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Kotsiopoulos

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[54] **PRESSURE REGULATING SYSTEM FOR COMPRESSED GAS POWERED WEAPONS OR THE LIKE**

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[52] **U.S. Cl.** **124/71**; 124/73; 124/74; 124/75

[58] **Field of Search** 124/74, 71, 70, 124/73, 75, 72; 60/407

[56] **References Cited**

U.S. PATENT DOCUMENTS

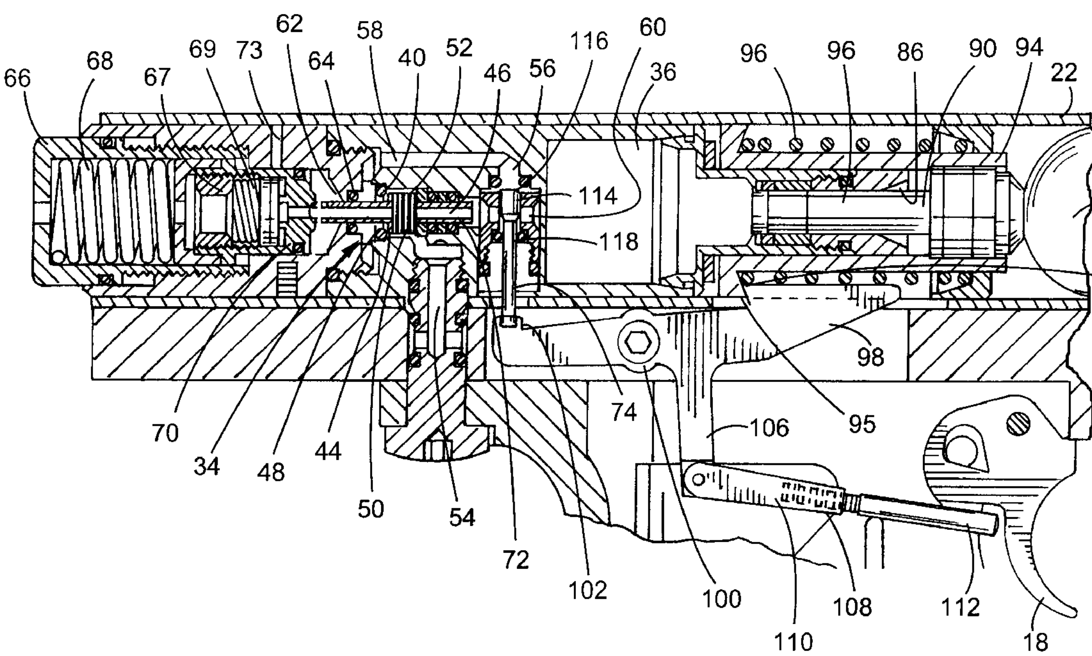
5,454,407	10/1995	Huza et al.	141/10
5,477,907	12/1995	Meyer et al.	164/133

Primary Examiner—J. Woodrow Eldred
Attorney, Agent, or Firm—Leydig, Voit & Mayer, Ltd.

[57] **ABSTRACT**

A compressed gas powered gun includes a firing system capable of achieving increased firing rates. The firing system includes a regulating system by which an air or firing chamber can be charged with compressed gas from a compressed gas source to a predetermined pressure very rapidly. The firing system also includes a trigger mechanism which enables rapid actuation of a trigger by a user.

15 Claims, 6 Drawing Sheets



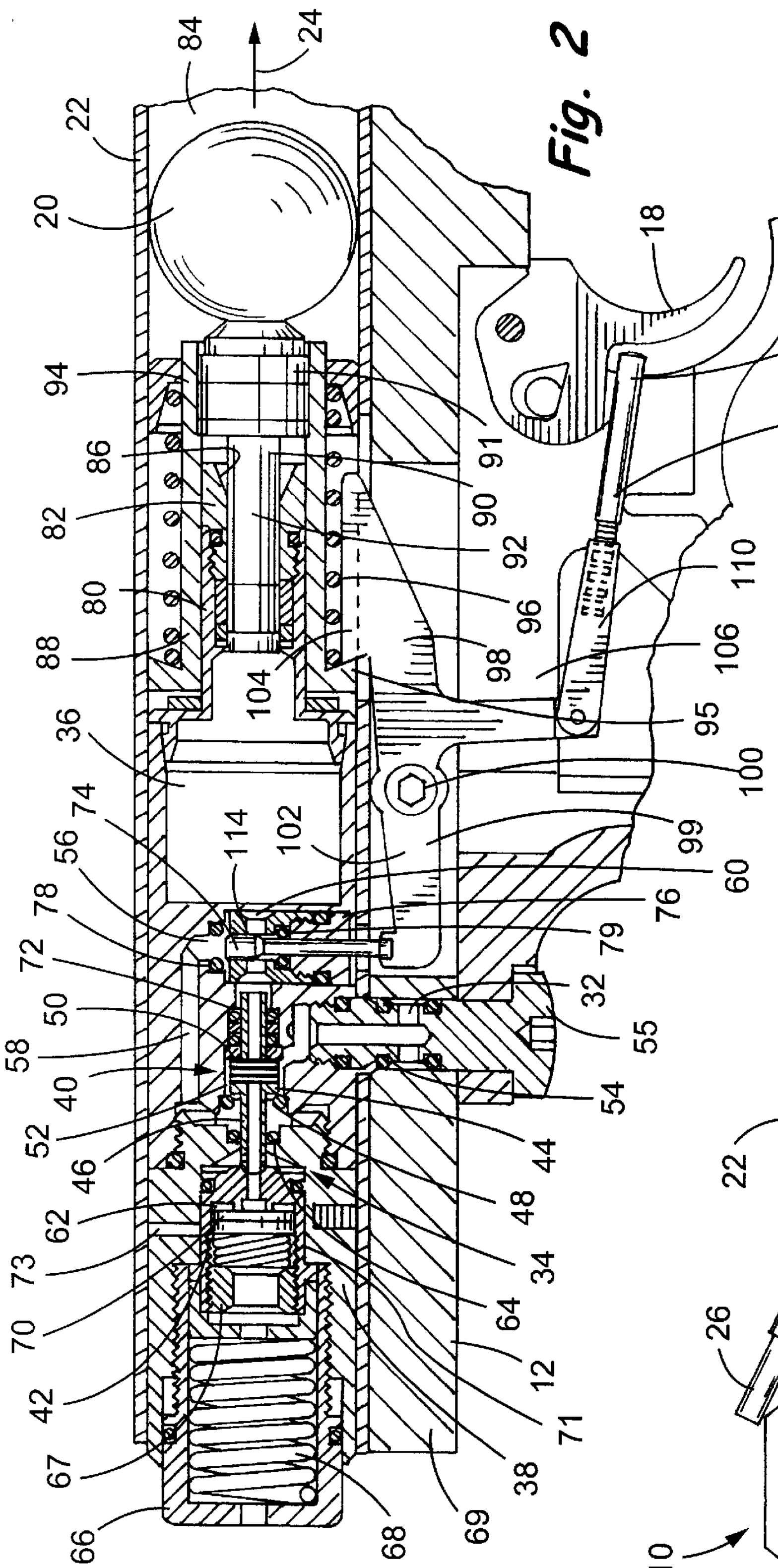

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Fig. 2

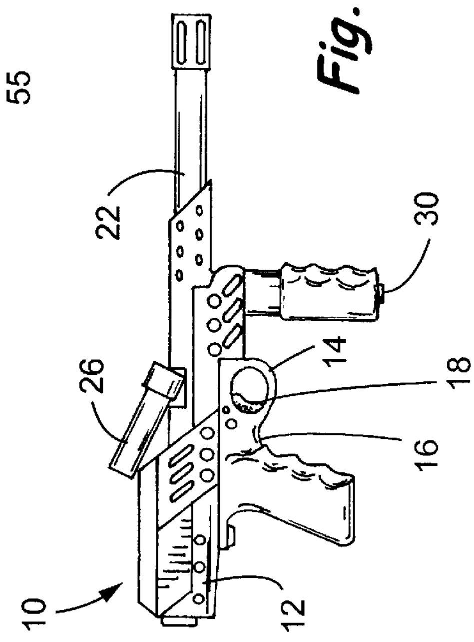
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Fig. 1

