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(54) **LOW PRESSURE ELECTRICALLY OPERATED PNEUMATIC PAINTBALL GUN**

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(52) **U.S. Cl.** **124/73**; 124/77
(58) **Field of Search** 124/73, 75, 77

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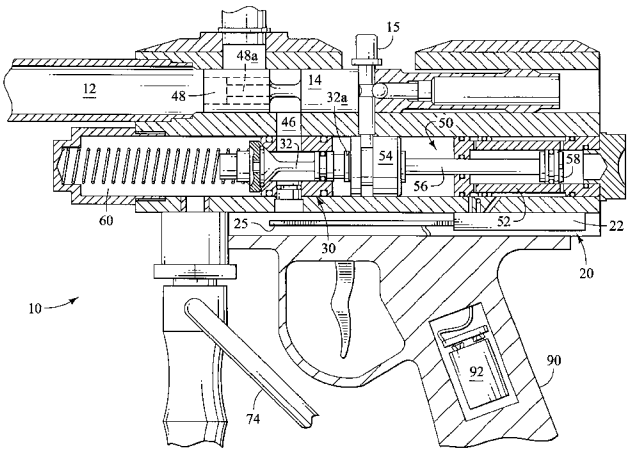
(57) **ABSTRACT**

A paintball gun according to this invention comprises a pressure regulator, an electronic solenoid valve, a firing valve assembly, a pneumatic ram assembly, and a firing chamber. The pressure regulator is configured to provide low pressure gas to a solenoid valve to control loading and firing operations of the paintball gun. The pressure regulator is further configured to supply low pressure gas to the firing chamber via operation of the firing valve assembly during a firing operation. The firing valve assembly can be configured with an opening, a valve chamber, and an exit port in fluid communication with the firing chamber, each having a size sufficient to allow an appropriate volume of gas flow to be supplied to the firing chamber with no significant drop-off in pressure. The firing valve assembly can also be provided with an o-ring seated around the valve cap to provide sensitivity to the firing valve, allowing it to open and close quickly in order to ensure near instantaneous shutoff with minimal load. The firing valve assembly is opened by the operation of the pneumatic ram assembly during a firing operation. The pneumatic ram assembly may also be connected to a bolt assembly via a mechanical assembly to perform a loading operation.

