled from the longitudinal axis L**1** by greater than about 30 degrees. When the piston **44** reciprocates, the bearing **74** can ride within the slot **72** and can interact with the cam **68** such that the tool free attachment assembly **76** and the accessory blade **38** oscillate together about a pivotal axis A**1** (FIG. **2**). It will be appreciated that a cam can be configured to receive a bearing of a tool free attachment assembly in any of a variety of suitable alternative arrangements. For example, a cam can be a closed-type cam and the bearing can be disposed within, and completely surrounded by, the cam.

[0059] With reference to FIGS. **2**, **5**, and **6**, the linear motor **40** can include a valve backing plate **78**, a valve seat **80**, a valve chest **82**, a cylinder end plate **84**, and a piston housing **86**. The valve backing plate **78**, the valve seat **80**, the valve chest **82**, and the cylinder end plate **84** are shown in FIGS. **2** and **3** to be sandwiched between the rear backing plate **42** and the piston housing **86**. As will be described in further detail below, the rear backing plate **42**, the valve backing plate **78**, the valve seat **80**, the valve chest **82**, the cylinder end plate **84**, and the piston housing **86** can cooperate together to route pressurized air from the air inlet **36** to the piston **44** to facilitate actuation of the piston **44**.

[0060] As illustrated in FIGS. **5** and **6**, the valve backing plate **78** can include a front surface **88** (FIG. **5**) and a rear surface **90** (FIG. **6**). The valve backing plate **78** can define a passageway **92**. The passageway **92** can extend into a recess **94** defined by the rear surface **90** such that the passageway **92** and the recess **94** are in fluid communication with one another. With the rear backing plate **42** and the valve backing plate **78** sandwiched together, as illustrated in FIGS. **2** and **3**, the recess **94** can be in fluid communication with an outlet port **98** defined by the rear backing plate **42**. The outlet port **98** is shown in FIG. **5** to have a larger lower opening portion, and the recess **94** can be located such that it registers with the larger lower opening portion of the outlet port **98**. The passageway **92** is shown in FIG. **6** to be located along an outer edge of the recess **94** (e.g., substantially tangential to the recess **94**) and more proximate to an outer edge of the valve backing plate **78** than to its center. In one embodiment, the passageway **92** and the recess **94** can be sized such that the recess **94** has a diameter that is about four times greater than a diameter of the passageway **92**.

[0061] The valve seat **80** can include a front surface **100** (FIG. **5**) and a rear surface **102** (FIG. **6**). The valve seat **80** can define a passageway **104**, a central bore **106**, and three outer perimeter passageways **108**. As illustrated in FIG. **6**, each of the three outer perimeter passageways **108** can extend into, and can be in fluid communication with, respective elongated recesses **110** defined by the rear surface **102**. Each of the elongated recesses **110** can extend from their respective outer perimeter passageways **108** and to the central bore **106** in a T-shaped arrangement. With the valve backing plate **78** and the valve seat **80** sandwiched together, as illustrated in FIGS. **2** and **3**, the passageway **104** of the valve seat **80** can be in fluid communication with the passageway **92** of the valve backing plate **78**. The front surface **88** of the valve backing plate **78** can cover the central bore **106**, the outer perimeter passageways **108**, and the elongated recesses **110**.

[0062] Referring still to FIGS. **5** and **6** and additionally to FIGS. **7** and **8**, the valve chest **82** can include a front surface **112** (FIG. **5**) and a rear surface **114** (FIG. **6**). The valve chest **82** can define a pair of passageways **116** and three outer perimeter passageways **118**. The front surface **112** can define a front recess **119**. As illustrated in FIGS. **6** and **8**, the passageways **116** can extend into a ring recess **120** defined by the rear surface **114**. As illustrated in FIG. **7**, the valve chest **82** can define a central bore **122** and four inner perimeter passageways **124** that extend into the front recess **119**. The inner perimeter passageways **124** can be disposed circumferentially about the central bore **122** and can be spaced from the central bore **122** by an inner shoulder **126**. The inner shoulder **126** can be disposed radially inwardly from the inner perimeter passageways **124** and the outer shoulder **128** can be spaced radially outwardly from the inner perimeter passageways **124**. As illustrated in FIG. **8**, the inner perimeter passageways **124** can extend into, and can be in fluid communication with, respective elongated recesses **130** defined by the rear surface **114**. The elongated recesses **130** can extend into, and can be in fluid communication with, the ring recess **120**. With the valve seat **80** and the valve chest **82** sandwiched together, as illustrated in FIGS. **2** and **3**, each of the outer perimeter passageways **108** of the valve seat **80** can be in fluid communication with respective ones of the respective outer perimeter passageways **118** of the valve chest **82**. The passageway **104** of the valve seat **80** can be in fluid communication with the ring recess **120** and thus in fluid communication with the inner perimeter passageways **124**. The central bore **106** of the valve seat **80** can be in fluid communication with the central bore **122** of the valve chest **82**.

[0063] Referring again to FIGS. **5** and **6** and additionally to FIG. **9**, the cylinder end plate **84** can include a front surface **132** (FIG. **5**) and a rear surface **134** (FIG. **6**). The cylinder end plate **84** can define a central bore **136** and three outer perimeter passageways **138**. The rear surface **134** of the cylinder end plate **84** can define a recess **140**. An inner shoulder **142** can extend from the recess **140** and can define at least part of the central bore **136**. The inner shoulder **142** can include an upper surface **144** that is substantially coplanar with the rear surface **134**.

[0064] As illustrated in FIGS. **5** and **6**, a flapper **146** can be provided between the valve chest **82** and the cylinder end plate **84**. With the valve chest **82** and the cylinder end plate **84** sandwiched together, as illustrated in FIGS. **2** and **3**, the flapper **146** can be disposed within the front recess **119** of the valve chest **82**. In addition, each of the outer perimeter passageways **118** of the valve chest **82** can be in fluid communication with respective ones of the outer perimeter passageways **138** of the cylinder end plate **84**.

[0065] Referring again to FIGS. **5** and **6**, the piston housing **86** can define three outer perimeter passageways **148**. The piston housing **86** can be formed as a substantially annular ring but with a pair of planar side portions **150**. An exhaust port **152** can be defined at each of the planar side portions **150**. A gasket **156** can be sandwiched between the cylinder end plate **84** and the piston housing **86** and can define through holes **158** and a central bore **159** that are arranged to permit passage of fluid between the cylinder end plate **84** and the piston housing **86**. For example, in this arrangement, each of the outer perimeter passageways **138** of the cylinder end plate **84** can be in fluid communication with respective ones of the outer perimeter passageways **148** of the piston housing **86**.

[0066] Referring again to FIGS. **5** and **6**, the linear motor **40** can include an outer housing **160** having an end wall **162** and a side wall **164** that cooperate to define an interior **166**. The outer housing **160** can have a pair of planar side portions **163** that each define an exhaust port **165**. Each of the valve backing plate **78**, the valve seat **80**, the valve chest **82**, the cylinder end plate **84**, and the piston housing **86** can be disposed within the interior **166** of the outer housing **160**, as illustrated in FIGS. **2** and **3**, and sandwiched between the end wall **162** and a securing ring **168**. A gasket **169** can be sandwiched between the end wall **62** and the piston housing **86**. The securing ring **168** can be threaded to the side wall **164** of the outer housing **160** to restrain the valve backing plate **78**, the valve seat **80**, the valve chest **82**, the cylinder end plate **84**, and the piston housing **86** within the interior **166** of the outer housing **160**. In other embodiments, the securing ring **168** can be secured with a circlip, through frictional engagement, through welding, or any of a variety of suitable alternative securement methods. As illustrated in FIGS. **5** and **6**, the linear motor **40** is shown to include an alignment pin **170** which projects through alignment holes **172**, **173**, **174**, **175**, **176**, **177** of the valve backing plate **78**, the valve seat **80**, the valve chest **82**, the cylinder end plate **84**, the gasket **156**, and the piston housing **86**, respectively to facilitate proper alignment during assembly of the linear motor **40**. As illustrated in FIG. **5**, the rear backing plate **42** can define an alignment recess **171**. As illustrated in FIG. **10**, the front wall **162** of the outer housing **160** can define an alignment recess **179**. Each of the alignment recesses **171**, **179** can receive respective ends of the alignment pin **170** when the linear air motor **40** is assembled. As illustrated in FIGS. **5** and **6**, the rear backing plate **42**, the valve backing plate **78**, the valve seat **80**, the valve chest **82**, the cylinder end plate **84**, the gasket **156**, the piston housing **86**, and the gasket **169** can define respective alignment notches **171***a*, **172***a*, **173***a*, **174***a*, **175***a*, **176***a*, **177***a*, **169***a* that allow for visual alignment of these components prior to installation of the alignment pin **170**.

