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(54) **Title:** LESS-THAN-LETHAL AMMUNITION UTILIZING A SUSTAINER MOTOR

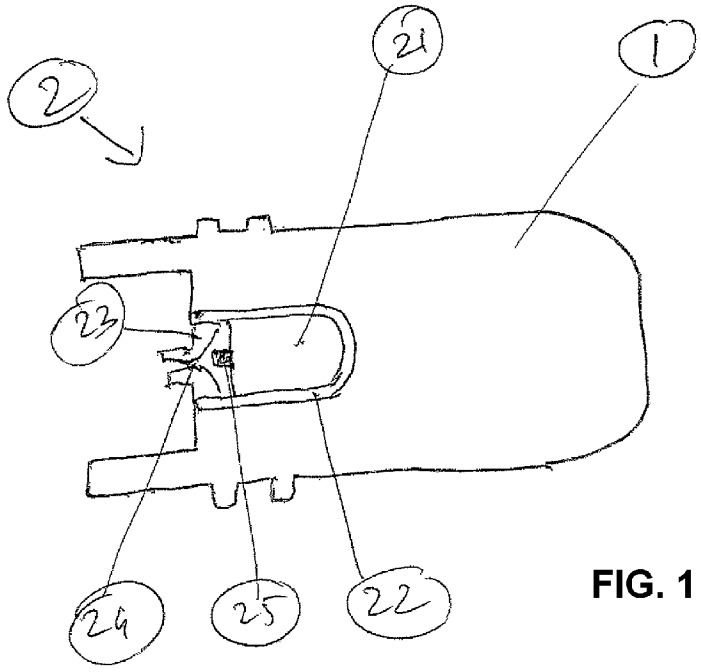


FIG. 1

(57) **Abstract:** A weapon system and corresponding ammunition for causing less-than- lethal effects to a target employ a projectile fired from a rifle-mounted, rifle- operated or dedicated rifle-like device and configured for generating less-than- Iethal effects to a human target. The projectile includes a rocket motor configured to mitigate velocity decay of the projectile. The rocket motor is preferably a sustainer motor for maintaining a roughly constant cruise velocity of the projectile.

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Less-Than-Lethal Ammunition Utilizing A Sustainer Motor

FIELD AND BACKGROUND OF THE INVENTION

The present invention generally relates to less-than-lethal ammunition. More specifically, the present invention relates to less-than-lethal ammunition including a projectile with a sustainer rocket motor, in order to mitigate velocity decay throughout the flight, thereby maintaining a constant level of non-lethality while at the same time reducing sensitivity to cross-range winds and increasing the effective range of the projectile.

Less-than-lethal ammunition is of particular importance in low-intensity conflicts in which military or law-enforcing units face rioting mobs agitated by hostile propaganda including fanatic elements. These military or law-enforcing units are generally outnumbered by the crowds and, if the situation deteriorates, these crowds might try to overwhelm the law-enforcing forces. The crowds might include a mix of civilians and para-military insurgents, and not until the law-enforcing units are exposed to physical danger they are permitted to use live ammunition. Such scenarios may cause casualties among civilians that have been incited to participate in the riots. Less-than-lethal ammunition gives the law-enforcement forces an additional option to handle riots while avoiding or at least minimizing casualties.

Less-than-lethal ammunition are typically unguided flat-trajectory projectiles fired from light arms, and particularly from rifle-mounted, rifle-operated or dedicated rifle-like devices. They must be capable of being fired

accurately over a range of applicable distances while maintaining a low penetrating capacity and being `eye safe`. Range, accuracy and effectiveness on one hand, and less-than-lethality on the other hand are opposing requirements that are not easy to reconcile over a broad range. In fact, velocity is a key factor for range accuracy and effectiveness, and a constrained parameter in terms safety. Even in state-of-the art less-than-lethal ammunitions, such as that taught in US Patent 7,207,276, the less-than-lethal projectile has a maximum effective range of approximately 50 meters from the weapon muzzle, when fired at a muzzle velocity of 90 – 120 meters per second.