20 Claims, 4 Drawing Sheets



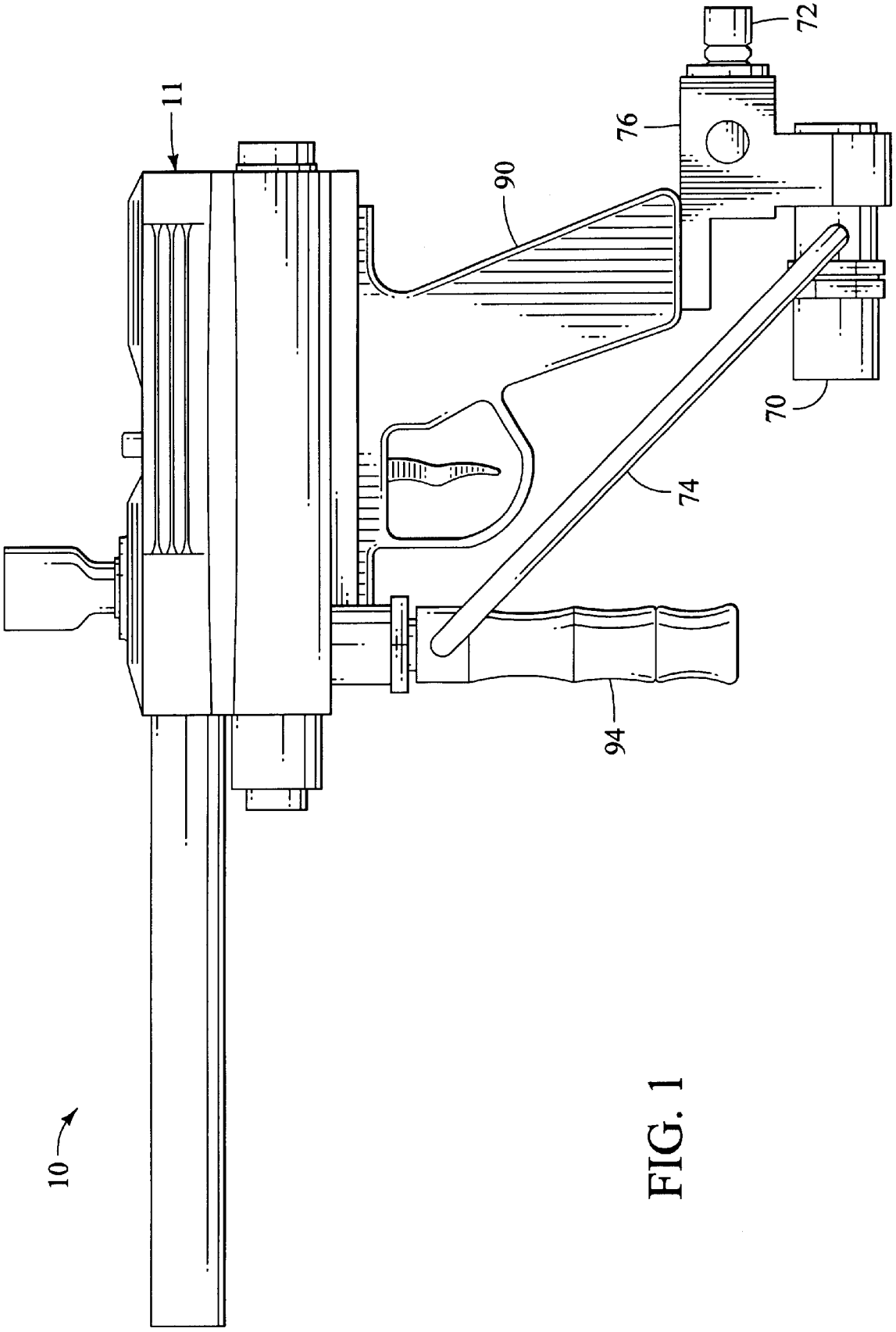
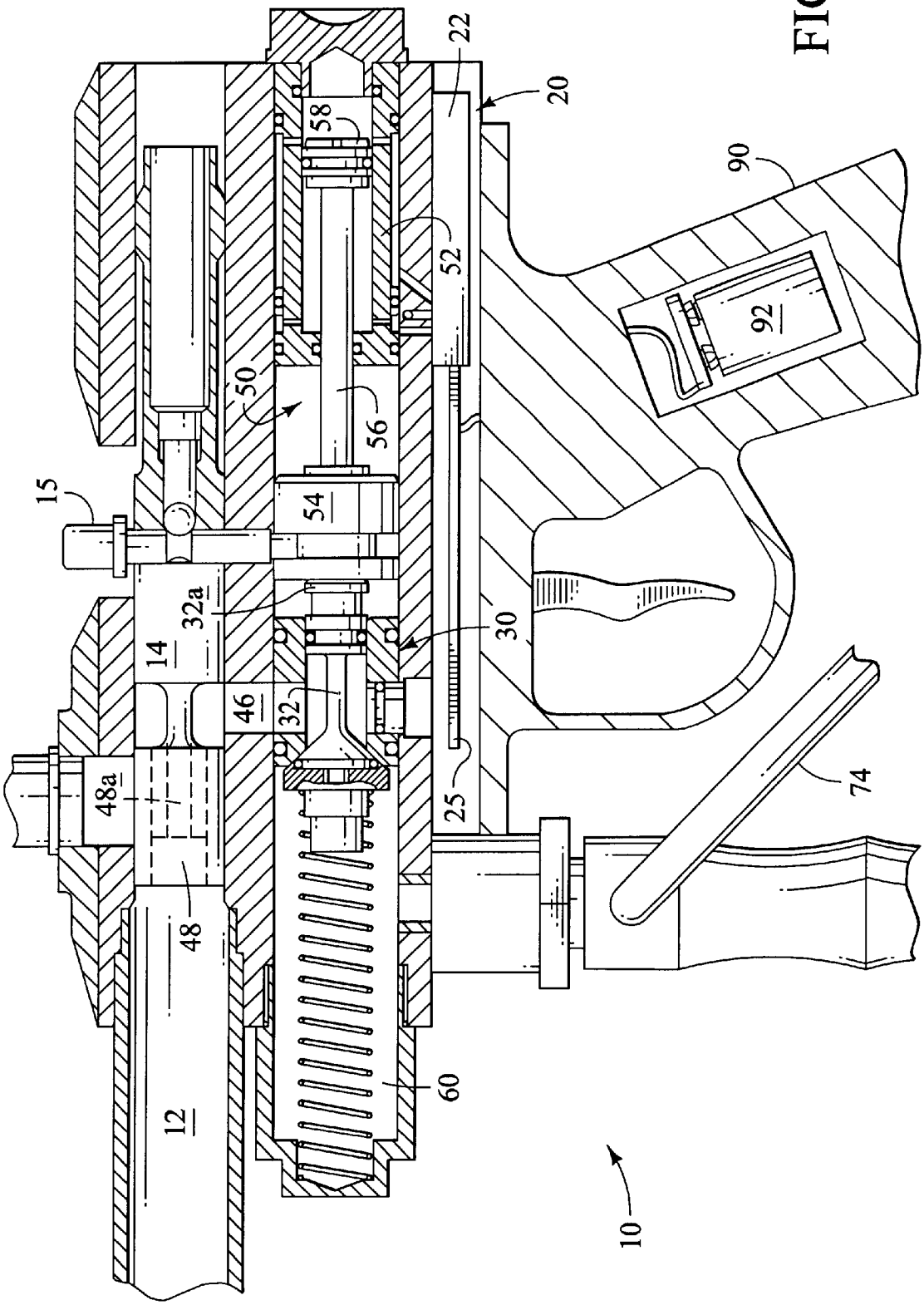


