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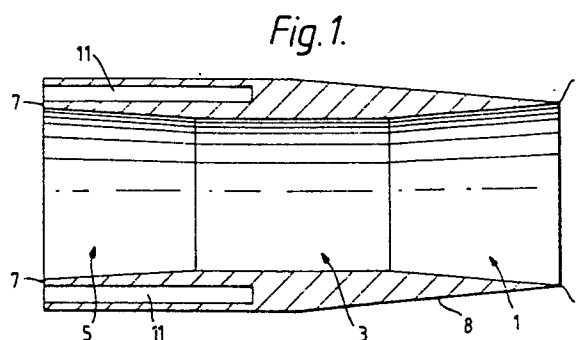
54 **Tubular projectiles.**

57 A tubular projectile suitable for use in training ammunition comprises a hollow tube having formed in the rear end of the tubular wall thereof a recess in which is embedded a tracer material comprising a flexible polymer bonded pyrotechnic composition eg in the form of a cylindrical sleeve.

The projectile may be sabot launched.

Constructions are described for igniting the tracer material directly or indirectly from the gases produced by burning of the main propellant charge when the projectile is fired from a gun, e.g. the RARDEN Gun of the Applicants.

Example of suitable tracer material and techniques for filling the said recess with them are also described.



TUBULAR PROJECTILES

The present invention relates to tubular projectiles. UK Patent No. 1,571,010 assigned to the present applicant Company describes a supersonic tubular projectile invented by Abraham Flatau and Joseph Huerta, which may be used in (but not exclusively in) training ammunition rounds. For example, the projectile may be incorporated as a sub-calibre component in discarding sabot training rounds fired from the 30mm RARDEN (Registered Trade Mark) gun of the present applicant Company.

The present invention provides a novel tubular projectile which may optionally comprise a beneficially modified form of the projectile described in UK Patent No. 1,571,010.

Tubular projectiles of this kind do not readily lend themselves to the inclusion of a tracer facility, on account of the narrow cross-section available in the rear end of the tube wall for the accommodation of tracer material.

US-A-3726495 discloses a projectile having a longitudinal bore which is deliberately constricted. Embodiments thereof include tracer material in annular form contained within the rear end of the projectile. Projectiles of this kind, are not properly described as "tubular" because of their relatively thick wall and extremely narrow bore. In this prior art design, the annular cross-section available for tracer material is quite substantial. The disclosure of US-A-3726495 does not include any special characteristic for the tracer composition, such as might render it suitable for use in mass production of tubular projectile in which only a narrow annulus is available for the accommodation of tracer material.

According to the present invention there is provided a tubular projectile comprising a hollow tube having a recess formed in the rear end of the tubular wall thereof, said recess containing a tracer material, characterised in that said tracer material comprises a flexible polymer bonded pyrotechnic composition.

Preferably the recess is of annular cross-section and said tracer material is in the form of a cylindrical sleeve.

By a "tracer material" is meant any material which may be incorporated in a projectile for the purpose of tracing or tracking the trajectory of the projectile.

The rear surface desirably comprises a flat annulus or a frusto-conical surface. Where the rear surface is frusto-conical it may extend and taper inwardly from the trailing edge of the projectile, i.e. forming a mouth at the rear end of the hollow portion of the projectile tube. Alternatively, the

frusto-conical surface may be on the outer surface of the projectile tube tapering toward the axis of the projectile at a point behind the projectile.

Preferably, the inner and outer lateral extremities of the recess, as observed at the rear end of the projectile, are contained in an intermediate region between the inner and outer diameters of the rear surface annulus, although the tracer-embedded recess could comprise substantially the entire rear surface of the projectile.

The recess may comprise a recess of annular cross-section, the recess annulus preferably being substantially coaxial with the portion of the projectile in which it is formed.

Alternatively, the recess may comprise one or a plurality of discrete holes extending into the rear projectile wall in its rear portion in a direction parallel to the projectile axis. The hole or holes may comprise one or more holes of circular or other suitable cross-section, e.g. an arcuate shape such as a bent rectangular or bent oval (e.g. sausage) shape. The holes preferably are arranged in cross-section in a circular formation.

The present invention provides a highly convenient and advantageous technique for incorporating a tracer material, e.g. a tracer composition, in a round incorporating a tubular projectile without substantially affecting the aerodynamic properties of the projectile.

