Nov. 19, 1935. C. FORNACI 2,021,685

ARMOR PIERCING PROJECTILE

Filed June 20, 1933 4 Sheets-Sheet 1

Fig. 1

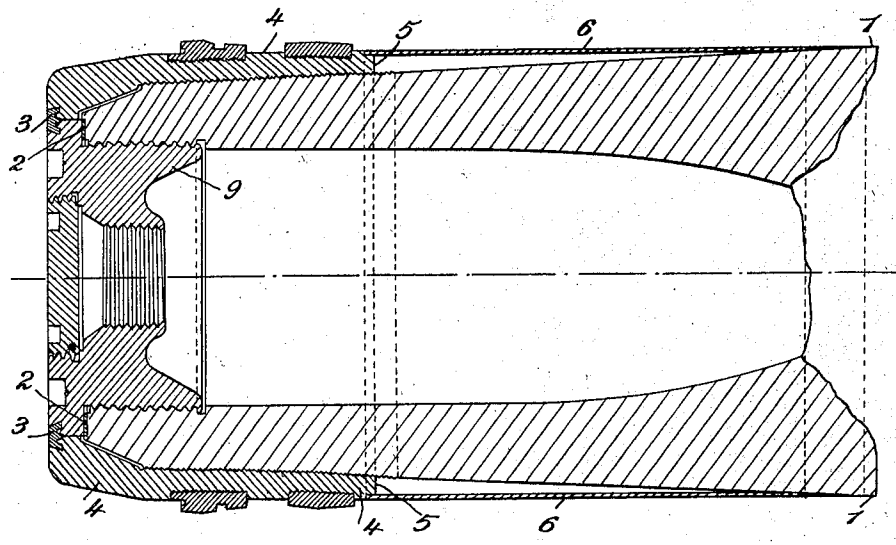
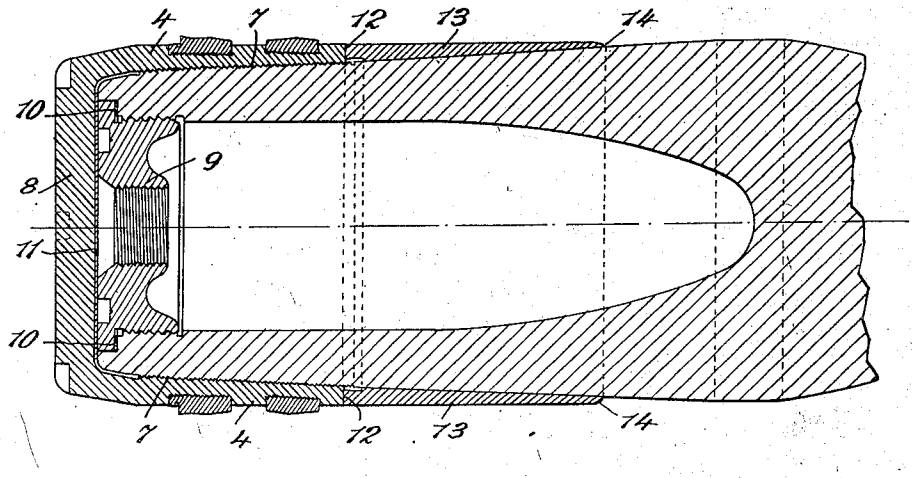


