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AIR SOURCE CONTROL FOR AN AIR OPERATED FLUID SPRAYER

Abstract

A fluid spraying system includes an air source unit operable by a motor to output a flow of pressurized air along an airflow path to a spraying device configured to output a spray of a fluid. When an actuator of the spraying device is in an open position, at least a portion of the pressurized air is emitted through an air outlet. When the actuator of the spraying device is in a closed position, airflow through the air outlet is inhibited. A control system is configured to receive an indication of an air pressure in a vented area configured to vent air when the actuator is in the closed position, generate an indication that the actuator is the closed position or the open position based on the indication of the air pressure, and generate a motor control signal to control the motor of based on the indication.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] The present application is based on and claims the benefit of U.S. provisional patent application Ser. No. 63/551,663, filed Feb. 9, 2024, the contents of which are hereby incorporated by reference in their entirety.

BACKGROUND

[0002] A fluid spraying system can be used by an operator to deliver a fluid from a fluid source to an application area. For example, a protective coating can be sprayed, or otherwise applied, by an applicator, such as a spray gun, to an application area, such as a surface of a wall.

[0003] The discussion above is merely provided for general background information and is not intended to be used as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all noted disadvantages.

SUMMARY

[0004] A fluid spraying system includes an air source unit operable by a motor to output a flow of pressurized air along an airflow path to a spraying device configured to output a spray of a fluid. When an actuator of the spraying device is in an open position, at least a portion of the pressurized air is emitted through an air outlet. When the actuator of the spraying device is in a closed position, airflow through the air outlet is inhibited. A control system is configured to receive an indication of an air pressure in a vented area configured to vent air when the actuator is in the closed position, generate an indication that the actuator is the closed position or the open position based on the indication of the air pressure, and generate a motor control signal to control the motor of based on the indication.

[0005] These and various other features and advantages will be apparent from a reading of the following Detailed Description. This Summary and Abstract are not intended to identify key features or essential features of the claimed subject matter, nor are they intended to be used as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all noted disadvantages.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1-1** is a diagrammatic view showing one example of an air-operated spraying system.

[0007] FIG. **1-2** is a perspective view of one example of an air source unit.

[0008] FIG. **2** is a schematic block diagram showing one example of an air-operated spraying system.

[0009] FIG. **3** is a flow diagram showing an example operation of motor speed control of an air source unit for a fluid sprayer.

[0010] FIG. **4** is a flow diagram showing an example operation of controlling motor speed of an air-operated fluid sprayer.

[0011] FIG. **5** is a flow diagram showing an example operation of controlling motor speed of an air-operated fluid sprayer.

[0012] FIGS. **6-1** and **6-2** (collectively referred to as FIG. **6**) are diagrammatic and exploded views, respectively, showing one example of an air source unit control system for an air operated fluid sprayer.

[0013] FIGS. **7-1** and **7-2** (collectively referred to as FIG. **7**) are cross-sectional views showing one example of an air source unit control system for an air operated fluid sprayer.
[0014] FIGS. **8-1** and **8-2** (collectively referred to as FIG. **8**) illustrate one example of an air source unit control system for an air operated fluid sprayer.
[0015] FIG. **9** is a flow diagram illustrating one example of motor speed control for an air source unit.
[0016] FIG. **10** is a flow diagram illustrating one example of motor speed control for an air source unit.
[0017] FIG. **11** is a flow diagram illustrating one example of motor speed control for an air source unit.
[0018] FIG. **12** is a flow diagram illustrating an example of a process for motor speed control.
[0019] FIGS. **13-1** and **13-1** (collectively referred to as FIG. **13**) provide a flow diagram illustrating an example of a process for motor speed control.
[0020] FIG. **14** is a perspective view of one example of an air source unit.
[0021] FIG. **15** is a cross-sectional view of the air source unit in FIG. **14** taken at line **15-15**.
[0022] FIGS. **16-1** and **16-2** (collectively referred to as FIG. **16**) is a flow diagram showing one example of an air source unit control system for an air operated fluid sprayer.
[0023] FIG. **17** is a graph illustrating detected air pressure over time for an example spray operation.
[0024] FIG. **18** is a derivative graph illustrating the rate of change of the detected air pressure in FIG. **17**.
[0025] FIG. **19** is a graph illustrating detected air pressure over time for an example spray operation.
[0026] FIG. **20** is a derivative graph illustrating the rate of change of the detected air pressure in FIG. **19**.
[0027] FIG. **21** is a graph illustrating detected air pressure over time for an example air source unit ramp down.
[0028] FIG. **22** is a derivative graph illustrating the rate of change of the detected air pressure in FIG. **21**.
[0029] FIG. **23** is a graph illustrating detected air pressure over time for a spray operation during air source unit ramp down, in one example.
[0030] FIG. **24** is a derivative graph illustrating the rate of change of the detected air pressure in FIG. **23**.
[0031] FIG. **25** is a second derivative graph illustrating changes in the rate of change of the detected air pressure in FIG. **23**.
[0032] FIG. **26** is a block diagram showing one example of a computing environment that can be used in the architectures shown in the previous Figures.
[0033] While the above-identified figures set forth one or more examples of the disclosed subject matter, other examples are also contemplated, as noted in the disclosure. In all cases, this disclosure presents the disclosed subject matter by way of representation and not limitation. It should be understood that numerous other modifications and examples can be devised by those skilled in the art which fall within the scope and spirit of the principles of this disclosure.

DETAILED DESCRIPTION

[0034] For the sake of illustration, but not by limitation, aspects of the present disclosure relate to air-operated fluid sprayers, sometimes referred to as pneumatic sprayers, that operate at least partially by air or gas pressure. For example, an air-operated fluid sprayer can utilize a flow of pressurized or compressed air from an air source unit to spray a liquid or other fluid, such as protective or decorative coatings, onto a surface. One example fluid includes paint.
[0035] As used herein, examples of paint include substances composed of coloring matter or pigment suspended in a liquid medium as well as substances that are free of coloring matter or

pigment. Paint can also include preparatory coatings. Paint can be applied to coat a surface as a liquid or a gaseous suspension, for example, and the coating provided can be opaque, transparent, or semi-transparent. Some particular examples include, but are not limited to, latex paint, oil-based paint, stain, lacquers, varnish, inks, and the like.

[0036] While some examples are described herein in the context of applying paint, other types of fluid can be applied to surfaces, including, but not limited to, primer, lacquers, foams, textured materials, plural components, adhesive components, etc.

[0037] Additionally, while some examples below are illustrated in the context of air-operated sprayers such as, but not limited to, high-volume low pressure (HVLP) or low-volume low-pressure (LVLP) sprayers, it is expressly contemplated that the present features can also be applicable to other types of sprayers, etc.

[0038] An air-operated fluid sprayer can use a portable air turbine, air compressor, or other air source, to generate airflow from an air outlet of the air turbine through an air hose to a hand-held spray gun that is controlled by a trigger and uses the air to atomize the fluid. One example of an HVLP sprayer can operate at air pressures between one tenth and ten pounds per square inch (PSI) at the air nozzle and consume air volumes between six and thirty cubic feet per minute (CFM).

[0039] In some applications, an air turbine includes a motor that typically runs at a constant power regardless of whether fluid is being emitted from the spray gun, which can become increasingly taxing to both the energy supply and the fluid sprayer itself as the motor consistently runs at a higher power during operation of the air source. Additionally, due to the pressurized nature of the air source, it is difficult to implement motor control systems without compromising the integrity and functionality of the motor and spraying system.

[0040] Moreover, in such systems having air supplied from an air blower, when the spray gun is not triggered (e.g., the trigger is released, thereby shutting off atomization air), the motor can incur over-speeding and/or over-heating due to the blocked outlet. Not only can this cause increased jobsite noise which is undesirable to the user, this increase in motor speed and heat build-up can cause damage to electrical and/or mechanical parts of the sprayer. Increased heat can also cause abnormal or undesirable spattering on the application area due to over-heating or drying of the applied material.

[0041] Some approaches to mitigate such issues are to detect the airflow and to slow down the motor. However, such approaches often incorporate airflow restrictive mechanisms, such as check valve(s), in the airflow path downstream of the air turbine outlet (i.e., between the air turbine outlet and the spray gun) which operate to trap air pressure in the air hose. This trapped pressure can be measured to determine the operational state of the air source motor. However, these mechanism(s) add restriction in the airflow path resulting in a significant pressure drop, and this airflow restriction must be overcome during normal operation of the air source (e.g., by the air turbine having to run a higher speed and/or pressure to generate the same output at the spray gun).