[0067] When the trigger assembly **46** is actuated, pressurized air can flow through the valve backing plate **78**, the valve seat **80**, the valve chest **82**, the cylinder end plate **84**, and the piston housing **86** in a manner that facilitates reciprocation of the piston **44**. For example, when the trigger assembly **46** is actuated with the piston **44** in a rearward position, as illustrated in FIG. **2**, pressurized air can flow through the rear backing plate **42**, out of the outlet port **98**, and to the recess **94** of the valve backing plate **78**. The pressurized air can be routed through the passageway **92**, through the passageway **104** of the valve seat **80**, to the ring recess **120** of the valve chest **82**, and to each of the passageways **116** and the inner perimeter passageways **124**. The flapper **146** can rest against the inner and outer shoulders **126**, **128** (e.g., in a rearward position) of the valve chest **82** to block the pressurized air at the inner perimeter passageways **124**. The pressurized air therefore can flow through the passageways **116** to the recess **140** of the cylinder end plate **84**, to the front of the flapper **146**, through the central bore **136**, through the gasket **156**, and can act upon a rear surface **178** of the piston **44** to move the piston **44** forwardly.

[0068] As the piston **44** moves past the exhaust ports **152**, and toward its forward position, the pressurized air can be exhausted through the exhaust ports **152**, **165** and into the atmosphere such that the pressurized air no longer acts upon the rear surface **178** of the piston **44**. Once the piston **44** reaches its forward position, the pressurized air through the inner perimeter passageways **124** of the valve chest **82** increases with respect to the passageways **116** and urges the flapper **146** forwardly and into contact with the upper surface **144** of the cylinder end plate **84**. The pressurized air is no longer permitted to flow through the central bore **136** of the cylinder end plate **84** and instead flows rearwardly through the central bore **122** of the valve chest **84** and through the central bore **106** of the valve seat **82**. The pressurized air can then be routed down the elongated recesses **110**, through the outer perimeter passageways **108**, **118**, and **138** of the valve seat **80**, the valve chest **82**, and the cylinder end plate **84**, respectively, through the through holes **158** of the gasket **156** and through the outer perimeter passageways **148** of the piston housing **86**. Three elongated recesses **180** defined by an inner front surface **182** of the outer housing **160**, as illustrated in FIG. **10**, route the pressurized air to a front surface **184** of the piston **44** to move the piston **44** rearwardly. As the piston **44** moves past the exhaust port **152**, and toward its rearward position, the pressurized air can be exhausted through the exhaust ports **152**, **165** such that the pressurized air no longer acts upon the front surface **184**. Once the piston **44** reaches its rearward position, the pressurized air through the passageways **116** of the valve chest **82** increases with respect to the inner perimeter passageways **124** and urges the flapper **146** rearwardly and into contact with each of the inner and outer shoulders **126**, **128** thereby urging the piston **44** forwardly. The pressurized air can repeatedly and alternatively act upon the respective front and rear surfaces **184**, **178** of the piston **44** to facilitate reciprocation of the piston **44**.

[0069] It will be appreciated that the use of a flapper-type arrangement in the linear motor **40** can provide for a compact and efficient design. As a result, the pressurized air though the linear motor **40** can undergo a relatively low pressure drop which can enhance the motor's efficiency as well as the throughput of air to the piston **44**. Accordingly, a smaller quantity of compressed air can be required for a hand-held pneumatic oscillating tool to accomplish a particular task, as compared with conventional hand-held pneumatic oscillating tools that incorporate a rotary vane-type motor. Reducing the required quantity of compressed air can allow for use of a smaller and less powerful air compressor, and can provide energy and cost savings. In addition, the compact size of the linear motor **40** can enhance the overall size and weight of a hand-held pneumatic oscillating tool thus making it easy to handle and store. It will also be appreciated, that although a particular type of linear motor is described herein, namely a flapper-type motor, any of a variety of other suitable types of linear motors having a pneumatically-operated linear piston can alternatively be provided to achieve various design objectives.

[0070] Referring again to FIGS. **2-3** and **5-6**, the linear motor **40** can include a return spring assembly **186** that is configured to bias the piston **44** to the rearward position. The return spring assembly **186** can include a front washer **188**, a spring **190**, and a rear washer **192**. The front washer **188**, the spring **190**, and the rear washer **192** can be circumferentially disposed about the shaft **70** of the piston **44** which is shown to extend from the front surface **184** of the piston **44**. The front washer **188** can abut an interior front shoulder **194** defined by a front collar **196** of the outer housing **160**. The rear washer **192** can abut the front surface **184** of the piston **44**. The spring **190** can be sandwiched between the front and rear washers **188**, **192** and can bias the piston **44** into the rearward position. In one embodiment, the front washer **188**, the spring **190**, and the rear washer **192** can be formed of steel or other alloy. In such an embodiment, the interior front shoulder **194** and the front surface **184** of the piston **44** can be less susceptible to wear from the front and rear washers **188**, **192** than some conventional, non-steel, washer arrangements. In other embodiments, the front and rear washers **188**, **192** and/or spring **190** might be formed of any of a variety of suitable alternative materials.

[0071] The return spring assembly **186** can urge the piston **44** into the rearward position once the linear motor **40** has ceased operation. The bias provided by the spring **190** might not be significant enough to aid significantly in the reciprocation of the piston **44** during operation of the linear motor **40**. However, when the linear motor **40** ceases operation (e.g., when the operator releases the trigger handle **60**), the force provided by the spring **190** can be substantial enough to return the piston **44** to the rearward position. Accordingly, the piston **44** can be returned to the rearward position when the linear motor **40** ceases operation, which can allow for more efficient and effective startup of the linear motor **40** than if the piston **44** were permitted to remain in any position when pressurized air is removed. For example, if the linear motor **40** were started without the piston **44** in the rearward position, the pressurized air may not be routed properly through the linear motor **40** and the piston **44** might not receive enough pressurized air to move the piston **44** in either direction.

[0072] The return spring assembly **186** is shown in FIGS. **2** and **3** to be disposed entirely within the interior **166** of the outer housing **160**. In this arrangement, the return spring assembly **186** can be protected from certain environmental conditions external to the linear motor **40** such as moisture or dust particles, for example. In addition, the return spring assembly **186** can remain contained within the interior **166** during assembly of the linear motor **40** which can promote effective and efficient installation of the linear motor **40**.

