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**United States Patent**  
**Woods , et al.**

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ATTACHMENT FOR RECOIL, NOISE, BLAST AND FLASH SUPPRESSION OF THERMODYNAMIC JETTING DEVICES SUCH AS FIREARMS, HIGH PRESSURE EXHAUST MECHANISMS AND OTHER HEAT ENGINE DEVICES, WHICH PRODUCE SUCH JETTING EXHAUST ACTION AS A RESULT OF THEIR FUNCTION

**Abstract**

Our invention describes a muzzle or exit exhaust attachment for firearms or other thermodynamic heat engine jetting devices and incorporates magnetic field diversion design features not previously utilized to increase efficiency in the reduction of noise, flash, barrel whip, exhaust flame temperature and muzzle blast effect. Our invention advantageously applies relatively recent discoveries in the field of ballistic studies; know as transition ballistics, and mitigates the high velocity, high pressure exhaust gasses from the instant of existence through decline to atmospheric pressure with greater efficiency than prior art devices such as, silencers, suppressors, mufflers and sound absorber attachments.

Inventors: **Woods; Robert James** (Phoenix, AZ), **Serrano; JeanMarie Evangeline** (Danville, CA)  
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9. The device of claim 1, wherein said magnetic toroids are separated from adjacent toroids by a plurality of washers.
10. The device of claim 1, wherein said washers are comprised of high strength, non-magnetic, metallic alloy.
11. The device of claim 1, wherein said washers are sufficient in number and strength to assure a compressive force on the stack assembly of between forty and sixty pounds when fully assembled.
12. The device of claim 1, wherein said tubular chambers are removably attached by means of mating threaded screw attachments at the mating ends of each pair of said chambers.
13. The device of claim 1, wherein magnetic field intensities of between 1 and 3 tesla are attained.
14. The use of the device of claim 1 to lessen and mitigate recoil, noise, blast and flash in a thermodynamic jetting device by following the steps of: a. attaching the device of claim 1 to the exit port of said jetting device; and, b. operating said jetting device while the device of claim 1 remains attached thereto.
15. The use of the device or claim 1 to lessen and mitigate recoil, noise, blast and flash in high pressure, high velocity heat engine exhaust by following the steps of: a. attaching the device of claim 1 to the exhaust pipe of an engine; and, b. operating said engine while the device of claim 1 remains attached thereto.
16. The use of the device of claim 1 to lessen and mitigate recoil, noise, blast and flash in a firearm by following the steps of: a. attaching the device of claim 1 to the muzzle of said firearm; and, b. operating said firearm while the device of claim 1 remains attached thereto.
17. A device for the suppression of high velocity gases, comprising: a cylindrical, substantially hollow tube, comprised of sectional chambers, arranged longitudinally end-to-end, comprising a continuous pathway permitting the passage of gases from one entrance end to the other exit end; at least one said chamber having a conical shaped interior space, possessing a large interior diameter at the chamber end closer to said entrance end, and a smaller interior diameter at the opposite end, closer to said exit end, thus forcing a gas flowing in one direction through said chambers to become compressed; and, at least one said chamber housing an array of high magnetic intensity rare earth magnetic toroids, separated by washers, and disposed in a radial array around said continuous pathway such that gases permeate said array when flowing in one direction through said chambers.
18. The use of the device of claim 17 to lessen and mitigate recoil, noise, blast and flash in a thermodynamic jetting device by following the steps of: a. attaching the device of claim 17 to the exit port of said jetting device; and, b. operating said jetting device while the device claim 17 remains attached thereto.
19. The use of the device of claim 17 to lessen and mitigate recoil, noise, blast and flash in high pressure, high velocity heat engine exhaust by following the steps of: a. attaching the device of claim 17 to the exhaust pipe of an engine; and, b. operating said engine while the device of claim 17 remains attached thereto.
20. The use of the device of claim 17 to lessen and mitigate recoil, noise, blast and flash in a firearm by following the steps of: a. attaching the device of claim 17 to the muzzle of said firearm; and, b. operating said firearm while the device of claim 17 remains attached thereto.



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#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 displays a Schlieren high speed photograph of the atmospheric contents of the barrel bore, exiting approximately 2 to 3 milliseconds after propellant ignition and directly ahead of the following projectile.