[0042] The present disclosure is generally directed to a system for providing motor control for an air turbine, or other air source, in an air-operated fluid sprayer. In some described examples below, the motor control scheme is configured in a manner that is non-airflow restrictive. By “non-airflow restrictive” it is meant that any mechanisms, such as sensors and control devices, that are utilized for detecting operation of the sprayer (e.g., whether the trigger is pulled) for purposes of determining how to increase or decrease the speed of the motor, or make other operational changes, has substantially no restriction on the airflow between the outlet of the air turbine and the outlet of the sprayer, such as a spray nozzle on a handheld spray gun. Further, by “substantially” no restriction, it is meant that any restriction that may be imparted, if at all, results in less than one half pound per square inch (PSI) drop. In one example, the pressure drop is less than one quarter PSI.

[0043] Airflow resistance Rf (Pa.Math.s/m3) can be defined as set forth in Equation 1 below.

[00001] $R_f = \quad p / q_v, \quad (\mathrm{Eq}\,.\,l)$

[0044] where Δp is the air pressure difference (referred to as differential pressure) with the respect to atmosphere (Pa), and q.sub.v is the volumetric airflow rating (m3/s). The volumetric airflow rate is q.sub.v=μS, where μ is the linear air velocity (m/s) and S is the cross-section area perpendicular to the direction of the flow (m.sup.2).
[0045] In at least one example discussed below, changes in air pressure at a vented area, such as a bleeder or exhaust port, are detected and used to determine whether air is flowing from the air nozzle, which can be utilized to speed up or slow down the motor driving the air source.
[0046] Alternatively, or in addition, aspects of the power supply, such as current flowing through the motor, the line voltage and/or, the line current, are measured and used to determine adjustments to the operating speed of the motor.
[0047] Alternatively, or in addition, an airflow sensor includes a movable element that reacts to the airflow in the air hose to the spray gun to indicate whether air is flowing through the air hose. While, in some examples, the cross-sectional area of the flow path can reduced by the placement of the movable sensor element in the airflow path, that cross-sectional area restriction is relatively small (e.g., placement of the sensor element results in a decrease in the cross-sectional area that is less than ten percent of the overall cross-sectional area), so as to have a negligible effect on the airflow through the airflow path to the spray gun.
[0048] FIG. **1-1** is a diagrammatic view showing one example of an air-operated spraying system **100**, also referred to as spraying system **100**. Spraying system **100** includes a spray gun **101** having a body **102**, a handle **104** and an actuator **106**, illustratively in the form of a finger trigger, configured to operate a flow control mechanism, such as a valve (e.g., needle valve). However, in other examples, actuator **106** can include a button, a switch, or other type of actuator.
[0049] A fluid reservoir **108** is fluidically coupled to body **102** by a coupler **110** and configured to hold a fluid, such as paint, to be sprayed from a spray nozzle (or spray tip) **112**. Spraying system **100** also includes a hose **114** coupled to an air source unit **116**. Air source unit **116** is configured to generate airflow by drawing air into spraying system **100** through an air inlet and creating a pressured flow of air from an air hose outlet to which hose **114** is connected.
[0050] In one example, air source unit **116** can be an air turbine. However, it is expressly contemplated that other systems capable of producing airflow to spraying system **100** can be utilized as well.
[0051] In operation, the user actuates actuator **106** to open the flow control mechanism, thereby releasing the pressured air from hose **114**, which causes atomization of the fluid from fluid reservoir **108**, which is released from spray nozzle **112**.
[0052] FIG. **1-2** is a perspective view of one example of an air source unit **150** (e.g., air source unit **116**). Air source unit **150** includes a housing **152**, an inlet **154**, an airflow outlet fitting **156**, a power control (i.e., on-off switch) **158**, and a motor speed setting input mechanism **160**. An electrical motor is housed within housing **152** and configured to operate on direct current or alternating current to drive a blower mechanism. A hose (e.g., hose **114**) can be coupled to airflow outlet fitting **156** to supply the airflow to a spray gun or other spray apparatus.
[0053] The motor is controlled by control circuitry to operate the blower in a plurality of different modes depending on a detected configuration of the spray gun (e.g., whether or not the trigger is pulled to release airflow from the spray gun outlet). In one example, the blower is operated in a first low-speed or idle mode when the spray gun is closed (e.g., when the trigger of the spray gun is released) and thus no air is flowing through the spray gun. In this first mode, the speed of the turbine is non-zero (some air is being output by the blower), but since the spray gun is closed, the output air is vented through a vent area, such as a bleeder or exhaust port.
[0054] When an open or spraying configuration is detected (e.g., the user pulls the trigger to release airflow from the spray gun outlet), the blower is driven by the motor at a second high-speed or spraying mode). In one example, the speed at which the blower is driven in the second mode is set or adjusted by user input through mechanism **160**.

[0055] Illustratively, mechanism **160** includes a dial that facilitates user selection of a desired speed setting from a plurality of speed settings. In one example, mechanism **160** adjusts a potentiometer which controls an amount of power supplied to the motor, and thus the speed at which the motor drives the blower. Thus, mechanism **160** controls the rate at which air is output through airflow outlet fitting **156**.

[0056] The air can be compressed and accelerated by a fan, impeller, turbine, or other type of bladed mechanism that is rotated within housing **152** by the motor. The control circuitry can increase and decrease the power output of the motor by increasing and decreasing the power input to the motor.

[0057] FIG. **2** is a schematic block diagram showing one example of an air-operated spraying system **200** (e.g., spraying system **100**), also referred to as spraying system **200**. Spraying system **200** illustratively includes a spray gun **202** having one or more spray nozzles **204** with a spray orifice configured to emit an atomized spray pattern. The spray fluid can be, for example, paint. In one example, the spray fluid and air mix within a mixing chamber in spray gun **202**, and are emitted from the spray orifice. Alternatively, or in addition, one or more air orifices can be disposed proximate the spray orifice to emit a stream of air that assists the spray of fluid from the spray orifice.

[0058] Spraying system **200** additionally includes an air source unit **206** (e.g., air source unit **116**), such as an air turbine, that includes a blower **208** having a fan, impeller, or other type of bladed mechanism, that is driven by an electric motor **210** generate airflow by drawing air into spraying system **200** through an air inlet **212** and to output a flow of pressured air from an air hose outlet **214**, in order to pressurize spraying system **200** and facilitate fluid flow out of spray nozzle **204**. Motor **210** is powered by a power supply **216**, such as a one hundred-twenty volt (V) alternating current (AC) power source. In another example, power supply **216** is a direct current (DC) power supply that powers a brushless DC motor (BLDC).

[0059] Air source unit **206** also includes a vented area **218** configured to vent at least a portion of the air, output by blower **208**, away from the air hose outlet to a point external to spraying system **200**. In one example, vented area **218** includes a bleeder or exhaust port **220** configured to release air to atmosphere. The amount of air bled through vented area **218** changes with restriction to airflow through air hose outlet **214** (i.e., whether or not air is being released from the spray gun **202**). Air source unit **206** can include other items **222** as well.

[0060] As illustrated by the dashed block in FIG. **2**, vented area **218** can be located in other locations in spraying system **200**.

[0061] Spray gun **202** includes a fluid line inlet **224** configured to receive a flow of fluid to be sprayed and an air hose inlet **226** configured to receive the pressured air from the air hose. Spray gun **202** also includes one or more actuators **228**, which are configured to allow fluid flow through nozzle **204**. Actuator(s) **228** can include, for example, a trigger. However, in other examples, a different type of actuator can be used as well.

[0062] Spraying system **200** includes a control system **232** configured to control one or more components of spraying system **200**, such as motor **210**. Control system **232** can include circuitry **234**. As illustrated by the dashed block in FIG. **2**, one or more elements of control system **232** can be included in air source unit **206**.

[0063] Power supply **216** is used to energize control system **232**. In one example, power supply **216** can include a wired configuration. However, in another example, power supply **216** can be in a wireless configuration. Additionally, it is expressly contemplated that power supply **216** can include a different configuration as well.

[0064] Spraying system **200** also illustratively includes one or more valves **236**, one or more sensors **238**, and can include other items **240** as well. As illustrated by the dashed block in FIG. **2**, one or more of sensor(s) **238** can be located in other areas as well.

[0065] Sensor(s) **238** can be coupled to control system **232** and any one or more of the other components in spraying system **200**. For instance, sensor(s) **238** can be coupled to and configured to control air source unit **206**, as further detailed below. In one example, controlling air source unit **206** can include lowering the speed of motor **210**, as further discussed below. In another example, controlling air source unit **206** can include raising the speed of motor **210**.

[0066] Sensor(s) **238** can include a current sensor **242**, a voltage sensor **244**, a vented air pressure sensor **246**, an airflow sensor **248**, an airflow indication sensor **250**, and can include other sensors **252** as well.

[0067] In one example, current sensor **242** is configured to detect a magnitude and/or changes in the current flowing through motor **210**. In one example, current sensor **242** is configured to sense the line current from power supply **216**. Voltage sensor **244** is configured to detect a magnitude and/or changes in the voltage from power supply **216** (e.g., line voltage). Based on the detected current and/or voltage, control system **232** can responsively change the motor run speed to an associated setting. For example, current sensor **242** can detect a rise in current, indicating that a motor run speed is to be set too high. In another example, current sensor **242** can detect a decrease in current, indicating that a motor run speed is to be set too low. As discussed in further detail below, the changes in the current and/or the voltage can result from changes in the power draw of motor **210**, which resulted from turbine speed changes caused by airflow changes when the user opens and closes the spray gun valve.

