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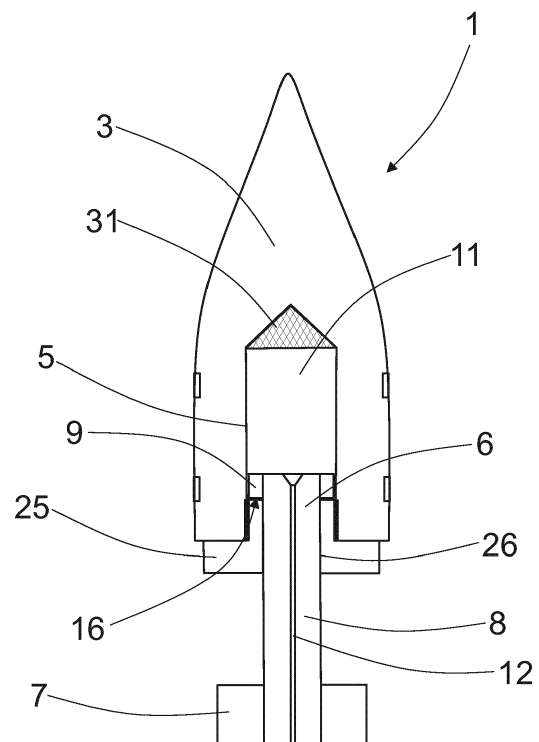
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(54) **PROJECTILE**

(57) The object of the invention is a projectile (1) comprising a jacket (2), a core (3) and a stabilizer part (6), the stabilizer part (6) comprising a shaft (8) and a fin part (7) fastened to the shaft at the first end (20) of the stabilizer part (6), whereby in the core (3) of the projectile (1) is a cylindrical cavity (5), which is closed at least partly with a shutoff part (25) in which shutoff part (25) is an aperture (26) for the shaft (8) of the stabilizer part (6), whereby a piston (9) is fastened to the second end (30) of the shaft (8) of the stabilizer part (6), which piston is disposed in a cavity (5) for forming a space (11) at the front end of the piston (9) and through the shaft (8) of the stabilizer part (6) a channel (12) passes into the space (11), and in the front part of the cavity (5) is a solid fuel (31), which is made to ignite by means of the powder pressure produced in conjunction with firing of the projectile (1).



**Fig. 2**

## Description

**[0001]** The object of the invention is a projectile according to the independent claim. The projectile is suited for use particularly, but not exclusively, in heavy weapons, in which case it offers improved targeting accuracy and impact velocity compared to conventional projectiles.

**[0002]** Cartridges suitable for weapons typically comprise projectiles, which is a general term comprising all objects that are propelled by an external force and that then move freely under the influence of gravity and air resistance. The main types of projectiles are bullets, grenades and special projectiles. Projectiles can include *inter alia* sharp arrows, blunt-headed bolts, sling shots, cannonballs, shrapnel shells, and stones shot from catapults. A cartridge, on the other hand, is an ammunition combination, in which the projectile plus primer, case, powder charge and detonator are combined into a single assembly. A cartridge comprises in a single unit all the elements needed for propelling the projectile. Almost all small-caliber firearms are weapons firing cartridge rounds.

**[0003]** In a canister round, the projectile and propelling charge are loaded into the weapon separately. This type of round is used especially in large-caliber (over 100 mm) guns, in which the use of cartridge rounds is not reasonable for technical reasons: the physical size and weight of a cartridge would become excessive. In this case the projectile is first loaded into the powder chamber and then the canister containing the propelling charge, which charge can be in a brass case containing the primer, or in a textile or cardboard package, in which case a separate primer is placed in last before closing the lock. Powder bags packed in textile are especially popular in naval guns of very large caliber, whereby the amount of propelling charge can easily be adjusted in relation to the range.

**[0004]** A bullet generally refers to a non-explosive projectile of a small-caliber, generally less than 20 mm, weapon, i.e. the part of a cartridge that is propelled to the target. The bullets of hunting weapons generally comprise a brass-alloy jacket and a lead core. The jacket can also be soft steel and the core can be some other metal than lead. Bullets can also be made completely of lead or of some other metal. Nowadays all-copper bullets are also used in big game hunting owing to the suitable softness (no damage to the barrel of the weapon) and toughness (changes its shape on impact but does not fragment) of the material.

