

Programmable Ammunition

The invention concerns the challenge of programming a projectile during passage through the barrel or the like. In addition, provision is also made for implementing the transmission of energy to the projectile during passage through the barrel, etc.

For programmable ammunition, information must be communicated to the projectile – which is to say programmed into it – concerning its detonation time and/or flight path. In systems in which the detonation time is calculated from the measured muzzle velocity V_0 , the information can be relayed no earlier than at the muzzle and/or in flight. If the programming takes place prior to exit from the gun barrel, as a general rule the projectile flies past a programming unit at the muzzle velocity V_0 and thus is in motion relative to the programming unit.

A known programming unit is described in CH 691 143 A5. With the aid of a transmitting coil, the information is transmitted inductively via a matching coil in/on the projectile. Aside from the heavy construction of the programming unit, an unshielded transmitting coil can result in unwanted radiation, since the coil also acts as an antenna. The radiated signal can be detected, and conclusions concerning the location of the gun can be drawn therefrom.

A method is known from WO 2009/085064 A2 in which the programming is undertaken by the transmission of light beams. To this end, the projectile has optical sensors on its circumference.

DE 10 2009 024 508.1, which is not a prior publication, concerns a method for

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correcting the trajectory of a round of terminal phase-guided ammunition, specifically with the projectile imprinting of such projectiles or ammunition in the medium caliber range. It is proposed therein to separately communicate with each individual projectile after a firing burst (continuous fire, rapid individual fire) and in doing so to transmit additional information regarding the direction of the earth's magnetic field for the individual projectile. The projectile imprinting takes place using the principle of beam-riding guidance of projectiles. In this process, each projectile reads only the guide beam intended for that projectile, and can determine its absolute roll attitude in space using additional information, in order to thus achieve the correct triggering of the correction pulse.

Alternative transmission possibilities, for example by means of microwave transmitters, are known to those skilled in the art from EP 1 726 911 A1, among other sources.

While programming during flight is indeed technically possible as a result, it nevertheless is also subject to simple interference.

For programmable ammunition, energy must be provided to the projectile for the electronics integrated therein and for starting of the detonating train. For this purpose, various rounds of ammunition have small batteries that supply the requisite energy. Others are programmed and supplied with energy before firing. If the energy quantity is available continuously, for example during storage or the process of loading in the weapon, undesired explosion of the projectile may occur in the event of a malfunction in the electronics. For this reason, the use of simple energy storage devices such as a battery is not always appropriate.

It is thus recommended for safety reasons to provide the energy to the projectile in close temporal proximity to firing, for example after the ignition of a propellant charge and before leaving the muzzle opening of a gun barrel. This ensures that the round of ammunition cannot detonate itself before firing, as it has no energy.

The battery from DE 31 50 172 A is not activated until after the [projectile] has left the gun barrel, which is accomplished by means that include a mechanical timer. The battery in DE 199 41 301 A also is first activated by high accelerations during firing.

According to DE 488 866, a capacitor of the detonator is charged via external contacts in the firing position. According to the teaching in DE 10 2007 007 404 A, an ignition capacitor is charged as early as following the end of muzzle safety, which is to say approximately two seconds before the end of the flight time. The ignition capacitor according to DE 26 53 241 A, is charged inductively via magnet coils before firing.

US 4,144,815 A describes a type of energy transmission device in which the gun barrel serves as a microwave guide, so that the energy and the data are transmitted prior to firing. A receiving antenna on the detonator receives the radiated signal and directs it through a changeover switch to either a rectifier device or a filter acting as a demodulator that filters the data out of the incoming signal. The rectifier device in this design serves to produce a supply voltage, which is then stored, from the incoming signal.

Also known are devices that obtain the energy from the kinetic energy of the projectile. Here, a mechanism is built into the projectile that converts the required energy from the acceleration following ignition of the propellant charge into electromagnetic energy, and in so doing charges a storage device located in the projectile.

Thus, CH 586 384 A describes a method in which a soft iron ring and a ring-shaped permanent magnet are displaced in the direction of the projectile axis relative to an induction coil as a result of the linear projectile acceleration, by which means a voltage that charges a capacitor is generated in the coil. For the sake of safety, this unit is then provided in CH 586 889 A with a transport safety device that is destroyed only by the, or a, high acceleration during firing.

It can be a disadvantage here that the acceleration of the projectile in the gun barrel is used, since this cannot be controlled with exact precision. This causes the energy charging to vary, so that the projectile is given too much or even too little energy in its travel. Too little energy then has the disadvantage that functionality is not guaranteed. A further disadvantage is the complex and thus space-consuming conversion mechanism for converting mechanical energy into electromagnetic energy. Moreover, with the extreme environmental influences (shocks during firing, transverse accelerations and spin) on the projectile during firing, this mechanism can be destroyed. In order to preclude this, design measures are necessary that not only make the round of ammunition costlier, but also require additional space in the projectile and make it heavier.

