The Legend of Eli Whitney and Interchangeable Parts

ROBERT S. WOODBURY

In some legends the story is such that from its very nature we can never establish its truth or falsity; in others patient historical work—usually external to the legend—can ascertain whether the events actually happened or not. The legend of Eli Whitney’s part in interchangeable manufacture is, however, unique in that the clues and even much of the evidence for its refutation are part of the legend as customarily recited. It is also unique in that the legend is not merely a popular one nor even a story given “authority” by inclusion in conventional textbooks. This legend has been retold at least twice with all the paraphernalia of historical scholarship—footnotes, elaborate bibliography, discussion of the sources, and even use of archival material. But in both cases we find the same failure to evaluate the evidence critically, to follow leads to other sources, and to question basic presuppositions. These same faults extend back to the origins of the legend.

Poking back into the beginnings of this legend, one finds evidence to show that it was at least partially created consciously by its hero and uncritically accepted by most of his contemporaries. The editio princeps of the legend is equally uncritical; in fact it is frankly an apologia pro vita sua. In his Memoir of Eli Whitney, Denison Olmstead gives us most of the elements of the legend...
and claims to have based his account upon conversations with those who knew Whitney, as well as upon examination of his correspondence and Miller's. Yet Blake writing in 1887 said: "... there have not been wanting persons who have endeavored to take from Mr. Whitney the credit of originating the uniformity system and making it a great practical success at the beginning of this century, thus leading in the van of progress of the mechanical arts, and laying the foundations for the enormous industry development of the nineteenth century."4 Evidently some of his contemporaries were not taken in by Whitney's claims, but the scholars have not asked either who these other inventors were or what their contributions may have been. Let us examine the principal parts of this legend in some detail.

I

THE CONTRACT

Whitney's contract of June 14, 1798 to manufacture arms for the Federal Government is the focus of a number of elements of our legend. His motives in this undertaking have been interpreted as those of a prudent businessman doing his patriotic duty and as those of a genius anxious to put into execution a new scheme of manufacture for the good of his country in a time of crisis. His actual motives were quite different.

In 1798 Miller and Whitney had lost all their suits to obtain their cotton gin patent rights in the courts of the South. What little legal merits these decisions had, stemmed from a defect in the Patent Law of 1793; clearly nothing further could be done until Congress corrected this defect. The efforts of Whitney and others did not finally result in a new patent law until 1800. The intervening years could be seen as a lull in the affairs of Miller and Whitney. But Whitney could hardly look forward to any relaxation, for their financial affairs were in desperate straits. Every source of credit had been exhausted by both partners.5 Certainly Whitney himself was on the verge of a nervous breakdown. Although some have tried to find in this situation a frustrated love for Catherine Greene, a more careful reading of his letter of October 7, 1797 to Miller indicates rather that Whitney's high hopes of financial security, respected position, and prestige have
not only come crashing to the ground, but the disgrace of bankruptcy is staring him in the face. All that winter of 1797-98 Whitney brooded alone, half-heartedly carrying on the affairs of Miller and Whitney. He shut himself off from all his old friends and even unjustly accused his partner and friend Miller.

Whitney needed a new opportunity—any opportunity. But, more important, he needed credit—credit to save Miller and Whitney from bankruptcy, credit to enable him to fight for his rightful profit and for his good name lost in the cotton gin suits. When he heard that the Congress was “about making some appropriations for procuring Arms etc. for the U.S.,” here was a heaven-sent opportunity.6 This would at least keep his manufactory going until he could get his cotton gin rights. The opportunity was so great and Whitney’s situation so desperate that he was willing to promise “ten or Fifteen Thousand stand of Arms,” a fantastic proposal! Whitney even promised to begin delivering “in a short time” and he “will come forward to Philadelphia immediately....” New hope for a desperate man!