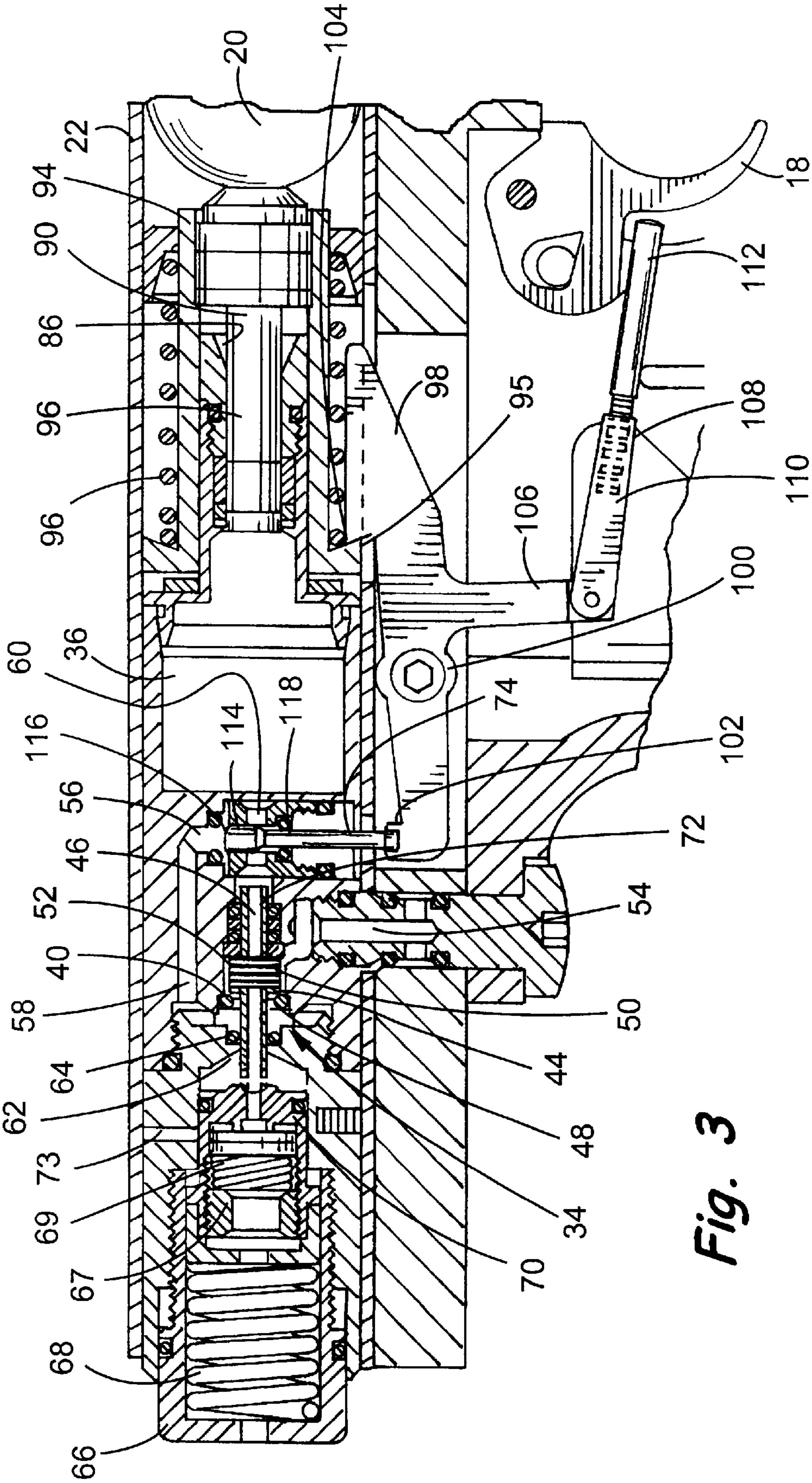
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Fig. 3

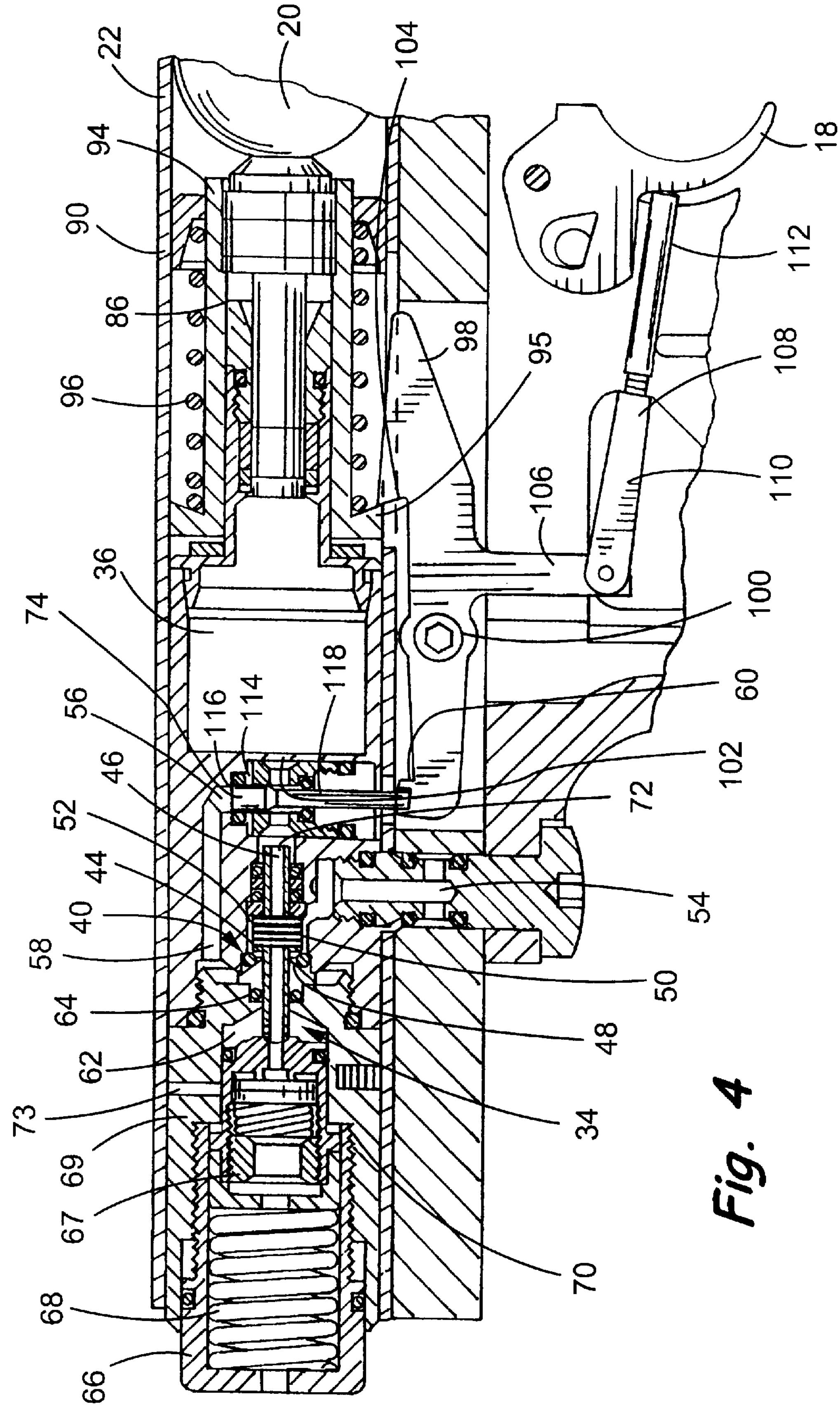
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Fig. 4

