

DESCRIPTION

Method and Device for Programming a Projectile

The invention concerns the problems of programming a projectile during passage through the barrel and/or passage through the muzzle brake. The associated device is suitable, moreover, for a V_0 measurement and, to round out the whole, is also suitable for transmitting energy to the projectile.

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. This programming unit has a heavy construction, which can adversely affect the gun on account of the mass and the torque. At the same time, an unshielded transmitting coil of the programming [unit] 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 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.

The object of the invention is to create a system that allows for optimal programming with simple construction.

The object is attained through the features of claim 1 and claim 6. Advantageous embodiments are shown in the dependent claims.

The invention is based on the idea of carrying out the programming inductively and/or capacitively during the projectile's passage through the gun barrel or muzzle brake. It is

proposed to use a waveguide for the programming, since the electromagnetic field in a waveguide is concentrated.

The utilization of a waveguide below the cutoff frequency to measure the muzzle velocity of a projectile or the like is already known from DE 10 2006 058 375 A. 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 .

The waveguide is now used not (only) for the V_0 measurement, but, in accordance with the invention, for the programming as well. In addition to the waveguide, the programming system or programming device has a transmitting coupler for the programming that is powered by a signal generator. The projectile to be programmed has a receiving coupler for the programming that is functionally connected to the transmitting coupler. Also located in the projectile is at least one programmable processor, etc., which evaluates the signal picked up by the receiving coupler and programs the projectile. In a preferred embodiment, the programming can be verified with the aid of a test signal from a receiving coupler functionally connected to the waveguide.

The waveguide for the programming can be the gun barrel, the muzzle brake, or an additional part between the end of the gun barrel and the start of the muzzle brake, or can also be attached to the end of the muzzle brake. Incorporation in the region before the opening of the muzzle brake has proven to be preferred when an energy transmission to the projectile or shell is also provided, for example.

As in the case of the V_0 measurement, the signal generator (e.g., oscillator) supplies a signal with a constant center frequency that lies below the lowest cutoff frequency of the

waveguide. As a function of the geometry and type of the transmitting coupler (coil, dipole, etc.), multiple waveguide modes (TE_{mn} where $m = 0, 1, 2, \dots$ and $n = 1, 2, 3, \dots$) are excited. The signal generator generates either a carrier in continuous-wave operation (CW operation) or a modulated signal.

If provision is made to perform the V_0 measurement with the aid of the one or more waveguides, the programming must take place after the V_0 measurement. It has likewise proven to be preferred here to incorporate the waveguide for the programming after the muzzle brake.

The muzzle velocity V_0 itself preferably can be measured or determined before and/or after the projectile. In the case of measurement before the projectile, the fact is taken into account that the tip of the projectile influences the magnetic field when passing through the waveguide. In the case of measurement after the projectile, the essentially flat or planar surface of the base is exploited, by which means the measurement takes place independently of the shape of the tip of the projectile. In this process, the base influences the electromagnetic field. In each case, this change is sensed by a receiving coupler and supplied to an analysis device. Such a method is known from WO 2009/141055 A1. The distance between a transmitting coupler, which for its part receives the signals from the oscillator, and the receiving coupler is variable and can be chosen individually as a function of the mode selection of the waveguide, but depends on the caliber, the interior dimensions of the waveguide, and the frequency.

Furthermore, the device can be augmented or combined with an energy transmission system. For programmable ammunition, the projectile must be supplied with energy for the electronics integrated therein and for starting the detonating train. The transmission preferably takes place inductively and/or capacitively, to which end the waveguide can be used. For the energy transmission, a transmitting coupler that is already present, or an additional transmitting coupler, is used; this coupler applies the requisite energy in the form of a third frequency to a sensor in the projectile, which in turn charges a storage device that is electrically connected to the sensor. For its part, the energy

transmission must take place before the programming, so it has proven to be preferred for the waveguide for the programming to be affixed to the end of the muzzle brake, with the result that the spacing between the energy transmission and the programming is sufficient to carry out the programming.

