(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 April 2009 (09.04.2009)

PCT

(10) International Publication Number
WO 2009/046390 A1

(51) International Patent Classification:
F16K 31/12 (2006.01) *F16K 31/36* (2006.01)

(21) International Application Number:
PCT/US2008/078868

(22) International Filing Date: 3 October 2008 (03.10.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/977,374 3 October 2007 (03.10.2007) US
PCTUS2007/088865
26 December 2007 (26.12.2007) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(54) **Title:** REGULATORS, POWER SUPPLY SYSTEMS AND METHODS FOR USING THE SAME

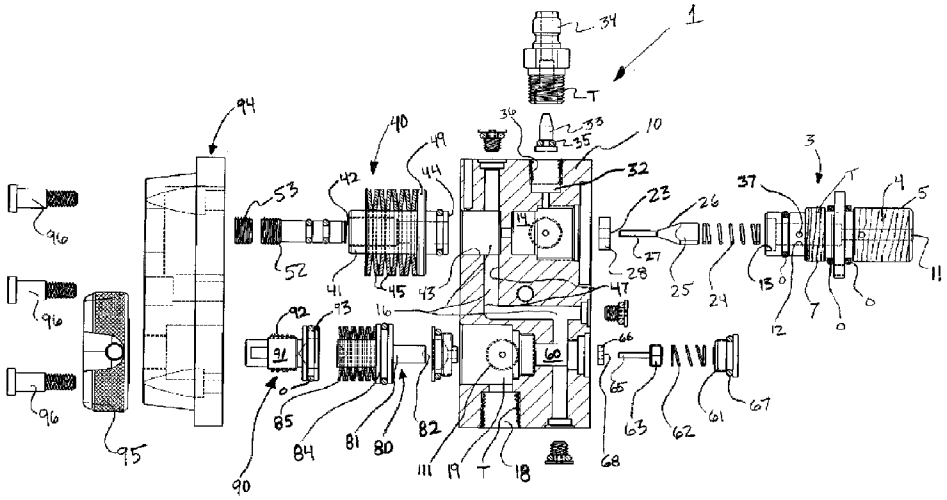


FIG.1B

(57) **Abstract:** Regulators and/or parts or components thereof useful, for example, in systems for powering pneumatic tools. In certain embodiments, dual-stage regulators wherein each stage of the regulators is adjustable and/or tunable. In certain preferred embodiments, tunable and/or adjustable dual-stage regulators which are capable of being used, selectively as desired, in low and/or high pressure applications, shot-type and/or continuous flow delivery applications, and/or low and/or high volume applications (or any combination thereof). In certain additional embodiments, in combination with or separate from the features of other embodiments described herein, regulators which exhibit stable performance regardless of, for example, cylinder supply pressure.

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REGULATORS, POWER SUPPLY SYSTEMS AND METHODS FOR USING THE SAME

RELATED APPLICATION DATA

This application claims priority to U.S. Provisional Patent Application No. 60/977,374, filed October 3, 2007, entitled PNEUMATIC REGULATOR ASSEMBLIES, POWER SUPPLY SYSTEMS AND METHODS FOR USING THE SAME, the entirety of which is hereby incorporated by reference. This application additionally claims priority to PCT Application PCT/US2007/88865, filed December 26, 2008, entitled PNEUMATIC REGULATOR ASSEMBLIES, POWER SUPPLY SYSTEMS, AND METHODS FOR USING THE SAME, the entirety of which is hereby incorporated by reference. The entirety of U.S. Patent No. 6,932,128, entitled APPARATUS AND METHOD FOR USING A LIGHTWEIGHT PORTABLE AIR/GAS POWER SUPPLY, is additionally hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates to regulators (and/or parts or components thereof), portable pneumatic power supply systems using such regulators, and methods of using the same.

BACKGROUND OF THE INVENTION

A tremendous variety of tool types and the like have been developed over the centuries to address the many numbers of construction and manufacturing arts which have evolved during civilization's technological progress through modern times. For example, in a single industry such as the construction industry, dozens of different tool types may be used on a single construction site. In particular, the number of such tool types which are used has increased due to the various specialties and subspecialties of carpentry and other construction techniques which continue to develop as modern buildings become more complex.

Throughout this evolution, substantial efforts have been made to automate tool operation, principally, to improve job efficiencies by improving tool operation speeds and by reducing fatigue of tool operators. In recent decades, such automation efforts have typically involved the development or innovation of compressor powered pneumatic tools or tools powered by electricity. In this regard, due to their improved efficiencies, the use of automated tools has become so commonplace that one would be hardpressed to not find a pneumatic nail gun or an

electrically powered drill at a typical construction job site. Nevertheless, conventional pneumatic or electrically operable tools suffer various disadvantages or drawbacks.

For example, pneumatic or electrically powered tools which are directly connected to a compressor via a hose or to an electrical outlet via a power cord are limited in their portability or mobility due to their attachment to their respective power sources (e.g., their portability is limited to the length of the hose or cord and/or they may be difficult or unsafe to carry up a ladder for example). Moreover, the longer the cord or hose, the greater the overall weight as well as the chance that such hose or cord will become entangled or otherwise act as a safety hazard (e.g., as a tripping hazard). Although battery operated tools address some of these disadvantages, such tools are burdened by their own drawbacks such as their increased weight and reliance on the finite charge of a battery (and, after battery depletion, one must wait for the battery to be recharged or have additional batteries available, for example).

Although U.S. Patent No. 6,932,128, entitled APPARATUS AND METHOD FOR USING A LIGHTWEIGHT PORTABLE AIR/GAS POWER SUPPLY has addressed or mitigated some of the above described drawbacks, the present invention is intended to, at least in part, further improve on the apparatus and methods disclosed therein as well as provide other improvements not necessarily addressed towards technologies specifically disclosed in the '128 patent. In particular, the present invention is intended to provide substantial improvements in regulator design for use, for example, with systems such as described in the '128 patent.

For example, certain types of pneumatic tools, such as nail guns, require short bursts of pressurized air ("air" being used generically throughout this application, interchangeably with "gas" or "air/gas", to include all other suitable gases such as nitrogen or helium), while others, such as pneumatic powered screw drivers, require a continuous flow of air, often at high pressures, over the duration of tool operation. Similarly, certain types of pneumatic "jobs" or projects are best addressed with low pressure, continuous flow air delivery such as the filling of a bicycle tire or a basketball or soccer ball (i.e., employing high pressure bursts or high pressure continuous flow in such applications may damage or burst the tire or ball). Still furthermore, certain more demanding applications, such as the operation of the certain cutting devices such as the "jaws of life" or a lift bag (e.g., each employed by fire departments in emergency operations) or certain impact wrenches, require high volume air delivery in addition to high pressure and continuous flow.

