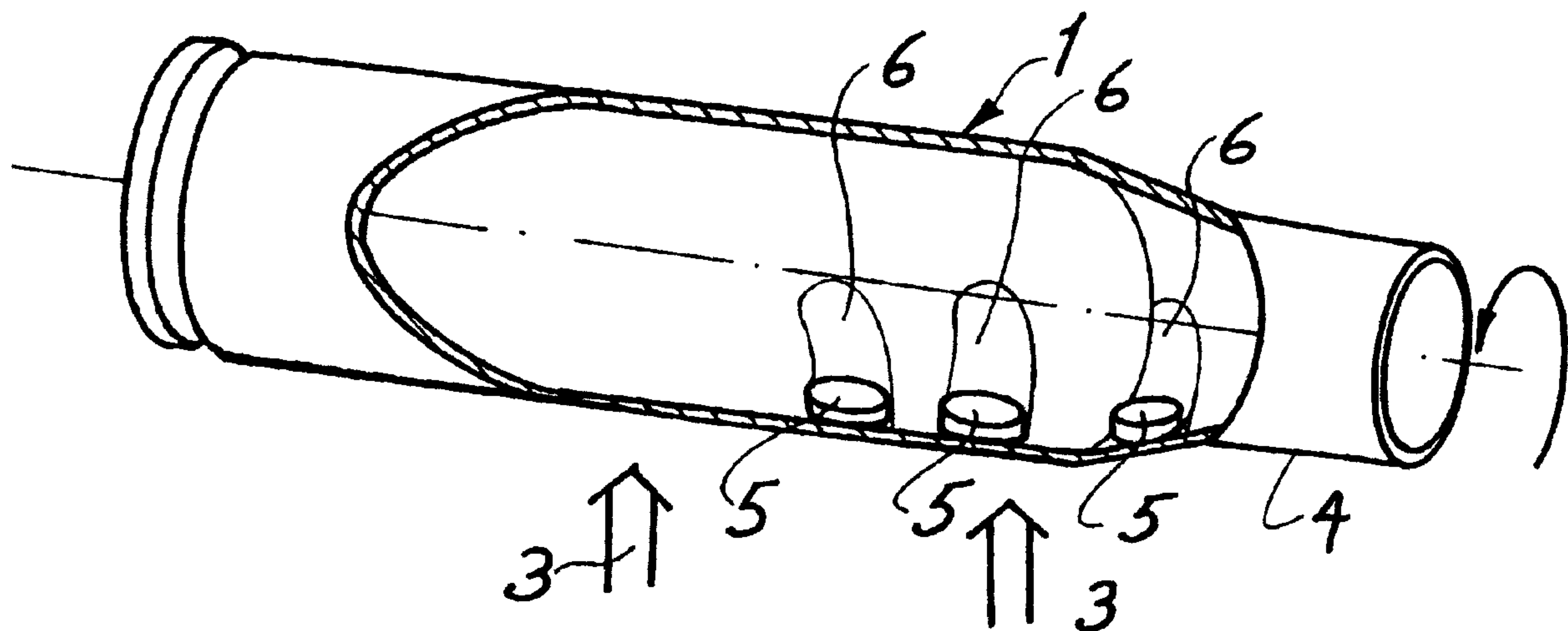




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(54) Title: METHOD OF PROVIDING FIXED AMMUNITION WITH AN ADDITIVE WHICH LIMITS BARREL WEAR, AND AMMUNITION PRODUCED IN ACCORDANCE THEREWITH



(57) **Abrégé/Abstract:**

The present invention relates to a method of applying a wear-protection substance (6, 9) of a type known per se to the inside of such metal cases (1, 7) as are used in both small-calibre and cannon and howitzer ammunition. According to the invention, the wear-protection substance (6, 9) is bound to the insides of the cases (1, 7) with the wax component included therein in the molten phase, whereupon the cases are cooled. The invention also relates to cases treated in accordance with the method indicated above.