The tracer material incorporated in the projectile according to the present invention permits the trajectory of the projectile to be tracked. The tracer composition may be a composition which strongly emits visible light when ignited. It could, however, be a composition which is a strong smoke emitter or an infra-red radiation emitter (which may, for example, be tracked by an infra-red detector) or a material which strongly reflects radio or microwave frequencies, e.g. for tracking by radar.

For example, where the tracer material comprises an emitter of visible light it may comprise a pyrotechnic or chemiluminescent material. Many such materials which could be used as pyrotechnic materials are well known to those skilled in the projectiles field. For example, such compositions may comprise a metallic fuel such as powdered magnesium, aluminium, titanium, or zirconium and an energetic oxidiser such as an inorganic nitrate or perchlorate, e. g. of ammonium, barium, or strontium optionally together with a polymeric binder, e.g. a polyester or polyurethane.

Suitable specific examples of pyrotechnic tracer compositions include the compositions commercially supplied by the present applicants under the designations SR889 and SR390B.

Preferably the flexible sleeve comprises a powdered metallic fuel and one or more fluoroelastomers as an oxidiser and flexible binder.

Advantageously the material of the sleeve comprises magnesium 30 to per cent by weight, polytetrafluorethylene 35 to 50 per cent by weight and a rubbery binder 5 to 25 per cent by weight.

The rubbery binder may be a copolymer of vinylidene fluoride and hexafluoropropylene.

Advantageously the material of the flexible sleeve comprises magnesium 48 per cent by weight, polytetrafluorethylene 35 per cent by weight, and a copolymer of vinylidene fluoride and hexafluoropropylene 17 per cent by weight.

The flexible sleeve may be produced by mixing the ingredients together as powders or particulate solids in the presence of a solvent such as acetone or ethyl acetate to form a soft processible dough-like mass. This is then cast, pressed or extruded into sheets. The solvent is allowed to evaporate from the sheets by drying in a warm atmosphere. After drying the resulting sheets which are pliant are cut to size and then rolled around a cylindrical former to produce the required sleeve as a pre-form for insertion into a projectile.

Alternatively, the sleeve may be formed by direct extrusion of a tubular shape from an extruder. It may for instance be convenient to extrude elongate tubes and then to cut these to size to form sleeves prior to drying.

A sleeve formed in one of the ways described above may be incorporated in the recess in a tubular projectile by insertion using a suitable guidance tool followed by consolidation using a plate driven by hydraulic press. Alternatively, a sleeve produced by extrusion may be extruded directly into the recess.

A further alternative process for filling a projectile recess with a sleeve of tracer material is to provide the projectile in a form in which the outer collar shaped ring of the projectile surrounding the recess is flared whereby the recess has a greater cross-sectional area at its outer end.

An annulus of tracer material formed in one of the ways described above may be inserted into the recess and, after evaporating of the solvent, this may be consolidated by swaging down the flared outer surface of the projectile, eg by pushing the projectile through a die or using rollers or any other well known swaging technique, whereby the required final shape of the projectile outer profile is obtained with the tracer material embedded in the recess therein.

Where a tubular projectile is used in conjunction with a sabot, according to the present invention the tubular projectile preferably has in cross-section in a plane containing the projectile axis a front portion having an inner surface conically converg-

ing in a direction facing toward the rear end of the projectile, an intermediate portion having an inner surface of substantially constant diameter and a rear portion having an inner surface conically diverging in a direction facing toward the rear end of the projectile. The material of which the body of the tubular projectile according to the present invention is made is not critical although high strength metallic materials are preferred. The material may for example be aluminium alloy, steel or in armour piercing applications, denser metal such as tungsten alloy. Generally, the overall shape of the projectile according to the present invention is desirably the same as that which is described and claimed in UK Patent No. 1,571,010 except that the sharp boattail rear end of the projectile is preferably replaced by a flat or frustro-conical annular surface as specified hereinbefore.

The tubular projectile according to the present invention may be a sub-component of a discarding sabot round, e.g. as described in UK Patent No. 1,571,010. The sabot may be made of a plastic material or a light metal, e.g. aluminium alloy. A driving band imparting spin from the rifling groove of a gun barrel to stabilise the projectile in flight may be provided, for example, on the sabot outer surface.