Fig. 2



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ARMOR PIERCING PROJECTILE

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Fig. 3

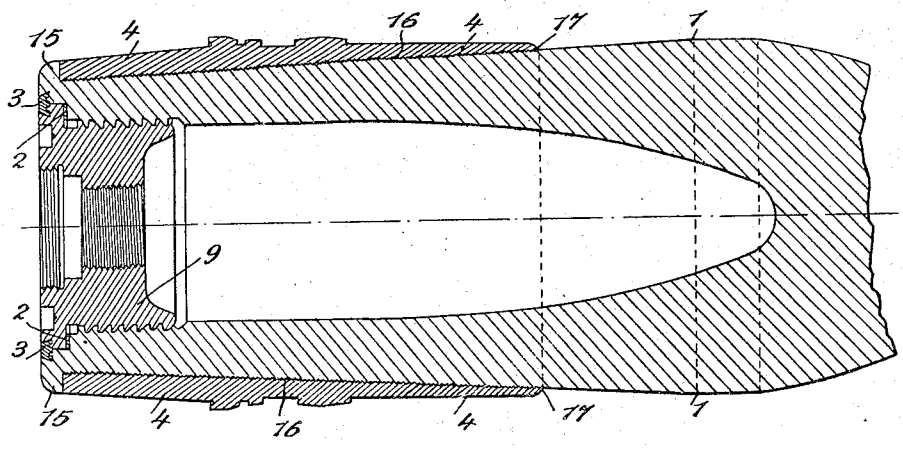
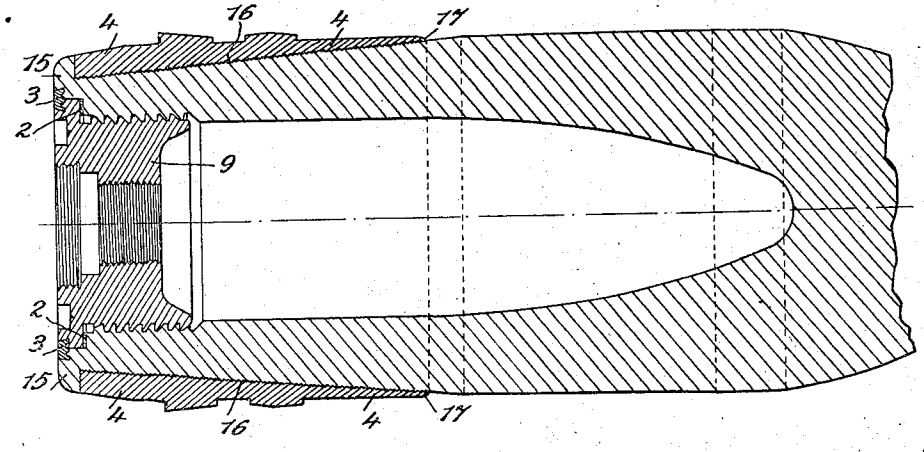