**[0005]** Rifling (grooving, fluting) in everyday language nowadays most commonly means a gently rotating groove running on the inner surface of the barrel of a firearm, the purpose of which groove is to improve accuracy by getting the bullet or other object being shot to spin around its longitudinal axis to during its flight. Rifled barrels are nowadays used in almost all rifles, pistols and guns. Unrifled, i.e. smooth-bore, barrels are nowadays used in shotguns, mortars, rocket launchers, tank canons

as well as in some guns. In most cases there are from four to eight rifling grooves in the barrel of handguns, but also other solutions are applied. The number of rifling grooves in rifle-caliber weapons is generally from four to six, and they are made for the whole length of the barrel. One exception is a separate rifled choke tube manufactured for a shotgun. The distance over which one rifling groove makes a complete revolution in the barrel is called the rifling twist rate. The depth of rifling grooves in a handgun is generally between 0.1-0.3 mm and the twist rate is approx. one revolution per 20-30 cm. A long bullet generally needs a short rifling twist rate to stabilize it. A rifling twist rate that is too dense might cause a phenomenon called overstabilization, whereby the axial angle of the bullet does not follow exactly the angle of the trajectory. In such a case, it travels on its trajectory at an inclined attitude with respect to its direction of travel, which is detrimental in terms of both accuracy and power. Also the pressure level and the susceptibility of the weapon to wear might increase, the barrel copperize more rapidly than normal, and accuracy therefore decline.

**[0006]** Although rifle-caliber weapons significantly improved in accuracy after adopting rifling, contrary developments have also taken place. For instance, guns with smooth-bore barrels are used in tanks, from which fin-stabilized projectiles are fired. Accuracy and penetration are good and the first shot towards e.g. an enemy tank can be fired at a distance of approx. 3,000 meters or from even farther away. Higher muzzle velocities can be achieved with smooth-bore barrels than with a rifled barrel, which in this context means a longer sweep and better armor penetration, especially with sub-caliber projectiles, flechettes and armor-piercing ammunition.

**[0007]** There can also be grooving, called rifling, on bullets. This is the case with some shotgun slugs. This rifling on the outside of the slug is referred to as ribs and has the same purpose as rifling in the barrel: to bring about rotational movement of the bullet, in this case by means of air resistance.

**[0008]** A flechette projectile or flechette cartridge is based on arrow-shaped "bullets". They resemble nails, at the end of which are arrow-type fletchings stabilizing their flight. They do not fragment at the target. Flechettes are used in military action against human targets. They are designed for different weapons: guns, rifles, pistols and shotguns. Flechettes are particularly effective against a variety of protection equipment, such as body armor, flak jackets and helmets. For this reason, the use of flechettes is often restricted to use by official authorities.

**[0009]** As a rule, sub-caliber flechettes are mainly used against other tanks. A flechette to be used in a smooth-bore tank canon (100-125 mm) reaches a muzzle velocity of over 1,500 m/s. The arrow itself is a sharp-nosed "dart" 2-3 cm in diameter and over half a meter in length (the dimensions depend on the caliber of the weapon), on the rear of which are small flight-stabilizing fins. The manufacturing material of the arrow is hard and very heavy

metal: "tungsten", i.e. wolfram carbide or "DU" (depleted uranium). The penetration of a flechette is based on an extremely high impact speed, high kinetic energy and a small impact area. The tip of the flechette is already inside the tank while the tail is still outside. The great weight of the flechette in relation to its cross-sectional area upholds the flight velocity and allows other weaponry to open fire earlier, and the short flight time is forgiving to errors in range-finding and other preliminary estimates. The high penetration velocity detaches hot fragments from the tank that cause fires and explosions inside the tank, destroying the structures and crew of the tank. The oxidization of depleted uranium (DU) in the penetration reduces penetration friction and causes an explosion inside the tank.

