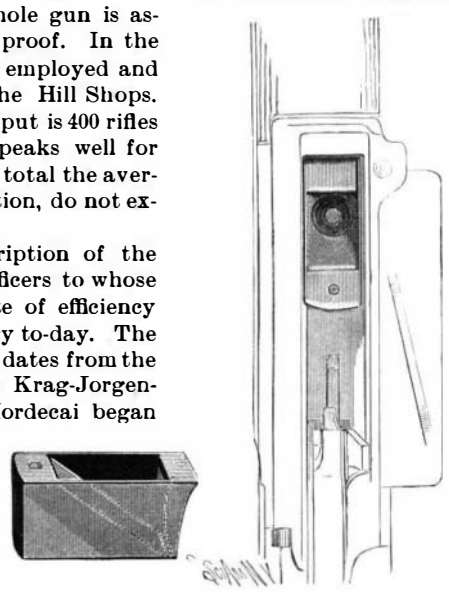
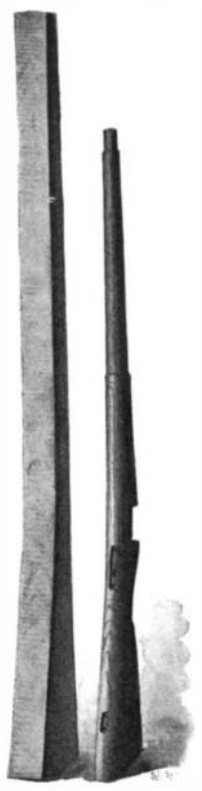
MANUFACTURE OF KRAG-JORGENSEN RIFLES AT THE SPRINGFIELD ARMORY.—II.

Our first article on the manufacture of the Krag-Jorgensen rifle (see SCIENTIFIC AMERICAN of April 29) described the Water Shops of the Springfield Armory, in which the whole of the forgings are made and where the gun barrels are rolled, bored, turned, rifled, and tested, ready for assembling in the finished weapon. The present article will be confined to the Hill Shops, where the complicated parts which go to make up the breech mechanism, such as the receiver, magazine, gate, bolt, etc., are machined and finished and where the wooden stocks are made and the whole gun is assembled, completed, and given its final proof. In the whole armory there are about 2,000 men employed and three-fourths of them are employed in the Hill Shops. As we have already stated, the total output is 400 rifles a day, or over 10,000 a month, and it speaks well for the quality of the work that out of this total the average rejections, after a very strict inspection, do not exceed 11 rifles per month.

Before taking up the detailed description of the shops, credit should be given to those officers to whose energy and zeal is due the excellent state of efficiency that characterizes the Springfield Armory to-day. The period of reconstruction and renovation dates from the year 1892, when the manufacture of the Krag-Jorgensen rifle was commenced. Col. Alfred Mordecai began the good work of removing the antiquated machinery which had long outlived its usefulness and of introducing labor-saving tools and more modern methods of shop management. The same policy has been followed to such good purpose that these government shops can to-day compare in administration, economy, and excellence of the finished products with the best of the private shops in the country.



8.—Bore Mirror for Examining Bore of Finished Gun.



9.—Rough and Finished Stocks.

THE RECEIVER.—The most complicated and costly piece that is made in the Hill Shops is the receiver. It comes from the Water Shops in the rough as a solid steel drop forging weighing 6½ pounds, and goes through no less than 120 separate operations of drilling and milling before it has been brought down to the finished weight of 1·4 pounds. In the "receiver room" there is collected about as fine a set of automatic and semi-automatic machinery as one could ask to see; not quite so elaborate as that used in watch manufacture (see SCIENTIFIC AMERICAN, March 4, 1899), but showing a thousand and one "wrinkles," such as are dear to the heart of the machinist.

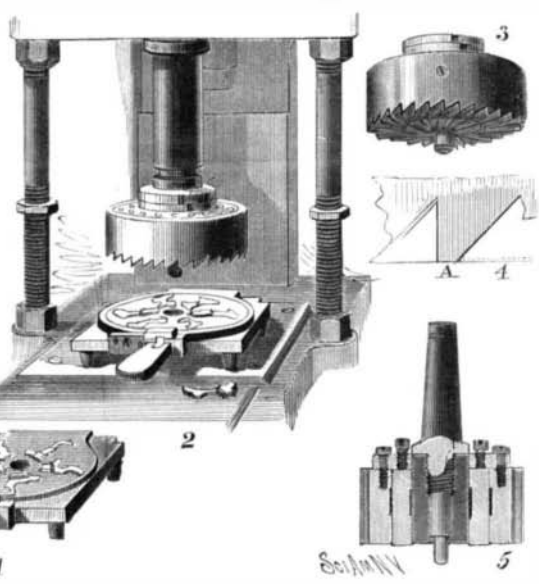
10.—Slotting the Stock—Roughing Cut Preparatory to Bedding.

