

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978

(To be lodged in duplicate)

PUBLICATION PARTICULARS AND ABSTRACT
(Section 32(3)(a) - Regulations 22(1)(g) and 31)

REFERENCE : P23098ZA00

OFFICIAL APPLICATION NO.			LODGING DATE		ACCEPTANCE DATE	
21	01	2001/9302	22/23	12 November 2001	43	20-6-2002

INTERNATIONAL CLASSIFICATION		NOT FOR PUBLICATION	
51	F41B, H05H	CLASSIFIED BY :	

FULL NAME(S) OF APPLICANT(S)	
71	GIAT INDUSTRIES

FULL NAME(S) OF INVENTOR(S)	
72	BRUNET, Luc LOMBARD, Jean, Mary PIERROT, Jean, François TAILLANDIER, Jean, Luc

EARLIEST PRIORITY CLAIMED		COUNTRY		NUMBER		DATE	
NOTE : The country must be indicated by its International Abbreviation - see Schedule 4 of the Regulations.		33	FR	31	00/04735	32	11 April 2000

TITLE OF INVENTION	
54	PLASMA TORCH COMPRISING ELECTRODES SEPARATED BY AN AIR GAP AND IGNITER INCORPORATING SAME

57	ABSTRACT (NOT MORE THAN 150 WORDS)	NUMBER OF PAGES	19
----	------------------------------------	-----------------	----

FOR ABSTRACT SEE THE NEXT SHEET

- 2001/9302

(12) DEMANDE INTERNATIONALE PUBLIÉE EN VERTU DU TRAITÉ DE COOPÉRATION
EN MATIÈRE DE BREVETS (PCT)

(19) Organisation Mondiale de la Propriété
Intellectuelle
Bureau international



(43) Date de la publication internationale
18 octobre 2001 (18.10.2001)

PCT

(10) Numéro de publication internationale
WO 01/78470 A1

(51) Classification internationale des brevets⁷ : **H05H 1/24**,
F41B 6/00

(71) Déposant (pour tous les États désignés sauf US) : **GIAT
INDUSTRIES** [FR/FR]; 13, route de la Minière, F-78000
Versailles (FR).

(21) Numéro de la demande internationale :

PCT/FR01/00962

(72) Inventeurs; et

(22) Date de dépôt international : 30 mars 2001 (30.03.2001)

(75) Inventeurs/Déposants (pour US seulement) : **BRUNET,
Luc** [FR/FR]; 27, rue Louis Mallet, F-18000 Bourges
(FR). **LOMBARD, Jean, Mary** [FR/FR]; 40, rue de Nev-
ers, F-18000 Bourges (FR). **PIERROT, Jean, François**
[FR/FR]; 558, route de Berry Bouy, F-18230 Saint
Doulchard (FR). **TAILLANDIER, Jean-Luc** [FR/FR];
13, rue Victor Hugo, F-18110 Fussy (FR).

(25) Langue de dépôt : français

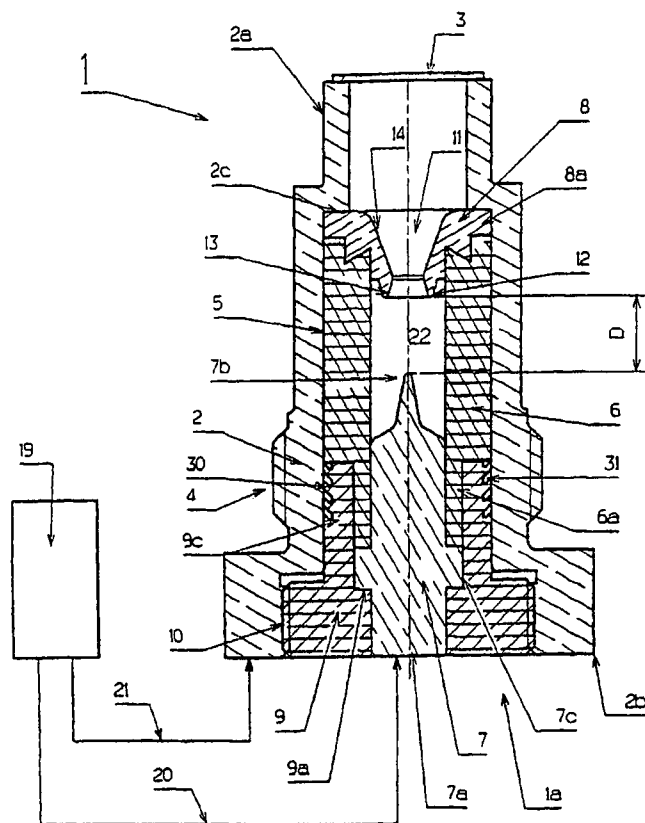
(26) Langue de publication : français

(30) Données relatives à la priorité :
00/04735 11 avril 2000 (11.04.2000) FR

[Suite sur la page suivante]

