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H. S. MAXIM.

PROCESS OF AND APPARATUS FOR HARDENING ORDNANCE.

No. 446,532. Patented Feb. 17, 1891.

Fig. 1.

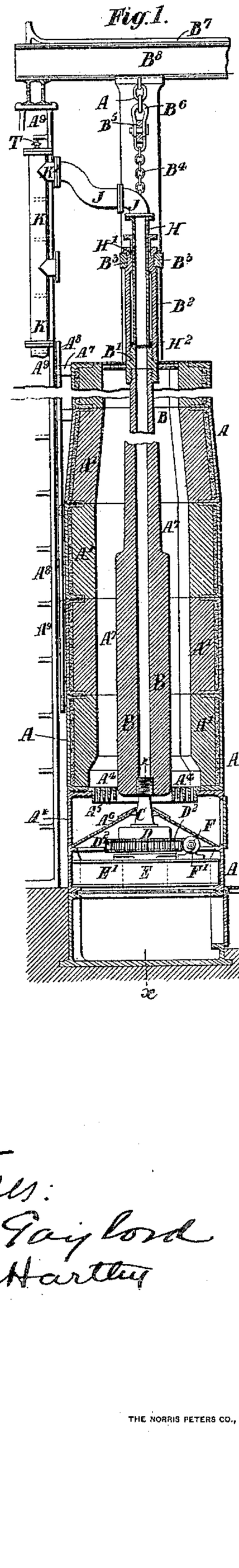

Fig. 2.

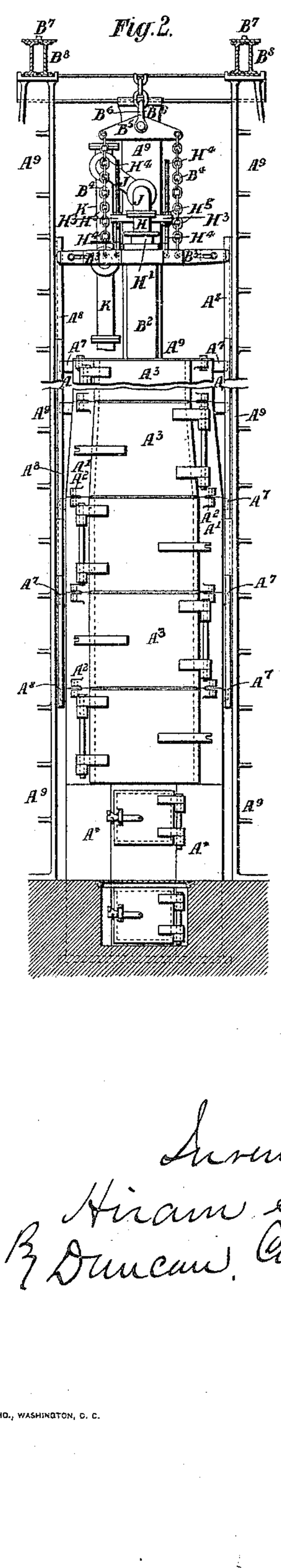

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Fig. 3.