The receiver answers to the breech-box of the big gun. Into it is screwed the barrel of the gun; it receives through the bolt the full force of the recoil; it serves as the magazine; and it has to withstand all the jar and shock of hasty loading and unloading in the heat of an engagement. Its parts must work together snugly, yet with great freedom, and they must stand long and hard usage without getting slack in the adjustments or allowing dangerous clearances to develop between breech and bolt. To secure this accuracy, only the best material is used, and the various operations are gaged from three points—the axis, the left side, and the front end. The first operation is to drill an axial hole by means of an automatic machine designed in the shops, which drills simultaneously from each end. These machines alone are saving $125 per day to the government. A closely fitting mandrel is then inserted, and all subsequent work is done from this mandrel as a center. The receivers are next milled on each face in milling machines that carry "double fixtures" and enable two pieces to be machined at one time. They are then shaped on the outside, and the cylindrical ends and the end faces of the magazine are milled in the machine shown in Fig. 6. The rotary milling may have left slight imperfections, to remove which the piece is given a finishing touch in the clamp miller, Fig. 4. This last cut has to be taken with the greatest care, as no tolerance is permitted in the finished work. Mention should be made of the fact that, wherever it is possible, the work in the milling shops is done with double fixtures, two identical pieces being clamped in the machine at a time. In some of the later machines, indeed, Lieut. Dickson is using quadruple fixtures, all the parts of the new rifle sight which he has designed being machined on this system, the economy of which is obvious. Previous to 1881, all similar work in the shops was done with single fixtures. The work of cutting out the stock and forming the irregular interior surfaces of the magazine is very tedious and involves an incredible number of operations. The stock is taken out by first drilling a series of holes in a semi-automatic drill, Fig. 4, and then using special rotary mills suited to cutting out the recesses and corners of the magazine. A noticeable feature in the machines employed in this work is the substitution of hand lever feed in place of the ordinary screw feed—one of those simplifications which account for much of the economy with which work is now turned out at the armory.

THE GATE.—To look at the "gate" one would never suppose that its construction involved 34 distinct operations, but as most of them are done on double fixtures, the work is turned out with great rapidity. They include, among others, the milling of the thumb-piece, the milling out of the joint (done by a mill with six different surfaces), and the drilling of the hinge-hole four inches in length. This last is done in the machine, Fig. 12, in which right and left hand drills, fed by hand, drill simultaneously from each end of the hinge.

TRIGGERS, SEARS, AND SMALL COMPONENTS.—Nowhere has a greater saving of time been secured than in the machining of the small parts, such as triggers, sears, and the various other details of the breech mechanism. They have so many irregular curves and offsets, all of which have to be finished to gage within a variation of $\frac{3}{10000}$ to $\frac{5}{10000}$ of an inch, that to produce each one on the old method would make its cost equal to that of a dozen made on the present improved automatic milling machines.

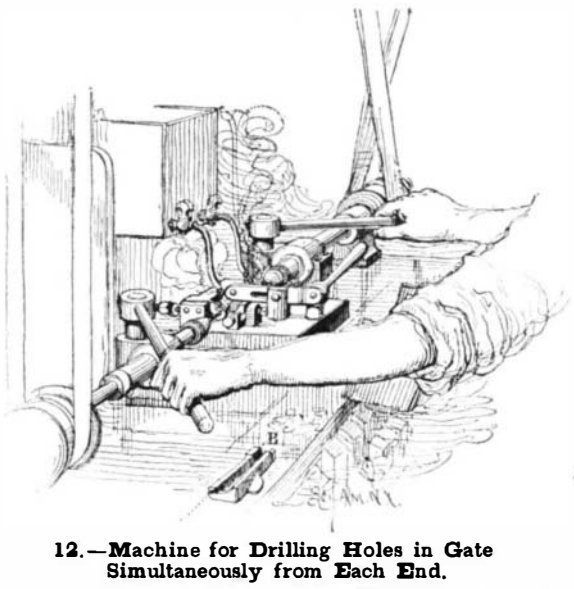
Each of the two sides of the sear and trigger are finished to the proper thickness, with the desired offsets, at a single operation in the face milling jig, Fig. 11. The jig for the sear has six and that for the trigger five sprockets, and the offsets are made by a set of cylindrical telescopic cutters (detail 5), which admit of adjustment to secure the required relative depth of cut. A stud projecting from the arbor on which the mills are assembled passes through a hole in the jig and engages an adjustable stop in the table of the machine, which is set to give the required finished thickness to the work. In Fig. 7 is shown a machine for milling the perimeter of triggers, with a fixture which allows the opposite perimeter of two triggers to be finished in one operation by using compound cutters carrying eight different cutting faces. In Fig. 13 is shown a set of rotary files of special design as used in the armory. The cut shown in Fig. 5 was designed by George Kempater, one of the oldest employes in the shops. The Springfield Armory cut on the flat file is widely known and in great favor among the tool makers.