[0073] Referring again to FIG. **4**, and additionally to FIG. **11**, the operation of the transmission assembly **64** in conjunction with the tool free attachment assembly **76** will now be described. As illustrated in FIG. **11**, the cam boss **66** and the cam **68** can be pivotally coupled together by a pin **198**. In one embodiment, the pin **198** can be press fit into the cam boss **66**. When the piston **44** reciprocates and the bearing **74** rides (e.g., slides) within the slot **72**, the cam **68** can pivot slightly with respect to the cam boss **66** about the pin **198**. Permitting the cam **68** to pivot in this manner during operation of the linear motor **40** can accommodate for any variation in the tolerances between the parts and/or other inconsistencies between the slot **72** and the bearing **74**. Pivoting of the cam **68** can also reduce the susceptibility of the bearing **74** becoming bound within the slot **72**.

[0074] The slot **72** is shown to be substantially u-shaped and defined by an inner surface **200** of the cam **68**. The slot **72** can be angled towards one side of the cam **68** such that a right end portion **202** of the cam **68** is wider than a left end portion **204**. When the piston **44** reciprocates and operates the transmission assembly **64**, the shape and orientation of the slot **72** can facilitate pivoting of the tool free attachment assembly **76** about the pivotal axis A**1**. For example, when the piston **44** moves forwardly, the bearing **74** can ride along the left end portion **204** of the cam **68**, such that the tool free attachment assembly **76** pivots counterclockwise (when viewing the oscillating tool **30** from above). When the piston **44** reaches its forward position, the bearing **74** can be cradled within a backstop portion **206** of the slot **72**. When the piston **44** moves rearwardly, the bearing **74** can ride long the right end portion **202** of the cam **68**, such that the tool free attachment assembly **76** pivots clockwise. The cam **68** can repeatedly and alternatively act upon the bearing **74** in this manner to facilitate oscillation of the tool free attachment assembly **76** about the pivotal axis A**1**.

[0075] As illustrated in FIG. **4**, the cam **68** can be supported by, and sandwiched between, a pair of linear bearing assemblies **208**. Each of the linear bearing assemblies **208** can be interposed between the cam **68** and respective right and left portions **210**, **212** of a head assembly **214**. Each of the bearing assemblies **208** can include a plurality of bearing balls **216**, a race **218**, and a slotted retainer **220**. The bearing balls **216** can ride within respective grooves (e.g., **222** shown in FIGS. **4** and **11**) of the cam **68** as well as within grooves (e.g., **224**) of the slotted retainer **220**. When the transmission assembly **64** is actuated by the linear motor **40**, the linear bearing assemblies **208** can facilitate journalled movement of the cam **68** with respect to the head assembly **214**. Although the bearing assemblies **208** are shown to include three bearing balls **216**, it will be appreciated that bearing assemblies with less than three bearing balls or greater than three bearing balls can be provided.

[0076] The oscillating tool **30** can include at least one resilient member provided adjacent to the transmission assembly **64** and configured to dampen forward movement of the piston **44** and/or portions of the transmission assembly **64**. In one embodiment, as illustrated in FIGS. **2-4**, the resilient member can comprise a pair of bumper members **226**, **228** that are disposed forwardly of the cam **68** and adjacent the right and left portions **202**, **204** of the cam **68**, respectively. The right and left portions **210**, **212** of the head assembly **214** can cooperate to define a head compartment **229** and the bumper members **226**, **228** can be disposed within the head compartment **229**. Each of the right and left portions **210**, **212** of the head assembly **214** can define a receptacle (e.g., **230** shown in FIGS. **2-4**) that is shaped similarly to the bumper members **226**, **228** and arranged to support the bumper members **226**, **228** forwardly of the cam **68**.

[0077] When the linear motor **40** operates, the right and left portions **202**, **204** of the cam **86** can selectively contact the respective bumper members **226**, **228** to prevent further forward motion of the piston **44**. For example, as the piston **44** approaches its extended position, the cam **68** can remain spaced from the pair of bumper members **226**, **228**, as illustrated in FIG. **2**. As the piston **44** approaches its forwardmost position, the cam **68** can contact the bumper members **226**, **228**. The bumper members **226**, **228** can absorb the impact of the cam **68** to assist in stopping the forward movement of the piston **44**. Once the piston **44** has stopped, the flapper **146** can change positions, as described above, and the pressurized air can cause the piston **44** to move rearwardly. It will be appreciated that although the transmission assembly **64** is shown to be disposed entirely within the head compartment **229**, a transmission assembly can be additionally or alternatively disposed in a motor compartment in a manner that still permits contact with bumper members.

[0078] The bumper members **226**, **228** can be formed of an elastic material that provides sufficient cushioning to slow the forward movement of the cam **68** as the piston **44** reaches its forward position and without contacting adjacent portions of the head assembly **214**. In one embodiment, the bumper members **226**, **228** can be formed of a fluoroelastomer having a durometer value of between about 65 and about 85.

[0079] It will be appreciated that slowing the forward movement of the piston **44** can enhance the overall operation of the linear motor **40**. For example, with portions of the transmission assembly **64** secured to the shaft **70** of the piston **44**, the mass of the linear motor **40** can be unevenly distributed towards the front of the linear motor **40**. As the piston **44** moves forwardly, the uneven distribution of mass can become more severe. By the time the piston **44** reaches its forward position, the imbalanced distribution of mass can become so significant that the inertia of the cam **68** might, were it not for the bumper members **226**, **228**, cause the piston **44** to impact the gasket **169** or the end wall **162** resulting in excessive and uncontrolled vibration to the oscillating tool **30** and/or damage.

[0080] It will be appreciated that any of a variety of resilient member configurations can be provided to facilitate dampening of movement of a piston and/or portions of a transmission assembly. In one example, a resilient member can comprise a spring that selectively interacts with a cam boss. In another example, the resilient member can be a hydraulic arrangement configured to interact with a portion of a piston shaft.

[0081] Referring again to FIG. **4**, and additionally to FIG. **12**, the operation of the tool free attachment assembly **76** will now be described. The tool free attachment assembly **76** can be at least partially disposed within the head compartment **229**. The tool free attachment assembly **76** can include an arm member **232** and a sleeve **234**. The arm member **232** can include a bearing support portion **236** that extends from a central portion **238**. The bearing support portion **236** can rotatably support the bearing **74**. The bearing **74** is shown to be releasably secured to the bearing support portion with a screw **240**, but, in other arrangements, a bearing can be coupled to an arm member with any of a variety of suitable alternative coupling arrangements. The sleeve **234** can include a first upper collar **242** and the central portion **238** of the arm member **232** can define an opening **244**. The central portion **238** of the arm member **232** can fit over the sleeve **234** and into frictional engagement with the first upper collar **242**. The opening **244** is shown to be substantially round. However, in an alternative embodiment, an opening of an arm member can define a flat portion (not shown) that can register with a corresponding flat portion (not shown) on a sleeve to ensure proper alignment and pivotal coupling of the arm member and the sleeve together. In an alternative embodiment, a sleeve and arm member can be coupled in an alternative configuration, or provided as a one-piece construction.

[0082] The tool free attachment assembly **76** can also include upper and lower bearings **248**, **250** that journal the sleeve **234** with respect to the head assembly **214**. The upper and lower bearings **248**, **250** can be respectively provided at opposite ends of the sleeve **234**. The upper and lower bearings **248**, **250** can be press fit or otherwise frictionally engaged with a second upper collar **252** and a lower collar **254**, respectively. The second upper collar **252** can have a smaller diameter than the first upper collar **242**, as shown in FIG. **12**.