**[0010]** The caliber (100-125 mm) of the main gun of main battle tanks (MBTs) is larger than a flechette, for shooting fragmentation grenades, shaped charges and missiles. For this reason, the flechette is bound to its case with a sabot that seals and centers the flechette, the sabot being e.g. a sleeve seal comprised of aluminum sectors. The sabot accompanies the flechette through the barrel and opens due to air resistance, falling away from the flechette and scattering in the forefield. The arrow might penetrate several meters of armor steel.

**[0011]** Nowadays a sub-caliber flechette is the most common anti-tank projectile used against heavily armored targets, such as main battle tanks.

**[0012]** The solution for a projectile according to the invention can be classified as a flechette. It eliminates or reduces the problems of conventional flechettes that are in use, such as by rendering sleeve seals unnecessary. The structure of the projectile allows a smooth-bore barrel, which enables firing with hard charges. The velocity of projectiles fired with larger charges is higher, in which case a stable trajectory and a high impact velocity at target impact are achieved. The effect on targeting accuracy caused by the rifling grooves is likewise eliminated, which becomes significant when firing over long distances. The velocity of the flechette according to the invention is maintained, or even accelerated, during flight by means of the combustion of a solid fuel occurring in a combustion chamber inside the projectile. As a result of the solid fuel, the impact velocity of the projectile, i.e. its velocity at the moment it strikes the target, is higher than that of projectiles without solid fuel.

**[0013]** The solution according to the invention comprises a projectile, manufactured with fine mechanics, which projectile is discharged into motion with a smooth-bore barrel. When the projectile is in the barrel of the weapon, the powder gas produced in conjunction with firing pushes the tail fin out from the rear of the projectile, which tail fin stabilizes the trajectory of the projectile after the projectile exits from the barrel. The use of a smooth-bore barrel enables the use of higher muzzle velocities than earlier, and thus enabling lengthening of the range and increased accuracy, especially over long ranges. A rotating motion like the motion brought about by rifling

grooves can be induced in the projectile by the shaping of the tail fins. When rifling is not needed in the barrel of a weapon, the manufacturing process of the barrel is simplified. The solution according to the invention comprises a solid fuel inside the flechette, in which case when firing the projectile the powder pressure is pushed inside the projectile, pushes the tail fin of the projectile out from the body of the projectile and forms a combustion chamber inside the projectile. The powder pressure simultaneously ignites the solid fuel inside the projectile, in which case discharge of the combustion gases out of the tail fin channel is brought about. The combustion gases maintain the velocity of the projectile or even accelerate it. The solution according to the invention is particularly, but not exclusively, suited to large-caliber weapons. Typically the solution according to the invention is advantageous for projectiles possessing a diameter of  $\frac{1}{2}$  inch or larger.

**[0014]** In the following the invention will be described in more detail with the aid of some examples of its embodiment with reference to the attached simplified drawings, wherein

Fig. 1 presents a simplified schematic drawing of a preferred projectile according to the invention, before firing of the projectile, and

Fig. 2 presents a simplified schematic drawing of a preferred projectile according to the invention, after firing of the projectile.

**[0015]** The terms frontmost, front and the like herein-after refer to the direction or surface corresponding to the direction of flight of the projectile and, correspondingly, the terms rearmost, rear and the like refer to the opposite direction or surface with respect to the direction of flight of the projectile. The longitudinal direction refers to the direction of the barrel of the weapon.

**[0016]** Fig. 1 presents a simplified schematic drawing of a preferred projectile 1 according to the invention, before firing of the projectile. The projectile comprises a jacket 2 and a core 3. The jacket 2 and the core 3 are typically the same material and the solution according to the invention is suited for use in all projectiles according to prior art. The projectile 1 is fastened to the case 4, whereby the case contains the detonator and powder (which are not presented in Fig. 1) needed for firing the projectile. When the weapon is fired, the detonator ignites the powder and the powder gas formed when the powder burns brings about movement of the projectile. The pressure of the powder gas forming in the case and later in the barrel makes the projectile move through the barrel providing the direction for the projectile.