The riot situations may develop in various ways, and it is not uncommon that, at the onset, the rioting group is at a considerable range from the law-enforcement forces and subsequently it closes the distance and comes very close to the law-enforcement forces. Therefore it is required that the less-than-lethal weapons operate safely and effectively from very short ranges (a few meters) to a range of least 100 m and preferably 200 meters.

Extending the range of less-than-lethal projectiles is a serious challenge in view of the fact that less-than-lethal projectiles must be launched with a kinetic energy that does not cause lethal effects on target impact, even at short range.

Existing less-than-lethal ammunitions typically feature a truncated hemispherical compliant nose. This compliant nose compresses to absorb energy upon impact, reducing the likelihood of skin abrasion, laceration,

skeletal or organ damage. This hemispherical shape contributes to increased drag.

Velocity decay is an unwelcome feature for less-than-lethal ammunition, as it will result in reduced effectiveness, increased sensitivity to cross-winds and other disturbances as well as a trajectory with a higher curvature that is detrimental to accuracy.

There is therefore a need for a solution to mitigate velocity decay of a less-than-lethal projectile, which constitutes a critical issue limiting the range of less-than-lethal projectiles. The present invention overcomes the problem of velocity decay in less-than-lethal ammunition by providing a less-than-lethal projectile with a miniature sustainer motor that is ignited upon launch and is designed to deliver a thrust force equal to the drag force at the cruise velocity. The cruise velocity is designed to be the preferred less-than-lethal velocity.

SUMMARY OF THE INVENTION

According a first aspect, the teaches a projectile for causing less-than-lethal effects to targets, equipped with a rocket motor mitigating the velocity decay of the projectile.

According to another aspect, the invention teaches the said projectile, wherein the rocket motor is a sustainer. According to yet another aspect, the said rocket motor is ignited by the effect of the gases of the cartridge propellant. According to a further aspect of the invention, the said rocket motor has an initiation system of its own.

According to a still further aspect of the invention, the burning time of the said rocket motor is least 5% of the flight time, more at least 25% of the flight time, yet more preferably at least 50% of the flight time, even more preferably at least 75% of the flight time and most preferably at least 95% of the flight time.

Thus, according to the teachings of the present invention there is provided, ammunition for causing less-than-lethal effects to a target, the ammunition comprising a projectile configured for generating less-than-lethal effects to a human target, the projectile including a rocket motor configured to mitigate velocity decay of the projectile.

According to a further feature of the present invention, the rocket motor is a sustainer.

According to a further feature of the present invention, there is also provided a cartridge initially associated with the projectile, the cartridge containing a quantity of propellant for firing the projectile, wherein the rocket motor is configured to be ignited by hot gases generated by combustion of the propellant.

According to a further feature of the present invention, there is also provided a pyrotechnic delay element associated with the rocket motor and deployed such that ignition of the rocket motor by the hot gases occurs via the pyrotechnic delay element at a delay after firing of the projectile.

According to a further feature of the present invention, there is also provided an electronic initiation system associated with the projectile for initiating operation of the rocket motor.

According to a further feature of the present invention, the electronic initiation system is configured to initiate operation of the rocket motor at a time delay after firing of the projectile.

There is also provided according to the teachings of the present invention, a less-than-lethal weapon system for causing less-than-lethal effects to a human target located between a minimum range and a maximum range, the weapon system comprising: (a) a projectile configured for generating less-than-lethal effects to a human target; and (b) a firing arrangement configured for firing the projectile towards the human target, wherein the projectile includes a rocket motor configured to mitigate velocity decay of the projectile.

According to a further feature of the present invention, the rocket motor is a sustainer.

According to a further feature of the present invention, the firing arrangement includes a cartridge initially associated with the projectile, the cartridge containing a quantity of propellant for firing the projectile, wherein the rocket motor is configured to be ignited by hot gases generated by combustion of the propellant.

According to a further feature of the present invention, there is also provided a pyrotechnic delay element associated with the rocket motor and

deployed such that ignition of the rocket motor by the hot gases occurs via the pyrotechnic delay element at a delay after firing of the projectile.

