

(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2006275975 B2**

(54) Title
Reciprocating pump with electronically monitored air valve and piston

(51) International Patent Classification(s)
F04B 49/00 (2006.01) **G01B 9/02** (2006.01)
F04B 9/08 (2006.01) **G01B 11/02** (2006.01)
F04B 35/02 (2006.01) **G01J 3/45** (2006.01)

(21) Application No: **2006275975** (22) Date of Filing: **2006.07.25**

(87) WIPO No: **WO07/016081**

(30) Priority Data

(31) Number	(32) Date	(33) Country
60/703,306	2005.07.28	US
60/704,290	2005.08.01	US

(43) Publication Date: **2007.02.08**

(44) Accepted Journal Date: **2011.08.25**

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(56) Related Art
US 5174731 A
GB1187026A
GB1237701A

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

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
8 February 2007 (08.02.2007)

PCT

(10) International Publication Number
WO 2007/016081 A3

(51) International Patent Classification:
F04B 49/00 (2006.01) **F04B 35/02** (2006.01)
F04B 9/08 (2006.01)

(21) International Application Number:
PCT/US2006/028826

(22) International Filing Date: 25 July 2006 (25.07.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/703,306 28 July 2005 (28.07.2005) US
60/704,290 1 August 2005 (01.08.2005) US

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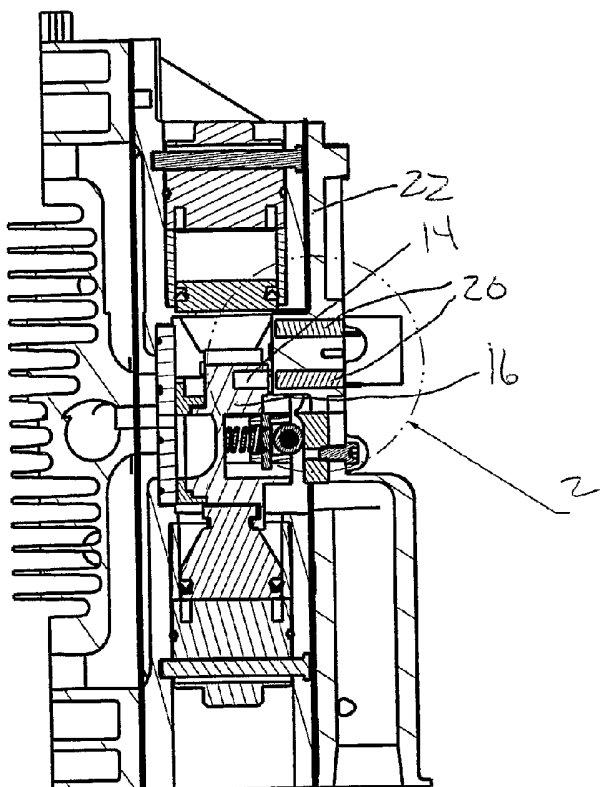
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, 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,

[Continued on next page]

(54) Title: RECIPROCATING PUMP WITH ELECTRONICALLY MONITORED AIR VALVE AND PISTON



(57) Abstract: An air operated pump 10 uses a magnet 14 mounted in the valve cup 16 of the air motor 18 and two reed sensors 20 mounted in the valve cover 22 to monitor the speed and position of the valve 16. A solenoid 24 is mounted on the valve cover 22 and can be commanded to extend a plunger 26 into the valve cup 16 to stop valve movement and therefore the pump from running away. A magnetoresistive sensor 34 is located in the center of the air motor 18 to precisely monitor the piston 36 position and with air valve sensors 20 provides the input necessary for precise control and diagnostics of the pump 10 and makes it suitable for metering and plural component application.

WO 2007/016081 A3



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, HU, IE, IS, IT, LT, LU, LV, MC, NL, 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*

(88) Date of publication of the international search report:
24 May 2007

(15) Information about Correction:

Previous Correction:

see PCT Gazette No. 15/2007 of 12 April 2007

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

RECIPROCATING PUMP WITH
ELECTRONICALLY MONITORED AIR VALVE AND PISTON

TECHNICAL FIELD

This application claims the benefit of US Application serial numbers 60/703,306, filed July 28, 2005 and 60/704,290 filed August 1, 2005.