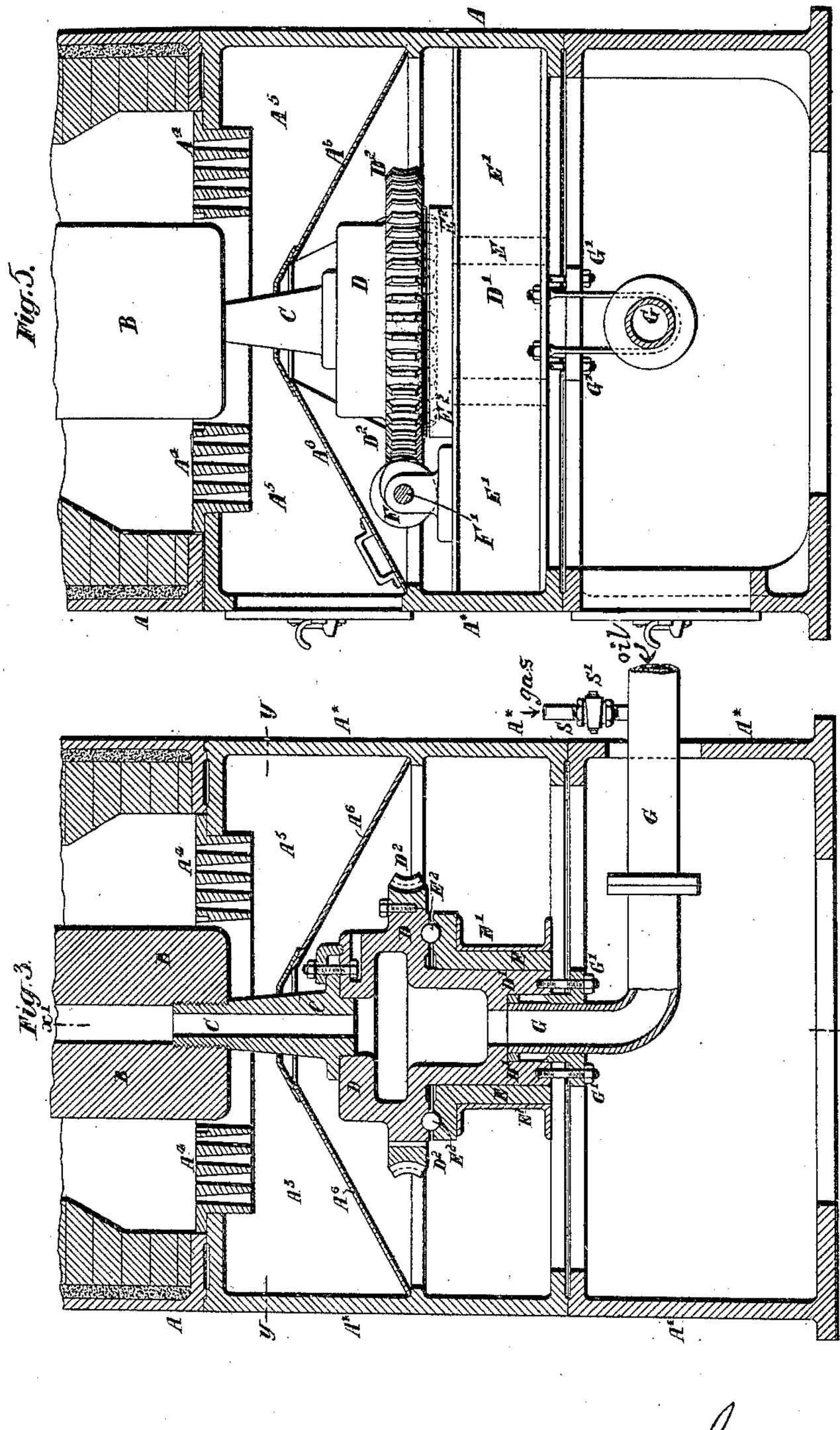

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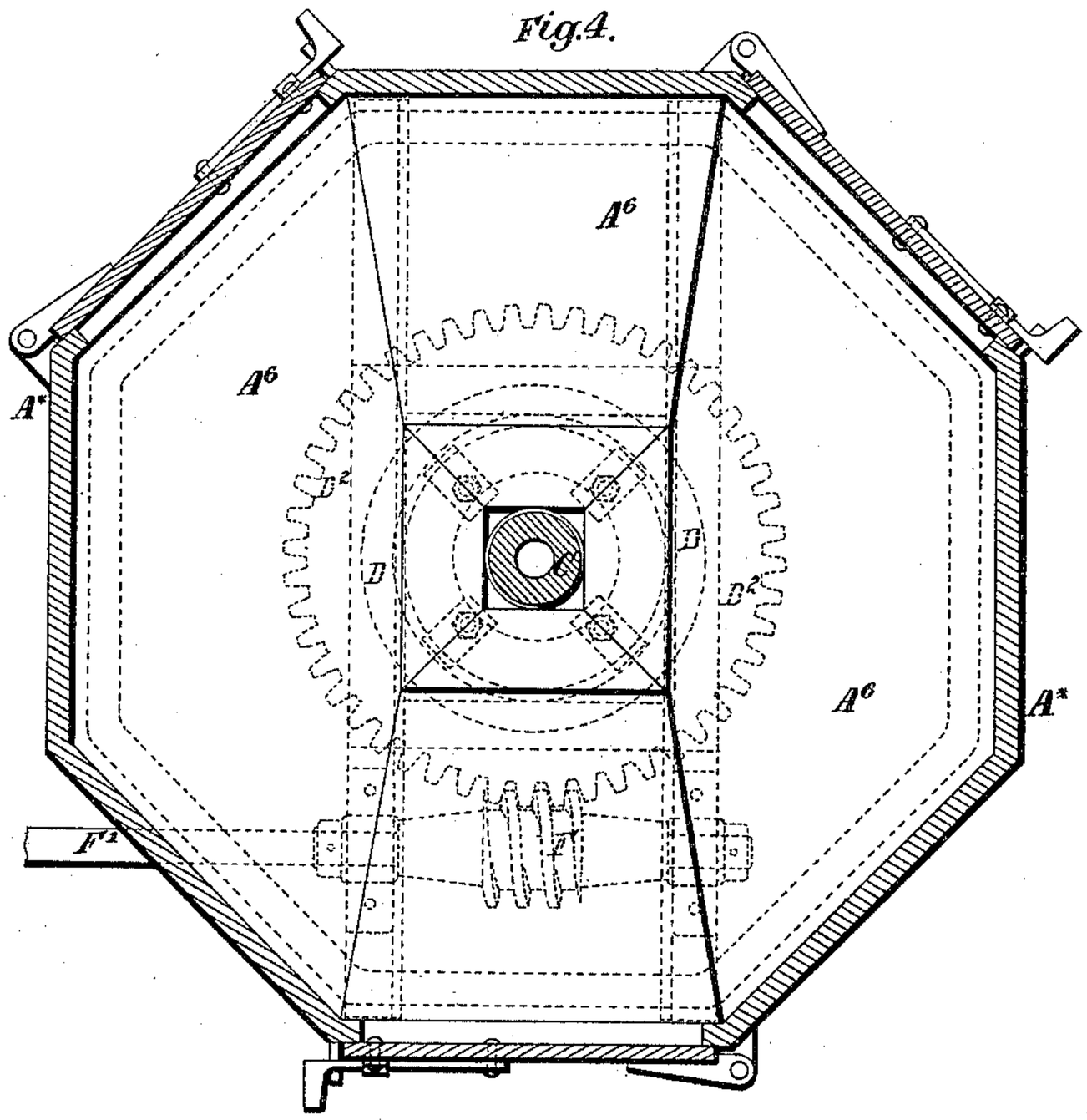
Fig. 4.



