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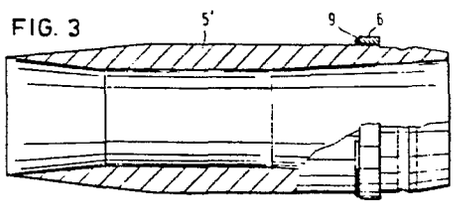
(54) Method of and apparatus for manufacturing a projectile body, as well as projectile body produced in that manner.

(57) According to a method of manufacturing a projectile body (51) of heat-treated steel closely encircled by an annular guide band (61) of softer metal, the body is subjected to a heat-treatment comprising at least a quenching step preceded by a heating step and the guide band (61) is secured to the body (51) at a predetermined location thereof during the heating step, by brazing with a brazing material having a brazing temperature above about 800°C, without the use of a fluxing agent, in a controlled atmosphere. The heating step extends over a period of time such that brazing is completed within said heating step. Prior to brazing, a loose annular guide band is disposed around the projectile body (51) and is fixed thereon at the predetermined location, e.g. by locally damaging the body, and an annular ring (9) of brazing material is placed around the projectile body adjacent the guide band, or the brazing material is first applied to a loose annular guide band by rolling it thereon or by electrodeposition.

An apparatus for carrying out this method comprises a brazing station and associated means for atmosphere control, e.g. for the supply of an inert gas.

FIG. 3



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TITLE MODIFIED
see front page

A method of manufacturing a projectile body.

This invention relates to a method of manufacturing a projectile body of heat-treated steel closely encircled by an annular guide band of softer metal, the body being subjected to a heat-treatment comprising at least a quenching step preceded by a heating step, the latter possibly being immediately followed by cooling to a limited degree, the guide band being secured to the body at a predetermined location also by heating. More particularly, the invention relates to a method of securing the guide band to the projectile body.

According to a method of manufacturing a projectile body disclosed by American patent specification 3.013.332, the guide band is secured by local inductive heating thereof and of an adjacent portion of the projectile body. Such local heating of a portion of the projectile body, however, does not form part of the required above-mentioned heat-treatment for the body and may even result in the heat-treatment effect being partially lost or else the heat-treatment itself must be modified in order to nullify any undesirable effects of the local heating. More generally, the local heating directed solely to securing the guide band to the projectile body does not form part of the required heat-treatment for the projectile body and is carried out independently of said heat-treatment, and this is a feature which

is less desirable in production engineering terms.

The object of the invention is to provide improvement in this respect and provide a manufacturing method which gives good results both in production engineering terms and as regards product quality.

To this end, in the case of a manufacturing method of the type indicated in the beginning, the guide band is secured to the body during the heating step prior to quenching, by brazing with a brazing material having a brazing temperature above about 800°C without the use of fluxing agent, in a controlled atmosphere. The advantage of this manufacturing method is not only that the desired or necessary heat-treatment for the projectile body is combined with securing the guide band, so that the total manufacturing method is simplified, but also that very high quality securing of the guide band on the projectile body is obtained. The said method of brazing is also referred to as "high-temperature brazing" and can in broad outlines be referred to as a brazing method by means of which materials can be interconnected at a temperature of about 800°C or above by means of a brazing material which melts or is molten at that temperature, without the use of a fluxing agent or flux in a controlled atmosphere, in vacuo if required, the interconnected materials not themselves melting. The expression "controlled atmosphere" refers to the use of a reducing gas or an inert gas as protective atmosphere to prevent oxidation, while a vacuum atmosphere is also considered as a "controlled atmosphere" in this text. Another important feature of high-temperature brazing is the fact that no fluxing agent or flux is used, so that no such agent has to be supplied or applied prior to brazing, does not need to be removed after brazing, leaves no undesirable residues in the resultant joint, and cannot exert any aggressive effect on the materials involved in the joint. These production engineering advantages are also coupled with a very good result to the effect that a very high adhesion percentage of, for example, more than 90% can be obtained with the guide band securing method according to the invention. A result of this kind is

particularly important for projectiles having a high firing speed, e.g. the projectiles with a tubular body of the kind developed for some time.