FIG. 1

FIG. 2



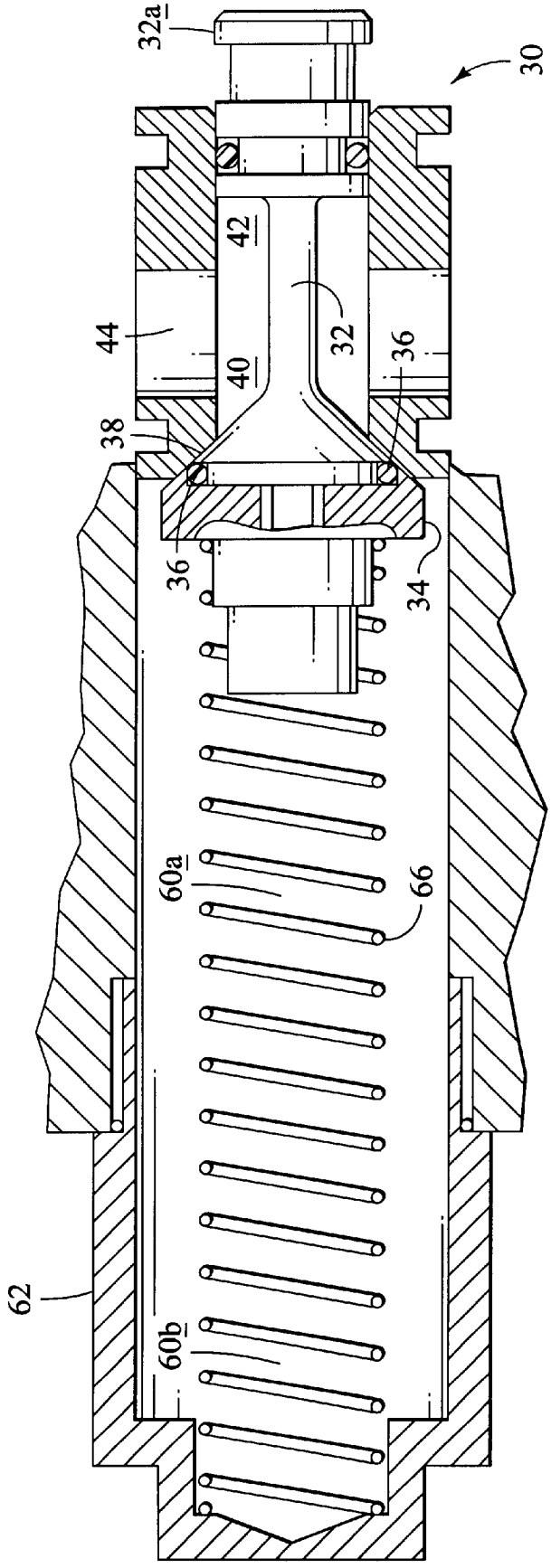


FIG. 3

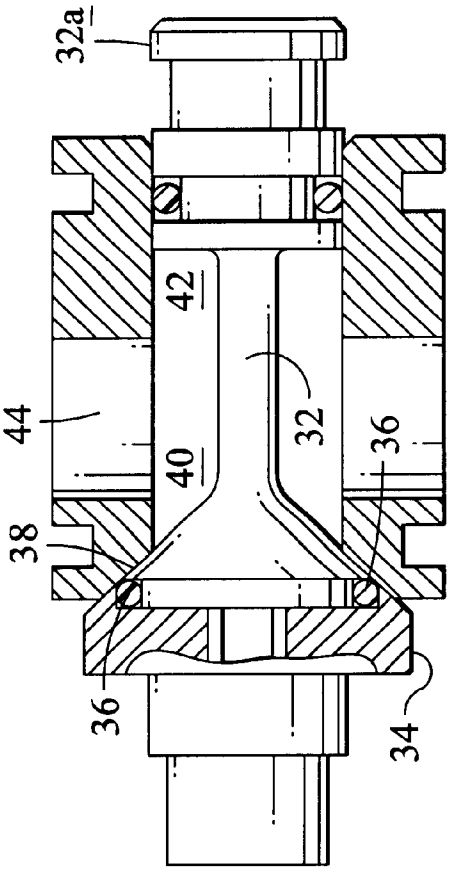


FIG. 5

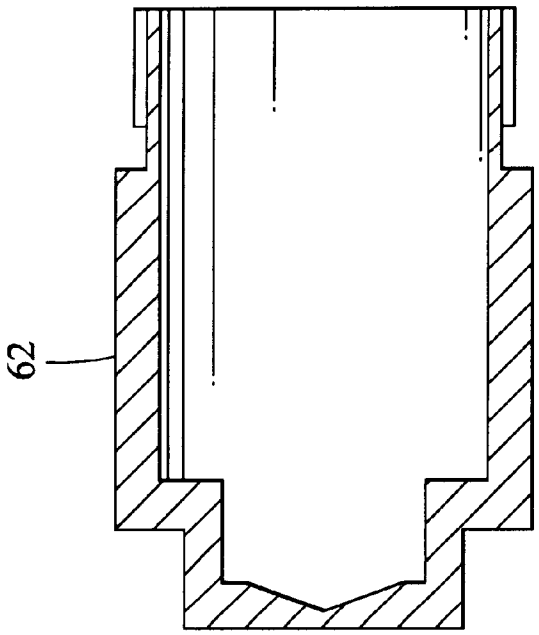


FIG. 4

LOW PRESSURE ELECTRICALLY OPERATED PNEUMATIC PAINTBALL GUN

BACKGROUND OF THE INVENTION

This invention relates generally to paintball guns with loading and firing operations controlled electronically through a solenoid. More specifically, this invention relates to a paintball gun that uses a pressure regulator to supply low pressure gas to both the solenoid and a firing chamber.

The industry has been unable to provide a simple, electrically-controlled, pneumatic paintball gun because, traditionally, high pressure gas has been required to launch a paintball from the gun, while low pressure gas is required for the solenoid-controlled loading and launch initiation (firing) operations. In the prior art paintball guns, therefore, two pressure regulators are generally required. U.S. Pat. No. 6,003,504, issued to Rice, et al. (Rice), describes one such gun having two separate pressure regulators for regulating gas from a high pressure gas source. Specifically, Rice discloses a paintball gun having a low pressure regulator that supplies gas of a pressure of around 80–90 psi to an electrically-controlled solenoid. The solenoid, in turn, controls movement of a pneumatic ram to control loading and firing operations of the gun. A high pressure regulator is also required, however. The high pressure regulator is used to supply gas having a pressure of around 400–600 psi to launch a paintball from a firing chamber during the firing operation. Although Rice suggests, in the concluding paragraph of the written description, that the same "high" pressure gas can