

No. 709,631.

Patented Sept. 23, 1902.

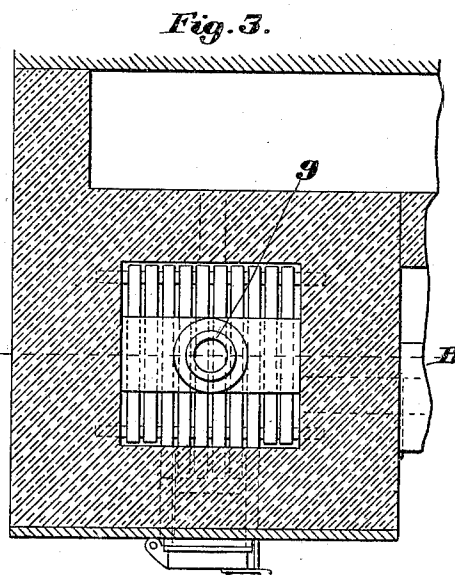
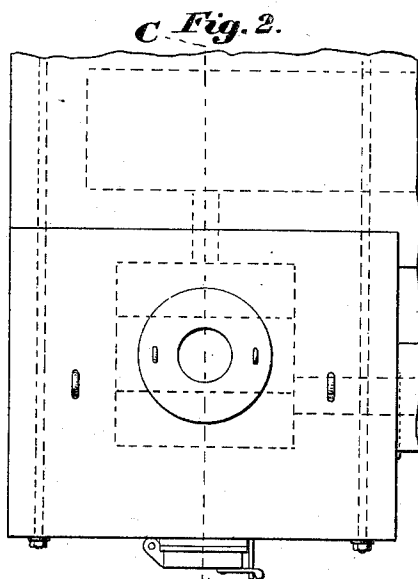
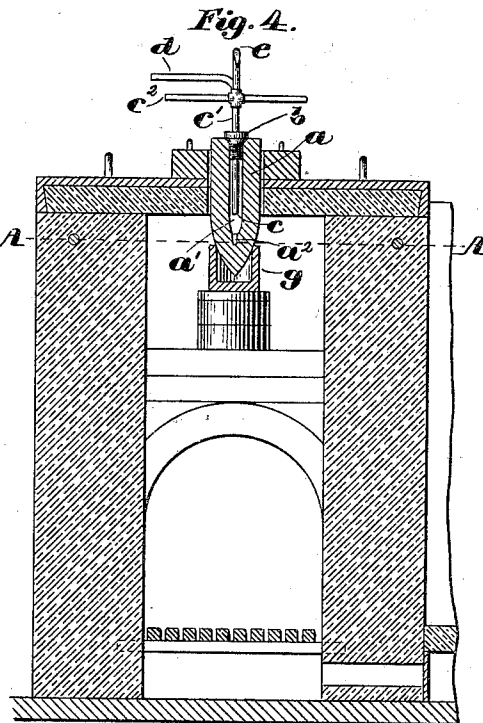
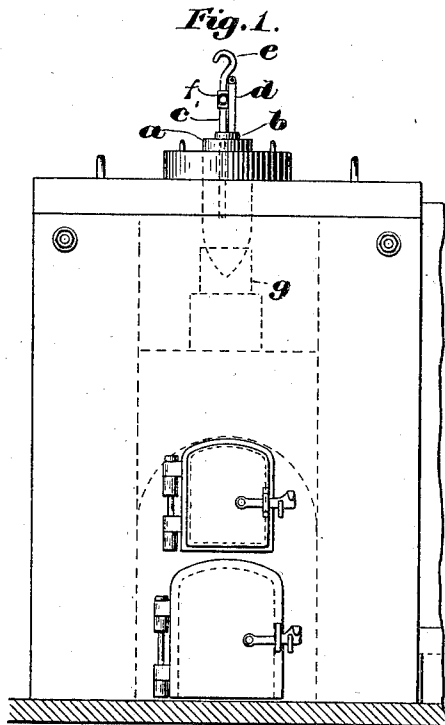
R. A. HADFIELD.

PROCESS OF HARDENING PROJECTILES.