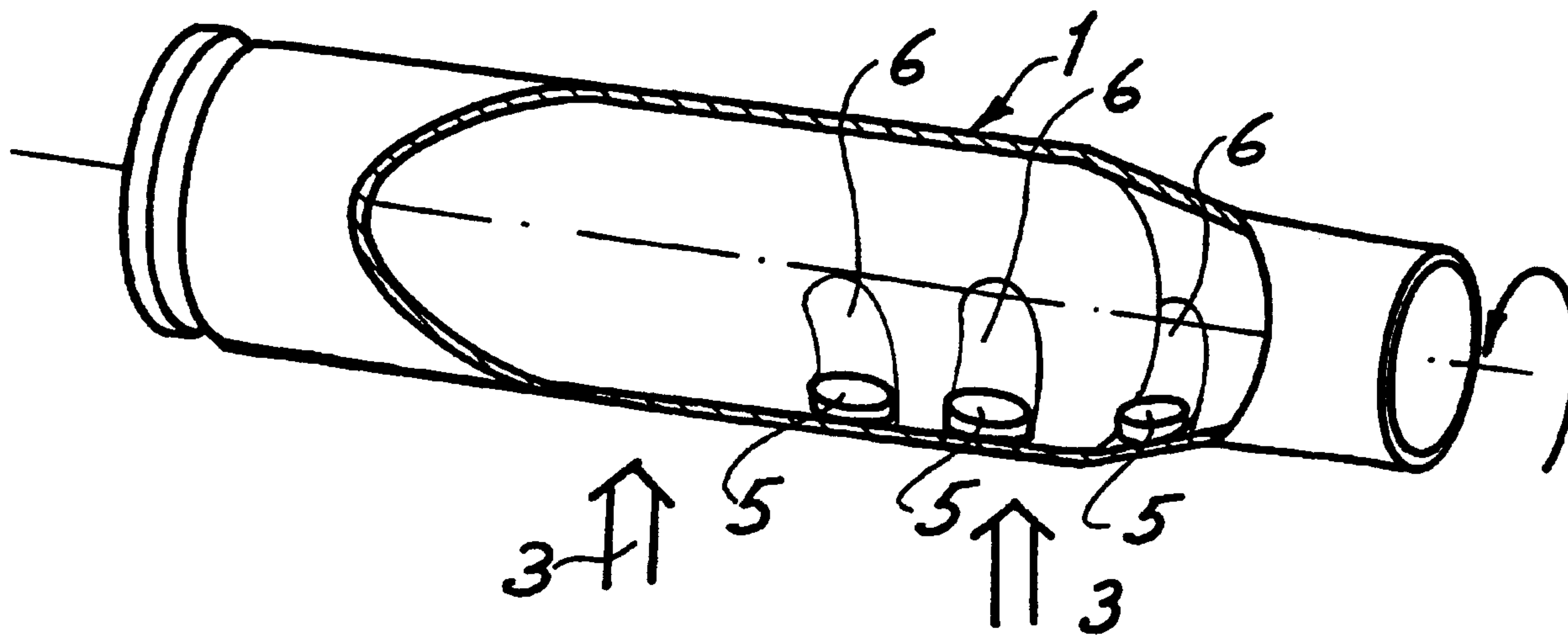


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2186602

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(57) Abstract

The present invention relates to a method of applying a wear-protection substance (6, 9) of a type known per se to the inside of such metal cases (1, 7) as are used in both small-calibre and cannon and howitzer ammunition. According to the invention, the wear-protection substance (6, 9) is bound to the insides of the cases (1, 7) with the wax component included therein in the molten phase, whereupon the cases are cooled. The invention also relates to cases treated in accordance with the method indicated above.

2186602

- 5 Method of providing fixed ammunition with an additive which limits barrel wear, and ammunition produced in accordance therewith.

The present invention relates to a method of providing chiefly small-calibre, cannon and howitzer
10 fixed ammunition in metal cases with a wear-protection additive for reduction of the barrel wear, it being possible for this wear-protection additive to be of a type known per se. The term small-calibre ammunition in this case means all ammunition for hand-guns and machine
15 guns, that is to say ammunition with calibres from 4.5 mm up to approximately 20 mm.