11.—Face-Milling Sears and Triggers.
1. Face-milling jig for triggers. 2. Face-milling sears. 3, 4. Details of cutters. 5. Cutters telescoped together.

MACHINE AND TOOL SHOP.—In shops like these, where practically the whole of the work is done by automatic and semi-automatic machines, a large and well appointed machine and tool shop is a necessity. The machines are as a rule purchased on the outside, chiefly from the well-known firm of Pratt & Whitney; but the armory manufactures all of its own tools and designs, and makes the many improvements which are added from time to time in its purchased machines. Among many labor-saving improvements we noted the system of making profiling cutters introduced by Lieut. Dickson, in which the turret of a No. 3½ P. & W. screw machine is provided with tools: (*a*) for removing the scale and finishing the tip, (*b*) for roughing, and (*c*) finishing the taper shank; and when the head on which the teeth are to be cut is larger than the shank, (*a*), a box tool for finishing head. Where the head is irregular in shape, or smaller than the shank, it is finished by a formed back tool.

The tools for roughing and finishing the taper shank consist of two form cutters, each of which is secured



12.—Machine for Drilling Holes in Gate Simultaneously from Each End.

13.—Rotary Filing.

to the lower end of a lever; through the upper end of each lever is an adjustable set screw that bears against a bar which has the same taper that the cutter shank is to have. The upper end of the levers are connected by a spring to insure a constant bearing of the set screws on the taper bar, so that, as the taper bar is moved automatically, the cutters will be uniformly opened while cutting the taper. Opposite the form tool on the slide rest is a special tool post, pivoted in its center and operated by a lever, so that two form cutters and one cutting-off tool can be used. On this machine from sixty to eighty shank cutter blanks are made in eight hours.

When set up for any cutter, a year's supply of the blanks is made direct from 10-foot bars of round steel. The operation of setting up for any cutter is very simple. After leaving this machine, the operations are centering, cutting the teeth, tempering and grinding. This system has materially reduced the cost of all shank cutters, of which an unusual variety are rendered necessary by the irregular cuts required on some of the components, notably the receiver.

CASE-HARDENING AND TEMPERING. — Most of the working parts, such as the receiver, bolt, gate, side plate, sleeve, and cocking mechanism are case-hardened. They are packed in powdered burnt bone in cast iron boxes, and heated to a cherry red and then plunged into a bath of lard oil. It should be noted that in this operation a little cyanide of potassium is placed on the first locking joint of the bolt to give it special hardness. The lug receives the full shock of the recoil, and if it is not hardened it is liable to upset. This actually happened in the case of some of the Spanish Mausers, and by allowing the cartridge to project slightly beyond the breech, the upsetting resulted in the rupture of the walls of the cartridge shell where it projected beyond the breech. The extractor, firing pin, and striker and all small springs are tempered by heating to a cherry red, cooling in oil, and drawing to a spring temper.

BROWNING THE BARRELS.—The process of browning the barrels involves several distinct operations. After the bore has been oiled and carefully plugged at each end the barrel is boiled for 10 minutes in lime water. The lime is then brushed off, and a coat of browning material applied with a sponge, after which the barrels are put for 5 minutes in a cabinet, in which the temperature ranges from 80° damp to 90° dry. The barrels are allowed to cool in the cabinet and are then boiled again, this time for from 5 to 7 minutes. They are then put on a revolving wire brush. A second browning coat is applied and the barrels are again placed in the cabinet, where they are exposed for 4 hours to a temperature of from 80° to 70°. This is followed by a third and fourth coat which are repetitions of the second coat.