[0068] Vented air pressure sensor **246** is configured to detect changes in air pressure in vented area **218**. In one example, sensor **246** includes a bleeder port pressure sensor **254** configured to detect changes in pressure at bleeder port **220**, as airflow is bled from air source unit **206**. Sensor **246** can include other sensors **256** as well.

[0069] One example of airflow sensor **248** is described in further detail below with respect to FIG. **8**. Airflow sensor **248** is configured to detect airflow through a flow tube of air source unit **206** and additionally detect any change in flow rate provided by air source unit **206** through the flow tube. In one example, airflow sensor **248** can include a hot wire anemometer. However, in another example, a different type of flow sensor can be utilized as well.

[0070] One example of airflow indication sensor **250** is described in further detail below with respect to FIGS. **6-7**. In operation, as air is flowing through air source unit **206**, a sensing element portion of airflow indication sensor **250** is biased into a position that engages with a corresponding sensing portion. When air is no longer flowing through air source unit **206**, the sensing element portion disengages with the sensing portion, which generates a signal that is transmitted to control system **232**, which determines that the motor speed should responsively decrease. Additionally, as air begins flowing through air source unit **206**, the sensing element portion is once again biased to engage with the sensing portion, which generates a signal that is transmitted to control system **232**, which determines that the motor speed should responsively increase.

[0071] FIG. **3** is a flow diagram **300** showing one example of an operation for control of motor speed of an air source unit for a fluid sprayer. In one example, the operation illustrated in FIG. **3** is performed, at least in part, by control system **232** and is non-airflow restrictive.

[0072] As noted above, non-airflow restrictive refers to configurations in which the effect on the airflow, caused by any sensors or other devices that detect or otherwise control operation of the air source unit, between the outlet of the air source unit and the spray gun is such that there is substantially no restriction in airflow, and thus a reduced pressure drop, which improves performance of the spraying system.

[0073] For example, a non-airflow restrictive approach does not utilize check valve(s) (or other types of valves) to trap the pressure in the flow path between the outlet of the air source unit and the spray gun. As noted above, use of such a valve would restrict the airflow such that a significant pressure drop would result in the airflow across the check valve.

[0074] While FIG. **3** will be discussed in the context of an air turbine and a spray gun, other types of air sources and sprayers can be utilized. For sake of illustration, but not by limitation, FIG. **3** will be discussed in the context of FIG. **2**.

[0075] At block **302**, the motor **210** of air source unit **206** is initialized. Initialization can include a power up sequence in which the power supply **216** connects a source of power to motor **210** or motor **210** is otherwise energized. One example of a power supply is a one hundred twenty volt alternating current (AC) power source.

[0076] At block **304**, a motor speed input is received. Block **304** can include a speed setting input by a user indicative of a desired pressure and/or flow rate for a target spraying operation, as represented at block **306**. Of course, the motor speed input can be received in other ways as well, as represented at block **308**.

[0077] At block **310**, motor **210** is operated at the speed setting to drive the air source unit **206** to drive pressurized air from the air hose outlet **214** through an air hose to spray gun **202**. An actuator **228**, such as actuator **106** shown in FIG. **1-1**, is actuatable by the user to open and close a valve in spray gun **202**, which selectively opens and closes the airflow path. When the valve is open, airflows through the air hose (e.g. hose **114**) and out of nozzle **204**. When the valve is closed, airflow from nozzle **204** is blocked which stops the flow of airflow through the air hose. In some examples, the spray gun **202** can include an air bleed port which causes a small portion of air to be bled from the spray gun when the valve is closed.

[0078] Due to the slowing or stopping of the airflow through the air hose, motor **210** can tend to incur over-speeding and/or over-heating, due to the blocked air outlet. To mitigate the effects of an over-heating condition (and/or over-speeding), motor speed control is performed at block **312**. In the illustrated example, the motor speed control is non-airflow restrictive as the motor speed control does not require mechanisms along the airflow path that restricts the airflow. Block **312** detects when the airflow path is blocked due to the user releasing the actuator of spray gun **202** and operates to decrease the motor speed to slow the air source. When the actuator of spray gun **202** is subsequently actuated by the user to open the valve and allow airflow through nozzle **204**, block **312** detects this change and can operate to increase the speed of motor **210** and prevent an undesired significant pressure drop which would otherwise adversely affect the spray pattern.

[0079] One example of block **312** is illustrated in block **314**. For example, at block **316**, one or more sensor inputs are received from sensors **238**. For example, the sensor input(s) can include a current sensor input (block **318**) received from current sensor **242**. Alternatively, or in addition, the sensor input(s) can include a pressure sensor input **320** from pressure sensor **246**, such as a vented air pressure sensor **246**, configured to measure the air pressure in vented area **218**. For sake of illustration, when airflow from air hose outlet **214** is reduced, the airflow from bleeder port **220** increases, and this increase can be detected as an increase in pressure by sensor **238**. Conversely, when airflow from air hose outlet **214** increases, a decrease in pressure can be detected at bleeder port **220**.

[0080] Alternatively, or in addition, at block **322**, a voltage sensor signal can be detected by a voltage sensor **244**. Alternatively, or in addition, an airflow signal **324** can be detected by airflow sensor **248**. Of course, other types of sensor inputs can be received as well, as represented at block **326**.

[0081] At block **328**, a motor speed adjustment is determined based on the sensor inputs received at block **316**. The motor speed adjustment can indicate a desired increase or decrease to the motor speed (e.g., motor revolutions per minute-RPMs).

[0082] At block **330**, the motor speed adjustment is utilized to change the motor speed setting. Operation can continue at block **332** in which the motor is operated at the current speed setting and motor speed control at block **312** can be performed based on any subsequent changes detected by sensors **238**.

[0083] FIG. **4** is a flow diagram showing an example operation of controlling motor speed of an air-operated fluid sprayer. The motor speed control can be accomplished in a number of manners. For example, the motor speed can be controlled utilizing any one or more of the sensors described above with respect to FIG. **2**. Operation **400** begins at block **410** where the air-operated fluid sprayer is powered up, or otherwise activated. The fluid sprayer can be powered up by, for example, a switch, a button, a power cable, or by any other method of supplying power to the fluid sprayer. As indicated at block **410**, the initial power up phase can include idling for a preset time as the spraying system achieves full power. In one example, the idle time is about 0.2 seconds. However, in another example, a longer idle time can be implemented as well. Additionally, in another example, no idle time may be required.

[0084] The operation proceeds at block **420** where the idle time elapses and initial power-up phase of the air-operated fluid sprayer is completed. At block **420**, the sprayer can be actuated or otherwise used to begin or resume a spraying job. Actuation of the fluid sprayer can be accomplished by, for example, using actuator **106** described above with respect to FIG. **1-1**. As indicated at block **420**, actuating or otherwise operating the fluid sprayer includes increasing the power to the electric motor of the fluid sprayer to a maximum.

[0085] Upon reaching maximum power, the operation proceeds at block **430** where the motor of the air source unit (e.g., a turbine) is defined as a high speed. As indicated at block **430**, if the motor was previously set to a lower speed, and therefore the output power was set to less than maximum, the output voltage is increased until returning to maximum power and defined high speed. As a decrease in airflow is detected, or low airflow is otherwise indicated, the operation proceeds at block **440** where the defined high speed is maintained for an idle period. As indicated above, the change in airflow can be detected by utilizing any one or more of the sensors described above with respect to FIG. **2** and further described below with respect to FIGS. **5-8**. The decrease in airflow can occur, in one example, by releasing actuator **106** described above with respect to FIG. **1-1**. The idle period is selected such that changes and/or modifications in the airflow provided by the air source unit (e.g., a turbine) can be detected. In one example, the idle period can be 10 seconds. In another example, the idle period can be 30 seconds. In another example, the idle period can be greater than **30** seconds. Additionally, in one example, the idle period can be manually set and/or modified by an operator of the spraying system.

[0086] As indicated in block **440**, the output power of the spraying system does not change during the idle period, and the operation can proceed in two modes based on airflow detection. If an increase in airflow is detected within the idle period, the motor of the air source unit is signaled to maintain the motor's high speed and maximum power, and the idle period time resets. The increase in airflow can occur by, for example, actuation of the actuator of the spraying system. Alternatively, if the idle period expires with no detection of airflow change (e.g., the spraying system is not being actuated), the operation proceeds at block **450** where the motor is signaled to decrease to a defined low speed, and the output power of the spraying system responsively decreases to a low level relative to the maximum power. As indicated at block **450**, if a change in airflow is detected that is indicative of an increase in airflow, the motor is signaled to increase to the defined high speed at block **430**, and the output power of the spraying system responsively increases until the output power returns to a maximum. In this way, the motor speed can be controlled based on airflow detection of the air source unit relative to fluid sprayer use in real-time.