According to a further feature of the present invention, the projectile includes an electronic initiation system for initiating operation of the rocket motor.

According to a further feature of the present invention, the electronic initiation system is configured to initiate operation of the rocket motor at a time delay after firing of the projectile.

According to a further feature of the present invention, the rocket motor is configured to operate for a burn time of at least 5% of a time of flight of the projectile from firing to the maximum range.

According to a further feature of the present invention, the rocket motor is configured to operate for a burn time of at least 25%, preferably at least 50%, more preferably at least 75%, and most preferably at least 95%, of a time of flight of the projectile from firing to the maximum range.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 depicts the flight configuration of a less-than-lethal projectile according to the present invention.

Figure 2 depicts the less-than-lethal projectile according to the present invention attached to its cartridge casing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is ammunition and a corresponding weapon system for causing less-than-lethal effects to a human target.

The principles and operation of ammunition and weapons systems according to the present invention may be better understood with reference to the drawings and the accompanying description.

By way of introduction before referring to the specific embodiment illustrated herein in the drawings, the present invention is a less-than-lethal weapon system and corresponding ammunition for causing less-than-lethal effects to a human target located between a minimum range and a maximum range. In general terms, the weapon system includes a projectile configured for generating less-than-lethal effects to a human target, and a firing arrangement configured for firing the projectile towards the human target. It is a particular feature of the present invention that the projectile includes a rocket motor, configured to be actuated on firing of the projectile, which is deployed to mitigate velocity decay of the projectile.

The terms "non-lethal", "less-than-lethal" and "less lethal" are used herein interchangeably to refer to types of projectiles and corresponding ammunition and weapon systems which are designed to temporarily incapacitate a human target with a reduced risk of death or permanent serious injury compared to a normal bullet. This definition includes a wide range of weapons including, but not limited to: kinetic projectiles such as rubber bullets, plastic bullets and flexible baton rounds; electrical stun projectiles; and rounds

carrying chemical agents such as tear gas or "pepper spray". The various devices intended for use as less-than-lethal weapons are typically identifiable by a relatively large cross-section compared to their mass, giving a low ballistic coefficient, and various arrangements for energy dissipation to reduce impact damage and reduce the likelihood of penetration into the target.

Turning now to the drawings, according to a preferred embodiment, there is described in Figure 1 a less-than-lethal projectile **1** in flight configuration. Lethal damage criteria might vary from target to target, and according to the lethality risk justified by the particular circumstances. For example, weapons to be used for civilian crowd control require a much lower risk to life than a weapon to be used against an armed terrorist for the purpose of trying to capture the terrorist alive. In each case the methodology as outlined remains the same. Depending on the other parameters (primarily mass and structural design) of a projectile 1, there is a certain maximum design velocity $V_{less\text{-}than\text{-}lethal_max}$ at which the projectile satisfies given criteria to be considered "less-than-lethal" for the given context. A projectile may be fired at a velocity $V_{less\text{-}than\text{-}lethal_max}$' or in some cases at a higher velocity, so long as the velocity decays to $V_{less\text{-}than\text{-}lethal_max}$ before reaching the minimum intended range for use. After firing, the velocity rapidly decays under the effect of aerodynamic drag, making the projectile less and less effective and more sensitive to atmospheric effects, such as cross-winds. The velocity decay, and associated loss of precision and efficacy, are particularly pronounced due to the low ballistic constant of less-than-lethal projectiles, corresponding to poor aerodynamic

properties. According to the teachings of the present invention, to mitigate the velocity decay (i.e., to reduce the adverse affect of velocity decay on the effective range and/or on the precision of the projectile), a miniature rocket motor **2** is mounted at the base (rear) of the projectile to reduce the velocity decay. Most preferably, the rocket motor is a sustainer rocket motor, i.e., that provides a thrust equal to the projectile aerodynamic drag at a chosen velocity, preferably close to (but no greater than) the velocity $V_{less\text{-}than\text{-}lethal_max}$, so that the projectile will cruise for at least part of its path of flight at this chosen velocity. In most preferred cases, the less-than-lethal projectile will thus cruise to the target at maximum range at a velocity substantially equal to $V_{less\text{-}than\text{-}lethal_max}$, thereby both maximizing the efficacy of the projectile and minimizing the loss of precision independent of the range of a given target.