MAKING THE STOCK. —The stock is turned out of the best selected walnut, which is delivered at the armory sawn to the rough shape shown in Fig. 9. It is first rough-turned in a machine which carries a cast iron former, of the shape to which the piece is to be roughed down. The rotary cutters and the tracing wheel are carried on a swinging lever, the cutters being driven by a belt. The next operation is to slot out the stock for the insertion of the receiver preparatory to cutting out the longitudinal bed for the barrel, Fig. 10. The bedding is done in the machine shown in Fig. 3, which is provided with six vertical cutters, and two horizontal cutters. Each cutter is provided with its own former, so that the finished stock is certain to receive the barrel and receiver with a snug fit when they are clamped together. In the illustration the machine is shown cutting out the half-round groove for the barrel. The operator guides the cutter 7 to form the proper taper to match the barrel with his right hand, while he traverses the barrel by means of the crank handle shown in his left hand.

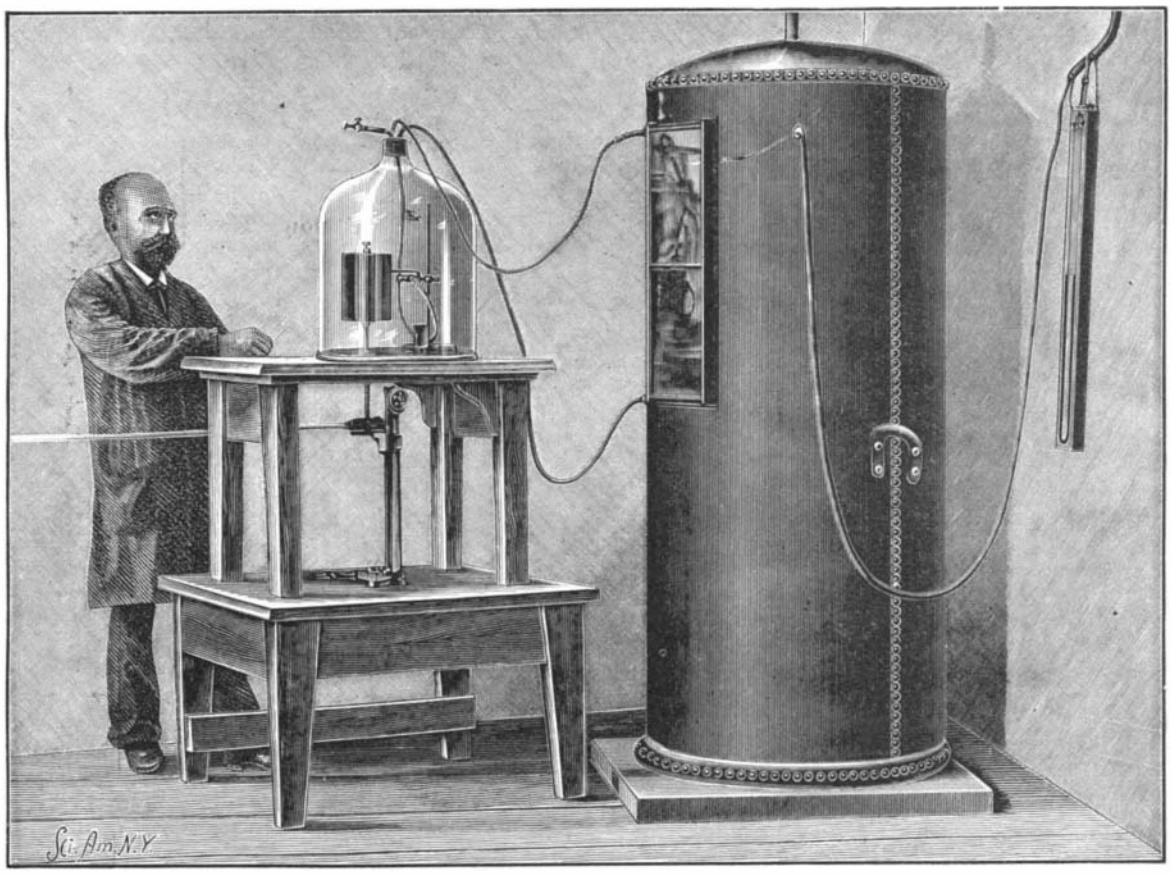


Fig. 1.—PNEUMATIC CHAMBER AND OTHER APPARATUS USED IN REGISTERING THE PULSATIONS OF THE BRAIN IN RAREFIED AIR.