[0087] FIG. **5** is a flow diagram showing an example operation of controlling motor speed of an air-operated fluid sprayer. Operation **500** can be accomplished by, for example, utilizing a current sensor, as described above with respect to FIG. **2**. Operation **500** begins at block **510** with initializing the air-operated fluid sprayer. Initializing the fluid sprayer can include, for example, powering up the spraying system similarly to block **410** described above with respect to FIG. **4**.

[0088] The operation proceeds at block **520** where a motor of the air source unit is set to run at a defined speed relative to whether the spraying system is being operated or idle. For example, as shown at block **520**, the motor is set at a defined low speed. However, it is expressly contemplated that the motor can alternatively be set to a defined high speed after initialization based on use of the spraying system. Upon detection of an increase in current consumed by the motor, the operation proceeds at block **530** where a timer having a predefined period begins based on the detected increase in current. The active period is selected such that changes and/or modifications in the current of the motor can be detected. Specifically, the active period is selected such that the current sensor senses the consistency of the current increase and/or whether the increased current is maintained, indicative of the spraying system being in continued use. In one example, the active period can be approximately 10 seconds. In another example, the active period can be greater than 10 seconds. In another example, the active period is less than 10 seconds (e.g., approximately 7 seconds). Additionally, in one example, the active period can be manually set and/or modified by an operator of the spraying system.

[0089] If the increase in current is maintained and the active period time elapses, the operation proceeds at block **540** where a signal is sent by the control system to the motor of the air source unit, causing the motor to switch to a defined high speed. The motor is configured to maintain the high-speed setting throughout continued use of the spraying system. Upon detection of a decrease in current consumed by the spraying system, the operation proceeds at block **550** where a timer having a predefined period begins based on the detected decrease in current. The idle period is selected such that changes and/or modifications in the current of the fluid sprayer (e.g., the motor) can be detected. Specifically, the idle period is selected such that the current sensor senses the consistency of the current decrease and/or whether the decreased current is maintained, indicative of spraying system use being discontinued. Upon the detection of the decrease in current and the idle time elapsing, the operation reverts to block **520**, where the motor returns to the defined low speed.

[0090] FIGS. **6-1** and **6-2** (collectively referred to as FIG. **6**) are diagrammatic and exploded views, respectively, showing one example of an air source unit control system for an air operated fluid sprayer. Air source unit **600** (illustratively a turbine) has an air inlet (not shown) and is configured to take in and compress air before delivering the compressed air at outlet **604**. As shown, air source unit **600** is powered by electric motor **602** that drives a blower assembly **603** that includes a fan, impeller, turbine, or other type of bladed mechanism that is rotated within a housing **605**.

[0091] In operation, air source unit **600** is coupled to a fluid sprayer at outlet **604** by a hose (not shown) and is configured to provide an airflow path for airflow through the hose and to the sprayer in order to pressurize the fluid sprayer and atomize the spray fluid. Air source unit **600** can be coupled to the hose in a number of configurations. For example, air source unit **600** can be threadably coupled to the hose. In another example, air source unit **600** can be coupled to the hose by a barbed fitting.

[0092] As shown in FIG. **6**, air source unit **600** illustratively includes flow indication sensor **606** coupled to and disposed within the flow tube of air source unit **600** near outlet **604**. Flow indication sensor **606** includes housing **608** and top portion **610** configured to secure the internal components of flow indication sensor **606** therein. Top portion **610** is coupled to housing **608** via fasteners **612**. Additionally, housing **608** is coupled to the flow tube via one or more fasteners **612**. As shown, fasteners **612** can include threaded fasteners, such as screws. However, it is expressly contemplated that other non-restrictive fasteners can be used as well, such as bolts.

[0093] Flow indication sensor **606** illustratively includes sensing element **614** configured to be retained within housing **608** and top portion **610**. As further described below with respect to FIG. **6**, sensing element **614** is configured to be disposed slightly within the top exterior of the flow tube. As shown in FIG. **6**, sensing element **614** is configured to be secured to air source unit **600** by securing mechanism **616**. Sensing element **614** has access to the interior of the flow tube via an aperture secured by aperture lining **618**. By combining housing **608**, top portion **610**, fasteners **612**, and aperture lining **618**, sensing element **614** has access to airflow within the flow tube without compromising the pressurized environment of air source unit **600**.

[0094] In operation, and further detailed below, sensing element **614** is configured to be secured within housing **608** and slightly sink into the flow tube when airflow is at a low flow rate and/or absent. Upon increasing flow rate within the flow tube, sensing element **614** is biased upwards out of the aperture defined by aperture lining **618** towards top portion **610** and within sensing portion **620**. As shown in FIG. **6-2**, sensing portion **620** includes a concave portion configured to allow sensing element **614** therethrough. As airflow biases sensing element **614** within the concave portion of sensing portion **620**, a control signal is transmitted via wiring **622** to motor **602**. The control signal can include, in one example, a signal to change the motor speed to a defined high speed. As airflow within the flow tube decreases and/or airflow is no longer present, sensing element **614** sinks slightly out of sensing portion **620** and into the flow tube. Upon sensing element **614** descending out of sensing portion **620**, a control signal is transmitted via wiring **622** to the control system to cause motor **602** to change the motor speed to a defined low speed. In this way, the speed of motor **602** can be regulated relative to the level of airflow present within the flow tube at varying points of the spraying operation.

[0095] FIGS. **7-1** and **7-2** (collectively referred to as FIG. **7**) are cross-sectional views showing one example of an air source unit control system for an air operated fluid sprayer. Air source unit **700** illustratively includes a flow indication sensor **702** coupled to flow tube **704**. Flow indication sensor **702** includes sensing element **706** disposed within housing **708** and top portion **710**. As shown in FIG. **7-1**, sensing element **706** is disposed at a position slightly sunken into flow tube **704**. As airflow within flow tube **704** increases, sensing element **706** is biased upwards towards sensing portion **712**, as shown in FIG. **7-2**. As sensing element **706** pivots towards sensing portion **712**, a control signal is transmitted to the control system via wiring **714**. As indicated above, the control signal can include, for example, a signal to change the motor speed to a defined high speed. As airflow diminishes within flow tube **704** relative to the use of air source unit **700**, sensing element **706** descends from sensing portion **712** and sinks towards flow tube **704**. The movement of sensing element **706** responsively causes a signal to be sent to the control system via wiring **714** to cause the control system to control the motor to change the motor speed to a defined low speed. Due to the contained nature of flow indication sensor **702**, controlling the motor based on airflow is achievable while retaining the pressurized environment of the fluid sprayer.

[0096] FIGS. **8-1** and **8-2** (collectively referred to as FIG. **8**) are cross-sectional views showing one example of an air source unit control system for an air operated fluid sprayer. FIG. **8-2** is a view taken at line B-B in FIG. **8-1**.

[0097] As shown in FIG. **8**, air source unit **800** illustratively includes flow sensor **802** generally disposed within flow tube **806**. Flow sensor **802** includes a first hot wire anemometer **804** and a second hot wire anemometer **805**. When air is flowing through flow tube **806**, hot wire anemometer **804** operates by transferring heat from the wire to the airflow, thereby reducing the temperature of the wire portion of hot wire anemometer **804**, corresponding to a change in resistance of hot wire anemometer **804** indicative of a measure of flow rate. Hot wire anemometer **805** is disposed within a plastic (or other suitable material) tube **810**, which shields hot wire anemometer **805** from the airflow in flow tube **806**.

[0098] As resistance of hot wire anemometer **804** changes, indicative of a change in airflow within flow tube **806**, a signal is sent via wiring **808** to the control system to change the speed of the motor of the air source unit relative to the airflow. For example, if the airflow within flow tube **806** is low, indicative of a stall in operation of the fluid sprayer, hot wire anemometer **804** of flow sensor **802** increases in temperature, thereby changing the resistance of hot wire anemometer **804** and sending a control signal to the control system to cause the motor to change to a defined low speed based on the detected airflow. In another example, if airflow within flow tube **806** increases, indicative of continued operation of the fluid sprayer, hot wire anemometer **804** decreases in temperature, thereby changing the resistance of hot wire anemometer **804** and sending a corresponding control signal to cause the motor to change to a defined high speed.

[0099] Because hot wire anemometer **805** is shielded from the airflow, the temperature sensed by hot wire anemometer **805** is less effected by the airflow. In this way, the signal from hot wire anemometer **805** can be utilized as a control comparison, that is the signal from hot wire anemometer **805**, indicating changes in temperature of hot wire anemometer **805**, can be compared to the signal from hot wire anemometer **804** to determine the airflow rate. A signal indicative of the comparison can sent to the control system to control the motor of air source unit **800** based on the detected change in airflow.

[0100] FIG. **9** is a flow diagram **900** illustrating one example of motor speed control performed at block **312**.