Fig. 4



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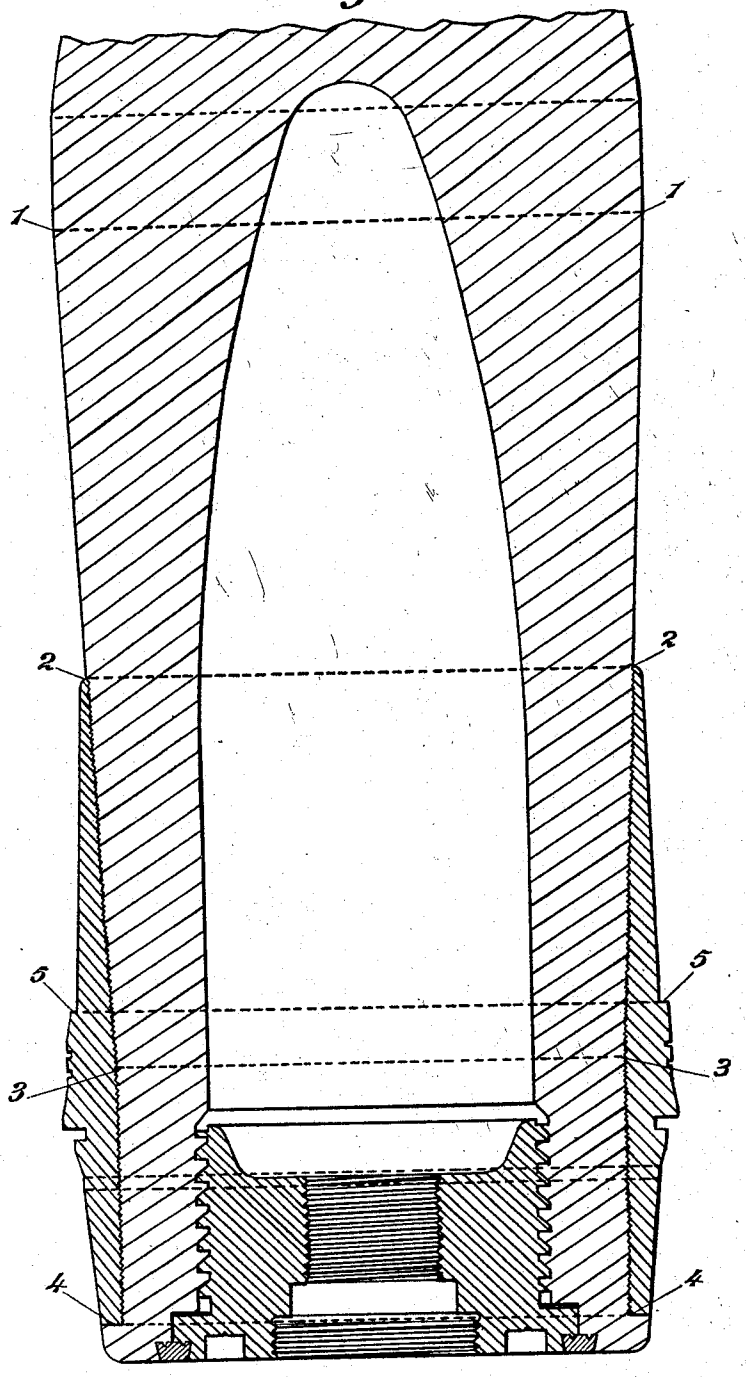
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ARMOR PIERCING PROJECTILE

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Fig. 5



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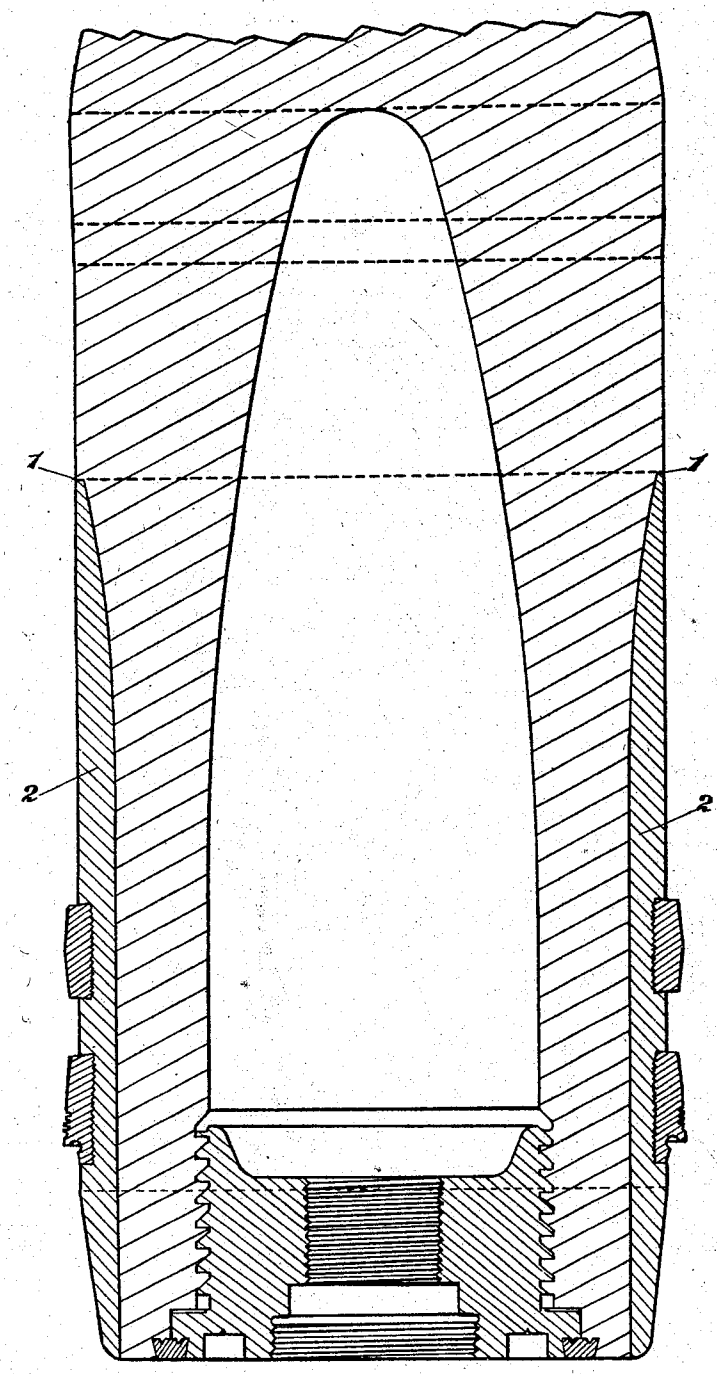
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Fig. 6



