R. A. HADFIELD.

ARMOR PIERCING PROJECTILE AND CAP THEREFOR.

APPLICATION FILED NOV. 8, 1907. RENEWED JUNE 20, 1914.

1,172,278.

Patented Feb. 22, 1916.

3 SHEETS—SHEET 1.

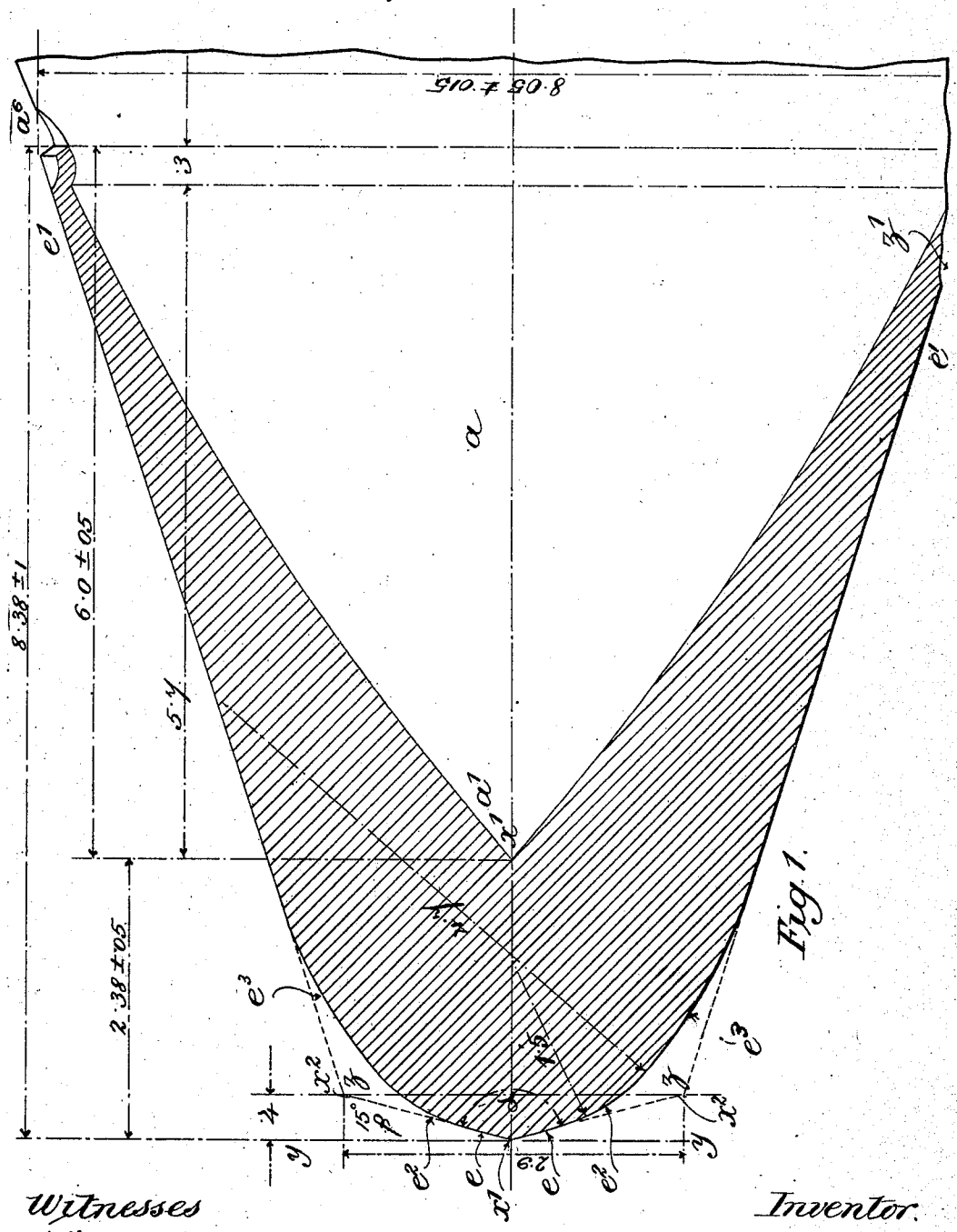


Fig. 1.