[0083] The tool free attachment assembly **76** can further include a plunger **256**, a spring **258**, and a cap **260**. The plunger **256** can include an upper end **262** and a lower end **264** and can be partially disposed within the sleeve **234** with the upper and lower ends **262**, **264** extending beyond the sleeve **234**. The spring **258** can be disposed within the sleeve **234** and sandwiched between the sleeve **234** and the cap **260**. The cap **260** can be threaded onto the upper end **262** of the plunger **256** to retain the spring **258** in place. An accessory disk **268** (e.g., arbor) can be sandwiched between the sleeve **234** and a flange portion **270** at the lower end **264** of the plunger **256**. An internal circular retaining ring **273** can be sandwiched between the lower bearing **250** and the accessory disk **268** and can facilitate selective securement of the lower bearing **250** to the sleeve **234**. The accessory disk **268** can be configured to engage or release an accessory (e.g., the accessory blade **38** shown in FIGS. **1-4**) depending upon whether the plunger **256** is in a released position (e.g., clamping position) or a depressed position. It will be appreciated that the position of the cap **260** on the plunger **256** can be adjusted to change the preloading of the spring **258** and thus the clamping force of the tool free attachment assembly **76**.

[0084] The spring **258** can bias the plunger **256** upwardly (e.g., into a clamping position) which can facilitate selective retention of the accessory blade **38** between the accessory disk **268** and the flange portion **270** of the plunger **256**. For example, as illustrated in FIGS. **2** and **3**, the spring **258** can bias the plunger **256** upwardly which can result in the flange portion **270** being pulled upwardly with respect to the sleeve **234** and applying a clamping force to the accessory blade **38**. When the plunger **256** is depressed, the spring **258** can be compressed and the flange portion **270** can move away from the accessory disk **268** to release the clamping force and permit removal of the accessory blade **38** from the tool free attachment assembly **76**. The installation/removal of the accessory blade **38** can accordingly be accomplished without requiring the removal of components as is typical in some conventional tool arrangements (e.g., detachment of an accessory disk by removing a screw).

[0085] As illustrated in FIGS. **1-4**, the oscillating tool **30** can further include an accessory release handle **272** that overlies the plunger **256** and is pivotally coupled with the head assembly **214**. The accessory release handle **272** can be depressed by a user to depress the plunger **256** for removal or installation of an accessory blade. The accessory release handle **272** can provide a mechanical advantage for actuating the plunger **256** and can also cooperate with adjacent portions of the head assembly **214** to substantially conceal the plunger **256** and provide an aesthetically pleasing look to the oscillating tool **30**. It will be appreciated that a plunger can additionally or alternatively be actuated directly by a hand of a user, or through a user's operation of a pushbutton, a servo, or any of a variety of other suitable alternative devices.

[0086] As illustrated in FIGS. **12-14**, the accessory disk **268** is shown to include an upper surface **274** and a lower surface **276**. The accessory disk **268** is shown to include an inner edge **280** that includes a flat portion **282** and defines a central aperture **278**. When the accessory disk **268** is attached to the plunger **256**, the flat portion **282** can register with a flat portion (not shown) on the sleeve **234** to prevent rotation of the accessory disk **268** relative to the sleeve **234**. A plurality of ovular protrusions (e.g., **284**) can extend from the lower surface **276** (or can otherwise be defined by the lower surface **276**) and can be disposed circumferentially about the inner edge **280**. The ovular protrusions (e.g., **284**) can be spaced substantially evenly from one another and can, in one embodiment, be spaced substantially evenly between the inner edge **280** and an outer edge **286**.

[0087] The accessory blade **38** is further illustrated in FIGS. **15** and **16** and can be configured for use with the accessory disk **268**. The accessory blade **38** can extend between a shank end **288** and a working end **290**. In one embodiment, the working end **290** can comprise a saw tooth edge, but in other embodiments, the working end **290** can be configured to accomplish any of a variety of tasks such as cutting, polishing, grinding, or the like. The shank end **288** can be selectively clamped between the flange portion **270** of the plunger **256** and the accessory disk **268** to secure the accessory blade **38** to the tool free attachment assembly **76**. More particularly, the shank end **288** of the accessory blade **38** can define a main opening **292** having a pair of angled edges **294** that respectively terminate at a generally U-shaped edge **296**. The angled edges **294** can define a generally V-shaped entryway **298** of the main opening **292** and the generally U-shaped edge **296** can define a generally U-shaped backstop **300** of the main opening **292**. The configuration of the angled edges **294** can narrow the main opening **292** into the generally U-shaped backstop **300**. When the shank end **288** of the accessory blade **38** is installed between the flange portion **270** of the plunger **256** and the accessory disk **268**, the generally V-shaped entryway **298** can accommodate for some initial misalignment between the plunger **268** and the generally U-shaped backstop **300**, and the angled edges **294** can facilitate guidance of the plunger **268** into a fully installed position (e.g., with the plunger **268** received in the generally U-shaped backstop **300**), thereby easing the installation process.

[0088] Still referring to FIGS. **15-16**, the shank end **288** can define a first slot **302**, a second slot **304**, a third slot **306** and a plurality of apertures **308**. The first, second, and third slots **302**, **304**, **306** can be in communication with the main opening **292**. A longitudinal centerline C**2** (FIG. **16**) can extend longitudinally between the shank end **288** and the working end **290**. A lateral centerline C**3** (FIG. **16**) can be substantially perpendicular to the longitudinal centerline C**2** and can extend laterally across the generally U-shaped backstop **300**. The first, second, and third slots **302**, **304**, **306** can be distributed about a circumference of the main opening **292** such that they are provided in a substantially T-shaped arrangement. The first slot **302** can be bisected by the longitudinal centerline C**2** and the second and third slots **304**, **306** can be bisected by the lateral centerline C**3**. Two of the apertures **308** can be distributed between the first slot **302** and the second slot **304**, two of the apertures **308** can be distributed between the first slot **302** and the third slot **306**, one of the apertures **308** can be disposed between one of the angled edges **294** and the second slot **304**, and one of the apertures **308** can be disposed between the other of the angled edges **294** and the third slot **306**. The shank end **288** is shown to have three slots (i.e., **302**, **304**, **306**) and six apertures (i.e., **308**), but it will be appreciated that a shank end of an accessory blade can have more or less than three slots and/or more or less than six apertures. It will also be appreciated that the configuration of the accessory blade **38** allows it to be used on any of a variety of oscillating tools including those oscillating tools that are identified as being only suitable for use with a particular manufacturer's blades.

[0089] When the shank end **288** is clamped between the flange portion **270** of the plunger **256** and the accessory disk **268**, respective ones of the ovular protrusions **284** can extend through the first, second, and third slots **302**, **304**, **306** and the apertures **308** to secure the shank end **288** and prevent the accessory blade **38** from inadvertently rotating during operation of the linear motor **40**. With the first, second, and third slots **302**, **304**, **306** and the apertures **308** being distributed substantially evenly around the main opening **292**, it will be appreciated that the accessory blade **38** can be clamped into any of a plurality of available radial positions upon the accessory disk **268**, which it will be appreciated can result in the accessory blade being indexed to predetermined angles to achieve cutting or other tool use at different angles, while keeping a user's hand(s) ergonomically positioned.

[0090] As illustrated in FIGS. **13** and **14**, each of the ovular protrusions **284** can be substantially frustoconically shaped. In particular, each of the ovular protrusions **284** can include a respective tapered sidewall **310**. Each of the tapered sidewalls **310** can extend from a respective end surface **312** to the lower surface **276** of the accessory disk **268**. The interaction between the tapered sidewalls **310** and the lower surface **276** can define respective lower perimeters **314** for the ovular protrusions **284**. The tapered sidewalls **310** can be angled such that each respective end surface **312** defines an upper perimeter that is substantially the same shape as the respective lower perimeter **314** but is smaller than the respective lower perimeter **314**.

[0091] Referring again to FIGS. **15** and **16**, the apertures **308** of the accessory blade **38** can have respective perimeters that are of similar shape, but of greater size than the lower perimeters **314** of the ovular protrusions **284**, but of less size than the upper perimeters of the ovular protrusions **284**. As such, when the accessory disk **268** is clamped between the flange portion **270** of the plunger **256** and the accessory disk **268**, the accessory blade **38** can be seated onto the tapered sidewalls **310** of the ovular protrusions **284** and can remain spaced from the lower surface **276** such that the accessory disk **268** is held securely in place. The clamping force necessary to hold the accessory blade **38** in place might be significantly less than the clamping force necessary for securing an accessory blade with a conventional arbor. As such, the spring **258** of the tool free attachment assembly **76** might not need to impart as much force to the accessory disk **268** and thus be formed using lightweight materials.