[0101] At block **902**, motor **210** is operated at the user speed setting and, at block **904**, a decrease in current is detected. In one example, block **904** detects that the current has decreased more than a threshold amount over a predefined time sampling window. If so, operation proceeds to block **906**, which determines whether one or more disqualifying events have occurred. Examples of the detection of disqualifying events are discussed below with respect to FIG. **13**. Briefly, however, a disqualifying event is used to determine whether a detected increase or decrease in current is to be ignored, such that there is no change to the motor speed setting. If a disqualifying event is detected, operation returns to block **902**. Block **910** detects when the timer has expired, which is detected as a time-out event. Prior to the time-out event (represented by loop **914**), block **912** determines whether or not an increase in current (e.g., more than a threshold increase in current over a defined time period) occurs. If no increase in current is detected, operation proceeds to block **916**. At block **916**, the motor is run at a reduced low-speed setting until an increase in current is detected at block **918**. Upon this detection of the increase in current at block **918**, operation proceeds to block **920** which detects one or more disqualifying events, as discussed above with respect to block **906**.

[0102] Returning to block **912**, if an increase in current is detected, operation proceeds to block **922**. One example of detecting disqualifying events is discussed above with respect to block **906**.

[0103] FIG. **10** is a flow diagram **1000** illustrating one example of motor speed control performed at block **312**.

[0104] At block **1002**, motor **210** is operated at the user speed setting and, at block **1004**, an increase in pressure at the exhaust port of the air turbine is detected. In one example, block **1004** detects that the pressure has increased more than a threshold amount over a predefined time sampling window. If so, operation proceeds to block **1006**, which determines whether one or more disqualifying events have occurred. Examples of the detection of disqualifying events are discussed below with respect to FIG. **13**. Briefly, however, a disqualifying event is used to determine whether a detected increase or decrease in pressure is to be ignored, such that there is no change to the motor speed setting. If a disqualifying event is detected, operation returns to block **1002**. Block **1010** detects when the timer has expired, which is detected as a time-out event. Prior to the time-out event (represented by loop **1014**), block **1012** determines whether or not a decrease in pressure (e.g., more than a threshold decrease in pressure over a defined time period) occurs. If no decrease in pressure is detected, operation proceeds to block **1016**. At block **1016**, the motor is run at a reduced low-speed setting until a decrease in pressure is detected at block **1018**. Upon this detection of the decrease in pressure at block **1018**, operation proceeds to block **1020** which detects one or more disqualifying events, as discussed above with respect to block **1006**.

[0105] Returning to block **1012**, if a decrease in pressure is detected, operation proceeds to block **1022**. One example of detecting disqualifying events is discussed above with respect to block **1006**.

[0106] FIG. **11** is a flow diagram **1100** illustrating one example of motor speed control performed at block **312**.

[0107] At block **1102**, motor **210** is operated at the user speed setting and, at block **1104**, a decrease in current is detected along with an increase in pressure at the exhaust port. In one example, block **1104** detects that the current has decreased more than a threshold amount over a predefined time sampling window. If so, operation proceeds to block **1106**, which determines whether one or more disqualifying events have occurred. Examples of the detection of disqualifying events are discussed below with respect to FIG. **13**. Briefly, however, a disqualifying event is used to determine whether a detected increase or decrease in current and/or pressure is to be ignored, such that there is no change to the motor speed setting. If a disqualifying event is detected, operation returns to block **1102**. Block **1110** detects when the timer has expired, which is detected as a time-out event. Prior to the time-out event (represented by loop **1114**), block **1112** determines whether or not an increase in current (e.g., more than a threshold increase in current over a defined time period) occurs along with a decrease in pressure at the exhaust port. If no increase/decrease is detected, operation proceeds to block **1116**. At block **1116**, the motor is run at a reduced low-speed setting until an increase in current is detected at block **1118**. Upon this detection of at block **1118**, operation proceeds to block **1120** which detects one or more disqualifying events, as discussed above with respect to block **1106**.

[0108] Returning to block **1112**, if an increase in current is detected along with a decrease in pressure at the exhaust port, operation proceeds to block **1122**. One example of detecting disqualifying events is discussed above with respect to block **1106**.

[0109] FIG. **12** is a flow diagram **1200** illustrating examples of subprocesses for an increase in pressure and a decrease in pressure.

[0110] At block **1202**, the raw sensor data is obtained and used to create or update a moving average filter at block **1204**. The raw data can represent the changes to pressure and/or current over time. A new data timer can be set at block **1206** after which a time-out event is identified at block **1208** and operation returns to block **1202** in which additional sensor data is obtained to adjust the moving average filter.

[0111] At block **1210**, a calibration timer is set. Upon occurrence of expiration of the calibration timer (represented by block **1212**), operation proceeds to block **1214** in which a new trigger threshold is calculated. However, prior to expiration of the time, the moving average filter data is compared to a trigger threshold level at block **1216**. If this comparison indicates an increase in pressure, operation proceeds to block **1218**. If an indication of a decrease in pressure is identified, operation proceeds to block **1220**.

[0112] At block **1218**, if the moving average filter data is above a data threshold, a disqualifying event subprocess is called at block **1222**. Similarly, if the moving average filter data is below the data threshold at block **1220**, the disqualifying event subprocesses is called as represented at block **1222**.

[0113] At block **1218**, if the moving average filter data is at or below the threshold level, the operation proceeds to block **1206** and waits for timeout at block **1208**. Likewise, at block **1220**, if the data is above or at the trigger threshold, the operation proceeds to block **1206** and waits for timeout at block **1208**.

[0114] FIGS. **13-1** and **13-2** (collectively referred to as FIG. **13**) provide a flow diagram **1300** illustrating one example of a disqualifying event subprocess. For example, the operation illustrated in FIG. **13** can be performed at one or more of blocks **906**, **920**, **922**, **1006**, **1020**, **1022**, **1106**, **1120**, and/or **1122**.

[0115] At block **1302**, saved sensor data is accessed and a statistical analysis is performed at block **1304**. The type of statistical analysis performed can be selected based on the type of sensors used for sensing the operation (this is represented at block **1306**).

[0116] For example, block **1308** determines whether there is no change in voltage or the change in voltage is within an acceptable slope range. Alternatively, or in addition, block **1310** includes a statistical analysis of a voltage history for a min, max, or mean difference in a Gaussian distribution. Alternatively, or in addition, block **1312** detects whether there is change in current within an acceptable slope range. Alternatively, or in addition, block **1314** performs a statistical analysis of a current history for a min, max, or mean difference in a Gaussian distribution. Alternatively, or in addition, block **1316** determines whether a change in pressure is within an acceptable slope range.

[0117] At block **1318**, the results of each of the one or more statistical analyses that are used are assigned a weight based upon an importance metric. The weights can be identified and applied in any of a number of ways. In any case, the results of the weights are calculated and compared to a maximum allowed level.

[0118] At block **1320**, operation determines whether the results of the calculated weights are above the maximum allowed level. If the result is below the maximum allowed level, operation proceeds to block **1322** which will be performed depending on whether or not adaptive triggering is utilized. If adaptive triggering is not being utilized, operation proceeds to block **1324** in which a passing result is returned and the subprocess of FIG. **13** is exited.

[0119] Adaptive triggering raises or lowers the trigger thresholds of voltage, current, and or pressure based on external line noise or environment changes. Furthermore, the weighted average from the disqualifications will be increased or decreased (less sensitive or more sensitive respectively) in the opposing direction of the triggering threshold change mentioned above.

[0120] If adaptative triggering is utilized, operation proceeds to block **1326** which determines whether a rolling counter is reduced below a set point. If so, operation proceeds to block **1328** in which tolerances of disqualifications and trigger level is adjusted to accommodate less noisy conditions.

[0121] If the results at block **1320** are above the maximum allowed level, operation proceeds to block **1330**. If adaptive triggering is not being utilized, operation proceeds to block **1332**. At block **1332**, a failing result is returned and the subprocess is exited.

[0122] If adaptive triggering is utilized, operation proceeds to block **1334** in which a rolling counter is incremented. If the rolling counter exceeds a threshold, as identified at block **1336**, the tolerances can be adjusted to accommodate noisier conditions.

[0123] The adjustments to the tolerances at blocks **1326** and **1338** can operate to account for noisy power supply conditions. For sake of illustration, but not by limitation, different power supplies may have different variations in current levels for a variety of reasons. Thus, the current and/or voltage sensors may detect more changes when one power supply is utilized versus another, regardless of the operation of the fluid sprayer. The process shown in FIG. **13** adjusts the tolerances to accommodate for these differences and learn the characteristics of the current power supply being utilized.

[0124] FIG. **14** is a perspective view of one example of air source unit **150** with a portion of housing **152** omitted for illustration purposes. FIG. **14** will be discussed in conjunction with FIG. **15**, which is a cross-section view taken at line **15-15** in FIG. **14**.