**[0017]** In the core 3 of the projectile 1 is a cylindrical cavity 5, in which is disposed at least partly the stabilizer part 6, i.e. the tail fin, of the projectile. The cavity 5 is closed at least partly at its rear part with a shutoff part 25. The stabilizer part 6 comprises a fin part 7 and a shaft 8, to the first end 20 of which shaft the fin part is fastened, and

also a piston 9 allowing movement and stopping of movement in the longitudinal direction of the stabilizer part, which piston is fastened to the second end 30 of the stabilizer part. The piston 9 of the stabilizer part 6 is disposed in the cavity 5 of the core 3 and is able to move in the longitudinal direction inside the cavity. In the shutoff part 25 of the cavity 5 is an aperture 26 for the shaft 8 of the stabilizer part 6. The shaft 8 of the stabilizer part 6 is able to move in the longitudinal direction inside the aperture 26 of the shutoff part 25. Before firing the projectile the stabilizer part 6 is positioned into its first extreme position according to Fig. 1, in which case the piston 9 at the second end of the stabilizer part is in its frontmost extreme position. The piston 9 of the stabilizer part 6, together with the cavity 5 formed in the core 3, forms a space 11 for the powder gases of the projectile 1 that are released in conjunction with firing the projectile. The powder gases pass into the space 11 along the channel 12 formed inside the shaft of the stabilizer part 6. The pressure of the powder gases makes the solid fuel 31 in the front part of the cavity 5 of the projectile 1 ignite. Alternatively, the solid fuel 31 can also be ignited with pressure detonators (not presented in the figures) that are activated by the powder pressure. The solid fuel 31 can be any solid fuel whatsoever known in the art that can be brought to ignite by means of the pressure of the powder gas or by means of a pressure detonator ignited by the pressure of the powder gas. Beveling 32 can be formed in the channel 12 at its space 11 end, in which case the mouth of the channel is shaped like a funnel. This shaping assists discharge of the combustion gases of the burning fuel from the chamber 5. The shaping is not mandatory, however, in which case the diameter of the channel 12 is constant for its full length.

**[0018]** The fin part 7 of the stabilizer part 6 is positioned against, or almost against, the rear part 13 of the projectile 1 before firing the projectile. The rear part 13 of the projectile 1 is formed at least partly by the shutoff part 25 enclosing the cavity 5 formed in the core 3 of the projectile. The shutoff part 25 is fastened to the projectile, to the inside surface of the rear part of the cavity 5, with threads 27. When it pushes out of the cavity 5 of the projectile 1 owing to the pressure brought about in the open space 11 by the powder gas, the fin part 7 of the stabilizer part 6 stabilizes the trajectory of the projectile 1 after the projectile exits the barrel of the weapon. The case 4 is in this embodiment fastened only to the shutoff part 25, but it is understandable that the case can extend also to the area of the jacket 2 of the projectile 1, whereby the case is fastened to both the jacket of the projectile and to the shutoff part. Likewise, the shutoff part 25 can be smaller in diameter than the diameter of the jacket 2 of the projectile 1 on the case 4 side, whereby the case is fastened exclusively to the jacket of the projectile.

**[0019]** On the outer surface of the jacket 3 of the projectile 1 are sealing rings 14, which seal the gap between the projectile and the barrel of the weapon. There can be one or more sealing rings 14 around the

projectile. These sealing rings 14 prevent the powder gas from escaping to the front of the projectile 1 in the barrel of the weapon after firing of the projectile and enable the maximal acceleration and muzzle velocity for the projectile. The sealing rings are typically manufactured from copper, a copper-bronze alloy or a corresponding material suited to sealing.