It is a well-known fact that barrel wear becomes greater, the "sharper" the powder which is used in the propellant powder charges and, since use is made of
20 particularly sharp propellant powder in ammunition for high-speed projectiles such as for example armour-piercing dart projectiles, the invention can be expected to be of special value in this connection, and this applies irrespective of whether the propellant powder
25 consists of nitrocellulose powder or so-called LOVA powder. As, however, the latter powder type has a certain reputation for producing greater barrel wear than corresponding nitrocellulose powder with approximately the same performance, the invention is in all probability
30 particularly applicable in association with ammunition charged with such powder.

LOVA powder means a relatively new type of powder intended where possible to constitute a more insensitive replacement for the conventional nitrocellulose powders.
35 The acronym LOVA stands for "low vulnerability ammunition" and in specialist literature a corresponding

2186602 - 2 -

designation IM standing for "insensitive munition" is sometimes found. LOVA powder includes inter alia fine-particle crystalline explosive substances. The main characteristic of these powders is their great pressure sensitivity as far as their burning speed is concerned. In the case of combustion in closed spaces where the pressure is increased rapidly by the powder gas pressure generated, for example inside a cartridge case, the combustion of the LOVA powders becomes approximately like the combustion of a conventional nitrocellulose powder while, in the case of combustion in an open space where no pressure increase takes place, the same LOVA powder goes very calmly, perhaps most like a stearin candle. A property of LOVA powders which is of relevance in this connection is that, in addition to the fact that, with the same charging power, they are often somewhat more space-consuming than nitrocellulose powders, they have proved to be more aggressive as far as barrel wear is concerned. It is therefore even more important to supplement the LOVA powder charges with wear-protection additives than it has been in the case of previous ammunition charged with nitrocellulose powder. In the case of all high-speed ammunition, for example such as is charged with armour-piercing darts, and where the propellant powder is made as "sharp" as possible, the same problem is in principle present.

Within artillery technology, it has long been known that barrel wear can be reduced most considerably if the combustion of the propellant powder charge takes place in the presence of a suitable wear protection. Various metals, metal oxides and salts of metal oxides have been proposed for this purpose and probably the most common wear-protection substance of all is TiO_2 , that is to say titanium dioxide combined with a wax of one type or another. In the wear-protection substance itself, the wax can be included in a quantity corresponding to approximately 50% by weight.

The abovementioned wear-protection substance has, to the extent that it is used, practically always been

23260-451

- 3 -

applied to the charges concerned in the form of a cartridge fabric impregnated with the substance in question. It has also, however, been proposed to manufacture combustible cartridge cases which would in themselves have consisted in part of the wear-protection substance in question. The latter variant is proposed for example in SE 460.417.

The cartridge fabric impregnated with the wear-protection substance and sometimes also with a flame damper has, as a charge additive, often been called "the Swedish additive" among experts, and this product has previously been patented in a large number of countries, although these patents lapsed several years ago. The most important original patents would probably have been SE 197.613, SE 197.614, SE 192.177, SE 202.999 and SE 205.002. A number of different products are proposed in these patents, but it is without doubt TiO_2 , which had the greatest practical use. It has also been observed for a long time that the wear protection gives the best result if it has from the outset been placed close to the barrel wall. It has therefore been usual, in the case of fixed ammunition, to lay the impregnated cartridge fabric along the insides of the cases and, in the case of cartridge charges, to lay it immediately inside the outer cartridge fabric.

A disadvantage of providing the wear protection in the form of an impregnated cartridge fabric is, however, that the additive in this manner takes up a not inconsiderable part of the available charging volume. In a certain howitzer charge, the cartridge fabric with the wear protection thus takes up a good 5% of the entire available charging volume. Add to this the fact that, especially in cases of smaller calibres and those which are provided with a narrowing case neck, it can often be difficult to make the cartridge fabric lie smoothly against the insides of the cases, which in turn thus causes the cartridge fabric to take up further space. All the same, it may perhaps be thought to be much too small a volume to constitute a problem, but the fact is that,

23260-451

- 4 -

as intensive work is now being carried out on attempting to increase the range for older gun systems and at the same time preparations are being made to go over to the insensitive and often more space-consuming so-called LOVA
5 powders, it is difficult to accept that an additive of this type which does not enhance the effect takes up such a large space. The same problem also applies of course to all high-speed projectiles, such as the abovementioned armour-piercing dart projectiles, which act by virtue of
10 their kinetic energy and as a result require the maximum possible exit speed, which in turn means that such ammunition must be charged with the sharpest possible powders.

