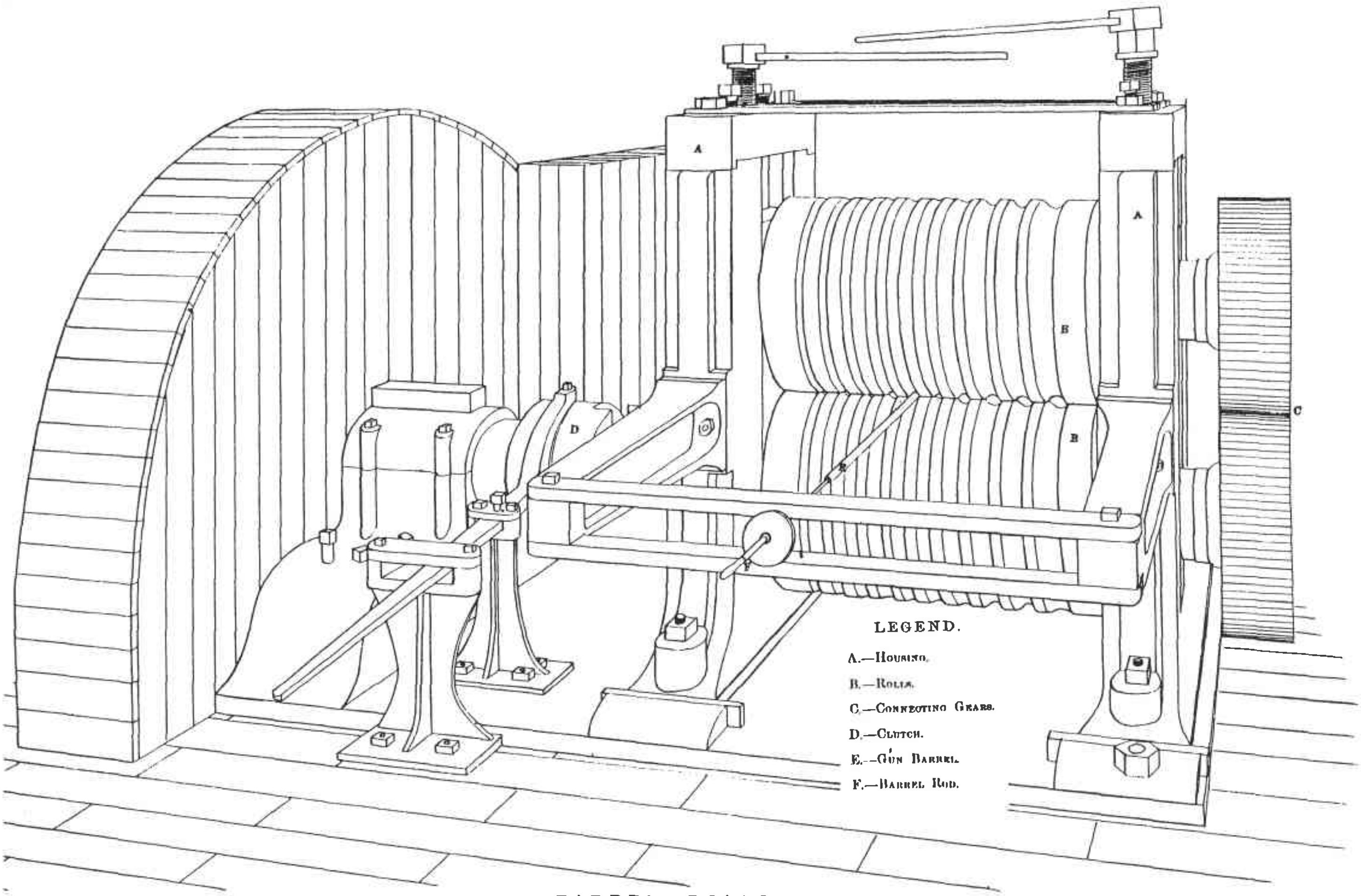

BARREL ROLLS.

