(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 May 2005 (12.05.2005)

PCT

(10) International Publication Number
**WO 2005/043069 A1**

(51) **International Patent Classification**[7]: **F41A 19/63**, F42B 5/08

(21) **International Application Number:** PCT/CH2004/000642

(22) **International Filing Date:** 27 October 2004 (27.10.2004)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
60/515,446 30 October 2003 (30.10.2003) US

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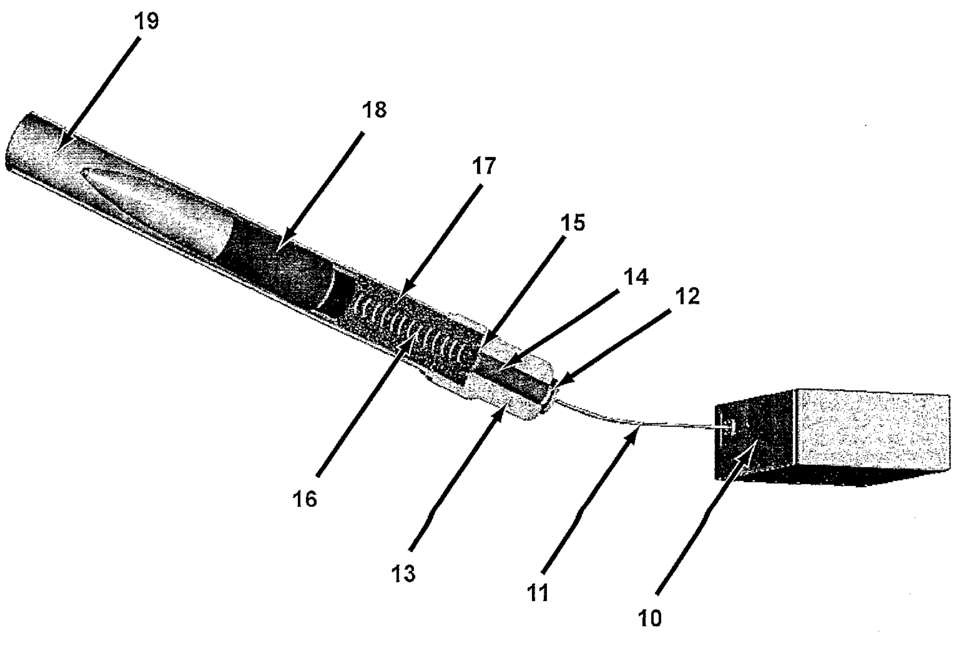
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI,

*[Continued on next page]*

(54) **Title:** EMP FIRING MECHANISM FOR LARGE CALIBER FIREARMS AND ARTILLERY




(57) **Abstract:** The invention comprises a device and method for firing firearm ammunition using an EMP generator (10). The device can be incorporated into or used with firearms of a variety of sizes and configurations to provide precise control of firing and improved range and safety. The device and method can be applied to conventional mechanical primer ammunition or used without the need for a primer, particularly in field artillery, aircraft, and watercraft.

WO 2005/043069 A1

SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# EMP FIRING MECHANISM FOR LARGE CALIBER FIREARMS AND ARTILLERY

## FIELD OF INVENTION

This invention relates to a firing mechanism for firearms, methods for firing firearms including artillery, and methods for improving the safety and effectiveness of firearms and the firing of firearms. In a particular embodiment, the mechanism or device more effectively controls and/or manages the firing of artillery projectiles.

## BACKGROUND FOR AND INTRODUCTION TO THE INVENTION

The use of a mechanical firing mechanism creates a risk that the firing pin, or equivalent, may strike a shell or cartridge too hard and penetrate it, causing gases to escape through the breach and increasing the chance of injury to the operator or damage to the weapon. There is also the risk that the firing mechanism will not strike the shell or cartridge in a manner that detonates the charge, leading to a potentially dangerous process of re-opening the breach with a live round still chambered. These dangers are magnified in large caliber and artillery weapons. Mechanical firing systems are also subject to wear and deterioration of performance over time.