be used in the pneumatic control circuit as well as in the high pressure chamber, Rice does not explain how to accomplish this. The BushMaster 2000 model paintball gun, manufactured by Indian Creek Design of Nampa, Id., is another example of a paintball gun having separate high and low pressure regulators for solenoid-controlled operations and paintball launching, respectively.

In addition to the added complexity of having dual pressure regulators, launching paintballs using high pressure gas has many of its own disadvantages. For instance, high pressure launching frequently results in the paintballs breaking within the firing chamber or within a barrel of the gun. High pressure launching also generally causes deformation of the paintballs leading to inaccuracy in aiming.

U.S. Pat. No. 5,881,707 (the '707 patent) and U.S. Pat. No. 5,967,133 (the '133 patent), both issued to Gardner, et al, disclose electrically-operated pneumatic paintball guns that use a low pressure gas to launch a paintball from a firing chamber in addition to performing the solenoid-controlled loading and firing operations. Although the paintball guns disclosed in these two patents offer a significant improvement in performance over dual-regulator guns that use high pressure gas for paintball launching, the '707 and '133 patent paintball guns are complex and, therefore, expensive to manufacture and repair. What is needed, therefore, is a simplified, electrically-operated, pneumatic paintball gun that uses low pressure gas for both solenoid-controlled operations and for launching the paintball. The industry would also be benefitted by a low pressure launching paintball gun which does not suffer from substantial pressure drop-off during firing.