A further part of the state of the art is
15 constituted by EP A1 0410075 which describes ammunition with combustible case parts of the so-called modular charge type comprising a layer, arranged on the inside, of the abovementioned previously known wear-protection substance consisting of titanium dioxide and wax and in
20 which this wear-protection layer is in turn covered by a thin metal foil, made of lead for example, which prevents direct contact between the propellant powder and the wear-protection layer. According to what is contained in the text of this document, it is considered to be
25 compulsory to prevent the propellant powder from direct contact with the wax/titanium layer since such contact could at high temperatures bring about a stabilization of the propellant powder and an associated reduction in its effectiveness. It is proposed in the patent specification
30 that this wear-protection layer is to be applied to the insides of the combustible cases by means of puttying, painting or spraying.

However, we have now found that it is possible to provide at least metal cases with corresponding wear
35 layers consisting of the wax and titanium dioxide wear-protection composition known per se which is so resistant that an anti-stabilization protection in the form of a metal layer never needs to be provided. This is because the wax/titanium dioxide layer produced according to

23260-451

- 5 -

an embodiment of the present invention is so resistant that a powder stabilization is never an issue, at the same time as the binding of the layer to the inside of the case is so stable that it requires no further support. One of the
5 reasons why this has become possible is that the method according to an embodiment of the invention permits the utilization of high-melting wax which gives the layer obtained extremely good strength.

A high-melting wax means in this case a wax which
10 has a melting point between approximately 80 and 300°C. Since ammunition is as a rule guaranteed to function within the temperature range -40° to +60°C and the low temperatures as a rule do not usually involve any problems as far as wax is concerned, so it is a clear advantage, also from other
15 points of view than the risk of the powder being stabilized by the wax, if high-melting wax can be utilized in wear-protection compositions of the type intended here.

Embodiments of the invention also include two different methods of producing the layer of wear-protection
20 medium and wax on the insides of the cases. The first method is particularly well adapted for cases of slightly larger calibres such as cannon and howitzer cases, while the second method is rather more suitable for small-calibre cases. It would also be possible to provide the latter type
25 with a suitable internal wear-protection coating by immersion, but then an outer coating would also be obtained which is preferably removed from the finished charged cartridge since such an outer coating can otherwise interfere with the functioning in automatic weapons. The
30 second method is preferably implemented with a relatively high degree of automation in order to become economically sound.

23260-451

- 5a -

Embodiments of the invention may thus be especially advantageous in that the smallest possible part of the available case volume is blocked, and at the same time the functioning of the charge is moreover not in the
5 least affected. Charging volume thus freed therefore becomes available for an increase in the quantity of

23260-451

- 6 -

propellent powder. A further advantage is that embodiments of the invention do not presuppose any extra additives to the wear-protection composition, for example in the form of solvents, and at the same time it is easy to utilize.

5 One basic principle of some embodiments of the invention therefore mean that the respective cartridge cases are coated on the inside with a preferably uniformly thick and homogeneous layer consisting of a wear-protection substance in the form of mixtures of a high-melting wax
10 and a fine-particle metal, metal oxide or other substance known per se or proposed in the future as wear-protection medium for this specific purpose. In the case of the first method indicated above, which is suited for coating slightly larger cases, the complete wear-
15 protection composition is applied to the interior of the cases in the form of solid pieces or tablets which are adapted to the size and shape of the cases and are distributed along the interior of the case at a tested distance from one another, after
20 which the wax in the composition in question is gradually melted in the heated case which is rotated about its essentially horizontally arranged axis at a speed which is adapted with regard to the desired coating. During this treatment, the solid pieces or tablets therefore
25 follow a helical path along the inside of the case and, since they are simultaneously melted, they leave behind them there a gradually growing cohesive layer of the wear-protection substance on the inside of the case. When this has obtained a desired spread and thickness, the
30 case is cooled. A wear-protection composition which can be used specifically for this method has proved to be that which also includes, in addition to a suitable high-melting wax, the previously mentioned fine-particle titanium dioxide. Together with the wear-protection
35 medium in particle form, a decopper-plating medium of a type likewise known per se can also be included together with the wax.