BACKGROUND ART

Air-operated reciprocating piston pumps are well known for the pumping of various fluids. Such pumps typically have mechanically or pneumatically operated air valves to control the flow of air to the two sides of the piston. Control of such pumps has traditionally been by monitoring and controlling the resulting fluid flow rather than the pump itself. Prior art devices such as Graco's EXTREME-MIX™ proportioner have monitored the position of the piston for purposes of control.

DISCLOSURE OF THE INVENTION

It is therefore an object of this invention to provide a system which allows enhanced monitoring and control of a reciprocating air motor so as to allow monitoring of piston position, cycle and flow rates, total cycles, runaway control and the ability to diagnose failing air motor and pump lower components.

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The control uses a magnet mounted in the valve cup of the air motor and two reed sensors mounted in the valve cover to monitor the speed and position of the valve. A solenoid is mounted on the valve cover and can be commanded to extend a plunger into the valve cup to stop valve movement and therefore the pump from running away (typically caused by the fluid supply being empty.) The user interface comprises an LCD and buttons to set up and control the pump. The display can be toggled to display cycle rate, flow rate (in various units), total cycles and diagnostic errors. Setup parameters can include fluid units (quarts, liters, etc.) and the runaway set point.

The reed switches and magnets are located so as to detect when the air valve is at the extreme position of each stroke or in transition or both. The controller calculates the rate at which the motor is running by counting the opening and closing of the reed switches activated by the varying positions of the air valve. The controller then compares that rate to a pre-programmed value to determine if the air motor is in a runaway condition. When that condition is present, the controller activates the solenoid preventing changeover which stops the motor. This acts to prevent spilled fluid and/or pump damage.

A magnetoresistive sensor is located in the center of the air motor to precisely monitor the piston position. The data from this sensor in conjunction with that from the air valve sensors provides the input necessary for precise control and diagnostics of the pump and makes it suitable for metering and plural component application.

These and other objects and advantages of the invention will appear more fully from the following description made in conjunction with the accompanying drawings wherein like reference characters refer to the same or similar parts throughout the several views.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 shows a cross-section of the air valve as part of the instant invention showing the magnets and reed switches.

Figure 2 shows a detail of the Figure 1 cross-section of the air valve as part of the instant invention.

Figure 3 shows a cross-section (opposite that of Figure 1) of the air valve as part of the instant invention showing the solenoid.

Figure 4 shows a view of a pump incorporating the instant invention.

Figure 5 shows a detail of the user interface of the instant invention.

Figure 6 shows the diagnostic codes which may be obtained by sensing the air valve.

Figure 7 shows the piston and magnetoresistive sensor.

BEST MODE FOR CARRYING OUT THE INVENTION

In an air-operated reciprocating piston pump 10, the controller 12 uses a magnet 14 mounted in the valve cup 16 of the air motor 18 and two reed sensors 20 mounted in the valve cover 22 to monitor the speed and position of the valve 16. A solenoid 24 is mounted on the valve cover 22 and can be commanded to extend a plunger 26 into the

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valve cup 16 to stop valve movement and therefore the pump 10 from running away (typically caused by the fluid supply being empty or the hose of other supply conduit having a leak/rupture.) The user interface 28 comprises an LCD display 30 and buttons 32 to set up and control the pump 10. The display 30 can be toggled to display cycle rate, flow rate (in various units), total cycles and diagnostic errors. Setup parameters can include fluid units (quarts, liters, etc.) and the runaway set point.

The reed switches 20 and magnets 14 are located so as to detect when the air valve 16 is at the extreme position of each stroke or in transition or both. The controller 12 calculates the rate at which the motor 18 is running by counting the opening and closing of the reed switches 20 activated by the varying positions of the air valve 16. The controller 12 then compares that rate to a pre-programmed value to determine if the air motor 18 is in a runaway condition. When that condition is present, the controller 12 activates the solenoid 24 preventing changeover which stops the motor 18. This acts to prevent spilled fluid and/or pump damage.