Alternatively the projectile according to the present invention may be a full calibre projectile and may for example be provided with a driving band on its outer surface.

A base member, e.g. a pusher or pusher obturator may be provided to impart the main launch forces upon the rear end of the projectile and its sabot if included. The base member may for example be made of a high strength plastics material such as polycarbonate material.

Where the tracer material incorporated in the projectile according to the present invention comprises a composition which is ignited to emit visible light during flight of the projectile the tracer composition may be ignited in a direct or an indirect manner when the propellant charge provided to launch the projectile is initiated. Preferably, a base member, e.g. used as a pusher in conjunction with the projectile has a groove, e.g. an annular groove, facing the recess in the projectile incorporating the tracer material to facilitate such ignition. Preferably the groove is sealed by the rear surface of the rear end of the projectile in which the said recess is incorporated. Such a groove permits ignition of the tracer composition without venting of the propellant gas by the main hollow aperture of the projectile.

In a construction for the indirect ignition of the tracer composition an igniter device may be located behind the projectile, e.g. housed in the base member substantially on the axis of the projectile, may be of a known kind which is arranged to be

initiated by the set-back force or spin of the projectile, e.g. by the action of pressure or a striker on a suitable composition, for example, an impact sensitive composition comprising lead azide. This device may be conveniently arranged to deliver when ignited hot gas to the tracer composition. For example, the igniter device may be located in a cavity in a base member which has one or more bleed channels extending from the cavity to a surface of the base member, e.g. at the said groove in a region adjacent to the recess of the projectile in which the tracer composition is incorporated. Where the pusher in this form of the invention has an annular groove facing the recess incorporating the tracer composition the hot gas emerges at this recess to ignite the tracer composition,

In a direct construction for ignition of the tracer composition hot gas obtained from the ignition of the main propellant charge may be bled through a narrow bleed hole or channel in the base member to the groove in the base member facing the recess in which the tracer composition is incorporated.

In this way the tracer composition may be ignited whilst restricting the build-up of gas pressure behind whilst restricting the build-up of gas pressure behind the projectile. A septum or burster disc or annulus may be provided in the path of the gas to delay the flow of hot gas to the tracer composition, thereby delaying the undesirable build-up of gas pressure upon the rear of the projectile.

The recess in the rear end of the tubular wall may be formed by machining. However, more conveniently, the said recess is formed as a gap between an insert and a portion of a wall of the projectile body at its rear end.

The said insert preferably has an inner or outer surface substantially continuous with the inner or outer surface of the body of the projectile forward of the insert.

Embodiments of the present invention will now be described by way of example with reference to the present invention, in which:

Figure 1 is a cross-sectional side view of a tubular projectile embodying the present invention;

Figure 2 is a cross-sectional end view of an alternative tubular projectile embodying the present invention.

Figures 3, 4 and 5 are cross-sectional side views of alternative tubular projectiles embodying the present invention;

Figure 6 is a part cross-sectional side view of a construction embodying the present invention comprising a tubular projectile together with its associated driving components;

Figures 7 and 8 are cross-sectional side

elevations of alternative base members for use in constructions embodying the present invention comprising a tubular projectile together with an associated pusher base.

Figure 9 is a cross-sectional side elevation of a projectile as shown in Figure 1 in the course of manufacture.

Figure 10 is a cross-sectional side elevation of an alternative tubular projectile embodying the present invention.

In Figure 1 a tubular projectile comprises a front portion 1, a middle or body portion 3 and a rear portion 5. In the front portion 1 the internal diameter converges conically in a direction facing toward the rear portion 5. In the middle portion 3 the internal diameter is constant. In the rear portion the internal diameter diverges conically in a direction facing away from the front portion 1. The rear portion 5 has a flat annular rear surface 7. The outer surface of the front portion 1 has a converging section 8 which meets the inner surface at a sharp annular leading edge 9. The outer surface is of constant diameter in the middle portion 3 and rear portion 5 behind the converging section 8. A recess 11 of annular cross-section is formed in the rear portion 5. This extends from the rear surface 7 inward to occupy part of the middle portion 3 in a direction parallel to the axis of the projectile. The recess 11, which may be formed by machining, is filled with a tracer composition in one of the ways described above.

In the alternative embodiment shown in Figure 2 the recess 11 is replaced by individual holes 11a which may be formed e.g. by machining and filled with tracer material.