In light of the existence of these numerous applications and job types, each with their own air delivery requirements, it would be desirable to have a single regulator which is capable, because of its configuration or design, of being used in such (or other) alternative application or job types (e.g., with a system such as disclosed in the '128 patent) with or without regulator adjustment or part swapping being required when switching between such applications or job types. In certain optimum designs, it would be desirable, of course, to have a single regulator which is capable of delivering air, alternatively (e.g., selectively, as desired), at both low and high pressures, in bursts (shots) or as continuous flow, and/or in low or high volume (or in any combination of the herein listed delivery types) without requiring part swapping and/or significant regulator adjustment (or no regulator adjustment, other than of the output pressure adjustment mechanism, after an initial adjustment generally temporally proximal the installation of the regulator on the high pressure cylinder or bottle).

Additionally, employing known regulator designs, it is common to experience unwanted pressure variations during regulator operation. As one example of such a deficiency in prior known regulator designs, as the high pressure air source (for example, a steel, aluminum, or carbon fiber cylinder or "bottle") is depleted or the air or gas pressure supplied by the source is reduced, the output pressure delivered by the regulator typically increases (i.e., it is believed that this is because less pressure is initially available in the low pressure chamber to deflect the low pressure piston, and therefore allow regulator seat closure by the regulator pin, to allow air flow delivery to the low pressure chamber to be timely stopped). This unexpected result causes problems in certain types of regulator operation, such as when used with portable air power systems, because, for example, certain tool types will be damaged or will not operate properly (e.g., they may drive a nail too deeply) if subjected to air pressures above threshold limits.

In view of the above enumerated drawbacks and/or desires for improvements in the art, it is a purpose of the herein described invention to address one or more of such drawbacks and/or desires as well as, or in the alternative, other needs which will become more apparent to the skilled artisan once given the present disclosure.

SUMMARY OF CERTAIN EMBODIMENTS OF THE INVENTION

Generally speaking, the present invention is directed, in certain example embodiments, to regulators (or parts or components thereof) which have configurations which exhibit improved performance (e.g., such as improved gas pressure delivery stability). In such or other example embodiments, regulators are provided which have configurations which exhibit improved operational capabilities (e.g., such as with respect to range of gas pressure delivery, type of gas delivery, and/or volume of delivery). In at least one preferred example embodiment, a regulator is provided which includes two stages with each stage being user adjustable to tune operational performance.

In certain example embodiments, the present invention provides: a regulator comprising: a regulator body including an inlet port for connecting to a high pressure gas supply, and the regulator housing a first stage and a second stage; the first stage including a first regulator piston and a first regulator seat for regulating air delivery between a high pressure chamber and a low pressure chamber of the regulator; the second stage including a second regulator piston and a second regulator seat for regulating air delivery between the low pressure chamber and an output pressure chamber; an output port in selective gas flow communication with the output chamber for delivering gas pressure at a desirable output pressure; a first adjuster mechanism in communication with the first stage for adjusting at least one operational parameter of the first stage; a second adjuster mechanism in communication with second stage for adjusting at least one operational parameter of the second stage; and wherein the first adjuster mechanism and the second adjuster mechanism are each adjustable, alone or in combination, to tune performance of the regulator to have desirable operational characteristics. In this or other example embodiments, the second adjuster mechanism is adjustable to select a desired operational output pressure for delivery by said output port (e.g., for use by pneumatically powered tools and the like). In such or other example embodiments, the first and second adjuster mechanisms are adjustable to selectively tune said regulator to be capable of delivering gas, via said outlet, in the alternative or in combination, at low pressures, at high pressures, at low volume, at high volume, in shots, and as continuous flow. In yet a further example embodiment, the first and second stages are housed in a single regulator body (i.e., the regulator is a substantially unibody design).

If desired, in any one or combination of the preceding embodiments, the regulator is so designed such that the regulator cap can be removed while the regulator is attached to a

pressurized high pressure cylinder without the high pressure cylinder substantially depressurizing.

In certain other contemplated examples, in any one or combination of the preceding embodiments, the regulator is so designed such that the Belleville-type springs (other spring types may of course be employed) may be selectively removed and replaced with springs of another type or of another "spring bias or strength rating" to thereby change the psi output of the regulator according to a desired selected end use. In certain preferred example embodiments (either as described specifically above or in any combination or sub-combination thereof), the psi output which can be changed is selected from the group comprising: maximum psi output, psi range output, minimum psi output, or some combination of the herein listed output variables.

In certain exemplar embodiments, a unique configuration of a cartridge assembly, comprised of a combination of a cartridge body (an example configuration of which is illustrated herein), a regulator pin, a regulator seat, and a biasing mechanism (e.g., spring), is achieved as a self-contained, removable module. The use of such module, in such example regulator configurations, lends to ease of maintenance and/or repair of the regulator as well as, or in the alternative, ease of manufacture and/or increased reliability.

In some preferred example embodiments, the psi range output can be quickly changed simply by switching out the Belleville (or other type) spring pack. For example, such a regulator may be converted to be capable of switching between 0-150 psi output and 0-300 psi output (in practice, conventionally to 150-300 psi output) by a simple spring pack (or biasing mechanism pack) switch-out. This is important, in at least one respect, where it is desired to use such regulator (e.g., as part of a portable power supply system) for a variety of end use types ranging from inflating sports balls such as basketballs or soccerballs to more high pressure applications such as for powering impact wrenches or operating emergency lift bags and the like.

In various exemplary embodiments the regulator is designed to connect to a source of pressurized air, such as a portable canister. In such embodiments the canister is preferably small enough to be carried by a user and connects through the regulator to a hose to be operatively coupled to any number of pneumatic tools.

In various exemplary embodiments, the flow of the gas from the high pressure chamber to the low pressure chamber may be regulated by a tunable or adjustable high pressure piston assembly and a high pressure pin assembly. Further, in such example or other embodiments, the

flow of gas from the low pressure chamber to the output chamber may be regulated by a tunable or adjustable low pressure piston assembly and a low pressure pin assembly. In still other embodiments, one or both of the high and low pressure piston assemblies are adjustable and/or tunable to ensure predictable, unchanging output pressure regardless of decreases in source pressure (e.g., provided by a high pressure cylinder connected to the regulator).

In some of the herein described embodiments, the longitudinal position of the inner piston within the outer piston is user adjustable (e.g., for regulator tunability), and the regulator may further include a knob for user adjustment of the low pressure piston.

Further, in some embodiments, the regulator may be capable of receiving air/gas at the air inlet port at a pressure of between at least 0-6000 PSI and stepping down such air/gas pressure, to deliver such air/gas from the air/gas outlet port, in certain preferred example embodiments, at pressures selected between 150-300 PSI, and in more preferred example embodiments, at pressures selected from between 0-300 PSI, and in still further preferred embodiments, at pressures selected from between 0-500 PSI (e.g., at various desirable volume delivery rates). In the most preferred (but still non-limiting) example embodiments, a wide variety of pressures and volumes can be selected and delivered without requiring part swapping and/or substantial regulator adjustment. In certain particularly efficacious embodiments, no adjustment of the regulator is required when switching between end use applications (e.g., other than possibly of the output pressure knob).