Why was such a rash proposal not rejected at once by such prudent men as President Adams and Timothy Pickering, the Secretary of War? The failure of the Pinckney mission had caused public concern, and French privateers were rumored to be off the coast. Even Washington was called out of retirement to head the armed forces. On the 4th of May 1798 Congress voted $800,000 for the purchase of cannon and small arms. When on the 24th of May Whitney arrived at the seat of government the plum was not only ripe and juicy but begging to be picked. Public sentiment was aroused, and the highest officials must do something—and that right promptly. Both sides could not close the contract quickly enough. Only the Purveyor of Public Supplies, Tench Coxe, seems to have kept his head—“I have my doubts about this matter and suspect that Mr. Whitney cannot perform as to time.”7

It is not necessary to see “influence” at work here, though it is true that Whitney did have a number of Yale graduates who could help him. Much less is there any evidence that the generous terms of Whitney’s contract grew out of the feeling that he had been shabbily used in his cotton gin suits. But he clearly had a personal friendship with Jefferson arising out of the patent for the cotton gin.
Certain features of the contract deserve closer examination. The legend makes much of the fact that the actual document was wholly handwritten. It says that all the other contractors of this time received printed contracts, and that there was therefore something special about Whitney's contract. Unfortunately an examination of the actual contracts, including Whitney's, in the National Archives shows that this was by no means the only handwritten contract—there were others, such as that of Owen Evans of Providence, Penn. The fact is that several of the early contracts were handwritten; the later contracts, mostly signed in September, were printed forms. These other contracts, printed or handwritten, were all identical in wording and provisions with Whitney's, except in the terms of the last paragraph. There was something special about Whitney's contract—it contained a paragraph six not included in any of the others. It was this paragraph that was crucial for Whitney. Having quickly sized up the situation in which the high officials found themselves, the shrewd Whitney saw his chance, consulted Baldwin as to the form the contract should take, and at one stroke solved all his immediate problems. This paragraph reads:

"6th. Five thousand dollars shall be advanced to the party of the second part on closing this contract, and on producing satisfactory evidence to the party of the first, that the said advance has been expended in making preparatory arrangements for the manufacture of arms, Five Thousand dollars more shall be advanced. No further advances shall be demanded until One thousand stands of Arms are ready for delivery, at which time the further sum of Five thousand dollars, shall be advanced. After the delivery of One thousand stands of arms, and the payment of the third advance as aforesaid, further advances shall be made at the discretion of the Secretary of the Treasury in proportion to the progress made in executing this contract. It is however understood and agreed by and between the parties to this instrument, that from time to time, whenever the party of the second part shall have the second thousand ready for delivery he shall be intitled to full payment for the same, so with respect to each and every Thousand until he shall have delivered the said Ten thousand stands."

Here was credit at last! Here was financial standing which assured further credit! Five thousand dollars at once, and five thousand more on terms which could be easily fulfilled by using his cotton
gin laborers and machines. And assured payment for each thousand stands of arms upon delivery—to a total of $134,000. Little wonder that Whitney wrote to his friend Stebbins: "Bankruptcy and ruin were constantly staring me in the face and disappointment trip’d me up every step I attempted to take, I was miserable . . . Loaded with a Debt of 3 or 4000 Dollars, without resources, and without any business that would ever furnish me a support, I knew not which way to turn . . . By this contract I obtained some thousands of Dollars in advance which saved me from ruin."\(^9\)

No wonder that in his eagerness to read paragraph six of the contract, Whitney evidently skimmed rapidly over the incredible terms of paragraph one.\(^{10}\) Whitney had contracted to deliver 4000 stands of arms by September 30, 1799, and 6000 more by September 30, 1800. Four thousand stands of arms in 15 months, from a factory yet to be built, and made by laborers as yet untrained, and by methods as yet unknown! And 6000 more in the following year! In his desperation Whitney had thrown all caution to the winds. He was no experienced manufacturer, as his deliveries of the relatively simple cotton gin indicate. He was aware that he knew nothing of arms making. And a prudent man would have expected at least some of the setbacks with which he fills his later letters to Wolcott, together with requests for further credit, contrary to the provisions of the contract. In short, despite his vague claims of new methods and what could be done by "Machinery moved by water," Whitney had only the vaguest idea of how he would actually fulfill the contract. He was not able to deliver even the first 500 muskets until September 26, 1801, and the contract was not actually completed until January 23, 1809. Further, the records of the Springfield Armory, now in the National Archives, show that even during the period 1815 to 1825, when his plant was fully established, Whitney never delivered muskets at the rate promised in his contract of 1798.\(^{11}\)