In Figure 3 parts similar to those shown in Figures 1 and 2 are given the same reference numerals. In the case of the Figure 3 embodiment, the annular recess 11 again extends from the rear surface 7 through the rear portion 3 in a direction parallel to the projectile axis. However, in this case the recess 11 is formed between an insert 17 and the inner wall of the body, indicated by reference numeral 18, forming the remainder of the tubular projectile. The insert could have axial grooves to provide the required recess rather than by forming this as a gap between the insert and the body of an inner wall of the body. Then inner wall of the body 18 has been machined to form a step 19 to provide the recess 15 with the insert 17 included. The insert 17 abuts against a further step 21 machined in the inner wall of the body 18 and has an inner surface which is substantially continuous with that of the inner wall of the body 18 forward of the insert 17. The recess 15 is filled with a tracer material which is a polymer bonded pyrotechnic composition as described above.

In Figure 4, parts similar to those shown in

Figure 3 are given the same reference numerals. In the case of the Figure 4 embodiment the flat annular rear surface 7 shown in Figure 3 is replaced by a frustro-conical annular rear surface 71. This has the added advantages of an increased rear surface area of the tracer-filled recess 11, to increase the burning area of the tracer material therein, and also a reduced drag on the rear of the projectile. The recess 11 extends inwardly parallel to the axis of the projectile from the surface 71.

In Figure 5 parts similar to those shown in Figure 3 are given the same reference numerals. In the case of the Figure 5 embodiment the rear surface 71 in Figure 4 is replaced by an inwardly sloping frustro-conical rear surface 72 from which the annular recess 11 extends inwardly.

In an alternative embodiment of the present invention (not shown) an insert replacing the insert 17 may have axial grooves to provide discrete holes (rather than an annulus) in which tracer material is embedded.

Figure 6 illustrates a construction for launching a tubular projectile embodying the present invention and for igniting the tracer composition therein by a direct method. The projectile indicated by reference numeral 31 may be of the form shown in Figure 1 or of the form shown in Figure 3. The tracer composition of the projectile 31 is indicated by reference numeral 33. A sabot 35 (which may for example be formed of segments in a known manner) is fitted around the projectile 31. A driving band 37 is attached to the outer surface of the sabot 35. A base pusher 39 carrying an obturator 38 is located behind the rear surface of the projectile 31 and the sabot 35. The pusher 39 has an annular channel 41 extending therethrough in a direction parallel to the axes of the pusher 39 and projectile 31. The channel 41 has three regions, namely an annular recess 41a facing the tracer composition 33, a narrow portion 41b and a wider portion 41c behind the narrow portion 41b. The wider portion 41c houses an annular septum 43.

In operation, the base pusher 39 is contained inside a gun in a conventional launch cartridge (not shown) in front of a known gun propellant (not shown). When the gun is fired the propellant is ignited causing a rapid expansion of gas which is obturated by the obturator 38. The pressure built up causes the projectile 31 and sabot 35 to be driven by the pusher 39 in a forward direction out of the gun. The driving band 37 engages the rifling of the gun (not shown) to impart spin to the projectile to maintain stability of the projectile in flight.

When the pressure of the hot propellant gas produced by the initiation of the main propellant charge reaches a predetermined limit the septum 43 bursts allowing the gas to enter the channel 41 and reach the tracer composition 33 which it there-

by ignites.

The narrow portion 41b allows this to be achieved without a build-up of undesirable high gas pressure behind the projectile 31. It is desirable to prevent such a build-up in order to prevent gas leakage on separation of the projectile 31 from the pusher 39 before acceleration starts.

On leaving the muzzle of the gun the sabot 35 is rapidly discarded allowing the projectile 31 to proceed toward the target. The tracer composition allows the trajectory of the projectile to be tracked in flight.

In Figure 7 there is shown an alternative base pusher 39. In this case, the channel 41 (Figure 4) is replaced by a channel 42 which has a narrow portion 42b conically diverging laterally from a common cylindrically shaped aperture 44 housing a cylindrical septum 46. The narrow portions 42b open at their front end into an annular recess 42a similar to the recess 41a which is adjacent to the tracer composition 33 (Figure 3). Operation of the Figure 7 embodiment is similar to that of the Figure 5 embodiment.