SUMMARY OF THE INVENTION

According to the needs of the industry, one object of the present invention is to enable a paintball gun with a simplified mechanical structure that uses a low pressure regulator for launching a paintball from a firing chamber and for driving solenoid-controlled operations.

Another object of the present invention is to provide a paintball gun which uses low pressure for paintball launching, but does not suffer from significant pressure drop-off during firing.

This invention provides a significant improvement in the art by enabling a paintball gun with a simplified mechanical structure that provides the benefits of a low pressure launching mechanism. Specifically, a paintball gun according to this invention comprises a pressure regulator, an electronic solenoid valve, a firing valve assembly, a pneumatic ram assembly, and a firing chamber. The pressure regulator is configured to provide low pressure gas, regulated from a high pressure gas source, to an electronic solenoid valve in order to control a loading and a firing operation of the paintball gun. The pressure regulator is further configured to supply low pressure gas to the firing chamber via operation of the firing valve assembly in order to launch a paintball. The firing valve assembly can be configured with an opening, a valve chamber, and an exit port in fluid communication with the firing chamber, each having a flow area large enough to allow a sufficient flow of gas to be supplied to the firing chamber without significant pressure drop-off. The firing valve assembly can also be provided with an o-ring seated around the valve cap to provide sensitivity to the valve, allowing it to open and close quickly in order to ensure a near instantaneous shutoff with minimal load. The firing valve assembly is opened by the operation of the solenoid valve-controlled pneumatic ram assembly during the firing operation. The pneumatic ram assembly may also be connected to a bolt assembly via a mechanical linkage to perform the loading operation.

The foregoing and other objects, features and advantages of the invention will become more readily apparent from the following detailed description of a preferred embodiment of the invention which proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevation view of an electrically-controlled pneumatic paintball gun according to a preferred embodiment of the present invention.

FIG. **2** is a vertically cross-sectioned side elevation view of the electrically-controlled pneumatic paintball gun of FIG. **1**.

FIG. **3** is an exploded cross-sectional side elevation view of a low pressure gas storage chamber and a firing valve assembly in the electrically-controlled pneumatic paintball gun of FIG. **1**, showing a relationship between the gas storage chamber and the firing valve assembly.

FIG. **4** is an exploded cross-sectional side elevation view of an end cap of the low pressure gas storage chamber used in the electrically-controlled pneumatic paintball gun of FIG. **1** for storing low pressure gas for launching a paintball.

FIG. **5** is an exploded cross-sectional side elevation view of the firing valve assembly used in the electrically-controlled pneumatic paintball gun of FIG. **1** for quickly supplying a sufficient volume of gas to a firing chamber to launch a paintball without significant pressure drop-off.

DETAILED DESCRIPTION

FIG. **1** is an external side elevation view of an electrically-controlled pneumatic paintball gun **10** according to a preferred embodiment of the present invention. Referring to FIG. **1**, the electrically-controlled pneumatic paintball gun **10** has a body **11**, generally configured in a handgun shape,

including a grip frame **90** and a handle **94**. The gun **10** is configured to receive pressurized gas from a high pressure gas source (not shown) through a pressure regulator **70**. Specifically, the high pressure gas source is connected to the pressure regulator **70** through a bottle connection **72**. The pressurized gas can be CO_2, compressed air, or any other pressurized gas suitable for use in a paintball gun. The preferred gas, however, is CO_2. In operation, the pressure regulator **70** converts a supply of high pressure gas from the high pressure gas source (i.e., having a pressure of between about 1,200 to about 5,000 psi) into a low pressure gas supply (i.e., having a pressure of between about 85 to about 300 psi, and preferably between about 160 to about 180 psi). The low pressure gas supply is then provided via a hose **74** to the internal gun components.

FIG. **2** is a vertically cross-sectioned side elevation view of the electrically-controlled pneumatic paintball gun **10** of FIG. **1**, showing the internal gun components. Referring now to FIGS. **1** and **2**, internal components of the electrically-controlled pneumatic paintball gun **10** include a firing chamber **12**, a loading (bolt) assembly **14**, an electronic solenoid valve assembly **20**, a firing valve assembly **30**, a pneumatic ram assembly **50**, and a low pressure gas storage chamber **60**, among other things. According to this invention, the storage chamber **60** receives the low pressure gas from the pressure regulator **70** through the hose **74**. The low pressure gas in the storage chamber **60** can then be used to launch a paintball. Additionally, because the gas from the pressure regulator **70** is supplied to the gun **10** at a low pressure, it can also be used directly in the electronic solenoid valve assembly **20**. The need for separate high and low pressure regulators is thereby avoided by this invention.