**[0020]** Fig. 2 presents a simplified schematic drawing of a preferred projectile 1 according to the invention, after firing of the projectile. The powder gases released in conjunction with firing of the weapon are able to push into the space 11 formed inside the core 3 of the projectile 1 via the channel 12 passing through the shaft 8 of the stabilizer part 6 of the projectile. The pressure of the powder gas brings about expansion of the space 11, in which case the powder gases push the piston 9 at the end of the shaft 8 of the stabilizer part 6 from its first extreme position to its second extreme position and maximize the space 11 in the cavity 5 of the core 3 of the projectile 1. Simultaneously, the pressure of the powder gas makes the solid fuel 31 inside the projectile 1 ignite, and the solid fuel combusts in the cavity 5, in which case the expanded space 11 has now become a combustion chamber for the solid fuel. The combustion gases of the solid fuel 31 exit from the space 11 of the channel 12 and maintain the velocity of the projectile 1 or even accelerate it. The diameter of the channel 12 is dimensioned in such a way that the combustion gases of the solid fuel are able to be discharged from the space 11 at the desired velocity, and so that the pressure of the space 11 does not become too high. As a result of the solid fuel 31, the impact velocity of the projectile 1, i.e. its velocity at the moment of striking the target, is increased compared to a projectile without fuel.

**[0021]** In its second extreme position the rear surface 16 of the piston 9 is pressed against the shutoff part 25. The shaft 8 of the stabilizer part 6 and the aperture 26 of the shutoff part 25 are dimensioned in such a way that when the stabilizer part moves from its first extreme position to its second extreme position, the shaft of the stabilizer part is locked into its second extreme position by the effect of the pressure of the powder gases. The stabilizer part 6 staying in its second extreme position also helps the combustion gas pressure produced by combustion of the solid fuel 31. In a preferred embodiment two or more channels are fabricated through the piston 9 and the shut-off part 25 (not presented in the figures), through which the combustion gases produced when the solid fuel burns are brought to discharge from the space 11. The channels are disposed symmetrically around the center axis of the projectile. This allows the use of faster-combusting solid fuel 31 and an increase in the effect on the flight velocity of the projectile 1. The combined cross-sectional area of all the channels determines the selection of the burning rate of the solid fuel in use.

**[0022]** Locking of the stabilizer part 6 is brought about e.g. by making the shaft 8 of the stabilizer part 6, at least in

the proximity of the piston 9, slightly thicker, in which case it is brought to jam in the aperture 26 of the shutoff part 25 when the stabilizer part moves into its second extreme position. As the shaft 8 of the stabilizer part 6 is firmly attached to the aperture 26 of the shutoff part 25, a pitch can be made in the fin 7 of the stabilizer part, the pitch enabling achievement of a rotational movement of the projectile 1 around its own longitudinal axis. The pitch of the fins 7 bring about the same effect on the projectile 1 as the rifling of the barrel of a weapon. In the solution according to the invention the barrel of the weapon is thus smooth-bore. The fins can also be shaped in some other manner in order to bring about rotational movement of the projectile around its longitudinal axis.

**[0023]** The solution according to the invention can, with regard to the stabilizer part 6, also comprise more than one shaft 8, in which case the parts of the shaft telescopically open and, due to friction, lock into their open extreme positions. Locking is brought about by making the sections of the shaft 8 very slightly conical, at least at the ends of the sections of the shaft, in such a way that in the open position of the shaft the external diameter of the end of an innermost section of the shaft is slightly larger than the internal diameter of an outer section of the shaft. In the closed position the parts of the shaft 8 are nested and they open only due to the pressure of the powder gases and wedge into the locked position. The fin part 7 can be fastened to any part of the shaft 8 whatsoever, in which case one or more parts of the shaft can further extend to behind the fin part. The fin part 7 can also be fastened to one or more parts of the shaft 8. Owing to the telescopic structure, the length of the projectile 1 can be increased and, if so desired, the fin part 7 can be disposed farther from the jacket 2 of the projectile. With this solution a more stable trajectory of the projectile 1 than before is obtained. Furthermore, the pressure in the space 11 brought about by the combustion gases produced during combustion of the solid fuel 31 helps to open, and to keep in the opened position, the parts of the shaft 8.