[0092] FIG. **17** illustrates an accessory blade **1038** according to another embodiment. The accessory blade **1038** can be, in many respects, similar to or the same as the accessory blade **38** shown in FIGS. **14-16**. For example, a shank end **1288** of the accessory blade **1038** can define a main opening **1292** having a generally V-shaped entryway **1298** and a generally U-shaped backstop **1300**. However, the shank end **1288** can define a plurality of apertures (e.g., **1308**) and can be devoid of any slots (i.e., **302**, **304**, **306**). The plurality of apertures (e.g., **1308**) can be distributed substantially evenly about a circumference of the main opening **1292**.

[0093] It will be appreciated that the overall configuration of the accessory disk **268**, and more particularly, the pattern of the ovular protrusions **284**, can in one embodiment, be only capable of mating with one or more specific patterns as provided by the accessory blades **38**, **1038**, thus preventing installation and use of other accessory blades (e.g., blades from other tool manufacturers) with the hand-held pneumatic oscillating tool. However, it will be appreciated that other accessory disk arrangements are contemplated that would permit acceptance and installation of different oscillating tool blades from a variety of oscillating tool manufacturers including those oscillating tool blades that are identified as being only suitable for use with a particular manufacturer's oscillating tool design.

[0094] FIG. **18** illustrates a tool free attachment assembly **2076** according to another embodiment. The tool free attachment assembly **2076** can be similar to, or the same in many respects as, the tool free attachment assembly **76** shown in FIGS. **1-4** and **12-13**. For example, the tool free attachment assembly **2076** can include a sleeve **2234**, an arm **2236** (e.g., bearing support portion), an upper bearing **2248**, a lower bearing **2250**, a plunger **2256**, a spring **2258**, and a cap **2260**. However, the tool free attachment assembly **2076** can include a spindle **2251**, balls **2255** and an accessory disk **2269**. The sleeve **2234** can be formed together with the arm **2236** as a one-piece construction such that the arm **2236** is disposed at an upper end of the sleeve **2234**. Alternatively, the sleeve **2234** can be coupled with the arm **2236** in a variety of different arrangements. The spindle **2251** can be disposed within the sleeve **2234** and can support the spring **2258**. The balls **2255** can be interposed between the spindle **2251** and the sleeve **2234** and can be disposed at least partially within a plurality of holes **2259** defined by the spindle **2251**. The holes **2259** can be spaced circumferentially about an upper portion of the spindle **2251** and can cooperate to define a groove (e.g., **2257**). The balls **2255** can be associated with respective ones of the holes **2259**. The spring **2258** can provide underlying support for the plunger **2256** and an upper end of the plunger **2256** can extend through the cap **2260** such that a portion of the plunger **2256** is sandwiched between the spring **2258** and the cap **2260**. The accessory disk **2269** can be coupled to the spindle **2251** with a screw **2261**. An accessory (not shown), such as an accessory blade or sanding disc for example, can be selectively and removably interposed between the sleeve **2234** and the accessory disk **2269**.

[0095] The plunger **2256** can have a frustoconical portion that defines an outer angled surface **2263**. The sleeve **2234** can define an inner angled surface **2265** (FIG. **19**). The balls **2255** can be interposed between the outer angled surface **2263** and the inner angled surface **2265**. The spring **2258** can bias the plunger **2256** upwardly, such that the outer angled surface **2263** of the plunger **2256** forces the balls **2255** outwardly and against the inner angled surface **2265**. The spindle **2251** can accordingly be biased upwardly which can facilitate selective retention of an accessory (not shown) between the sleeve **2234** and the accessory disk **2269**. In one embodiment, the groove **2257**, the spindle **2251** and the sleeve **2234** can cooperate to permit the balls **2255** to only move perpendicularly to (as opposed to along) a pivotal axis A2 of the sleeve **2234**.

[0096] A bearing **2274** can be coupled with the arm **2236** by a screw **2240**. The upper bearing **2248** and the lower bearing **2250** can be supported by the cap **2260** and a lower portion of the sleeve **2234**, respectively. The spindle **2251** can include a stem portion **2267** that can extend into the sleeve **2234** and can define a threaded aperture (not shown). The screw **2261** can be threaded into the threaded aperture of the stem portion **2267** to facilitate releasable coupling of the accessory disk **2269** to the spindle **2251**.

[0097] The plunger **2256** can be selectively depressed by a user of the tool to release the accessory from between the sleeve **2234** and the accessory disk **2269**. Depressing the plunger **2256** can compress the spring **2258**, which can allow the balls **2255** to move towards each other (e.g., recede into the spindle **2251**), and the spindle **2251** to lower to release an accessory from between the sleeve **2234** and the accessory disk **2269**. It will be appreciated that the plunger **2256** can be actuated directly by a hand of a user, or through a user's operation of a lever, a pushbutton, a servo, or any of a variety of other suitable alternative devices. It will be appreciated that any of a variety of alternative tool free attachment assemblies can be provided that facilitate selective retention of an accessory. Other accessory attachment mechanisms are contemplated such as those that might require use of a separate tool (e.g., an allen wrench) to facilitate selective retention of an accessory.

[0098] Additional details of the actuation of the plunger **2256** can be appreciated from FIGS. **19-21**. When the plunger **2256** is in a released (e.g., clamping) position, as illustrated in FIG. **19**, the spring **2258** can bias the plunger **2256** upwardly which pushes the balls **2255** outwardly against the respective angled surfaces **2263**, **2265**. The spindle **2251** can accordingly be pulled upwardly with respect to the sleeve **2234**, which can apply a clamping force between the sleeve **2234** and the accessory disk **2269**. Depressing the plunger **2256**, as illustrated in FIG. **20**, results in the plunger **2256** beginning to move into the spindle **2251** and compression of the spring **2258**, such that the balls **2255** begin to retract into the holes **2259**, and the accessory disk **2269** begins to separate from the sleeve **2234**. As the plunger **2256** continues to be depressed, the plunger **2256** can move further into the spindle **2251**, the balls **2255** can retract further into the holes **2259**, and the accessory disk **2269** can become further spaced from the sleeve **2234**. Once the plunger **2256** is fully depressed, as illustrated in FIG. **21**, the accessory disk **2269** is spaced from the sleeve **2234** sufficiently enough to allow an accessory blade (e.g., **38** shown in FIGS. **1-4** and **15-16**) to be removed or installed. Spacing the accessory disk **2269** from the sleeve **2234** in this manner can avoid the need to completely detach an accessory disk, such as by removing a screw threaded into a spindle, to remove/install an accessory blade as is typical in some conventional tool arrangements.

[0099] The accessory disk **2269** is shown in FIGS. **22-27**. The accessory disk **2269** can include an upper surface **2274** and a lower surface **2276**. The accessory disk **2269** can also include a central ring **2280** that defines a central aperture **2278**. A pair of fingers **2271** can extend upwardly from the central ring **2280**. When the accessory disk **2269** is attached to the spindle **2251** (e.g., with the screw **2261**), the fingers **2271** can interact with the spindle **2251** to prevent rotation of the accessory disk **2269** relative to the spindle **2251**. A plurality of ovular protrusions (e.g., **2284**) can extend upwardly from the upper surface **2274** (or can otherwise be defined by the upper surface **2274**) and can be disposed circumferentially about the central ring **2280**, as shown in FIG. **22**, for example. The ovular protrusions **2284** can be spaced substantially evenly from one another and can, in one embodiment, be located more proximate an outer edge **2286** than the central ring **2280**. The lower surface **2276** is shown in FIG. **23** to be substantially planar. It will be appreciated that an accessory disk can be provided in any of a variety of suitable alternative configurations.