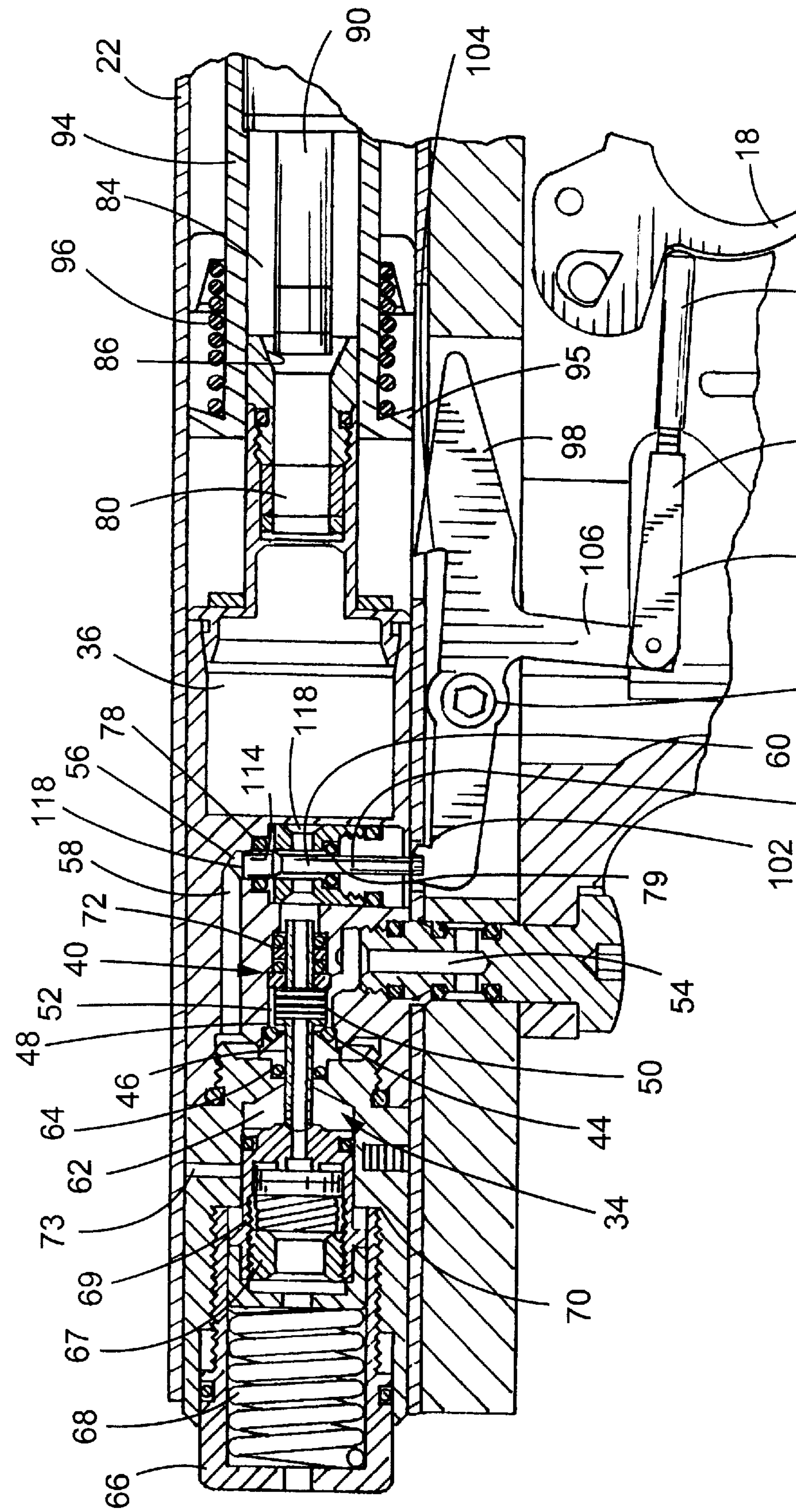
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Fig. 5

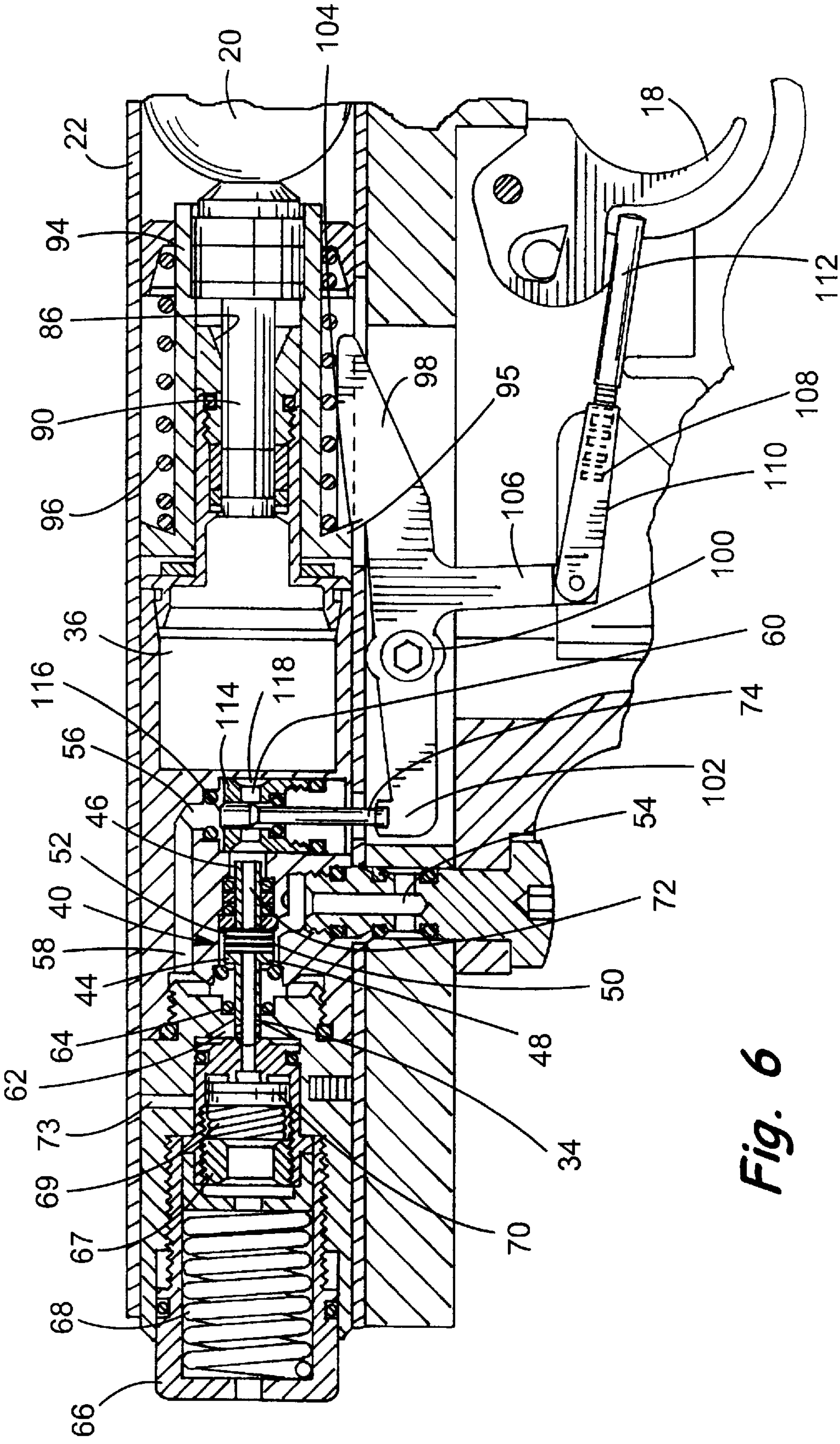
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Fig. 6

