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(54) **SOUND SUPPRESSOR USING CLOSED LOOP RECIRCULATION**

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(57) **ABSTRACT**

The present invention relates a sound suppressing system for a firearm explosion gases with two coaxial tubes mounted on the gun barrel, defining two coaxial chambers, an inner chamber and an outer chamber, communicating at their ends through rear passages and front passages and two end caps, rear end cap and front end cap, and where the gases flow in one direction through the inner chamber and in opposite direction through the outer chamber and create a continuous loop that extends the travel path of the gases and allow for a gradual dissipation of the energy. Only a small portion of the gases, go straight through without being turned around.

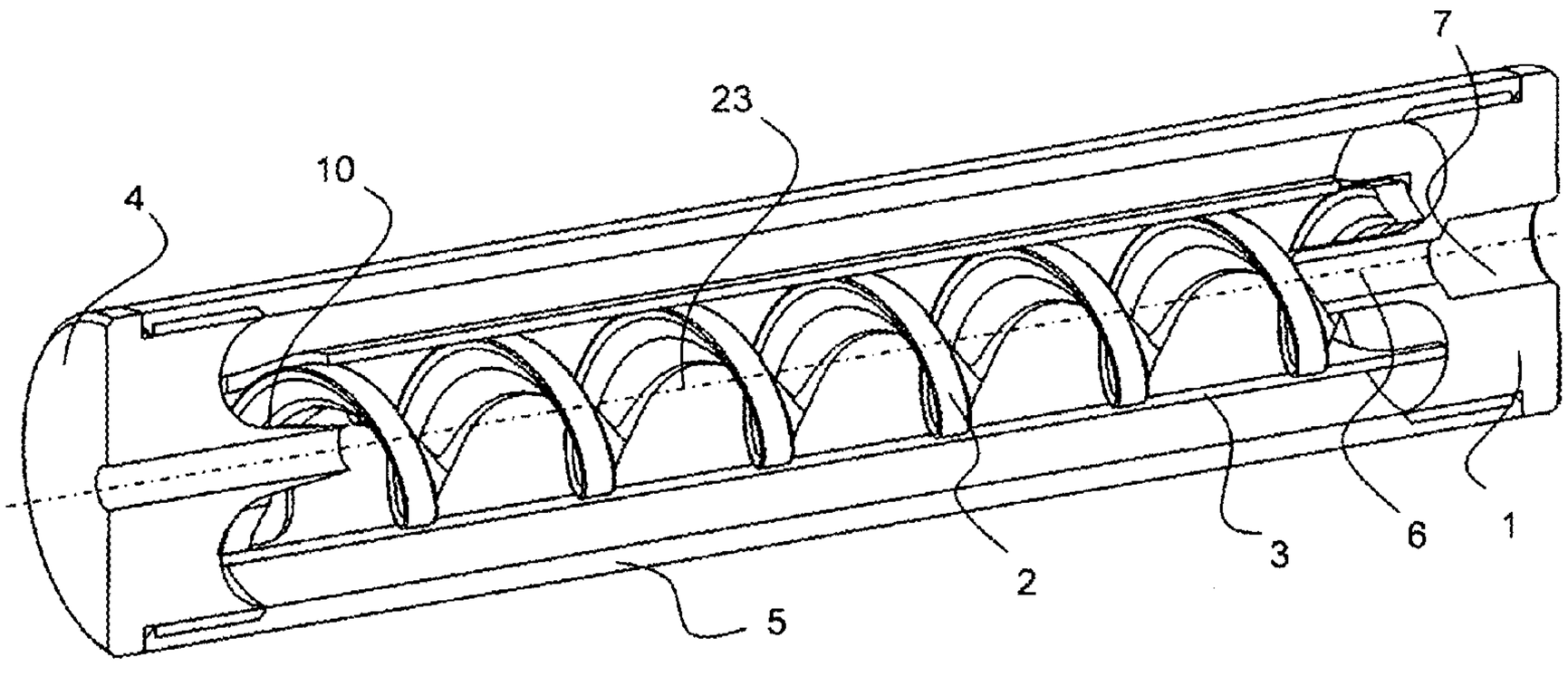


Figure 1

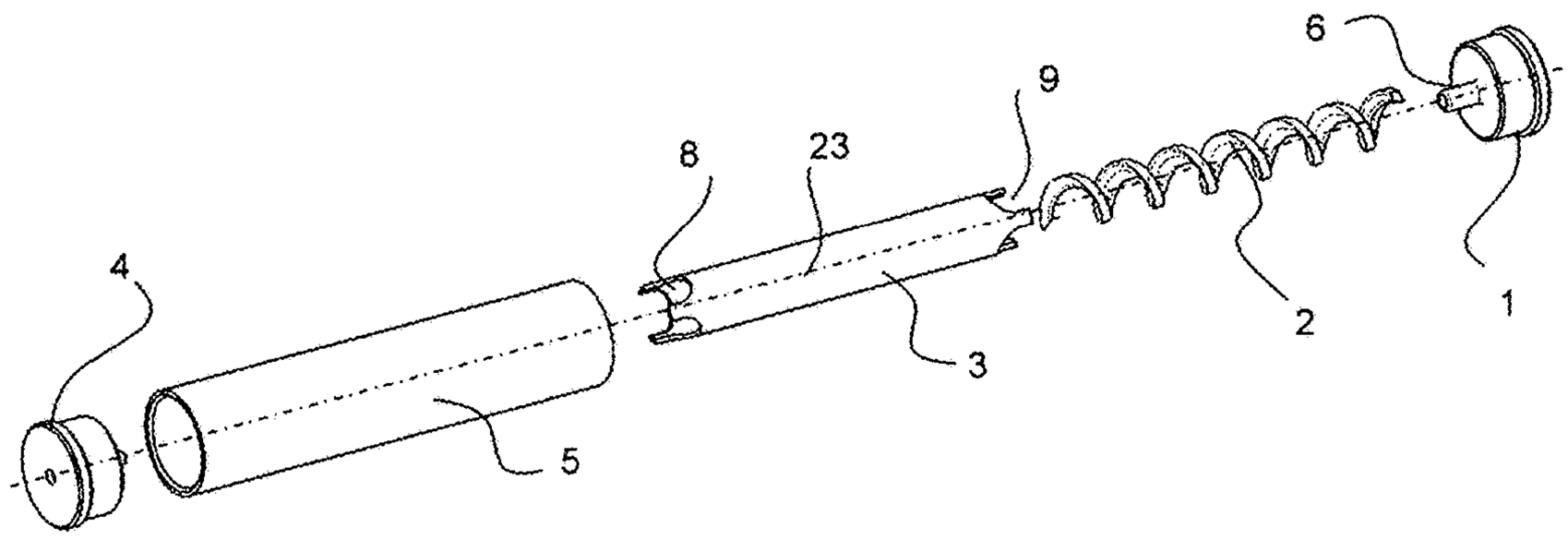


Figure 2

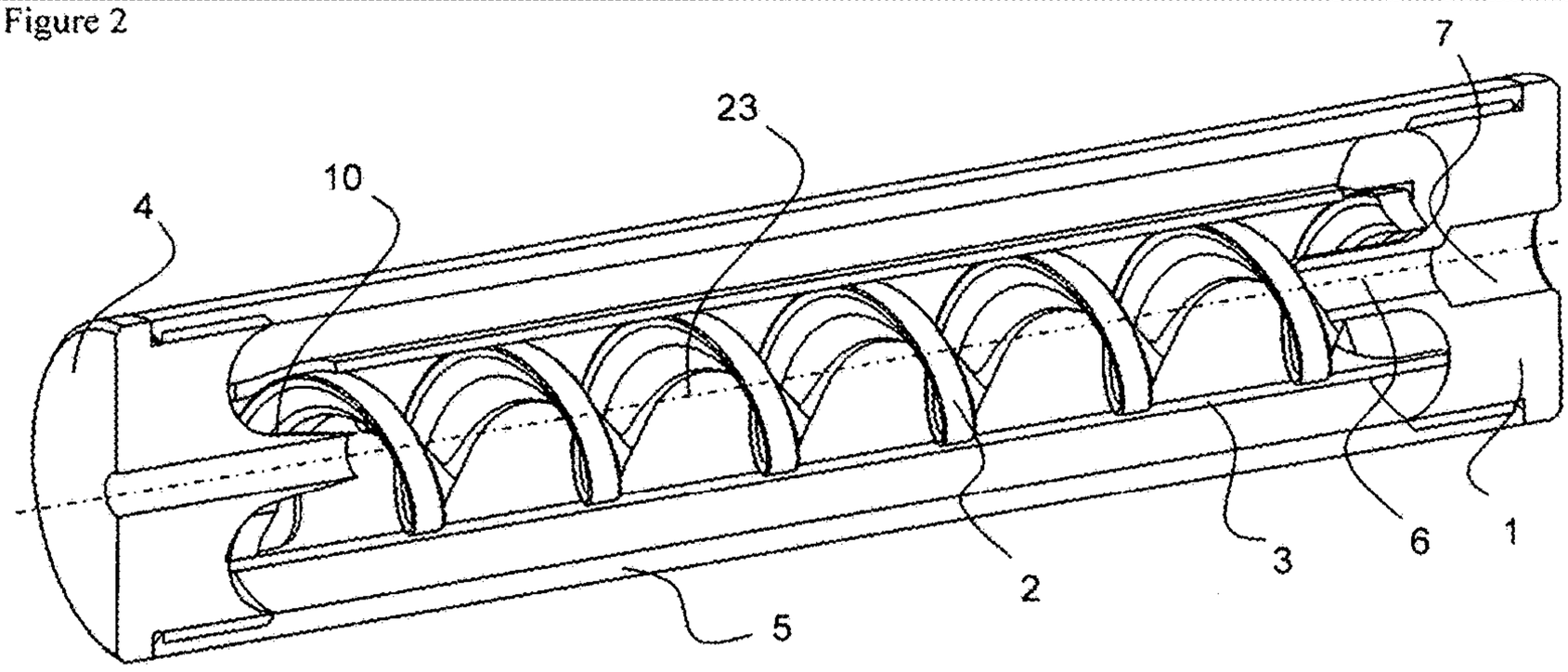


Figure 3:

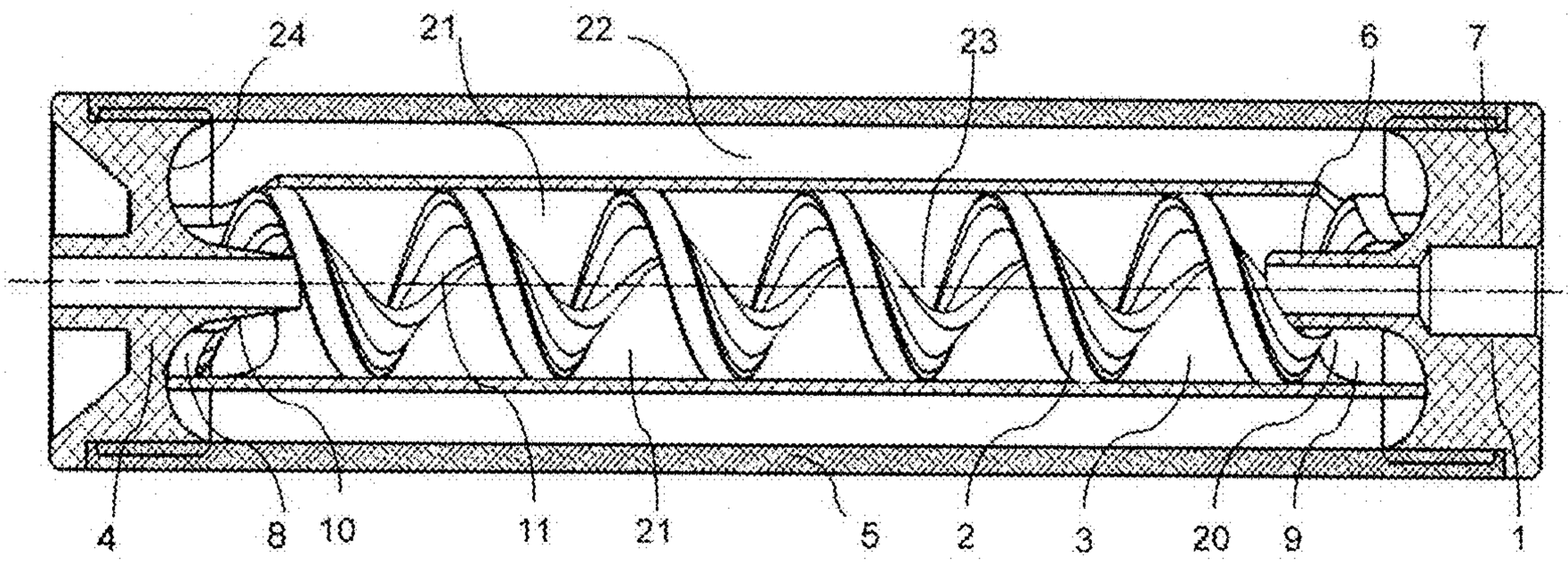


Figure 4

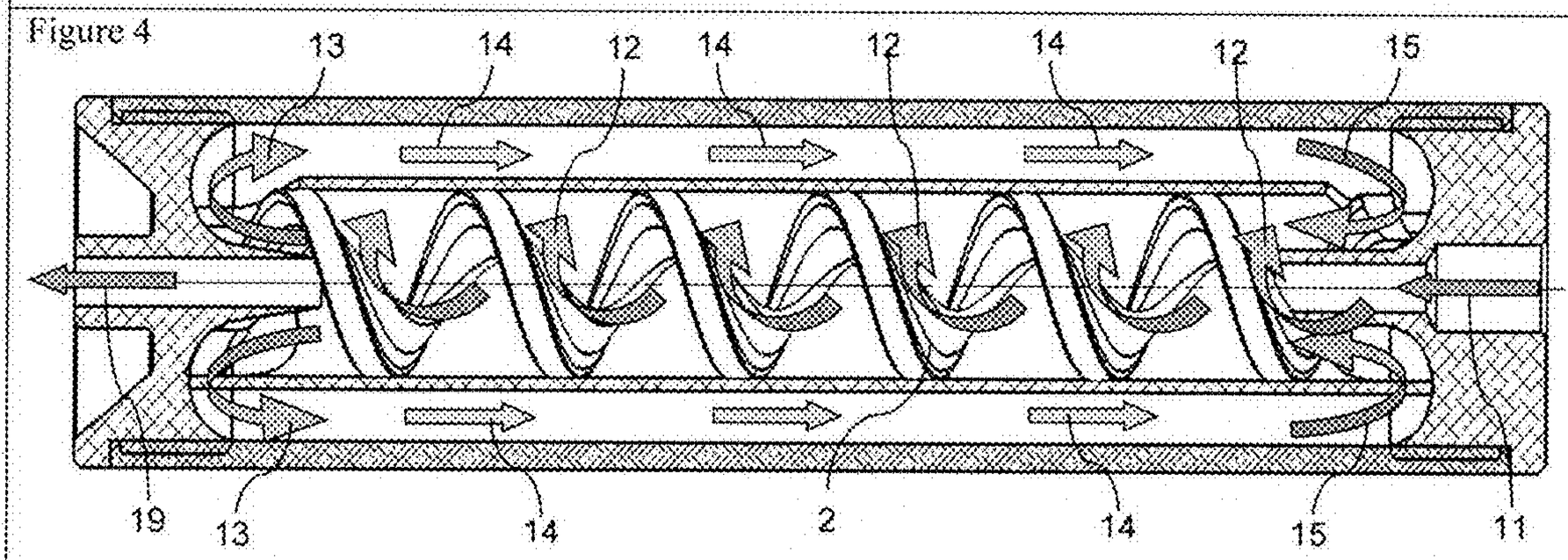