The electronic solenoid valve assembly **20** preferably comprises an electronic 4-way solenoid valve **22** that controls a flow of low pressure gas from the regulator **70** to operate the pneumatic ram assembly **50**. The operation of the electronic 4-way solenoid valve **22** is controlled electrically by a circuit board **25**. A power source, such as a 9-volt battery **92**, supplies power to the circuit board **25**. The power source **92** is preferably located in the grip frame **90** of the paintball gun **10**. As is well known in the art, a trigger-actuated microswitch or other electronic actuation mechanism can be used to transmit a signal to the circuit board to initiate an operation of the solenoid valve **22**.

The construction and operation of the electronic solenoid valve assembly **20**, the pneumatic ram assembly **50**, and the loading mechanism **14** are generally known in the art, but will be described briefly. The pneumatic ram assembly **50** includes a piston cylinder **52**, a head (or hammer) **54**, a rod **56**, and a piston **58**. The rod **56** and piston **58** can be formed integrally. In operation, the low pressure gas is supplied to ports along the piston cylinder **52** of the pneumatic ram assembly **50** from the electronic 4-way solenoid valve **22** in order to drive the piston **58** forward or backward.

A loading operation takes place by first supplying the low pressure gas to an area E in front of the piston **58** and simultaneously venting an area D behind the piston **58**, driving the piston backwards. The piston **58** is connected to the head **54** via the rod **56**. The head **54** is further connected to the bolt assembly **14** via a mechanical linkage **15**. Accordingly, as the piston **58** is driven backwards, the head **54** retracts toward the piston cylinder **52** and draws the bolt assembly **14** into an open position. While the bolt assembly **14** is open, a paintball is allowed to drop into the firing chamber **12**. Next, low pressure gas is supplied to an area D behind the piston **58**, while the area E in front of the piston **58** is vented, thereby driving the piston **58** forward, toward the front of the gun. Accordingly, the head **54** and bolt assembly **14** are also driven forward, loading the paintball into a firing position within the firing chamber **12**.

A firing operation, which initiates a launching of the paintball, takes place at the end of the loading operation. Specifically, as the piston **58** reaches its forward position, the hammer **54** strikes a protruding end **32**A of a valve pin **32** of the firing valve assembly **30**. As the pin **32** is struck, the firing valve **30** opens and releases the low pressure gas from the gas storage chamber **60** into the firing chamber **12**, thereby launching the paintball. The area of piston **58** that is exposed to the pressurized gas in chamber D should be configured with a size that ensures that a correct force is applied to the valve pin **32** to enable smooth and precise opening of the firing valve assembly **30**. The preferred diameter of the piston **58** according to this embodiment is 0.375 inches.

FIG. **3** is an exploded cross-sectional side elevation view of a low pressure gas storage chamber **60** and a firing valve assembly **30** in the electrically-controlled pneumatic paintball gun of FIG. **1**, showing a relationship between the gas storage chamber **60** and the firing valve assembly **30**. Although using a gas storage chamber to supply high pressure gas to the firing chamber through a firing valve exists in the prior art, this invention is unique in its use of the gas storage chamber **60** to supply low pressure gas to the firing chamber **12** via the firing valve assembly **30**. The sizing of the gas storage chamber **60** and the components of the firing valve assembly **30** are important in facilitating the use of low pressure gas for launching the paintball. The gas storage chamber **60**, for example, must contain the appropriate volume C of low pressure gas in order to ensure that a proper flow of gas is supplied to the paintball for launching.

As shown in FIG. **3**, the gas storage chamber **60** is partially formed from a cavity **60**A within the body **11** of the gun **10**. Additionally, however, the gas storage chamber **60** is formed from an end cap **62** that attaches to the front of the gun **10**, e.g., by threaded engagement, and has a cavity **60**B in communication with the cavity **60**A. These two cavities **60**A, **60**B together form the gas storage chamber **60**. FIG. **4** is an exploded cross-sectional side elevation view of the end cap **62** showing its preferred dimensions. The end cap **62** helps provide the appropriate storage volume C in the low pressure gas storage chamber **60** by providing a cavity **60**B that forms part of the storage chamber **60**. In the preferred embodiment, the storage chamber **60** contains approximately 1.65 $in.^3$ of gas at about 170 psi. In operation, low pressure gas from the pressure regulator **70** is supplied to and fills the gas storage chamber **60**. The low pressure gas remains in the storage chamber **60** until the firing valve **30** is opened. When the firing valve assembly **30** is open, gas from the storage chamber **60** rushes into the firing chamber **12** to launch the paintball.