(54) Title: PLASMA TORCH COMPRISING ELECTRODES SEPARATED BY AN AIR GAP AND IGNITER INCORPORAT-
ING SAME

(54) Titre : TORCHE A PLASMA COMPORTANT DES ELECTRODES SEPARÉES PAR UN ENTREFER ET ALLUMEUR
INCORPORANT UNE TELLE TORCHE



(57) Abstract: The invention concerns plasma torch (1) comprising at least two electrodes (7, 8) separated by an insulating cylindrical case (6) defining an internal volume (22). Said torch is characterised in that the electrodes are separated by a sufficiently reduced distance (D) to allow the occurrence of a priming arc between the electrodes (7, 8) when a supply voltage fed by a generator (19) is applied between said electrodes. The invention is useful for producing igniters for ammunitions.

(57) Abrégé : L'invention a pour objet une torche à plasma (1) comprenant au moins deux électrodes (7, 8) séparées par un étui cylindrique isolant (6) délimitant un volume interne (22), torche caractérisée en ce que les électrodes sont séparées par une distance (D) suffisamment réduite pour qu'il apparaisse un arc d'amorçage entre les électrodes (7, 8) lorsqu'une tension d'alimentation fournie par un générateur (19) est appliquée entre ces dernières. Application à la réalisation d'allumeurs pour munitions.

WO 01/78470 A1

**PLASMA TORCH INCORPORATING ELECTRODES SEPARATED BY AN AIR
GAP AND SQUIB INCORPORATING SUCH A TORCH"**

The technical scope of the present invention is that of
5 plasma torches and more particularly torches used to ignite
the propellant charge of a piece of ammunition.

A plasma torch is a system that enables high pressure
(around 500 MPa) and high temperature (over 10000 K) gases
to be generated by a high voltage (around 20 kV) electrical
10 discharge made between two electrodes.

Plasma torches are used in industry, for example, to
cut conductive materials, or else to destroy certain
products or materials, or to carry out metallic deposits.
They are also used in the field of armaments to generate
15 pressure allowing a projectile to be fired.

Known plasma torches comprise an anode and a cathode
separated by a capillary tube made of a material that is
both electrically insulating and able to decompose in order
to generate a plasma (for example a plastic material). The
20 electrical discharge between anode and cathode is excited
by means of a copper fuse or other conductive material. The
electric arc thus created produces a plasma, which ablates
the capillary tube wall, thereby causing the generation of
light high-pressure high temperature gases.

25 These gases are used either to directly accelerate a
projectile, or to vaporise a working fluid (for example,
water) allowing the volume of the gas to be increased.

Patents FR2754969 and FR2768810, which describe plasma
torches used to ignite the propellant charge of a piece of
30 ammunition, may be consulted.

One drawback to known plasma torches lies in the
fragility of the fuse wire allowing the plasma to be
excited. Such a fuse wire has a diameter of 0.1 to 0.5 mm.
It may break further to thermal and mechanical stresses
35 (vibration, impacts) that occur during the storage and
implementation phases of the ammunition elements.

Moreover, the manufacture of known torches is made
difficult and costly by the operation to mount such a fuse.

The aim of this invention is to overcome such drawbacks.

Thus the torch according to the invention has improved mechanical strength thereby increasing its reliability.
5 Moreover, it is simple in structure and may be manufactured at low cost.

The torch according to the invention may be manufactured at different lengths without difficulty.

A further subject of the invention is an igniter squib
10 implementing such a plasma torch, such squib facilitating the diffusion of the plasma towards the propellant charge and this for load configurations that are very different from the point of view of mass or geometry.

Thus, the invention relates to a plasma torch
15 comprising at least two electrodes separated by an insulating cylindrical case delimiting an inner volume, said torch wherein the electrodes are separated by a sufficiently small distance for an igniting arc to appear between the electrodes when a serviceable voltage supplied
20 by a generator is applied between them, the distance between the electrodes and the serviceable voltage of the generator being selected such that the electrical field appearing between the electrodes is of around 1 Megavolt/meter.