[0125] As shown, a motor **1402** is configured to drive rotation of a blower **1404** to provide a flow of air through a conduit **1406** having airflow outlet fitting **156**. An air hose (e.g., hose **114**) is coupled to airflow outlet fitting **156** which forms an airflow path to a spray gun or other applicator (e.g., spray gun **101**). When the spray gun is actuated (e.g., a user pulls the trigger to release a mixture of the spray fluid and air), airflows in a downstream direction generally represented by arrow **1408** (also referred to as direction **1408**). When the trigger is released (i.e., the spray gun is in a non-spraying configuration), airflow ceases in direction **1408**.

[0126] Air source unit **150** includes a vented area **1410** configured to vent at least a portion of the airflow, generated by air source unit **150**, to a point external to the air source unit (e.g., to atmosphere). Vented area **1410** illustratively includes at least a portion of conduit **1406** (e.g., an area in conduit **1406** upstream of airflow outlet fitting **156**), a vent fitting **1411**, and a vent conduit **1412** to a bleeder or exhaust port (not shown in FIG. **14**) configured to release a portion of the air from blower **1404** to atmosphere. Air is vented through vented area **1410** both when air is being released from the spray gun (i.e., air is flowing in direction **1408**) as well as when the spray gun is closed (i.e., there is no airflow in direction **1408**). In this way, the flow rate and/or pressure in vented area **1410** fluctuates in response to opening and closing of the airflow path through the spray gun.

[0127] Air source unit **150** includes a vented air pressure sensor **1414** fluidically coupled to vented area **1410** by a conduit **1416**. Illustratively, vented air pressure sensor **1414** is exposed to pressurized air in vented area **1410** by conduit **1416** branching from vent fitting **1411**, and is configured to generate indication of the air pressure in vented area **1410**. In the example of FIGS. **14** and **15**, vented air pressure sensor **1414** is configured to detect the changes in pressure in a non-trapped air volume. That is, the air within vented area **1410** is not trapped within air source unit **150**, even when the airflow path through the spray gun is closed. Further, this detection of changes in airflow along the airflow path to the spray gun is accomplished through a sensing and control scheme that is non-airflow restrictive.

[0128] As shown in FIG. **15**, the flow path through vented area **1410** includes a first orifice **1420** having a first cross-sectional area and a second orifice **1422** having a second cross-sectional area. Conduit **1416** is fluidically coupled to vented area **1410** between orifices **1420** and **1422**. In the illustrated example, the second cross-sectional area of orifice **1422** is smaller than a cross-sectional area of orifice **1420**. The size of orifices **1420** and/or **1422** can be selected based on a desired air pressure sensing precision. In one example, orifice **1420** has a diameter of approximately one-quarter inch and orifice **1422** has a diameter of approximately one-eighth inch.

[0129] Further, it is noted that sensor **1414** can be fluidically coupled to vented area **1410** to sense the vented air pressure in other ways. For instance, in one example, sensor **1414** can be fluidically coupled directly to conduit **1406**. In another example, sensor **1414** can be configured to detect air pressure in a chamber that is coupled to a side **1424** of conduit **1406** that is opposite a side **1426** on which the orifice **1420** for the bleeder port resides. In any case, sensor **1414** is configured to detect pressure changes in vented area **1410**.

[0130] FIGS. **16-1** and **16-2** (collectively referred to as FIG. **16**) is a flow diagram **1600** showing one example of motor speed control for an air source unit. Some or all features of flow diagram **1600** can be implemented by a control system, such as control system **232**. For sake of illustration, but not by limitation, FIG. **16** will be discussed in the context of spraying system **200**.

[0131] At block **1602**, spraying system **200** is initialized, such as by powering up control system **232** (e.g., operably connecting spraying system **200** to a power source). At block **1604**, control system **232** receives an indication of a motor speed setting. The motor speed setting can be defined for one or more operational modes. For example, a motor speed for motor **210** can be set for a spraying mode (block **1608**). The spraying mode motor speed is used to control the speed at which motor **210** drives blower **208** when control system **232** detects that spray gun **202** is in an open position (e.g., trigger is pulled by the user). Also, a motor speed for motor **210** can be set for an idle mode (block **1610**). The idle mode is illustratively a relatively lower speed mode, compared to the spraying mode, and is used to control the speed at which motor **210** drives blower **208** when spray gun **202** is in a closed position (e.g., fluid is not being sprayed). In one example, the motor speed for the idle mode is determined based on the motor speed setting for the spraying mode (e.g., the idle mode speed is a predetermined ratio of the spraying mode speed).

[0132] In one example, at block **1612**, the motor speed setting is determined based on a user setting input, such as a potentiometer (block **1614**) or other input mechanism (block **1616**), which specifies the desired motor speed for the spraying mode. Of course, the motor speed setting can be set in other ways as well, as represented at block **1618**.

[0133] At block **1620**, control system **232** generates a motor control signal based on the detected mode and/or the motor speed setting. For instance, control system **232** operates the motor at a first, low or idle speed when spray gun **202** is not spraying and at a second, high or spraying speed when spray gun **202** is spraying.

[0134] At block **1622**, air source unit **206** is operated in a steady state mode, in which spraying system **200** remains in one of the spraying mode or the idle mode. Accordingly, control system **232** operates motor **210** at the first speed (block **1624**) or the second speed (block **1626**). In either mode, air is continuously flowing through vented area **218**, regardless of whether spray gun **202** is opened or closed, as represented at block **1628**.

[0135] If operation continues at block **1630** (e.g., spraying system **200** remains powered on), at block **1632** an air pressure at vented area **218** is detected by vented air pressure sensor **246**. Based on a sensor signal from vented air pressure sensor **246**, control system **232** performs steady state detection at block **1634** to identify trigger pulls (or trigger releases) which start (or stop) the airflow through spray gun **202**. In the illustrated example, the detection is based on air pressure changes in vented area **218** relative to one or more thresholds, as indicated at block **1636**. For instance, in one example, a rate of change of the air pressure in vented area **218** over time is utilized to detect trigger pulls or trigger releases, which is represented by block **1638**.
[0136] For sake of illustration, but not by limitation, FIG. **17** illustrates a graph **1700** representing a vented air pressure curve detected by sensor **246**, in one example. FIG. **18** illustrates a graph **1800** representing the rate of change (or derivative) of the vented air pressure curve from FIG. **17**. The derivative of the pressure curve represents the rate of change of pressure with respect to another variable, in this case, time. The derivative of pressure over time (dP/dt) describes how fast the pressure is changing over time. A positive derivative (dP/dt>0) indicates that pressure is increasing. A negative derivative (dP/dt<0) means pressure is decreasing. A zero derivative (dP/dt=0) indicates that pressure is constant.
[0137] In graph **1700**, pressure is represented along the y-axis **1702** (in units of Pascals (Pa), or Newtons (N) per square meter) and time is represented along the x-axis in milliseconds (ms). As shown at reference numeral **1706**, a drop in the vented air pressure occurs when the user pulls the trigger of spray gun **202**. As shown at reference numeral **1708**, when the trigger is released, the vented air pressure rises.
[0138] In graph **1800**, the value of the derivative is represented on the y-axis **1802** and time is again represented on x-axis **1804**. A first, positive, rate of change threshold is represented by line **1806** and a second, negative, rate of change threshold is represented by line **1808**. When the derivative crosses the positive rate of change threshold, control system **232** determines that a positive spike in the pressure derivative has occurred, corresponding to a release of the trigger of spray gun **202** (i.e., a stop spraying condition). When the derivative crosses the negative rate of change threshold, control system **232** determines that a negative spike in the pressure derivative has occurred, corresponding to a pull of the trigger of spray gun **202** (i.e., a start spraying condition). In the example of FIG. **18**, the shaded area between a time at which the negative rate of change threshold is crossed (represented by reference numeral **1810**) and a time at which the positive rate of change threshold is crossed (represented by reference numeral **1812**) is identified as a spraying operation in which the trigger is pulled and held open to release the spraying of fluid using the pressurized air.
[0139] FIG. **19** illustrates a graph **1900** representing a vented air pressure curve detected by sensor **246**, in one example of the user pulling and releasing the trigger multiple times. In FIG. **19**, pressure is represented along the y-axis **19002** and time is represented along the x-axis **1904**.
[0140] FIG. **20** illustrates a graph **2000** representing the rate of change of the vented air pressure curve from FIG. **19**. In FIG. **20**, the value of the derivative is represented on the y-axis **2002** and time is represented on the x-axis **2004**.
[0141] As shown in FIG. **19**, there are multiple drops in the vented air pressure, which correspond to points in the graph of FIG. **20** where the derivative crosses a negative rate of change threshold represented by line **2006**. These points are represented by reference numeral **2008**. Also, there are multiple spikes in the vented air pressure, which correspond to points in the graph of FIG. **20** where the derivative crosses a positive rate of change threshold represented by line **2010**. These points are represented by reference numeral **2012**.
[0142] As can be seen, in the described example, multiple trigger pulls in rapid succession can be detected even where the air pressure does not return to the steady state pressure in between temporally adjacent pulls.
[0143] Referring again to FIG. **16**, at block **1640**, control system **232** detects whether a state

change has occurred based on the detection of trigger pulls or trigger releases at block **1634**. If block **1640** detects that a begin or start spraying condition (i.e., the user pulls the trigger) occurs during the idle mode in which the motor is running at the low or idle speed, operation proceeds to block **1642**. If block **1640** detects that a stop spraying condition (i.e., the user releases the trigger) occurs during the spraying mode in which the motor is running at the higher or spraying speed, operation proceeds to block **1644**.

