

PATENT SPECIFICATION

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(54) A DEVICE FOR PRODUCING AN ELECTRIC IGNITION CURRENT IN THE DETONATOR OF A PROJECTILE

(71) We, WERKZEUGMASCHINEN-FABRIK, OERLIKON-BUHRLE AG, a company organised and existing under the laws of Switzerland of Birchstrasse 155, 8050 Zurich, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a combination of a weapon having a barrel and a projectile therefor, the combination having means for generating an electrical ignition current in a fuze of the projectile during firing of the projectile out of the weapons.

Known combinations of this type include an induction coil in the projectile, a magnet for producing a magnetic field, a yoke in two sections, one section located on the projectile and the other on the weapon barrel to produce change in magnetic flux during the passage of the projectile through the weapon barrel.

In a known device of this type (U.S. Patent 1,739,921) an electromagnet is fitted at the muzzle of a barrel, the detonator has an induction coil, receiving an induction current on passing through the electromagnet, which, on the one hand, is used for charging a condenser and, on the other hand, for switching on a mechanical time relay.

The disadvantage of this known device is that an electromagnet must be fixed at the muzzle of the barrel in the vicinity of the hot gases and that only one current impulse can be induced by this electromagnet.

Another device of this type, (U.S. Patent 3,417,700) has a number of induction coils with permanent magnets distributed equally over the circumference of the projectile and the coil axes arranged radially of the projectile. The magnetic field produced by the permanent magnets is closed, while the projectile is in the barrel and opens as soon as the projectile leaves the firing barrel, thereby inducing a tension in the induction coil.

This known device has the following disadvantages: an arrangement of this type for induction coils is not possible with small bore ammunition, the radial acceleration with rifling ammunition does not allow such an arrangement of the induction coils, only one impulse can be produced.

The present invention proposes to produce an arrangement with which the greatest possible energy can be produced on the passage of the missile through the barrel and which is suitable for small bore missiles, as well as for rifling ammunition.

The present invention provides a combination of a weapon having a barrel and a projectile therefor, the combination having a means for generating an electric ignition current into a fuze of the projectile during firing of the projectile out of the barrel of the weapon, the means comprising, an induction coil located in the projectile, a permanent magnet for generating a magnetic field, a two-part yoke, one part of which is located in the projectile and the other part in the weapon barrel, in order to produce a change in the magnetic flux through the coil upon passage of the projectile through the weapon barrel, the part of the yoke located in the weapon barrel comprising a plurality of ferromagnetic rings spaced apart axially along the barrel by paramagnetic rings arranged between the ferromagnetic rings, and the part of the yoke located in the projectile comprising a substantially cylindrical body member having a substantially disc-shaped flange for the reception of the induction coil, and a soft iron disc, the axis of the induction coil coinciding with the axis of the projectile, and said ferromagnetic rings and paramagnetic rings being arranged at the muzzle of the weapon barrel.

Preferably the magnet is a permanent magnet formed of cobalt-samarium alloy. Alternatively the combination may comprise three ferromagnetic rings separated by paramagnetic rings arranged therebetween, and a second yoke, the second yoke having three arms, each arm

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being fixed to one of the said ferromagnetic rings, and being encircled by two electromagnetic coils which are polarized in opposite directions relative to each other.

5 Reference is now made to the accompanying drawings in which:

Figure 1 is a sectional view of an electronic detonator for a projectile having a generator;

10 Figure 2 is a sectional view of the front of a weapon barrel having a muzzle brake;

Figure 3 is a sectional view of modified construction of an electronic detonator for a projectile having a generator;

15 Figure 4 is a sectional view of an ignition current generator;

Figure 5 is a cross sectional view on line V—V in Figure 4;

20 Figure 6 is a circuit diagram of the wiring between generator and condenser;

Figure 7 is a perspective view of the front end of a weapon barrel;

25 Figure 8 is a sectional view of a further modified construction of an electronic detonator of a projectile having a generator;

Figure 9 is a diagram of the magnetic flow and the induced stresses and the components of this invention; and

30 Figure 10 is a part sectional view of a further construction of an electronic detonator having a generator.

Various generators are known for electronic detonators for projectiles, where both sections of the yoke are arranged in the projectile. In these types of generators only the forces of inertia can be used to produce electric energy.

For example, rotary generators can be used for rifling of spinning ammunition: in these the twist or an alteration of the inertia momentum is made use of for producing electric energy. Friction forces occur between the rotor and stator and difficulties result in the bearing of the rotor.

45 In addition, for example, impulse generators can be used for rifling ammunition. The effect varies in accordance with the design of these generators. Various safety devices, e.g., security measures for transport are necessary. Only impulse generators or batteries can be used for fin-stabilized projectiles

55 Piezoelectric generators may be used both for rifling ammunition and wing-stabilized projectiles. Generators of this type, however, can produce only a little electric energy per unit volume.