Other types of priming systems exist and others have been proposed, especially for large caliber artillery ammunition and aircraft and watercraft armaments. In the case of aircraft armaments in particular, one alternative to mechanical firing or percussion is electrical percussion, which is used with electrical primer ammunition. In an electrical percussion system, the mechanical firing pin is replaced by an electrically conductive firing pin that makes good electrical contact with an electrical primer prior to initiating a firing sequence. The electrically primed cartridges have an electrically conductive portion that is grounded electrically to the walls of the firing chamber. One serious drawback of electric percussion is the requirement for specialized ammunition with embedded electrodes. Conventional primer initiated ammunition will not work in a weapon designed for electric percussion and the specialized ammunition with embedded electrodes will not work with conventional weapons. This prevents interoperability or sharing of ammunition and complicates logistics for supply of military units that employ both conventional and electric percussion weapons.

Another possible alternative to mechanically primed ammunition, particularly in the artillery context, is laser-fired ammunition. For laser-fired artillery systems, the projectile and propellant are loaded in a conventional fashion, but the mechanical primer and firing pin are replaced by a laser firing system that is typically integral to the breech block of the cannon. An optical window is provided in the breech block to allow the passage of high energy, pulsed laser light into the propellant chamber to directly ignite the propellant ignition pad and fire the projectile. The laser firing system eliminates the complexity and delays caused by the loading of a mechanical primer and mechanical percussion by the firing pin. However, laser firing systems (none of which have been placed into production) are generally expensive and require considerable development and manufacturing time when compared to mechanical primer systems. In addition, the optical viewing window of the laser system must be sealed against the pressure and heat of the propellant chamber while maintaining suitable optical properties. The combination of heat, pressure, and propellant residue from the propellant chamber and the laser energy passing through the viewing window can cause clouding, obscuration, and/or pitting of the viewing window over time, resulting in degraded performance of the laser ignition system.

Thus, the firing methods used in current firearms, aircraft and watercraft armaments, and artillery suffer from a number of deficiencies. For these and other reasons, improvements in the design and operation of firing systems and methods for firing weapons, especially heavy caliber firearms and artillery are needed.

## SUMMARY OF THE INVENTION

In one aspect, the invention provides improved devices for controlling the firing of individual rounds of ammunition. However, the invention is not limited to solving any particular problem or addressing any particular disadvantage. In addition, the invention is not limited to use with any particular size or type of ammunition. The advantages made available through the invention can be used with conventional mechanical primer initiated ammunition and/or in place of the mechanical primer and firing pin arrangement of the conventional firearm. "Firearm," as used here, encompasses artillery, handguns, pistols, heavy caliber guns, rifles, sniper rifles, guns with automatic and semiautomatic action, mountable and portable cannons, cannons mounted on motor vehicles, aircraft, watercraft or naval vessels, cannons mounted on armored personnel carriers or other armored vehicles, and machine guns or cannons mounted on armored or non-armored vehicles or vessels. The terms "firearm" and "artillery" are used interchangeably here. The term "EMP" as used here is the abbreviation of Electro-Magnetic Pulse.

One aspect of the invention is to reduce and/or eliminate the lag time between initiating a firing sequence, by pulling a trigger or by other means, and detonation of the chambered round. The invention also allows for a safer operation of heavy caliber and artillery firearms. In addition, for artillery rounds, the invention allows more efficient use of powder increments or modular charges so that, for example, a longer standoff can be used in the chamber to generate greater pressure and/or a greater burst of energy to propel the projectile through the cannon than in conventionally fired artillery. In addition, because detonation is caused by an EMP pulse, very high efficient detonation of each and/or every powder increment or modular charge is possible.

In another aspect, the EMP firing mechanisms of the invention provide robust and reliable components that can be used in a variety of ammunition systems. Thus, incorporating one or more of the many aspects of the invention into a firearm improves the control and effectiveness of the firearm.

In a general aspect of the invention, an EMP pulse is used to detonate ammunition or fire a bullet or projectile. The EMP pulse is generated by a power supply, typically a portable power supply with a battery. In one embodiment, a 2.5 GHz magnetron can be used for sending the EMP pulse to a waveguide. However, the selection of a particular frequency can be determined by the size of the breech in the firearm of the size of the waveguide desired to fit in the breech. In general, a frequency range from about 2.5 to about 10 GHz is preferred. The waveguide, typically including a combination of rigid waveguides and flexible waveguides, with standard connectors if necessary, send the EMP pulse to a window in the breech of a firearm. As known in the art, a flange can be used to connect a rigid waveguide to a flexible waveguide. The window is made of durable and EM transmissible material, generally ceramic and fiberglass, and can withstand extremes in temperature and pressure. Also as known in the art, a feed horn can be used to connect the rigid waveguide to the window for transmitting the EMP pulse. The feed horn can be made of nickel or silver plated copper material. The part of the window that is open to the chamber of the firearm can be shaped to protect it from damage. For example, a conical surface or curved surface facing the interior of the chamber can direct heat and pressure away from the window.