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Patented Nov. 19, 1935 2,021,685

UNITED STATES PATENT OFFICE

2,021,685

ARMOR PIERCING PROJECTILE

Curio Fornaci, Terni, Italy

Application June 20, 1933, Serial No. 676,737
In Italy July 11, 1932

10 Claims. (Cl. 102—28)

As is well known when a perforating projectile pierces through an armor plate of large thickness especially in the case of an oblique impact with high inclination, the projectile is subjected to very hard strains of a complex character tending to cause its body or base to remain sticking and be drawn out through the hole produced in the plate, in many cases with the consequence of the breakage and separation of said base.

Said breakage is favoured by the presence in the base of the projectile of some sections of minor resistance, in correspondence of the grooves for the driving bands and of the threaded mortise of the screw plug; whenever the breakage takes place the charge is rendered impossible of explosion and the destructive effect of the projectile irremediably compromised.

Various means have heretofore been proposed for avoiding this serious disadvantage. None of the known means have however proved entirely satisfactory and reliable at all times and under various conditions of attack of a hard faced armor plate.

Furthermore it is clear that even if the breakage does not take place the deformations suffered by the projectile always imply a certain quantity of energy absorbed and not utilized for the effects of perforation; it is consequently necessary to reduce said loss to a minimum in order to increase the efficiency of the projectile.

Object of the present invention is to propose a piercing projectile which in the unfavourable conditions of firing, as those above mentioned, is not subjected to those strains producing deformations and breakage of the base while at the same time with respect to projectiles of common type a better utilization of the impact energy is realized for the effects of the perforation of the armor plate.

The construction is based on the fact, generally known, that deformations and breakage of the base or body preferably occur when the hole produced in the armor plate has a very narrow and remarkably circular section, while there are very rare examples of the inconvenience occurring when the hole is of remarkable dimensions with regard to the projectile, but all these cases may be explained through the intervention of accidental factors.

Without entering into a detailed analysis of all the phenomena occuring during perforation it may be easily deduced from above considerations that the strains producing the breakage of the base or body of the projectile cannot have any way of manifestation if there is the possibility for the projectile's body to be easily freed from the hole produced on the plate. Meanwhile in order to avoid angular displacements or oscillations of the projectile which may cause its base to be blocked and drawn out through the hole, and in any case in order to render void the effect of said displacements and oscillations it is necessary that the projectile's body may be shaped in such a way that it cannot be gripped at all and blocked by the edges of the hole.