25 The torch may comprise a rear electrode and a front electrode, the rear electrode incorporating an axial tip oriented towards the front electrode and the front electrode incorporating a thinned crown oriented towards the rear electrode as well as an axial perforation.

30 The front electrode's axial perforation may be nozzle-shaped incorporating a convergent conical profile open at the rear electrode side and followed by a divergent conical profile open towards the outside of the torch.

According to a variant embodiment, the torch may
35 incorporate a block of energetic material placed between the electrodes.

The block may be ring-shaped.

The torch will generally incorporate a metallic body having an axial bore inside which the electrodes and insulating case are placed.

The bore in the body may incorporate a shoulder onto
5 which the front electrode is applied, the insulating cylindrical case being in axial support, firstly on the front electrode and secondly on the rear electrode, and insulating closing ring being screwed at a rear threading of the body ensuring the axial joining of the electrodes
10 and insulating case with the body.

The closing ring may incorporate a lip surrounding a thinned extension to the insulating case.

The front electrode may incorporate a cylindrical seat onto which the insulating case will be fitted.

15 The torch may incorporate a spacer ring coaxial to the insulating case and placed between the front electrode and the energetic block, the latter pressing on a countersink made in the insulating case.

A further subject of the invention is an ammunition
20 squib wherein it comprises such a plasma torch.

The squib may comprise a tubular nozzle perforated by at least one hole and integral with the torch at its front part so as to receive the plasma generated by the torch.

The nozzle may incorporate at least two holes evenly
25 spaced angularly and/or axially and perforated according to the radial directions of the nozzle.

Other advantages of the invention will become apparent after reading the following description of the different embodiments, such description being made with reference to
30 the appended drawings, in which:

- Figure 1 shows a longitudinal section of a first embodiment of a torch according to the invention,

- Figure 2 shows a longitudinal section of a second embodiment of a torch according to the invention,

35 - Figure 3 shows a longitudinal section of a squib implementing a torch according to the invention.

With reference to Figure 1, a plasma torch 1 according to a first embodiment of the invention comprises a tubular

metallic body 2, obturated at a front part 2a by a thin lid 3 made of a plastic or metal material and bonded to the body 2.

5 The rear part 2b of the body 2 has an enlarged diameter so as to constitute an abutted collar making it easier to fasten the torch in a bore of a support (not shown), for example a munition base. Also in order to allow the torch 1 to be attached, the body 2 has threading 4.

10 The tubular body 2 will be covered over substantially all its outer surface by an insulating material (not shown), for example by the deposit under vacuum of 30 to 80 micrometers of a plastic material such as polyurethane or another insulating material, such as glass or ceramic. Such an arrangement improves the electrical insulation of the
15 torch. Plastic material will not, however, be deposited on the threading so as not to hinder the attachment of the body.

The body 2 has an axial bore 5 inside which a cylindrical insulating case 6 is placed made of a plastic
20 material able to ablate, that is to say able to generate light gases through the action of a plasma. The case 6 may, for example, be made of polyoxymethylene or polytetrafluorethylene. The case 6 may also be made of an energetic material, for example nitrocellulose.

25 Such a case is generally called a capillary tube in known plasma torches.

Two metallic electrodes 7 and 8 (made, for example, of a copper alloy) are separated by the insulating case 6.

30 A rear electrode 7, globally cylindrical and of the same axis as the body 2, extends inside the case 6.

It has a rear end 7a that is flush with the rear face of the torch. Its front end 7b forms a tip forming a foot for the electric arc that will generate the plasma.

35 A ring-shaped front electrode 8 is applied against an internal countersink 2c in the case 2. It has a peripheral shoulder 8a that is fitted tightly to the body 2. The front electrode 8 incorporates an axial perforation 11 and also

has a thinned crown 12 that is oriented towards the tip 7b of the rear electrode 7.

According to the invention the front electrode 8 and rear electrode 7 are axially separated by a distance D (or
5 air gap) that is selected such that (for the electrical voltage selected) the electrical field between the electrodes is around 1 Megavolt/m. By way of an example, for a voltage between electrodes of 10 000 Volts, the distance D will be 10 mm. This reduced spacing between the
10 electrodes as well as the pointed shapes 7b and 12 of the two electrodes promote the formation of an electrical arc in the air gap separating the electrodes.

It is therefore unnecessary to provide a priming fuse wire connecting the electrodes. The mechanical strength and
15 reliability of the torch according to the invention is thus much greater than that of known torches since there is no risk of a fuse breaking.