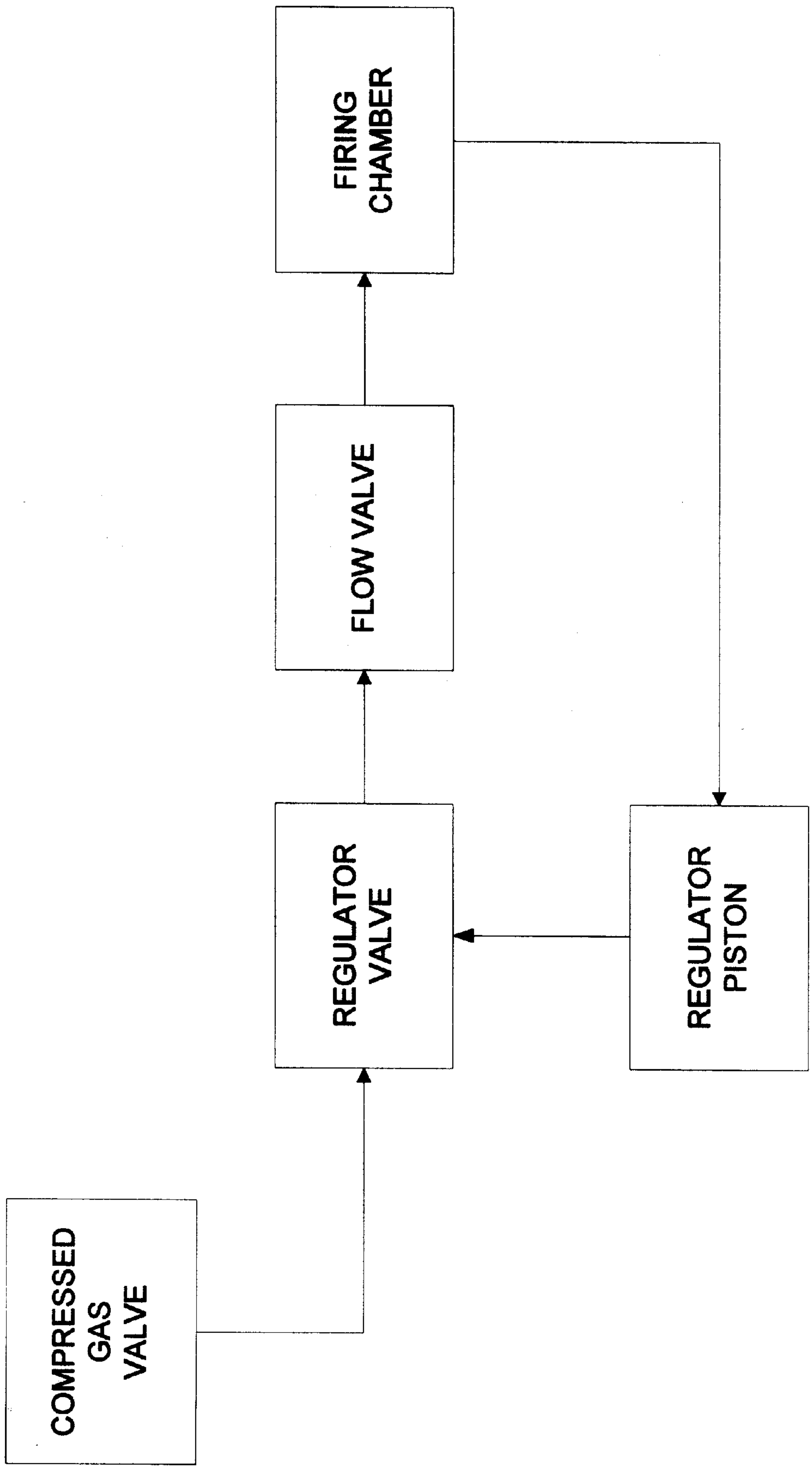
FIRING CHAMBER
FLOW VALVE
REGULATOR VALVE
REGULATOR PISTON
COMPRESSED GAS VALVE

Fig. 7

PRESSURE REGULATING SYSTEM FOR COMPRESSED GAS POWERED WEAPONS OR THE LIKE

FIELD OF THE INVENTION

This invention generally relates to a pressure regulating system, and more particularly, to a regulating system for use in compressed gas powered weaponry or the like.

BACKGROUND OF THE INVENTION

A variety of different types of weaponry which utilize discharged compressed gas to fire projectiles are known. These compressed gas powered weapons have particular use in a variety of applications including tranquilizer guns and pellet marking guns which are sometimes referred to as "paint ball guns." Generally marking guns use compressed gas to fire a relatively fragile projectile which comprises a frangible shell which is filled with a marking composition. The capsules are designed to break upon impact with a target and thereby discharge the marking material onto the target.

Such marking guns have a variety of different uses. For example, they may be employed to segregate livestock within a herd, assist in the counting of wild animals or for training of military or law enforcement personnel through simulation exercises. Likewise, they may be used by military and law enforcement personnel for crowd control. Another very popular use for such marking guns is for recreation. In particular, paint ball marking guns are used for "war games" in which participants attempt to hit other combatants with paint balls thereby marking them and eliminating them from the game.

One attribute which is extremely important to users of paint ball marking guns which are intended for such recreational war games, as well as those used for other purposes, is the rate at which the gun may be fired. Obviously, paint ball marking guns which are capable of increased firing rates offer the user a significant competitive advantage over his/her fellow combatants. One significant factor which influences the firing rate of any weapon is the type of firing arrangement that is employed. Paint ball marking guns typically may employ manual, semi-automatic and fully automatic firing arrangements. A manual firing arrangement requires appropriate manipulation of the gun before successive projectiles are fired. In contrast, a semi-automatic firing arrangement enables a projectile to fired each time the trigger is depressed, while an automatic firing arrangement will fire multiple projectiles each time the trigger is pulled.

Although fully automatic weapons may seem desirable, they suffer from various shortcomings. For example, they consume increased amounts of both ammunition and compressed air and have proven problematic, particularly due to feeding mechanism failure. Moreover, they have not achieved widespread success due to regulation prohibiting their use in many recreational settings.

One limitation on the firing rate in known weapons of this type is the fill cycle time namely, the time required to fill the firing chamber of the gun with compressed gas to the appropriate pressure. Known regulation systems have been employed that provide a regulated pressure from a compressed gas source to an air chamber to ensure that a consistent projectile velocity is achieved. One example of compressed gas powered weapons of this type may be constructed in accordance with the teachings in U.S. Pat. No. 5,280,778, assigned to assignee of the present invention. These systems regulate the pressurized gas which is supplied from the compressed gas source to the firing chamber. In this

way a consistent pressure is achieved in the firing chamber for each shot, thus helping to ensure that a consistent projectile velocity is achieved for successive shots. Although this system achieves a consistent projectile velocity and enhanced accuracy of the gun, certain limitations are imposed. With the regulator system which is used in compressed gas powered weapons at this type, as the pressure in the firing chamber nears to the desired pressure, the regulator valve substantially, or at least partially closes. Thus, the gas flow into the firing chamber slows.

The result is that the regulator limits the rate at which the gun may be fired without adversely effecting the velocity of the projectile and, in turn, the accuracy of the gun. Specifically, when a user attempts to fire the gun faster than the rate at which the firing chamber is filled with compressed gas, there is insufficient time between shots for the gas in the firing chamber to reach the desired pressure. This leads to an inconsistent and lower projectile velocity which will result in diminished accuracy of the gun.