Figure 1. **Burton-process barrel rolls, from Ordnance Memorandum No. 22, *The Fabrication of Small Arms for the United States Service*, Plate III. A partly finished barrel is passing through the rolls, and the disc-shaped collar on its mandrel (here identified as F, Barrel Rod) has struck the frame in front of the rolls, so that the barrel, moving away from the viewer, is being peeled off the mandrel. A driving belt runs over a big pulley in a protective wooden guard at left and drives the lower roll through a clutch. The lower roll is geared to the upper one at the right.**

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Gun Iron and Mild Steel

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While I have known about iron and steel in a general way for a long time, I first focused on the matter when I was invited to join the Research Team of the Remington Society of America about 5 years ago. The Remington family, who founded what later became the Remington Arms Company, were (at least after about 1808) iron forgers by trade, and even though we have a description of their forge in the Industrial Schedules of the *Census of the U.S., 1820,* it has taken me some time to find out exactly what they did. At the University of Rochester I found a copy of a book published in 1850 by Frederick Overman called *The Making of Iron and Steel,* and I thought my problem was solved. I took the copy with me when I drove to the Albuquerque meeting of the American Society of Arms Collectors, and I read and reread it without feeling very enlightened. Then a year or two ago, the Johns Hopkins University Press published *American Iron* by Dr. Robert Gordon. I called for it on interlibrary loan, and I was so impressed by it that I phoned Johns Hopkins and bought a copy.

So right here at the outset I want to acknowledge my indebtedness to Dr. Gordon and his very helpful book. Should any of you find the matter of interest, I can tell you that this is the most useful book I have found in several years of looking. To be sure, there are many other sources that are of interest, but you should know that much of what follows is either based on or clarified by Gordon.

The major point to be remembered is that before the end of the Civil War, all steel was tool steel, and it was an expensive and none-too-reliable product, hard both to make and to manage. The ordinary material was wrought or cast iron. Cast iron is still common, but today wrought iron is an exotic material, so far as I know no longer available in the Western world. Thus when someone describes a model 1816 musket, say, and refers to "the steel parts," he speaks from ignorance. The springs and frizzen are steel, to be sure, but the barrel, furniture, and most of the lock are iron, and there is a big difference.

Iron is an element defined by the *American Heritage Dictionary* as

> A silvery-white, lustrous, malleable, ductile, magnetic or magnetizable, metallic element occurring abundantly in combined forms, notably in hematite, limonite, magnetite, and taconite, and used alloyed in a wide range of important structural materials. Atomic number 26, atomic weight 55.847, melting point 1,535°C.

Put into layman's language, iron occurs naturally as an ore in which more or less iron is combined with various earthy or stony components. Metallic iron is recovered from the ore by the process of smelting, which before the Civil War was carried on in tall stone blast furnaces built for the purpose. They were fueled with charcoal for centuries; only in the 19th century did coke and then coal come into use, because the wood that was the raw material for charcoal began to become scarce. The furnace was open on top and was commonly built beside a hill so that a bridge could be built out from ground level on which workmen could wheel barrows out to the furnace top.

The furnace was filled with a mixture of charcoal and iron ore plus perhaps 15% limestone (sometimes even old seashells) as a flux. The fire was lit, and gradually a powerful blast of air, produced by a so-called "blowing engine" driven by a waterwheel, was introduced at the bottom. As the fire, urged by the air blast, got hotter and hotter, the iron was melted out of the ore and drizzled down in drops to the bottom of the furnace. The stony or earthy components, technically called "gangue," were melted into slag, which also passed down the furnace stack to float on top of the molten iron. The slag was tapped off and discarded. The molten iron was tapped into a sand bed prepared with a long channel from which side channels led off. Each side channel produced a "pig" of iron that weighed about 100 pounds. The name "pig iron" comes from the analogy of a sow nursing little pigs.

Pig iron is cast iron. In fact, some furnaces cast various products—hollowware, stove plates, or whatnot—directly from the furnace. Cast iron is fairly strong in compression, it can be poured into a mold, and it is resistant to heat. But as it drips down through the burning fuel—which is practically always some form of carbon such as charcoal, coke, or coal—it gains carbon from the fuel. Cast iron will include 3% or 4% carbon or even more, which makes it brittle. It cannot be forged to shape under the hammer, hot or cold.

What the Remingtons, and many other forgemen, did was to convert pig or cast iron into wrought iron. Wrought iron is relatively pure iron, with little or no carbon content. It is ductile, it can be shaped under the hammer, and as was very important in the 19th century, it welds readily in the forge. Remember that there was no gas or electric welding until almost 1900.

Welding in the forge is the process of bringing two pieces of wrought iron to a sparkling white heat and hammering them heavily together. They will weld. But neither cast iron nor steel—as we'll see in a moment—will weld that way. This was important for gunmakers, because the ordinary way to get the tube that a gun barrel begins as was to weld it up out of a flat "skelp" of wrought iron that was heated and wrapped around a rod—a "mandrel"—and then was forge-welded with a longitudinal seam.