[0100] The accessory blade **38** is shown in FIGS. **28-30** to be engaged with the accessory disk **2269**. When the shank end **288** is clamped between the sleeve **2234** and the accessory disk **2269**, respective ones of the ovular protrusions **2284** can extend through the first, second, and third slots **302**, **304**, **306** and the apertures **308** to secure the shank end **288** and prevent the accessory blade **38** from inadvertently rotating during operation of the linear motor **40**. With the first, second, and third slots **302**, **304**, **306** and the apertures **308** being distributed substantially evenly around the main opening **292**, it will be appreciated that the accessory blade **38** can be clamped into any of a plurality of available radial positions upon the accessory disk **2269**, which it will be appreciated can result in the accessory blade being indexed to predetermined angles to achieve cutting or other tool use at different angles, while keeping a user's hand(s) ergonomically positioned.

[0101] It will be appreciated that the overall configuration of the accessory disk **268**, and more particularly, the pattern of the ovular protrusions **2284**, might only be capable of mating with the accessory blades **38**, **1038** thus preventing installation and use of other accessory blades (e.g., blades from other tool manufacturers) with the hand-held pneumatic oscillating tool. However, it will be appreciated that other accessory disk arrangements are contemplated that would permit acceptance and installation of different oscillating tool blades from a variety of oscillating tool manufacturers including those oscillating tool blades that are identified as being only suitable for use with a particular manufacturer's oscillating tool design.

[0102] Referring now to FIGS. **2-3** and **31**, the head assembly **214** can be rotatably coupled with the housing **31** and the linear motor **40**. As illustrated in FIG. **31**, the right and left portions **210**, **212** of the head assembly **214** can be secured together (e.g., with bolts **316** shown in FIG. **4**) and can cooperate to define a rear sleeve portion **318**. As illustrated in FIGS. **2** and **5**, the front collar **196** of the linear motor **40** can extend into the rear sleeve portion **318** such that the rear sleeve portion **318** is circumferentially disposed about the front collar **196**. A grommet **320** can be sandwiched between the front collar **196** and the rear sleeve portion **318**. The front collar **196** can define a groove **322** and the rear sleeve portion **318** can define an annular rib **324**. The groove **322** can be machined or otherwise provided onto the outer housing **160**. The rear sleeve portion **318** can also define a radial lip portion **326** that extends into or over a portion of the grommet **320**. The groove **322**, the annular rib **324**, and the radial lip portion **326** can interact with the grommet **320** to facilitate rotatable coupling of the head assembly **214** to the linear motor **40** while preventing the rear sleeve portion **318** and the front collar **196** from being pulled apart. It will be appreciated that a rotating head can be coupled to a motor housing in any of a variety of other suitable embodiments.

[0103] When the head assembly **214** is rotated, the piston **44** can be configured to maintain engagement with the transmission assembly **64** and can rotate with respect to the piston housing **86**. In one embodiment, as illustrated in FIGS. **2-3**, a sleeve bearing **328** can be interposed between the shaft **70** of the piston **44** and the front collar **196**. The sleeve bearing **328** can journal the shaft **70** of the piston **44** with respect to the front collar **196** such that the shaft **70** is permitted to rotate and reciprocate. The head assembly **214** is free to rotate with respect to the linear motor **40** among an infinite amount of different positions and without requiring removal of the head assembly **214** as is common in some conventional arrangements. As such, a user can selectively rotate the head assembly **214** to achieve a precise position.

[0104] The head assembly **214** can be configured for selective locking among different rotational positions. Referring again to FIG. **31**, a plurality of indexing tabs **330** can be arranged circumferentially about the head assembly **214**. Each pair of the indexing tabs **330** can define a slot **332** therebetween. As illustrated in FIGS. **1-4** and **32**, the housing **31** can include a locking button **334** having a lower tab portion **336** that is configured for selective interaction with each of the slots **332** to facilitate locking of the head assembly **214** in different positions. When the locking button **334** is in a released position, as illustrated in FIG. **1**, the lower tab portion **336** can extend into any of the slots **332** to rotatably lock the head assembly **214** in position. When the locking button **334** is slid rearwardly, the lower tab portion **336** can be retracted from entering any of the slots **332** to permit the head assembly **214** to rotate. The slots **332** are shown to be arranged such that the angular position of the head assembly **214** can be locked at about 45 degree intervals. It will be appreciated that if the locking button **334** is released when the lower tab portion **336** is not aligned with any of the slots **332**, the head assembly **214** is still permitted to rotate between the nearest slots **332**. However, once the lower tab portion **336** aligns with one of the slots **332**, the lower tab portion **336** can automatically project into the slot **332** to lock the head assembly **214** in position. In one embodiment, the oscillating tool **30** can be configured with a cutoff switch (not shown) that enables operation of the linear motor **40** only when the head assembly **214** is locked in place (e.g., the lower tab portion **336** extends into one of the slots **332**). In another embodiment, the oscillating tool **30** is free to operate irrespective of the locking of the head assembly **214**. In such an embodiment, the position of the head assembly **214** can be provided at an infinite amount of different angles to allow the head assembly **214** to achieve cutting or other tool use at different angles, while keeping a user's hand(s) ergonomically positioned. In one embodiment, the head assembly **214** can include a stop arrangement that prevents continuous rotation of the head assembly **214** (e.g., beyond about 360 degrees). It will be appreciated that in other embodiments, a head assembly can be fixed with respect to a linear motor and/or a housing. For example, a head assembly and a housing can be formed together in a one-piece construction such that the head compartment and motor compartment are defined by the one-piece construction.

[0105] Referring again to FIG. **32**, the locking button **334** can be supported along a cuff portion **338** of the housing **31**. As illustrated in FIGS. **2** and **3**, when the housing **31** is installed over the linear motor **40**, the cuff portion **338** can overlie and conceal the indexing tabs **330**. A decorative ring **340** can be sandwiched between the cuff portion **338** and the head assembly **214**. In one embodiment, the decorative ring **340** can be formed of nylon and can be arranged to reduce vibration.

[0106] The cuff portion **338** can define a plurality of exhaust ports **342** that are in fluid communication with the exhaust ports **152**, **165** of the piston housing **86** and the outer housing **160**, respectively. The plurality of exhaust ports **342** can be located along a lower portion of the housing **31** (e.g., underneath the oscillating tool **30**). When the pressurized air is exhausted from the exhaust ports **152**, **165** of the piston housing **86** and the outer housing **160** respectively, the pressurized air can be routed between the housing **31** and the head assembly **214** (e.g., through the motor compartment **41**) and through the exhaust ports **342** of the housing **31**. In one embodiment, an air filter can be provided upstream of the exhaust ports **342** (e.g. attached directly to the cuff portion **338**) to filter the exhaust air provided through the exhaust ports **342**. The exhaust ports **342** can direct the pressurized air from the exhaust ports **152**, **165** towards the accessory blade **38**. The exhaust air can accordingly remove debris (e.g., sawdust) from around the accessory blade **38** which can enhance the ability of an operator to view the operation of the accessory blade **38** thereby enhancing precision and efficiency. The exhaust ports **342** can be located forwardly of the trigger assembly **46** (e.g., interposed between the trigger handle **60** and the plunger **256**) to prevent a user's hand from interrupting the flow of the pressurized air to the accessory blade **38**. In one embodiment, the exhaust ports **342** can be angled such that they are substantially parallel to the pivotal axis A**1**, but in other embodiments, the exhaust ports **342** can be angled towards the accessory blade **38**. It will be appreciated that, in some embodiments, the pressurized air routed from the linear motor **40** to the exhaust ports **342** can facilitate cooling of the transmission assembly **64** and or the tool free attachment assembly **76**.