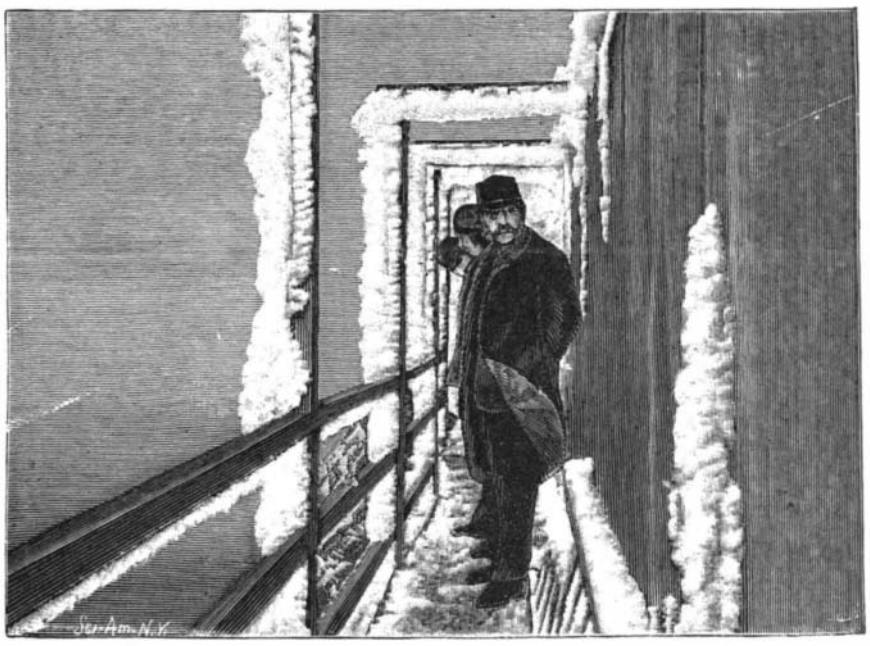


Fig. 2 —FROST ON THE REGINA MARGHERITA CABIN AFTER THE STORM OF AUGUST 13, 1894.