Figure 5

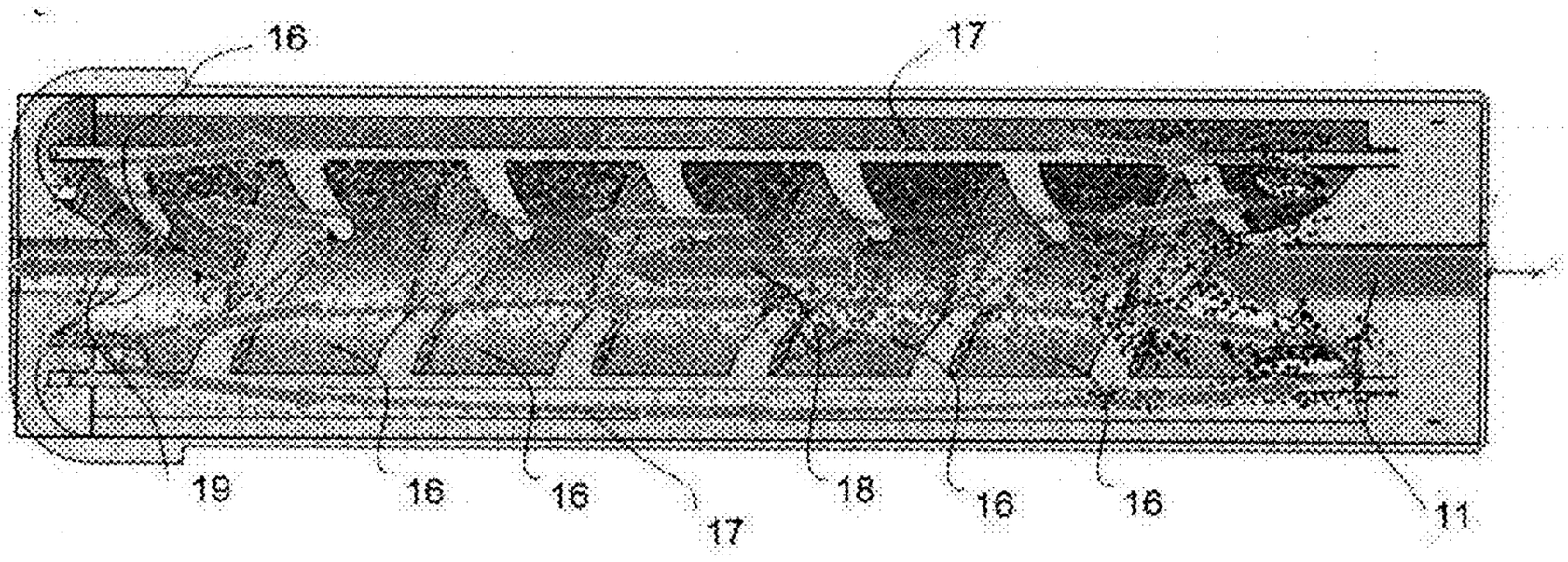
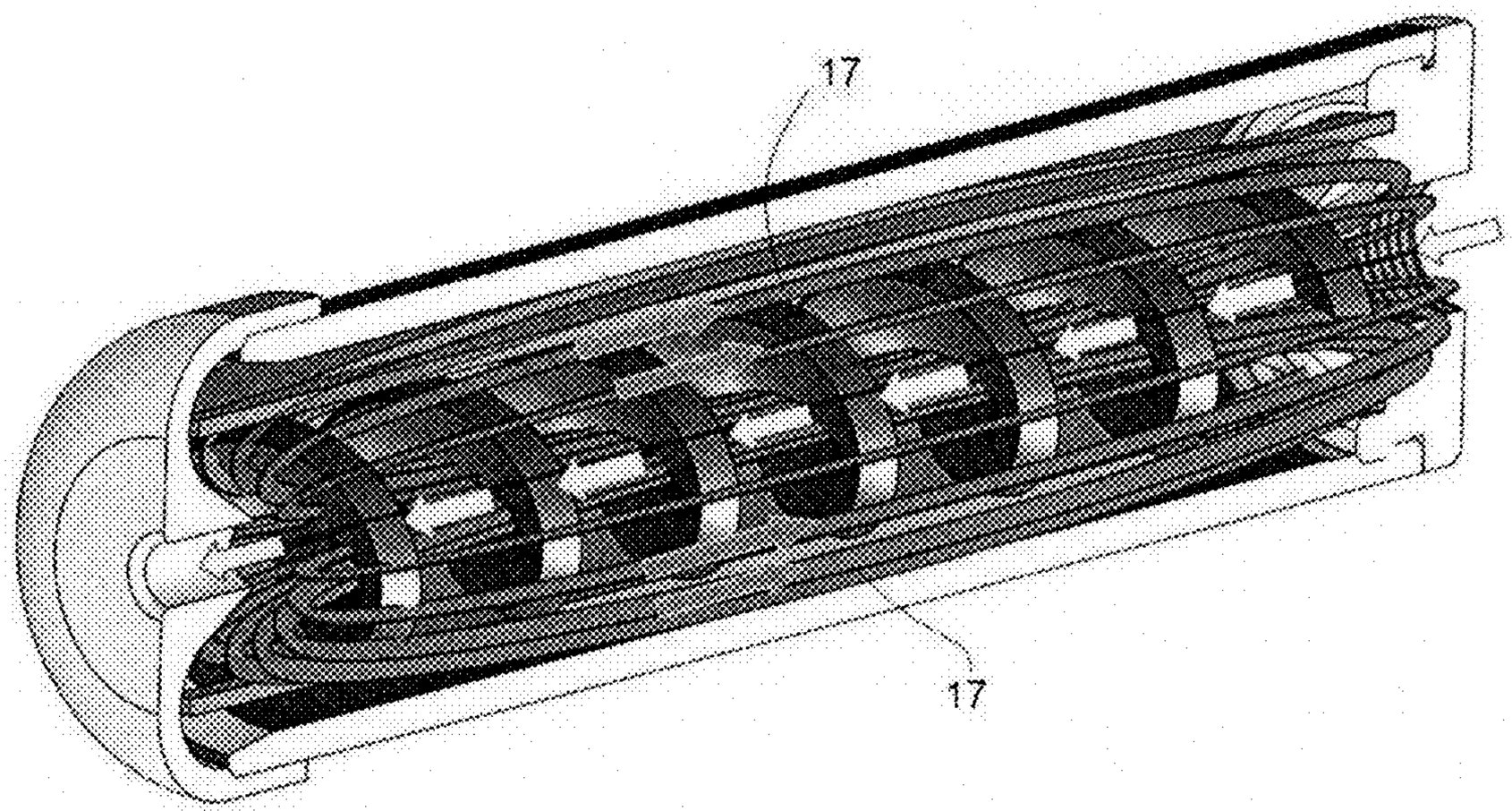