OBJECTS OF THE INVENTION

Accordingly, in view of the foregoing, it is an general object of the present invention to provide a firing system for a compressed gas powered weapon which is capable of operating at increased firing rates without adversely effecting the velocity of the projectiles or the accuracy of the weapon.

And even more general object of the present invention is to provide a system by which an enclosure, such as a firing chamber of a compressed gas powered weapon, can be rapidly filled with compressed gas to a predetermined pressure.

Another object of the present invention is to provide a firing system for a compressed gas powered weapon or the like which is very reliable and easy to maintain.

These and other features and advantages of the invention will be more readily apparent upon reading the following description of a preferred exemplified embodiment of the invention and upon reference to the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a compressed gas powered gun that utilizes the teachings of the present invention.

FIG. **2** is a partial side sectional view of the compressed gas powered gun of FIG. **1**, taken axially through the gun, showing the firing system in a ready-to-fire mode.

FIG. **3** is also a partial side sectional view taken axially through the compressed gas powered gun, showing the firing system in the ready-to-fire mode with a regulator valve in the closed position.

FIG. **4** is a partial side sectional view of the compressed gas powered gun showing the firing system in a firing mode prior to release of an actuating bolt assembly.

FIG. **5** is a partial side sectional view of the compressed gas powered gun showing the firing system in the firing mode with the trigger fully depressed and the actuating bolt assembly released.

FIG. **6** is a partial side sectional view of the compressed gas powered gun showing the firing system returning to the ready-to-fire mode after execution of a firing sequence.

FIG. **7** is a block diagram illustrating the pressure regulating system of the present invention.

While the invention will be described and disclosed in connection with certain preferred embodiments and procedures, it is not intended to limit the invention to those specific embodiments. Rather it is intended to cover all such alternative embodiments and modifications as fall within the spirit and scope of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Generally, the present invention relates to a firing system for a compressed gas powered weapon or the like which is capable of being operated at increased firing rates as compared to known firing systems. These firing rates are achieved with a novel compressed gas regulating system which enables an air chamber such as a firing chamber of a compressed gas powered weapon to be rapidly filled to a preselected pressure from a compressed gas source having a pressure higher than the preselected pressure. In the context of a compressed gas powered weapon, such rapid filling or charging of the firing chamber allows the weapon to achieve increased firing rates without adversely affecting the accuracy of the gun.

In accordance with one preferred embodiment, the firing system of the present invention also incorporates a trigger mechanism which helps a user overcome physical limitations which otherwise prevent the user from achieving increased firing rates. This invention is also described in patent application Ser. No. 08/995,047, now U.S. Pat. No. 5,913,303, filed on the same date as the present application, entitled "Trigger Mechanism For Compressed Gas Powered Weapons Or The Like" and incorporated herein by reference in its entirety. In particular, the trigger mechanism actually assists the user in successively actuating the trigger to thereby take advantage of the increased firing rates achieved by the firing system of the present invention.

While the present invention is described in connection with a compressed gas powered gun, which has particular use a paint ball marking gun, it will be readily appreciated that the teachings of the present invention can also be applied in other contexts. These include, for example, other types of compressed gas powered weapons. The regulating system of the present invention may be utilized in many applications other than compressed gas powered weapons. In particular, the regulating system may be employed in any application where it is desirable to rapidly fill a chamber with a compressed gas to a preselected pressure. Similarly, it will be appreciated that the trigger mechanism of the present invention could be utilized in weapons other than simply compressed gas powered weapons.

FIGS. **1–6** illustrate one preferred embodiment of a compressed gas powered gun which incorporates the firing system of the present invention. Certain details of the gun are also disclosed in U.S. Pat. No. 5,280,778, which is incorporated herein by reference in its entirety. As best shown in FIG. **1**, the gun **10** comprises a longitudinally extending frame support or rail **12** with a trigger-guard **14** and handle **16** depending therefrom. A pivotally mounted trigger **18**, the operation of which is described in more detail below, is disposed within the trigger-guard **14**. The firing system is operable in a firing mode wherein a projectile is expelled from the gun and a ready-to-fire or reloading mode which places the gun in condition for firing. As seen in FIG. **2**, a projectile **20**, such as a marking pellet or paint ball, exits an elongate, generally cylindrical barrel **22** in the direction of arrow **24** during the firing mode. An ammunition feeding tube **26** (FIG. **1**) is disposed to supply a plurality of projectiles in a manner in which the projectiles are fed to the gun, one at a time, as will be understood by those skilled in the art.

For providing connection of the gun to a source of compressed gas, the gun includes an inlet port **30** which in the preferred embodiment comprises a conventional adapter which allows an air line or hose (not shown) to be quickly and easily connected and disconnected from the gun. The source of the compressed gas preferably comprises a tank of compressed air (not shown) as will be understood by those skilled in the art. In order to provide for ease of movement, the compressed air tank could be strapped to the back of the user or could carried on a belt. The compressed gas source preferably is supplied at a pressure of approximately 700 pounds per square inch (psi). Of course, it should be appreciated that different types of sources of compressed gas could be used with the present invention. In addition, while compressed air is preferred, other compressed gases such as nitrogen may be used.

The compressed gas or air passes from the inlet port **30** via an annular inlet passageway **32** which, in the illustrated embodiment, extends along the rail of the frame **12**. This inlet passageway provides a passageway to a compressed gas delivery system which operates to control and meter the compressed gas received from the compressed gas source in both the firing and ready-to-fire modes of the firing system. Specifically, the compressed gas delivery system includes a pressure regulating system or assembly **34** and a fluid pathway which interconnects the compressed gas inlet port **28** with an air or firing chamber **36**.

In accordance with one aspect of the present invention, a pressure regulating assembly is adapted to rapidly recharge the firing chamber after it is expelled by filling at an increased pressure until a preselected pressure is attained. In the illustrated embodiment, the pressure regulating assembly **34** is adapted to operate at a very high speed and provide for full pressure recharge of the firing chamber **36**. This results in the firing chamber **36** being charged with compressed gas to the preselected pressure very rapidly thereby increasing the potential firing rate of the gun **10**.

The pressure regulating assembly **34** and the fluid pathway are disposed in a cylindrical terminal housing or valve body section **38** of the gun. The regulating assembly **34** generally comprises a screw-type control and valve arrangement including a valve **40** disposed in the fluid pathway interconnecting the inlet port **30** and the firing chamber **36** and a regulator piston subassembly **42**. The main structural details of the valve **40** include a head portion **44**, a valve stem **46**, a seat **48** and a biasing spring **50**. A generally cylindrical regulator valve chamber **52** is formed in the valve body section **38** of the gun which is in fluid communication with the inlet passageway **32** via a fluid passageway **54** provided in the field strip screw **55**. The valve head **44** is contained within the regulator valve chamber **52** while one end of the stem portion **46** extends outwardly to the regulator piston subassembly **42**.

The valve **40** is operable to move between an open position, wherein compressed gas flows from the inlet port **30** to the firing chamber **36** via the fluid pathway and a closed position, wherein the inlet port **30** is isolated from the firing chamber **36**. Specifically, when the valve **40** is in the closed position, the valve head **44** engages the valve seat **48** to thereby close off the flow of compressed gas to the firing chamber **36** as shown in FIG. **3**. When the valve **40** is in the open position, compressed gas flows between the outer periphery of the valve head **44** and the walls of the regulator valve chamber **52** as shown in FIG. **2**. The flow of compressed gas past the valve **40** continues to an on/off flow valve chamber **56** via a fluid passageway **58**. In turn, the flow valve chamber **56** is interconnected with the firing chamber **36** by way of a second fluid passageway **60** which completes the fluid pathway between the inlet port **30** and the firing chamber **36**.