(Application filed May 17, 1898.)

(No Model.)

2 Sheets—Sheet 1.



Witnesses: C
Walter Edmund
Edward H. Allen.

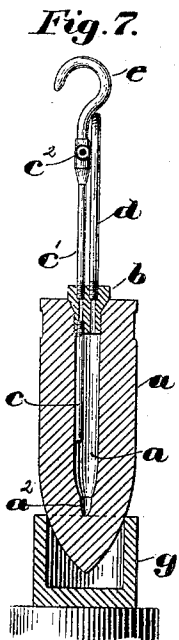
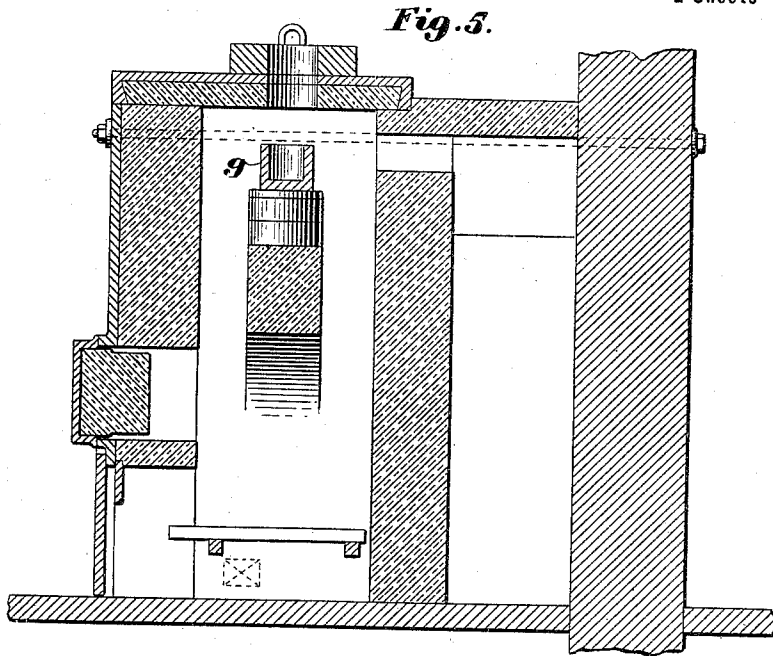
Inventor:
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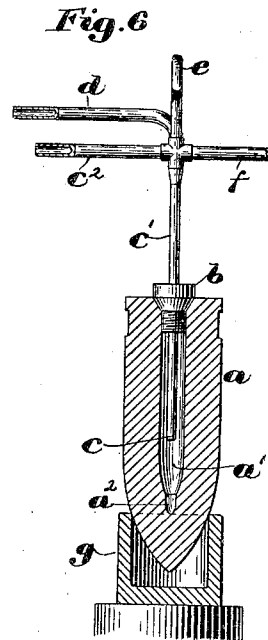
(Application filed May 17, 1898.)

(No Model.)

2 Sheets—Sheet 2.



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UNITED STATES PATENT OFFICE.

ROBERT A. HADFIELD, OF SHEFFIELD, ENGLAND.

PROCESS OF HARDENING PROJECTILES.

SPECIFICATION forming part of Letters Patent No. 709,631, dated September 23, 1902.

Application filed May 17, 1898. Serial No. 680,955. (No specimens.)

To all whom it may concern:

Be it known that I, ROBERT A. HADFIELD, a subject of the Queen of Great Britain, residing at Sheffield, county of York, England, have invented Improvements in the Method of Hardening Projectiles, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My invention has for its object the manufacture in an economical manner of steel armor-piercing projectiles of an efficient kind produced by casting, or it may be partly by casting and partly by forging. (See the specification of my British Patent No. 3,237 of 1892 and United States Patent No. 522,012.)

Of any suitable alloy I cast a hollow projectile of any desired form in a mold of appropriate construction.

If the projectile is to have a forged point or a forged point and shoulder, I produce it after the manner described in the specification of my former patent, No. 3,237 of 1892, already mentioned.