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PROCESS OF AND APPARATUS FOR HARDENING ORDNANCE.

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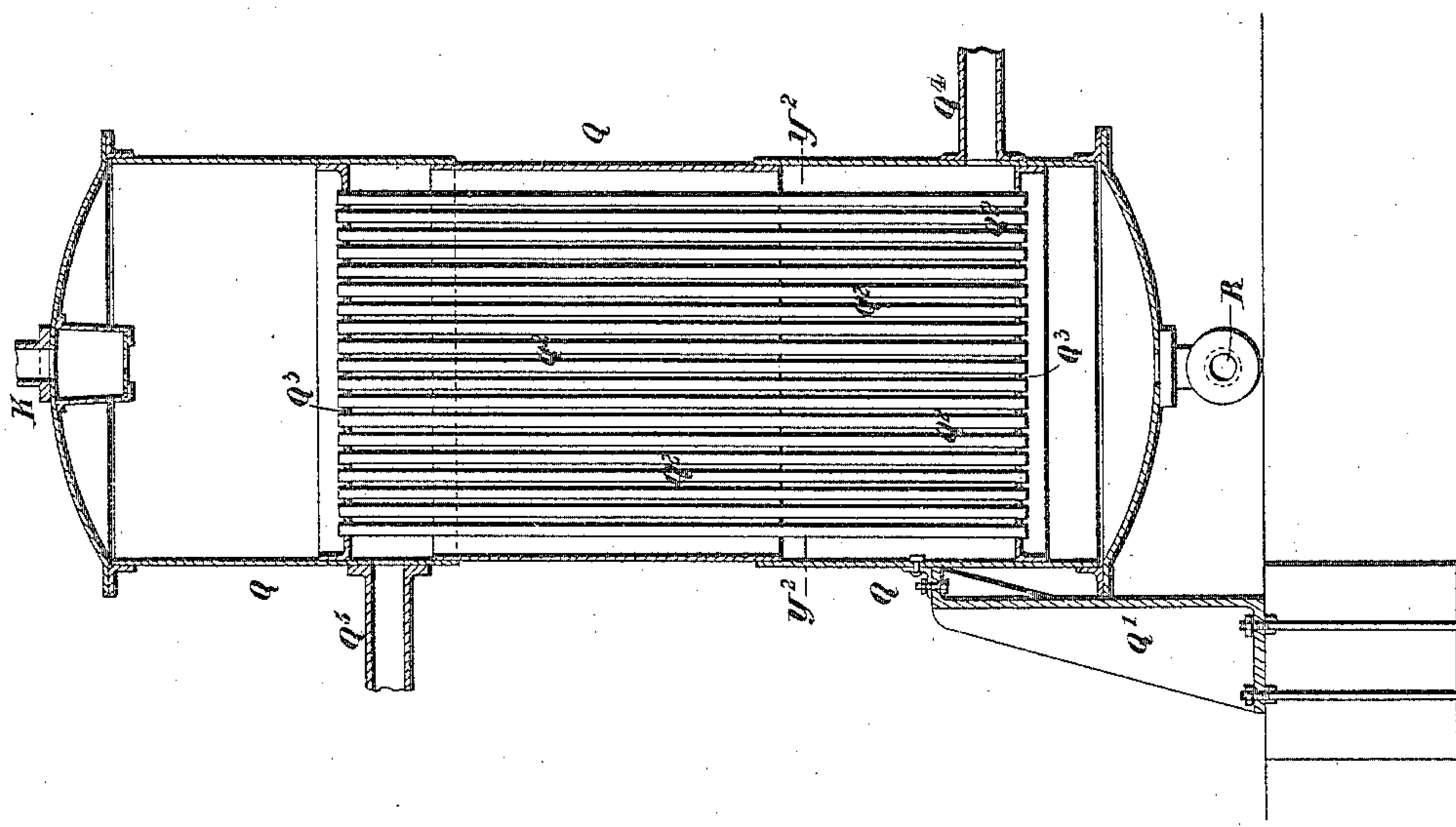

Fig. 8.