[0107] Referring now to FIGS. **2-4** and **33-34**, the oscillating tool **30** can include a flow control collar **344** that is rotatably coupled with the air inlet **36** and is rotatable with respect to the air inlet **36** to vary the operating speed of the linear motor **40**. The control collar **344** can define a central passageway **346** that is bordered by an inner shoulder **348**. The control collar **344** can include an outer shoulder **350** that is disposed radially outwardly from, and is raised with respect to, the inner shoulder **348**. The flow control collar **344** can also include an outer cuff **352**. As illustrated in FIGS. **2** and **3**, the outer shoulder **350** of the flow control collar **344** can engage the rear backing plate **42** and the outer cuff **352** can engage the housing **31**. A sealing member **354** (e.g., O-ring) can be sandwiched between the outer shoulder **350** and the rear backing plate **42** to provide a sealed interface. A sealing member **355** can also be sandwiched between the stem portion **37** of the air inlet **36** and the flow control collar **344**. The flow control collar **344** can cooperate with the air inlet **36** and the rear backing plate **42** to define an air chamber **356**.

[0108] The stem portion **37** of the air inlet **36** can extend through the central passageway **346** such that the inner shoulder **348** is radially disposed about the stem portion **37** and such that the air inlet **36** at least partially rotatably supports the flow control collar **344**. The stem portion **37** can be secured to the rear backing plate **42**, as described above, and the base portion **35** can abut the rearmost portion of the flow control collar **344** to restrain lateral movement of the flow control collar **344** relative to the rear backing plate **42** and the housing **31** (i.e., preventing the flow control collar **344** from being removed from the rear backing plate **42** and the housing **31**).

[0109] Referring now to FIGS. **33-36**, the air inlet **36** can define an inlet passageway **357** that is in fluid communication with a first port **358**, a second port **360**, and a third port **362**. Each of the first, second, and third ports **358**, **360**, **362** can extend radially outwardly from the inlet passageway **357**. The air inlet **36** can also define an output passageway **364** that is substantially L-shaped. The output passageway **364** can be spaced entirely from the first, second, and third ports **358**, **360**, **362** such that the output passageway **364** does not fluidly communicate through the air inlet **36** with any of the first, second, and third ports **358**, **360**, **362**.

[0110] As will be appreciated with reference to FIG. **33**, the first, second, and third ports **358**, **360**, **362** of the air inlet **36** can be disposed below the inner shoulder **348** of the flow control collar **344** and the output passageway **364** can be disposed above the inner shoulder **348**. As illustrated in FIG. **33**, the inner shoulder **348** can define a notch **366**. The flow control collar **344** can be rotated to align the notch **366** with different ones of the first, second, and third ports **358**, **360**, **362**. When the notch **366** is aligned with a port, that port is in fluid communication with the air chamber **356** such that air can flow through the aligned port, into the air chamber **356** and through the output passageway **364** to power the linear motor **40**. The ports which are not aligned with the notch **366** can be blocked by the inner shoulder **348** to prevent fluid communication between those ports and the output passageway **364**.

[0111] As illustrated in FIGS. **33-36**, each of the first, second, and third ports **358**, **360**, **362** can have different diameters such that each of the first, second, and third ports **358**, **360**, **362** can provide pressurized air to the output passageway **364** at different fluid pressures. The operating speed of the linear motor **40** can vary in response to the different fluid pressures from the first, second, and third ports **358**, **360**, **362**. For example, when the first port **358** is aligned with the notch **366**, the air pressure provided to the linear motor **40** can be greater than the air pressure provided by either of the second or third ports **360**, **362** such that the linear motor **40** operates at a maximum speed. When the second port **360** is aligned with the notch **366**, the air pressure provided to the linear motor **40** can be less than the air pressure from the first port **258** but greater than the air pressure from the third port **262** such that the linear motor **40** operates at a moderate speed.

When the third port **362** is aligned with the notch **366**, the air pressure provided to the linear motor **40** can be less than the air pressures from either the first and second ports **258**, **260** such that the linear motor operates at a minimum speed.

[0112] As illustrated in FIGS. **2-4**, a detent arrangement **368** can be housed in a recess **370** defined by the base portion **35** of the air inlet **36**. The detent arrangement **368** can include a detent **372** and a spring **374** that biases the detent **372** into contact with the flow control collar **344**. As illustrated in FIG. **38**, the flow control collar **344** can define a plurality of indexing recesses **376**. When the flow control collar **344** is rotated, the detent **372** can selectively and alternatively engage the indexing recesses **376** to maintain the flow control collar **344** in one of four different positions. Three of the different positions can align a different one of the first, second, and third ports **358**, **360**, **362** with the notch **366** such that the linear motor **40** is selectively operable at three different speeds (e.g., a maximum speed, a moderate speed, and a minimum speed, respectively). In one embodiment, the fourth position can correspond to each of the first, second, and third ports **358**, **360**, **362** being blocked by the upper shoulder **348** such that linear motor **40** does not operate. In other embodiments, an air inlet can be provided with only two ports or more than three ports. It will be appreciated that, in other embodiments, the inlet valve might be provided with only two ports or might more than three ports and the flow control valve can be configured accordingly to provide varying degrees of speed variation of the linear motor **40**.

[0113] FIGS. **39-42** illustrate an alternative embodiment of a linear motor **3040** in conjunction with a rotary transmission **3378**. The linear motor **3040** can be, in many respects, similar to, or the same as, the linear motor **40** shown in FIGS. **1-6**. However, as illustrated in FIG. **39**, a shaft **3070** of a piston of the linear motor **3040** can include a pair of gear racks **3080** (e.g., geared surfaces), each disposed on opposite sides of the shaft **3070**. The gear racks (e.g., **3380**) can be machined or otherwise provided on the shaft **3070** in any of a variety of suitable alternative arrangements. For example, the gear racks **3080** can be welded, brazed, or formed as a one-piece construction (e.g., pressed onto the shaft **3070**). The rotary transmission **3378** can include a pair of pinion gears **3382**, a pair of lower gears **3384**, a pair of one-way bearings **3386**, a spiral bevel gear **3388**, a spiral pinion gear **3390**, and a central gear **3392**. The pinion gears **3382** can be operably coupled with the pair of lower gears **3384** by the one-way bearings **3386**. The lower gears **3384** can each be intermeshed with the central gear **3392**. The central gear **3392** can be coupled with the spiral bevel gear **3388** which is intermeshed with a spiral pinion gear **3390**.

[0114] The shaft **3070** can be sandwiched between the pair of pinion gears **3382**. The gear racks **3080** can be intermeshed with the pinion gears **3382** such that reciprocation of the shaft **3070** can rotate the pinion gears **3382** simultaneously and in opposite directions. The counter-clockwise rotating pinion gear **3382** can drive its associated lower gear **3384** in a counter-clockwise direction to rotate the central gear **3392** in a clockwise direction. The clockwise rotating pinion gear **3382** can rotate freely with respect to its associated lower gear **3384** due to its associated one-way bearing **3386**. As the shaft **3070** reciprocates, one of the pinion gears **3382** can be rotated counter-clockwise, which can facilitate continuous rotation of the central gear **3392** in a clockwise direction about a rotational axis R**1** (FIG. **40**) in response to the reciprocation of the shaft **3070**. This rotation of the central gear **3392** can rotate the spiral pinion gear **3390** in a counter-clockwise direction. An output shaft (not shown) can be coupled with the spiral pinion gear **3390** and an accessory, such as a cutting disc or a drill bit, can be coupled with the output shaft. When the hand-held rotary pneumatic tool is operated, the accessory can be rotated by the output shaft. It will be appreciated that, in other embodiments, the drive direction of any or all of these various components can be reversed.