60 Some of these problems relating to the known generators mentioned should be avoided with the generator in the invention. Figure 1 shows a detonator 12 fixed at the rear of a projectile 10, containing an explosive charge.

65 This detonator consists of a pot-shaped

casing 13 and a rear screw 14, screwed into a femal thread 15 of the casing 13. The casing 13 is screwed into a female thread 16 of the projectile 10. A section of a yoke is located between the rear faces of the projectile 10 and the casing 13, on the one side, and the head of the rear screw on the other side. This section of the yoke has a permanent magnetic ring 18 and a soft iron disc 19, as well as an induction coil 20. The induction coil 20 is encircled by an insulator ring 21. Finally, a guide ring 24 is fixed to the outer circumference of the projectile 10. Inside the rear screw 14 are located various elements of the detonator which do not belong to the invention and which are designed in the usual manner. A part of these elements is an accumulator 25, which is charge by the ignition current generator in the invention. To this accumulator 25 is connected a detonator cap 26, which can be ignited by the charge stored in the accumulator 25.

An electronic control 27 provides for the ignition of the detonator cap 26 at the right time. In front of the detonator cap 26 is located a detonator 28, which transfers the ignition from the detonator cap 26 to an amplifier charge 29. The amplifier charge 29 is fixed to the casing 13 and extends to the explosive charge 11. The detonator 28 is located in a rotor 30, which can be turned from the firing position indicated to a safety position. Through the rifling, the rotor 30 moves out of the safety position into the firing position. While the projectile 10 is in the cartridge case 23, the magnetic field produced by the permanent magnet 18 is briefly closed by the cartridge case 23. An impact switch 31 has been arranged so that the missile can be ignited without fail on reaching its target.

Figure 2 shows a muzzle brake 33 fixed at the front of a barrel 32. Since this muzzle brake is not part of the invention its construction and mode of operation are not specified in greater detail, but are assumed to be known. The second section of the yoke mentioned is arranged on the interior wall of the case-shaped muzzle brake. This section contains rings 34 of a paramagnetic material, e.g. of titanium. Between and in front of these rings 34, rings 35 are fixed, made of a ferromagnetic material, e.g., steel. The front ring 35 is screwed into the muzzle brake 33. The width of these rings is preferably a little larger than the width of the first part of the yoke with the soft iron disc 19 (Figure 1).

The mode of operation of the device shown in Figure 1 and 2 is the following. When, on firing, the projectile 10 leaves the cartridge case 23, the magnetic field produced by the permanent magnet 18, located in the yoke section, in the soft iron

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disc 19 and in the neck of the cartridge case 23, remains closed by the barrel 32. As soon as the projectile 10 flies through the muzzle brake 33 with the detonator fixed at its rear, the magnetic field is opened by the paramagnetic rings 34 and closed again briefly by the ferromagnetic rings 35. This opening and closing of the magnetic field causes a stress to be induced at the time in the induction coil 20. The condenser 25 connected to the induction coil can be charged by this stress. The control 27 provides that the condenser 25 cannot be discharged again by the use of diodes. Since the direction of the induced stress is altered by the movement of the projectile, the use of the full wave rectifier 75 (Figure 6) in the control is an advantage.

The detonator shown in Figure 3 differs from the one shown in Figure 1 by the shape of the yoke, the soft iron disc 19 and the use of a suitable plastic ring 36.

The purpose of this alteration in shape is primarily to transfer the large forces, concentrated on the rear screw 14 by the fuel gases, to the projectile 10, so that the ignition current generator, particularly the induction coil 20, is not damaged.

The ignition current generator, shown in Figures 4 and 5, has a two piece sector-shaped yoke 37 and 38, which is fixed to a basically rectangular plate 39. This yoke 37 and 38 is encircled by an induction coil 40, arranged coaxially to the axis of the projectile. A permanent magnet 42 is fixed to a second rectangular plate 41; its shape corresponds to the yoke 37, 38. The induction coil 40 is surrounded by a plastic composition 43.