Figure 8 shows a further alternative base pusher construction which may be used in conjunction with the projectile 31 and sabot 35 shown in Figure 5. In the embodiment shown in Figure 7 an igniter device 51 is housed inside the base pusher indicated by reference numeral 50 behind the projectile 31 (Figure 3). A cap 53 having a striker pin is arranged in front of the device 51. An aperture 56 behind the device 51 leads into an annular recess 55, similar to the recess 41a shown in Figure 1, via a narrow annular channel portion 57.

In operation of the Figure 8 construction the cap 53 is set back by the projectile 31 (Figure 3) upon firing the gun, causing its striker pin to initiate the device 51. Hot gas produced by initiation of device 51 flows from the aperture 56 to the recess 55 via the channel portion 57 thereby causing ignition of the tracer composition 33 (Figure 3) adjacent to the recess 55. It will be appreciated that the method of ignition of the tracer composition 33 by the base pusher construction shown in Figure 7 is an indirect method.

In a further alternative embodiment (not shown) the igniter device 51 and cap 53 may be replaced by a known igniter which is sensitive to and ignited by the spin, rather than the set-back, of the projectile 31.

In a further embodiment (not shown) a tubular projectile similar to those shown in Figures 1 or 2 or Figures 3, 4 or 5 may be a full calibre projectile which is launched by a base pusher similar to that shown in Figure 6, 7 or 8 but having a diameter substantially the same as that of the projectile. In this case the driving band is provided on the outer surface of the projectile.

Figure 9 shows an example of a projectile as shown in Figure 1 in the course of manufacture. This illustrates a method of filling the projectiles shown in Figure 1 and Figures 3 to 5 with tracer material. In this example, the outer ring labelled 5a in Figure 9, of the rear portion 5 surrounding the recess 11 is flared toward its rear surface 7 so that the recess 11, prior to insertion of its tracer material, has a greater cross-sectional area at its rear (outer) end than at its front (inner) end. A flexible sleeve of tracer material (not shown in Figure 8) manufactured in one of the ways described above is inserted into the recess 11 and, after any necessary drying of solvent from the tracer material, the ring 5a is swaged down so that the projectile is obtained in the form shown in Figure 1.

Figure 10 shows an alternative to the construction shown in Figure 3. In the case of the Figure 10 construction, the projectile comprises a front portion 1, a middle portion 3 and a rear portion 5 all similar to those of Figure 3 but an insert 81 is provided as a collar fitted in a recess 82 in the rear outer wall of the projectile. The recess 82 has, extending from a step 83 toward the rear end of the projectile, a region 84 of increased spacing in which tracer material 85 is embedded inside the insert 81.

Claims

1. A tubular projectile comprising a hollow tube having a recess (11) formed in the rear end (5) of the tubular wall thereof, said recess (11) containing a tracer material (33), characterised in that said tracer material (33) comprises a flexible polymer bonded pyrotechnic composition.

2. A projectile as claimed in claim 1 characterised in that the recess (11) is of annular cross-section and said tracer material is in the form of a cylindrical sleeve.

3. A projectile as claimed in claim 1 and characterised in that the pyrotechnic composition comprises a powdered metallic fuel and one or more fluoroelastomers serving as an oxidiser and flexible binder.

4. A projectile as claimed in claim 3 and characterised in that the pyrotechnic composition comprises magnesium 30 to 60 per cent by weight, polytetrafluorethylene 35 to 50 per cent by weight and a rubbery binder 5 to 25 per cent by weight.

5. A projectile as claimed in claim 4 and characterised in that the rubbery binder is a copolymer of vinylidene fluoride and hexafluoropropylene.

6. A projectile as claimed in claim 5 and characterised in that the pyrotechnic composition comprises magnesium 48 per cent by weight,

polytetrafluorethylene 35 per cent by weight, and a copolymer of vinylidene fluoride and hexafluoropropylene 17 per cent by weight.

7. A projectile as claimed in any one of the preceding claims and characterised by a base member (39) fitted behind the rear end (5) of the projectile, the base member having a groove (41a) facing the recess (11) in the projectile incorporating the tracer material (33), the said groove being sealed by the rear end surface (7) of the projectile.

8. A projectile as claimed in claim 7 and characterised in that the base member (50) incorporates an igniter device (51) arranged to be initiated by the set-back force or spin of the projectile, the igniter device being located in a cavity in the base member which has one or more bleed channels (57) extending from the cavity to the said groove (55) in the base member which permits gas produced by the initiation of the igniter device to be delivered to the tracer material (33).