All these were craft processes. No one on earth really knew what was going on inside a blast furnace, and chemistry, particularly analytical chemistry, was an infant science. Not until the 1880s and 1890s could a sample of iron or steel be analyzed adequately. No one realized that very small amounts of, say, phosphorus would seriously injure iron smelted out of a phosphorus-bearing ore, or that small amounts of, say, nickel would strengthen iron or steel. Experienced ironmasters knew that if they did everything right, good iron would result—but they didn't quite know how to define "right."

The Remingtons were running a finery forge. Unfortunately, they and their contemporaries were not careful or consistent in using their terms; for example, Overman, who wrote in the time of Eliphalet Remington II, was quite inconsistent in his use of technical terminology. Furthermore, all these crafts were changing in the period from about 1810 to about 1850, and no doubt the language used to describe them was changing too. But what the Remingtons did was to melt cast iron so that the excess carbon burned out. As it did so, the melting point of the iron rose, and a pasty ball or lump of carbon-free iron gathered in the hearth of the finery forge. The finer took this lump to a trip hammer, where the hammerman forged it into a bar suitable for sale to a blacksmith, or into whatever other shape he chose. The hammering consolidated the iron and drove out some of the slag, and the result was wrought iron. (The old term "wrought" merely means that the iron had been worked.)

Steel is a form of iron containing from 0.2% to a little more than 1% of carbon. If a piece of steel with carbon content of more than about 0.6% is heated to a suitable level, usually well over 1,000°F, and then suddenly quenched in a cool fluid, it will become hard. It is usually then reheated or "drawn" to a lower heat and then quenched again. This hardenability was the defining characteristic of steel before the latter end of the 19th century. Steel was obtained by recarburizing wrought iron—that is, by painfully putting back at least some of the carbon that the finery forge had been at such pains to remove. Bars of wrought iron were packed in charcoal in a closed chest and held at a high heat for several days. The carbon in the charcoal literally soaked into the iron bars, making them steel of a sort. This was called "blister" steel, because the process raised blisters on the surface of the bar.

But blister steel gave a lot of trouble. It was hard to control the amount of carbon transferred into the iron, and worse, it was hard to get a uniform transfer in any one bar. This meant, for one example, that if a tool maker were making wood chisels, some would be harder and some softer even if they came from the same bar of steel and were heat-treated the same way.

To partly cure this lack of homogeneity, bars of blister steel were sheared to shorter lengths, repiled in their chests of charcoal, and reheated for several days. This tended to even out the carbon content. The result was called "shear" steel. For an even better product, bars of shear steel were again sheared, piled, and carburized, and the result was called "double-shear" steel. Finally, in the 18th century a man named Benjamin Huntsman in Sheffield, England, found the cure for the lack of homogeneity in recarburized steel. He made clay crucibles and melted his iron completely; he could then add exact amounts of carbon, and the fusion of the iron ensured that the carbon was evenly distributed throughout the resulting steel. The result was called "cast" steel because it had been poured from the crucible into an ingot mould. Today, though it is obsolete, it is called crucible steel.

But others had less success with the Huntsman or cast-steel process. When Huntsman went to a nearby clay bed to get clay for his crucibles, he happened by chance to get nearly the only clay in England that would make a crucible that would stand the heat necessary to completely melt the charge of iron. It took decades to find that out; in the meantime, efforts to replicate the Huntsman process elsewhere in England and in the United States were failures. As a result, good quality steel almost all came from Sheffield, though some was made by very painstaking processes in Sweden.

For many years, Springfield Armory got iron for its barrels from Sheffield, though smaller amounts came from a particular ore bed in Salisbury, Connecticut. American iron-masters and armorers referred to this as "gun" iron, meaning merely high-quality iron suitable for gun barrels and similar work. Such iron from England came from a particular iron works whose full title I do not know. The product was known as "Marshall" iron, no doubt as today we speak of a Ford car.[1] Dr. Gordon several years ago published a comparative analysis of a known sample of Marshall iron from London, of a sample from a Springfield rifle musket made between 1859 and 1861, and, as a control, one from a Whitney musket presumed to date from the 1830s and presumed to be made of American iron. With full-dress scientific methods, he was able to demonstrate that the London sample and the Springfield barrel were very much alike and of high quality, but the Whitney sample was quite different and of significantly lesser quality.