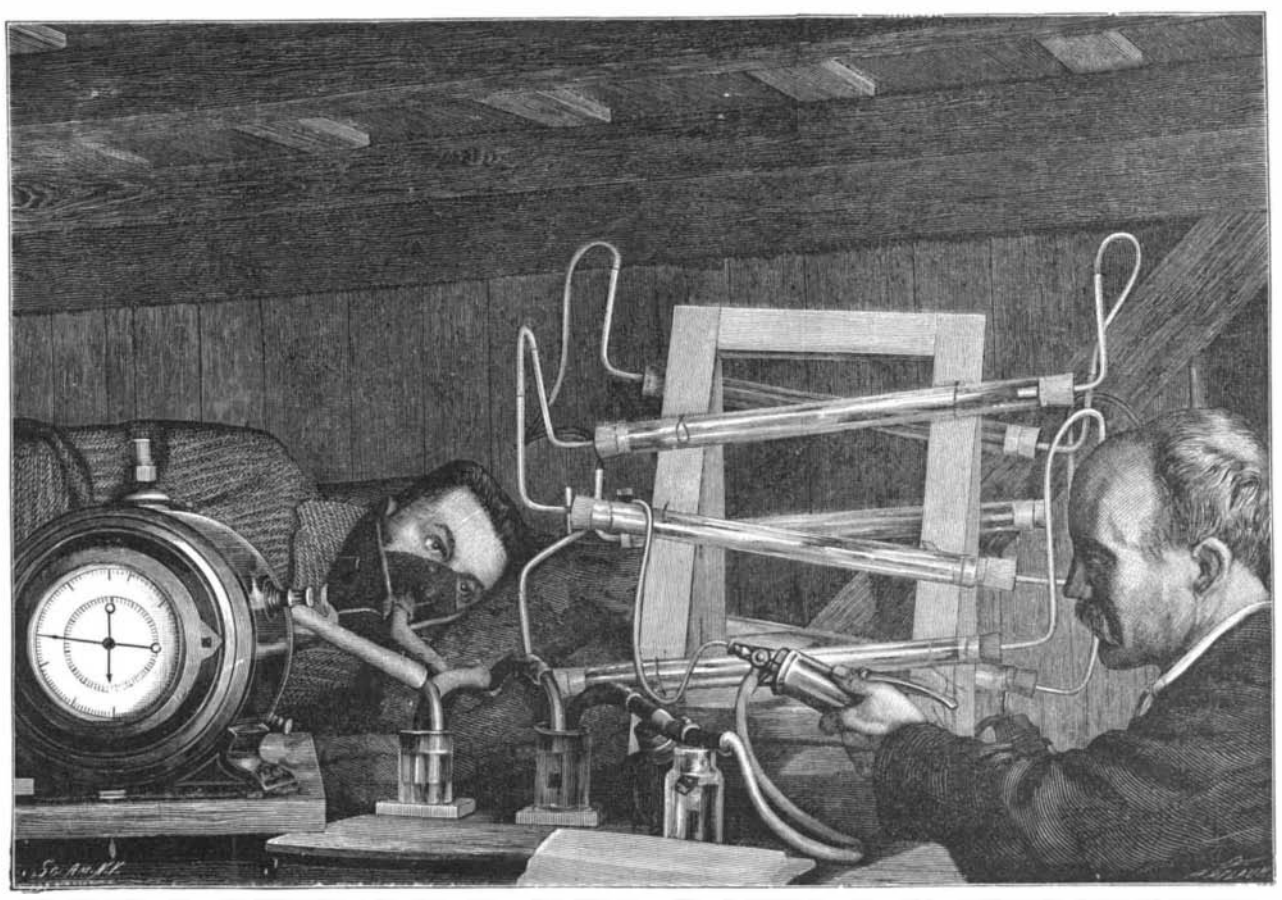


Fig. 3.—APPARATUS FOR MEASURING THE VOLUME OF AIR INHALED AND THE CARBONIC ACID EXHALED.

FINAL INSPECTION AND TEST. — After the various parts have been assembled into the finished rifle a final and very careful inspection is made by special experts. The bore is examined by means of the little mirror, Fig. 8, which is slipped into the receiver at the base of the barrel and presents a clear image of the bore as shown in the illustration. As we have stated, every barrel has already undergone a test of 70,000 pounds to the square inch in the chamber, and to determine the ultimate strength of the guns, ten or more rifles out of every lot made from a certain delivery of steel are tested up to 100,000 pounds to the square inch. This is two and a half times greater than the service pressure. Illustration Fig. 1 shows one of the very few rifles that have failed to stand this supreme test, and in this case the examination revealed a slight flaw in the stock.

THE KRAG-JORGENSEN IN THE WAR. —At the conclusion of the Spanish-American war, when the army was gathered at Camp Wyckoff, a special board of ordnance officers was ordered to assemble at the camp and gather statistics as to the behavior of our rifles, field artillery, etc. Every officer at the camp was requested to report any case of failure in guns or ammunition. It speaks volumes for the excellent workmanship put into our new rifle that not a single case of failure or even of miss-fire was reported.

THE PHYSIOLOGY OF MAN ON THE ALPS.

A short time ago a most interesting book on the Physiology of Man on the Alps ("Fisiologia dell' uomo sulle Alpi) appeared simultaneously in Milan, Paris and Leipsic, where it was published in Italian, French and German respectively, and it has now been translated into English. The author, Prof. Angelo Mosso, had already given much study to the subject, but was desirous of testing certain theories in regard to Alpine physiology which would require a residence of several weeks on the summit of Monte Rosa, and therefore, feeling sure that he could never accomplish his end with the assistance of only his guides and porters, he applied to the Minister of War for a detachment of ten soldiers under the command of a military physician, to stay with him on the mountain as long as might be necessary. His request was granted, and he went to