Various types of wax have for a long time been used in connection with powder, and so a wealth of

23260-451

- 7 -

experience has been gathered on which wax can be used together with powder, and this is of great importance since, within the branch, there has always been great reluctance, perhaps in view of the long-term storage problems, to introduce new untested products in powder and explosives. In this connection, it is therefore chiefly a matter of selecting a suitable high-melting wax which gives a wax wear-protection layer with the desired strength properties.

10 In reality, the designation wax is linked more to the physical properties of these products than to their chemical structure. Within the general designation wax, two different main groups are usually to be reckoned with. One of these main groups includes chiefly esters with the general formula RCOOR' where R and R' are an acid and alcohol group, respectively, with as a rule 16-30 carbon atoms. However, alcohols in the form of so-called sterols can also be included in this main group. An example of the latter type which has previously proved of interest in connection with powder and explosives is oxazoline wax which is manufactured synthetically from nitroparaffins and which contains the so-called oxazoline group. The second main wax group consists of paraffin wax with crystalline structure. These are obtained from 25 certain petroleum crude oils and clay slate oils. The molecular form of these waxes is $\text{C}_{20}\text{H}_{42}$ and above. From a chemical point of view, waxes are in fact generally rather inert.

30 In order further to clarify what is meant here by the designation wax, refer to the book "Industrial Waxes" Volume I by H. Bennet, Chemical Publishing Company New York 1975.

35 The wax utilized according to some embodiments of the invention has an adequately good adhesion against the inside of the case and to have an adequately high melting point so that at high temperatures there are no problems of stabilization of the powder charged in the cases.

In practical tests with ammunition for a 40 mm automatic cannon in which the wear-protection composition

23260-451

- 8 -

was applied to the heated case in the form of pieces or tablets of 1-3 grammes, it has emerged that a coating according to an embodiment of the invention corresponding to 0.5-1.0% of the charge weight gives acceptable wear protection.

5 This relatively small quantity is to be compared with the 5% mentioned previously in the text with reference to a wear protection of the older model comprising a space-consuming cartridge fabric plus wear-protection substance. As far as comparisons with the wear protection
10 with protective metal foil described in EP 0410075 are concerned, the difference is of course considerably smaller as far as the space gain is concerned, but then there is instead the advantage that the actual protection layer does not have to be applied. We have moreover been
15 unable to find any more detailed description of how this is brought about in the patent specification in question.

In order for the wear-protection composition to be able, in an effective manner, to go with the hot powder gases out into the barrel, it should preferably be
20 applied to the inside of the case in its front third directly behind the fixed projectile. With this positioning, the wear protection is exposed to the maximum possible overflow of hot powder gases, and the maximum possible utilization of its positive properties
25 is thus guaranteed. In the case of the first method which is characteristic of an embodiment of the invention, the desired positioning of the wear-protection layer is selected by fixing or varying, during rotation of the case, the inclination of the case relative to the horizontal plane
30 and by selecting the distance between the starting positions of the tablets.

In the case of the second method which is characteristic of another embodiment of the invention and is suitable for chiefly small-calibre cases, the wear-protection
35 composition is applied with the wax in the molten phase to the interior of the heated case, which is rotated at a suitable speed, through a thin heated pipe which is introduced through the case neck and opens directly adjacent to the case wall and, on rotation of the case,

23260-451

- 9 -

spreads the wear-protection composition out into a uniform layer with the desired spread. The spread of the wear-protection layer can be controlled by means of a relative displacement between the application pipe and the case.

Of the components included in the wear-protection composition, the titanium dioxide has the effect that it reduces the heat radiation of the powder gases to the barrel wall by shielding the same and by dilution, at the same time as it forms a foundation for a dispersion of particles which is distributed over the barrel surface. Moreover, the titanium dioxide catalyzes the reduction of oxidizing combustion products so that these are not able to attack the barrel wall.

Turning then to the wax component of the wear-protection composition, this contributes to a reduction of the flame temperature through an energy-requiring decomposition, and at the same time it forms a "swollen" layer of gasified and partly decomposed material distributed along the barrel wall and produces a coating of the barrel wall with an insulating layer of residues from the wear protection which prevents heat transmission and chemical influence from the powder gases.