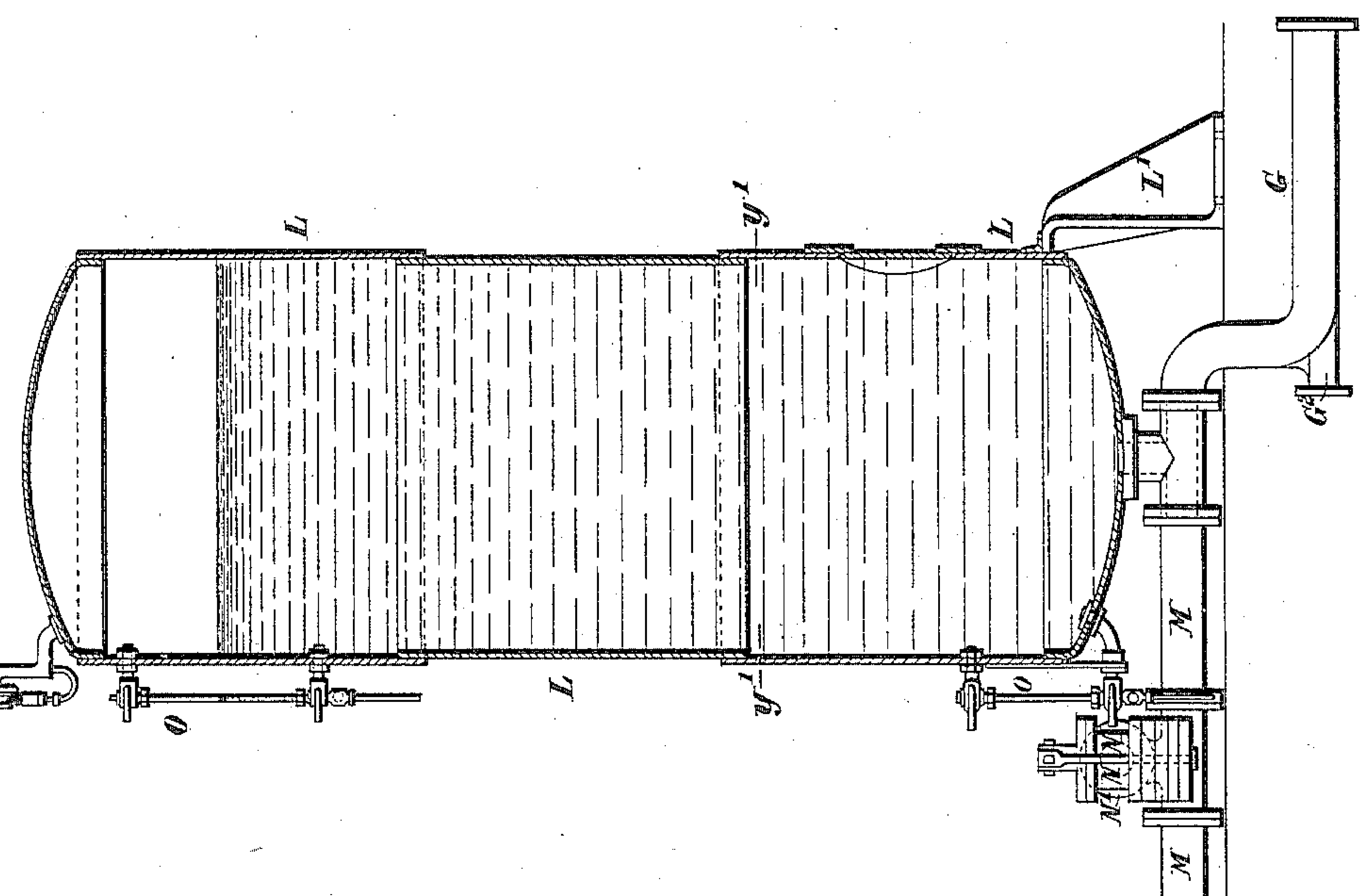

Fig. 6.

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(No Model.) 5 Sheets—Sheet 5.

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PROCESS OF AND APPARATUS FOR HARDENING ORDNANCE.