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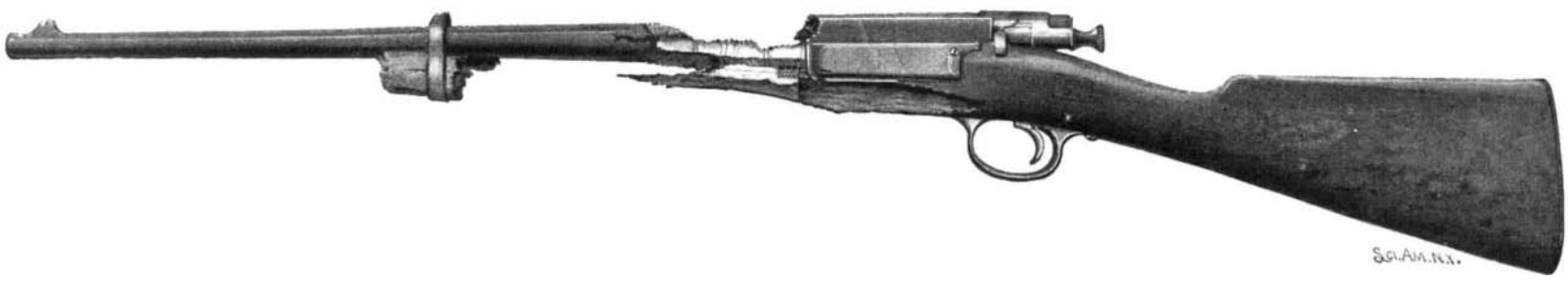
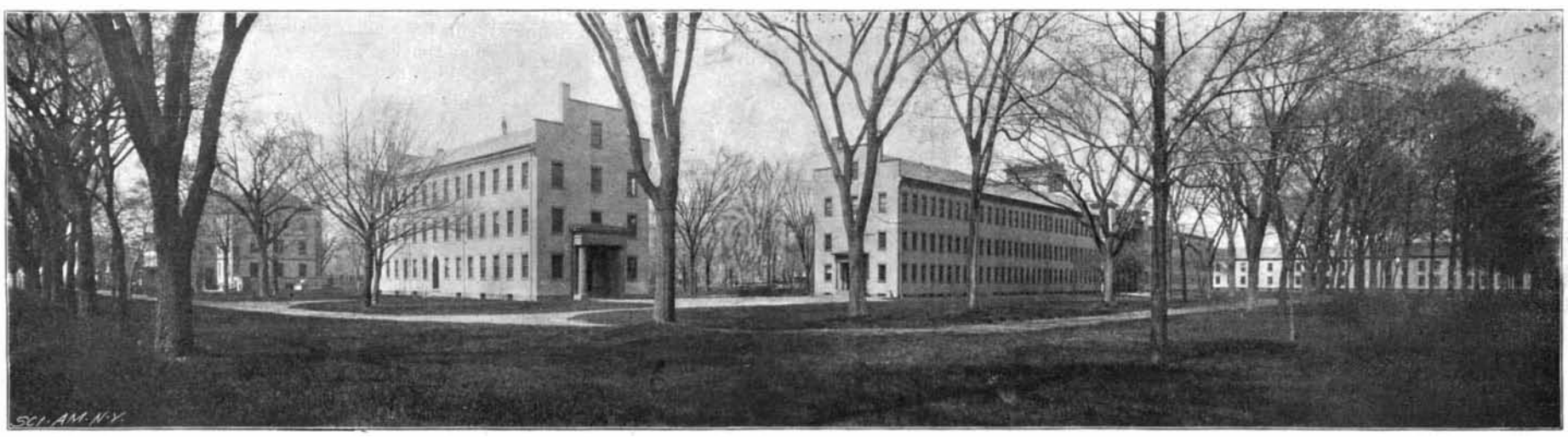
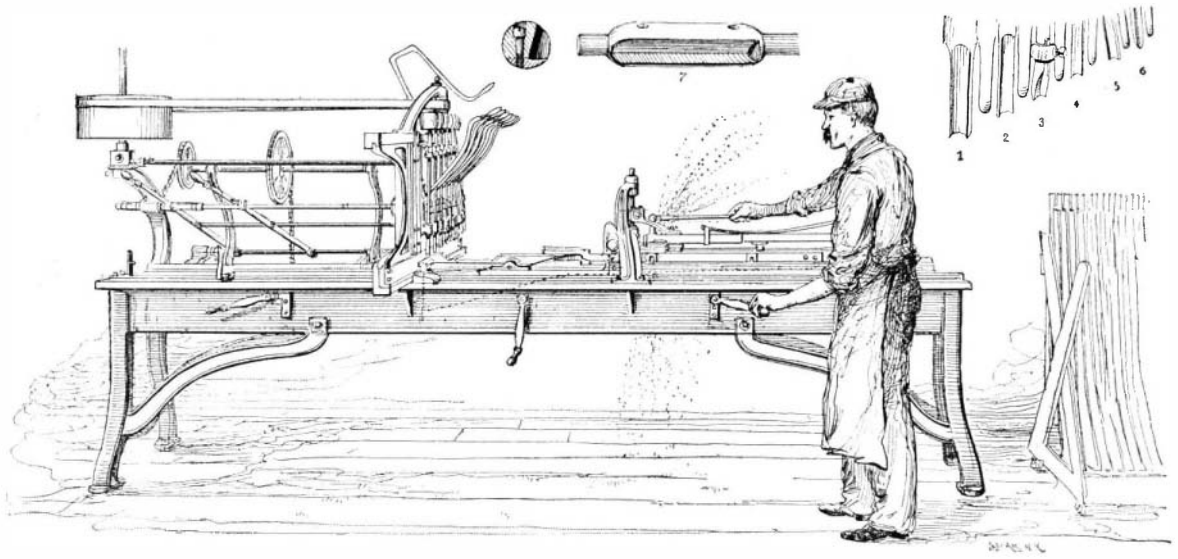