To that object the projectile's body instead of being of the usual cylindrical shape with a diameter only a little smaller than that of the fore ring or front band that is approximating 1%, is provided for with a remarkably tapering shape from the ogival head or fore ring downwards to the base. This tapering form may be usually conical, that is composed of one or more truncated conical surfaces eventually combined with one or more cylindric surfaces, all concentric with the axis of the projectile and conveniently jointed together and to the remaining parts of the projectile; according to circumstances curvilinear or mixed profiles may be also provided for, that is profiles consisting of curvilinear and rectilineal sections with different inclinations to the axis of the projectile.

Generally speaking the nature of the profile of the tapering part of the projectile's body has to be determined for each case in particular in relation with the shaping of the explosion chamber, the thickness of the projectile's parts and the results of trials executed.

The essential is that there should be a remarkable difference of diameter between the fore part of the projectile which defines the dimensions of the hole on the armor plate and its base. When these conditions are realized it is evident that the play between the edges of the hole and the body of the projectile gradually increases as the projectile proceeds through the thickness of the armor plate, the danger for the body or base being blocked and broken being meanwhile entirely removed with the further advantage not to be neglected of a smaller quantity of energy being wasted owing to friction and deformation of the projectile.

Of course within the limits of protection of the invention there are also comprised all those profiles in which the tapering begins in any point whatever of the cylindric projectile's body and consequently after the fore ring, provided in each case this original point is before the driving band. In fact whenever it only matters to maintain the projectile's body integral, (and it is possible to

neglect the greater absorption of energy occurring during the perforation with respect to completely tapered projectiles) it is clear that it will do to give a slippery shape only to the part of the projectile directly subjected to be blocked in the hole produced on the armor plate. In consequence the projectile's body is maintained from the fore ring downwards for a certain length of the usual cylindrical form with a diameter only a little smaller than that of the said fore ring and then in the point recognized as convenient assumes one of the tapering profiles above mentioned. In any case it is however necessary that the tapering should begin before the driving bands to avoid to provide grooves for the application of said bands always constituting a zone of smaller resistance and may be gripped by the edges of the hole the effect of the slippery shape being thus destroyed.

As to the entity of the tapering it is to remark that according to practical trials it is advisable to fix a difference of diameter of at least 10 to 20% between the fore part of the projectile defining the dimensions of the hole on the armor plate and the bottom end; of course if owing to peculiar exigencies a smaller difference may be required then the percentage indicated will be less, provided always over 1%, in said cases the objects of the invention being equally obtained.

In consequence of the projectile's shape above specified the driving bands which in their present form must necessarily be applied on a diameter very little different from the bore of the gun cannot be inserted with the usual methods on the projectile's body.

Moreover as already mentioned it is necessary to remove from the body of the shell and especially from its base all parts or lines of reduced strength as driving band grooves; it is then necessary to discover means for overcoming this difficulty.

Such a device generally comprises a metallic jacket partially or totally enveloping the tapered portion of the shell with the object of providing the necessary support for the driving bands, which as a matter of fact may be also integral with the jacket.

Said jacket may be united to the body of the shell by a cylindrical or conical threading, by soldering the contacting surfaces by a process similar to the one used for the caps; or also by heating or by contraction in which case the profile of the tapered portion has to comprise a cylindrical section of a sufficient length.

Should the jacket consist of a sufficiently plastic material it may be conveniently applied by a similar manner as the driving bands, that is by means of a hydraulic press or other like device by which it is tightened in the heat or cold against the outside surface of the shell's body conveniently provided with projections capable of penetrating into the jacket.

Whatever may be the system chosen for the application said jacket has to fulfill the following conditions:

(*a*) it must be of course proportioned in such a manner as to be able to resist the strains it is subjected to in the gun and on the trajectory;

(*b*) its connection with the projectile's body must be such that the propelling pressure directly exercised on the jacket as the rotation impressed by the rifling of the gun may be transmitted to the projectile;

(*c*) it must be tight-close connected with the projectile's body to make it gas-tight so that the closure operated in the gun by the driving bands is not in the least damaged;

(*d*) the resistance offered to the penetration of the projectile through the plate either by freeing itself from the projectile's body or by breaking without an excessive strain or during the penetration through the armor plate or by the action of the repercussion at the impact of the projectile on the plate, is to be negligible;

(*e*) the jacket should allow, when necessary the application of a device whatever capable of modifying the external profile of the projectile's body for bringing said profile back to a correct ballistic shape.