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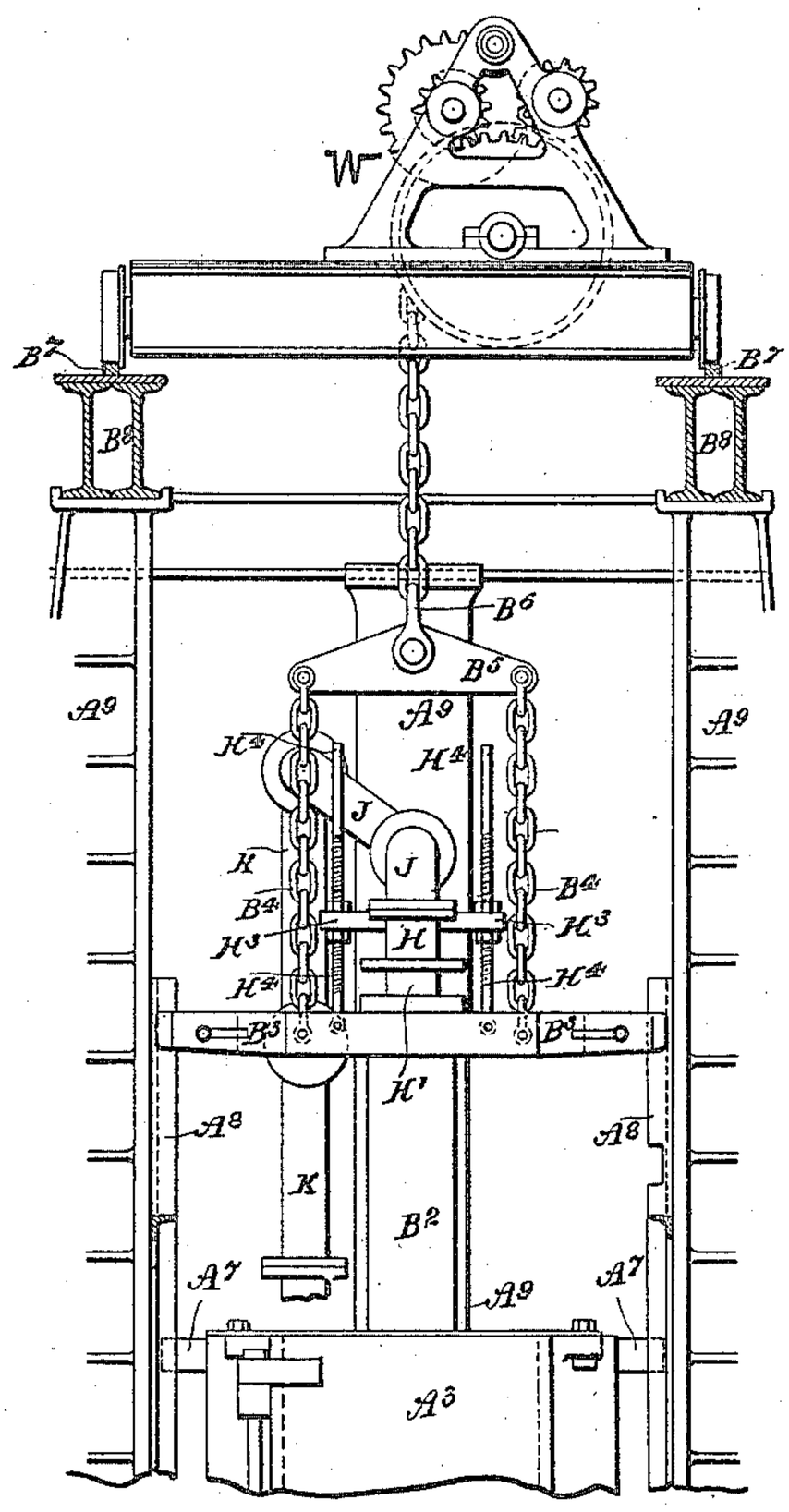
Fig. 7



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UNITED STATES PATENT OFFICE.

HIRAM STEVENS MAXIM, OF LONDON, ENGLAND.

PROCESS OF AND APPARATUS FOR HARDENING ORDNANCE.

SPECIFICATION forming part of Letters Patent No. 446,532, dated February 17, 1891.

Application filed June 17, 1889. Serial No. 314,654. (No model.) Patented in England September 20, 1888, No. 13,624; in France February 13, 1889, No. 195,070; in Belgium February 15, 1889, No. 84,735; in Austria-Hungary March 20, 1889, No. 4,996; in Spain April 1, 1889, No. 9,142; in Italy April 23, 1889, No. 24,799, and in Germany September 7, 1889, No. 48,506.

To all whom it may concern:

Be it known that I, HIRAM STEVENS MAXIM, mechanical engineer, a citizen of the United States of America, residing at London, England, have invented certain new and useful Improvements Relating to the Tempering and Toughening of Ordnance and to Apparatus therefor, of which the following is a specification, reference being had to the accompanying drawings.

This invention I have patented in Great Britain, No. 13,624, dated September 20, 1888; in France February 13, 1889, No. 195,070; in Belgium February 15, 1889, No. 84,735; in Germany September 7, 1889, No. 48,506; in Italy April 23, 1889, No. 24,799; in Austria-Hungary March 20, 1889, No. 4,996, and in Spain April 1, 1889, No. 9,142.

My invention relates to the tempering and toughening of ordnance and to apparatus therefor, and is designed to provide for imparting great hardness to the interior surface or bore of a gun, while greatly toughening the mass of metal around the bore.

In the accompanying drawings I have shown how my said invention may be conveniently and advantageously carried into practice.