As a result of the field concentration in the waveguide, less supply energy is required for the necessary signal-to-noise ratio (S/N). On account of the choice of the frequency below the cutoff frequency, only a small amount of radiation to the outside is present, and the programming is more resistant to interference.

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

Fig. 1 a programming unit,

Fig. 2 a process chart for depicting the programming sequence,

Fig. 3 an extension of the device with a V_0 measurement and also with an energy transmission device.

Fig. 1 shows a programming unit or programming device 1. The programming unit 1 consists of at least one waveguide 2 or waveguide segment(s), as well as at least a transmitting coupler 3 that is supplied with a frequency f_1 by an oscillator 4. The reference number 5 identifies a projectile into which the requisite information – e.g., detonation time – is to be impressed during transit through the programming unit 1. The waveguide 2 in this design can be placed after (viewed in the direction of firing) a muzzle brake 6 (if present), or can be incorporated between the muzzle brake 6 and a gun barrel 7 (see Fig. 4; similar to the device for energy transmission when this is not incorporated).

The mode of operation, or the method for programming, is as follows:

The signal with frequency f_1 is below the cutoff frequency of the relevant waveguide mode. So that the programming is independent of the magnitude of the muzzle velocity V_0 , the frequency should be > 0 Hz. This has the result that the V_0 of slow projectiles as well as fast projectiles has no effect on the programming. The carrier with the frequency f_1 is modulated (18) with the information, and the modulated signal is then provided to the transmitting coupler 3. The transmitting coupler 3 now excites or stimulates the corresponding electromagnetic field in the waveguide 2. When the projectile 5 passes through the waveguide 2, the projectile 5 receives the signal in a contactless manner with capacitive and/or inductive coupling by means of a receiving coupler 8 located in the projectile 5. Suitable for this purpose are, for example, a coil on the projectile or shell 5, a dipole incorporated into / on the projectile 5, or also a slot antenna (slot(s) is / are incorporated into the surface), etc. In the projectile 5, a processor 19 or the like that carries out the programming in the projectile 5 is electrically connected to the receiving coupler 8.

A test signal received by a receiving coupler 9 located in / on the waveguide 2 and transmitted by a receiving device 10 connected to the coupler 9 can be used for testing the programming, but is only conditionally necessary, so that this test could also be omitted. Fig. 2 shows the sequence of this programming in an overview.

In a further development, the programming can be combined with an energy transmission and/or a V_0 measurement. This is reflected in Fig. 3.

The frequencies f_2 and f_3 preferably are likewise optimized for both the V_0 measurement and energy transmission when the frequency used for both the measurement and the energy transmission (the same $f_2 = f_3$) is already optimal.

Since the programming takes place at a point in time after the V_0 measurement, for example by means of a device 20, and after an energy transmission by means of the energy transmission unit 21, the components (couplers) for the measurement and

transmission should be incorporated into the measurement and programming device ahead of the waveguide 2 for the programming in the direction of motion of the projectile. The incorporation of an additional waveguide 11 between the gun barrel 7 and an existing muzzle brake 2 has been shown to be a proven arrangement. This waveguide is a component of both the device 20 and the unit 21 in this design.

When the projectile 5 passes through the waveguide 11, the muzzle velocity V_0 is measured in a known manner by means of the transmitting coupler 12 and the receiving coupler 13. To this end, the transmitting coupler 12 is supplied with the frequency f_2 by a signal generator 22. The receive signal required for the measurement is received by the receiving coupler 13 and is passed to an analysis unit 16. The muzzle velocity determined therefrom can be provided to the programming unit 1 and modulated onto the carrier with the frequency f_1 via the modulator 18 as an information signal.

For the additional energy transmission, the projectile 5 has a sensor 14 that receives the signal with the frequency f_3 from an additional signal generator 23 and charges a storage device 15 in the projectile 5. As it flies through, the projectile 5 receives the requisite amount of energy, so that the storage device 15 is charged after exiting the waveguide or waveguide segment 11. The same transmitting coupler 12 can be used in this process; however, for the energy transmission it is preferably supplied by an additional signal generator 17.