In the meantime, Remington had been making steel rifle barrels for some years. As most collectors know, percussion sporting rifle barrels by Remington are common, and are often stamped "Cast Steel." Zouave rifle muskets, Jenks carbines, and some other Remington products are stamped merely "steel," as were, by the time of the Civil War, those of a few other manufacturers. It now appears that Remington was offering steel rifle barrels at least as early as 1831. The account books of the Troy, N.Y., gunsmith Alvin Cushing have survived at the Rensselaer County Historical Society; Cushing bought his barrels from Remington, and in 1831, apparently for the first time, he differentiated in his accounts between ordinary barrels (which would have been iron) and steel barrels.

We know a little more about Remington's cast-steel barrels. In 1854, the British government sent a Committee on the Machinery of the United States of America to this country to examine manufacturing methods and also to purchase machinery for gunmaking as equipment of the newly established (and yet incomplete) Royal Arsenal at Enfield Lock, outside of London. The three-person committee consisted of a Lieutenant Colonel of artillery, a Lieutenant of artillery, and the Ordnance Inspector of Machinery. It got to the United States in May 1854 and travelled widely. The committee report was printed for Parliament, but it is an exceedingly scarce work in the United States today. However, in 1969 an American economic historian named Nathan Rosenberg published *The American System of Manufactures* in Edinburgh, Scotland, and reprinted the report in its entirety. This too is hard to find in the United States, but the University of Rochester has a copy. Lieutenant Warlow visited the Remington works at some unspecified time in the summer of 1854. What he had to say was that

> Mr. Remington was the first person who introduced into the [military] service barrels bored out of the solid bar of steel. . . . The barrels are bored straight through in a vertical boring machine. . . . All the steel used is brought from England, as that made in the United States cannot be depended on.

This steel was, of course, cast steel of reasonably homogeneous carbon content—a product that for practical purposes could not be obtained in the United States. A drawing of the Remington shops exists that shows (in poor detail) a multiple-spindle vertical barrel-boring machine, which apparently fed the barrels downwards by means of heavy overhead weights that looked like cannon balls. There is a tradition that the barrels revolved against fixed drills, driven by the overhead weights.

But all this changed in about the middle of the 19th century. In England, a man named Henry Bessemer (later Sir Henry Bessemer), who had been working on glass manufacture, had a new idea. He fed several tons of molten cast iron into a "converter" (a big pear-shaped container mounted on trunnions) and then introduced a powerful cold air blast. Contrary to the conventional wisdom of the day, this did not chill the liquid iron. Instead, it provided oxygen enough to burn out the carbon and phosphorus with a spectacular spout of flame from the converter mouth. Not quite all the carbon would burn; the result of the process was several tons of steel with a carbon content of about 0.2%. This was not enough for the steel to harden if it were heated and quenched, and because the faculty of hardening was the basis for the definition of steel, there was long-continued debate about just what the metal from a Bessemer converter was. Ultimately, the definition of steel changed from "a form of iron that would harden if suitably heat-treated" to "an alloy of iron and carbon, usually from 0.2% to 1.5% carbon," which is (roughly) the modern dictionary definition.

Bessemer steel was very much cheaper to make than cast steel or the other forms, especially when produced on a large scale. It came along at a very fortunate time. There were complications over the U.S. patent rights, but the first U.S. Bessemer plant opened in Troy, N.Y., in the fall of 1865, and more quickly followed. There was a tremendous post–Civil War boom in railroad construction and repair, with a resulting high demand for rails. Bessemer steel rails had been shown to be much better than wrought iron ones. They wore several times longer than iron. For a couple of decades, practically all the U.S. production of Bessemer steel went into rails.

But some of it went into rifle barrels too. When that

British committee, whose 1854 report I quoted earlier, was in the United States, they bought machinery for the new Royal Arsenal at Enfield Lock. A good deal of it was stockmaking machinery that came from N. P. Ames & Co. in Chicopee Falls, Mass. The committee intimated to Ames that it would be nice if they could hire an American competent to superintend the installation and operation of the machines in England—and Ames knew just the man.