The size of the cavity or opening in the breech can be tailored to a particular frequency and power of EMP pulse. Similarly, the size of the waveguide can vary with the frequency or frequency range selected and power selected. For a 155 mm artillery gun, such as a Denel 155 mm gun, the cavity or opening in the breech to accommodate the waveguide is slightly larger than 6 cm diameter in order to accommodate a window of approximately 6 cm diameter. A rigid waveguide fits within the breech and connects the protection window to the flexible or other waveguide from the EMP generator. The rigid waveguide can be composed of nickel-plated aluminum or nickel-plated copper and in the case of the 155mm gun, can be approximately 88mm long by about 44mm in width for a 2.5 GHz EMP employing the 6cm diameter window. As noted above, all or any one of these values can be varied by one of skill in the art depending on the desired characteristics and the operational sizes needed. In addition, the power supply to generate a 5-6 kW pulse, for example, can be a 10 kW power supply, and many such power supplies and magnetrons are available in the art. A preferred example employs a 2.5 GHz magnetron capable of over 3 kW of output, or up to 10 kW of output. Again, the power supply and selected power of the pulse can be varied by one of skill in the art.

In general, the devices and methods of the invention can function to create intense heat through the EMP pulse, which can be used to cause a primer, propellant charge, and/or modular or bi-modular charge to detonate. In certain operational circumstances, this will cause a bullet or projectile to be ejected and propelled along the barrel of the firearm by the expanding gases produced by the detonation. Because the EMP pulse can be such that all of the propellant change can be detonated at the same time, the pressure and power generated from the detonation is higher than in traditionally fired firearms. For example, in a 155 mm gun that can use 1-6 powder increments (*see, for example,* Sochem modular and bi-modular charge systems, at www.army-technology.com/contractors/artillery/somchem/), the EMP firing mechanism can detonate multiple or all of the increments at once. In traditional firing operation, the number of increments used in part determined the range of the gun, and the detonation of the increments would necessarily progress from the closest to the primer or fuze to the farthest from the primer. This detonation is accompanied by a pulse-like or less than optimum production of pressure and energy to propel the projectile. By sending an EMP pulse that detonates all of the increments together, a much higher level of pressure and energy can be created. This allows fewer increments to be used and increases the range of a gun. It may also promote a cleaner burning of all the propellant charge and residue in the combustion chamber.

Another advantage of the invention and its use is the ability to avoid separate primers in firearms. The use of EMP pulse to detonate propellant can be combined with a primer, but there is no requirement for a separate primer. In some circumstances, a resonator can be used in the propellant charge or as a primer to assist in the detonation. One of skill in the art is familiar with the use of resonators and can design appropriate resonators for use in the invention. In one example, a small diameter copper wire (approx. 0.02 mm) can be used to detonate propellant charge in the presence of an EMP pulse. Depending on the type and amount of propellant charge selected, the use of a resonator, or several resonators, in the propellant charge can allow one to further vary the power of the EMP pulse, the standoff distance from the window to the propellant charge, or to effectively replace a primer with resonators for certain propellant charges or powders.

One of skill in the art will understand that the arrangement of the breech window, the rigid waveguide in the breech, the connection of the rigid waveguide to the EMP generator, and the generation of the EMP pulse are all aspects that can be varied and optimized for a particular operational situation, gun, or as desired. In preferred examples, the power supply is seated on one or more vibration dampers to protect it from damage. Also in preferred examples, a rectangular waveguide is used to connect the EMP generator to the rigid waveguide in the breech.

In another aspect, the present invention can be used to render obsolete the mechanical primer and firing pin arrangement for cannons and artillery or vehicle mounted weapons. This reduces the length of the percussion reload cycle by eliminating the step of inserting the mechanical primer manually or mechanically. This alone can increase the maximum allowable firing rate of the weapon and improve operator safety by eliminating the need for personnel to handle mechanical primers. In preferred embodiments of the artillery or large gun applications, parts of the EMP generator, for example the power supply and/or cooling system for power supply and/or battery, are protected from the environment of the propellant chamber, from weather, and from vibrational damage. Once the fuzed projectile and propellant are loaded, the breech is closed and the weapon is ready to fire. When the firing sequence is initiated, the EMP pulse is generated in much the same fashion as described above. The introduction of the EMP pulse can be precisely timed to fire the projectile. When initiated, the EMP pulse is sent into the combustion chamber, igniting the propellant and firing the projectile.