The axial perforation 11 of the front electrode 8 also has a nozzle-shaped profile incorporating a convergent
20 conical profile 13 open on the rear electrode 7 side and succeeded by a divergent conical profiles 14 open towards the exterior of the torch 1.

The convergent and divergent angles of the nozzle will be easily determined by the expert according to the
25 performances required for the torch (required velocity and pressure for the plasma exiting the nozzle).

The convergent angle 13 is of around 15° and the divergent angle 14 around 20° (half angles at the vertex of the cones).

30 The total length of the nozzle will be of around 15 mm.

The nozzle allows a reduction in heat loss from the plasma generated by the torch. Indeed, the nozzle allows the gases located at the periphery to be brought back into the axis of the torch. These gases are thus heated by the
35 plasma.

The rear electrode 7 also has a peripheral shoulder 7c that acts as a positioning abutment for the rear electrode 7 with respect to the body 2. The shoulder 7c presses

against a countersink 9a of an insulating closing ring 9 that has threading 10 allowing it to be screwed onto a rear screw cutting in the body 2.

The ring 9 is made of an insulating material with high mechanical strength, for example polyoxymethylene. The ring 9 incorporates a tubular front part 9c that is fitted in a bore 5 in the body 2. This front part forms a sealing lip providing, via its radial deformation when the torch operates, sealing for the gases produced by the torch 1.

10 The cylindrical insulating case 6 presses axially on the shoulder 8a of the front electrode and on the rear electrode 7. The case incorporates a thinned extension 6a that is sandwiched between a cylindrical seat of the electrode 7 and the tubular front part 9c of the ring 9.

15 This front part incorporates ring-shaped sealing lips 30 separated by ring-shaped grooves 31. Through their radial deformation, the lips 30 provide sealing for the gases produced by the torch 1 during its operation. The grooves 31 form expansion chambers also improving gas-tightness.

20 Thus, screwing the ring 9 on ensures the axial joining of the electrodes 7, 8 and the insulating case 6 to the body 2.

This torch operates as follows.

25 An electric generator 19 is connected by electric connections 20, 21 to the torch 1. A first connection 20 is in electrical contact by appropriate means (for example a spring needle, not shown) with the rear electrode 7. A second connection 21 is in electrical contact with the metallic body 2 of the torch, for example by a spring needle pressing on the rear part 2b of it.

30 The body 2 is in electrical contact with the front electrode 8 thanks to the tight fit of the shoulder 8a of the electrode in the bore 5 in the body 2.

35 The generator 19 is designed to deliver power of around 1 million Joules at a voltage of around 20 kilo Volts. Such an arrangement ensures the presence of an electrical field between the electrodes of 1 Megavolt/meter thereby igniting

the plasma without needing a fuse. Such a generator is conventional and comprises capacitors, an inductor, thyristors and a stabilised power supply.

This voltage is applied to electrodes 7 and 8. Because
5 of the pointed shape of the electrode ends and the reduced air gap separating them, an electrical arc is produced between the electrodes 7 and 8. The arc is confined in the chamber 22 delimited by the insulating case 6 and the electrodes 7 and 8. The substantial pressure (around 100
10 Mega Pascal) present in this chamber will cause the case 6 material to ablate and a plasma to be created that will flow out of the body 2 through the nozzle 11. The thin lid 3 will be broken as soon as the torch is ignited.

This plasma allows, for example, the propellant charge
15 of a piece of ammunition to be ignited. It ensures the advantages commonly associated with ignition by electrical plasma: higher pressure level than that of a conventional pyrotechnic ignition due to the supply of electrical energy by the generator. This results in a higher velocity for the
20 projectile. The plasma may also be used for a civil application, such as cutting or destruction of material, the creation of safety openings, etc.

The nozzle 11 assists the axial flow of the plasma gases out of the torch 1 and accelerates these gases.

25 The pressure level in the chamber 22 is thus limited to an acceptable value for the mechanical strength of the torch whilst accelerating the diffusion of the plasma thereby improving ignition performance for the propellant charge of a piece of ammunition.

30 It is thus possible using the torch according to the invention to obtain a plasma velocity of around 10 000 m/s.

The electrical energy being consumed is of around 1 Mega Joule for an air gap D between the electrodes of around 20 mm, and a voltage of 20 Kilo Volts.