A magnetoresistive sensor 34 is located in the center of the air motor 18 to precisely monitor the piston 36 position. The data from this sensor 34 in conjunction with that from the air valve sensors 20 provides the input necessary for precise control and diagnostics of the pump 10 and makes it suitable for metering and plural component application.

It is contemplated that various changes and modifications may be made to the pump control without departing from the spirit and scope of the invention as defined by the following claims.

The claims defining the invention are as follows:

1. An air operated pump having an air valve with an valve cup and a valve cover, said pump including:

5 a magnet mounted in said valve cup of an air motor; and
first and second reed sensors mounted in the valve cover to monitor the speed and position of the valve.

10 2. The air operated pump of claim 1 further including a solenoid having a plunger and being mounted on said valve cover said solenoid being capable of extending said plunger into said valve cup to stop valve movement and therefore the pump from running away.

15 3. The air operated pump of claim 1 further including a user interface monitoring said reed sensors to allow the display of various parameters.

4. The air operated pump of claim 3 wherein said parameters may include cycle rate, flow rate, total cycles and diagnostic errors.

20 5. The air operated pump of claim 1 wherein said air operated pump includes a piston and further including a sensor for sensing the position of said piston.

25 6. The air operated pump of claim 5 wherein said sensor includes a magnetoresistive sensor.