Figure 1 is a vertical central section of a furnace constructed according to my said invention, showing also a gun suspended in position in the said furnace ready for being hardened and tempered or toughened by my improved process. Fig. 2 is a front elevation of the said furnace. Fig. 3 is a vertical central section on the line $x\ x$, Fig. 1, drawn to an enlarged scale. Fig. 4 is a horizontal section on the line $y\ y$, Fig. 3, the turning-gear hereinafter described being shown in dotted lines. Fig. 5 is a section on the line $x'\ x'$, Fig. 3, some of the parts being shown in side elevation. Fig. 6 is a vertical central section of an accumulator used with this apparatus. Fig. 7 is a view in elevation of the upper portion of Fig. 2 on an enlarged scale. Fig. 8 is a vertical central section of a cooler or condenser hereinafter described.

A is the furnace, which is constructed in lengths or sections A′, arranged one above another on a metal base or foundation A*. The said furnace is made with an outer casing of iron or other suitable metal and with a lining of fire-bricks or other refractory material, ashes or other non-conducting substances being introduced between the said casing and lining. Any desired number of lengths or sections A′ may be removed from or added to the furnace to alter the height of the same. The said furnace is thus adapted for operating upon guns of different lengths. The said sections A′ are secured together by bolts passing through lugs A^2, formed on the exterior of each section, or in any other convenient manner. A door A^3 is provided for each section, which door occupies the entire height of the said section. These doors are arranged to open alternately in either direction. The whole of one side of the furnace may thus be thrown open to permit the insertion and withdrawal of the gun.

$A^4\ A^4$ are the fire-bars.

A^5 is the ash-pit.

A^6 is a cover or casing for protecting the mechanism, hereinafter described, and preventing the falling of ashes thereon.

The sections A′ are provided with studs or projections A^7, which fit between guides composed of angle-irons A^8, firmly attached to vertical pillars or columns A^9. One of these angle-irons is cut away at suitable intervals to facilitate the introduction of the said sections into their places one above another.

B indicates the gun-barrel to be operated upon, which is suspended or supported in an upright or vertical position in the furnace with the breech downward in such a manner that it can be rotated while subjected to heat in the furnace. In the arrangement shown in the drawings the gun is supported at its upper end by a traveling crab w, Fig. 7, and at its lower end by a ball-bearing, as hereinafter described—that is to say, the muzzle end of the barrel B is screwed into a socket B′, which is screwed into a tube B^2. This tube is formed with a neck or recess near its upper end, into which fit the two parts of a clip or cross-bar B^3, the said parts being firmly secured by bolts or otherwise in such a manner as to support the tube B^2 while permitting rotation of the same within the said clip or cross-bar.

The said clip or cross-bar is suspended by chains B^4 from another cross-bar B^5, connected by means of a shackle B^6 to a chain attached to and wound upon the drum or chain-barrel of an ordinary crab *w*, arranged to run upon rails B^7, suitably supported by means of girders B^8 on the vertical pillars or columns A^9. By means of the said traveling crab the gun-barrel may be conveniently supported and deposited within the furnace or removed therefrom. The ends of the cross-bar or clip B^3 engage with one of the guide-bars or angle-irons A^8, so that rotation of the said cross-bar or clip with the gun is prevented. A series or set of sockets B′ is provided for fitting gun-barrels of different sizes.

To provide for the rotation of the barrel while subjected to heat in the furnace, the said barrel is screwed at its lower end upon a hollow vertical spindle C, fixed in a hollow turn-table D. This turn-table is formed with an extension D′, which is fitted in a socket or base E, mounted upon girders E′, and which forms the central pivot of the turn-table. The said turn-table is, moreover, supported upon the said base E by means of a ring of balls E^2 or other rollers. The turn-table D has fixed thereon a worm-wheel D^2, with which is geared a worm F, fixed upon a shaft F′, arranged to be driven by a steam-engine or other suitable motor. A series or set of spindles C is provided for fitting gun-barrels of different sizes.

By rotating the barrel while it is subjected to heat in the furnace I insure the equal or uniform heating of the said barrel on all sides thereof, thus effectually preventing warping or twisting of the same in the tempering thereof.

G is a pipe for the introduction of the oil or other cooling medium, as hereinafter described. This pipe extends through a stuffing-box G′ in the lower end of the extension D′ of the turn-table D. A pipe H is provided at the upper end of the furnace A for the passage of the oil to a cooler or condenser, hereinafter described. This pipe extends through a stuffing-box H′ in the upper end of the tube B^2, and is provided with a collar H^2, fitting within the said tube, so that the said pipe, while securely retained in the tube B^2, is capable of sliding longitudinally in the said tube and in its stuffing-box H′, thus forming a telescopic joint. The pipe H is, moreover, provided with a cross-head H^3, through which are passed two long screw-bolts H^4, coupled or pivoted to the clip or cross-bar B^3 and provided with nuts H^5, whereby the said pipe may be raised or lowered and may be firmly secured in any desired position. The said pipe H is connected by a bent pipe J with a branch K′ of a vertical pipe K, communicating with the condenser or cooler hereinafter described. This vertical pipe K is provided with any desired number of branches K′ at intervals corresponding with the length of the sections A′ of the furnace, so that the pipe J may be connected with one or other of the said branches, according to the length of the barrel to be tempered. The branches which are not for the time being in use are closed by blank flanges. By raising or lowering the pipe H in the tube B^2 the pipe J can be adjusted so that its flange accurately coincides with that of the adjacent branch K′ of the pipe K.