The invention comprising the use of an EMP generator is simpler, cheaper, and more durable than laser ignition devices and lacks the requirement for an optical window. The EMP firing device of the invention also eliminates the delays and safety issues associated with manual or mechanical loading of percussion primers in conventional artillery or cannons. It also eliminates the dangers in opening the breech when the propellant charge does not detonate upon firing.

In yet another aspect, the invention comprises a method for firing a firearm employing an EMP generator as well as method for generating and/or calibrating an EMP pulse to fire a round or propellant charge. For example, the invention encompasses a method for firing a propellant charge by providing an EMP generator, where the EMP generator sends an EMP pulse through a waveguide into the breech of the firearm. Similarly, the invention encompasses a method for calibrating an EMP generator to fire a particular propellant charge or a particular firearm. The method can comprise altering one or more of a number of factors involved in or known to be involved in generating an EMP pulse. For example, any one or more of the following, or combinations, can be altered: the type and amount of power used from the power supply; the frequency of the EMP pulse; the size and shape of the waveguides used, rigid waveguides and/or flexible waveguides; the material in the protection window of the breech (ceramic, fiberglass, Teflon, combinations of these and/or other heat-resistant and shock-resistant materials); the size and shape of the protection window; and/or the standoff distance used in the chamber. One of skill in the art is familiar with methods and techniques to vary each of these factors.

In addition, gaskets and protection devices can be used to insulate the waveguide, protection window, and other parts of the EMP generator and waveguide, especially through or near the breech, to shield or protect it from heat and shock damage. A rubber and/or rubber/graphite gasket can be used at the base of the breech to protect the rigid waveguide in the breech from damage. Gaskets can be placed at various points along the waveguide, or even incorporated into the waveguide itself, to prevent damage. Vibration damper(s) can also be used to protect the EMP generator and/or power supply.

The EMP generator, device, and methods of the invention can be manifested as in one of the Figures accompanying this disclosure. Also, numerous embodiments and alternatives are disclosed in the accompanying claims. Other embodiments and advantages of the invention are set forth in part in the description that follows, and in part, will be obvious from this description, or may be learned from the practice of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the invention and some advantages thereof, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

Figure 1 shows a preferred embodiment of the invention, and exemplary component parts, for use in artillery guns or firearms. Here, a 155 mm artillery gun is schematically depicted with the EMP firing device.

Figure 2 shows a view of an exemplary part of an EMP generator comprising a magnetron and waveguide.

## DETAILED DESCRIPTION OF THE INVENTION

The invention can be used in a variety of firearm designs, sizes, configurations and operational settings. With artillery embodiments, the invention can be used with each of the three basic types of artillery ammunition, fixed ammunition, semi-fixed ammunition, and separate loading ammunition. The ammunition is classified based on the manner in which the components are assembled for loading and firing. The invention can be advantageously employed with each of these three types of ammunition. In fixed ammunition, the cartridge, primer, propellant, and projectile are preassembled and used as a single unit, making it impossible for the weapon operator to adjust the amount of propellant in the cartridge case. Fixed ammunition also is typically used for small to medium caliber ammunition.

Semi-fixed ammunition permits an adjustable propellant charge, by dividing the propellant into increments, or charges. Each increment of propellant is typically contained in a cloth bag. There are usually 7 increments numbered 1 through 7, each of which is a different size. All of the cloth bags may be held together by an acrylic cord and stored in the cartridge case.

The primer is typically located in the base of the cartridge and is an integral part of the cartridge case. Semi-fixed ammunition may be fuzed or unfuzed and is generally used in 105 mm howitzers.

Separate loading ammunition has four separate components: primer, propellant, projectile, and fuze. The four components are issued separately and the projectile and propellant are loaded in two separate operations to prepare the cannon or howitzer for firing. Typically, the fuzed artillery projectile is loaded and rammed in the breech of the cannon chamber. Propellant charges are then loaded into the chamber. The propellant charges are conventionally provided in increments so that the quantity of propellant can be readily varied to adjust the distance and height of the projectile's flight path. The mechanical primer then is inserted into the breech block, either by hand or by mechanical means. On firing, the firing pin mechanism impacts the mechanical primer, which detonates and extends a flame into the propellant chamber that ignites the propellant and fires the projectile. The use of mechanical primers in artillery delays the percussion and reload cycle by introducing additional steps to the loading process. Although semi-automatic and even automatic processes for mechanical primed artillery firing have been developed, their maximum rate of fire is limited in part by the time required to manually or mechanically load the mechanical primer and to initiate the mechanical firing sequence.