FIG. **5** is an exploded cross-sectional side elevation view of a firing valve assembly **30** according to this invention. Although firing valves exist in the prior art, the firing valve assembly of this invention **30** is unique in its particular design. Particularly, because the paintball gun **10** of this invention launches the paintball using low pressure, the valve assembly **30** must be configured to allow the low pressure gas to be supplied to the paintball rapidly and in high volume in order to supply the force necessary for launching. This is achieved by maximizing a flow area between the low pressure gas storage chamber **60** and the firing chamber **12**.

The design and operation of the firing valve assembly **30** will now be described in detail with reference to FIG. **5**. Of

particular interest, the valve assembly **30** according to this invention is provided with an o-ring **36** around a valve cap **34**. The o-ring **36** provides a sensitive interface between the valve cap **34** and a valve seat **38** that allows the valve **30** to open and close quickly. This helps ensure that the low pressure gas from the storage chamber **60** will be supplied to the firing chamber **12** quickly and uniformly, with no significant drop-off in pressure. Further important to this invention, a valve opening **40**, a valve chamber **42**, and a valve port **44** each have a size large enough to allow the low pressure gas from the storage chamber **60** to be supplied to the firing chamber **12** with minimal pressure loss when the valve **30** is opened. As shown in FIG. **5**, the opening **40** has a preferred diameter of about 0.47 inches, and the exit port **44** has a preferred diameter of about 0.38 inches. The flow area in the valve chamber **42** is also maximized, having a diameter of about 0.47 inches. Accordingly, pressure loss between the low pressure gas storage chamber **60** and the firing chamber **12** during launching of the paintball is reduced.

Referring to FIGS. **2–5**, a firing operation of the paintball gun **10** will now be described in detail. As noted previously, during a firing operation, the hammer **54** of the pneumatic ram assembly **50** strikes an end **32**A of the valve pin **32** to initiate the launching of the paintball from the firing chamber **12**. Specifically, as the head **54** strikes the pin **32**, the o-ring **36** of valve cap **34** is unseated from the valve seat **38**, thereby opening the firing valve **30**. Gas from the low pressure gas storage chamber **60** is thereby allowed to travel through the valve opening **40**, into the valve chamber **42**, and out the valve exit port **44**. The gas is then delivered up through a flow aperture **46** in the gun body **11** and on through a firing aperture **48** in the bolt assembly **14** where it enters the firing chamber **12** and launches the paintball. An interface **48**A between the bolt **14** and the paintball is configured such that the low pressure gas is applied over a large area of the paintball. This application of force over a large area of the paintball allows it to be launched at a high velocity with little deformation using a relatively low pressure gas. Furthermore, because of the sizing of the flow areas (valve opening **40**, valve chamber **42**, valve exit port **44**, flow aperture **46**, firing aperture **48**, and interface **48**A), the low pressure gas is supplied from the gas storage chamber **60** to the paintball very quickly. Accordingly, very little pressure drop-off is experienced during the firing operation. The minimization of pressure loss ensures the uniform application of a launching force on the paintball and maximizes gun efficiency. Following the firing operation, the hammer **54** is retracted toward the piston cylinder **52**. A light spring **66** exerts just enough force on the valve head **34** to ensure that the valve **30** returns to its closed position when the hammer **54** is retracted. With the valve assembly **30** closed, the storage chamber **60** then refills in preparation for the next firing operation.

Having described and illustrated the principles of the invention in a preferred embodiment thereof, it should be apparent that the invention can be modified in arrangement and detail without departing from such principles. We claim all modifications and variations coming within the spirit and scope of the following claims.

What is claimed is:

1. An electrically-controlled pneumatic paintball gun, comprising:

a pressure regulator for regulating gas from a high pressure source into a low pressure gas;

a firing valve assembly configured to receive the low pressure gas from the pressure regulator and to transmit the low pressure gas to a firing chamber during a firing operation; and

an electrically-controlled solenoid valve configured to operate a pneumatic ram assembly using the low pressure gas, the pneumatic ram assembly configured to control a firing operation to launch a paintball from the firing chamber.

2. A paintball gun according to claim **1**, wherein the low pressure gas comprises a pressure of between about 85 psi to about 300 psi.

3. A paintball gun according to claim **2**, wherein the low pressure gas comprises a pressure of between about 140 and about 220 psi.

4. A paintball gun according to claim **1**, further comprising a low pressure gas storage chamber for storing the low pressure gas from the pressure regulator in a volume sufficient to launch the paintball during the firing operation.