James H. Burton, a Virginian, had gone to Harpers Ferry Armory in 1844 from a job as a machinist. In 1849 he was appointed Master Armorer.[2] In 1855, after a bitter political controversy, he resigned to accept a position with the Ames Company, which he knew well because they were suppliers of machinery to the Armory.[3] Thus, when the British Committee asked Ames for a recommendation, Ames proposed Burton, who went to England in 1855 with a 5-year contract to be chief engineer at Enfield.

By this time, rolling mills had come into common use to replace forging hammers in forming wrought iron, at least into long shapes such as rails and bar stock. At first these consisted of a pair of power-driven rollers that had grooves in their faces. A hot piece of iron could be inserted successively in smaller and smaller grooves; in passing through the rolls, it was formed into a long piece of whatever cross section was indicated by the form of the grooves. In the 1850s a man named John Fritz developed the "three-high" roll stand[4] with a third roller on top. This permitted the workpiece to be passed back to the boss roller, who had started the process, between the top and the middle rollers, thus greatly reducing the time and labor involved in passing a heavy, hot workpiece around the roll stand.

It didn't take long for high-production gunmakers to become interested in rolling barrels, even though their requirements were far less than the railroad requirements for rails. In 1856, James T. Ames undertook to obtain barrel-rolling machinery for Springfield Armory from England, where rolling mill technology was more advanced than in the United States. In 1858, Ames brought over from Birmingham William Onions (or Onyans),[5] who successfully introduced barrel rolling to Springfield. In October 1859, Alfred M. Barbour, the newly appointed superintendent of Harpers Ferry Armory, traveled to New England, partly to "consult with the Ames Manufacturing Company about building a mill for rolling gun barrels at Harpers Ferry."[6]

In the meantime, James H. Burton was in Enfield, and because he was close to James T. Ames, it seems a fair guess that it may have been he who located and recruited William Onions. While he was in England he patented an improvement on the rolling process. As a matter of fact, it seems quite possible that Burton's interest in rolling barrels dated back to his year with Ames, 1854-1855, because it was James T. Ames who acquired the American rights to Burton's patent.

Burton's process involved inserting a long mandrel or rod in the hot barrel just before it entered the rolls. This mandrel had a knob at one end and a prominent collar near the other. As the hot barrel was fed forward by the rolls, the collar struck a frame in front of the rolls. This held the mandrel, and the rolls peeled the barrel off the mandrel, the knob forcing the bore to stay open. The knobs were successively smaller down to about .40 caliber for the barrel for a .45 caliber Springfield breechloader.

Fortunately for later students, Burton applied for an extension of his patent, No. 27,539, and a hearing was held in Springfield on August 23, 1873. Burton was ill and was in England, and he was represented by no less than James T. Ames; the other witness was Joseph D. Alvord from the Wheeler and Wilson sewing machine factory, who previously had been at Springfield Armory and at the Sharps Rifle Company. The testimony was printed in a pamphlet that ran to 24 pages.[7]

In his testimony, James Ames (who controlled the American rights to this patent, remember, and was therefore not an entirely disinterested witness) said that efforts were made in 1859 to roll steel barrels without good success because the steel, which was "such as could be found in the market," was "too highly carbonized." A few lines later, describing a further trial begun in 1860, he is more specific. The second batch of steel (which came from England), he reports,

> . . . worked better in the rolling. It was objected to on account of being steel, by the workmen, in consequence of having to weld a lump for the cone seat.

This is natural enough, because mild steel is difficult or impossible to weld in the forge, which is the only way they had to do it in 1860 and for many years thereafter. The fact that a cone seat, or what we now mostly call a bolster, had to be provided shows that it was rifle-musket barrels that were being made. What Ames did not say was that the difficulty existed only with steel barrels. As a matter of fact, Springfield Armory turned out about 700,000 rifle muskets during the Civil War (according to Norm Flayderman), and I suppose all or most of these had rolled iron barrels, which would present no difficulty in welding on iron bolsters.

Before long, William Onions, the English-born barrel roller, moved from Springfield. He turns up in Ilion in the *Census of the U.S., 1870,*[8] identified as "WIA," the shorthand used by that Census Marshal for "Works in Armory," meaning that the individual concerned was employed by E. Remington & Sons. James T. Ames knew about this. When asked (in more complex phraseology) when steel gun barrels began to be rolled in the United States, Ames replied

> The first that I know about were made at Ilion in 1868. . . .