A projectile of the above type rests prior to, and during, firing, at its rear end against a baffle which closes said rear end and which is usually in the form of a mainly flat plate and, after firing, is separated from the body by the propelling force occuring inside the hollow projectile body. As a result of the presence of the baffle, the projectile has, during firing, an effective cross-section which is relatively large with respect to the joint weight of the projectile body and the baffle, so that a high firing speed is obtained. After separation of the baffle, the projectile has an effective cross-section which is relatively small with respect to the projectile weight, so that it experiences low air resistance during its flight. The guide band, which projects radially beyond the tubular projectile body, serves to build up a rotational force in co-operation with the barrel rifling, on firing, this force being transmitted to the tubular projectile body and serving to stabilize the projectile in its flight. The location where the guide band should be secured to the body for this purpose in such a manner as to prevent relative rotation, is determined in the axial direction of the body on the basis of the ballistic considerations applicable to the projectile concerned and/or the associated barrel, and these considerations will not be discussed in detail herein, and may vary from one projectile to another. In this text this location will be referred to generally as the "predetermined location". It will be apparent that if more than one guide band is fitted to the projectile body there will be proportionally more of such "predetermined locations". The choice of the predetermined location does not form part of the invention. It is generally assumed that the predetermined location is situated between the front end and the rear end of the tubular projectile body. As already noted, the invention relates more particularly to

the securing of the guide band on the tubular projectile body.

In the case of projectiles of a type other than those just considered, comprising a tubular body, i.e., projectiles of the type having a body solid over at least part of the projectile length, the guide band is usually secured at the location of the relevant part on the projectile body or in a peripheral groove pre-formed therein, by means of a pressure exerted on the guide band from all directions and extending radially inwards, special presses being in existence for this purpose. In the case of a projectile of the type described in the previous paragraph, comprising a hollow tubular body having a relatively thin wall, a similar procedure cannot be adopted because the clamping forces necessarily required to achieve an adequately solid fixing would result in deformation of the tubular projectile body unless a mandrel internally supporting the body is used, while on the other hand such clamping forces do not provide sufficient protection against relative rotation (rotational slip) of the body and the guide band. It must also be remembered that a projectile of the type comprising a tubular body may have a very high speed so that the rotational force transmitted to the projectile body via the guide band during firing causes considerable rotational shear forces at the location of the adhesion of the guide band to the projectile body. Attempts to secure the guide band to the tubular projectile body in the manner described have proved less attractive from the production engineering aspect and have not provided sufficiently satisfactory results.

It will be clear that the invention is important more particularly for the manufacture of such projectiles with a tubular body but also means a considerable improvement for the manufacture of projectiles having a solid body over at least part of the projectile length.

Since the technique of high-temperature brazing does not of itself form part of the invention, no further details of this brazing method will be given than

necessary to a good understanding of the invention. It should be noted in this connection that the above-mentioned American patent specification 3.013.332 refers to the use of a "controlled atmosphere" in securing the guide band to the projectile body while German patent specification 221.407 refers to such securing by "brazing". Neither of the two earlier publications, however, describes or indicates the combination of securing a guide band to a projectile body with a heating step directed solely or mainly to the required heat-treatment of the projectile body itself, as now proposed by the invention.

Of course the various operating parameters, such as the temperature, duration, type of brazing material and atmosphere (reducing gas, inert gas, vacuum) should always be selected according to the initial data, production circumstances and objectives (e.g., respectively, the properties of the materials used, production output and technical specification of the end product), and this is someting that is within the range of the expert. In this connection it should be noted that although it is not necessary, for production engineering considerations it is preferable, according to the invention, if the heating step prior to quenching extends over a period of time such that brazing is completed during said heating. The advantage of this is that the atmosphere required for brazing requires to be maintained and controlled only during the relevant stage of the heat treatment of the projectile body.

As a practical embodiment of the proposed manufacturing method, the invention specifies that prior to brazing a loose annular guide band is disposed around the projectile body and is fixed thereon at the predetermined location whereupon an annular quantity of brazing material is placed adjacent the guide band. As soon as the brazing material flows during the heat-treatment stage in question, it will move by capillary action between the projectile body and the guide band to produce the required joint. To ensure that the guide band is in the required predetermined location

of the projectile body, advantageously according to the invention, the loose guide band is fixed on the projectile body by external deformation, e.g. damage, of the projectile body. According to the invention, for example, the loose guide band may be fixed by local surface roughening of the projectile body.