In some embodiments, the air/gas outlet is connected via an air/gas hose to a pneumatically operated tool, and the regulator may further include an air fill inlet, which may be connectable via an air hose, for example, to a reservoir or compressor for refilling an air tank connected to the regulator.

In another aspect, the present invention is directed to a portable pneumatic tool power supply system that includes (a) a two stage regulator that includes a housing having at least a first chamber and a second chamber in fluid communication with the first chamber; a high pressure cartridge assembly and a high pressure piston assembly housed within the first chamber; the high pressure cartridge assembly having an air inlet port, and a low pressure cartridge assembly and a low pressure piston assembly housed within the second chamber, the low pressure cartridge assembly having an air outlet port, the high pressure piston assembly including an outer piston and an inner piston housed at least partially within the outer piston and user

moveable longitudinally within the outer piston; (b) a pressurized air tank; and (c) a hose connected to the air inlet port on one end and to the pressurized air tank on the other end.

In some embodiments, the portable pneumatic power supply system further includes a pneumatic tool and a hose connected to the air outlet port of the regulator on one end and to the pneumatic tool on the other end.

In certain embodiments described herein, having adjustability at both the first and second stages allows tunability of the regulator so that it can be readily used with a wide range of pneumatic tools (which utilize shot-type gas delivery or continuous flow delivery). In such or other embodiments, having first and second stage adjustability, additionally, or in the alternative, permits tunability so that the regulator delivers a generally or substantially stable output gas pressure regardless of the gas supply pressure (e.g., the pressure of the gas supplied by a high pressure steel, aluminum, or carbon fiber cylinder).

Certain examples of the invention are now below described with respect to certain non-limiting embodiments thereof as illustrated in the following drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A illustrates a plan view of one embodiment of a regulator according to the subject invention with certain parts shown in x-ray (shown with regulator pins in an "open" position).

FIG. 1B illustrates an exploded, plan view of the embodiment of the regulator illustrated in FIG. 1A.

FIG. 2A illustrates a top view of an embodiment of a high pressure regulator pin according to the subject invention.

FIG. 2B illustrates a profile view of an embodiment of a high pressure regulator pin according to the subject invention.

FIG. 2C illustrates a bottom view of an embodiment of a high pressure regulator pin according to the subject invention.

FIG. 3A illustrates one embodiment of a high pressure piston assembly employed in the regulator illustrated in FIG. 1A, with certain parts shown in x-ray.

FIG. 3B illustrates an exploded view of the high pressure piston assembly illustrated in FIG. 3A.

FIG. 3C illustrates an assembled, perspective, non-x-ray view of the high pressure piston assembly illustrated in FIG. 3A.

FIG. 4 illustrates, in perspective view, one embodiment of a low pressure regulator pin according to the subject invention.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

For a more complete understanding of the present invention, reference is now made to the following description of various illustrative and non-limiting embodiments thereof, taken in conjunction with the accompanying drawings in which like reference numbers indicate like features.

Referring initially to FIGS. 1 and 2, assembled and blown apart views of an example regulator according to the subject invention are illustrated therein. Such figures in this regard, illustrate regulator 1 as comprising an assembly of four main components or sub-assemblies including a high pressure sub-assembly, a low pressure sub-assembly, main regulator body 10, and regulator cap 94 each, as assembled together, comprising and/or operatively enclosing regulator 1's main functional components.

In this regard, regulator 1's high pressure sub-assembly is generally comprised of high pressure cartridge 3 which itself comprises a unibody cartridge body 4 having a first end 5 for threadably engaging a high pressure cylinder and a second end 7 for threadably engaging main regulator body 10. First end 5, in this regard, includes a high pressure input aperture 11 for gas flow communication with a high pressure cylinder to which it attaches (or is attached). At its opposite or second end 7, cartridge 3 includes a regulator seat aperture 13 for retaining a regulator seat 28, adjoined to a middle aperture 12 which serves both as a seat for a biasing mechanism 24 (e.g., a conventional coil spring or other suitable mechanism) as well as connects

apertures 11 and 13 for gas flow communication therebetween. Additionally, as illustrated, middle aperture 12 houses a portion of regulator pin 25 (illustrated in detail in Figs. 2A, 2B, and 2C) which has a first narrow, elongated end or tip 27 which is installed in a generally central aperture 23 of regulator seat 28 (itself press fit into aperture 13). Pin 25's opposite or second end, as can be seen in the figures, is in biasing contact with biasing mechanism 24 (e.g. a coil spring). It is noted, in this regard, that regulator pin 25 is moveable bi-directionally upwards and downwards within aperture 12 of cartridge 3 during regulator operation with such pin 25 acting to open or close the gas pathway to the low pressure side of the regulator by effectively "opening" and "closing" aperture 23 in regulator seat 28 as the conical or wide portion 26 of pin 25 moves out of and into engagement with the aperture respectively (e.g., by physically obstructing the air/gas passageway).

As can best be seen in FIG. 1, the entire high pressure cartridge 3 (e.g., including cartridge body 4 housing the above described regulator pin, spring, and regulator seat) connects to main regulator body 10 by simply threading thereto employing o-rings where appropriate to obtain or achieve necessary seals (threads, whether male or female, throughout the drawings are sometimes referred to by the designation "T"; similarly, for efficiency purposes, o-rings are sometimes designated employing the label "O", rather than with a specific part number).

Generally opposite the location of installation of cartridge 3 to main regulator body 10 (preferably in axial alignment therewith), high pressure piston assembly 40 is housed in piston aperture or chamber 43. Installed as such, a low pressure chamber 16 is defined, in part, by the first end or portion 44 of the high pressure piston assembly and the opposing and adjoining walls of aperture 47 (thus, the volume of the low pressure chamber increases or decreases as the position of high pressure piston assembly 40 changes axially within the regulator).

In this example embodiment, high pressure piston assembly 40 generally comprises a generally cylindrical main piston body 41 having a shoulder or flange region 49. A plurality or bank of Bellville-springs 45 are installed on body 41 with one end of the bank of springs engaged to shoulder 49 of the piston assembly and the other end enclosed or "captured" by regulator cap 94 (which removably attaches to main regulator body 10 via male and female threaded portions, e.g., conventional bolts 96, in this embodiment, but which, of course, can be attaches by other mechanisms or means as well). Although Belleville-type springs (e.g., preferably stainless steel) have proven particularly effective in achieving good regulator

performance characteristics, other spring types or biasing mechanisms may, of course, be employed.