While a primer may not be required for firing, the invention allows the use of conventional mechanical primer ammunition for improved interoperability with existing firearms, and thereby simplifies the supply requirements for military operations that employ both plasma fired and mechanically fired firearms. For artillery cannons and naval guns, the present invention replaces the mechanical primer and firing pin of conventional mechanisms. This eliminates the safety issues and time delay caused by manual or mechanical loading of mechanical primers.

Terms such as "under," "over," "in front of," "the back of the gun," or "behind," "anterior," "posterior," or "transverse," are used here as somebody firing a gun or firearm would understand them, which is by reference to the longitudinal or firing axis of the barrel when the firearm is held or positioned in the usual horizontal attitude.

In one preferred embodiment, the present invention may be used as an EMP firing device in conjunction with conventional ammunition or propellant charge. Figure 1 shows a preferred embodiment of the invention for use with a 155 mm artillery gun. EMP generator (10) produces a high power pulse, generally 3 kW and 2.5 GHz, but other settings of power and frequency can be selected as noted above. In one example, a commercially available power supply and magnetron can be used (*see, for example,* Richardson Electronics, LaFox, IL; CPI Beverly Microwave Division, Beverly, MA). In general, the EMP generator selected incorporates a pulsed magnetron and is capable of a duty cycle for approximately 20kW power, however this can be varied. Preferably, the power supply and/or EMP generator is protected from vibration and shock, for example with a shock absorbing housing or a vibration- dampening base. One of skill in the art is familiar with mechanisms to transfer the EMP pulse from the generator through a waveguide (see Figure 2, for example). A flexible waveguide (11) can be used to connect the EMP generator to the breech of the gun (13). A gasket (12) protects the rigid waveguide (14) in the breech from shock and/or heat. Typically and in preferred embodiments, the rigid waveguide (14) is composed of nickel-plated aluminum. The size and shape of the rigid waveguide can be tailored for the particular gun. In a preferred example, the interior of the rigid waveguide is rectangular, as in commercially available waveguides (CPI Beverly Microwave Division, Beverly, MA; Richardson Electronics, LaFox, IL). As one of skill in the art appreciates, the resonant frequency of a waveguide (microwave cavity) is determined by the physical dimension of the resonator together with the reactive effect of any perturbations to the inductive or capacitive portion of the circuit. Accordingly, any reference to frequency and power values or ranges noted here can be varied according to the physical dimensions and the circuit either required or preferred in an operation circumstance. Furthermore, most EMP generators are equipped with mechanisms to vary output power and mode control, which allows further variations in the design of the EMP device of the invention or selection of an EMP generator with a longer or shorter operating lifetime.

The window (15) or protection window allows the EMP pulse to pass through, or at least enough EMP to detonate the propellant charge or primer. Typically, the window is composed of heat and shock-resistant materials, such as high strength ceramics, fiberglass, Teflon, or combinations of these. The shape of the window can allow it to be protected from the reaction in the interior of the chamber or the shape can protrude into the chamber, so that a conical shape or rounded surface deflect debris away from the surface of the window. The

EMP pulse wave (16) is shown moving inside the chamber from the window (15) towards the propellants charges (17). A standoff distance can be incorporated between the lowest placed charge and the window or breech head. The projectile (18) is subjected to forces that propel it once the charge(s) is detonated. The cannon barrel (19) is also shown.

In one embodiment, the EMP generator employs a magnetron as shown in Figure 2. Many commercially available magnetrons can be selected for use or adapted for use (*see* CPI Beverly Microwave Division, Beverly MA; Richardson Electronics Ltd., La Fox, IL). The magnetron (100) is connected to the power supply. A standard magnetron probe (102) and connecter (101) propagates the EMP to a waveguide, such as a coaxial cable or other rigid or flexible waveguide. The rigid waveguide used (103) can be made of nickel-plated copper.

One of skill in the art can substitute a variety of electrical elements to construct a suitable EMP generator and waveguide in accordance with the present invention. The power of the EMP pulse can be dictated by a number of factors, such as the power supply, the frequency used, the magnetron used, the dielectric length employed at the breech, and the waveguide in the breech. Also, the standoff distance can be varied. Generally, with one powder increment, an 18-inch standoff can be used in a 155 mm gun. With the mechanism and methods of the invention, one increment can be used and fired with an EMP pulse to generate a stronger propelling force, as the single increment is detonated at once. For example, the intense heat resulting from the EMP pulse detonates a primer or the propellant charge, causing it to ignite all the powder or propellant loaded in the chamber at once.