The invention includes a method of fixing which to some extent calls to mind the securing method followed in the case of projectiles having a partially solid projectile body. Thus it is possible for the projectile body to be provided with a shallow peripheral groove at the predetermined location, the loose guide band being fixed in said groove, and is later secured by brazing. According to the invention, for example, the loose guide band may be placed around the projectile body in the form of an open ring of a smaller diameter than the outside diameter of the projectile body, is then moved axially therealong until entering the peripheral groove, and finally elastically assumes a closed form within the peripheral groove. During the subsequent high-temperature brazing, the joint quality achieved is such that there is no risk of any disturbance in the behaviour of the guide band during the firing of a projectile manufactured in this way. Also, according to the invention, the loose guide band may be placed in the peripheral groove by light pressure over some depth. Of course this method very much calls to mind the conventional securing method long followed in the case of projectile bodies having a solid part, but in the case of the invention this is only an auxiliary step aimed at the fixing of the guide band, prior to the actual securing thereof through brazing, and this part-step also promotes good securing of the guide band to the projectile body.

We shall not go into greater detail here concerning any necessary after-treatment of a projectile body treated by means of the manufacturing method according to the invention and having the guide band secured thereto, such as machining of the workpiece resulting from the manufacturing

method according to the invention, nor the further stages of the heat-treatment to be given to the tubular body. These manufacturing steps do not form any special part of the invention and are within the range of the expert.

The invention also provides apparatus for using the methods described hereinbefore, and is based on apparatus comprising an installation for the heat-treatment of a projectile body of steel in one or more treatment stages, said installation comprising at least one heating source. According to the invention, an apparatus of this kind should be provided with a brazing station added to at least one of the treatment stages and comprising associated means for atmosphere control e.g. means for supplying a reducing gas, means for supplying an inert gas or means for creating a vacuum atmosphere.

The invention will be illustrated in the following description with reference to the accompanying drawing showing a number of embodiments, although the invention is not limited thereto. In the drawing:

Fig. 1 diagrammatically and in axial section shows a cartridge comprising a projectile of the type having a tubular body and a separate baffle and sealing body.

Fig. 2 is also a diagrammatic view of an installation referred to generally as a "furnace" for carrying out at least some of the stages of the heat-treatment for the projectile body and for carrying out the securing of the guide band by brazing during at least one of said stages.

Fig. 3 is an axial section to an enlarged scala through a projectile having a tubular body and a guide band loosely applied thereto prior to brazing.

Fig. 4 is a similar section to Fig. 3 according to another embodiment of the invention, and

Fig. 5 is a similar section through the projectile according to Fig. 3 after after-treatment thereof.

The cartridge 1 illustrated in axial section in Fig. 1 contains, as the most important components, the cartridge case 2 with a propellent charge 3 therein and, at

the base, a percussion cap 4 to ignite the propellent charge 3, on the one hand, and a tubular projectile body 5 having a guide band 6, and a sealing body 8 and a baffle 7 fitted to the projectile body 5, on the other hand.

As will be apparent from Fig. 1, prior to firing (and also during the firing) the projectile body 5 rests at its rear end against an annular flange of the baffle or "pusher plate" 7, which is of conventional type in Figure 1, i.e. it has the form of a relatively flat plate of the same material as or similar material to the projectile body 5, i.e. heat-treated steel. Behind the baffle 7 is the sealing body 8, which is intended to seal off the rear end of the projectile, during firing, from the barrel (not shown).

As is known, the baffle 7 serves to make the effective cross-section of the projectile as large as possible with respect to the projectile weight during firing so that the projectile acquires a very high initial speed, whereupon the rearward propelling force occuring within the projectile body results in the baffle 7 and the sealing body 8 being separated from the projectile after the forward propelling force ceases. The projectile then has the smallest possible effective cross-section so that it experiences low air resistance during its continued trajectory, in which it is stabilized by the rotational force transmitted by the rifled barrel via the guide band 6.