9. A projectile as claimed in claim 7 and characterised in that the base member includes a channel (41) incorporating a narrow bleed hole or channel portion, the channel extending from the rear end of the base member (41b) to the said groove (41a), the channel (41) permitting gas at the rear end of the base member to be delivered to the said groove in the base member to ignite the tracer material (33) in the recess (11) adjacent thereto.

10. A projectile as claimed in claim 8 or claim 9 and characterised in that the said channel incorporates a septum or burster disc or annulus (43) which bursts at a pre-determined pressure allowing gas to be delivered along the channel (41) only after bursting of the septum or burster disc or annulus.

11. A projectile as claimed in any one preceding claim and characterised in that said recess (11) is formed as a gap between an insert (17) and a portion of a wall of the projectile body at its rear end.

12. A projectile as claimed in claim 11 and characterised in that said insert (17) has an inner or outer surface substantially continuous with the inner or outer surface of the body of the projectile forward of the insert.

Fig. 1.

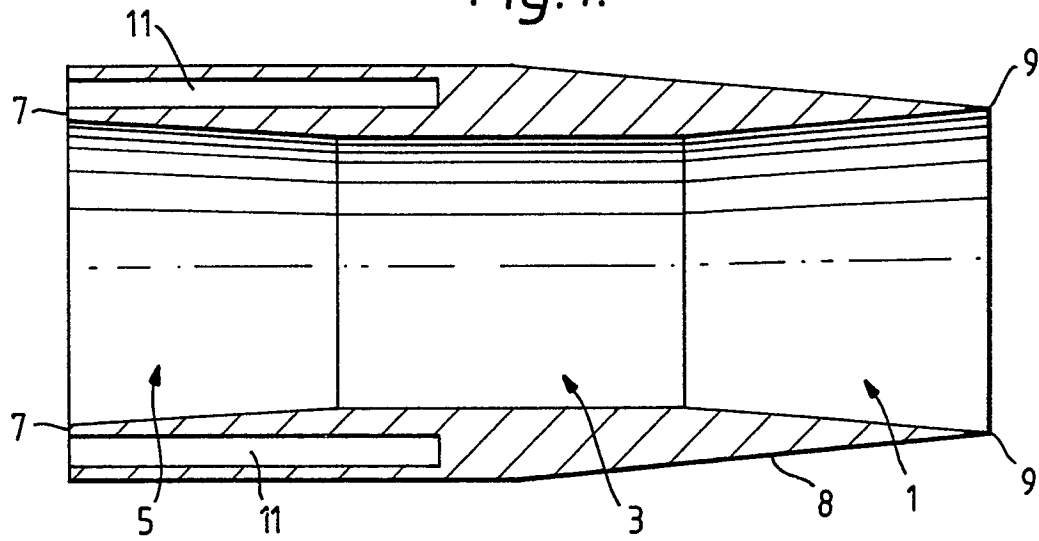


Fig. 2.

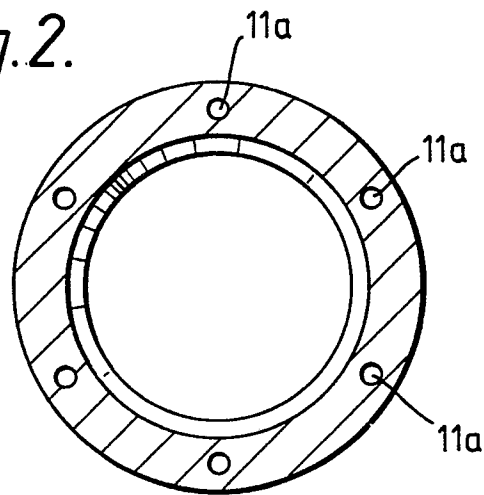


Fig. 3.