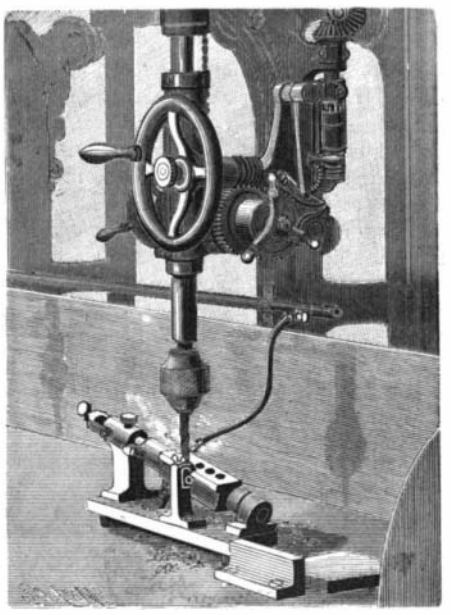
1.—Krag-Jorgensen Rifle Tested to Destruction—Chamber Pressure, 100,000 Pounds.



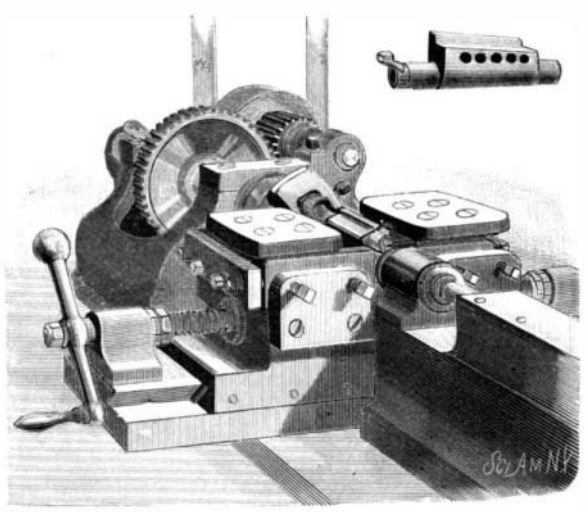
2.—Armory Square, Including Arsenals, Offices, and the Old Shops.



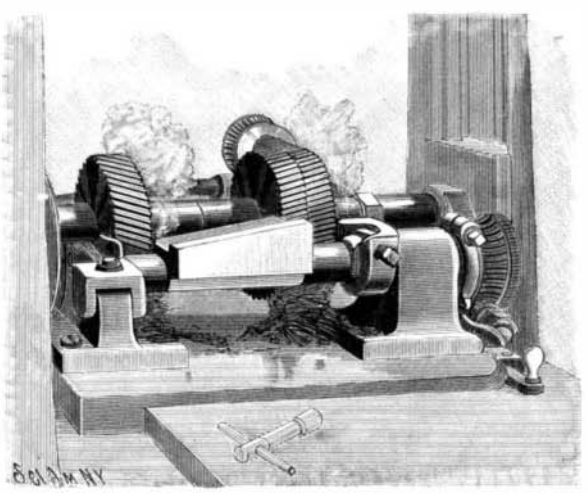
3.—Barrel-bedding Machine—Grooving the Stock to Receive Barrel.



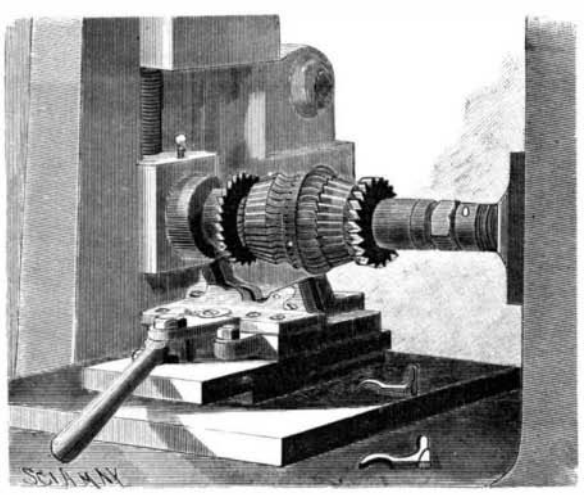
4.—Semi-automatic Drilling of Magazine Holes in Receiver.



5.—Clamp-milling Cylindrical Ends of Receiver.



6.—Milling Cylindrical Surfaces of Receiver and Facing Ends of Magazine.



7.—Milling Perimeter of Triggers.

MANUFACTURE OF KRAG-JORGENSEN RIFLES AT THE SPRINGFIELD ARSENAL.—II.—[See page 330.]