35 The torch according to the invention has thus an excellent bulk/performance ratio, whilst being of a simple design that is easy to manufacture.

Figure 2 shows a second embodiment of a plasma torch according to the invention.

This embodiment differs from the previous one in that a block 23 of energetic material is placed between electrodes
5 7 and 8.

The block is made by the hot or cold compression of an energetic material such as nitrocellulose or a pyrotechnic composition. The following classical compositions may be used by way of a pyrotechnic composition: Boron / potassium
10 nitrate (B/KNO₃), Aluminium / potassium perchlorate (Al/KClO₄), Aluminium / copper oxide (Al/CuO).

The block 23 presses on a countersink 24 made in the insulating case 6. A spacer ring 25 is placed coaxially to the insulating case 6 and it is placed between the front
15 electrode 8 and the block 23.

Thus, the block 23 is positioned rigidly between the two electrodes.

Its ring shape avoids hindering the formation of the discharge arc between the electrodes.

20 According to the embodiment shown in Figure 2, the block 23 has a bore delimited by symmetrical conical profiles forming a convergent followed by a divergent. Such an arrangement facilitates the ablation and/or combustion of the material of the block 23.

25 When such a torch operates, the pressure and temperature established in the chamber 23 ensures the ignition of the block 23. This combustion allows the plasma pressure level to be increased.

The spacer ring 25 will preferably be made of the same
30 material as the case 6. It will thus ablate similarly to the case and will take part in the formation of the plasma.

The spacer ring 25 shown in Figure 2 incorporates one conically bevelled end 25a that penetrates in a housing of matching shape made in the electrode 8. Such an arrangement
35 improves gas-tightness and prevents gases from passing between the spacer 25 and the electrode 8.

The plasma torch shown in Figures 1 and 2 may be directly installed onto an ammunition base. Such an

embodiment is more particularly adapted to the ignition of small or medium calibre munitions (less than 50 mm).

Figure 3 shows a squib 26 according to one embodiment of the invention.

5 This squib incorporates a torch 1 according to one or other embodiment described previously, said torch not being shown here in detail.

This squib comprises a tubular nozzle 27 attached by bonding or screwing to a cylindrical extension 28 of the
10 torch 1.

The nozzle is made of a plastic material able to be ablated by the plasma (such as polyoxymethylene) or else a combustible material, for example nitrocellulose. It is perforated with holes 29 evenly spaced angularly and
15 axially and perforated according to radial direction of the nozzle.

The holes 29 have a conical profile that flares towards the outside of the body 2 to facilitate the evacuation of the plasma gases.

20 The nozzle receives the plasma generated by the torch 1 and diffuses it in radial directions.

Such an embodiment is more particularly adapted to igniting munitions of a calibre over 50 mm.

For a given torch 2 dimension, the length of the nozzle
25 27 may vary between 20 and 300 mm without any significant loss of performance.

By way of a variant, an energetic material may be placed inside the nozzle 27 that allows the pressure or the energy of the plasmas to be improved. For example, a
30 pyrotechnic composition, a propellant powder or a propellant. An axial channel may be provided in this energetic material.

By way of a variant, an axial hole may be provided at the end of the nozzle 27.

35 It is naturally possible for one or other of the torches shown in Figures 1 or 2 to be associated with the squib shown in Figure 3.

CLAIMS

1. A plasma torch (1) comprising at least two electrodes (7, 8) separated by an insulating cylindrical case (6) delimiting an inner volume, said torch wherein the
5 electrodes (7, 8) are separated by a sufficiently small distance (D) for an igniting arc to appear between the electrodes (7, 8) when a serviceable voltage supplied by a generator (19) is applied between them, the distance (D) between the electrodes (7, 8) and the serviceable voltage
10 of the generator (19) being selected such that the electrical field appearing between the electrodes is of around 1 Megavolt/meter.

2. Plasma torch according to Claim 1, wherein it comprises a rear electrode (7) and a front electrode (8),
15 the rear electrode (7) incorporating an axial tip (7b) oriented towards the front electrode (8) and the front electrode incorporating a thinned crown (12) oriented towards the rear electrode (7) as well as an axial perforation (11).

3. Plasma torch according to Claim 2, wherein the front electrode's (8) axial perforation (11) is nozzle-shaped incorporating a convergent conical profile (13) open at the rear electrode (7) side and followed by a divergent conical profile (14) open towards the outside of the torch (1).

25 4. Plasma torch according to one of Claims 1 to 3, wherein it incorporates a block (23) of energetic material placed between the electrodes (7, 8).