In order to control the pressure in the firing chamber **36**, the regulator piston subassembly **42** is adapted to move the valve **40** to the closed position (FIG. **3**) when a predetermined pressure of compressed gas is sensed and to urge the valve **40** to an open position when a pressure less than the preselected pressure is sensed. The regulator piston subassembly **42** is arranged in a regulator piston bore **62** which is sealed from the flow of gas from the regulator valve chamber **52**. In order to prevent gas from leaking into the regulator piston bore, around the valve stem an o-ring seal **64** is provided. The main structural components of the regulator piston subassembly include a threaded adjusting nut **66**, a biasing spring **68** and a regulator piston **70**.

In the preferred embodiment, a blow off valve arrangement valve is provided which includes a head **67** and biasing spring **69**. When an over-pressure condition is sensed, the valve permits the compressed to vent to atmosphere via an overflow port **73**.

In order to sense the pressure of the gas in the firing chamber **36**, the regulating assembly **34** further includes a sensing line **72**. The sensing line **72** is in fluid communication with the regulator piston bore **62** and is adapted to apply the pressure of the gas in the firing chamber **36** to the regulator piston subassembly **42**. In a preferred embodiment, the forward end of the valve stem **46** extends to a location adjacent the firing chamber **36** and the sensing line **72** comprises a bore in the valve stem **46** which extends from adjacent the firing chamber **36** to the regulator piston bore **62** as shown in FIGS. **2–6**.

When the firing chamber **36** is being filled or charged with compressed gas during the ready-to-fire mode of the firing system, the regulating springs **68**, **69** bias the regulator piston **70** toward a forward position in the piston bore **62**, which in turn, acts to move the valve head **44** away from the valve seat **48** as best shown in FIG. **2**. The regulator piston **70** remains in this forward position and thereby prevents the valve **40** from closing until a predetermined pressure is supplied to the firing chamber **36** and to the piston bore **62** via the sensing line **72**. When the pressure in the firing chamber **36** and the piston bore **62** reach the predetermined pressure, as shown in FIG. **3**, the regulator piston **70** is moved counter to the force of the regulator springs **68**, **69** to a rearward position which causes the valve **40** to engage the valve seat **48** and seal the regulator valve chamber **52**. The compressed gas in the portion of the fluid pathway upstream from the valve head **44** and the biasing spring **50** coact to maintain a closure tension on the valve **40**.

When the pressure in the air chamber **36** and, in turn, in the regulator piston bore once again falls below the predetermined pressure such as after a firing sequence, the regulating piston subassembly **42** urges the valve **40** to an open position as shown in FIGS. **5–6**. Compressed gas supplied to the regulator piston bore **62** via the sensing line **72** thereafter acts against the tension of the regulating springs **68**, **69** to move the piston **70** rearward. Thus, compressed gas is again discharged until the pressure in the air chamber **36** reaches the predetermined level sufficient to urge the valve **40** closed.

The operation of the compressed gas delivery system including the regulating system of the present invention is perhaps best understood by reference to the block diagram of FIG. **7**. In contrast to conventional arrangements in which the compressed gas is regulated to a lower pressure as soon as it enters the gun or the compressed gas delivery system, the present invention "regulates" the pressure in the firing chamber **36** itself by shutting of the supply of compressed gas when the firing chamber **36** reaches the desired pressure. Thus, the regulating system of the present invention allows the firing chamber **36** to charge at very nearly the full line pressure of the compressed gas source. As can be appreciated, this allows the firing chamber to fill with compressed gas to the desired pressure much more rapidly than conventional designs. As shown in the block diagram of FIG. **7**, this is accomplished, at least in part, by drawing off the compressed gas which acts on the regulator piston **70** from a location adjacent the firing chamber **36**. Drawing off, or sensing, the pressure at this point, as opposed to as soon as it passes the valve, eliminates the problem of the flow of gas slowing substantially through a nearly closed regulator valve as the pressure in the system nears the desired pressure. For example, while known regulating systems in compressed gas powered guns limited the firing rate to no more than five rounds per second before the projectile velocity started to drop off, in one preferred embodiment the regulating system of the present invention is capable of achieving a firing rate of twenty-five rounds per second with no velocity dropoff.

This arrangement also ensures precise operation of the gun **10** for successive firings over a wide range of ambient temperatures. For example, when the ambient temperature increases, thereby increasing the gas pressure in firing chamber **36** and the piston bore **62**, the regulator piston **70** is urged rearward to close the valve **40**. If the ambient temperature increases to a level where the pressure in the piston bore **62** exceeds the desired firing chamber pressure and the gas supply pressure by a sufficient amount, i.e., 650 p.s.i., the overflow valve will move sufficiently rearwardly to permit venting through the port **73**. Conversely, when the ambient temperature decreases, thereby decreasing the pressure in the firing chamber **36** and the piston bore **62**, the gas supply pressure decreases, urging the valve **40** to an open position. In this way, the pressure regulating assembly **34** operates to maintain a desired pressure supplied to the air chamber **36** for each firing of the gun.

In order to allow for the adjustment of the pressure to which the firing chamber **36** is charged, and thereby the velocity of the projectile **20**, means are provided for adjusting the pressure at which the regulator valve **40** closes. Specifically, in the illustrated embodiment, the amount of force exerted by the first regulating spring **68** on the regulating piston **70** can be controlled through manual adjustment of a threaded velocity nut **66** provided on the end of the valve body **38**. For example, in order to increase the pressure to which the firing chamber **36** is charged, the velocity nut **66** is turned so as to increase the force that the first regulating spring **68** applies to the regulating piston **70**. A relatively higher pressure will then be required to urge the regulating piston **70** rearward and thereby close the valve **40**. In a preferred embodiment, the pressure regulating assembly **34** should be set to shut off the flow of compressed gas from the inlet port **30** when the pressure in the air chamber **36** reaches approximately 450 psi.

In order to protect against an over pressure condition in the compressed gas delivery system resulting from a seal failure or the disassembly of the gun when the firing system is under pressure, the blow off valve and over pressure vent **73**, discussed above, may also be provided.

It will be appreciated from the foregoing description that the compressed gas delivery system and, in particular, the pressure regulating system of the present invention may also have application outside of the context of compressed gas powered weapons. In fact, the compressed gas delivery system of the present invention could be used in any application where the object is rapidly charging an air chamber with compressed gas to a preselected pressure.

In order to ensure that the preselected pressure is maintained in the firing chamber **36** for the firing mode, the firing system further includes a on/off valve **74** which seals off the firing chamber **36** from the compressed gas source when the firing system is operating in the firing mode. The on/off flow valve **74** is movable between open and closed positions and, in particular, is operable to open and thereby permit fluid communication between the firing chamber **36** and the inlet port **30** in the ready-to-fire mode of operation, as shown in FIG. **2**. This enables the firing chamber **36** to be charged with compressed gas to the predetermined pressure via the compressed gas delivery system during the ready-to-fire mode. In the firing mode of operation, the on/off flow valve **74** closes thereby isolating the firing chamber **36** from the inlet port **30** and the compressed gas source, as shown in FIG. **4**. This isolation of the firing chamber **36** from the compressed gas source prevents compressed gas from flowing into the firing chamber to replace the air which has been discharged from the firing chamber in order to expel the projectile. This is of particular importance because the pressure in the regulator piston bore **62** has dropped resulting in the opening of the regulator valve **40**. As shown in FIGS. **2** and **4–6**, the on/off flow valve **76** is movable transversely relative to the longitudinal axis of the gun between the open and closed positions. In order to prevent compressed gas from leaking past the on/off flow valve when it is in the closed position, an o-ring seal **78** is provided adjacent the upper end of the flow valve chamber **56**. In addition, a second o-ring seal **79** is provided adjacent the lower end of the flow valve chamber to prevent compressed gas from leaking out of the compressed gas delivery system.