Although the effect of the wear protection obtained according to embodiments of the invention corresponds in principle to the effect of previously used cartridge fabric-borne wear protection, the method of producing the wear protection is completely different, and at the same time the product obtained is different and moreover important charging space is gained, and at the same time it becomes possible to utilize a more energy-rich powder which in both cases can be utilized in order to improve the performance of the artillery pieces in question.

23260-451

- 9a -

Thus, one broad aspect of the invention provides a method of reducing barrel wear on firing fixed ammunition having a metal case, including the steps of: heating said case; applying to the insides of the cases, before charging
5 thereof, a molten substance comprising a wax, having bound therein a solid material in particle form with known barrel-wear-reducing effect, via a narrow heated pipe introduced through a case neck; utilizing an outlet end of said pipe for distribution of said molten substance over the inside of
10 said case; forming said substance into a coherent layer on the inside of said case; and cooling said layer to solidification.

There is also provided a method of providing a metal cartridge case of fixed ammunition with an inner
15 barrel wear reducing layer, said layer comprising a composition of wax and a solid component in particle form which has a known barrel-wear-reducing effect, comprising the steps of: applying said composition to the inside of a case in the form of solid pieces or tablets; heating said
20 case to gradually melt said wax included in said composition against the inside of the case, thereby forming a layer of wax and said solid component on the inside of the case, wherein the case is rotated about its essentially horizontal longitudinal axis until a layer of desired thickness and
25 spread has been obtained; and cooling the case so that the composition is transformed completely to a solid form.

Embodiments of the invention will now be illustrated somewhat further by examples below, at the same time as reference is made to the attached figures for
30 further details.

In order to test embodiments of the invention,
200 cases of

2186602

- 10 -

40 mm ammunition intended for Bofors L/70 automatic cannon were coated on the insides along the front third of the cases with a layer of wax plus titanium dioxide. The coating was made in the manner indicated above by
5 three pellets per case of around 3 grammes each of a ready-mixed wax/titanium dioxide mixture (50:50) being melted in the cases which have been heated to a suitable temperature while these were rotated with an essentially horizontal axis. In the coated parts of the cases, the
10 coating was given a thickness of approximately 1 mm which in this case corresponded to less than 1% of the available charging space. The cases were charged with a high-energy nitrocellulose powder and an armour-piercing
15 dart projectile. The test firing of this ammunition showed that the barrel wear was approximately 1/10 of the corresponding wear for the same ammunition but without wear protection.

Figure 1 shows a partly cut-away 40 mm artillery case during application of wear-protection medium
20 according to method one, while

Figure 2 shows a partly cut-away small-calibre case during application of wear-protection medium according to method two.

The case 1 shown in Fig. 1 is rotated about its
25 longitudinal axis 2 and is heated for example by means of radiation heat or induction marked 3. Three tablets 5 of solid wear-protection composition have been placed relatively close to the case neck 4. When the case 1 is rotated with simultaneous heating, the wear-protection
30 composition in the tablets 5 is gradually spread out on the inside 5 of the case and when the layer 6 thus obtained has reached a desired thickness and spread, the case is cooled.

It is a prerequisite for the case 7 shown in Fig.
35 2 also to be heated, the heat supply having been indicated at 3 and the case being rotated about its longitudinal axis 8, but here the wear-protection composition 9 is applied with the wax in molten phase through a heated pipe 10 which is narrow in relation to

- 11 -

the case neck 11 and which has been introduced through the case neck and opens directly above the inner wall of the case and there functions as both application member and distribution member in that it spreads the wear-
5 protection composition applied into a thin layer 12, the spread of which in the longitudinal direction of the case can be adjusted by a mutual longitudinal displacement between the case 7 and the pipe 10.