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William Cross

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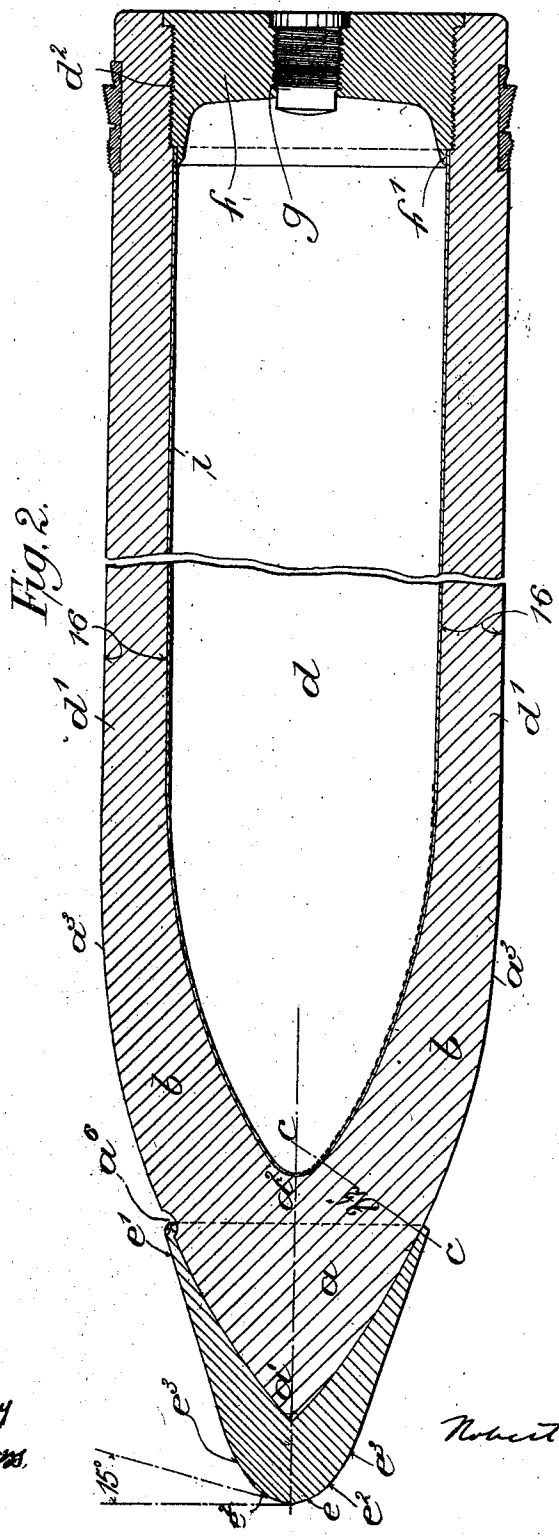
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3 SHEETS—SHEET 2.

Fig. 2.



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3 SHEETS—SHEET 3.

Fig. 3.

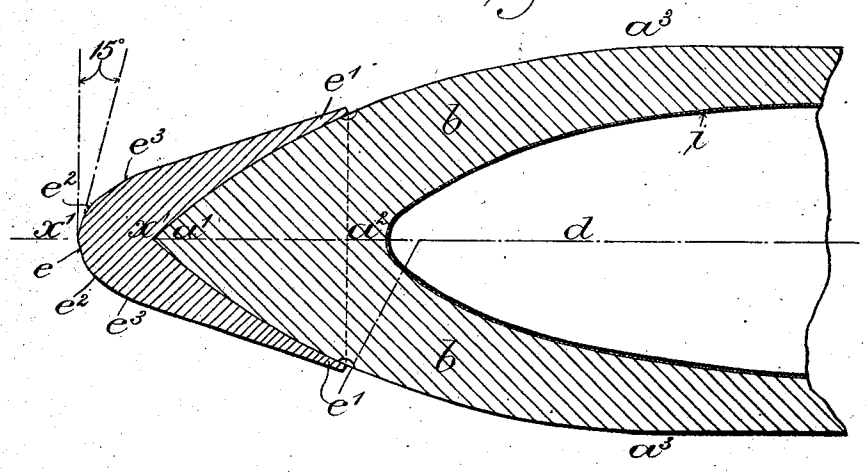
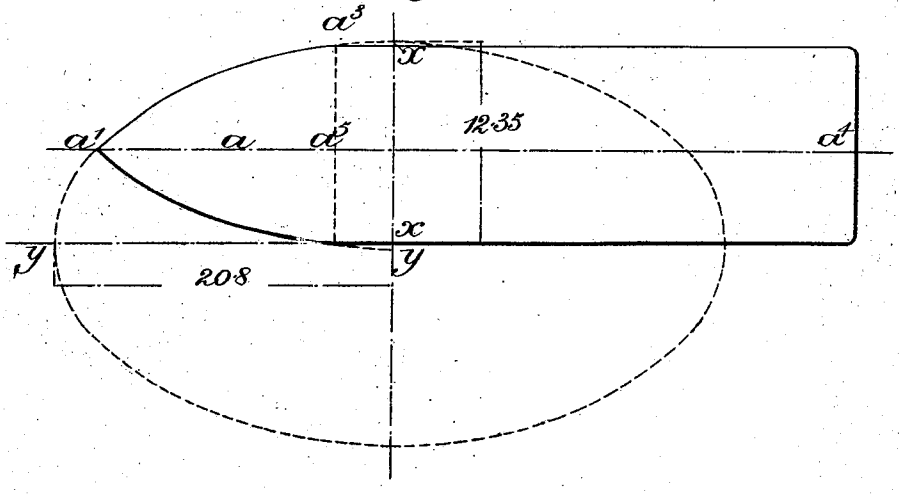