As already noted, the invention relates to the manufacture of the projectile body and, more particularly, the combined heat-treatment of the tubular projectile body 5 and the securing thereof to the guide band 6 of softer metal. Solely by way of example it is assumed that the projectile body 5 is made from a type SAE 4340 steel which is required to be heat-treated by a heat-treatment comprising a number of stages, and that the guide band is made from soft iron.

The brazing material may, for example, be gold, silver, copper, nickel, palladium in pure form or as an alloy.

As already noted, Fig. 2 diagrammatically illustrates an installation referred to generally as a "furnace" for carrying out at least some of the stages of the heat-treatment for the projectile body 5 and for carrying out the securing of the guide band 6 by brazing, which takes place during at least one of said stages. It should be noted that the "furnace" illustrated symbolizes any suitable heating source, such as an inductive or high-frequency heating source, a heating source operating with infra-red radiation, or an actual furnace such as a shaft furnace, bell furnace or a conveyor belt furnace frequently used for brazing in a protective atmosphere, or a furnace of the chamber type frequently used for brazing in a vacuum atmosphere. As already noted, the choice of the heating source in question will be determined by an expert in the light of considerations related to the initial data of the material being used, the extent and output of the production method used, and the technical specification of the end product, and which of themselves do not form part of the invention.

The installation shown only diagrammatically in Fig. 2 consists basically of four units: a unit 10 referred to as a furnace, an arbitrarily chosen suitable heating source (not shown in the drawing) and a "gas pump" 11 for supplying a protective gas to the interior of the furnace 10 or for producing a vacuum therein, a conveyor unit 20 for transferring a charge from unit 10 to unit 30, comprising an oil bath for quenching (abrupt cooling) of the charge, and a highly diagrammatically illustrated unit 40 for machining each projectile body 5 subjected to the heat-treatment, with the guide band 6 secured thereto by high-temperature brazing. It should be noted that the installation according to Fig. 2 is only a highly diagrammatic illustration and, for example, a unit interposed between unit 30 and unit 40 for subsequent annealing of the charge products is not shown in the drawing. The same applies to control means associated with the installation, conveyor means, and other

means operative for proper operation of the installation.

Fig. 3 is an enlarged scale axial section through a tubular projectile body 5' with a guide band 6' fitted loosely thereto, prior to its securing by brazing. Immediately adjacent the loose guide band 6' is an annular quantity of brazing material 9 which melts during the heat-treatment stage associated with the brazing, and flows by capillary action between the tubular projectile body 5' and the loose guide band 6'. As already noted, an adhesion percentage of at least 90% can be obtained in this way.

Fig. 4 is a similar view of a modified embodiment in which a shallow peripheral groove 50 is formed in the outer surface of the projectile body 5' at the predetermined location in question, the profile of the groove matching the inner profile of the loose guide band 6''. As already noted, a guide band 6'' of this kind can originally be fitted as an open ring around the projectile body 5', e.g. from the rear end, whereupon the guide band 6'' elastically resumes its closed form. An originally wider guide band can be introduced into the groove 50 by light pressing. Groove 50 may, if required, be provided with a milling, but this is not shown separately in Fig. 4.

It should also be noted that the groove 50 in Fig. 2 also serves to fix the loose guide band 6'', prior to brazing, temporarily at the predetermined location of the tubular projectile body as is desirable from ballistic considerations. In the embodiment shown in Fig. 3, such fixing should take place in some other way, e.g. by local damage or substantially systemetic roughening of the outer surface of the projectile body 5'. Fixing of the annular quantity of brazing material 9 may be derived from that of the loose guide band 6' or 6''. This immediately becomes apparent by turning the sheet of drawings containing Figs. 3, 4 and 5 through 90° to the right, thus giving the position of the charge inside the unit 10 in Fig. 2, so that the rings 9 rest on the guide bands 6' or 6''.

The temperatures used during the heat-treatment

for the projectile body 5' and for brazing a guide band will not be discussed in detail. It will simply be noted that they may be considerably above 800°C.

As will be apparent from the foregoing, the invention provides a simplified method of manufacturing a projectile body having a guide band secured thereto in a reliable manner, i.e. having a high adhesion percentage. The invention is not confined to the embodiments illustrated in the drawing and described hereinbefore by way of example. The important feature for the invention is simply that the guide band is secured to the body by high-temperature brazing, as defined hereinbefore, during at least one of the stages of the heat-treatment, to which the projectile body should be subjected in order to heat-treat the steel used.