The rocket motor is most preferably a cigarette burning-sustainer, burning from its aft end to its forward end with a constant burning surface. The propellant burns at a constant velocity. The propellant may be any suitable type of propellant, such as, for example, a standard HTPB/AP (Hydroxyl-terminated polybutadiene / Ammonium Perchlorate) cast composite propellant. The propellant charge length is equal to the product of the burning velocity and burn time, which is set essentially equal to the maximum flight time. The propellant charge **21** is bonded to a casing **22** that serves as a support and pressure vessel. A nozzle assembly **23** is screwed onto the casing, with a throat **24** as required by the ballistic conditions corresponding to the required level of thrust. In the example illustrated here, the rocket motor **2** is further provided

with an ignition pellet, for example, a Boron/ Potassium Nitrate (BPN) ignition pellet **25**, but has no initiation system of its own. In this case, the ignition pellet is ignited by the hot gases generated during combustion of the primary propellant which occurs during firing of the projectile. Optionally, a pyrotechnic delay element (not shown) may be interposed between ignition pellet **25** and propellant charge **21**, thereby delaying initiation of the rocket motor until a desired point during flight of the projectile, such as when the velocity has dropped from an initially higher launch velocity to near the $V_{less\text{-}than\text{-}lethal_max}$. In other cases, immediate initiation of the rocket motor on firing may be preferred.

To illustrate one possible sustainer motor configuration, one example will now be described complete with an outline of the theoretical basis for the design parameters. It should be noted however that the present invention as described thus far may readily be implemented by one ordinarily skilled in the art, independent of the accuracy or otherwise of the following theoretical analysis and calculation which are for illustrative purposes only. Let us assume a desired cruise velocity $V_{less\text{-}than\text{-}lethal_max}$ of 75 m/sec, a drag coefficient C_d of 0.4 and a cross-section *A* corresponding to a circle of 40 mm diameter. Accordingly, the drag will be $0.5\rho_{air}V^2A\ C_d = 0.177$ kgf. The sustainer motor thrust will be designed to equal to the drag. For a range of 200 meters the flight-time will be 200/75 = 2.666 sec. The total impulse will be 0.177kgf*2.666 sec = 0.47 kgf*sec. With a typical specific impulse of 200 sec, 2.3 grams of propellant will be needed to produce this total impulse. This

quantity of propellant, with the casing enclosing it and the nozzle assembly weighing another few grams, provide a miniature propulsion unit which is light-weight compared to the typical weight of a 40 mm less-than-lethal round which is around 90 grams and can therefore easily be accommodated within the projectile (replacing a corresponding mass of inert material in order to keep the total weight unchanged). The integration of the miniature rocket motor into the projectile is straight-forward for those skilled in the art of mechanical design of projectiles.

As mentioned before, the principles of the present invention are applicable to substantially all types of less-than-lethal ammunition, and similarly to all types of appropriate firing arrangements. In a typical case as illustrated in Figure 2, the projectile is fired from a firearm by use of a pyrotechnic charge. In this case, the less-than-lethal projectile according to the present invention is attached to a cartridge casing **3**, as is known in the art of less-than-lethal ammunition. The projectile is assembled onto the front rim of the cartridge casing. The cartridge casing is typically made of soft material, such as brass. The pyrotechnic igniting cartridge **4** is at the center of the bottom of the cartridge casing.

The complete round is loaded into a weapon barrel and the cartridge percussion primer **5** is initiated by the weapon firing pin. Once the cartridge percussion primer is initiated, it ignites the cartridge propellant charge. The propellant charge gases generate high pressure that impinges on the projectile and causes it to separate from the cartridge casing and to move along the rifled

weapon barrel, thereby gaining the spin velocity required for its gyroscopic stabilization. The hot propellant gases flow through the miniature rocket motor nozzle throat **24**, igniting the BPN pellet **25**, which ignites the sustainer rocket motor propellant **21**, either immediately or via a pyrotechnic delay element, as discussed above.