Fig. 4.



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UNITED STATES PATENT OFFICE.

ROBERT ABBOTT HADFIELD, OF SHEFFIELD, ENGLAND.

ARMOR-PIERCING PROJECTILE AND CAP THEREFOR.

1,172,278. Specification of Letters Patent. Patented Feb. 22, 1916.

Application filed November 8, 1907, Serial No. 401,362. Renewed June 20, 1914. Serial No. 846,383.

To all whom it may concern:

Be it known that I, ROBERT ABBOTT HADFIELD, a subject of the King of Great Britain and Ireland, residing at Sheffield, in the county of York, England, have invented Improvements in or Relating to Armor-Piercing Projectiles and Caps Therefor, of which the following is a specification.

This invention has reference to the manufacture or production of armor piercing projectiles having great penetrative power and range, a charge chamber of as large capacity as that of what are known as common or bursting shell, of corresponding size, and yet having a much stronger and harder head as compared with the weaker and unhardened head of such common shell, and non-liability to accidental ignition of the charge through premature or spontaneous fracture of the head or hardened portion of the projectile.

The invention also has reference to improvements in the construction of caps for use with armor piercing projectiles whereby not only is the efficiency of the caps improved but also the flight of the projectiles with which they are employed.

For these purposes an armor piercing projectile and a cap for use therewith, are constructed as will now be described with reference to the accompanying illustrative drawings wherein—

Figure 1 shows, in longitudinal section, a portion of a twelve inch capped projectile according to the invention; Fig. 2 shows in longitudinal central section and to a reduced scale, the whole of the capped projectile. Fig. 3 shows, in longitudinal section, part of a slightly modified construction of such capped projectile, and Fig. 4 is a diagram.

The projectile is constructed of high tenacity steel, such as nickel steel, or nickel chromium steel. It is preferably made of nickel chromium steel containing from about .6% to .7% (decimal six to decimal seven per cent.) of carbon, from about 1.5% to 2.5% (one decimal five to two decimal five per cent.) of chromium, and from about 1.5% to 2.5% (one decimal five to two decimal five per cent.) of nickel. Manganese, while preferably kept low, may go up to about 0.45% (decimal four five per cent.) Silicon and aluminium may advantageously be added either separately or in conjunction, for the purpose of producing sounder and better steel. The silicon should not usually exceed about 0.4% (decimal four per cent.,) and aluminium ordinarily about .1% to 0.2% (decimal one to decimal two per cent.)