The air or firing chamber **36** supplies the compressed gas that expels the projectile through the barrel **22** when the firing system is in the firing mode. The air chamber **36** is defined by a bore formed in the main body portion of the gun **10** terminating at one end with an intermediate firing tube or power tube **80**. An annular sleeve **82** interfits within the power tube **80** and, along with the power tube **80**, defines a discharge path for compressed air contained in the firing chamber **36** to blast into a breech **84** of the gun **10**. The annular sleeve **82** includes a tapered portion **86** that further defines a passage for the blast of compressed gas. This tapered portion **86** on the power tube **80** is configured such that the air flows out of the air chamber **36** and the power tube at a controlled rate which prevents relatively fragile projectiles such as paint balls from breaking as a result of too much pressure building up behind the paint ball. Inasmuch as the pressure supplied to the firing chamber **36** has been substantially reduced from the maximum available pressure from the compressed gas source, the volume defined by the firing chamber **36** is substantially larger than found in many known arrangements.

The blast of compressed gas exits the air chamber **52** upon actuation of a bolt assembly **88** which includes a power piston **90**. The power piston **90** comprises head and body sections **91** and **92**, respectively, with the body section **92** being sized to fit within the annular sleeve **82** and power tube **80**. FIG. **2** best illustrates the remaining structural features of the bolt assembly **88**, including a cylindrical actuating bolt **94** disposed in surrounding relation to the annular sleeve **82** and power tube **80**. The actuating bolt **94** includes a protruding dog portion **95** disposed at one of its ends. A recoil spring **96** retracts the actuating bolt **94** against a bumper **97** when the actuating bolt **94** is returned to a ready-to-fire position.

As described in detail in said U.S. Pat. No. 5,280,778, the bolt assembly **88** is maintained in a ready-to-fire position with the use of a trigger mechanism which includes a sear **98** having an arm **99** that is rotatable about a pivot **100**, which in a preferred embodiment comprises a threaded roller bearing axle. The arm **99** has a transversely extending actuating member **101** at one end, located on one side of pivot **100**, and an interlocking element **104** at the other end, located on the other side of the pivot **100**. The actuating member **102** is generally aligned with the on/off flow valve **74**. The interlocking element **104** includes a notched portion that engages the dog portion **95** of the actuating bolt **94** in the ready-to-fire position. The interlocking element **104** preferably also includes an elongated portion extending substantially along the path of travel of the actuating bolt assembly **88** to provide a stop surface that prevents the actuating bolt assembly from engaging the interlocking element **104** during recoil of the actuating bolt assembly.

An actuating lever **106** projects transversely on the side of the latch arm **99** opposite the actuating member **102** and the interlocking element **104**. A sliding trigger arm **108** disposed within the handle **16** operates to transmit force from the trigger **18** to the actuating lever **106**. As explained in detail in said U.S. Pat. No. 5,280,778, this provides for semi-automatic firing of the gun **10** in operation. In the illustrated embodiment, the trigger arm **108** comprises a first link **110** which is pivotally connected to the actuating lever **106** and a second link **112** which is threaded into the first link. With this arrangement, any play in the trigger mechanism can be selectively adjusted merely by turning the second link **112** relative to the first link **110** and thereby thread the second link further out of or in to the first link.

In accordance with another important feature of the present invention, the trigger mechanism may be configured such that a user's finger is "pushed back" after the gun **10** is fired through the execution of a pull stroke of the trigger **18**. This provides the sensation of a "reactive trigger." The pushing back of the finger after the trigger **18** is actuated or pulled to fire the gun **10** helps the user pull the trigger in more rapid succession, thereby helping the user to achieve an increased firing rate. The trigger mechanism is operable to actuate the firing system from the ready-to-fire mode to the firing mode to fire the gun upon the execution of a pull stroke of the trigger **18** and from the firing mode back to the ready-to-fire mode to place the gun back in condition for firing upon the execution of a return stroke of the trigger **18**. The pushing back of the user's finger after the gun is fired is accomplished by increasing the force applied through the trigger mechanism on the trigger **18**, and counter to which the trigger must be pulled to fire the gun, immediately after the gun is fired. Since a lesser force is necessary to pull the trigger **18**, this increase in the force opposing the trigger pull has a tendency to force the trigger **18** through the return stroke even if the user has not sufficiently released the trigger. Once the gun **10** is urged back in condition for another firing sequence, the force applied on the trigger **18** through the trigger mechanism is reduced in order to enable the trigger to be manually pulled with greater ease.

In the illustrated embodiment of the invention, an increased force applied on the trigger after the gun is fired is accomplished by configuring the on/off flow valve **74** with a differential piston head **114**. The differential head **114** of the flow valve comprises a first portion **116** with a relatively larger effective surface area and a second portion **118** with a relatively smaller surface area. Thus, when the flow valve **74** is open, the system relies on the second portion **118** of the differential piston since as the effective area to which the pressure is applied. This results in a relatively smaller force being applied to the on/off flow valve **74** by the compressed gas in the system when the flow valve is moving to the closed position as compared to the force applied on the on/off flow valve **74** as it moves to the open position. As the differential piston head **114** is moved toward the O-ring seal **78**, the system relies on the force applied to the lesser diameter portion **118** to provide resistance to the trigger pull.

On the other hand, when the air chamber has expelled and the differential piston head **114** is in engagement with the upper O-ring seal **78**, the force applied to the system is transferred to the larger first portion **116** of the piston head **114**. At this point, the gas from flow chamber beneath the head **114** has expelled. Likewise, the regulator valve **40** opens and the system upstream from the on-off valve goes to the full line pressure of the compressed gas source. This slams the on-off valve back to the open position with greater force than applied to the valve when moved from the open position to the closed position. Once returned to the open position, i.e, when the larger diameter head **114** is disengaged from the O-ring seal **78**, the effective area of the on-off valve upon which the pressure acts is once again the smaller diameter piston head **116**.

Specifically, as the first step of the firing sequence, the trigger **18** is pulled and the resultant longitudinal movement of the trigger arm **108** acts to rotate the actuating lever element **106** of the sear in a clockwise direction (relative to FIGS. **2–6**) which in turn rotates the sear arm **99** in the clockwise direction. As shown in FIG. **4**, the rotation of the sear arm **99** forces the on/off flow valve **74** into the closed position in response to the movement of the actuating member **102**. This movement of the flow valve **74** into the closed position is resisted by the downward force (relative to FIGS. **2–6**) exerted on smaller second portion **118** of the differential piston head on the flow valve **74** by the compressed gas in the system.

As shown in FIG. **5**, once the on/off flow valve **74** has closed, the interlocking element **104** on the sear **98** releases the dog portion **95** of the actuating bolt and the compressed gas in the firing chamber **36** moves the power piston **90** rapidly forward and is released from the power tube **80** resulting in the discharge of the projectile **20** from the barrel **22**. Upon the release of the compressed gas in the firing chamber **36**, the compressed gas in the regulator piston bore **62** is also released via the sensing line **72** resulting in movement of the regulator valve **40** back into the open position. After the gun **10** has been fired, the gas pressure maintained in the system upstream from the on/off flow valve **74** continues to exert a downward force on the on/off flow valve. However, since all of the compressed gas downstream from the on/off flow valve **74** has been discharged, the effective area on which it acts is the larger first portion of the differential piston head. Thus, the force acting on the flow valve **74**, and in turn on the trigger **18** through the sear **98**, is increased immediately after the compressed gas is discharged from the firing chamber **36**. Since the force now applied on the trigger **18** is greater than the force that had to be overcome to pull the trigger, this force tends to force a user to release the trigger **18** and allow the firing system to return to the ready-to-fire mode. In one preferred embodiment, it takes approximately 4 lbs. to pull the trigger and as soon as the gun is fired the force increases to 8 lbs. It has been found that this "reactive trigger" can enable a user to increase his or her firing rate by approximately thirty-three percent over conventional trigger arrangements.