**[0024]** The charge of the projectile according to the invention is larger than that of a corresponding projectile according to prior art, in which case a higher muzzle velocity is obtained with the projectile and, as a result of the solid fuel, the velocity is maintained and even accelerated. A higher muzzle velocity and maintenance/acceleration of the velocity achieve a more stable trajectory and a higher impact velocity at the target. At the same time the targeting accuracy of the projectile improves compared to a conventional projectile. This is considerable, especially at long ranges of fire. At the same time the impacts caused by rifling on the trajectory and targeting accuracy of the projectile are eliminated. Rifling grooves affect the stability of a weapon and try to turn the barrel/tube of the weapon when the projectile is in the barrel/tube of the weapon. The effects of rifling on targeting accuracy are highlighted in particular when shooting rounds requiring accuracy at targets a long way away. Furthermore, some of the pressure of the

powder gas is able to discharge via the rifling, in which case the type of smooth-bore solution of the invention utilizes the pressure generated more efficiently.

**[0025]** The projectile according to the invention also produces a double impact on striking the target, which is extremely effective in the case of armored targets. When the projectile hits its target, the first impact comes from the impact of the envelope and core. Simultaneously, the stabilizer part plus its piston and fins, starts moving forwards. As the stabilizer part hits the target slightly later than the jacket and core, the stabilizer part brings about a second impact on the target, which increases penetration effectiveness. In the case of an embodiment having a shaft 8 of telescopic structure, a number of impacts occur as the telescopic structure crumples after the hit.

**[0026]** It is obvious to the person skilled in the art that the invention is not limited solely to the examples described above, but that it may be varied within the scope of the claims presented below.

## Claims

1. Projectile (1) comprising a jacket (2), a core (3) and a stabilizer part (6), the stabilizer part (6) comprising a shaft (8) and a fin part (7) fastened to the shaft at the first end (20) of the stabilizer part (6), whereby in the core (3) of the projectile (1) is a cylindrical cavity (5), which is closed at least partly with a shutoff part (25), in which shutoff part (25) is an aperture (26) for the shaft (8) of the stabilizer part (6), whereby a piston (9) is fastened to the second end (30) of the shaft (8) of the stabilizer part (6), which piston is disposed in a cavity (5) for forming a space (11) at the front end of the piston (9) and through the shaft (8) of the stabilizer part (6) a channel (12) passes into the space (11), in which case movement is brought about by powder pressure for pushing the stabilizer part (6) out, **characterized in that** in the front part of the cavity (5) is solid fuel (31), which when combusting maintains or accelerates the velocity of the projectile (1).
2. Projectile (1) according to claim 1, **characterized in that** the shaft (8) of the stabilizer part (6) widens as it approaches the piston (9) and at the root of the piston (9) is larger in diameter than the aperture (26) of the shutoff part (25) for fastening the stabilizer part (6) with friction to the shutoff part (25).
3. Projectile (1) according to claim 1 or 2, **characterized in that** the shaft (8) of the stabilizer part (6) comprises more than one part, which parts are telescopically openable and closable, and fasten to each other by means of friction in their open position.
4. Projectile (1) according to claim 3, **characterized in that** the fin part (7) is fastened to one of any of the

parts of the telescopic shaft (8).

5. Projectile (1) according to claim 3, **characterized in that** the fin part (7) comprises more than one part, which parts of the fin part (7) are fastened to more than one part of the telescopic shaft (8). 5
6. Projectile (1) according to any of the preceding claims, **characterized in that** the fin part (7) of the stabilizer part (6) is shaped to bring about rotational movement of the projectile (1) around the axis of its own longitudinal axis. 10
7. Projectile (1) according to any of the preceding claims, **characterized in that** the shutoff part (25) is fastened to the inside surface of the cavity (5) with threads (27). 15
8. Projectile (1) according to any of the preceding claims, **characterized in that** on the jacket (2) of the projectile (1) is at least one sealing ring (14), which seals the projectile (1) against the inside surface of the barrel. 20
9. Projectile (1) according to any of the preceding claims 1-8, **characterized in that** the case (4) is fastened to the shutoff part (25). 25
10. Projectile (1) according to any of the preceding claims 1-8, **characterized in that** the case (4) is fastened to the shutoff part (25) and to the jacket (2) of the projectile (1). 30
11. Projectile (1) according to any of the preceding claims 1-8, **characterized in that** the case (4) is fastened to the jacket (2) of the projectile (1). 35
12. Projectile (1) according to any of the preceding claims 1-11, **characterized in that** there is beveling (32) in the channel (12) at its space (11) end. 40
13. Projectile (1) according to any of the preceding claims 1-12, **characterized in that** the projectile (1) further comprises a pressure detonator in the cavity (5) for igniting the solid fuel (31). 45
14. Projectile (1) according to any of the preceding claims 1-13, **characterized in that** from the space (11) of the cavity (5) of the projectile (1) are two or more channels in addition to the channel (12), from which channels the combustion gases of the solid fuel (31) are able to exit from the space (11). 50