The projectile is produced by casting it of steel of the kind referred to and of approximately the shape shown, with a charge or bursting chamber. For a twelve inch projectile, the head portion a is made of an axial length $a^1\ a^2$ of say about $7\frac{3}{8}''$ (seven and three eighth inches) and with a shoulder b of a thickness, say at the line $c\ c$, of about $3\frac{1}{2}''$ (three and a half inches), the thickness gradually diminishing rearward to the part where the wall d^1 of the bursting chamber d is of a uniform thickness of say about 1.6" (one decimal six inches). The bursting chamber is made about equal in capacity to that of an ordinary or bursting shell and for a considerable portion of its length is of cylindrical shape, as shown, its rear end being continued of practically or substantially the full diameter through the base of the projectile to the rear end thereof. For a projectile of a different size, the dimensions will usually be proportionate to those mentioned, or nearly so. The curve a^1—a^3 of the ogival head portion a of the projectile shown in Figs. 1 and 2 is circular and may correspond or approximate to a radius of about twice the diameter or caliber of the projectile, viz. twenty four inches in the case of the twelve inch projectile shown. In some cases however the curve a^1—a^3 of the head portion a is made, not with a constant radius, as in Figs. 1 and 2 but, as shown in Fig. 3, with a gradually increasing radius from the point a^1, so that the surface of the ogival head is flattest near the point a^1 and is of gradually increasing radius toward the point a^3. The curve a^1—a^3 preferably forms, as shown in Figs. 3 and 4, part of an ellipse whose semi-minor axis $x\ x$ is equal to about the diameter of the projectile, preferably to the diameter plus .4 (decimal four) and whose semi-major axis $y\ y$ is equal to about one and three quarter times the diameter of the projectile, preferably to the diameter multiplied by 1.74 (one decimal seven four), the ogival surface of the head a corresponding to that of a solid of revolution formed by the rotation of the portion a^1—a^3 of the ellipse, adjacent to the minor axis $x\ x$, about the longitudinal axis $a^1\ a^4$ of the projectile. In the case of a twelve inch projectile, whose real diameter is about 11.95" (eleven deci-

mal nine five inches), the semi-minor axis $x\ x$ of the ellipse will be 11.95″+.4=12.35″ (twelve decimal three five inches), and the semi-major axis $y\ y$ will be 11.95″×1.74=20.8″ (twenty decimal eight inches). The axial length a^1—a^5 of the ogival head portion of the projectile may be equal to about 1.2 (one decimal two) times the diameter of the projectile, that is to say, for a 12″ inch projectile, about 11.95×1.2=14.3″ (fourteen decimal three inches).

The form of head just described has been found to give better results in practice than the old form of head with a true radius, as regards its ability to perforate armor and is believed to be theoretically correct for armor perforation and probably also for range.

The projectile constructed as described, is then subjected to annealing and hardening and stiffening treatments such as described in the specification of my former British Patent No. 15219 of 1904, except that the head of the projectile is immersed to a less depth than before, in the cooling or hardening liquid, say to a depth of from about six to nine inches in the case of a twelve inch shell.

The projectile thus produced is provided with a metal cap having an obtuse conical pointed portion e and an acute conical rear portion e^1, these two portions being joined by a curved or rounded surface preferably made of two different radii, the front end portion e^2 of such curved surface being of smaller radius than the succeeding portion e^3. In the example, the conical front portion e has an angle α of about 150° (one hundred and fifty degrees), and the rear end portion e^1 an angle of about 36° (thirty six degrees); the forward ogive portion e^2 of the cap is made of small radius, say about 1.5″ (one decimal five inches) for the twelve inch shell shown, and the rearward ogive part e^3 of a larger radius, say of about 4.7″ (four decimal seven inches). The shape of the front end portion of the cap may be arrived at as follows: The axial thickness x^1—x^1 of the cap having been determined, about $2\frac{3}{8}$″ (two and three eighth inches) in the example, line $x^1\ x^2$ at an angle θ of about 15° (fifteen degrees) to a transverse plane $y,\ y$ at the end of the cap are marked off and a width $z\ z$ of about 2.9″ (two decimal nine inches) set out. The lines $z\ z^1$ joining the ends of the line $z\ z$ to the base of the cap are then drawn, forming a truncated cone having an angle of about 36° (thirty-six degrees). With its center on the axial line $x^1\ x^1$ and with a radius of about 1.5″ (one decimal five inches), an arc forming the curved portions e^2 is then struck so that the lines $x^1\ x^2$ are tangential thereto, and with a radius of about 4.7″ (four decimal seven inches) arcs forming the curved portions e^3 are drawn so as to be tangential to the lines $z\ z^1$ and touching the arc forming the curved portions e^2. The rear end portion e^1 of the cap may advantageously be of the dimensions indicated, but these may be varied to some extent without materially affecting the advantages resulting from the peculiar formation of the front end of the cap. It is however deemed advantageous to make the whole of the cap of the relative shape and dimensions indicated for a twelve inch projectile. For projectiles of other diameters, the dimensions of the cap will usually be proportionate to those indicated, or nearly so, except that the angles of the conical portions will be maintained at about those mentioned. The cap may be made of wrought iron, or of mild steel suitably toughened, as by heating it to a temperature between 950° C. and 1100° C. (nine hundred and fifty and eleven hundred degrees centigrade), then cooling it in air or other cooling medium, but preferably quickly, as by quenching in water or other liquid, afterward reheating it to a temperature of between about 600° C. and 800° C. (six hundred and eight hundred degrees centigrade), according to the toughness desired, and cooling it slowly.