I effect the hardening of the projectile as I will now proceed to explain, with reference to Figs. 1 to 7, inclusive, of the accompanying illustrative drawings, premising that, as will be evident, the details are susceptible of modification according to requirement.

Figure 1 shows a tempering-furnace in front elevation adapted for use in practicing my invention. Fig. 2 shows a plan of the furnace. Fig. 3 is a horizontal sectional view of the furnace on the line A A of Fig. 4. Fig. 4 is a vertical sectional view thereof on the line B B of Fig. 3. Fig. 5 is a vertical sectional view thereof on the line C C of Fig. 2. Figs. 6 and 7 show, on a larger scale, vertical sections in planes at right angles to one another of a shell with its point in a pot and with internal liquid cooling appliance, hereinafter described.

The plant I employ includes, besides a couple of furnaces, which are preferably of the construction shown, suitable cooling-tanks and an overhead crane adapted to command the furnaces and the hardening-tanks; but I only show one furnace and the crane. The ways it travels on and the hardening-tanks are not illustrated in the drawings.

The shell produced by casting or casting and forging, as the case may be, is prepared to receive and has screwed into it the combined suspending and liquid cooling arrangement represented in Figs. 1 and 4 and to a larger scale in Figs. 6 and 7, where *a* is the shell, *a'* its chamber, *a²* a forwardly-extending portion thereof, which enables the cooling medium to abstract heat more quickly from the thick mass of metal, and thereby prevents cracking. This portion *a²* is preferably bored and is so small that it does not appreciably affect the strength of the shell-head.

b is a plug which is screwed into the threaded base end of the chamber *a'* and is made with two holes through it, into one of which are screwed the inner and outer portions *c c'* of the inlet-pipe, while into the other hole is screwed one end of the outlet-pipe *d*. The upper part of the part *c'* of the inlet-pipe carries a junction-piece, into which are screwed to the part *c²* of the inlet-pipe the suspending-hook *e* and the handle *f*. Thus it will be understood that by means of the hook *e* the shell, with the appliances attached to it, can be supported and that by means of the handle *f* the shell can have imparted to it during the heating process sufficient movement in a rotary sense to insure uniform heating of the shell, which for this purpose is not left in the one position, but is continually turned by the attendant.

In practicing my invention I prefer to use two furnaces to save time and also to prevent the steel from remaining long at a high temperature.

It would be impossible to put into the high-temperature furnace a cold projectile, and consequently I prefer to first heat the projectile in the preliminary or low-temperature furnace, as will be described, and thereafter the heating of the projectile is quickly completed in the second furnace. Again, the projectile having been heated in the first furnace to, say, a low red, the final heating can be accomplished very quickly in the second furnace, and the steel is not kept at a high temperature for a long time—a most objectionable feature present in most methods of hardening.

The shell is first heated in one furnace very gradually—say for about thirteen minutes,

more or less—and so that it comes out of this furnace at a very dull red at the point and only black-hot at the shoulder. *g* is a pot, preferably of cast-steel, into which the point of the shell may be and preferably is caused to project, so as to be thereby protected during the process of heating in the first furnace and prevented from becoming overheated, as it would otherwise be liable to do, in consequence of being of thinner section than other parts of the shell, and therefore heating more rapidly. The shell is then placed into the second or high-temperature furnace for completion of the heating operation. It is kept in that second furnace, say, about fourteen minutes, more or less, so as to bring the point and shoulder (which are again protected by a pot *g*) to a temperature suitable for hardening—say to a bright-red or low-yellow heat—gradually tapering off until, for example, in a six-inch shot, which is eighteen inches long, it dies out entirely at about seven inches from the base—that is to say, until seven inches down from the base there is no visible appearance of heating. It is important that the portion which is to be hard be kept at as uniform a temperature as practicable.

The heating is not pressed much at first. It is desirable to get a covering of soot on the projectile, as this is useful in preventing overheating and oxidation.

As the correct temperature for quenching is approached care must be exercised to prevent overheating and consequent water-cracking or underheating and consequent failure to secure the required hardness.