As mentioned earlier, the present invention is not limited to the particular example described above, and may be used with any and all types of less-than-lethal ammunition and firing arrangements. By way of one further non-limiting example, rounds without a propellant-filled cartridge may be fired from a firing arrangement employing pressurized gas to fire the projectile. In such cases, the projectile includes an electronic initiation system (not shown), as is known in the art, for initiating operation of the rocket motor. One non-limiting example is the provision of a piezo-electric generator, operated by launch set-back, by the pressure applied during firing or by any other means, which generates an electric charge that is stored in one or more capacitors as a power source, electronic delay circuit, electronic firing circuit providing current to an electric initiator bridge-wire, serving as an input for the rocket motor ignition pyrotechnic train. Such an arrangement allows initiation of the rocket motor at a desired delay after firing of the projectile. Where no delay is required, the electronic delay circuit may be omitted. According to further options, a battery may be included to power an electrical initiator circuit.

After leaving the muzzle, the projectile flies towards the target. The miniature sustainer burns during at least part of the flight-time and provides a

thrust equal to the drag. In this situation, the velocity remains constant and the projectile flies in essentially "vacuum conditions". According to the principles of the exterior ballistics of rockets (as taught by example in the classical manuscript of Davis, Exterior Ballistics of Rockets, Van Nostrand, 1958), whenever the drag equals thrust, there will be no influence of cross-winds on the trajectory.

It should be noted that mitigation of velocity decay and of sensitivity to cross-winds, while being of great ballistic importance, does not translate directly in achieving a specific range. There are other parameters that will determine the actual maximum range: gunner dispersions and accuracy of range estimation. It should be noted that the current invention does not deal (at least not directly) with the issue of probability of hit. Nevertheless, those familiar with the art of exterior ballistics of rockets (as taught in the above-mentioned manuscript by Davis) will recognize the importance of velocity for achieving hit probability at extended ranges.

It should be noted that various other designs of the rocket motor may be feasible, aimed at the same goal of mitigating velocity decay, with various degrees of success in this aim. For example, instead of a constant thrust profile, the rocket motor may be of a booster type, essentially providing a velocity increase at a certain point along the trajectory in order to compensate for velocity losses that have already evolved. The burning time of a booster type motor may be at least 5% of the flight time and more preferably at least 25% of the fight time.

Also, even a sustainer might not burn along the entire length of the trajectory but rather only for part of the flight time, such as possibly at least 50% of the flight time, more preferably for at least 75% of the flight time and most preferably for 95% of the flight time.

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It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible within the scope of the present invention as defined in the appended claims.

WHAT IS CLAIMED IS:

1. Ammunition for causing less-than-lethal effects to a target, the ammunition comprising a projectile configured for generating less-than-lethal effects to a human target, said projectile including a rocket motor configured to mitigate velocity decay of the projectile.

2. The ammunition of claim 1, wherein said rocket motor is a sustainer.

3. The ammunition of claim 1, further comprising a cartridge initially associated with said projectile, said cartridge containing a quantity of propellant for firing said projectile, wherein said rocket motor is configured to be ignited by hot gases generated by combustion of said propellant.

4. The ammunition of claim 3, further comprising a pyrotechnic delay element associated with said rocket motor and deployed such that ignition of said rocket motor by said hot gases occurs via said pyrotechnic delay element at a delay after firing of said projectile.

5. The ammunition of claim 1, further comprising an electronic initiation system associated with said projectile for initiating operation of said rocket motor.

6. The ammunition of claim 5, wherein said electronic initiation system is configured to initiate operation of said rocket motor at a time delay after firing of said projectile.

7. A less-than-lethal weapon system for causing less-than-lethal effects to a human target located between a minimum range and a maximum range, said weapon system comprising:

(a) a projectile configured for generating less-than-lethal effects to a human target; and

(b) a firing arrangement configured for firing said projectile towards the human target,

wherein said projectile includes a rocket motor configured to mitigate velocity decay of the projectile.