5. A paintball gun according to claim **4**, wherein the volume of the low pressure gas storage chamber is approximately 1.65 cubic inches.

6. A paintball gun according to claim **1**, further comprising a bolt assembly connected to the pneumatic ram assembly via a mechanical linkage to perform a loading operation.

7. A paintball gun according to claim **6**, wherein the pneumatic ram assembly is configured to perform the loading operation of the paintball gun by moving the bolt assembly backwards to allow the paintball to drop into the firing chamber and forwards to move the paintball into a firing position within the firing chamber.

8. A paintball gun according to claim **1**, wherein the pneumatic ram assembly is configured to control a firing operation of the paintball gun by striking a valve pin of the firing valve assembly to open the firing valve assembly and to allow gas from the pressure regulator to be supplied to the firing chamber.

9. A paintball gun according to claim **1**, wherein the firing valve assembly comprises:

a valve opening;

a valve chamber;

a valve exit port; and

wherein the valve opening, valve chamber, and valve exit port each have a size sufficient to allow gas to be supplied from the low pressure regulator to the firing chamber without a significant pressure drop-off.

10. A method of launching a paintball from a paintball gun comprising a pressure regulator, a firing valve assembly, an electronic solenoid valve, a pneumatic ram assembly, and a firing chamber housing the paintball, the method comprising:

supplying low pressure gas from the pressure regulator to the firing valve assembly;

supplying low pressure gas from the pressure regulator to the electronic solenoid valve;

using the low pressure gas supplied to the electronic solenoid valve to initiate a firing operation through the operation of the pneumatic ram assembly; and

launching the paintball from the paintball gun by opening the firing valve assembly to transmit the low pressure gas supplied to the firing valve assembly to the firing chamber.

11. A method of launching a paintball according to claim **10**, wherein supplying low pressure gas from the pressure regulator to the firing valve assembly further comprises supplying low pressure gas from the pressure regulator to a gas storage chamber in fluid communication with the firing valve assembly.

12. A method of launching a paintball according to claim 10, wherein using the low pressure gas supplied to the electronic solenoid valve to initiate a firing operation by operating the pneumatic ram assembly comprises driving a head of the pneumatic ram assembly into contact with a valve pin of the firing valve assembly to open the firing valve assembly.

13. A method of launching a paintball according to claim 10, further comprising using the low pressure gas supplied to the electronic solenoid valve to initiate a loading operation by operating the pneumatic ram assembly.

14. A method of launching a paintball according to claim 10, wherein launching the paintball from a paintball gun by opening the firing valve assembly to transmit the low pressure gas supplied to the firing valve assembly to the firing chamber further comprises transmitting the low pressure gas through the firing valve assembly to the firing chamber without significant pressure drop-off.

15. A method of constructing a paintball gun, comprising:

providing a pressure regulator for regulating gas from a high pressure gas source into a low pressure gas supply;

providing one or more pneumatic ram assemblies for controlling a loading and a firing operation of the paintball gun;

providing one or more electronic solenoid valves for controlling the pneumatic ram assembly or assemblies using the low pressure gas supply; and

providing a firing valve assembly for transmitting low pressure gas from the low pressure gas supply to a firing chamber during the firing operation.

16. A method of constructing a paintball gun according to claim 15, further comprising:

providing a low pressure gas storage chamber in fluid communication with the firing valve assembly to receive and store low pressure gas from the pressure regulator and to supply a known volume of low pressure gas to the firing chamber during the firing operation.

17. A method of constructing a paintball gun according to claim 16, further comprising:

sizing a valve opening, a valve chamber, and a valve port of the firing valve assembly such that the low pressure gas is supplied from the low pressure gas storage chamber to the firing chamber without a substantial pressure drop-off.

18. A method of constructing a paintball gun according to claim 15, further comprising:

configuring a valve cap of the firing valve assembly to enhance sensitivity of the firing valve assembly by enabling quick opening and near instantaneous closing of the firing valve assembly with minimal load.

19. A method of constructing a paintball gun according to claim 18, wherein configuring a valve cap of the firing valve assembly to enhance sensitivity of the firing valve assembly comprises providing the valve cap with an o-ring.

20. A method of constructing a paintball gun according to claim 15, further comprising:

configuring a surface area of a piston in the pneumatic ram assembly to communicate with low pressure gas from the low pressure gas supply such that a correct force is applied from a head of the pneumatic ram assembly to a valve pin of the firing valve assembly during the firing operation to enable smooth and precise opening of the firing valve assembly.

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