[0144] In response to the start spraying condition at block **1642**, block **1646** initiates a motor speed change to ramp up the motor speed.

[0145] In response to the stop spraying condition at block **1644**, block **1648** initiates a timer for a ramp down delay. The ramp down delay defines a time window, following release of the trigger, motor speed is slowed down. In one example, the ramp down delay is ten seconds, but this, of course, is for sake of example only. The ramp down delay can prevent undesired motor slowdowns between relatively short interval of trigger releases and trigger pulls.

[0146] At block **1650**, control system **232** performs steady state detection of a trigger pull during the ramp down delay (i.e., before expiration of the timer and the motor speed is slowed). If a trigger pull is detected, operation returns the block **1632**. If a trigger pull is not detected, operation proceeds in a loop (through block **1652**) until the timer has expired. After the timer expires, operation proceeds the block **1654** in which the motor speed is ramped down to the first or idle speed.

[0147] At block **1656**, non-steady state detection is performed during ramp up (from block **1646**) or ramp down (from block **1654**). During the non-steady state detection, trigger pulls or trigger releases are detected based on pressure changes at block **1658**.

[0148] FIG. **21** illustrates a graph **2100** showing a pressure curve during air source ramp down when the user is not spraying, in one example. During the spraying mode, the air source unit is operated at a first pressure, which is detected as a first vented air pressure represented at reference numeral **2102**. At a time represented by reference numeral **2104**, the air source begins a ramp down which lowers the air source unit to a second pressure during an idle mode, represented at reference numeral **2106**.

[0149] FIG. **22** illustrates a graph **2200** showing the derivative, or rate of change, of the pressure curve in graph **2100**. As shown, there is a single large negative spike in dP/dT which cross a negative rate of change threshold **2202**. However, in this example, the threshold cross is due to the air source unit ramp down, and not user actuation of the trigger. To distinguish pressure drops due to motor speed ramp down from pressure drops due to trigger actuation, block **1660** calculates the rate of change of the rate of change of the vented air pressure. Illustratively, block **1660** calculates the second derivative of the vented air pressure. The trigger pulls or trigger releases are detected, in one example, based on a number of inflection points in the rate of change (e.g., the number of zero crossings in the second derivative) (block **1662**) and/or comparison of the second derivative to a threshold (block **1664**).

[0150] To illustrate, FIG. **23** illustrates a graph **2300** showing a pressure curve during air source ramp down when the user actuates the trigger to begin spraying, in one example. As can be seen, there is a slight change in inflection of the downward slope at reference **2302**. FIG. **24** illustrates a graph **2400** showing the derivative, or rate of change, of the pressure curve in graph **2300**. As can be seen at reference numeral **2402**, the trigger pull during ramp down results in multiple peaks and valleys in the derivative (dP/dT). These inflection points in the rate of change can be seen in the second derivative graph **2300** shown in FIG. **25**.

[0151] In one example, block **1660** identifies a number of instances in which the second derivative crosses zero after the second derivative value had met or exceeded one of an upper threshold **1502** or a lower threshold **1504** (referred to as “zero crossings”). If the number of zero crossings meets a count threshold (e.g., more than one), control system **232** determines that the trigger was pulled (or released, depending on whether the crossing occurred on the downward or upward slope of the first derivative).

[0152] Referring again to FIG. **16**, at block **1666**, the operation determines whether a trigger pull is detected during ramp down. If so, operation returns to block **1646**. At block **1668**, the operation determines whether a trigger release is detected during ramp up. If so, operation returns to block **1648**.

[0153] It should also be noted that the different examples described herein can be combined in different ways. That is, parts of one or more examples can be combined with parts of one or more other examples. All of this is contemplated herein.

[0154] It will be noted that the above discussion has described a variety of different systems, components and/or logic. It will be appreciated that such systems, components and/or logic can be comprised of hardware items (such as processors and associated memory, or other processing components, some of which are described below) that perform the functions associated with those systems, components and/or logic. In addition, the systems, components and/or logic can be comprised of software that is loaded into a memory and is subsequently executed by a processor or server, or other computing component, as described below. The systems, components and/or logic can also be comprised of different combinations of hardware, software, firmware, etc., some examples of which are described below. These are only some examples of different structures that can be used to form the systems, components and/or logic described above. Other structures can be used as well.

[0155] The present discussion has mentioned processors and/or servers. In one embodiment, the processors and/or servers include computer processors with associated memory and timing circuitry, not separately shown. The processors and/or servers are functional parts of the systems or devices to which the processors and/or servers belong and are activated by and facilitate the functionality of the other components or items in those systems.

[0156] Also, the figures show a number of blocks with functionality ascribed to each block. It will be noted that fewer blocks can be used so the functionality is performed by fewer components. Also, more blocks can be used with the functionality distributed among more components.

[0157] As used herein, if a description includes “one or more of” or “at least one of” followed by a list of example features with a conjunction “or” between the penultimate example feature and the last example feature, then this is to be read such that (1) one example includes at least one of or one or more of each feature of the listed features, (2) another example includes at least one of or one or more of only one feature of the listed features, and (3) another example includes some combination of the listed features that is less than all of the features and more than one of the features.

[0158] As used herein, if a description includes “one or more of” or “at least one of” followed by a list of example features with a conjunction “and” between the penultimate example feature and the last example feature, then this is to be read such that the example includes at least one of or one or more of each feature of all the listed features.

[0159] As used herein, if a description includes “one or more of” or “at least one of” followed by a list of example features with a conjunction “and/or” between the penultimate example feature and the least example feature, then this is to be read such that, in one example, the description includes “one or more of” or “at least one of” followed by a list of example features with a conjunction “or” between the penultimate example feature and the last example feature, and, in another example, the description includes “one or more of” or “at least one of” followed by a list of example features with a conjunction “and” between the penultimate example feature and the last example feature.

[0160] It will be understood that the term exceeding with reference to a value exceeding a threshold value, as used herein, does not mean, in every example, that the value is greater than the threshold value. Rather, it will be understood that exceeding means that the value does not satisfy the threshold value, which can, in some examples, mean that the value is greater than the threshold value or, in other examples, can mean that the value is less than the threshold value. Also, in some examples, a threshold value can be a range of values and thus, exceeding means that the value does not satisfy the threshold value range (e.g., is outside of the range, whether higher or lower).

[0161] The above discussion has described a variety of different systems, components, logic, and interactions. One or more of these systems, components, logic and/or interactions can be implemented by hardware, such as processors, memory, or other processing components. Some particular examples include, but are not limited to, artificial intelligence components, such as neural networks, that perform the functions associated with those systems, components, logic, and/or interactions. In addition, the systems, components, logic and/or interactions can be implemented by software that is loaded into a memory and is executed by a processor, server, or other computing component, as described below. The systems, components, logic and/or interactions can also be implemented by different combinations of hardware, software, firmware, etc., some examples of which are described below. These are some examples of different structures that can be used to implement any or all of the systems, components, logic, and/or interactions described above.

[0162] FIG. **26** is one example of a computing environment in which elements of the above figures, or parts of it, (for example) can be deployed. With reference to FIG. **26**, an example system for implementing some embodiments includes a computing device in the form of a computer **2610**. Components of computer **2610** may include, but are not limited to, a processing unit **2620** (which can comprise processors or servers from previous FIGS.), a system memory **2630**, and a system bus **2621** that couples various system components including the system memory to the processing unit **2620**. The system bus **2621** may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. Memory and programs, or other elements, described with respect to FIG. **2** can be deployed in corresponding portions of FIG. **26**.

[0163] Computer **2610** typically includes a variety of computer readable media. Computer readable media can be any available media that can be accessed by computer **2610** and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer readable media may comprise computer storage media and communication media. Computer storage media is different from, and does not include, a modulated data signal or carrier wave. Computer storage media includes hardware storage media including both volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules or other data. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by computer **2610**. Communication media may embody computer readable instructions, data structures, program modules or other data in a transport mechanism and includes any information delivery media. The term “modulated data signal” means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal.

[0164] The system memory **2630** includes computer storage media in the form of volatile and/or nonvolatile memory such as read only memory (ROM) **2631** and random-access memory (RAM) **2632**. A basic input/output system **2633** (BIOS), containing the basic routines that help to transfer information between elements within computer **2610**, such as during start-up, is typically stored in ROM **2631**. RAM **2632** typically contains data and/or program modules that are immediately accessible to and/or presently being operated on by processing unit **2620**. By way of example, and not limitation, FIG. **26** illustrates operating system **2634**, application programs **2635**, other program modules **2636**, and program data **2637**.