As noted above, a resonator substance can be used in conjunction with the mechanism and methods of the invention. For example, a mixture of about 2-3 grams of powder from a .50 caliber cartridge and 2-3 resonators (0.02 mm Cu wire of approx. 3 cm length each) is placed at a distance of 31 cm from a magnetron. A power supply generating 1 kW of power output is used to detonate the powder. The same mixture of powder and resonator can be scaled up to larger amount in order to propel projectiles in a gun.

The present invention is not limited to any particular arrangement of the displayed components. For example, one of skill in the art will recognize that the power supply can be portable or fixed and can be located external to the moving parts of the weapon.

In an exemplary method for firing a 155 mm artillery gun, a 10 kW power supply can be used and a 2.5 GHz producing magnetron. A waveguide for the selected frequency is also used.

The protection window in the breech is made of composite ceramic, stable at high temperature and shock-resistant, and more than one window can be used. In general, a protection window can comprise one or more of Teflon, fiberglass, ceramics, glass, quartz, boron nitride, and other materials. As discussed above and as know in the art, a flange can be used to connect the waveguides in order to allow the EMP to be transmitted through the window and in the direction of the propellant charge in a chamber. The flange can comprise metals such as aluminum, kovar, stainless steel, with irridited, plated and paint finishes. A nickel-plated copper rigid waveguide is fit inside the breech and connects the waveguide from the EMP generator to the window using a feed horn of nickel-plated copper. Again, the use of a feed horn and the manipulation of an EMP pulse through various waveguides, connectors, and other devices designed to transmit an EMP pulse is well known in the art and parts and materials can be purchased from commercial suppliers. A gasket, comprising rubber and/or graphite, at the external end of the breech (the end opposite the window end of the breech), protects the rigid waveguide from shock.

One skilled in the art can devise and create numerous other examples according to this invention. The invention is in no way limited by the scope of the examples, disclosure, or claims herein.

What is claimed is:

1. A method for firing a propellant charge, comprising:

providing an EMP generator that is connected by a waveguide for transmitting an EMP pulse to an EMP transmissible window in the breech of a firearm; and

generating an EMP pulse sufficient to detonate the propellant charge in a chamber that is connected to the breech of the firearm;

whereby the EMP pulse sends energy through the transmissible window to fire the propellant charge in the chamber.

2. The method of claim 1, wherein the EMP pulse is about 3kW to about 10kW.

3. The method of claim 1, wherein the EMP pulse is generated from a mobile power source.

4. The method of claim 1, wherein a rigid waveguide in the breech of the firearm is connected to the EMP transmissible window.

5. The method of claim 1, wherein a rigid waveguide in the breech of the firearm is connected to the EMP transmissible window, wherein rigid waveguide is made of Ni-plated copper or Ni-plated aluminum.

6. The method of claim 1, wherein a frequency of about 2.5 GHz is used.

7. An EMP firing device for use with a firearm comprising:

an EMP generator;

a flexible waveguide connecting the EMP generator to a rigid waveguide in the breech of the firearm;

a window in the breech to allow the EMP pulse to irradiate the propellant in the chamber of the firearm;

wherein an EMP pulse generated is capable of detonating a propellant charge loaded into the chamber of the firearm.

8. The device of claim 7, wherein the EMP generator comprises a 10kW power supply.

9. The device of claim 7, wherein the EMP generator employs a 2.5 GHz frequency.

10. The device of claim 7, wherein the EMP generator comprises a portable power supply.

11. The device of claim 7, wherein the firearm is a 155 mm artillery gun.

12. The device of claim 7, wherein the rigid waveguide is made of Ni-plated copper or Ni-plated aluminum.

13. The device of claim 7, wherein the flexible waveguide has a rectangular interior shape.

14. A firearm comprising:

a chamber for accommodating a projectile and a propellant charge;

a breech operably connected to the chamber, wherein a rigid waveguide internal to the breech and running the length of the breech connects the external end of the breech to the chamber end of the breech, and wherein a heat resistant window is placed at the chamber end of the waveguide; and

an EMP firing device connected to the rigid waveguide for generating an EMP pulse to detonate the propellant charge.