5. Plasma torch according to Claim 4, wherein the block (23) is ring-shaped.

30 6. Plasma torch according to one of Claims 1 to 5, wherein it incorporates a metallic body (2) having an axial bore (5) inside which the electrodes (7, 8) and insulating case (6) are placed.

7. Plasma torch according to Claim 6, wherein the bore
35 (5) in the body incorporates a shoulder (2c) onto which the front electrode (8) is applied, the insulating cylindrical case being in axial support, firstly on the front electrode (8) and secondly on the rear electrode (7), and insulating

closing ring (9) being screwed at a rear screw cutting of the body (2) ensuring the axial joining of the electrodes (7, 8) and insulating case (6) with the body (2).

8. Plasma torch according to Claim 7, wherein the
5 closing ring (9) incorporates a lip (9c) surrounding a thinned extension (6a) to the insulating case (6).

9. Plasma torch according to one of Claims 7 or 8, wherein the front electrode (8) incorporates a cylindrical seat onto which the insulating case (6) is fitted.

10 10. Plasma torch according to Claim 9 and to one of Claims 4 or 5, wherein it incorporates a spacer ring (25) coaxial to the insulating case (6) and placed between the front electrode (8) and the energetic block (23), the latter pressing on a countersink (23) made in the
15 insulating case (6).

11. A squib (26) for a piece of ammunition, wherein it comprises at least one plasma torch (1) according to one of Claims 1 to 10.

12. A squib according to Claim 11, wherein it comprises
20 a tubular nozzle (27) perforated by at least one hole (29) and integral with the torch (1) at its front part so as to receive the plasma generated by the torch.

13. A squib according to Claim 12, wherein the nozzle (27) incorporates at least two holes (29) evenly spaced
25 angularly and/or axially and perforated according to the radial directions of the nozzle.