Notably, main piston body 41 has a central aperture 46 for retaining and/or engaging inner piston 50 which can be threaded into different axial positions within piston body 41 to change its effective length and therefore relative bias against regulator pin 25 (at its tip 27) to tune and/or adjust the output characteristics of the regulator (with o-rings being used about the diameter of inner piston 50 to obtain an airtight installation within piston body 41 as well as at least one o-ring being used on piston body 41 for an airtight seal between it and main body 10). In this regard, inner piston 50 includes a pin seat 42 (having a detent region, shown best in Fig. 3A) which, when the regulator is assembled, is in biasing engagement with regulator pin 25 via tip 27. Regulator pin 25, in turn, is biased in the opposite direction by biasing mechanism or spring 24. Having this configuration, it will be recognized, of course, that piston assembly 40 travels axially, back and forth, within piston chamber 43 as a function of internal system pressures and spring values during and as part of regulator operation. Moreover, it will be recognized that the axial position of inner piston 50 can be adjusted (within piston body 41) to change the "balance" of the opposing spring biasing forces provided by springs 24 and 45 (as relative to internal system air/gas pressures). Adjusting the axial position of inner piston 50, in this regard, allows volume and/or pressures of air/gas which travels or passes through regulator seat 28, during regulator operation, to be tailored or tuned as desired. In order to adjust piston 50, threaded plug or cap 53 can be removed by simply threading it out of cap 94 for access to the piston (see Figs. 3A, 3B, and 3C for a more detailed view of piston assembly 40).

At the low pressure side of the regulator, and referring still to Figs. 1 and 2, low pressure sub-assembly of regulator 1 generally comprises a spring seat 61 (threaded to main body 10 and sealed with o-ring 67, in this example), a spring (or other suitable biasing mechanism) 62, and a regulator pin 63 (hexagonally shaped to allow air/gas flow around its circumference; see Fig. 4) installed in a low pressure regulator chamber 60 with its tip 65 installed and extending within aperture 68 of regulator seat 66 (which is seated against and structurally supported, on one side, by deformable threaded insert 70). As can be seen in the drawings, spring 62 is installed positioned between seat 61 and pin 63 and therefore acts to bias regulator pin 63 towards the regulator seat 66 (i.e., it acts to bias it towards a sealing engagement with the regulator seat).

Similar to the high pressure sub-assembly described herein, the low pressure sub-assembly further includes a low pressure piston assembly 80 located oriented generally coaxial and in- line with the axis of regulator pin 63. In this example embodiment, the low pressure piston assembly 80 generally comprises a piston body 81 having a shoulder or flange portion 84 for seating Bellville-type springs 85 (although other spring or biasing mechanism types may, of course, be employed). Moreover, piston body 81, similar to its high pressure counterpart, includes a low pressure pin seat 82 which engages low pressure regulator pin tip 65 in a biasing relationship (i.e., springs 85 provide a biasing force to piston body 81 which is applied against pin tip 65 via pin seat 82). Capturing springs 85 against shoulder 84 is an adjustment mechanism 90 which is provided so that the output pressure delivered by regulator 1 (via output port 18) can be user selected in accordance with pneumatic tool or other needs, for example. More specifically, adjustment mechanism 90 comprises an adjuster body 91 which is threadably engaged to cap 94 via threads 92. At one end, adjuster body 91 includes a flange portion 93 (with a corresponding o-ring for providing an appropriate air/gas seal) which, when installed in regulator 1, acts as a seat for springs 85. Configured as such, adjustment mechanism 90 can be employed to change or tune the biasing force provided against regulator pin 63 (at its tip 65) by threading adjuster body 91 axially farther in or farther out of regulator cap 94 thereby changing the amount of force applied against springs 85 by flange 93 (which in turn determines the amount of spring or biasing force applied against regulator pin 63). This is accomplished, in this embodiment, by merely hand turning adjustment knob 95 which, when assembled, is connected to body 91 to provide user adjustability of the force of springs 85. This, in turn, determines the relative balance or differential of opposing spring forces applied on regulator pin 63 (between springs 62 and 85), in combination with internal system air/gas pressures (which act to trigger the opening and closing of the regulator seat by pin 63 in combination with the spring forces), and thereby determines the amount of air flow (including volume and/or pressure) which is permitted to pass through regulator seat 66 during operation i.e., from low pressure chamber 16 to output chamber 19 through aperture 68.

As illustrated in the figures, output chamber 19 is in open air/gas communication with outlet port 18. Port 18, in this regard, is provided, in this embodiment, with threaded walls for accepting installation of a quick connect/disconnect type coupler for connecting to an air/gas hose, for example (e.g., for connection, in turn, to a pneumatic tool).

Furthermore, in the illustrated embodiment, regulator 1 is provided with a fill pathway and fill port 34 for allowing pressurized air/gas to be introduced to an air/gas cylinder connected to the regulator, for example (not shown). The fill pathway includes a fill chamber 32, having threads 36 for threadably connecting to fill port 34 and a corresponding fill aperture 37 (in cartridge body 4) for providing air/gas communication between chamber 32 and aperture/pathway 11 (aperture 37 is in air/gas communication with chamber 32). Fill port, 34, in turn, includes a one-way valve type assembly comprised of a poppet or strut 33 selectively sealed and unsealed by an o-ring 35 during use and fill operations, respectively.

In operation, the two stage regulator which is illustrated is preferably attached to a portable, high pressure air/gas cylinder so that aperture 11 is in air/gas flow communication with a source of pressurized air/gas (e.g., as contained in the connected high pressure air/gas cylinder). In this regard, spring 24 will normally bias pin 25 against regulator seat 28 when the internal chambers (high and low) of the regulator are pressurized. However, when pressure is evacuated from low pressure chamber 16, such as during pneumatic tool use, for example (when air is evacuated from port 18), the corresponding drop in internal pressure in the low pressure chamber relieves biasing pressure from against the end 44 of the high pressure piston assembly thereby permitting springs 45 to overcome the opposing biasing force of spring 24. As a result, regulator pin 25 withdraws axially away from regulator seat 28 and permits pressurized air to reenter the low pressure chamber 16 from high pressure chamber 14 (via regulator seat aperture 23). After a threshold amount of pressure rebuilds in the low pressure chamber 16, air/gas force builds against high pressure piston face 44 and the high pressure piston assembly is urged back against the force of springs 45, allowing springs 24 to overcome the force of such springs (45) and for regulator pin 25 to reseat against regulator seat 28 and thereby close the air/gas communication between the low and high pressure chambers 14 and 16 (by physically obstructing the air passageway, at aperture 23, between them).