Generators in the projectile head are proposed in DE 25 18 266 A and DE 103 41 713 A. An alternative to these is the use of piezo crystals, as proposed and implemented in DE 77 02 073 A, DE 25 39 541 A or DE 28 47 548 A.

In this context, the latter proposals already take the route of replacing prior art energy conversion mechanisms with an energy transmission system that for its part impresses the necessary energy on the projectile no later than during passage through the muzzle opening.

The object of the invention is to create a projectile that allows for optimal programming and / or optimal energy transmission with simple construction.

The object is attained through the features of claim 1 and claim 4. Advantageous embodiments are shown in the dependent claims.

The invention is based on the idea of carrying out the programming and energy transmission inductively and/or capacitively. To this end, the projectile contains a sensor that receives the programming signal, as well as a processor that is electrically connected to this sensor and that performs the programming and thereby initiates

detonation of the projectile at a predetermined point in time. An electrical storage device serves to supply power to the electronics of the processor. In the preferred embodiment, this storage device receives its energy during passage through a gun barrel and / or a muzzle brake.

In the preferred embodiment, the part that is used as a waveguide – the gun barrel, muzzle brake, or additional part between gun barrel and muzzle brake, and a part that can be attached to the muzzle brake – is operated below the cutoff frequency. From DE 10 2006 058 375 A, such a method with device is already known for measuring the muzzle velocity of a projectile or the like. This document proposes using the gun barrel or launcher tube and/or parts of the muzzle brake as a waveguide (a tube with a characteristic cross-sectional shape that has a wall with very good electrical conductivity is considered a waveguide. Primarily square and round waveguides are widely used as a technology), which, however, is operated below the cutoff frequency of the applicable waveguide mode. WO 2009/141055 A carries this idea further and combines two methods of measuring V_0 .

Parallel applications from the applicant disclose a method and a device for programming and energy transmission. They primarily deal with the structure of the incorporation in the weapon of the components for programming and/or energy transmission. The V_0 measurement here preferably also takes place with the aid of a waveguide. In this case, such a solution can constitute the foundation for programming in the weapon as well as for energy transmission to the projectile.

The invention shall be explained in detail using an exemplary embodiment with drawings. The drawings show, in schematic representation:

Fig. 1 a programmable round of ammunition in a first variant with bandpass filter,

Fig. 2 the programmable round of ammunition from Fig. 1 with energy path connected,

Fig. 3 the programmable round of ammunition from Fig. 2 with programming path connected,

Fig. 4/5 flowcharts of the programming of or of the energy transmission to the round of ammunition.

Fig. 1 through 3 show a projectile or round of ammunition 1 with at least one sensor 2 for receiving a programming signal with the frequency f_3 and/or an energy transmission signal with the frequency f_2 . The sensor can be, for example, a coil for an inductive signal transmission and/or an electrode for a capacitive signal transmission. The number 7 labels a detonator (electric), which is electrically connected to an electronics unit (processor) 6 and to an energy storage device 5. The signal with the frequency f_2 supplies the energy storage device 5 with energy, and the signal with the frequency f_3 programs the electronics unit 6, for example with the detonation time. The energy storage device 5 supplies power to the electronics unit 6 and the detonator 7.

In the preferred embodiment, the energy transmission can be tuned to the signal of the programming. In this design in Fig. 1, the programming signal with frequency $f_3 \neq f_2$ is used so that the same sensor 2 can be used for both processes in order to save space. Thus, in this preferred embodiment, only one sensor 2 is used for the programming as well as for an energy transmission to provide energy for the storage device 5 in the projectile 1. This is also supported by the means that the energy transmission takes place during passage of the projectile 1 through a gun barrel, a muzzle brake, etc., and the programming takes place chronologically after this energy transmission. It is also possible of course to use two separate sensors and to connect them in a fixed manner.

In accordance with the preferred exemplary embodiment in Fig. 1, the energy input (energy transmission) at the projectile 1 takes place through the reception of a frequency f_2 , and the programming takes place through the reception of a frequency f_3 . Since a common receiving sensor 2 is used for both frequencies, a bandpass filter 3, 4

is incorporated which passes the signal with the frequency f_2 through to the storage device 5, and also passes the signal with the frequency f_3 through to the electronics unit 6. The two bandpass filters 3, 4 thus separate the received signals based on their frequencies.