The mode of operation of the ignition current generator does not differ from the ignition current generators shown in Figures 1 and 3. The muzzle brake illustrated in Figure 7 has three ferromagnetic rings 44, 45 and 46, connected together by a yoke with three arms 49 made of an easily magnetizable material. This yoke 49 is encircled by two electromagnetic coils 50 and 51, by which the three ferromagnetic rings 44—46 can be magnetized in such a manner that, for example, the middle ring 45 forms a North pole and the outer rings 44 and 46 the South poles. As can be seen from Figure 7, the paramagnetic rings 47, 48 have bore holes 52, through which the fuel gas can escape. These bore holes 52 are arranged so that they serve as a muzzle brake in the usual way. The projectile detonator, shown in Figure 8, differs from the one in Figure 3 only by the fact that there is no permanent magnetic ring 18. This permanent magnetic ring 18 is not necessary if, as shown in Figure 7, there are electromagnetic coils 50 and 51 on the

muzzle brake. These electromagnetic coils 50 and 51, together with the yoke 49 and the three ferromagnetic rings 44—46, produce a magnetic field. As the projectile passes through the muzzle brake, i.e., through the rings 44—46 this magnetic field induces in the induction coil (Figure 8) voltage impulses, which cause the charging of the condenser 25. The ignition current generators specified have the following advantages:

The projectile has no movable parts. Either a permanent magnet 18 is fixed (Figure 1 and 3) to the yoke 17 or there are electromagnets 50, 51 in the muzzle brake (Figure 7 and 8). Several shock impulses or voltage impulses can be produced, since in the barrel or the muzzle brake a number of ferromagnetic and paramagnetic rings can be arranged. For this reason the charge stored in the condenser 25 can be increased.

These ignition current generators are independent of the projectile spin and firing velocity. No inertia forces are required but the relative motion between barrel and projectile is used to produce the charge.

This ignition current generator can be used particularly for small calibre and is also suitable for rockets, where firing velocity and rifling are relatively small.

No essential alteration in the weapon is required for the ignition current generator, only the muzzle brake need be specially adapted.

Magnetic flow and voltage variation can be seen from Figure 9. As soon as the yoke 17, with the induction coil 20, as well as the permanent magnet 18 and the soft iron disc 19 are within the range of a paramagnetic titanium ring 34, the magnetic flow through the induction coil 20 is small (Point 1 in Figure 9). As soon as the yoke 17, with the induction coil 20, as well as the permanent magnet 18 and the soft iron disc 19 are within the range of a ferromagnetic steel ring 35, the magnetic flow through the induction coil 20 is considerable (Point 4 in Figure 9).

Since the induced stress U_i shows the leakage of the magnetic flow Φ , this stress U_i , at point 4, jumps to a negative value with a decrease of the magnetic flow. The rectifiers, as shown in Figure 6, make sure that the condenser is charged, even with the alternating voltage produced.

The projectile detonator, as shown in Figure 10, differs basically from the projectile detonators so far specified in that the generator has two induction coils 54 and 55.

Between these two induction coils 54 and 55 a permanent ring 56 is arranged, which is radially magnetized. This permanent ring 56 is fixed to a yoke 57, formed by a casing 58

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and two flanges 59 and 60.

The mode of operation of this generator is the following:

5 With the passage of the projectile through the barrel 32 the magnetic field around the first induction coil 54 is initially opened by the paramagnetic rings 34 (Figure 2) and then the magnetic field around the second induction coil 55 is opened by the paramagnetic rings 34. The magnetic field
10 around the first induction coil 54 is initially closed again by the ferromagnetic rings 35 and then the magnetic field around the second induction coil 55 is closed by the ferromagnetic rings 35.

15 In case one of these two magnetic fields is open and the other closed, the closed magnetic field cases the magnetic flow Φ fall to zero in the open magnetic field.

20 WHAT WE CLAIM IS:—

1. A combination of a weapon having a barrel and a projectile therefor, the combination having means for generating an electric ignition current in a fuze of the projectile during firing of the projectile out of the barrel of the weapon, the means comprising an induction coil located in the projectile, a permanent magnet for generating a magnetic field, a two-part yoke, one part of which is located in the projectile and the other part in the weapon barrel, in order to produce a change in the magnetic flux through the coil upon passage of the projectile through the weapon barrel, the part of the yoke located in the weapon
30 barrel comprising a plurality of ferromagnetic rings spaced apart axially along the

barrel by paramagnetic rings arranged between the ferromagnetic rings, and the part of the yoke located in the projectile comprising a substantially cylindrical body member having a substantially disc-shaped flange for the reception of the induction coil, and a soft iron disc, the axis of the induction coil coinciding with the axis of the projectile and said ferromagnetic rings and paramagnetic rings being arranged at the muzzle of the weapon barrel.

2. A combination according to Claim 1, having a muzzle brake in the weapon barrel and in which the ferromagnetic and paramagnetic rings are arranged in the muzzle brake.

3. A combination according to Claim 1 or 2, in which the magnet is a permanent magnet formed of a cobalt-samarium alloy.

4. A combination according to Claim 1, 2 or 3, comprising three ferromagnetic rings separated by paramagnetic rings arranged therebetween, and a second yoke, the second yoke having three arms, each arm being fixed to one of said ferromagnetic rings, and being encircled by two electromagnetic coils, which are polarized in opposite directions relative to each other.

5. A combination of a weapon having a barrel and a projectile therefor, substantially as described herein with reference to the drawings.

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