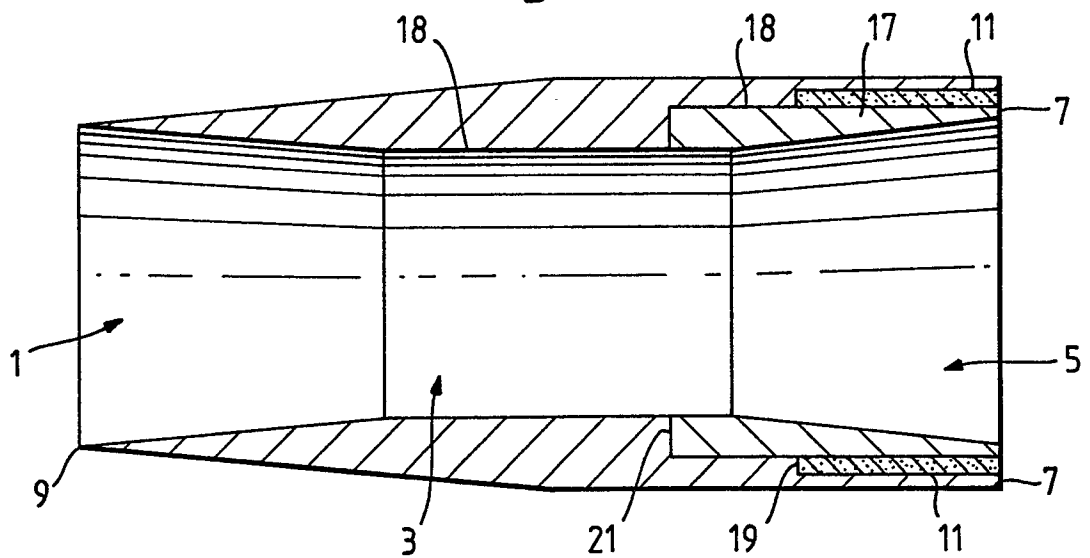


Fig. 4.

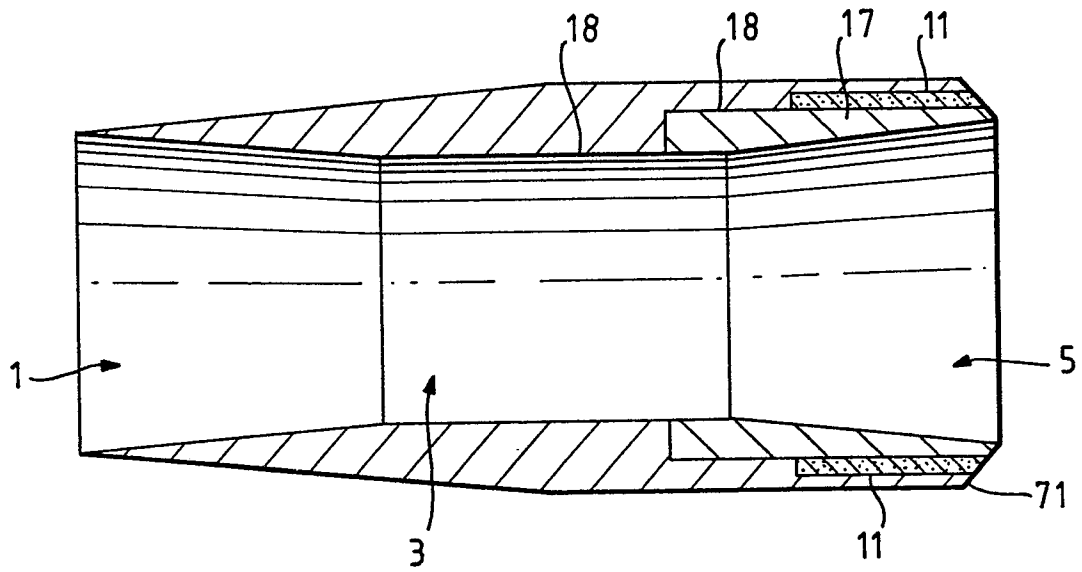


Fig. 5.