In addition, upon the release of the compressed gas in the firing chamber **36**, the recoil spring **96** drives the actuating bolt **94** rearwardly against the bumper **97** where it is held in place by the force of the recoil spring. The increased downward force exerted on the on/off flow valve **74** will force the trigger **18** through the return stroke. In particular, the force on the on/off flow valve **74** moves the actuating member **102** of the sear to effect slight counterclockwise rotation of the sear **98** to both open the on/off flow valve **74** and to latch the actuating bolt **94** with the interlocking element **104**. The firing chamber is then recharged to the desired pressure via the compressed gas delivery system as described above.

The differential between the force applied on the trigger **18** during the pull stoke and the force applied during the return stroke is further accentuated by the regulating system of the present invention. Particularly, as soon as the regulator valve **40** reopens because of the discharge of gas from the firing chamber **36**, the pressure in the portion of the compressed gas delivery system upstream from the on/off flow valve **74** increases from the regulated pressure to the full line pressure of the compressed gas source. This increase in the pressure results in a greater downward force being applied to the on/off flow valve **74**. Of course, it will be appreciated that the advantages of the differential head on/off flow valve of the present invention could be achieved in firing systems which do not utilize the regulating system disclosed herein. Moreover, it will be appreciated that the teachings of the trigger mechanism of the present invention could also be applied to weapons other than the compressed gas powered gun disclosed herein. That is, the invention may be incorporated in any device actuated by hand manipulation with the use of a differential force transmission arrangement which is operable to apply a relatively greater force during a return stroke of the device than the force applied during the actuating stroke.

While this invention has been described with an emphasis upon preferred embodiments, it will be obvious to those of ordinary skill in the art that variations of the preferred embodiments may be used and that it is intended that the invention may be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications encompassed within the spirit and the scope of the invention as defined by the following claims.

What is claimed is:

1. A system for supplying compressed gas from a relatively high pressure compressed gas source to a gas chamber such that the gas chamber is rapidly filled with compressed gas to a preselected pressure, the system comprising:

a fluid pathway interconnecting the gas source with the gas chamber;

a regulator valve arranged in the fluid pathway and operable to rapidly move between an open position permitting relatively high pressure gas from the source to flow into the gas chamber at a supply pressure and a closed position isolating the compressed gas source from the gas chamber;

a valve regulator assembly adapted to move the valve to the closed position when a predetermined pressure of compressed gas which is less than the supply pressure is sensed and urging the regulator valve to the open position when a pressure less than the preselected pressure is sensed,

a flow control valve arranged in the fluid pathway interposed between the gas chamber and the regulator valve and having an open position for permitting gas to flow through to the gas chamber and a closed position wherein the gas chamber is sealed from the compressed gas source, and

a sensing line in fluid communication with the valve regulator assembly disposed to sense the pressure in the gas chamber, the sensing line applying the sensed pressure of the gas in the gas chamber to the valve regulator assembly.

2. The system of claim **1** wherein the valve is arranged in a valve chamber disposed in the fluid passageway.

3. The system of claim **2** wherein the valve regulator assembly includes a regulating piston arranged in a piston chamber which is sealed from the flow of gas from the valve chamber and is coupled to the valve, the regulating piston being movable in response to the pressure of compressed gas received in the piston chamber through the sensing line.

4. The system of claim **3** wherein the regulator assembly further includes biasing means coupled to the regulator piston and having a preselected tension to restrict movement of the regulator piston to prevent the valve from moving into the closed position until the piston chamber reaches the preselected pressure.

5. The system of claim **4** wherein the valve regulator assembly further includes a valve stem which couples the regulator piston and the valve.

6. The system of claim **5** wherein the valve stem extends to a point adjacent the chamber and wherein the sensing line is a bore extending through the valve stem from a first location adjacent the gas chamber to a second location inside the piston chamber.

7. A compressed gas firing system for discharging a projectile from a barrel, the firing system being powered by a compressed gas source, the firing system comprising:

a firing chamber for supplying compressed gas to expel the projectile;

a fluid pathway interconnecting the firing chamber with the compressed gas source;

a pressure regulating assembly including a regulator valve arranged in the fluid pathway and operable to move between an open position wherein gas from the source can flow to the firing chamber and a closed position wherein the compressed gas source is isolated from the chamber, a sensing line for sensing the pressure of the compressed gas in the firing chamber and a regulator in fluid communication with the sensing line and adapted to move the regulator valve to the closed position when a preselected pressure of compressed gas is sensed and to move the valve to the open position when a pressure less than the preselected pressure is sensed;

a flow valve arranged in the fluid pathway upstream from the regulator valve and having an open position for permitting gas to flow through to the firing chamber and a closed position wherein the firing chamber is sealed from the compressed gas source; and

an actuating assembly operable to open the flow valve and to seal the firing chamber in a ready to fire position and close the flow valve and to direct compressed gas discharged from the firing chamber toward the projectile in a fire position.

8. The firing system of claim **7** wherein the sensing line senses the pressure of the gas in the firing chamber from a location downstream from the flow valve.

9. The firing system of claim **7** wherein the regulator valve is arranged in a valve chamber and the regulator is arranged in a regulator chamber which is sealed from the flow of gas from the valve chamber and in fluid communication with the sensing line.

10. The firing system of claim **9** wherein the regulator includes a regulating piston coupled to the regulating valve and movable in response to the compressed gas received in the regulator chamber through the sensing line.

11. The firing system of claim **10** wherein the regulating piston is coupled to the regulating valve by a valve stem.

12. The firing system of claim **11** wherein the regulator includes biasing means coupled to the regulator piston and having a preselected tension to restrict movement of the regulator piston to prevent the valve from moving into the closed position until the regulator assembly reaches the preselected pressure.

13. The firing system of claim **12** wherein the sensing line comprises a bore in the valve stem extending from adjacent the firing chamber to the regulator chamber.

14. A method for filling an air chamber in a regulator system with compressed gas to a preselected pressure, the regulator system including a valve operable to move between an open position wherein gas can flow to the air chamber and a closed position wherein the air chamber is isolated from the flow of gas, a regulator coupled to the valve and adapted to move between the open closed position and means coupled to the regulator for sensing the pressure of the compressed gas, the method comprising the steps of:

supplying relatively high pressure compressed gas at a first pressure greater than the preselected pressure at an inlet,

feeding the compressed gas from the inlet past the valve to the air chamber;

passing a portion of the compressed gas flowing from the inlet to the air chamber back to the regulator from a point adjacent the air chamber,

sensing the pressure of the compressed gas which has passed back to regulator with the sensing means;

actuating the regulator assembly with the sensing means to rapidly close the valve and thereby close off the flow of compressed gas to the air chamber when the pressure in the chamber reaches the preselected pressure;

isolating the air chamber from the flow of gas at a point upstream from the regulator assembly; and

discharging the compressed gas from the air chamber.

15. A compressed gas delivery system for supplying compressed gas from a compressed gas source to a gas chamber such that the gas chamber is rapidly filled with compressed gas to a preselected pressure, the system comprising:

a fluid pathway interconnecting the gas source with the gas chamber;

a regulator valve arranged in the fluid pathway and operable to move between an open position wherein gas from the source can flow into the gas chamber at a supply pressure and a closed position wherein the compressed gas source is isolated from the gas chamber;

means for sensing the pressure in the gas chamber;

a regulator assembly coupled to the sensing means and adapted to move the valve to the closed position when the sensing means senses a predetermined pressure of compressed gas which is less than the supply pressure and for urging the valve to the open position when the sensing means senses a pressure less than the preselected pressure is sensed, and

a flow valve interposed in the fluid pathway upstream from the regulator valve and having an open position for permitting gas to flow through to the gas chamber and a closed position wherein the fining chamber is sealed from the compressed gas source.

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