23260-451

- 12 -

CLAIMS:

1. A method of reducing barrel wear on firing fixed ammunition having a metal case, including the steps of:

 heating said case;

5 applying to the insides of the cases, before charging thereof, a molten substance comprising a wax, having bound therein a solid material in particle form with known barrel-wear-reducing effect, via a narrow heated pipe introduced through a case neck;

10 utilizing an outlet end of said pipe for distribution of said molten substance over the inside of said case;

 forming said substance into a coherent layer on the inside of said case; and

15 cooling said layer to solidification.
2. A method according to claim 1, wherein a longitudinal axis of the case is, inclined relative to a horizontal plane whereby the obtained layer of wax and solid material is substantially limited to the front third of the
20 case.
3. A method according to claim 1 further comprising the step of rotating said case about its longitudinal axis until said coherent layer of desired thickness and spread has been achieved.
- 25 4. A method according to claim 1 further comprising the step of displacing said pipe and said case in relation to one another.

23260-451

- 13 -

5. A method of providing a metal cartridge case of fixed ammunition with an inner barrel wear reducing layer, said layer comprising a composition of wax and a solid component in particle form which has a known barrel-wear-reducing effect, comprising the steps of:

applying said composition to the inside of a case in the form of solid pieces or tablets;

heating said case to gradually melt said wax included in said composition against the inside of the case, thereby forming a layer of wax and said solid component on the inside of the case,

wherein the case is rotated about its essentially horizontal longitudinal axis until a layer of desired thickness and spread has been obtained; and

cooling the case so that the composition is transformed completely to a solid form.

6. A method according to claim 5, wherein said desired layer thickness is obtained by providing a number of layers successively laid on each other.

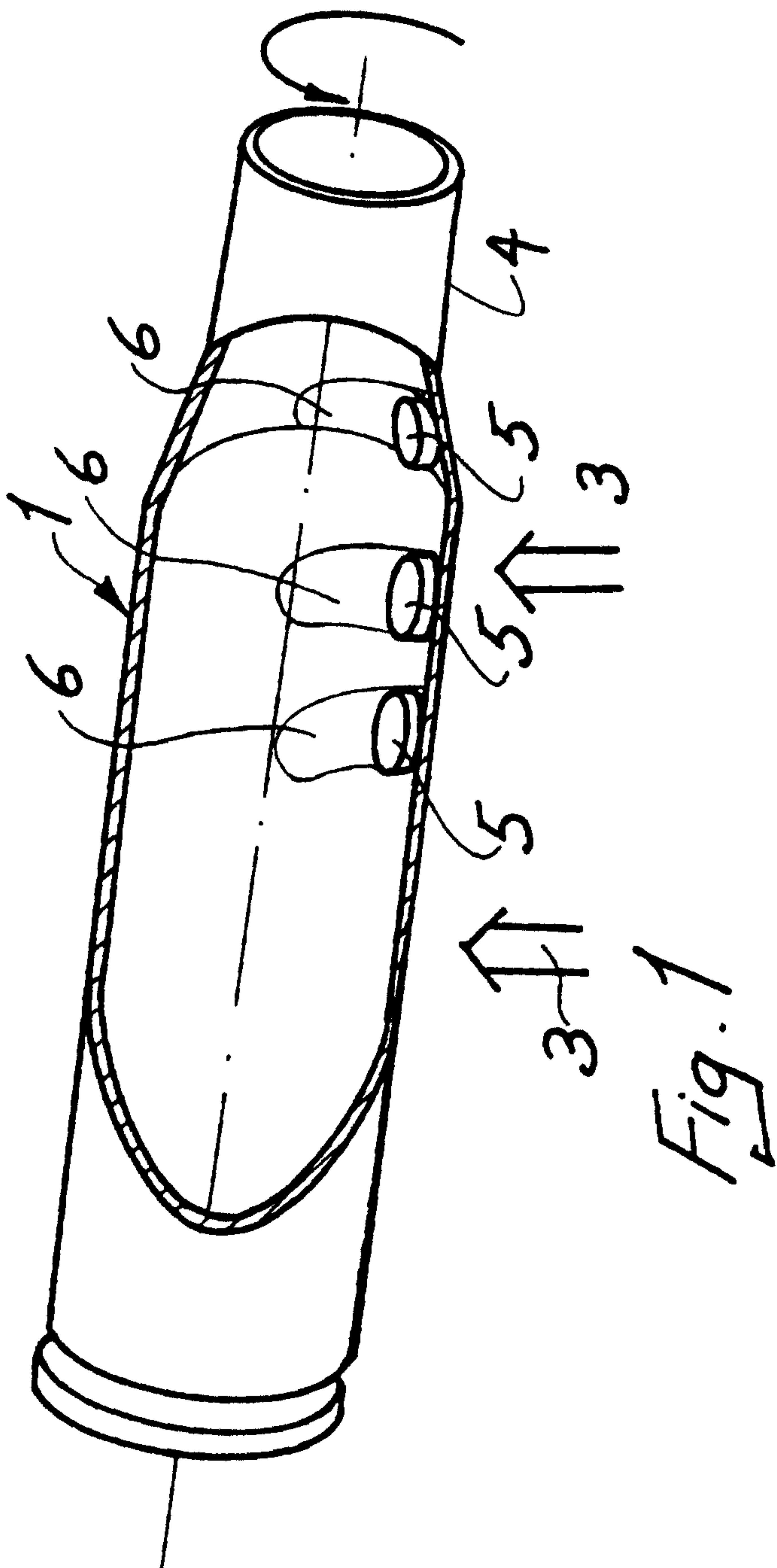
7. A method according to claim 5 wherein a longitudinal axis of the case is inclined relative to a horizontal plane whereby the obtained layer of wax and solid material is substantially limited to the front third of the case.