To provide for the rapid or sudden and forcible introduction of the oil or other cooling medium into the barrel, I employ a tank or accumulator L, Fig. 6, constructed of boiler-plating or other suitable material and supported on suitable standards L′. This tank or accumulator is connected by the pipe G with the turn-table D for supporting the gun-barrel in the furnace A. It is, moreover, connected by an inlet or feed pipe M with a force-pump for the purposes hereinafter specified. The pipe G is provided with a branch pipe G^2 for draining or drawing off the oil from the accumulator L when necessary.

N is a safety-valve applied to the inlet-pipe M for the purpose of preventing excessive pressure in the accumulator. The said safety-valve is provided with an overflow-pipe N′, which conducts the oil back to the cooler or condenser hereinafter described, from which the said force-pump draws its supply.

O O are glass gages for showing the high and low levels of the oil in the accumulator. P is a pressure-gage.

In Fig. 7, Q is a cooler or condenser, which is supported on standards Q′, and is constructed with numerous small tubes Q^2, fixed in tube-plates Q^3. The said tube-plates divide the cooler into three compartments, communication being established between the two end compartments by means of the said tubes Q^2. The upper compartment is connected with the pipe K for the return of the oil from the gun-barrel, and the lower compartment is connected by a pipe R with the suction side of the aforesaid pump, so that a complete circuit is formed through the pump, the accumulator, the gun-barrel, and the cooler. The heated oil or other medium which has been employed in cooling the gun-barrel will return by the pipe K, and, entering the upper compartment of the cooler, will pass through the tubes Q^2 into the lower compartment thereof, which serves as the suction-well of the pump. In passing through the said tubes the oil is cooled by contact with the interior surface thereof, the said tubes being kept cool by water, which is caused to circulate around the said tubes in the middle compartment of the cooler. The said cooling-water enters the cooler through the inlet-pipe Q^4 and flows therefrom through the outlet-pipe Q^5.

To prevent oxidation of the interior surface or bore of the barrel during the heating of the same and to form a hard skin or surface thereon, I introduce hydrocarbon gas or vapor into the said barrel and cause it to pass

through the same during the whole of the time the latter is being heated in the furnace. For this purpose I sometimes use ordinary coal-gas. I find it more efficacious, however, to employ coal-gas enriched by mixing therewith petroleum-vapor.

For admitting the gas or vapor to the interior of the barrel, I connect with the pipe G, for the introduction of the oil, a small pipe S, communicating with the gas holder or main and provided with a suitable cock S′, and I provide a cock T at or near the upper end of the pipe K to permit the escape of the gas or vapor after its passage through the barrel.

Suitable cocks or valves are provided where necessary in the pipes for the circulation of the oil or other cooling medium.

The tempering and toughening of a gun-barrel by my improved method or process are effected by means of the above-described apparatus, as follows, viz: The tank or accumulator L is filled by means of the force-pump with oil, and air therein compressed to a pressure of about one hundred and fifty pounds per square inch, the oil standing at about the level indicated in Fig. 6. Communication between the said tank or reservoir and the gun-barrel is prevented by a suitable cock or valve, which is kept closed until the gun is properly heated. The barrel being placed in its proper position in the furnace, heat is applied to the said barrel therein and the barrel is rotated by the worm-gearing above described during the whole of the time the heating is in progress in order to insure a uniform temperature of the mass of metal.

During the heating of the barrel in the furnace the cocks T are opened, so that carbureted-hydrogen gas enters through the pipe G, and, passing through the barrel after it has become heated, not only keeps the air away from the surface of the barrel, but also hardens the said surface, a portion of the carbon becoming separated from the hydrogen and combining with the steel, thus converting it into a higher grade of steel. The gas after it has passed through the barrel escapes through the cock T. When the barrel has been heated to the required temperature, the cocks S T are closed. Then while the barrel is still rotating the cock or valve for the admission of the oil is opened. By reason of the sudden expansion of the compressed air in the accumulator L the oil from the said accumulator is forced suddenly and with great violence into and through the heated gun-barrel, and the oil flows through the barrel very rapidly at first and more slowly afterward as the pressure in the accumulator diminishes until a balance is established between the pressure due to the head of liquid in the gun and its connections and the pressure in the accumulator, when the subsequent flow of the oil or other cooling medium is wholly maintained by the action of the aforesaid force-pump, which is set to work at the moment of or immediately after opening the cock for the admission of the oil to the gun-barrel. In this manner I insure the rapid cooling of the interior of the gun while its exterior is subjected to heat. The passage of the oil through the barrel not only hardens the interior surface thereof, but the cooling of the inside of the barrel before the outside is allowed to cool causes the outer layers or portions of the barrel to shrink upon the interior layers or portions thereof with great force, setting up practically the same stresses in the mass that are set up by the various rings or hoops in a built-up gun, the exterior of the gun being in a state of tension, while the inside is in a high state of compression. As the oil leaves the gun it passes through the pipe K to the cooler Q. It then passes to the pump and is pumped into the accumulator, whence it flows again through the gun.