FIG. 2 displays the emerging projectile from the barrel bore, approximately 3 milliseconds after propellant ignition accompanied by small amounts of propellant gasses that have forced by the projectile body.

FIG. 3 displays the emerging propellant gasses directly after projectile exit from bore and includes unburned propellant and hydrogen gas.

FIG. 4 displays the full assembly of the attachment as affixed to barrel muzzle and depicts a phantom view of the barrel, the primary chaotic expansion chamber followed by the secondary convergent compression chamber and lastly, the magnetic toroid diversion chamber coaxially secured and retained by wave washers and the threaded compression flange.

FIG. 5A displays the sectionalized view of the primary chaotic diversion chamber in a typical configuration of attachment by threaded coupling to the muzzle of a barrel or other exhaust system outlet.

FIG. 5B displays the sectionalized view of the secondary convergent diversion chamber with it's



particle flow, it also enhances the disruption of the Coanda effect that describes the tendency of any gas flow to cling or entrain to the wall of the surface it is flowing past. The Lorenz force, by disrupting the clinging and entraining effect of the Coanda force, extracts additional energy from the gaseous particle flow that adds to the overall efficiency of our invention in the suppression of noise, blast, recoil, flash and barrel whip that exceeds the efficiency of prior art suppressors, silencers, mufflers and sound absorbers.

Virtually since the inception of firearms, the processes utilized to analyze, evaluate, test and classify firearms performance was addressed solely by the parameters of interior and exterior ballistics. That is, the interior events prior to exit of the projectile from the barrel bore and exterior events affecting projectile and high velocity, high pressure propellant gas behavior after exit from the barrel bore until final projectile impact. Relatively recent developments in high speed photography know as Schlieren photography have allowed the clarification of the critical transition area of ballistics providing visual proof of events that occur in all firearms from the instant of propellant ignition and events occurring thereafter. One of the claims of our invention is to advantageously address all events of ballistic study, including transition ballistics, in developing a muzzle attachment that exceeds prior art devices in efficiency of overall function of controlling and mitigating recoil, noise, flash, blast and barrel whip.

In order to support our claims in this invention, it is necessary to define and illustrate the events that comprise the previously stated interior, transition and exterior ballistics and the manner in which our invention utilizes these events to mitigate recoil, noise, flash, blast and barrel whip.

The first event is that column of forward atmospheric air, illustrated in FIG. 1, which occupies the entire length of the barrel bore immediately ahead of the projectile of the chambered cartridge prior to propellant ignition. Upon propellant ignition, the projectile moves forward, compressing and accelerating the forward air mass toward the muzzle, causing the forward air mass to emerge from the muzzle first. The forward air mass, now traveling at high velocity, strikes the atmospheric air which is at rest at the muzzle, creating a shock wave known as the report wave 70, that develops spherically and greatly disturbs the atmospheric air at the muzzle. This event is instantly followed by a rush of small amounts of propellant gas 72, FIG. 2, which have forced their way past the projectile body and therefore emerge from the muzzle before the projectile. This condition is proven to exist in all firearms, regardless of caliber or bore or great care in sizing the projectile to the bore. As the projectile clears the muzzle of the barrel, FIG. 3, the main mass of propellant gasses 74 are violently ejected into the already disturbed outside atmosphere. At this instant, the velocity of the propellant gas is equal to the projectile velocity; but due to the great residual gas pressure, and small mass and momentum of the propellant gas, its velocity instantly increases, causing the main propellant gas column to overtake the projectile; rapidly passing it. This time period is the cause of what is known as secondary muzzle flash and is present in all propellant actuated firearms, caused by the now depleted source of oxygen in the propellant mixture not being sufficient to consume all of the propellant and its residual hydrogen. These residual unburned particles and hydrogen gas instantly receive a substantial source of fresh oxygen from the atmospheric air that instantly detonates the unburned fuel thereby enhancing the muzzle blast effect. During this brief but critical phase of the total event, the propellant gasses achieve a maximum velocity of more than twice that of the projectile and consequently imparts to the projectile additional thrust pressure, causing the projectile to reach maximum velocity, not at the muzzle, but a short distance ahead of the muzzle.