During the heating the room must be practically light-proof, darkness being necessary to obviate confusion arising from various shades of light. Sliding roof-doors easily adjusted give sufficient light when the heating operation is over.

The indication that the proper temperature has been attained will to some extent vary according to the particular temper of steel; but a workman accustomed to tempering shell will be able to judge from the appearance when the correct temperature has been attained.

The shell must be thoroughly heated through. In some cases the interior of the chamber—that is, for a certain distance, say about one inch to two inches from the bottom—may be hardened. When the shell is cold, it can be readily determined by the use of a round file inserted into the chamber of the shell whether the desired hardening has been effected.

As will be seen from the drawings, only about one-half of the entire length of the shell extends into the furnace. The point and shoulder will thus be heated most, while the remaining portion of the shell will remain comparatively cool, decreasing in temperature toward its base. For example, on a six-inch shell eighteen inches long I consider it

advantageous to aim at about from nine inches to nine and one-half inches of unfillable portion, measuring from the point. The shell after attaining the desired temperature is then rapidly removed to the hardening-tank. I have found it advantageous to use water only in the tank, keeping it at a temperature of about 80° Fahrenheit.

The inlet-tube *c*² (see Fig. 6) is connected, preferably, while the shell is traveling from the furnace to its position in the hardening-tank in some suitable way, such as by an india-rubber pipe, to the service-main, in which the liquid should be at a high pressure—say, for example, by preference, a pressure of about seventy-five pounds per square inch. I so arrange the supply that the exact quantity of liquid passing through the chamber of the shell may be known, and I aim at keeping this as nearly uniform as practicable. A short time—say five seconds or thereabout—before and during the whole period of the immersion of the shell in the tank, cooling liquid, such as water or oil at a temperature of 60° Fahrenheit, or thereabout, is allowed to pass through the chamber of the shell. This enables the contraction to be led from the center. If it be desired not to cool the interior of the chamber so quickly, the temperature of the water may be increased, or if it be desired to cool the chamber still more slowly steam or compressed air may be passed through the chamber. For a short time—say a second or two—before or at the commencement of the immersion or during the immersion of the shell steam comes from the outlet-pipe, followed by water, first at a high temperature, but quickly cooling down.

When it is not desired to harden the interior of the shell, I often find it advantageous to employ as the liquid for cooling the chamber of the shell an emulsion of water and oil, or during the first few seconds of the cooling (or more than this, if requisite) I pass through the chamber oil only; this being followed by an emulsion of oil and water or by water only, the supply of the liquids being continuous. In this case the oil is pumped or driven through the chamber from an independent source or sources. If desired, various cooling liquids may be passed through the chamber successively, the liquids being supplied from independent sources, communication with which is controlled by a series of cocks so arranged that any one or more of them can be operated without interfering with the others or with the main supply of water. I have obtained satisfactory results in a six-inch shell by using whale-oil and water successively, passing about one gallon of oil through the chamber before admitting the water.

In some cases it may be desirable to pass oil through the chamber during the whole of the cooling operation, this being varied according to the hardness it is desired to give the projectile.

If the shell be made too hard, then it may break at once. If it be not hard enough, the heating operation must be repeated, care being taken to heat the once-hardened shell much more slowly, for which purpose I find it convenient to first place it on the top of the furnace until it becomes too hot to touch by hand. In order to ascertain if each shell is hardened to a certain length on the outside and also if the interior is hardened at the bottom of the chamber, the operator should test the shells with a file. The hardening zone will, as is well understood, vary to some extent, according to the caliber of the shell and the qualities and thickness of the plate the shell is intended to pierce.

I immerse the shell completely in the hardening-tank, as distinguished from merely dipping it as far as the hardening-line, the immersion being effected after the initial cooling has begun.

A convenient size of quenching-tank for shell of six inches caliber is about three feet square and deep enough to permit complete immersion of the shell to be treated, and, although somewhat larger shell might be quenched in tanks of these dimensions, it is advisable to have proportionately larger tanks for larger calibers of shell. The temperature of the water in the tank should be 80° Fahrenheit, or thereabout, and the shell should remain immersed, in the case, for example, of shell six inches by eighteen inches long, say, for from fifteen to eighteen minutes, or thereabout, and then removed when quite cold. The temperature of the water in the tank will then usually be 88° Fahrenheit, or thereabout. The tank is kept supplied with fresh cold water in any convenient manner, usually by means of a pipe passing up through the bottom of the tank and so arranged that the water supplied through it will play upon the downturned point and the shoulder of the shell.