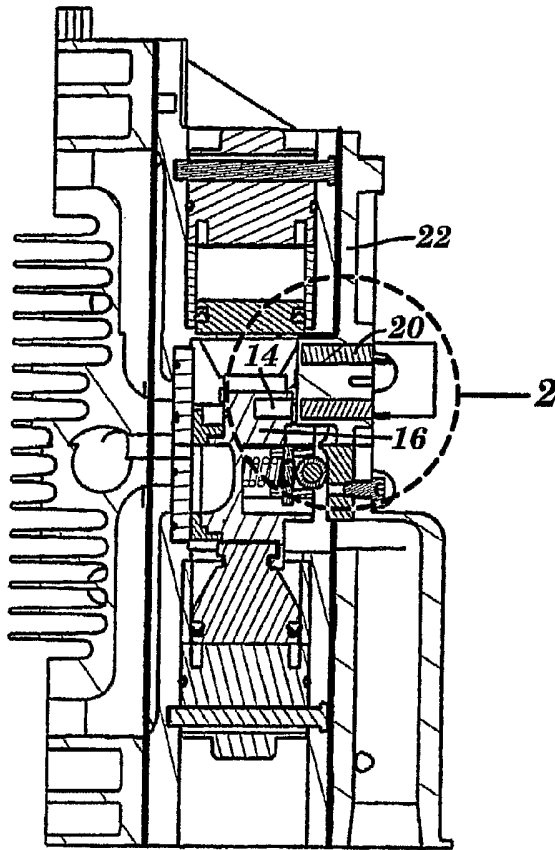


FIG. 1

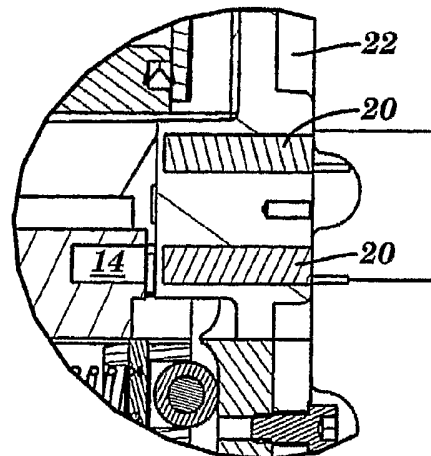


FIG. 2

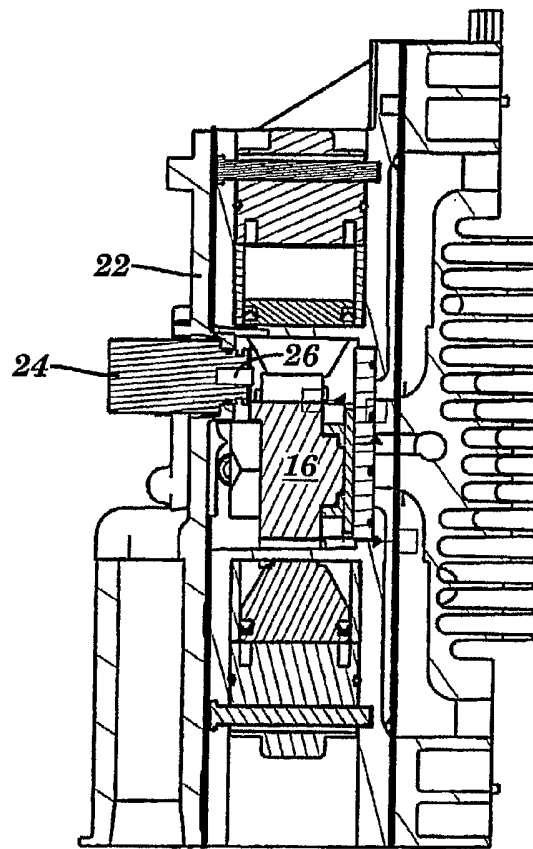


FIG. 3

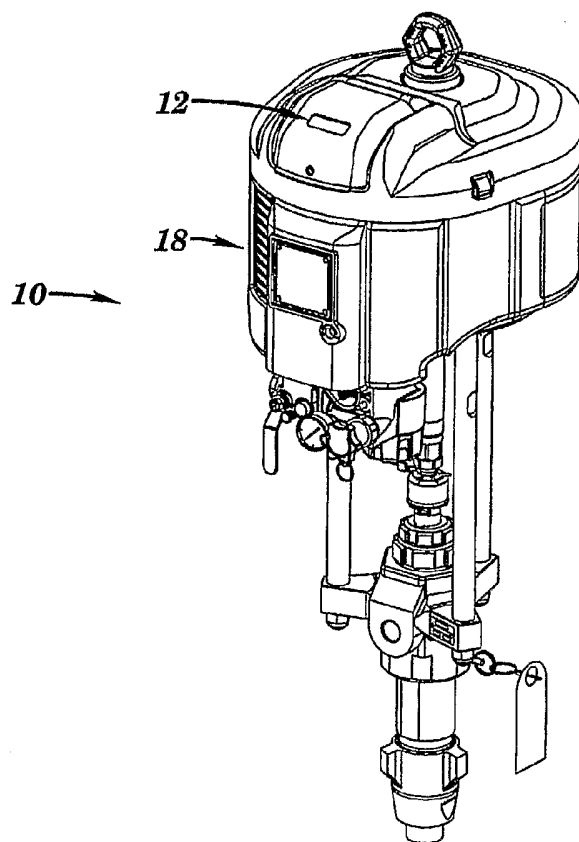


FIG. 4

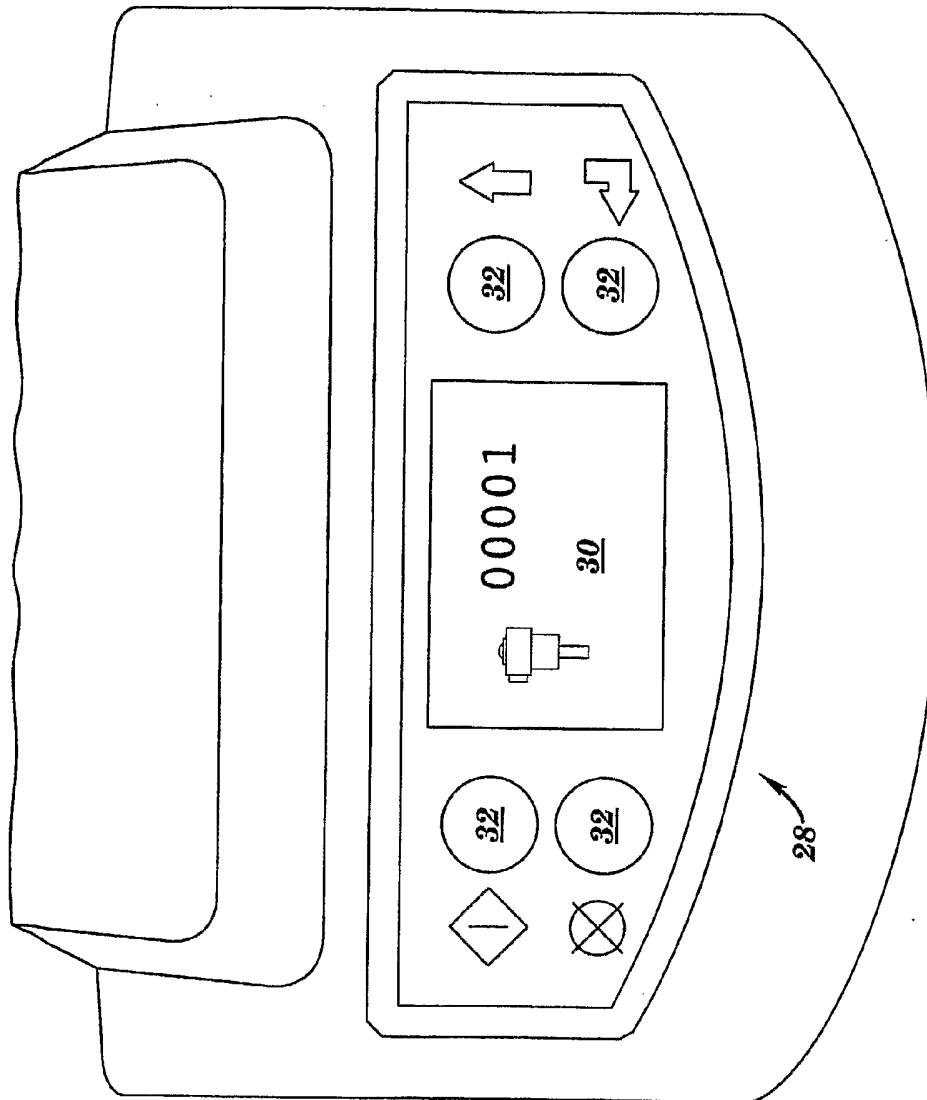


FIG. 5

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PICTURE	DIAGNOSTIC CODE	DIAGNOSTIC NAME	PICTURE	ALARM OR WARNING	TECHNICAL DESCRIPTION	CAUSES
	1	RUNAWAY	THE MOTOR IS IN RUNAWAY. THE CYCLE RATE IS TOO HIGH COMPARED TO THE DESIRED MAXIMUM CYCLE RATE.	ALARM	THE CURRENT PUMP SPEED EXCEEDED THE MAXIMUM CYCLE RATE FOR 5 CONSECUTIVE CYCLES.	PUMP IS RUNNING TOO QUICKLY. CAN OCCUR IF PISTON SEAL OR FOOT VALVE ERROR OCCURS.
	5	SOLENOID FAILURE	THE AIR MOTOR HAS DETECTED A RUNAWAY CONDITION, THE INTERNAL SOLENOID EXTENDED BUT FAILED TO ENGAGE THE VALVE CUP.	WARNING	OCCURS WHEN THE SOLENOID HAS BEEN EXTENDED BUT MOVEMENT STILL OCCURS.	SOLENOID PLUNGER DOES NOT ENGAGE SHUTTLE.
	8	SOLENOID NOT EXTENDED ERROR	THE AIR MOTOR HAS DETECTED A RUNAWAY CONDITION, BUT THE INTERNAL SOLENOID DID NOT EXTEND.	WARNING	OCCURS WHEN THE SOLENOID SHOULD HAVE BEEN EXTENDED BUT DOES NOT.	SOLENOID DOES NOT EXTEND. SOLENOID NOT CONNECTED.