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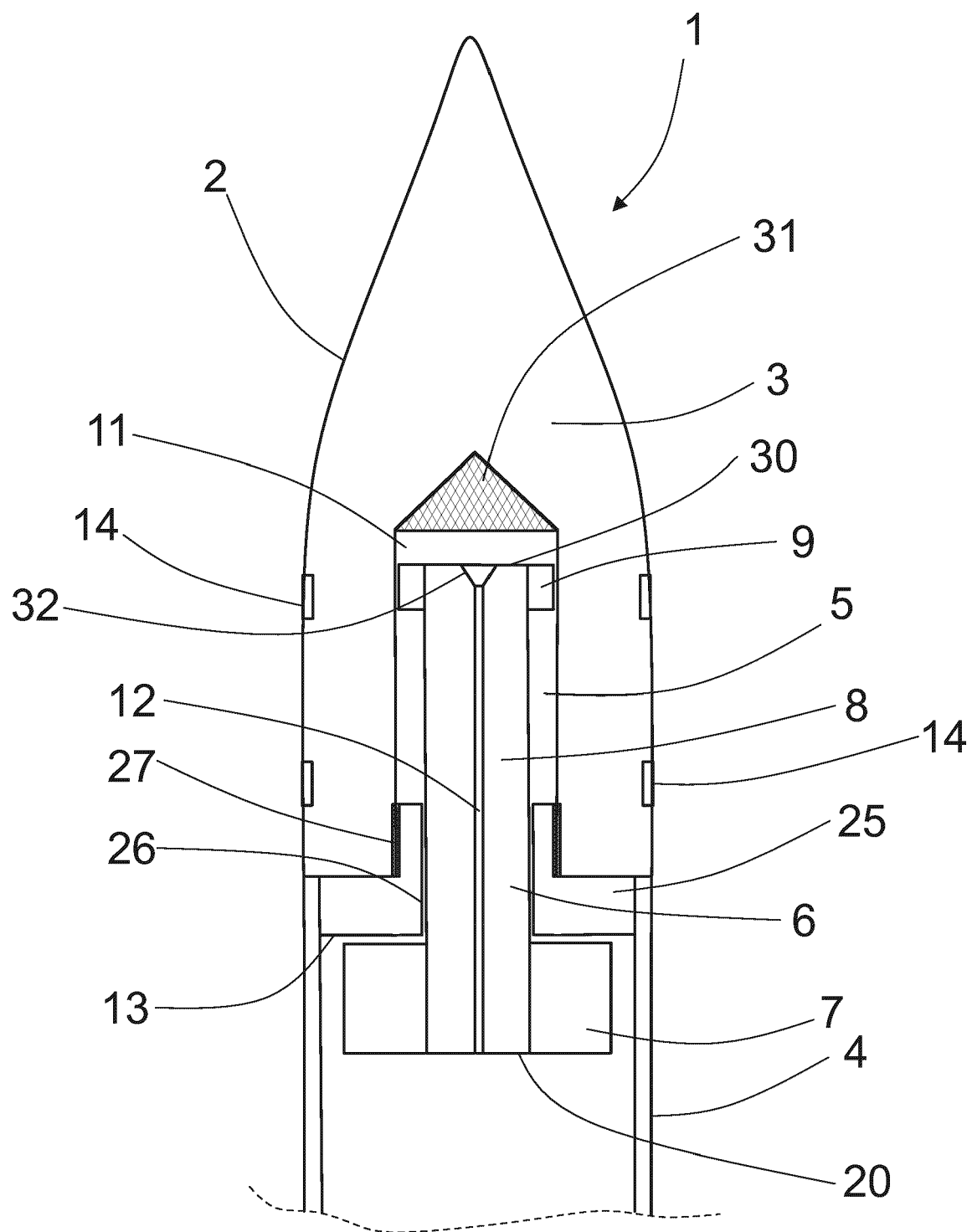