The V_0 measurement can be carried out before and/or after the energy transmission. Both processes are to be carried out before programming, however.

Claims:

1. Method for programming a projectile (5) during its passage through a gun barrel (7), muzzle brake (6), or the like by means of a programming unit (1), with the steps:
 - the programming takes place during passage through a waveguide (2) that is operated below the cutoff frequency of the applicable waveguide mode (TE, TM),
 - signal generator (4) supplies a signal with a constant center frequency (f_1) that lies below the lowest cutoff frequency of the waveguide (2),
 - the carrier with the frequency (f_1) will be modulated with the for the programming necessary information by the modulator (18) and impressed on the projectile (5).
2. Method according to claim 1, characterized in that a V_0 measurement of the projectile (5) can take place in the waveguide (2, 11) by means of a frequency (f_1) generated for the measurement, although this measurement takes place chronologically before the programming.
3. Method according to claim 2, characterized in that the muzzle velocity determined therefrom can be provided to the programming unit (1) and modulated onto the carrier with the frequency (f_1) via the modulator (18) as an information signal.
4. Method according to one of claims 1 through 3, characterized in that the appropriate electromagnetic field is excited in the waveguide (2, 11), so that the frequency (f_1) can be reflected at the projectile (5) and analyzed.
5. Method according to one of claims 1 through 4, characterized in that an energy transmission to the projectile (5) can take place in the waveguide (2, 11) by means of a frequency (f_3) generated for the energy transmission.
6. Method according to one of claims 1 through 5, characterized in that the frequencies ($f_{1,3}$) are > 0 Hz.
7. Method according to one of claims 1 through 6, characterized in that in function of the geometry and type of the transmitting coupler (coil, dipole, etc.), multiple waveguide modes (TE_{mn} where $m = 0, 1, 2, \dots$ and $n = 1, 2, 3, \dots$) are excited.
8. Device for programming a projectile (5) during its passage through a gun barrel (2), muzzle brake (6), or the like by means of a programming unit (1), having the features:
 - the programming unit (1) comprises at least one waveguide (2) that can be the gun barrel (7), the muzzle brake (6) or an additional part between the end of the gun barrel (7) and the start of the muzzle brake (6), or is additionally attached to the end of the muzzle brake (6),

- at least one transmitting coupler (3) that is supplied with a frequency (f_1) by a signal generator (4),
 - at least one modulator (18) in which the information provided for the projectile (5) is modulated onto the carrier frequency (f_1), and
 - at least one receiving coupler (8) incorporated on/in the projectile (5) that is electrically connected to a storage device or processor (19) in the projectile (5).
9. Device according to claim 8, characterized in that the receiving coupler (8) can be a coil on the projectile (5), a dipole incorporated into/on the projectile (5), and/or a slot antenna, etc.
10. Device according to claim 8 or 9, characterized in that a receiving coupler (9) and a receiving device (10) connected to the coupler (9) are additionally incorporated, the signal of which can be used as a test signal for testing the programming.
11. Device according to claim 10, characterized in that components (12, 13, 22, 23) for a V_0 measurement and / or an energy transmission, such as transmitting couplers (12), receiving couplers (13), and signal generators (22, 23) of a measurement device (20) and / or an energy transmission unit (21) are incorporated ahead of the programming device (1), said components furthermore including a preferably common waveguide (11).
12. Device according to claim 11, characterized in that the projectile (5) has a sensor (14) for the energy transmission that receives the signal with the frequency (f_3) from the signal generator (23) and charges a storage device (15) in the projectile (5).

[key for figures:]

Fig. 1:

[column 1, top to bottom]

Information: e.g., detonation time

Test signal

[column 2]

4 Oscillator for programming carrier with frequency f_1

18 Modulation: Impression of information onto the carrier

Fig. 2:

Projectile enters waveguide

Projectile programming in the waveguide

Projectile exits waveguide

Fig. 3:

22 Oscillator for V_0 measurement frequency f_2

23 Oscillator for energy transmission frequency f_3