Similarly, prior to evacuation of pressure at output port 18 (e.g., during tool operation), the force of spring 62 combined with the air/gas pressure contained in output chamber 19, which applies force against the face of shoulder 84, is sufficient (when the regulator is properly tuned) to overcome the biasing force of springs 85 and therefore keep pin 63 seated against regulator seat 60, thereby preventing air/gas flow between the low pressure chamber and the output chamber. When, however, chamber 19 is evacuated (such as when a pneumatic tool, connected

to port 18, is operated), the lack of internal air/gas pressure in chamber 19 (and therefore lack of air/gas force being applied to the face of shoulder 84) temporarily permits the force of springs 85 to overcome the force of spring 62 sufficiently long enough such that regulator pin 63 is biased away from regulator seat 66 by pin seat 82 (of the low pressure piston) such that air/gas of sufficient/desired pressure and/or volume is reintroduced into output chamber 19. At such time, the introduced pressure and/or volume is sufficient to reintroduce a bias force against springs 85 via air/gas force pressure on the face of shoulder 84 such that the force of spring 62, assisted by the air/gas force, overcomes the biasing force of springs 85, and aperture 68 of regulator seat 66 is once again closed by regulator pin 63 (because the pin is reseated against the regulator seat).

In particular, adjustment mechanism 90 is provided so that the biasing force of springs 85, as they act on the low pressure piston assembly, can be manually adjusted (via knob 95) so that the amount of air pressure which is obtained in or provided to chamber 19 (and therefore provided at output port 18) is user selectable. In particular, this feature is provided so that a user can choose a desired output pressure for use with a particularly selected pneumatic tool or for another pneumatic use. Aiding in this purpose, certain embodiments of the regulator, such as the embodiment illustrated, are provided with a port/passageway 111 for connecting a pressure gauge (actual gauge, not shown) which permits accurate and active selection of output pressures.

In certain particularly exemplary embodiments of the regulators described herein (such as the regulator illustrated), an optional safety feature is provided to the regulator. For example, as depicted best in FIG. 1, a safety aperture SA is provided which is bored through main regulator body 10. In the location depicted, if piston body 41 is advanced outwardly (away from regulator pin 25) a sufficient distance due to possibly unsafe high pressures in the regulator (perhaps because regulator seat 28 has failed and the full, high pressure of the cylinder is biasing piston body 41 upwardly), safety aperture SA becomes exposed to the atmosphere (it is normally sealed off from the atmosphere by certain o-rings depicted in the figures) and the pressurized air/gas contained within the regulator is allowed, at least in part, to off-gas thus minimizing or at least reducing the potential adverse effects of regulator part failure, for example.

Once given the above disclosure, many other features, modifications, and improvements will become apparent to the skilled artisan. Such features, modifications, and improvements are therefore considered to be part of this invention, without limitation imposed by the example embodiments described herein. Moreover, any word, term, phrase, feature, example,

embodiment, or part or combination thereof, as used to describe or exemplify embodiments herein, unless unequivocally set forth as expressly uniquely defined or otherwise unequivocally set forth as limiting, is not intended to impart a narrowing scope to the invention in contravention of the ordinary meaning of the claim terms by which the scope of the patent property rights shall otherwise be determined:

What is claimed is:

1. A regulator comprising:

a regulator body including an inlet port for connecting to a high pressure gas supply, and said regulator housing a first stage and a second stage;

said first stage including a first regulator piston and a first regulator seat and pin assembly for regulating air delivery between a high pressure chamber and a low pressure chamber of said regulator;

said second stage including a second regulator piston and a second regulator seat and pin assembly for regulating air delivery between said low pressure chamber and an output chamber;

an output port in gas flow communication with said output chamber for delivering gas pressure at a desirable output pressure;

a first adjuster mechanism in communication with said first stage for adjusting at least one operational parameter of said first stage;

a second adjuster mechanism in communication with second stage for adjusting at least one operational parameter of said second stage; and

wherein said first adjuster mechanism and said second adjuster mechanism are each adjustable, alone or in combination, to tune performance of said regulator to have desirable operational characteristics.

2. A regulator according to claim 1 wherein one of the stages further comprises: a piston assembly; having an outer piston and an inner piston.

3. A regulator according to claim 2 wherein the inner piston is axially adjustable with respect to the outer piston.

4. A regulator according to claim 3 wherein the adjustability is facilitated by a threaded connection between the inner piston and the outer piston.

5. A regulator according to claim 3 wherein the inner piston is in general co-axial alignment with the outer piston.

6. A regulator according to claim 3 wherein the outer piston is biased by a spring.

7. A regulator according to claim 1 wherein the second stage further comprises a low pressure piston having a low pressure adjuster; a low pressure piston, and a low pressure piston seat.

8. A regulator according to claim 7 wherein the low pressure adjuster further comprises a shaft having a first end which is threaded for connecting to a knob, and a second end having a flange for engaging said low pressure piston.

9. A regulator according to claim 8 where the low pressure piston is biased by a spring.

10. A regulator according to claim 1 wherein the low pressure chamber and high pressure chamber each house a pin assembly having a regulator seat, a pin, a spring, and a pin seat.

11. A regulator according to claim 10 wherein the high pressure pin assembly is in general coaxial alignment with the inlet port.

12. A regulator comprising: a regulator body having; an inlet port for connecting to a source of pressurized gas; a high pressure chamber in fluid connection with said inlet port having an adjustable high pressure piston assembly and a high pressure pin assembly; a fluid channel connecting said high pressure chamber with a low pressure chamber, said low pressure chamber having an adjustable low pressure piston assembly and a low pressure pin assembly; and an outlet port in fluid connection with said low pressure chamber.

13. A regulator according to claim 12 wherein one of either the high pressure piston assembly or the low pressure piston assembly further comprises an outer piston and an inner piston.

14. A regulator according to claim 13 wherein the inner piston is axially adjustable with respect to the outer piston.

15. A regulator according to claim 14 wherein the axial movement is facilitated by a threaded connection between the inner piston and the outer piston.

16. A regulator according to claim 13 wherein the inner piston is in a coaxial relationship with the outer piston.

17. A regulator according to claim 13 wherein the outer piston is biased by a spring.

18. A regulator according to claim 15 wherein the outer piston is biased by a spring.

19. A regulator according to claim 18 wherein the spring is a Bellville spring.

20. A regulator according to claim 15 wherein one of either the high pressure piston assembly or the low pressure piston assembly further comprises a pressure adjuster; a piston, and a piston seat.

21. A regulator according to claim 20 wherein the pressure adjuster further comprises a shaft having a first end which is threaded for connecting to a knob, and a second end having a flange for engaging said piston.

22. A regulator according to claim 20 wherein the piston is biased by a spring.

23. A regulator according to claim 22 wherein the spring is a Bellville spring.

24. A regulator according to claim 12 further comprising a regulator cap for securing the high pressure piston assembly and the lower pressure piston assembly to the regulator body.

