(No Model.)

R. LOW.

PROCESS OF HARDENING OR TEMPERING STEEL PROJECTILES.

No. 442,065. Patented Dec. 2, 1890.

Fig. 4.

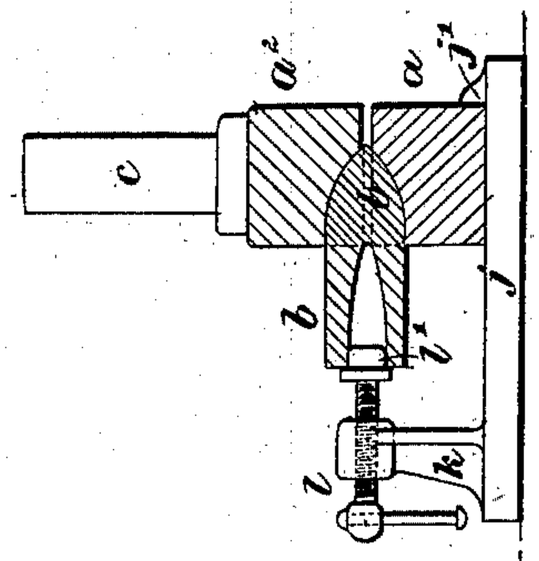


Fig. 3.

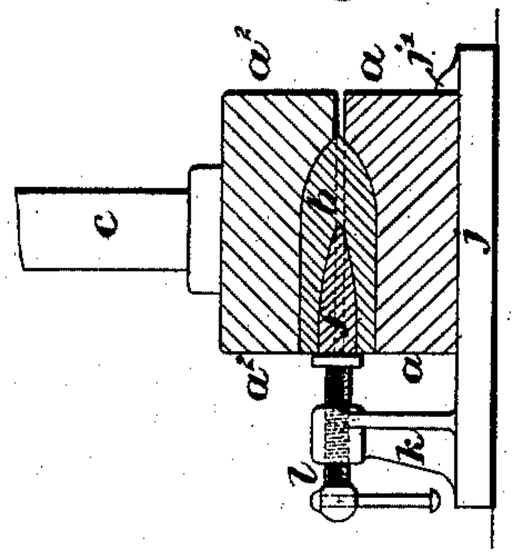


Fig. 2.

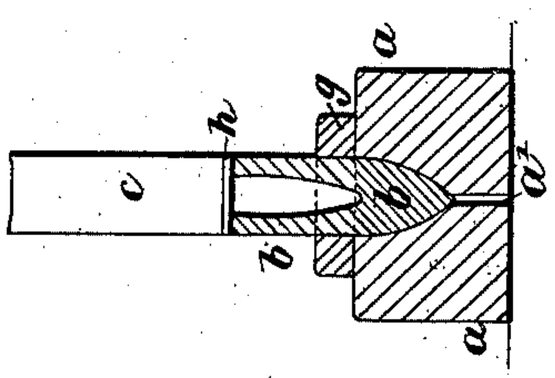
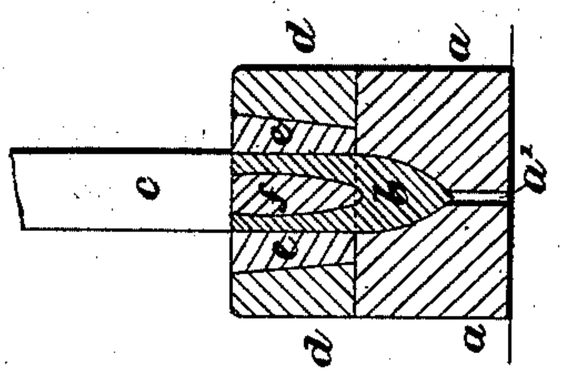


Fig. 1.



Witnesses.

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UNITED STATES PATENT OFFICE.

ROBERT LOW, OF WOOLWICH, ENGLAND.

PROCESS OF HARDENING OR TEMPERING STEEL PROJECTILES.

SPECIFICATION forming part of Letters Patent No. 442,065, dated December 2, 1890.

Application filed November 16, 1888. Serial No. 291,060. (No model.) Patented in England April 23, 1887, No. 5,954; in Belgium February 29, 1888, No. 80,724, and in France April 25, 1888, No. 188,799.