	6	SOLENOID NOT RETRACTED ERROR	THE INTERNAL SOLENOID DID NOT RETRACT WHEN THE RUNAWAY CONDITION WAS CLEARED. MOST LIKELY OCCURS BECAUSE THE AIR VALVE IS STILL ON.	WARNING	OCCURS WHEN THE SOLENOID SHOULD HAVE RETRACTED BUT DOES NOT. MOST LIKELY CAUSED BY THE AIR VALVE BEING TURNED ON.	SOLENOID DOES NOT RETRACT. SOLENOID NOT CONNECTED.
	2	PISTON SEAL	THE PISTON SEAL IS WORN.	WARNING	THE UP STROKE PUMP SPEED IS TWICE AS FAST AS THE DOWN STROKE FOR 5 CONSECUTIVE CYCLES.	
	3	FOOT VALVE	THE FOOT VALVE SEAL IS WORN.	WARNING	THE DOWN STROKE PUMP SPEED IS TWICE AS FAST AS THE UP STROKE FOR 5 CONSECUTIVE CYCLES.	
	7	REED SENSOR ERROR	ONE OF THE REED SENSORS HAS FAILED.	WARNING	OCCURS WHEN ONE OF THE SENSORS IS SWITCHED 5 TIMES WITHOUT THE OTHER SENSOR BEING SWITCHED.	REED SENSOR DOES NOT OPERATE. REED SENSOR WIRE IS BROKEN OR DISCONNECTED.
	4	LOW BATTERY	THE BATTERY NEEDS TO BE REPLACED.	WARNING	OCCURS WHEN THE BATTERY LEVEL IS TOO LOW.	BATTERY VOLTAGE IS TOO LOW.