Fig. 1

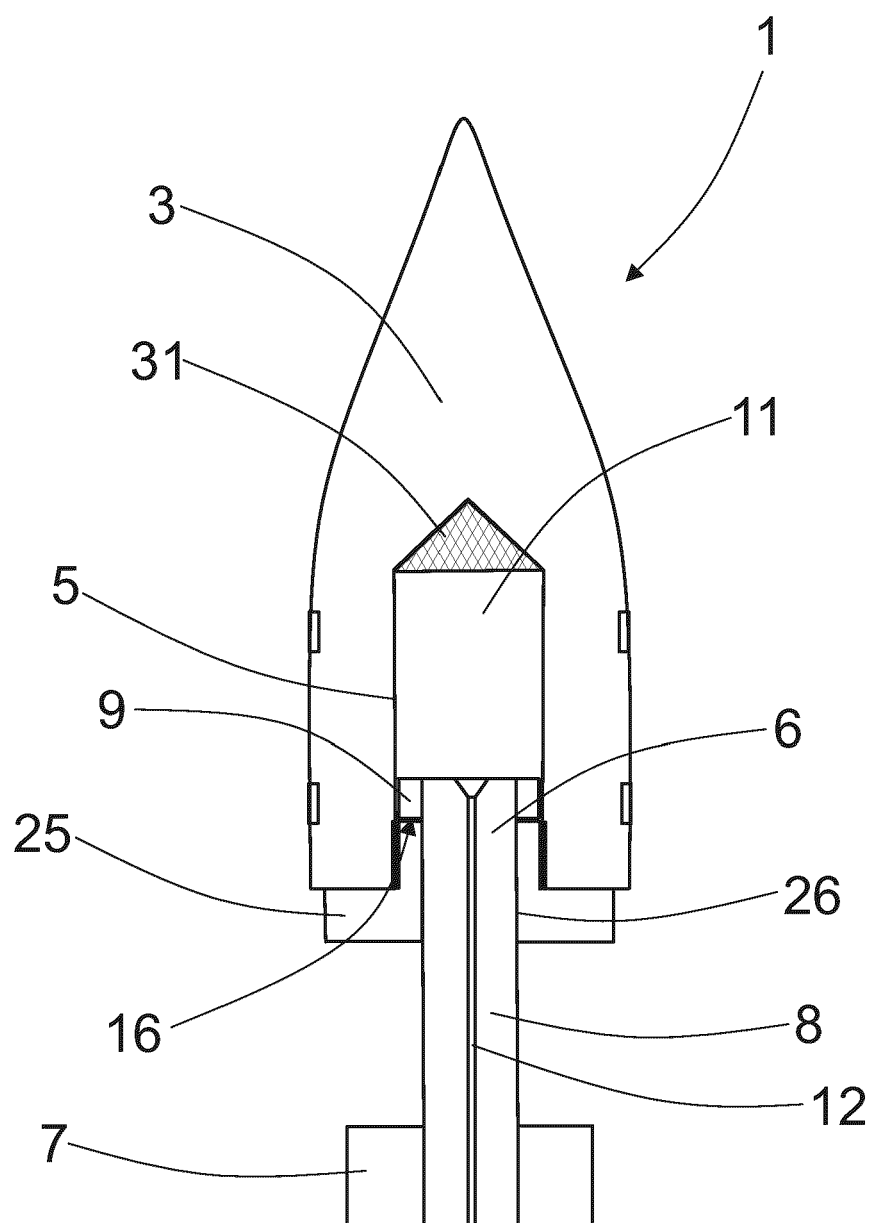


Fig. 2



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Application Number

EP 24 18 3143

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# **ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.**

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