I take the temperature of the liquid in the tank at frequent intervals—say every quarter of a minute—as well as the temperature of the water escaping from within the shell. The temperatures thus obtained serve to indicate, approximately, whether the shell has been hot enough and whether the hardening process has been correctly carried out in the particular case. The exact hardening zone is first determined by the specification the shell has to meet. If intended for penetrating a thick plate, the hardening zone of the shell must be greater, in which case the risk of fracture would be greater; but if the operation be carried out carefully and the shell be thoroughly sound and free from defects the risk of breakages may generally be confined to a small percentage.

In speaking of increasing or decreasing the hardening zone of the projectile I mean the depth of hardness in the mass of metal and also the greater or less distance the hardened portion extends from the point toward the

base of the projectile, the hardening zone being graduated according to the character of armor-plate which is to be attacked by the projectile—that is, if the projectile is to attack thin plates the depth of the hardening zone would be much less than if the projectile is designed to attack heavy plates.

The hardening zone is increased or diminished according to the heat of the projectile and the depth to which it is allowed to enter the furnace. The greater the hardness the lower the projectile will be inserted into the furnace, and vice versa.

Having fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The method of hardening projectiles, which consists in gradually heating the point and shoulder of the projectile to a temperature suitable for hardening; wholly removing it from the action of the heating medium; subsequently cooling the projectile initially from its interior, and finally completely immersing the projectile in a cooling liquid.

2. The method of hardening projectiles, which consists in gradually heating the point and shoulder of the projectile to a bright-red or low-yellow heat, and wholly removing it from the action of the heating medium; thereafter cooling the projectile initially from its interior, and after such internal cooling has begun completely immersing the projectile in a cooling fluid.

3. The method of hardening projectiles, which consists in rotating the projectile and gradually heating the point thereof to a dull red, continuing the heating until the point and shoulder are brought to a temperature suitable for hardening; removing the projectile from the heating medium, and thereafter circulating a cooling medium through the chamber of the projectile, and completely immersing the projectile in a cooling fluid after the internal cooling has been initiated.

4. The method of hardening projectiles, which consists in suspending the projectile, point down, in a furnace, rotating the projectile, and gradually heating the point and shoulder of the same to a hardening temperature while rotating the projectile, and protecting the point thereof from the direct action of the heat, and finally completely immersing the projectile in a cooling medium.

5. A method of hardening projectiles, which consists in raising the temperature of the point and shoulder to a bright-red or low-yellow heat by successive heatings while protecting the point of the projectile from the direct action of the heat; circulating a cooling medium under pressure through the chamber of the projectile after removal of the same from the heating medium; withdrawing the protection from the point of the projectile, and completely immersing the latter in a cooling medium after internal cooling and hardening has begun.

6. The method of hardening projectiles,

which consists in raising the temperature of the point and shoulder to a bright-red or low-yellow heat by successive heatings, while protecting the point from the direct action of the heat; thereafter circulating a cooling medium under pressure and at a temperature of about 60° Fahrenheit through the chamber of the projectile, beginning before and continuing throughout the immersion, and completely immersing the projectile in a cooling liquid having a temperature of about 80° Fahrenheit until the projectile is quite cool.

7. The method of hardening chambered projectiles, which consists in rotating the projectile, suspended, point downward, in a furnace, and gradually heating the point and

shoulder to a hardening temperature while protecting the point from the direct action of the heat; removing the projectile from the furnace to a hardening-tank; circulating a cooling medium under high pressure through the chamber of the projectile after its removal from the furnace, and completely immersing the projectile in a cooling medium in the tank.

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

R. A. HADFIELD.

Witnesses:

LILLIE JANE WHEELER,
RICHARD WHEELER.