Numerous are the systems which may be devised for realizing said organ simply called for brevity's sake "jacket" which is to be studied for each singular case with the contribution of the results of firings for trial executed with the object of choosing the most adapted type for each perforating projectile in relation to the gauge of the bore, the profile of the charge, the conditions or fire, the exigencies of manufacturing and other considerations of the theoretic and practical character.

It is clear that what is above said is also applicable to the case of a projectile provided with one instead of two or more driving bands.

It is to be remarked that the jacket as specified is not only useful for the application of the bands, but also for the object of protecting the base of the projectile against rupture, the direct contact between said base and the edges of the hole produced on the armor plate being thus avoided. In this aspect it is advisable that the jacket should cover a considerable part of the body of the projectile.

Only by way of example for the realizations of above fundamental ideas are now briefly described, as follows, modifications of a perforating projectile's body according to the present invention.

In the accompanying drawings:

Fig. 1 illustrates a longitudinal section of a shell according to the first modification.

Fig. 2 shows a longitudinal section of the shell according to a second modification.

Fig. 3 is a longitudinal section of the shell according to a third modification.

Fig. 4 is a longitudinal section of the shell according to a fourth modification.

Fig. 5 is a longitudinal section of the fifth modification.

Fig. 6 is a longitudinal section of the sixth modification.

With reference to Fig. 1 after the ogival head and from the fore ring (1) (these two parts being destined to produce the efficient work of penetration) the profile of the projectile's body becomes conical, this conical shape being maintained constant as far as near the bottom end. In correspondence to the median line of the mortise for the screw plug, that is in a zone where an excessive tapering off of the projectile's walls cannot represent a danger, said conicity increases remarkably, so that a still more slippery shape is offered to the edges of the hole on the armor plate.

The screw plug destined to constitute a back closure for the explosion chamber and to bear the fuse is of the ordinary type.

The gas tight closure is secured by a lead packing (2) inserted between the back flange of the screw plug and an adapted annular seat provided on the back end of the projectile's walls.

The copper packing (3) inserted between said flange of the screw plug and the metallic jacket (4) serves on the contrary not only to better secure the close tightness produced by the screw plug but also to prevent eventual infiltrations of the gases of the service charge between the jacket (4) and the projectile's body.

The metallic jacket (4) is enveloped round the projectile's body for such a length as to allow the application on the same jacket of the driving bands; the connection with the projectile's body is effected by means of a fine thread, proportioned in such a way that the rotation impressed by the rifling of the gun may be transmitted to said projectile's body.

The jacket consists of a material well resistant to the compressive strains as those substantially produced in the gun, but at the same time relatively fragile as to easily break as soon as coming in contact with the armor plate. Should however this breakage not occur in due time the type of fine thread is such that not a great resistance may be opposed to the sliding off of the jacket under the action of the edges of the hole on the armor plate acting against the fore edge (5) of the jacket.

Between the edge (5) of the jacket and the fore part of the projectile a sheet casing (6) is applied by means of tin solder, the casing being sufficiently thick to resist to accidental shocks or falls of the projectile, without increasing in a sensible way the resistance opposed to the penetration through the plate and allowing the external profile of the projectile's body to take again the usual cylindric shape by avoiding reentrancies or sharp edges which might be detrimental for the projectile's motion on the trajectory.