25. A regulator according to claim 24 wherein the regulator cap is secured to the regulator body with at least one screw.

26. A regulator according to claim 25 wherein the high pressure piston assembly is adjustable through the regulator cap and the low pressure piston assembly is adjustable via an knob located on the outside of the regulator cap.

27. A regulator according to claim 12 wherein the high pressure pin assembly further comprises a regulator seat, a pin, a spring, and a pin seat.

28. A regulator according to claim 27 wherein the pin seat is threadably connected to the regulator body.

29. A regulator according to claim 12 wherein the low pressure pin assembly further comprises a regulator seat, a pin, a spring, and a pin seat.

30. A regulator according to claim 29 wherein the pin seat is threadably connected to the regulator body.

31. A regulator according to claims 1 or 12 wherein the low pressure chamber is of sufficient to allow for a continuous flow at a constant pressure between the low pressure chamber and the outlet port.

32. A regulator according to claims 1 or 12 wherein the regulator body further comprises a gauge for measuring the pressure in the high pressure chamber and a gauge for measuring the pressure in the low pressure chamber.

33. A regulator according to claims 1 or 12 wherein a hose coupling is connected to the outlet port.

34. A regulator according to claim 33 wherein the hose coupling is a quick connect coupling.

35. A regulator according to claims 1 or 12 wherein the inlet receives gas at a pressure between 0 and 6000 psi.

36. A regulator according to claims 1 or 12 wherein the output pressure is selectable between 0 and 400 psi.

37. A regulator according to claims 1 or 12 wherein the output pressure is selectable between 100-350 psi.

38. A regulator according to claims 1 or 12 wherein the regulator is connected to a tool.

39. A regulator according to claims 1 or 12 wherein the regulator body further comprises a fill assembly.

40. The method of powering a pneumatic tool comprising: connecting a pneumatic tool to a pneumatic regulator and connecting the pneumatic regulator to a source of pressurized gas wherein the pneumatic regulator further comprises a first adjustable pressure regulator and a second adjustable pressure regulator.

41. A regulator according to claim 1 wherein said second adjuster mechanism is adjustable to select a desired operational output pressure for delivery by said outlet.

42. A regulator according to claim 1 or 41 wherein said first and second adjuster mechanisms are adjustable to selectively tune said regulator to be capable of delivering gas, via said outlet, in the alternative or in combination, at low pressures, at high pressures, at low volume, at high volume, in shots, and as continuous flow.