In the second embodiment from Fig. 2 and Fig. 3 (condition can be $f_2 \neq f_3$ or $f_2 = f_3$), a control unit 8 is incorporated in place of the bandpass filters 3, 4; this control unit arranges a switchover to the individual paths – energy path and programming path – by means of a switch 9 or the like. In this context, Fig. 2 shows the connection to the storage device 5 of the energy path, and Fig. 3 shows the connection of the sensor 2 to the electronics unit 6 of the programming path.

Fig. 4 reflects the programming sequence for the condition $f_2 \neq f_3$. Fig. 5 reflects the programming sequence for the condition $f_2 = f_3$. The structure on the weapon for the programming and energy transmission is not shown in detail (reference is made in this regard to the applicant's two parallel applications).

The projectile or round of ammunition or shell 1 flies into the waveguide, which is not shown in detail. The energy transmission to the projectile 1 within the waveguide HL1 takes place in a first step. Either the bandpass filters 3, 4 are used for this purpose, or the control unit 8 in accordance with the exemplary embodiment in Fig. 2 and Fig. 3. The programming, for example within the waveguide HL2, takes place next. The two said waveguides can also be composed of one and the same waveguide. If multiple arrangements of waveguides are present, and they are passed through sequentially (corresponding to $N > 1$: yes), the process is repeated. Otherwise, the projectile 1 exits the waveguide.

If only one frequency ($f_2 = f_3$) is used for the programming as well as the energy transmission, the electrical paths in the projectile 1 must be alternately opened and closed. In the simplest embodiment, this is accomplished by the switch 8 in the round of

ammunition. Here, too, multiple waveguides may be present that are passed through sequentially (corresponding to $N > 1$: yes) before the projectile 1 exits the waveguide.

Claims

1. Programmable ammunition (1) having at least an energy storage device (5), an electronics unit (6), and a detonator (7), and also having at least one sensor (2)
 - for receiving a signal with a frequency (f_2) for an energy transmission that can be routed to the energy storage device (5), and
 - for receiving its signal transmitted for the programming with a frequency (f_3) and for forwarding this signal to the electronics unit (6) for programming.
2. Ammunition according to claim 1, characterized in that two bandpass filters (3, 4) are incorporated, wherein one bandpass filter (3) passes the signal with the frequency (f_2) through to the storage device (5), and the other bandpass filter (4) forwards the signal with the frequency (f_3) to the electronics unit (6).
3. Ammunition according to claim 1, characterized in that a control unit (8) with a changeover switch (9) is incorporated so that the signal with the frequency (f_2) is delivered to the storage device (5), and the signal with the frequency (f_3) is delivered to the electronics unit (6).
4. Method for programming and/or transmitting energy to a round of ammunition (1) having at least an energy storage device (5), an electronics unit (6), and a detonator (7), and also having at least one sensor (2), characterized by the steps:
 - transmission of energy to the projectile (1) by transmitting a signal with the frequency (f_2), and
 - programming of the projectile (1) by transmitting a signal with the frequency (f_3), wherein
 - from the at least one sensor (2)

- the signal with the frequency (f_2) is routed to the energy storage device (5), and
 - the signal with the frequency (f_3) is routed to the electronics unit (6).
5. Method according to claim 4, characterized in that the routing takes place by means of filtering.
6. Method according to claim 4, characterized in that the routing takes place by means of a controlled switchover.
7. Method according to one of claims 4 through 6, characterized in that both the programming and the energy transmission take place during the passage of the projectile (1) through a gun barrel, a muzzle brake, or the like, which is operated as a waveguide below the cutoff frequency.

[key for figures:]

Fig. 1:

- 3 Bandpass filter for signal with frequency f_2
- 4 Bandpass filter for signal with frequency f_3
- 5 Storage device
- 6 Electronics unit
- 7 Detonator

Fig. 2:

- 5 Storage device
- 6 Electronics unit
- 7 Detonator
- 8 Control unit

Fig. 3:

- 5 Storage device
- 6 Electronics unit
- 7 Detonator
- 8 Control unit

Fig. 4:

[first column, top to bottom:]

Projectile enters waveguide

Energy transmission in waveguide HL1 to projectile with $f = f_2$

Projectile programming in waveguide HL2 with $f = f_3$

yes

$N > 1$?

no

Projectile exits waveguide

[second column]

f_2 NOT equal to f_3

HL1 can be HL2

Fig. 5

[first column, top to bottom:]

Projectile enters waveguide

Disconnection of programming path in projectile

Connection of energy storage path in projectile

Energy transmission in waveguide to projectile with $f = f_2$

Disconnection of energy storage path in projectile

Connection of programming path in projectile

Projectile programming in waveguide with $f=f_2$

yes

$N > 1$?

no

Projectile exits waveguide

[second column]

f_2 EQUAL to f_3