[0115] As in the embodiment of FIGS. **39-42**, the accessory can accordingly rotate about an axis that is coaxial with, or substantially parallel to, the reciprocation axis of the shaft **3070** (e.g., the axis R**2** illustrated in FIG. **40**). In one embodiment, the output shaft can include a tool free attachment assembly to facilitate coupling of an accessory (e.g., a drill bit or cutting wheel) to the hand-held pneumatic rotary tool, but in other embodiments, an accessory can be selectively coupled with the output shaft in any of a variety of other suitable arrangements.

[0116] In an alternative embodiment, the rotary tool can be arranged as a right-angle type hand tool. In such an embodiment, an output shaft can be coupled with a central gear (e.g., **3392**) such that the output shaft can rotate about an axis that is substantially perpendicular to the reciprocation axis of the piston (e.g., the axis R**1** illustrated in FIG. **40**). A spiral bevel gear (e.g., **3388**) and spiral pinion gear (e.g., **3390**) can accordingly be omitted from the right-angle design, which can reduce the overall size, weight, complexity and cost of the rotating head.

[0117] Through use of a linear motor and conversion of oscillating motion into rotary motion such as shown and described with reference to FIGS. **39-42**, a smaller quantity of compressed air can be required for a hand-held pneumatic rotary tool to accomplish a particular task, as compared with conventional hand-held pneumatic rotary tools that incorporate a rotary vane-type motor. Reducing the required quantity of compressed air can allow use of a smaller and less powerful air compressor, and can provide energy and cost savings.

[0118] It will be appreciated that some of the features described above, such as the tool free attachment assembly **76**, the head assembly **214**, and the accessory disk **258**, for example, can be provided on electric motor-type oscillating tools as well as other types of pneumatic-type oscillating tools, and that others of the features above, such as the arrangement of the exhaust ports **342**, can be employed on other types of pneumatic hand-tools.

[0119] The foregoing description of embodiments and examples has been presented for purposes of illustration and description. It is not intended to be exhaustive or limiting to the forms described. Numerous modifications are possible in light of the above teachings. Some of those modifications have been discussed, and others will be understood by those skilled in the art. The embodiments were chosen and described in order to best illustrate principles of various embodiments as are suited to particular uses contemplated. The scope is, of course, not limited to the examples set forth herein, but can be employed in any number of applications and equivalent devices by those of ordinary skill in the art.

1. A hand-held tool comprising:

a housing defining a motor compartment;

a head assembly defining a head compartment;

an air inlet supported by the housing;

a pneumatic linear motor disposed at least partially within the motor compartment and comprising a piston, the piston comprising a shaft, wherein the piston is configured for reciprocation between a forward position and a rearward position;

a transmission assembly coupled to the shaft and disposed at least partially within at least one of the motor compartment and the head compartment;

at least one resilient member disposed at least partially within the head compartment adjacent the transmission assembly and configured for selective contact with one of the transmission assembly and the shaft when the piston is in one of its forward position and rearward position to facilitate dampening of the piston.

2. The hand-held tool of claim **1** wherein said at least one resilient member is disposed forwardly of the transmission assembly and is configured for selective contact with the transmission assembly.

3. The hand-held tool of claim **2** wherein said at least one resilient member is configured for selective contact with the transmission assembly when the piston is in the forward position.

4. The hand-held tool of claim **1** wherein said at least one resilient member comprises a pair of bumper members.

5. The hand-held tool of claim **4** wherein the pair of bumper members are formed of a fluoroelastomer having a durometer value of between about 65 and about 85.

6. The hand-held tool of claim **1** wherein the transmission assembly comprises a cam that defines a slot.

7. The hand-held tool of claim **6** wherein said at least one resilient member is disposed forwardly of the cam and configured for selective contact with the cam when the piston is in a forward position.

8. The hand-held tool of claim **7** wherein said at least one resilient member comprises a pair of bumper members.

9. The hand-held tool of claim **8** wherein the pair of bumper members are formed of a fluoroelastomer having a durometer value of between about 65 and about 85.

10. A hand-held tool comprising:

a housing defining a motor compartment;

a head assembly rotatably coupled with the housing and defining a head compartment;

a linear motor disposed at least partially within the motor compartment and comprising a piston, the piston comprising a shaft and being configured for reciprocation;

a transmission assembly coupled to the shaft and disposed at least partially in at least one of the motor compartment and the head compartment;

wherein each of the transmission assembly, the piston and the head assembly are rotatable together.

11. The hand-held tool of claim **10** wherein the linear motor comprises a pneumatic linear motor.

12. The hand-held tool of claim **11** wherein the head assembly is further configured for selective locking among different rotational positions relative to the housing.

13. The hand held tool of claim **12** further comprising:

a plurality of indexing tabs arranged circumferentially about the head assembly, wherein pairs of the indexing tabs cooperate to define respective slots therebetween; and

a locking button having a lower tab portion configured for selective interaction with each of the slots to facilitate locking of the head assembly in different angular positions.

14. The hand-held tool of claim **13** wherein the slots are arranged such that the angular position of the head assembly can be locked at about every 45 degrees.

15. The hand-held tool of claim **10** wherein the head assembly is further rotatably coupled to the pneumatic linear motor.

16. The hand-held tool of claim **10** wherein the pneumatic linear motor further comprises an outer housing and each of the transmission assembly, the piston and the head assembly are rotatable together with respect to the outer housing.

17. A hand-held tool comprising:

a housing defining a motor compartment;

a head assembly defining a head compartment;

an air inlet supported by the housing;

a pneumatic linear motor disposed at least partially within the air motor compartment and comprising a piston, the piston comprising a shaft, wherein the piston is configured for reciprocation along a longitudinal axis;

a transmission assembly disposed at least partially in at least one of the motor compartment and the head compartment, the transmission assembly comprising a cam that defines a slot, wherein a centerline bisects the slot and the slot is angled with respect to the longitudinal axis such that the centerline and the longitudinal axis form an acute angle.

18. The hand-held tool of claim **17** wherein the centerline is angled from the longitudinal axis by an angle greater than about 30 degrees.

19. The hand-held tool of claim **17** wherein the cam is pivotally coupled with the shaft.

20. The hand-held tool of claim **17** further comprising an accessory attachment mechanism that comprises a bearing that is disposed within the slot and interacts with the slot to facilitate pivoting of the accessory attachment mechanism about a pivotal axis.

21. A hand-held tool comprising:

a housing defining a motor compartment;

an air inlet supported by the housing;

a pneumatic linear motor disposed at least partially within the air motor compartment and comprising a piston, the piston comprising a shaft, wherein the piston is configured for reciprocation along a longitudinal axis; and

a transmission assembly disposed at least partially in one of the motor compartment and the head compartment, the transmission assembly comprising:

a boss coupled to the shaft of the piston; and

a cam pivotally coupled with the boss and configured to interact with a support a bearing of an accessory attachment mechanism to facilitate pivoting of the accessory attachment mechanism about a pivotal axis.

22. The hand-held tool of claim **21** wherein the cam that defines a slot, a centerline bisects the slot, and the slot is angled with respect to the longitudinal axis such that the centerline and the longitudinal axis form an acute angle.

23. The hand-held tool of claim **22** wherein the centerline is angled from the longitudinal axis by an angle greater than about 30 degrees.

24. The hand-held tool of claim **21** further comprising at least one resilient member disposed forwardly of the cam and configured for selective contact with the cam when the piston is in a forward position to facilitate dampening of the piston.

25. The hand-held tool of claim **24** wherein said at least one resilient member comprises a pair of bumper members formed of a fluoroelastomer having a durometer value of between about 65 and about 85.

26-52. (canceled)

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