[0165] The computer **2610** may also include other removable/non-removable volatile/nonvolatile computer storage media. By way of example only, FIG. **26** illustrates a hard disk drive **2641** that reads from or writes to non-removable, nonvolatile magnetic media, an optical disk drive **2655**, and nonvolatile optical disk **2656**. The hard disk drive **2641** is typically connected to the system bus **2621** through a non-removable memory interface such as interface **2640**, and optical disk drive **2655** is typically connected to the system bus **2621** by a removable memory interface, such as interface **2650**.

[0166] Alternatively, or in addition, the functionality described herein can be performed, at least in part, by one or more hardware logic components. For example, and without limitation, illustrative types of hardware logic components that can be used include Field-programmable Gate Arrays (FPGAs), Application-specific Integrated Circuits (e.g., ASICs), Application-specific Standard Products (e.g., ASSPs), System-on-a-chip systems (SOCs), Complex Programmable Logic Devices (CPLDs), etc.

[0167] The drives and their associated computer storage media discussed above and illustrated in FIG. **26**, provide storage of computer readable instructions, data structures, program modules and other data for the computer **2610**. In FIG. **26**, for example, hard disk drive **2641** is illustrated as storing operating system **2644**, application programs **2645**, other program modules **2646**, and program data **2647**. Note that these components can either be the same as or different from operating system **2634**, application programs **2635**, other program modules **2636**, and program data **2637**.

[0168] A user may enter commands and information into the computer **2610** through input devices such as a keyboard **2662**, a microphone **2663**, and a pointing device **2661**, such as a mouse, trackball or touch pad. Other input devices (not shown) may include a joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit **2620** through a user input interface **2660** that is coupled to the system bus but may be connected by other interface and bus structures. A visual display **2691** or other type of display device is also connected to the system bus **2621** via an interface, such as a video interface **2690**. In addition to the monitor, computers may also include other peripheral output devices such as speakers **2697** and printer **2696**, which may be connected through an output peripheral interface **2695**.

[0169] The computer **2610** is operated in a networked environment using logical connections (such as a local area network-LAN, or wide area network-WAN or a controller area network-CAN) to one or more remote computers, such as a remote computer **2680**.

[0170] When used in a LAN networking environment, the computer **2610** is connected to the LAN **2671** through a network interface or adapter **2670**. When used in a WAN networking environment, the computer **2610** typically includes a modem **2672** or other means for establishing communications over the WAN **2673**, such as the Internet. In a networked environment, program modules may be stored in a remote memory storage device. FIG. **26** illustrates, for example, that remote application programs **2685** can reside on remote computer **2680**.

[0171] It should also be noted that the different examples described herein can be combined in different ways. That is, parts of one or more examples can be combined with parts of one or more other examples. All of this is contemplated herein.

[0172] Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts mentioned above are disclosed as example forms of implementing the claims. Workers skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and scope of the invention.

Claims

1. A fluid spraying system comprising: an air source unit operable by a motor to output a flow of pressurized air along an airflow path to a spraying device configured to output a spray of a fluid, the spraying device having an air outlet, wherein, when an actuator of the spraying device is in an open position, at least a portion of the pressurized air is emitted through the air outlet, and, when the actuator of the spraying device is in a closed position, airflow through the air outlet is inhibited; and a control system configured to: receive an indication of an air pressure in a vented area, wherein the vented area is configured to vent air when the actuator of the spraying device is in the closed position; generate an indication that the actuator of the spraying device is the closed position or the open position based on the indication of the air pressure; and generate a motor control signal to control the motor of the air source unit based on the indication.

2. The fluid spraying system of claim 1, wherein a pressure drop of the airflow path between the air source unit and the spraying device is less than a one-half pound per square inch (PSI).

3. The fluid spraying system of claim 1, wherein the indication comprises an air pressure signal from a vented air pressure sensor, and the vented area is vented to atmosphere both when the actuator of the spraying device is in the closed position and when the actuator of the spraying device is in the open position.

4. The fluid spraying system of claim 3, wherein the vented area comprises a bleeder port.

5. The fluid spraying system of claim 1, wherein the spraying device comprises a spray gun, the air source unit comprises a blower, the motor comprises an electrical motor, and the control system is configured to control a speed of the motor by increasing or decreasing electrical power to the motor.

6. The fluid spraying system of claim 5, wherein the blower comprises at least one of a fan, an impeller, or a turbine that is rotatably driven by the motor to output the flow of pressurized air

7. The fluid spraying system of claim 1, wherein the actuator comprises a trigger configured to control a valve to actuate between the closed position and the open position to control the spray of the fluid using the pressurized air.

8. The fluid spraying system of claim 7, wherein the indication indicates an actuation of the valve from the closed position to the open position that initiates the spray of the fluid using the pressurized air, and the motor control signal defines an increase of a motor speed of the motor in response to the indication of the actuation of the valve.

9. The fluid spraying system of claim 7, wherein the indication indicates an actuation of the valve from the open position to the closed position that stops the spray of the fluid, and the motor control signal defines a decrease of a motor speed of the motor in response to the indication of the actuation of the valve.

10. The fluid spraying system of claim 9, wherein the motor speed is decreased after a predefined time delay following the indication of the actuation of the valve.

11. The fluid spraying system of claim 1, wherein the control system is configured to: determine a rate of change of the air pressure in the vented area with respect to time; and detect actuation of the actuator of the spraying device from the open position to the closed position based on a comparison of the rate of change to a rate of change threshold.

12. The fluid spraying system of claim 11, wherein the control system is configured to: based on the actuation of the actuator of the spraying device from the open position to the closed position, generate the motor control signal to initiate a ramp down of a motor speed of the motor.

13. The fluid spraying system of claim 12, wherein the control system is configured to: during the ramp down of the motor speed of the motor, detect an occurrence of one or more inflection points in the rate of change of the air pressure; and based on the occurrence of the one or more inflection points, detect actuation of the actuator of the spraying device from the closed position to the open position during the ramp down, and, in response, increase the motor speed.

14. The fluid spraying system of claim 1, wherein the control system is configured to: operate in a first control mode during a first time period in which a motor speed of the motor remains in a steady state; and operate in a second control mode during a second time period in which the motor speed is increased or decreased.

15. The fluid spraying system of claim 14, wherein the first control mode controls the motor speed based on a rate of change of the air pressure in the vented area; and the second control mode controls the motor speed based on detected inflection points in the rate of change of the air pressure.

16. A method of controlling a fluid spraying system, the method comprising: operating an air source unit to output an airflow, having a first airflow rate, along an airflow path to an outlet of the fluid spraying system to spray a fluid; detecting a first spray condition that restricts the airflow through the outlet; in response to the first spray condition, operating the air source unit to output the airflow at a second airflow rate that is less than the first airflow rate; while the air source unit is operated to output the airflow at the second airflow rate, receiving one or more sensor signals indicative of one or more characteristics in a vented area of the fluid spraying system and detecting a second spray condition that resumes airflow through the outlet based on the one or more sensor signals; and operating the air source unit to increase the airflow based on the detecting the second spray condition.

17. The method of claim 16, wherein the one or more characteristics comprises a vented air pressure in the vented area of the fluid spraying system.

18. The method of claim 17, and further comprising: determining a rate of change of the vented air pressure with respect to time; and detecting actuation of the fluid spraying system from an open position to a closed position based on a comparison of a rate of change of the vented air pressure to a rate of change threshold.

19. The method of claim 17, wherein the first spray condition comprises a cease spray condition in which the outlet is switched from an open configuration to a closed configuration, and the second spray condition comprises a start spray condition in which the outlet is switched from the closed configuration to the open configuration, the method comprises: operating a motor of the air source unit at a first speed based on the cease spray condition, and operating the motor of the air source unit at a second speed based on the start spray condition.

20. A fluid spraying system comprising: an air source unit configured to provide airflow along an airflow path to a spraying device configured to output a spray of a fluid from a spray nozzle, wherein a pressure drop of the airflow path between the air source unit and the spraying device is less than a one-half pound per square inch (PSI). a motor configured to drive the air source unit; and a control system configured to: receive one or more sensor signals indicative of an operation that changes the airflow along the airflow path; and generate a motor control signal to control a motor speed of the motor based on the indication.

21. The fluid spraying system of claim 20, wherein the one or more sensor signals are indicative of at least one of: a line current to the motor, a line voltage to the motor, an airflow in the airflow path, or an air pressure in the airflow path.

22. The fluid spraying system of claim 20, wherein the control system is configured to: detect a spraying condition indicative of a user operating the spraying device to begin the spray of the fluid from the spray nozzle based on detected changes in air pressure in a vented area of the fluid spraying system; and generate the motor control signal to increase the motor speed of the motor based on the spraying condition.