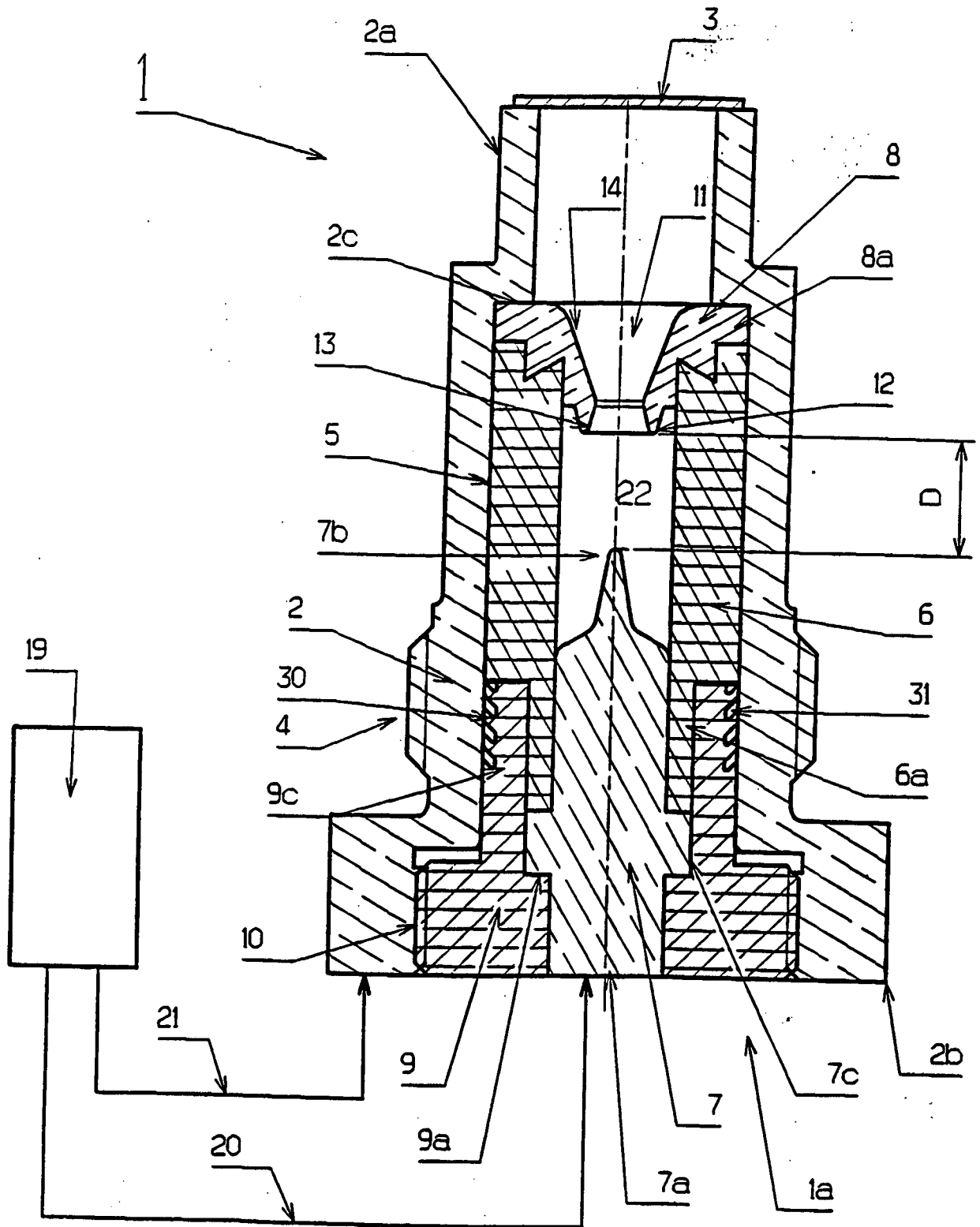


FIG 1

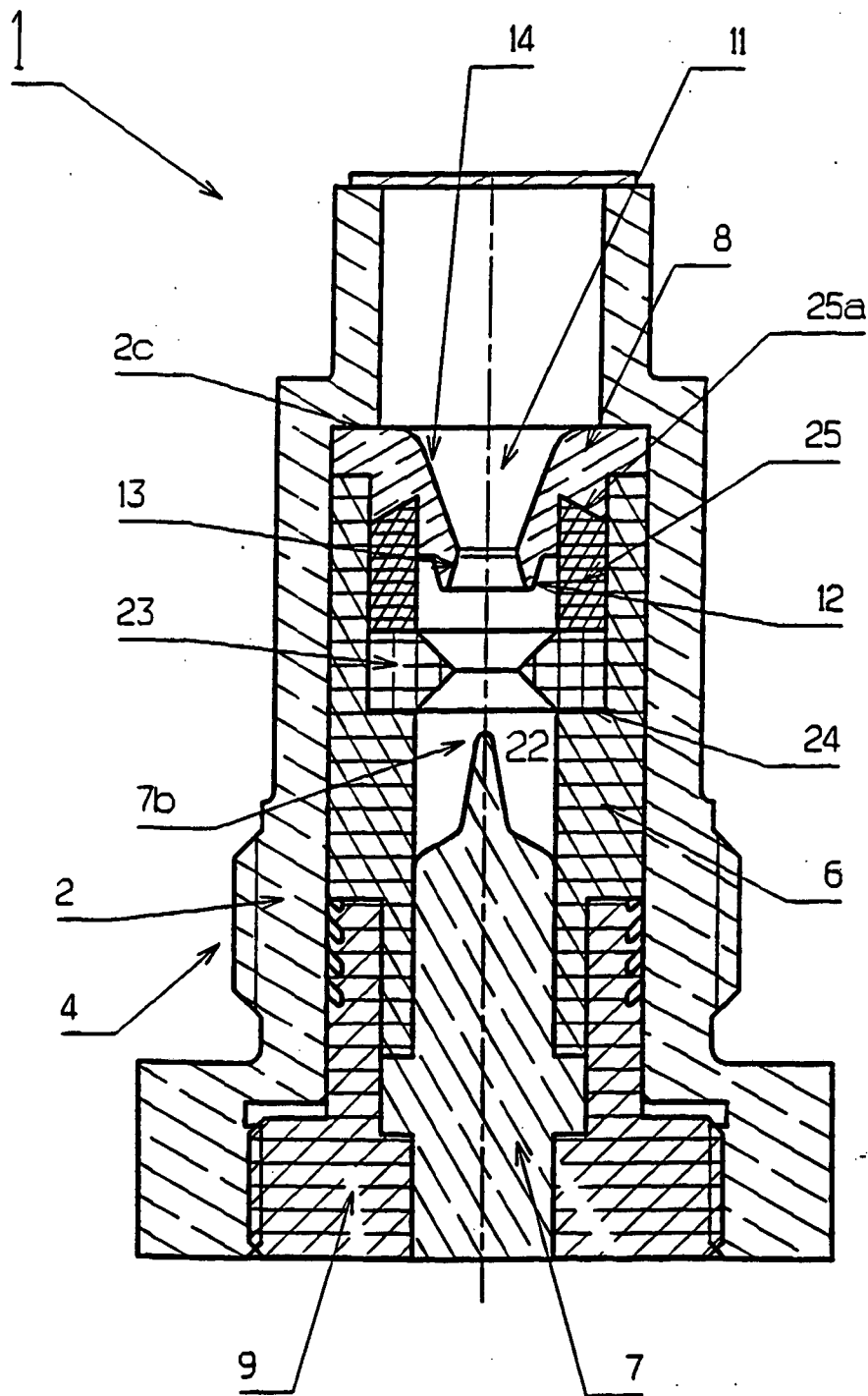