To all whom it may concern:

Be it known that I, ROBERT LOW, engineer, a subject of the Queen of Great Britain, and a resident of Woolwich, England, have invented a new and useful Improved Process of Hardening or Tempering Steel Projectiles, (for which I have obtained patents in the following countries: in Great Britain, No. 5,954, dated April 23, 1887; in France, No. 188,799, dated April 25, 1888, and in Belgium, No. 80,724, dated February 29, 1888,) of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to steel projectiles, and comprises an improved process or method of hardening or tempering the same, so that their strength and penetrativeness are greatly increased as compared with those hardened or tempered by the methods hitherto adopted.

The hardening or tempering of armor-piercing projectiles has heretofore been usually effected by heating them to the required temperature, and then wholly or partially immersing them in oil or other liquid. It has been found, however, that this method of hardening or tempering such articles as projectiles, though efficient in respect of imparting the required hardness to the steel at or near the surface of the projectile, is attended with the serious disadvantage of liability to splitting or cracking of the metal and consequent destruction of the projectile after the entire cost of its manufacture has been incurred.

My invention affords the means for effectually hardening or tempering the projectiles without the use of water or other liquid, and, moreover, it obviates the risk of injuring or destroying the projectiles in the manner above described.

In hardening or tempering a projectile according to my said invention, I proceed as follows—that is to say: I heat the said projectile to the required temperature and place the same (preferably in a vertical position with its conical, conoidal, or ogival end downward) in a supporting die or mold of cast-iron or other suitable material, the cavity in which is of the same or approximately the same dimensions and shape or configuration as the projectile or portion thereof. When commencing operations, the mold is preferably heated (say to a temperature of from 200° to 300° Fahrenheit) before a projectile is inserted, in order to avoid chilling of the surface of the said projectile. In continuing the operations sufficient heat is imparted to the mold by each projectile to prevent chilling of the next projectile inserted. While the projectile is in this mold I subject it to pressure by means of hydraulic or other power for the purpose of keeping the surface of the projectile in intimate contact with the interior of the mold, and thus insuring the conduction of the heat away from the projectile through the metal of the mold. This pressure is maintained until the projectile is sufficiently cooled and hardened, and the projectile is then removed from the mold. If the projectile to be tempered by the above-described process is made from steel rich in carbon and containing about four per cent. of chromium, I find that very good results are obtained by heating the said projectile before placing it in the die or mold to a temperature of from 1,400° to 1,600° Fahrenheit, according to its size, and then allowing the said projectile to cool down to a temperature of about 200° Fahrenheit before removing it from the mold. The temperatures to which the projectiles are heated and allowed to cool will, however, necessarily vary with different compositions of steel, and as in tempering by the well-known methods with water or oil the operator must to a great extent be guided by his experience of the steel with which he is dealing. I find it advantageous to use a mold having a central hole or recess into which the point of the projectile will enter. I thus avoid liability to excessive hardening of the point of the projectile and injury of the point in the operation of placing the projectile in the mold. Moreover, the said hole permits the escape of any scale, dust, or the like which may be introduced into the mold with the projectile or otherwise. The mold must be of greater or less depth, according to the length of the portion of the projectile which it is desired to harden or temper. If the entire surface of

the projectile is to be hardened, the cavity in the mold should be of the same or nearly the same depth or length as the projectile.

In the accompanying drawings, Figure 1 is a vertical central section of apparatus for holding a projectile while subjected to pressure and at the same time cooling it, a part of the hydraulic ram for applying the pressure being shown in elevation. Fig. 2 is a similar view showing a modified form of the said apparatus.

The remaining figures are hereinafter referred to.

a is the mold; *b*, the projectile; *c*, the hydraulic ram. The mold *a* is made with a central hole *a'* for the purpose above specified, and its cavity is of such dimensions and shape or configuration that the conical or conoidal end of the projectile will fit accurately therein. A ring or annular piece *d* is placed upon the mold *a* and has fitted therein taper segments *e*, so formed that they will fit accurately within the said ring or annular piece and closely around the cylindrical portion of the projectile. These segments can be readily withdrawn from the ring or annular piece *d* to facilitate the removal of the projectile from the mold *a*.

A plug, mandrel, or core-piece *f* is inserted in the chamber or cavity of the projectile to prevent upsetting of its walls or deformation of the said chamber or cavity. This mandrel receives pressure from the ram and transmits it to the interior of the shell.

The apparatus shown in Fig. 1 is designed for use when the entire mass of the projectile is to be condensed and hardened.