Figure 6



SOUND SUPPRESSOR USING CLOSED LOOP RECIRCULATION

BACKGROUND

Field of Invention

[0001] The present invention relates generally to an advanced sound suppressor device which can be used for any type of system where there is an explosive gaseous generation and sound muffling is an important factor. More particularly, the invention can be used in fire arm applications (hunting, law enforcement, crime fighting, armed conflict etc.) where sound suppression is required.

[0002] Most prior art silencers are designed as a large expansion volume many times (up to 30 times or more) greater than the inside volume of the barrel. This volume is rapidly occupied with the pressurized, hot and rapidly moving explosion gases. A functional silencer design will offer a solution that will decrease the speed, pressure and temperature of these gases—the potential and kinetic energy—before they are expelled out of the silencer. The result of this functionality is that the sound emitted by the fire arm will also be decreased with the reduction of the parameters mentioned above.

[0003] The currently known solutions for spending the gases energy (speed, pressure and temperature) are either too complex, involving many components, have very expensive to manufacture parts, are too bulky and large in size, are difficult to maintain and rapidly deteriorate as efficiency, or have reduced efficiency right from the start.

[0004] There is presently no known design that solves all these problems and does not have at least one or a combination of the disadvantages above.

[0005] The current invention provides a simple, high-efficiency, cheap, maintenance-free and practical solution to the prior art disadvantages in order to reduce or eliminate sound in explosive gas systems.

PRIOR ART

[0006] U.S. Pat. No. 9,500,108:

[0007] A silencer having an outer shell with a first opening at a first end is configured with two flow paths and designed to attenuate sound waves. A tube is positioned within the outer shell, the tube having a first end and a second end forming a path through the interior of the silencer. A baffle is positioned between the inner tube and the outer shell to form a second path through the silencer. The first path may be longer than the second path. The sum of the cross-sectional areas of the first path and second path may be equal to the cross-sectional area of the first opening.

U.S. Pat. No. 7,207,258:

[0008] Silencers are provided for a weapon having a combustion chamber and a barrel. The weapon is configured to launch a projectile with combustion gases generated in the combustion chamber. An exemplary silencer includes a proximal end and a distal end, the proximal end being configured for mounting the silencer to the barrel, the distal end being configured to allow the projectile to pass therethrough, and at least one vortex chamber disposed between the proximal end and the distal end. The at least one vortex chamber includes a circular peripheral wall for inducing a vortex on a portion of the combustion gases expelled from the combustion chamber during launch of the projectile. The vortex impedes flow of the combustion gases from the barrel such that acoustic energy associated with the launch of the projectile is dissipated.