CLAIMS

1. A method of manufacturing a projectile body of heat-treated steel closely encircled by an annular guide band of softer metal, the body being subjected to a heat-treatment comprising at least a quenching step preceded by a heating step, the latter possibly being immediately followed by cooling to a limited degree, the guide band being secured to the body at a predetermined location also by heating, characterised in that the guide band is secured to the body during the heating step prior to quenching, by brazing with a brazing material having a brazing temperature above about 800°C without the use of fluxing agent, in a controlled atmosphere.

2. A manufacturing method according to claim 1, characterised in that the heating step prior to quenching extends over a period of time such that brazing is completed within said heating step.

3. A manufacturing method according to claim 1 or 2, characterised in that prior to brazing a loose annular guide band is disposed around the projectile body and is fixed thereon at the predetermined location and an annular quantity of brazing material is placed around the projectile body adjacent the guide band.

4. A manufacturing method according to claim 1 or 2, characterised in that a quantity of brazing material is applied to a loose annular guide band by rolling it

thereon or by electrodeposition, whereupon the thus treated guide band is placed around the projectile body and is fixed thereon at the predetermined location.

5. A manufacturing method according to claim 3 or 4, characterised in that the loose guide band is fixed on the projectile body by local deformation, e.g. local damage, of the projectile body.

6. A manufacturing method according to claim 5, characterised in that the loose guide band is fixed by local surface roughening of the projectile body.

7. A manufacturing method according to claim 5, characterised in that the projectile body is provided with a shallow peripheral groove at the predetermined location, the loose guide band being fixed in said groove.

8. A manufacturing method according to claim 7, characterised in that the loose guide band is placed around the projectile body in the form of an open ring of smaller diameter than the outside diameter of the projectile body, is then moved axially therealong until entering the peripheral groove, and finally elastically assumes a closed form within the peripheral groove.

9. A manufacturing method according to claim 7, characterised in that the loose guide band is placed in the peripheral groove by light pressing over some depth.

10. Apparatus for the use of a method according to one or more of the preceding claims, comprising an installation for the heat-treatment of a projectile body of steel in one or more treatment stages, said installation comprising at least one heating source, characterised by a brazing station added to at least one of the treatment stages and comprising associated means for atmosphere control, e.g. means for supplying a reducing gas, means for supplying an inert gas or means for creating a vacuum atmosphere.

11. A projectile body of heat-treated steel and a guide band of softer metal secured thereto using a method according to one or more of claims 1 to 9.