The cap may be secured to the projectile in any desired and approved manner. In the example, it is secured by depressing portions of its base into a number of notches or recesses a^6 in the head of the projectile.

The rear end of the charge chamber d is screw-threaded at d^2 to receive a correspondingly screw threaded base closing plug f carrying the fuse holder g. The chamber d is or may advantageously be provided with a liner i of thin sheet metal, for example copper, made of the same shape as and closely fitting the inner surface of the chamber d. For this purpose, the liner, which may be made of sheet copper of about three one-hundredths of an inch thick, may be made as a hollow body of approximately the shape of the chamber and be forced into close contact with the inner surface thereof, which may be in its ordinary cast condition, by expanding it, as by an elastic or expansible core. The rear open end of the liner is extended backward sufficiently to surround the forwardly projecting end f^1 of the base closing plug f which is made of slightly less diameter than the remainder of the plug so as to fit into and close the rear end of the liner and securely hold the liner in place in the projectile. By the construction described, the liner i can be readily fitted into the projectile and securely fixed in place therein at any time after the projectile has been completely finished, and it can, if required, be readily removed after screwing the plug f out of the base of the projectile.

Armor piercing capped projectiles or shells constructed as hereinbefore described and of the relative dimensions set forth, possess great practical advantages as compared with earlier constructions of armor piercing projectiles, their hardened head portions being specially adapted for perforating hard armor plate and the stiffened and toughened walls of their bursting chambers being specially adapted to withstand the shock of impact, while such walls are at the same time capable of being readily burst by ignition of the bursting charges within such chambers. Furthermore, by the use of a liner secured in place as described, any liability of the bursting charge being accidentally ignited by a spark produced by premature or spontaneous fracture of the head or hardened portion of the projectile, either when being fired, or while in store, will be prevented. Also, caps constructed as described can advantageously be used with armor piercing projectiles other than those of the special construction hereinbefore described and shown in the drawings.

As best shown in Fig. 2 the cap is short and small as compared to the projectile, the length of the portion of the cap in front of the projectile point being less than one fifteenth the total length of the projectile, and said cap portion being in length substantially one third the length of said projectile portion in front of the chamber and the cap extending back over more than about two thirds of said projectile portion in front of the chamber whereby the cap is firmly secured in place.

What I claim is:—

1. An armor piercing shell provided with a steel cap, said cap having an obtuse conical point, an acute conical rear portion and an intermediate curved surface merging into the end portion and the rear portion, said curved surface being of two radii of different lengths, the front portion of said curved surface being of a shorter radius and the rear portion of a longer.

2. An armor piercing projectile provided with a metal cap comprising a conical front end portion having an angle of conicity of about 150 degrees, a conical rear portion having an angle of conicity of about 36 degrees, and an intermediate portion having its surfaces merging into those of the front and rear portions and made of two different radii in the proportion of about 1.5 inches and 4.7 inches for a twelve inch projectile, substantially as described.

3. A cap for an armor piercing shell, having an obtuse conical point, the sides of the conical point being substantially at an angle of 15° to a plane transverse to the end of the point, said cap having an acute conical rear portion and a curved portion intermediate the point and the rear portion.

4. An armor piercing projectile made of high tenacity steel and having an ogival head the surface of which, in longitudinal section, is in the form of a segment of an ellipse as set forth, and a metal cap attached to said head and having an obtuse angled conical front end portion, an acute angled conical rear end portion and an intermediate portion having a curved surface in longitudinal section, the side walls of the cap extending back adjacent to a transverse plane through the front end of the chamber.

5. An armor piercing shell fitted with a small light cap and having a charging chamber not substantially less in length than three-quarters the length of the shell and being substantially cylindrical throughout the greater portion of its length, the various parts of the shell and cap being made in about the following proportions as compared to a twelve inch shell, namely the axial length of the shell head from the chamber to the tip about seven and three-eighths inches, the thickness of the shell wall at the shoulder about three and one-half inches, and the thickness of the wall tapering therefrom to a uniform thickness of about one and six-tenths inches; the axial length of the cap being about two and three-eighths inches and tapering therefrom to its end about the shoulder.

Signed at 28 Hertford street, Mayfair, London, England, this fourteenth day of October, 1907.

ROBERT ABBOTT HADFIELD.

Witnesses:
WILLIAM CRAWLEY,
WILLIAM CROSS.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."