The propellant gasses lose velocity very rapidly, due to their low mass and air resistance it meets which retards continued motion. High speed photography shows the projectile overtakes the main propellant gasses 74 very close to 35 centimeters, about 14 inches, in front of the muzzle in virtually all firearms up to light cannon caliber. Shortly after this occurrence, the projectile overtakes and pierces the well developed report wave, the source of the familiar noise commonly associated with gunfire. Concurrent with this event, the projectile is accompanied by its normal head wave that is defined as the projectile

shock wave.

It is important to define that a projectile shock wave cannot exist unless the relative difference between projectile velocity and gaseous envelope velocity equals or exceeds the speed of sound, and this condition exists in the muzzle area of all but a few firearms. The act of simply loading ammunition to impart projectile velocities below the speed of sound will diminish report wave noise only to the degree that the relative velocity between the projectile and propellant gas velocities are below the speed of sound. These events are directly related to the claims of efficiency that our invention takes advantage to mitigate muzzle flash; suppress report noise and counter recoil force.

The second and third aspect of transition ballistics is vertical and horizontal or lateral barrel whip; studies indicate this event provides a significant psychological portion of perceived recoil by the person discharging the firearm. All gun barrels tend to bend down during rest to a degree determined by their form and rigidity factors. This condition is most prevalent in light shoulder fired firearms; but is also a factor up to cannon bore barrels. Vertical barrel whip is that action that takes place as the projectile moves rapidly through the bore; causing an upward rise of the barrel that attains its maximum the instant the projectile exits the barrel.

Concurrently; rotation of the projectile as defined by the rifling helix imparts a counter torque to the barrel and the vertical vector of this torque amplifies barrel rising whip. Horizontal or lateral barrel whip has a similar effect; but of far less magnitude than vertical whip. Lateral barrel whip is mechanical and is most often caused by poor manufacturing techniques that result in a lateral bend in the barrel and greater attention to barrel manufacturing accuracy can relegate lateral whip to insignificance in actual practice.

Susceptible recoil force is defined as that increment of total recoil force that can be mitigated by muzzle attached devices. The recoil in all projectile launching devices begins instantly upon acceleration of the projectile by the rapid expansion of propellant gas; and instantly transfers equivalent kinetic energy to the gun mechanism, mount and holding device. The most significant transfer of recoil energy is during the earliest stages of the forcefully expanding propellant gas and accompanying high pressure; accelerating the projectile from rest to near maximum velocity at the muzzle. Prior art suppression devices have consistently emphasized that their effect on recoil, flash, noise and blast is dependent on conditions at projectile exit from the bore and utilization of the escaping gas at the muzzle; a condition much later than recoil has begun. Consequently, with prior art devices, during the critical two or three milliseconds the projectile is within the bore, the only significant factor acting to suppress recoil is the mass of the gun and its mount or holding device.

The description of the various events of a firearm discharge indicates that prior art devices intended to suppress recoil, noise, blast and flash act after the exit of the projectile from the bore which is two to three milliseconds after propellant ignition. It is known that propellant generated recoil force on the firearm and projectile does not cease until the propellant gas pressure has fallen to atmospheric pressure; and tests on firearms up to light cannon caliber defines this circumstance as occurring some eight milliseconds after propellant ignition and six milliseconds after the projectile has left the bore. This six-millisecond time interval of the projectile launching event; and unlike prior art devices, the very earliest three-millisecond movement of the forward air mass in the bore in front of the projectile is the precise object our invention design utilizes to achieve greater efficiency in the mitigation of recoil, noise, blast and flash in thermodynamic jetting devices and other high pressure, high velocity heat engine exhaust mechanisms.

To clarify the design, intended object of use, manufacture methods and functional efficiency of our invention, we herein address in detail each drawing that displays high speed photographs of events that



object of this chamber is to recompress the supersonic, high pressure gaseous column that enters it from the primary chaotic expansion chamber; FIG. 5A.

The supersonic, high pressure gas column that enters the secondary convergent compression chamber 20 is instantly compressed by the smaller volume and tapered cone 25 of this chamber forcing the high pressure gas flow into an exit hole 35 percent larger than the bore diameter of the barrel. This action results in a gas column that will be recompressed; thereby raising its pressure and; upon exit from the secondary chamber, the gas velocity cannot exceed the speed of sound; regardless of the magnitude of the pressure then existing within the convergent diversion chamber.