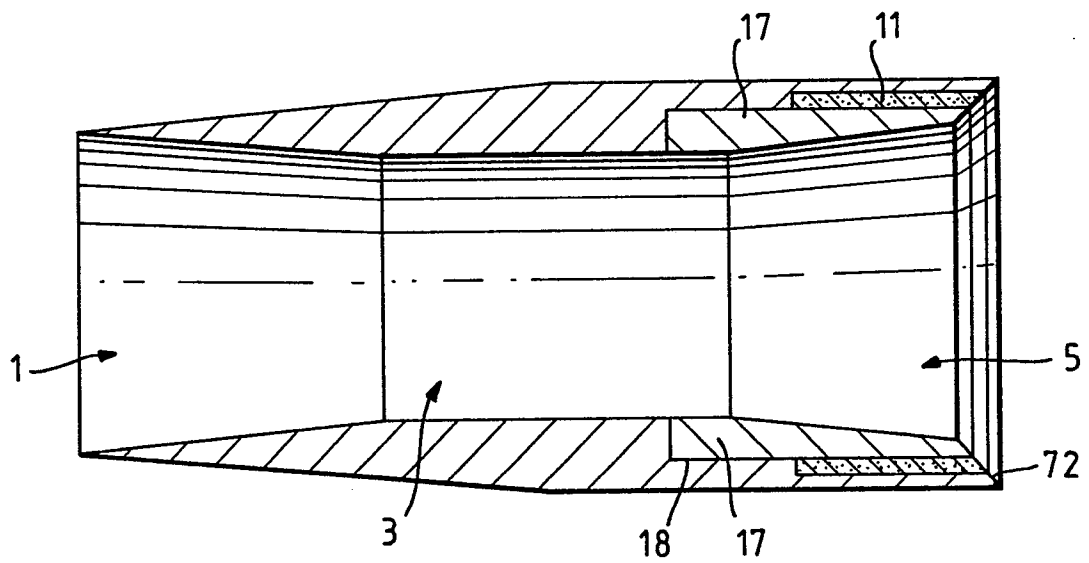


Fig.6.

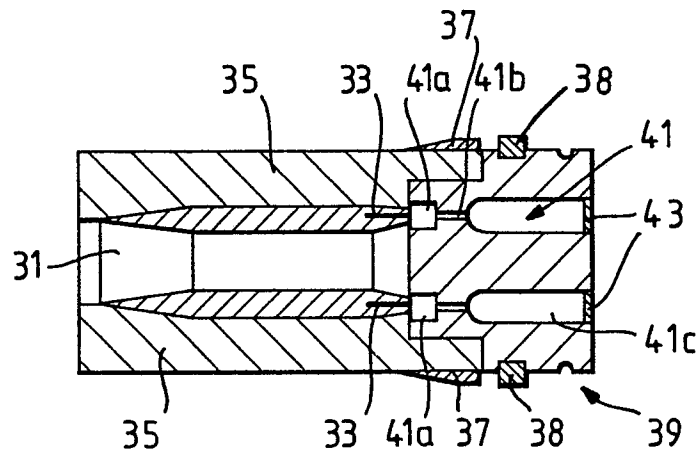


Fig.7.

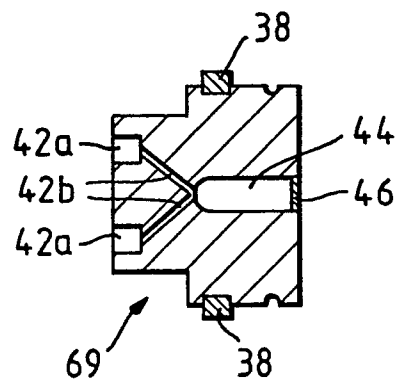


Fig.8.

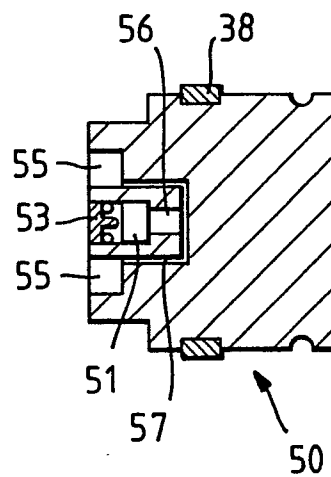


Fig. 9.

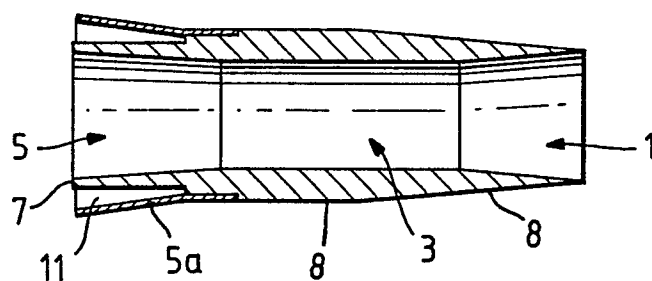


Fig. 10.