When a gun is to be used for firing a large number of steel-covered projectiles, such as are used in modern rifles, it is necessary that the bore should be very hard, so that the rifling shall not be destroyed, while the mass of metal around the bore should be of tough steel. To obtain this result I sometimes introduce into the barrel carbonized bones, bone-dust, leather, or horn, which is allowed to remain therein during the process of heating and which is driven out afterward by the flow of oil. I introduce the carbonized bones, bone-dust, leather, or other suitable material into the bore of the gun either alone or in addition to the hydrocarbon gas or vapor for the purposes of case-hardening the interior of the barrel.

It is evident that I can, if desired, employ other means than those above described for suddenly introducing a large quantity of oil under pressure into the gun-barrel while the latter is subjected to heat, for the purpose specified.

What I claim is—

1. The herein-described method of hardening or tempering heavy guns or ordnance, consisting in first heating the gun while rotating it about its longitudinal axis and then cooling the same from the interior by very rapidly forcing into and through it, by means of compressed air, a volume of the cooling medium larger than is required to fill the bore of the gun, and then maintaining a slower circulation of the said cooling medium through the gun while the exterior of the said gun is subjected to heat, for the purpose above specified.

2. The combination, with the furnace composed of easily-detachable sections, as above described, and means for supporting a gun therein, of an inlet-pipe for introducing a cooling medium into the gun and a discharge-pipe for the same provided with branches at distances apart corresponding to the length of the sections of the furnace, substantially as set forth.

3. The combination, with the furnace, of a hollow turn-table provided with a hollow vertical spindle for supporting a gun in the said

furnace, a pipe extending through a stuffing-box in the said turn-table for the supply of the cooling medium to the bore of the gun, a tube adapted to be secured at its lower end to the upper end of the gun, and a pipe extending through a stuffing-box at the upper end of the said tube for the discharge of the cooling medium, substantially as and for the purposes set forth.

4. The combination, with the furnace, of an accumulator for containing the cooling medium and compressed air for forcing the same through the bore of the gun, a hollow turn-table provided with a hollow vertical spindle for supporting the gun in the said furnace, a pipe connected with the said tank or accumulator and extending through a stuffing-box in the said turn-table, a tube adapted to be secured at its lower end to the upper end of the gun, and a pipe extending through a stuffing-box at the upper end of the said tube for the discharge of the cooling medium, substantially as and for the purposes set forth.

5. The combination, with the furnace, of an accumulator for containing the cooling medium and compressed air for forcing the same through the bore of the gun, a pump connected with the said accumulator for maintaining the flow of the cooling medium through the gun, a hollow turn-table provided with a hollow vertical spindle for supporting the gun in the said furnace, a pipe connected with the said tank or accumulator and extending through a stuffing-box in the said turn-table, a tube adapted to be secured at its lower end to the upper end of the gun, and a pipe extending through a stuffing-box at the upper end of the said tube for the discharge of the cooling medium, substantially as and for the purposes set forth.

6. The combination, with the furnace, of an accumulator for containing the cooling medium and compressed air for forcing the same through the bore of the gun, a pump connected with the said accumulator for maintaining the flow of the cooling medium through the gun, a hollow turn-table provided with a hollow vertical spindle for supporting the gun in the said furnace, a pipe connected with the said tank or accumulator and extending through a stuffing-box in the said turn-table, a tube adapted to be secured at its lower end to the upper end of the gun, and a pipe extending through a stuffing-box at the upper end of the said tube for the discharge of the cooling medium, and an apparatus for cooling the liquid after its passage through the barrel, substantially as and for the purposes set forth.

7. The combination of the furnace composed of easily-detachable sections A A, arranged one above another and provided with doors A^3, the hollow turn-table D, provided with the hollow vertical spindle C, for supporting a gun in the said furnace, the pipe G, extending through a stuffing-box in the said turn-table for the introduction of the cooling medium into the bore of the gun, the socket B′, adapted to be secured to the upper end of the gun, the tube B^2, attached to the said socket, the pipe H, extending through a stuffing-box at the upper end of the said tube for the discharge of the cooling medium, a pipe K, provided with branches K′, at distances apart corresponding to the length of the sections of the furnaces, and the pipe J, for connecting the pipe H with one or other of the said branches K′, substantially as and for the purposes set forth.

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

HIRAM STEVENS MAXIM.

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