FIG 2

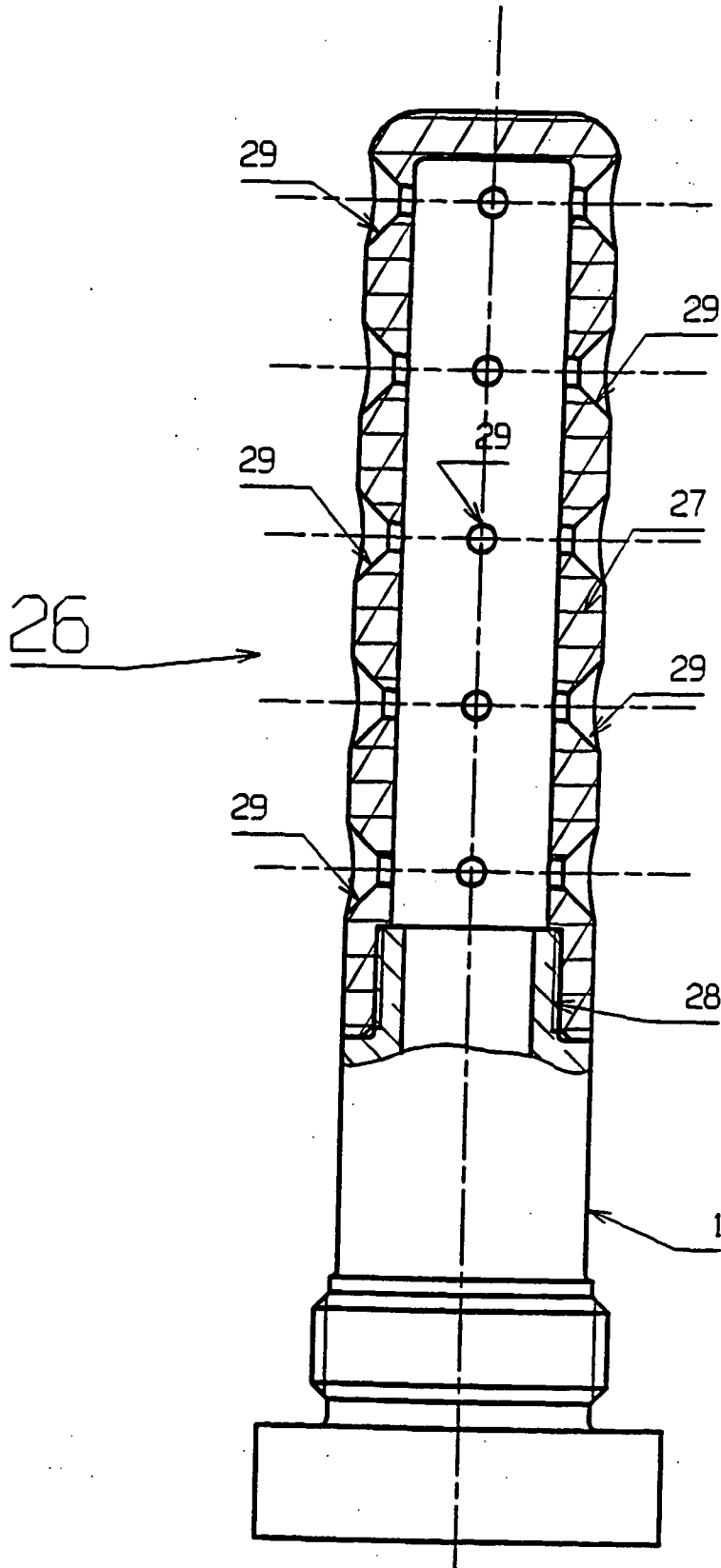


FIG 3