FIG.1

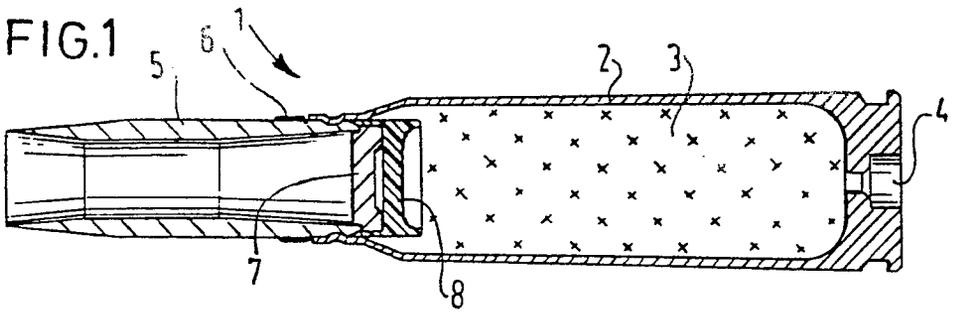


FIG. 2

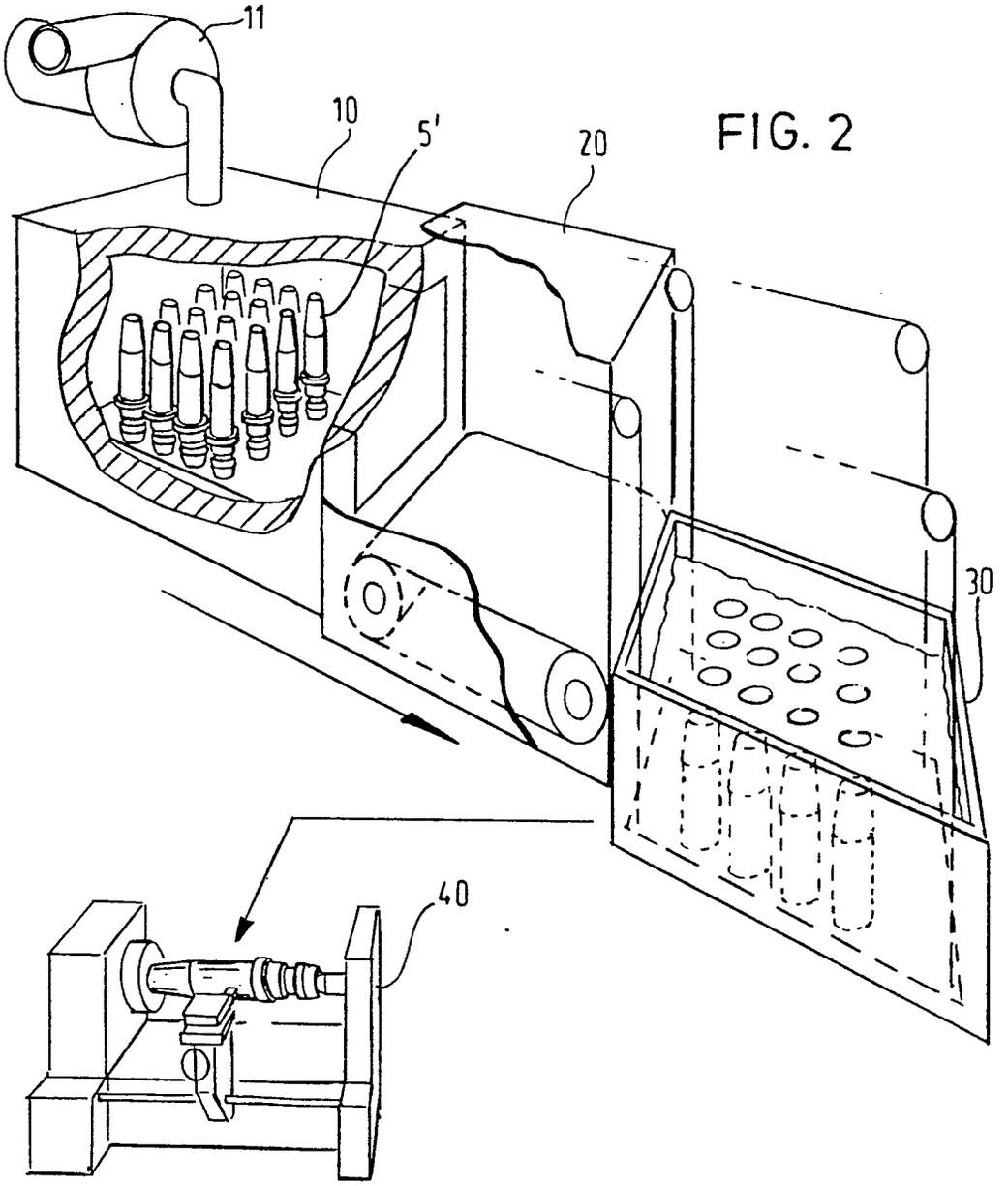


FIG. 3

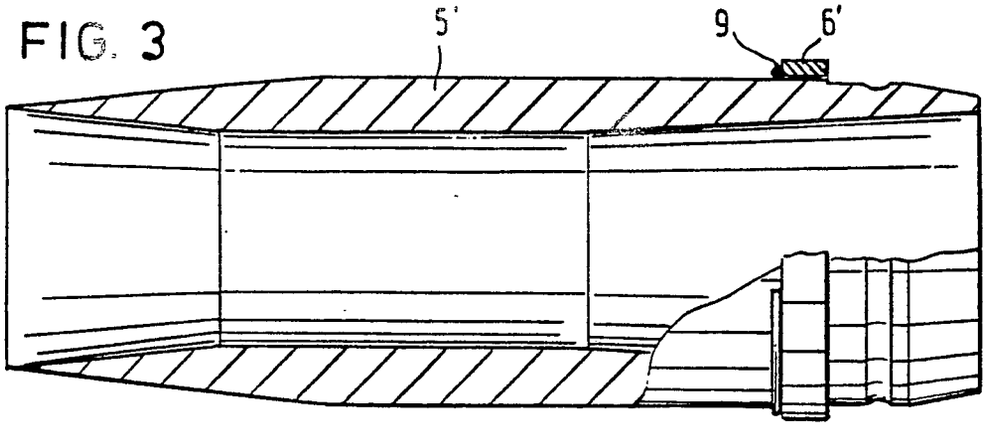


FIG. 4

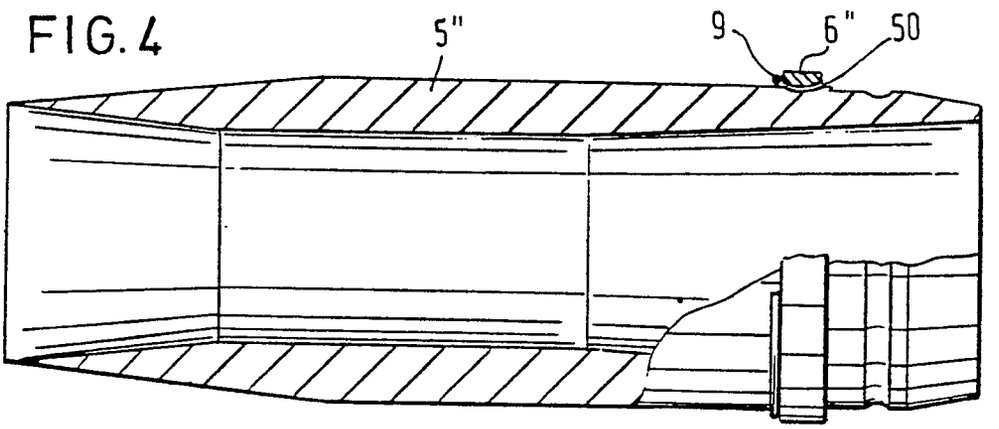
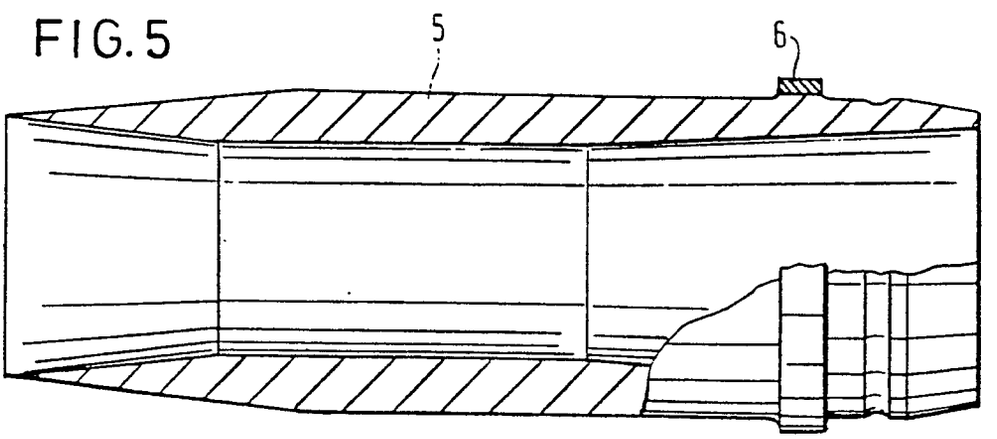


FIG. 5



European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 80 20 1184

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - C - 221 407 (PLATZ) * Figure; claim * --	1,11
	FR - A - 2 365 097 (MOLL) * Figure; page 2, line 35 * --	11
A	US - A - 3 013 332 (TERRELL) * Figures 5-7; column 1, lines 33-35; column 3, lines 16-65; column 4, lines 68-73 * ----	

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

F 42 B 31/00

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

F 42 B

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	25-03-1981	FISCHER