15. The firearm of claim 14, wherein the EMP generator is external to the breech.

16. The firearm of claim 14, wherein the EMP generator comprises a power supply capable of generating about 3 kW to about 10 KW of output.

17. The firearm of claim 14, wherein the EMP generator comprises a magnetron for producing an EMP of about 2.5 GHz.

18. A method of using a propellant charge, comprising

placing a propellant charge a distance from an EMP generator;

producing an EMP pulse from the EMP generator and in the direction of the propellant charge;

and observing the effect of the EMP pulse on the detonation of the propellant change.

19. The method claim 18, wherein the propellant charge is located inside the chamber of a firearm.

20. The method of claim 18, wherein the propellant charge comprises one or more resonators.

21. The method of claim 18, wherein the propellant charge comprises one or more resonators of Cu wire

22. The method of claim 18, wherein the EMP output power is about 1kW or above.

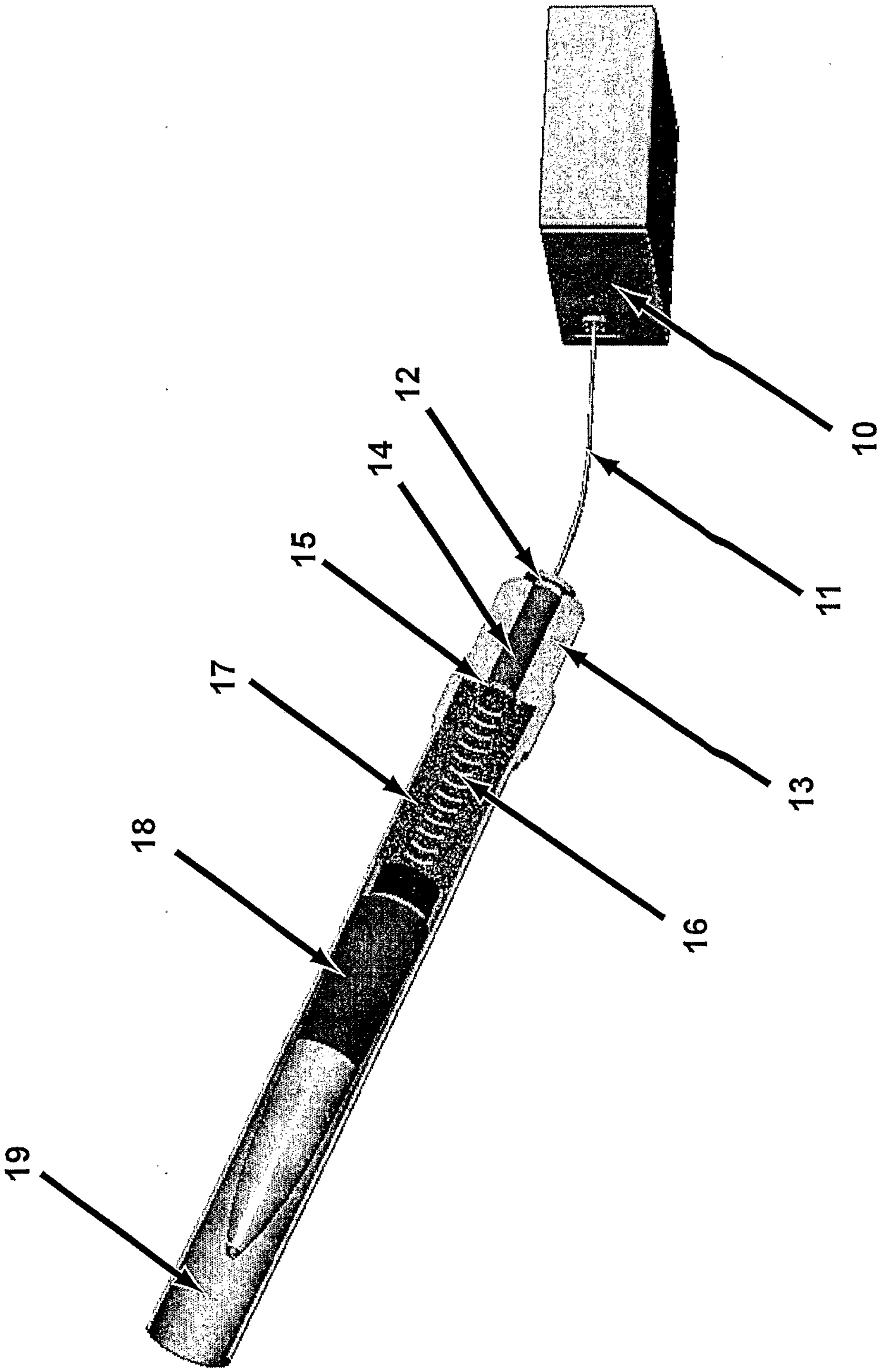



Figure 1

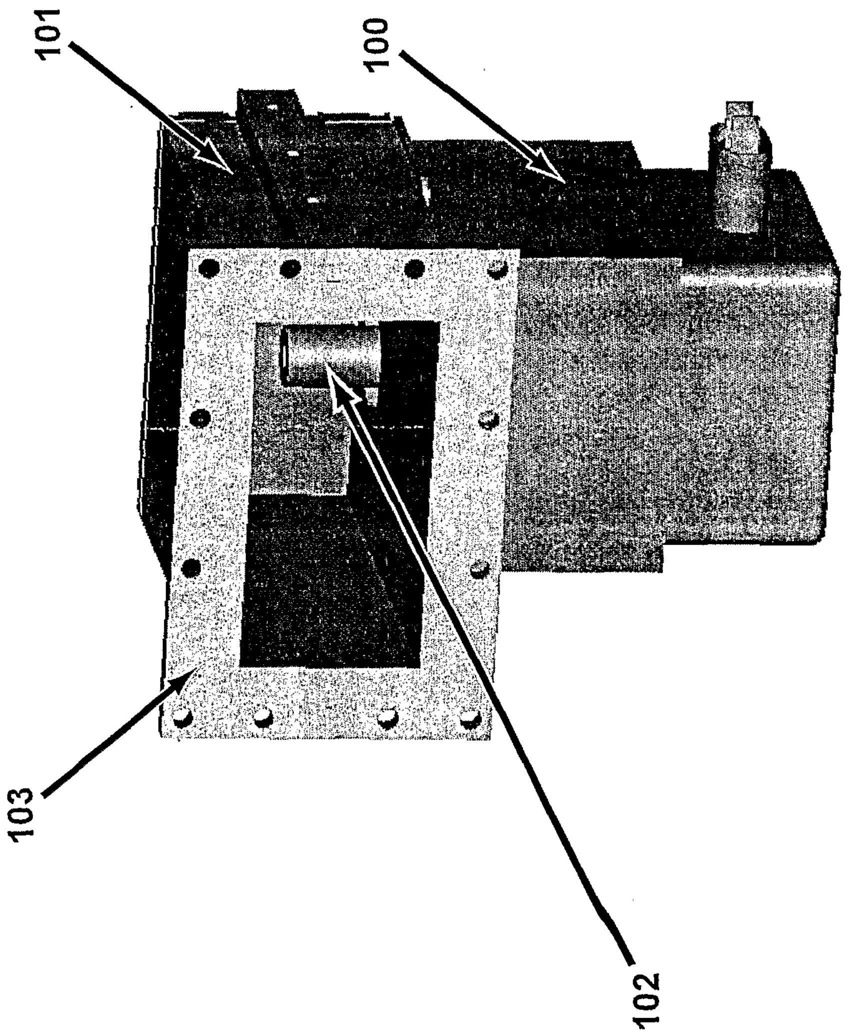



Figure 2

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/CH2004/000642

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 F41A19/63 F42B5/08

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F41A F41C F42C F42B F41B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 6 152 039 A (LEE PETER RAYMOND ET AL)<br>28 November 2000 (2000-11-28)<br>column 1, line 10 - line 14<br>column 1, line 39 - column 2, line 18<br>column 4, line 13 - line 46<br>figures 1,2<br>----- | 1-19,22 |
| X | EP 1 067 354 A (GIAT IND SA)<br>10 January 2001 (2001-01-10)<br><br>paragraphs ‘0008! - ‘0010!<br>paragraphs ‘0030! - ‘0040!<br>paragraph ‘0053!<br>----- | 1,3,4,6,<br>7,9-11,<br>14,15,<br>17-22 |

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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| European Patent Office, P.B. 5818 Patentlaan 2<br>NL – 2280 HV Rijswijk<br>Tel. (+31–70) 340–2040, Tx. 31 651 epo nl,<br>Fax: (+31–70) 340–3016 | Gex-Collet, A-L |

# INTERNATIONAL SEARCH REPORT

International Application No
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**C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT**

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