8. The weapon system of claim 7, wherein said rocket motor is a sustainer.

9. The weapon system of claim 7, wherein said firing arrangement includes a cartridge initially associated with said projectile, said cartridge containing a quantity of propellant for firing said projectile, wherein said rocket motor is configured to be ignited by hot gases generated by combustion of said propellant.

10. The weapon system of claim 9, further comprising a pyrotechnic delay element associated with said rocket motor and deployed such that ignition of said rocket motor by said hot gases occurs via said pyrotechnic delay element at a delay after firing of said projectile.

11. The weapon system of claim 7, wherein said projectile includes an electronic initiation system for initiating operation of said rocket motor.

12. The weapon system of claim 11, wherein said electronic initiation system is configured to initiate operation of said rocket motor at a time delay after firing of said projectile.

13. The weapon system of claim 7, wherein said rocket motor is configured to operate for a burn time of at least 5% of a time of flight of said projectile from firing to the maximum range.

14. The weapon system of claim 7, wherein said rocket motor is configured to operate for a burn time of at least 25% of a time of flight of said projectile from firing to the maximum range.

15. The weapon system of claim 7, wherein said rocket motor is configured to operate for a burn time of at least 50% of a time of flight of said projectile from firing to the maximum range.

16. The weapon system of claim 7, wherein said rocket motor is configured to operate for a burn time of at least 75% of a time of flight of said projectile from firing to the maximum range.

17. The weapon system of claim 7, wherein said rocket motor is configured to operate for a burn time of at least 95% of a time of flight of said projectile from firing to the maximum range.