This coincides with William Onions' arrival in Ilion, which can be worked out from other evidence as having been in 1868. Onions also appears in Ilion in the *Census of the State of New York, 1875,* and the *Census of the U.S., 1880;* the former identifies him as "Barl Roller, Armory." He was still in Ilion in 1886, and probably for years thereafter. In December 1872, the local newspaper published an article that said in part

> The making of gun barrels is an interesting process. Bars of the best decarbonized steel . . . are drawn out to the required lenth [sic] by causing them to pass between cylinders having grooves shaped to correspond with the external form of the barrel. The rolling of barrels is done under contract by Mr. Wm. Onyens, who first imported this kind of machine from England, before the war, since which he has rolled over 300 000 barrels.[9]

At the time of the article, Remington was running full blast, making mostly rolling block military rifles for foreign governments. They were presumably the most productive armory in the world.

By 1873, Springfield Armory was making trap-door rifles in .45-70 caliber. The very first trap-doors, in .50-70 caliber, had relined .58 musket barrels, apparently of iron, but the .45-70s had steel barrels. Ordnance Memorandum No. 22, *The Fabrication of Small Arms for the United States Service,* published in 1878, describes the work in detail, making clear that barrels were produced by the Burton process. Page 22 is a table of the iron and steel required for component parts. A total of 5.843 lb of iron was used, and a total of 9.460 lb of steel. (The weights are those of the material before machining; for example, the barrel mold—today we would probably call it a billet—was a piece of decarbonized steel 2 inches in diameter and 9¼ inches long, and in the rough state it weighed 7 lb. This piece alone comprised 73% of the steel used.) One stand of barrel rolls needed three men—one roller and two helpers—and could turn out 150 barrels per 8-hour day.

Production of wrought iron fell steadily, while steel production rose rapidly. After 1880, the American Iron and Steel Association discontinued reporting production and price statistics for iron railroad rails. In that year, Bessemer steel made up 86% of all steel produced, and 83% of all Bessemer steel was rolled into rails.[10] Today both Bessemer steel and wrought iron are obsolete; when the United States was producing steel it did so by the open-hearth process, and wrought iron is no longer obtainable.

The gunmaker's world had changed too. After the Civil War, few young men entered the trade as apprentices, and when older men retired or died there was no one to step forward. The Civil War had brought the breech-loading rifle, made by factory machines and methods, to a level of precision that could not be attained by country gunsmiths in small shops with limited machinery. The financial depression called the Panic of 1873 ruthlessly combed out what small shops were left, leaving the field to factory breechloaders, many of them repeaters. Although these still used wrought iron for some parts (particularly unstressed parts such as buttplates) they typically used steel barrels and some steel action parts. The day of smokeless powder and high pressures came within a few years, just as more began to be known about alloy steels, and steel became the ordinary material for most gun parts. Today we use it for everything from nails and paper clips to structural beams, and the working of wrought iron has largely been lost. But to 19th century gunmakers—at least to pre-Civil War gunmakers—iron was a familiar and more or less friendly material, while steel presented problems. The difference is important and is worth remembering.

NOTES

1. In the Burton patent testimony (see note 7 below), Ames testified (answer 37, p. 13) that from about 1858 to about 1861 he supplied "marshall iron" to the armory.

2. Merritt Roe Smith, *Harpers Ferry Armory and the New Technology* (Ithaca and London, 1977) 285, 285 n. 42, 287. For the Ames Company, see *ibid,* p. 288-290 *passim.*

3. *Ibid,* p. 302 and p. 302 n. 60.

4. Thomas J. Misa, *A Nation of Steel* (Baltimore and London, 1995), p. 19.

5. Felicia Deyrup, *Arms Makers of the Connecticut Valley* (Northampton, Mass., 1948), p. 152.

6. Smith, *Harpers Ferry,* p. 304.

7. There is no title page as such; the paper outside cover says "Before the Commissioner of Patents/Testimony in Behalf of the Applicant./Springfield, Mass:/Clark W. Bryon & Company, Printers." This appears to be an excessively scarce item. A copy is in the company archives of the Remington Arms Company, but that archives is not open to the general public.

8. *Census of the U.S., 1870,* Herkimer County (NY), T. of German Flatts, dwelling number 232, family number 330, taken June 24, 1870. The village of Ilion is in the Town of German Flatts.

9. The Ilion *Citizen,* Vol. IX, No. 46, December 26, 1872, p. 1: "Remington Armory and Sewing Machine Factory" by Prof. C. H. Dann.

10. Misa, *A Nation of Steel,* p. 31 and Fig. 1.12, p. 32.