Prior Art Shortcomings

[0009] We have discovered that many of the failures which have occurred in the prior art are related to complexity of the parts, number of components, cost of manufacturing longitudinal and radial size, durability before maintenance, difficulty to clean (U.S. Pat. Nos. 8,579,075, 8,910,745, 5,164,535, 4,584,924, 8,973,481, 8,950,546, 5,029,512).

U.S. Pat. No. 9,500,108:

[0010] The disadvantage of this prior art solution is the need for two very accurate spiral components, so that the two sound waves meet in anti-phase (180°). Also, the length the gases travel is only equal to the length of the device.

[0011] The proposed solution under the current design offers an extended length of the path for the gases to travel by using a closed loop design where gases run multiple lengths of the suppressor physical length. The components of the proposed device are also few, cheap, and don't require manufacturing precision.

U.S. Pat. No. 7,207,258:

[0012] The disadvantage of this prior art solution is the fact that it is based on capturing the combustion gases in closed, dead-end type spaces with a vortex-based flow, where gas particles flowing in one direction conflict with other particles going in an opposite direction in a highly turbulent type of flow and based on a limited space available, thus having a limited energy dissipation efficiency. Most of the effect of this solution is based on just capturing some of the gases, not the dynamic energy dissipation (kinetic and thermal).

[0013] Another disadvantage of this prior art solution is that it requires three separate coaxial chambers, which demands a large overall outside diameter with implications on blocking the sighting systems of the fire arm.

[0014] The proposed solution under the current invention solves the disadvantages of the above design by being based on a continuous, more laminar gas recirculation design where gases flow in just one continuous closed loop direction in dedicated spaces, never conflicting with gases coming from different directions and uses multiple whole lengths of the device as the offered path for energy dissipation.

[0015] Also the solution per the present invention allows for a much tighter and compact design, close to the longitudinal axis, thus not impeding with a sighting system as it may exist.

[0016] It is the task of the present invention to offer a solution that solves the disadvantages of the prior art with a design having the following advantages:

[0017] 1. Compact size

[0018] 2. Few components

[0019] 3. Simple and cheap to manufacture construction

[0020] 4. Excellent efficiency per units of size (longitudinal and radial)

[0021] 5. Easy maintenance and very reasonable cleaning required.

[0022] 6. The original design with closed loop recirculation has excellent suppressing efficiency by using progressive amortization during each loop and over multiple loop around travels of the total length of the device.

[0023] 7. It can be customized to also work as a recoil absorbing device.

[0024] The system per the current invention is based on a cycle as follows:

[0025] a. A continuous and repeated closed-loop recirculation along the length of the whole device,

[0026] b. A system to force the gas away from the longitudinal axis,

[0027] c. A way to turn the gas around by the front bulkhead cap through a return path within a dedicated space between an internal tube and external tube until they reach back to the rear bulkhead cap,

[0028] d. A lower pressure area in the area of the rear bulkhead nozzle that allows the returned gas to go in through dedicated slots and engage once more time to the central path toward the front,

[0029] e. This re-circulation cycle can be repeated more than once and because this process is happening over a longer period of time it allows for the kinetic and thermal energy, as well as the pressure to gradually dissipate thus increasing the efficiency of the device, without creating increased backpressure.

[0030] f. A feature of the current invention that contributes to high efficiency of the device is the fact that the gas runs in only one direction through dedicated spaces, never encounters a gas flow coming from a different direction.

[0031] g. At this same time, the internal two-sense circulation of the gases contributes to reduce the recoil of a firearm.

SUMMARY OF THE INVENTION

[0032] The device as per the present invention solves the prior art shortcomings and in accordance with the above principles of the present invention, a new sound suppression device is provided based on an original and novel idea of gas flow recirculation.

[0033] It is therefore, a feature and benefit of the present invention to provide an improved sound suppressing system, using:

[0034] 1. A rear bulkhead cap as per the current invention, composed of a body with a threaded hole along the longitudinal axis of the main system, centered on said axis and having a long nozzle front in order to prevent gas expansion and pressure build up in the rest of the system before the opportune time and location;

[0035] 2. An inner tube coaxial with the rear cap and having front and rear slots to allow gases to migrate radially, away from the central axis and also toward the central axis at the front and respectively at the rear of the tube;

[0036] 3. An outer tube, coaxial with the inner tube and the whole system, large enough in diameter to allow gas flow in the space between the inner tube and outer tube;

[0037] 4. A helical spiral inside and along the whole inner tube, in order to cause the high speed travelling gas molecules to follow a helical path and, under the thusly imposed centrifugal forces to be forced toward the periphery of the inner tube. The longer path and friction would also cause them to slow down and loose some of the thermal energy too by convection to the tube;

[0038] 5. A front bulkhead cap with a nozzle shape such that it will capture the gas molecules that the helical spiral diverted toward the periphery of the inner tube and lead them through the front slots of the inner tube and back along a toroidal path into the space between the inner tube and the outer tube, traveling now back toward the rear where they initially came from;

[0039] 6. When reaching the rear of the system, the back travelling gas flow will travel though the rear slots of the inner tube back toward the center axis, pushed by the kinetic energy and the lower pressures it will find in the rear of the system after the initial pulse of high burst pressure had time to subside.