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OTTAWA, CANADA

PATENT AGENTS

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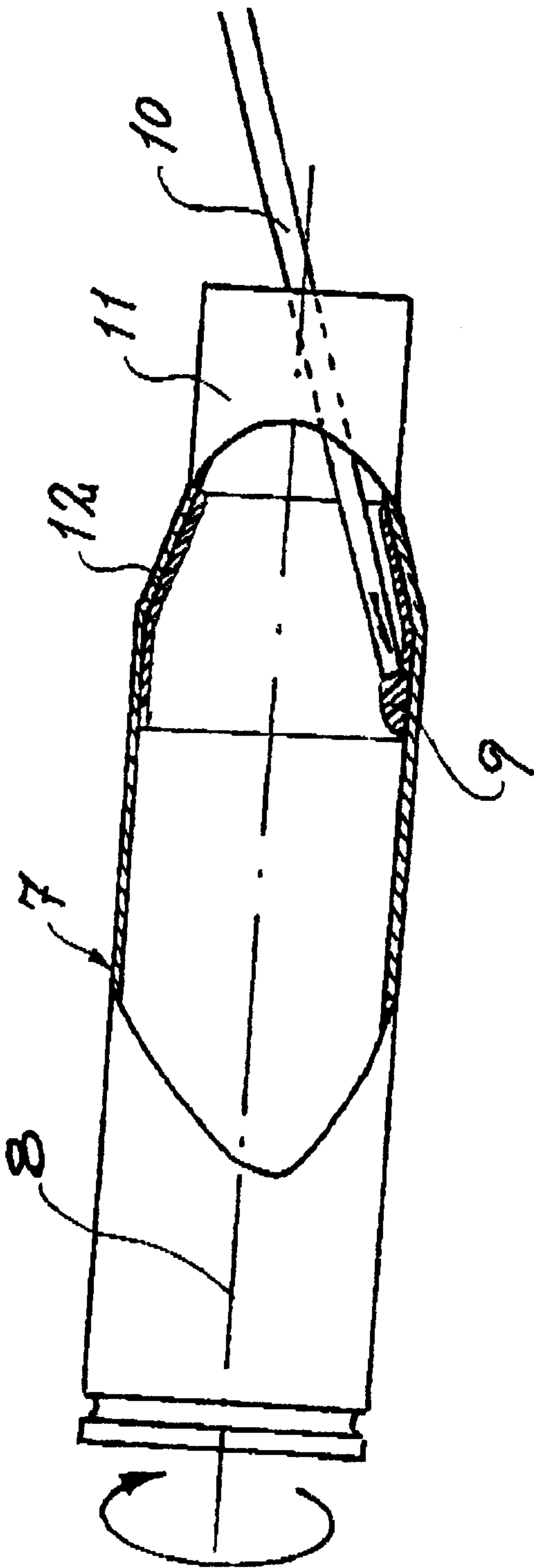


Fig. 24