If the conical, conoidal, or ogival end only of the projectile is to be condensed and hardened, I dispense with the said ring or annular piece and segments and also with the said core-piece, and, as shown in Fig. 2, simply place a ring *g*, of metal or other suitable material, upon the mold *a* to conduct away some of the heat from the projectile, and thus insure a gradual diminution of the hardness of the metal of the projectile at the top of the mold *a*. I prefer, moreover, to place a disk or pad *h*, of asbestus or other suitable nonconductor or slow conductor of heat, between the base of the projectile and the ram *c* to prevent cooling of the said base by the ram.

By applying the pressure in the manner illustrated in Figs. 1 and 2 the particles or molecules are compelled to assume under the contraction due to the cooling such a condition or arrangement that they will offer the greatest resistance to endwise compression, and this result is effected without inducing the state of tension which would be induced by cooling in liquids. Consequently the stress to which the projectile is subjected in the act of penetration is a repetition of that to which it has already been subjected when in the mold. In some instances I employ a mold in which the projectile lies horizontally. This mold is made in two parts or halves, in one of which the projectile is to be laid and the other of which is to be placed over the said projectile, and I apply pressure either continuously or intermittently to the projectile while in the said mold in a direction at right angles to its axis; or I may form the mold of three, four, or more segments provided with means for adjusting them, so as to apply the pressure equally all round the projectile.

Figs. 3 and 4 are sectional elevations showing different forms of apparatus in which the projectile is to be placed horizontally. This apparatus comprises lower and upper dies or molds a a^2. The lower die or mold a is supported upon a base-plate j, formed with lugs or bearing-pieces j'. The upper die or mold a^2 may be firmly attached to the ram *c*. The base-plate j is provided with a standard k, through which is passed a screw l. In some instances a mandrel or plug f is inserted in the cavity of the projectile or shell, as in Fig. 3. In other instances the screw l is provided with a plug l', as in Fig. 4, which fits into the cavity of the projectile or shell. This screw prevents the displacement of the projectile from the mold when subjected to the pressure of the ram. If the pressure is to applied intermittently, the said screw may be slackened from time to time and the projectile partially rotated. Whatever may be the construction of the mold it should be made to conform to or fit the exterior of the projectile or a portion thereof, and the projectile while in the mold should be kept under pressure, so that there may be close contact between all parts of the surface to be hardened and the mold, and the heat of the red-hot mass of metal may be conducted freely away through the body of the said mold.

Having now fully described and ascertained the nature of my said invention and the manner in which it is to be performed, I wish it understood that I do not claim generally or irrespectively of my improvements herein set forth the treatment of steel by heating the same and subjecting it to pressure in a mold, as I am aware that such treatment of steel has been described in the specification of the British Patent No. 3,062, of 1874, granted to Sir Joseph Whitworth, and also in the specification of the French Patent No. 147,010, granted to M. Clemandot; nor do I claim the methods of treatment described in the specifications of the United States Patents Nos. 178,044 and 407,536.

What I claim is—

1. The method of hardening or tempering a projectile or shell, consisting in heating the said projectile, placing it in a metal mold the internal shape of which exactly corresponds to the external shape of the projectile or of the part thereof to be hardened, and which has been previously warmed to prevent chilling of the surface of the projectile, and then subjecting the projectile to pressure in the mold to insure intimate contact of the surface of the projectile with that of

the mold until the said projectile is cooled sufficiently to impart to it the desired degree of hardness, substantially as and for the purposes set forth.

2. The method of hardening or tempering a projectile or shell, consisting in heating the said projectile, placing it in a metal mold the internal shape of which exactly corresponds to the external shape of the projectile or of the part thereof to be hardened, and which has been previously warmed to prevent chilling of the surface of the projectile, and then subjecting the projectile to pressure in the mold to keep its surface in intimate contact with the interior of the mold until the said projectile is cooled sufficiently to impart to it the desired degree of hardness, such pressure being caused to act from the base toward the point of the projectile, substantially as and for the purposes set forth.

3. The method of hardening or tempering a projectile or shell, consisting in heating the said projectile, placing it in a metal mold the internal shape of which exactly corresponds to the external shape of the projectile or of the part thereof to be hardened, and which has been previously warmed to prevent chilling of the surface of the projectile, and then subjecting the projectile to pressure in the mold to keep its surface in intimate contact with the interior of the mold until the said projectile is cooled sufficiently to impart to it the desired degree of hardness, the said mold having a cavity or opening through which the extreme point of the shell will project and through which the gases and scoriæ may escape, substantially as and for the purposes set forth.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

ROBERT LOW.

Witnesses:
WM. ROBT. LAKE,
DAVID YOUNG.