According to the second modification illustrated in Fig. 2 the projectile's body has nearly the same profile as in Fig. 1. The metallic jacket (4) is connected to the projectile by a fine conical thread (7) as according to the first modification; however said jacket has the characteristic of completely enveloping the whole base of the projectile and being closed by the bottom (8), bottom and jacket forming one piece so that the projectile's body is completely withdrawn from the direct action of the gases of the service charge. Consequently the screw plug (9) has the dimensions strictly necessary for lodging the fuse and effecting a closure of the projectile sufficient for the detonation of the explosive contained therein, the capacity of the projectile's chamber being thus utilized in the best way for the action of the explosion charge.

The metallic packing (10) inserted between the flange of the screw plug and the annular seat provided on the end of the projectile's walls and the metallic packing (11) inserted between the base (8) of the jacket and the projectile's base do not serve for tight closing but to uniformly distribute the tightening pressure of the screw plug's thread and of the jacket respectively.

Between the fore edge (12) of the jacket and the fore part of the projectile's body there is provided a metallic ring (13) with the object of bringing the outside profile of the projectile back to a shape little different from the usual cylindrical form, a useless loss of energy being thus avoided on the trajectory.

As this ring is simply run on the projectile's body and then soldered thereto so it does not contribute to the perforation and can consequently be made of light alloys. In front of the fore edge (14) of said ring solder or other filling material may be applied for better connecting the profile with the fore ring.

According to the third modification shown in Fig. 3 the projectile's body becomes conical from the fore ring downwards, and this conicity is constant for the whole length the minimum diameter being reached against the small stop (15) provided on the same base of the projectile.

Object of said stop (15) is to produce with the metallic jacket (4) a tight closure so as to avoid eventual infiltrations of gases between the said jacket and the projectile's body, said stop being proportioned in such a way that it may break without offering too much resistance to the jacket for sliding off from the projectile's body during the penetration through the armor plate. The jacket (4) is integral with the driving bands and is obtained out of a metallic ring applied by a hydraulic press or other similar machine against the milled body (16) and then turned on the spot. Between the original point (1) of the tapering and the fore edge (17) of the metallic jacket there may be provided tin solder or other similar filling material in order to remove the small reentrancy produced on the body of the projectile during manufacture.

All the remaining organs of the projectile are of usual type; only to be remarked is the trapezoidal thread chosen for the screw plug with the object of improving the connection with the breech block.

As to the 4th modification shown in Fig. 4 there is no need of particular specifications, the modification differing very little from the third illustrated in Fig. 3, the tapering off beginning just near the middle of the projectile's body rather than from the fore ring.

Also for the fifth modification illustrated in Fig. 5 a detailed description is not necessary the difference as regards the third modification illustrated in Fig. 3 being only that the shell's body instead of being entirely conical is partially conical (namely from point 1 to point 3) and partially cylindrical (namely from point 3 to point 4). It is to be remarked that on the front of the fore rim 5 of the driving band the metallic jacket is not kept externally cylindrical but is gradually tapered so as to be flushed with point 2 of the shell's body. In correspondence of this point 2 tin solder may be applied in order to conceal the slight projection of the fore rim of the metallic jacket.

According to Fig. 6, a sixth modification is illustrated of a shell's body partially tapered according to a multilineal profile. From the origin 1 of the tapering the shell's body shrinks in the diameter at first abruptly so that a small shoulder is produced for supporting the jacket, then gradually continues according to a curvilineal profile as far as a diameter is obtained of 13% smaller than the initial one, with said diameter the body continuing of a cylindrical shape down to the base end. The metallic jacket 2 is applied around this tapered portion, the external profile of the shell being thus brought back to the usual cylindrical shape, the jacket being united to the shell's body by welding the contacting surfaces or by being fitted on the shell in hot conditions.

In order to facilitate the execution of the jacket this may be formed of two distinct portions, namely of a first ring covering the curvilineal part of the tapered profile simply slid on the body and of a second ring corresponding to the cylin-

drical part, made solidary with the body by the means above specified.

It is evident also that in proximity of the base end and preferably in correspondence of the rear half of the screw plug the shell's body may be further tapered and in this case the metallic jacket keeps internally a profile according to the profile of the shell's body.