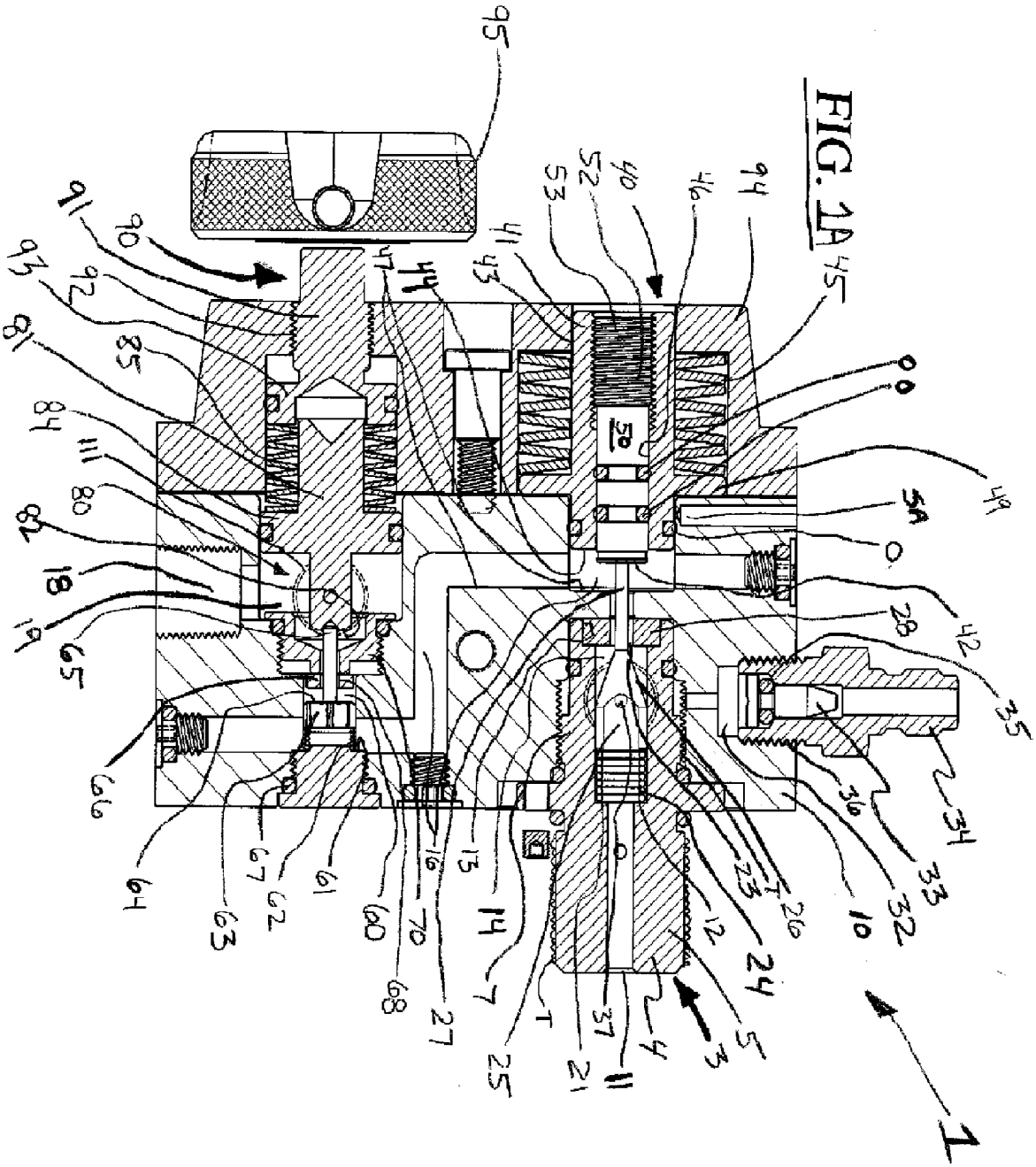


FIG. 1A

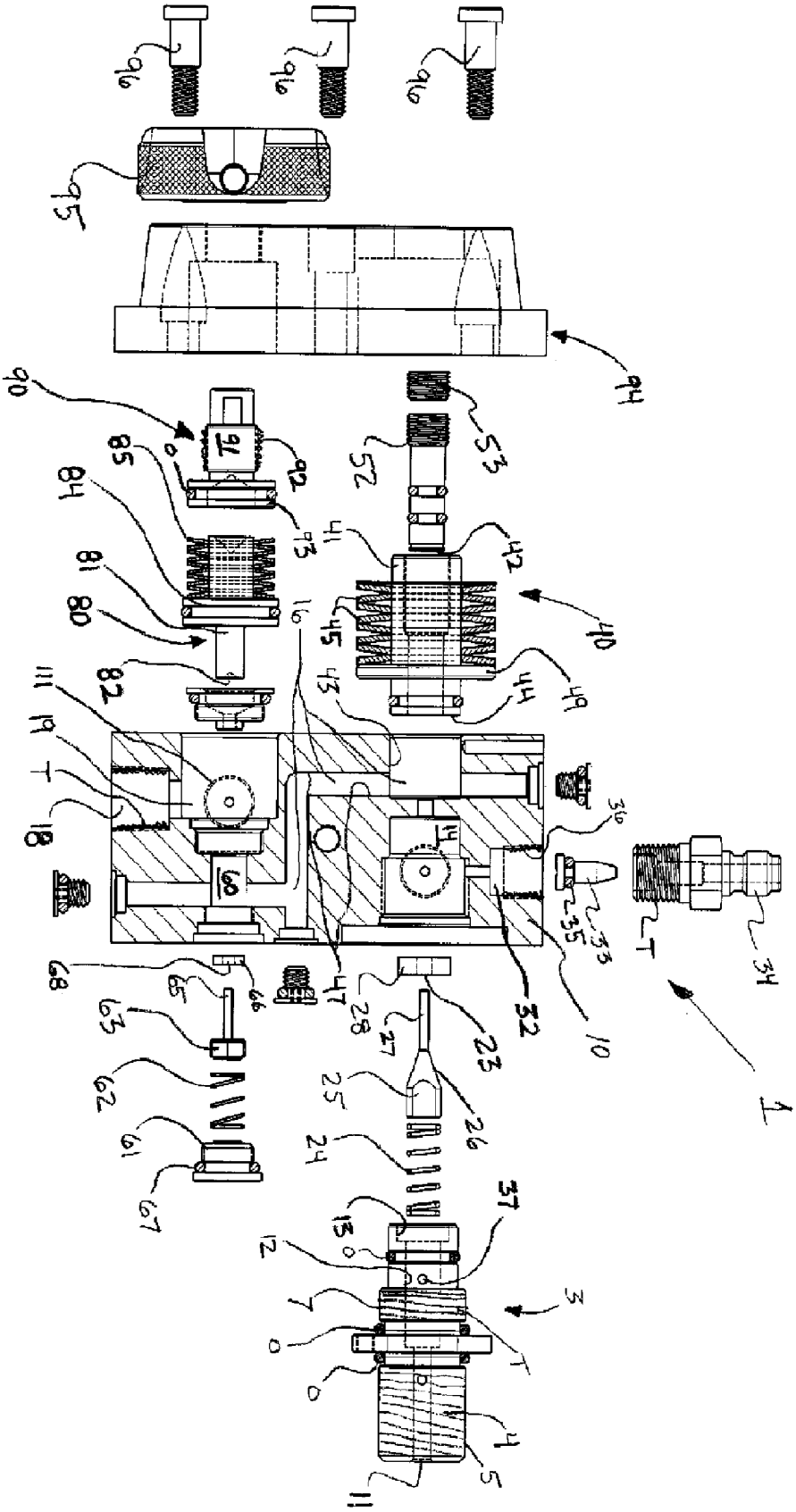

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FIG.1B

FIG. 2A

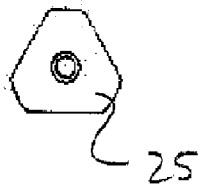


FIG. 2B

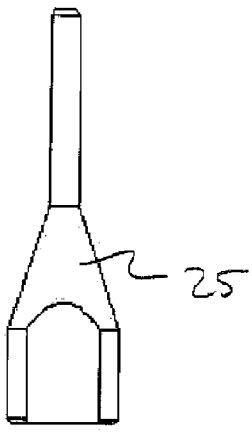
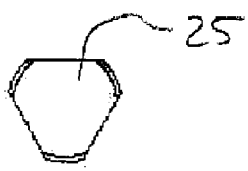