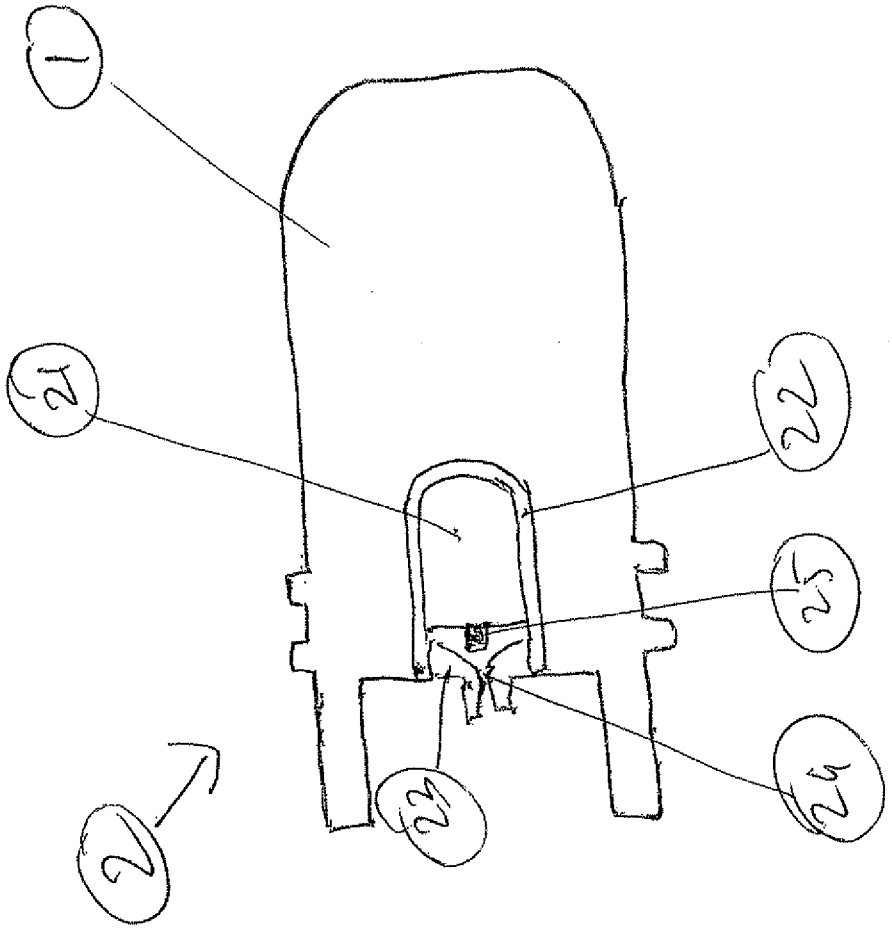


Figure 1

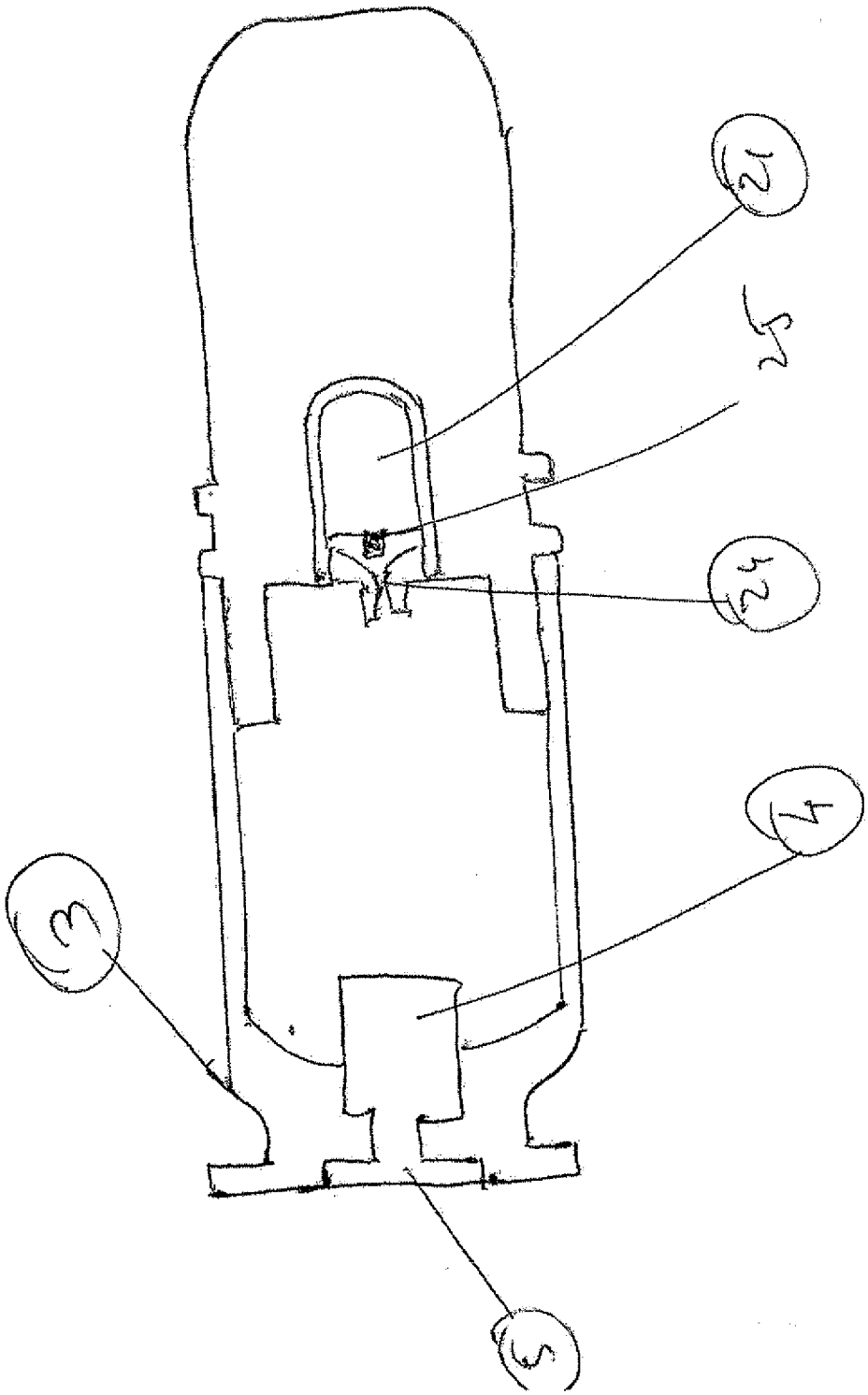


Figure 2