In all the six figures there is to be noted the position of the driving bands relatively distant from the projectile's base according to the most modern views as regards external ballistics. Said position which practically produces a greater range and a greater exactness of firing represents an indirect and not to be neglected advantage of this invention since the driving bands are no longer inserted in the projectile's body and can be arranged in the position of greatest efficiency without any fear about the integrity of the projectile's bottom.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. A projectile including a body, a driving band on said body, a screw plug in said body, said body having an ogival head of a diameter corresponding to the calibre and being progressively tapered in the direction of the base from a point in front of the driving band, the profile of said tapered portion being devoid of sharp diametrical reductions of section in the zone adjacent the screw plug, a metallic jacket substantially enveloping the whole tapered portion of the body from the base thereof and supporting said driving band, said jacket having an external shape to form a cylindrical continuation of the projectile body, means to tightly fit said jacket on said body against the passage of gases of the service charge and to transmit to the jacket the rotation imparted by the gun rifling and to permit the jacket to be detached from the projectile body only during the piercing of the armor plate, a minimum resistance being thus offered to the air by the jacket on the trajectory.

2. A projectile as claimed in claim 1 characterized in that said body terminates at its rear end in a projecting rim of relatively small thickness liable to breakage during the piercing of the armor plate and retaining the metallic jacket.

3. A projectile as claimed in claim 1 characterized in that said body terminates at its rear end in a projecting rim of relatively small thickness liable to breakage during the piercing of the armor plate and retaining the metallic jacket, said driving band and metallic jacket being formed integral and of the same material.

4. A projectile as claimed in claim 1 characterized in that said metallic jacket consists of a plurality of annular elements applied one behind the other about the tapered portion of said projectile.

5. A projectile including an ogival head, a front band of the largest diameter allowed by the calibre and a body progressively shrinking in diameter for at least the greater portion of its length from the front band toward the base, a jacket of relatively plastic material rigidly applied around said part shrunk in diameter, a driving band on said jacket, said jacket extending in front of said band with an external diameter smaller than the diameter of the shell's head and decreasing in thickness progressively so as to become flush with the external surface of the body.

6. A projectile including an ogival head, a front band of the largest diameter allowed by the calibre and a body progressively decreasing in diameter from the front band towards the base, a jacket of relatively plastic material rigidly applied around said part of lesser diameter, a driving band on said jacket, said jacket extending in front of said band with an external diameter smaller than the diameter of the shell's head and decreasing in thickness progressively so as to become flush with the external surface of the body.

7. A projectile including an ogival head, a front band of the largest diameter allowed by the calibre and a body having a cylindrical section at the forepart and decreasing in diameter but free from abrupt decreases from a point between the front and the driving band and a substantial distance in advance of the driving band, toward the base, a jacket of a relatively plastic material rigidly applied around said part of decreased diameter, a driving band carried by said jacket, said jacket extending in front of said band with an external diameter smaller than the diameter of the shell's head and decreasing in thickness progressively so as to become flush with the external surface of the body.

8. A projectile including an ogival head, a body, a jacket of relatively plastic material rigidly applied around said body, a driving band carried by said jacket said body being of its maximum diameter at a point between the front of said body and said driving band but substantially in front of said driving band and decreasing toward the base, said jacket surrounding said part of larger diameter and decreasing in thickness toward the front to merge with the circumference of the body, the external diameter of said jacket being never greater than the maximum diameter of said body.

9. A projectile as claimed in claim 5, in which there is a circumferential rim at the rear-end of the body integral therewith and of substantially less thickness, the rear-end of said jacket abutting against said rim whereby the jacket is retained on the projectile during flight but may be torn away during perforation.

10. A projectile as claimed in claim 6, in which there is a circumferential rim at the rear-end of the body integral therewith and of substantially less thickness, the rear-end of said jacket abutting against said rim whereby the jacket is retained on the projectile during flight but may be torn away during perforation.

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