FIG. 2C



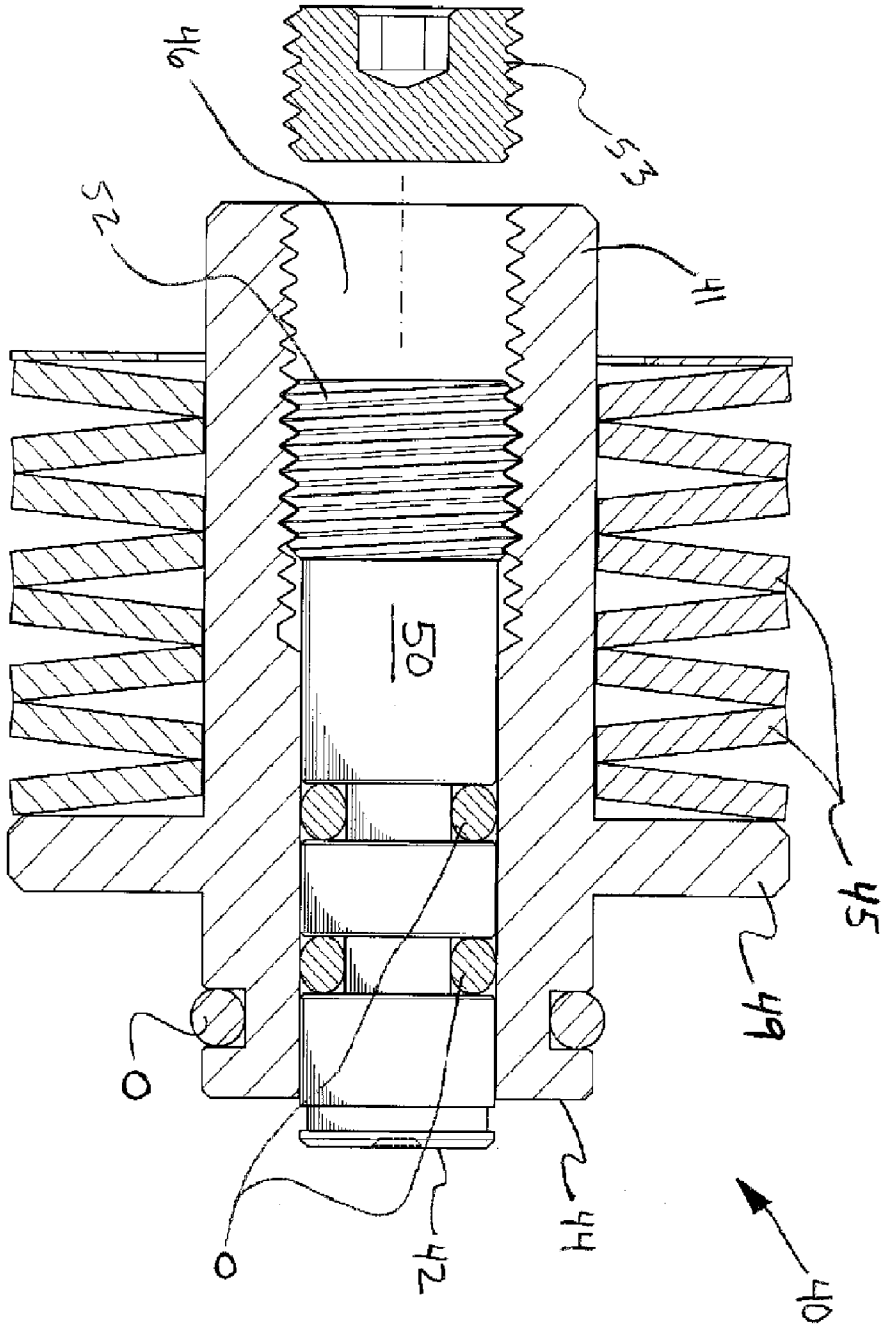


FIG. 3A

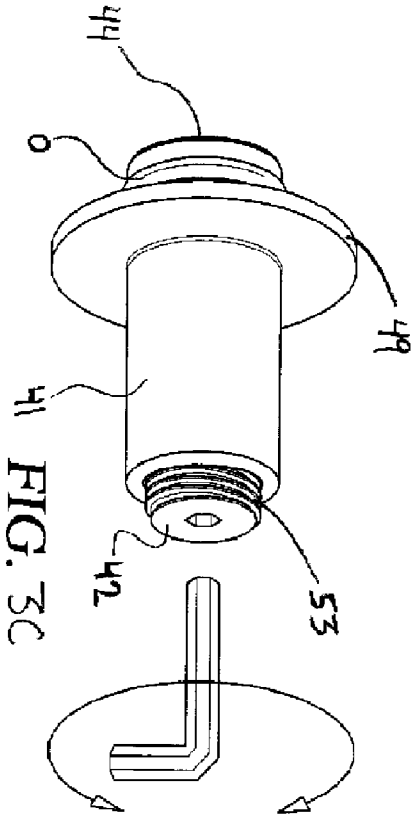


FIG. 3C

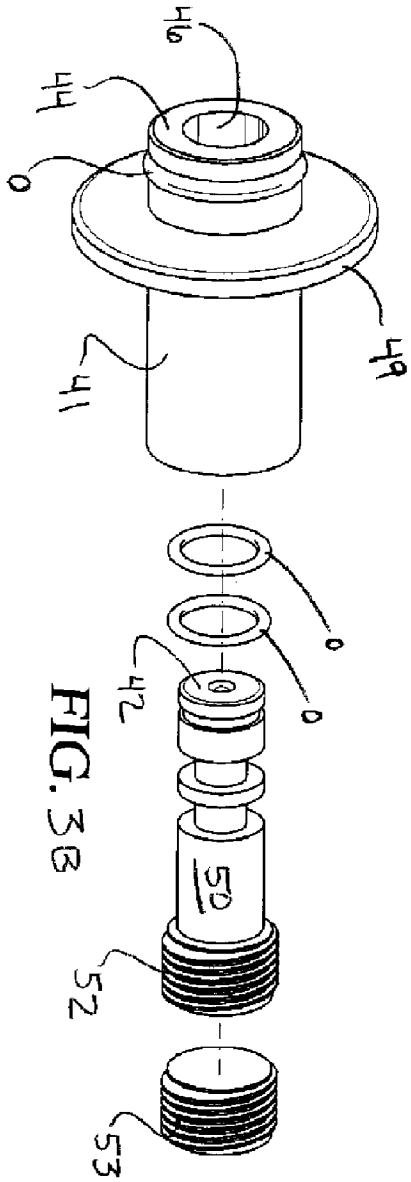
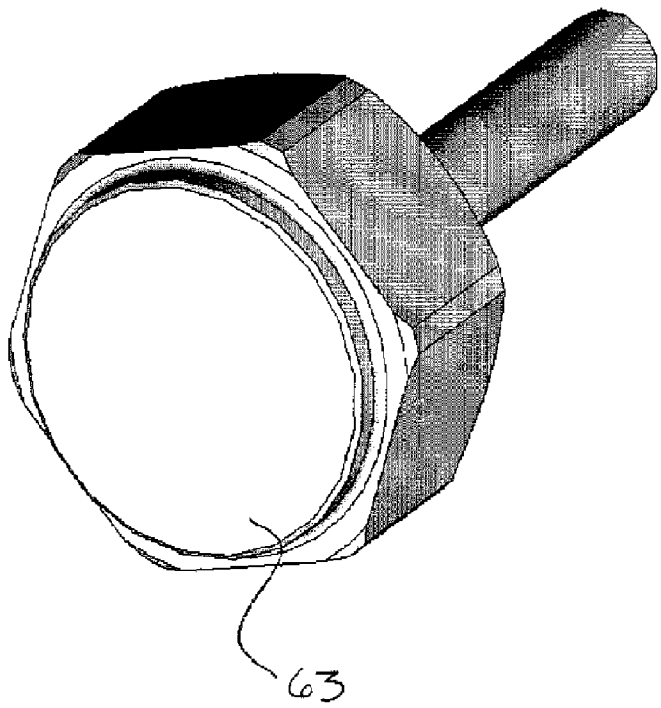


FIG. 3B

FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 08/78868

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F16K 31/12,31/36 (2008.04)
USPC - 137/505.12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): F16K 31/12,31/36 (2008.04)
USPC: 137/505.12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 137/505,505.12; 251/205 - and generally all classes as limited by search terms below

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(USPT,PGPB,EPAB,JPAB); Google Scholar
Search Terms Used: pressure regulator, pneumatic tool, piston, adjustable, high pressure, low pressure, outer piston, inner piston, seat, pin, tank, hose, fill valve, threaded

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0214781 A1 (Lee) 20 September 2007 (20.09.2007); fig 1, 7, 10, 12; Abstract; para[0007], [0020]-[0022], [0025], [0027], [0029], [0031]-[0037]	1-3, 5-14, 16, 17, 24-38, 40-42
Y		4, 15, 18-23, 39
Y	US 2,909,248 A (Gies) 20 October 1959 (20.10.1959); fig 1; col 1 ln 63; col 2 ln 65-68	4, 15, 18-23
Y	US 2005/0111995 A1 (Everson) 26 May 2005 (26.05.2005); fig 8; para[0037]	39

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 January 2009 (07.01.2009)	30 JAN 2009
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)