[0040] 7. The gas molecules will continue to have the same trajectory and loop around the system as long as they still have the energy to do so. They will gradually loose this energy and slow down over a longer period of time thus discarding the energy that otherwise would have resulted in a powerful sounding explosion.

[0041] 8. Another embodiment of the invention uses a compression spring and washer to absorb some of the backpressure energy thus reducing the recoil of a firearm.

DRAWINGS

General Note

[0042] Since many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative, and not in a limiting sense.

[0043] In order that the invention is fully understood it will now be described with reference to the following drawings in which:

[0044] FIG. **1** is a first drawing showing the five components of the device per the present invention in an isometric exploded view.

[0045] FIG. **2** is a second drawing showing the same main components in an assembled isometric cross-section view.

[0046] FIG. **3** is a third drawing showing a front cross-section view of the device per the present invention with the direction of the gases flow indicated by an arrow.

[0047] FIG. **4** is a front cross-section view of the device per the present invention with arrows showing intermediate arrows to demonstrate the effect of the helical spiral on the gas flow.

[0048] FIG. **5** is an FEA simulation in a front cross-section view of the device per the present invention with particles showing the actual flow of the gas within the device and the secondary return flows created per the present invention.

[0049] FIG. **6** is an isometric partial cross section of the device per the present invention with arrows and trajectories of gas particles showing the actual flow of the gas within the device and the secondary return flows created per the present invention.

REFERENCE NUMBERS

[0050] **1**—Rear end cap/bulkhead with barrel adapter threaded hole.

[0051] **2**—Helical diffuser, gas spreader

[0052] **3**—Inner tube with front and back air passages.

[0053] **4**—Front end cap with "U" shaped return wall.

[0054] **5**—Outer tube.

[0055] **6**—Rear end cap nozzle

[0056] **7**—Rear cap threaded adapter hole for the gun barrel.

[0057] **8**—Inner tube front passages.
[0058] **9**—Inner tube rear passages.
[0059] **10**—Front end cap gas separation nose
[0060] **11**—Incoming air from the firearm flowing close to the axis.
[0061] **12**—Arrows: direction of particles being spun by the helical diffuser and diverted into a spiral rotary path throwing them toward the inner wall of the inner tube **3**.
[0062] **13**—Arrows: direction of particles separated by the front cap nose **10** and turned around through the front passages **8** in between the inner tube **3** and outer tube **5**.
[0063] **14**—Arrows: direction of the particles of gas being returned back through the rear passages **9** in between the inner and outer tube.
[0064] **15**—Arrows: direction of returning particles of gas being forced through the rear passages **9** of the inner tube **3** and returning one more time to the trajectory inside the inner tube **3**.
[0065] **16**—Particles of gas being spun around and toward the periphery by the helical diffuser.
[0066] **17**—Representation of the closed loop cycle elliptical path of the gas particles being returned back and going around.
[0067] **18**—Arrow Gas flow near the axis after being reduced by the helicalspiral.
[0068] **19**—Arrow—Gas flow near the axis after being further reduced by the helical spiral and the backflow.
[0069] **20**—Lower pressure area.
[0070] **21**—Inner chamber.
[0071] **22**—Outer chamber.
[0072] **23**—Device axis.
[0073] **24**—"U"-shaped return wall of the front end cap.