The pre-conditioning of the high pressure, high velocity gas flow by the primary chaotic expansion chamber 30; FIG. 5A, and the secondary convergent compression chamber 20; FIG. 5B, is critical to the overall efficiency of our invention and to the performance of the final stage of our invention; the magnetic diversion chamber 10, FIG. 5C.

FIG. 5C displays a sectionalized view of the magnetic diversion chamber 10 that is the final stage of our invention; and acts to exert a high intensity, permanent magnetic flux field that is coaxially arranged and retained by magnetic toroids 16 to enclose the final exit passage of our invention. This chamber utilizes the effects of high intensity magnetic fields; and the concurrent advantage of the Lorenz force that is inherent in the magnetic field to so modify the environment of the chambers as to mitigate, cool, helically redirect and delay a high pressure, high velocity gas column flowing through the central hole 15 of the toroidal shaped magnetic rings.

FIG. 5C, the magnetic diversion chamber 10 is constructed as a tubular sleeve manufactured of non-magnetic stainless steel such as the 303 alloy or; of high strength aluminum such as the 7075T6 alloy. Within the tubular sleeve; fitted coaxially and sequentially, is the magnetic stack comprised of toroidal rare earth magnets of neodymium-iron-boron (NIB) with a centrally located hole in the ring center that is no greater than 25 percent larger than the diameter of the projectile which will pass through the magnetic ring.

Further, spaced between each rare earth magnetic toroid 16 are located non-magnetic stainless steel wave washers 18 of a compressed in-service thickness to maintain a compressed spacing between each magnetic toroid not less than 35 percent of the bore diameter of the barrel bore. FIG. 5C depicts the magnetic stack as assembled; and clearly indicates the manner in which the flanged and threaded compression boss aligns and retains the assembly coaxially within the bore of the magnetic diversion chamber. The flange on the exterior exit face of the compression assembly reduces the possibility of reformation of the spherical shock wave.

Empirical jesting showed that a stack of sixteen rare earth magnets 16 approximately one quarter inch thick and four inches in diameter yielded a total magnetic coercive force within the magnetic diversion chamber of approximately 180,000 gauss or 18 tesla. These magnetic rings are sequentially spaced, compressed, aligned and retained coaxially by non-magnetic stainless steel wave washers 18 to assure a compressive force on the stack assembly of not less than forty pounds and not more than sixty pounds fully assembled for use.

FIG. 6 displays a view through the central axis of the bore of the magnetic diversion chamber and illustrates the concept and manner of concentric and coaxial alignment of the magnetic toroid 16 and wave washer 18 stack around the central exhaust bore.

FIG. 7 displays a lateral sectionalized view of the magnetic diversion chamber assembly method and concept showing the stacking and aligning of the magnetic toroids 16; separated and cushioned by the

spacing wave washers 18 to be compressed by the threaded muzzle flange bushing 5 upon final assembly.

We claim that our invention will, with appropriate design application, mitigate, modify and cool the exit column of jet engine exhaust gasses thereby providing a reduction of the density of hot, humid condensation products emitted from jet engine exhaust; that directly cause the production of after-effect patterns known as *contrails*.

We further claim our invention will mitigate, modify and reduce noise and blast damage during the planned or unplanned actuation of high pressure steam safety relief valves, blowdown and letdown valves that may instigate collateral equipment damage such as displacement of valve baffles, mechanism or piping system supports.

We further claim that our invention will provide greater efficiency in the mitigation, reduction and suppression of; noise, recoil and primary and secondary muzzle blast of propellant actuated firearms; reduce the flame temperature of the exhaust gas column to less than 500 degrees centigrade; thereby mitigating the infrared signature of the firearm and canceling the effectiveness of infrared detection systems utilized to locate snipers in the performance of legitimate law enforcement duties, counterinsurgency defense and military clandestine mission activity.

We further claim our invention exceeds the efficiency of prior art devices; by the novel application of magnetic helical gas column particle diversion, in the mitigation and suppression of noise, recoil and blast of high pressure exhaust devices, reducing and mitigating the effect of the high specific impulse of hydrogen gas in the propellant exhaust cloud due to the very low molecular weight of hydrogen; thereby further increasing the efficiency of our invention in blast and flash suppression.

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