FIG. 6

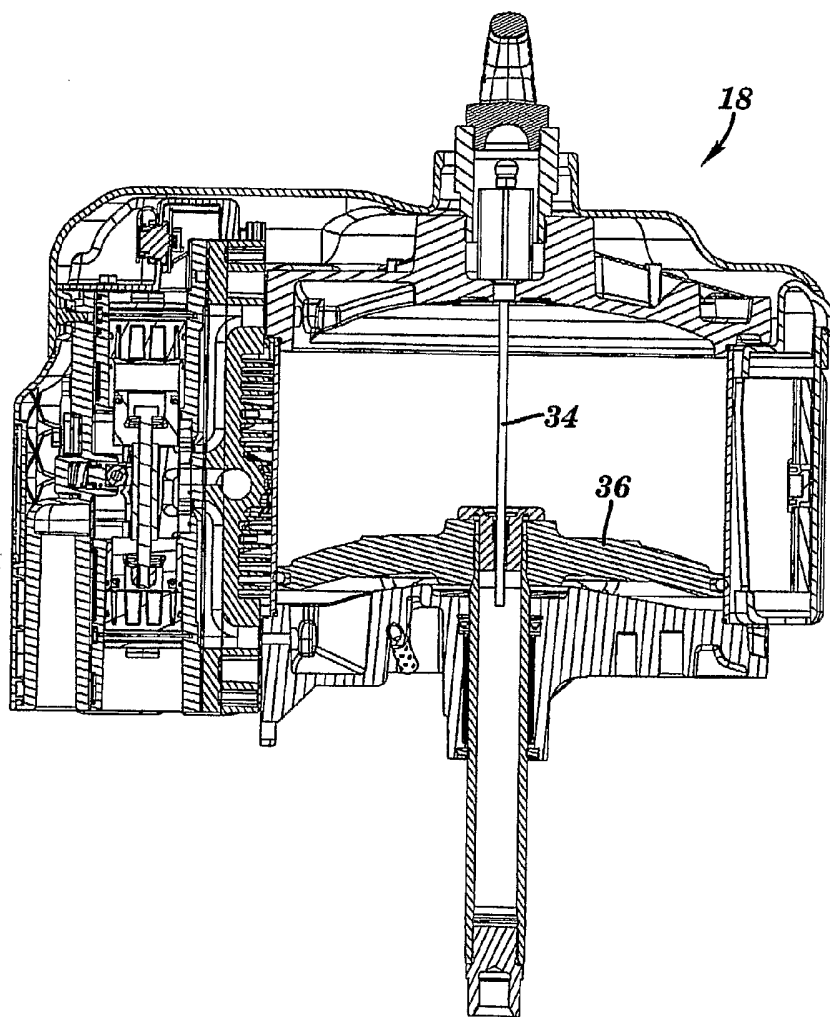


FIG. 7