DESCRIPTION

[0074] In order that the current invention is fully understood it will now be described by way of a handgun example of application. The many features and advantages of the present invention are apparent from the detailed specification, and thus, it is intended by the appended claims to cover all such features and advantages of the invention which fall within the spirit and scope of the invention. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation illustrated and described, and accordingly, all suitable modifications and equivalents may be resorted to falling within the scope of the invention.
[0075] It is therefore, a feature and benefit of the present invention to provide an improved sound reducing sighting system, using am original gas recirculation concept, which returns and reflows the pulse of gases until the pressure equalizes atmospheric pressure.
[0076] The solution uses a total of 5 components:
[0077] 1. A rear cap/barrel adapter **1** as per the current invention, with a nozzle **6** and a threaded hole **7**.
[0078] 2. A helical diffuser/gas spreader **2**.
[0079] 3. An inner tube **3** with front slots **8** and rear slots **9**.
[0080] 4. A front cap **4** with a nozzle **10**.
[0081] 5. An outer tube **5**.
[0082] The device per the present invention mounts onto the barrel of a firearm by means of the threaded hole **7** in the rear cap **1**. The gases resulted from the gun powder explosion in the gun cartridge enter the device per the present invention through the hole **7** in the rear cap and then the nozzle **6** as shown by the arrow **11** in FIG. **3**. At this point the gases come with a great speed, high pressure and high temperature.
[0083] Immediately after leaving the nozzle **6**, the gases start to expand in the area of the inner chamber **21** of the inner tube **3** between the nozzle **6** and the first loops of the helical diffuser **2**, then some of the expanding gases hit the first loop of the diffuser **2**. Each loop of the diffuser **2**, diverts more and more of the gas molecules and particles ejected from the barrel into a helical motion and a spin **12** that forces them away from the center axis **23** toward the inner wall of the inner tube **3**, as shown by the arrows **12** in FIG. **4**. A very small percentage of the gases **11**, **19**, will travel straight through and will not be diverted from a straight path. This functionality has a few simultaneous effects:
[0084] Engages the gas particles onto a longer path slowing them down by effect of friction onto the helical surface of the diffuser **2** and inner wall of the inner tube **3**.
[0085] Cools the gas particles down by conduction with the same surface of the diffuser **2** and inner wall of the inner tube **3**.
[0086] The high speed of the gases **11** right of the nozzle **6** of the rear end cap, "steals" molecules of gas in the area **20**, creates a suction effect and creates in this area a zone of lower pressure behind the nose of the nozzle **6** (the Coanda effect).
[0087] By the time the gas wave reaches the reversed nozzle **10** of the front cap **4**, a large number of molecules are not in the center anymore but travel into a corkscrew motion **12** around the periphery of the inner tube **3** as forced by the helical spiral and by their own expansion tendency. As a consequence, they will get diverted this time backwards by the nozzle **10** and the round internal shape **24** of the front cap **4** toward the space in between the inner tube **3** and the outer tube **5** created by the front passages **8** and will start travelling backwards, through the outer chamber **22**, as shown by the arrows **14** in FIG. **4**. When the gases travelling forward hit the nozzle **10** and the round toroidal shape **24** they create a higher pressure area in the vicinity of the passages **8** that will help push the gasses back in direction **14** though the outer chamber **22**. As they travel back in chamber **22** between tube **3** and **5**, the gas molecules loose more pressure, cool down and slow down even more.
[0088] When the returning gas particles **14** in FIG. **4** reach the rear passages **9** of the inner tube **3** (FIG. **1** and FIG. **3**), the pressure in the area of the rear cap **1** which by the Coanda effect was already lower, has already further decreased considerably, so they will be sucked in through the rear passages **9** back inside the inner chamber **21** of the inner tube **3** and will restart the same path they have already gone through, only this time they will be slower, cooler and at lower pressure. FIG. **5** shows the closed loop cycles **17** of the gas particle trajectories that have been diverted by the helical diffuser **2** and the arrows **11**, **18** and **19** show the center flow of gas particle trajectory that is smaller and smaller as it is being deprived of a large portion of gas flow by the migration of gas toward the periphery of the inner

I claim:

1. A sound suppressing system for a firearm explosion gases with two coaxial tubes **3** and **5** mounted on the gun barrel, defining two coaxial chambers, inner chamber **21** and outer chamber **22**, communicating at their ends through rear

passages **9** and front passages **8** and two end caps, rear end cap **1** and front end cap **4**, characterized by:

Repeated recirculation **17** of the explosion gases taking place in successive opposite directions, direction **11** and direction **14** through each of the two coaxial chambers **21** and **22**, such that through every recirculation cycle **17**=12+13+14+15 the speed, temperature, pressure and energy of the gases are continuously and slowly decreased with low rate energy transfer in noise until the pressure inside the device in all chambers equals the ambient exterior pressure,

A helical spiral part **2** in the inner chamber **21** deviating part of the gases toward a spiral and longer path closer to inside wall of the inner tube **3** and spending more of the energy of the explosion gases.

2. (canceled)

3. (canceled)

4. (canceled)

5. A sound suppressing system as recited in claim **1**, where a rear end cap **1** is equipped with an inlet rear nozzle **6** designed in such a shape as to guide the incoming gases **11** and delay the expansion of the gases over the rear end passages **9**.

6. A sound suppressing system as recited in claim **1**, where a front cap **4** of a toroidal inside shape **24** with a center nozzle **10** is used to receive, guide and turn back the incoming jet of gases **13** diverted by the spiral **2** toward the space between the inner tube **3** and outer tube **5**.

7. A sound suppressing system as recited in claim **1**, where the current invention uses a helical baffle **2** to impose a corkscrew motion **12** to the gas particles and direct some of the expanding gases away from the central axis **23** of the tubes **3** and **5** and toward the passages **8** and "U"-shaped return wall **24** of front end cap such that the gases will transfer from the inner chamber **21** to the outer chamber **22**.

8. Any other solution based on a closed loop recirculation of the expanding gases in coaxial, cylindrical chambers where the gases travel in opposite sense through the chambers and a closed loop using end passages, so that the pressure, speed and the temperature are given an opportunity to progressively decrease over each loop and over a longer period of time than the normal explosion would using any combination of the features as per claim **1**, **2**, **3**, **4**.

9. (canceled)

* * * * *