Not only have these facts been forgotten in estimating Whitney's motives in the contract, but also in attempting a proper evaluation of his troubles with Samuel Dexter, who had replaced Wolcott as Secretary of the Treasury. We are asked to see Dexter as a villain abusing our hero with "malice" by demanding that he perform in accordance with his contract. The other contractors of 1798 had in many cases failed to fulfill their contracts, and some
of them had even gone into bankruptcy as a result of their efforts to manufacture arms for the federal government. But Springfield Armory records show that some of them had performed as contracted, a few on time and even more eventually. Yet these men had all ventured into arms making by financing themselves privately. There are no records of their writing the long apologetic letters full of troubles, promises, and requests for further advances, which characterize Whitney's correspondence from 1798 on. Nor had they been given the numerous informal extensions of time with which Wolcott, strongly under the influence of Hamilton's theories of the importance of manufactures, had favored Whitney and which culminated in a formal modification of the contract just before Wolcott left office. Whitney had been given more consideration than any other contractor.

But one might give at least a moment to the position of Dexter. He was a government official sworn to carry out the law and to protect the interests of the government. Whitney had been given every chance and had not performed. Some of the other contractors had. Even had Dexter seen the ultimate interests of the government in this matter in the broad terms that Wolcott and Jefferson did, he had no authority to make the extremely loose interpretation of Whitney's contract that Wolcott had. Actually Wolcott had left office partially as a result of other similar easy exercise of the discretions permitted his high office. Dexter did not deserve such blame.

And had Whitney, for his part, acted in good faith since 1801? We can leave out of our discussion the troubles Whitney so fully related in his numerous lengthy letters to Wolcott. They were real enough, even if recounted in rather unmanly fashion, but they were all of the sort, magnitude, and frequency which a prudent man would expect in an undertaking of this sort. And one could argue that if Whitney had been carelessly optimistic in what he had promised in the contract of 1798, so had the responsible government officials, who had also been warned by the Purveyor of Public Supplies to expect delay in delivery. However, despite Whitney's claims of the exhausting efforts and attention he had devoted to his arms manufacturing, the facts prove otherwise.

It is true that the lull in the affairs of Miller and Whitney from 1798 to 1801, plus the credit advanced him by the federal govern-
ment, did enable Whitney to devote most of his time in these years to make a beginning on fulfilling his arms contract, and by September of 1801 he did deliver the first 500 muskets. But from this initial delivery until 1807 there is no twelve-month period during which he delivered over 1000 muskets. During this same period he had been given advances from the Treasury such that he was constantly in debt to the United States. In fact, when Whitney finally completed delivery in January 1809 he received a payment of only $2450 as final settlement of the total contract of $134,000. Only on this date was his account up to date. The Whitney account in the Springfield Armory records also shows that in 1806 Whitney delivered 1500 muskets, in 1807 he delivered 2000, and in 1808 and the first few days of 1809 he delivered 1500. What is the explanation of these facts?

I do not wish to imply that Whitney was misrepresenting his troubles in his letters to Wolcott, Dexter, and Dearborn; but he most certainly was not telling the whole story, as his other correspondence clearly shows. In April 1800 the Congress revised the patent law which had been the legal means of defeating Whitney's claims to his cotton gin rights. Under the new law Miller at once started suit against the principal offenders. The "lull" was over. But it became increasingly evident that justice would not be done Miller and Whitney in Georgia under any law. On September 4, 1801, Miller wrote to Whitney of a new possibility—their patent rights were to be purchased by the state legislatures. Here was a greater reward than Whitney could have dreamed of! Miller needs Whitney's help and his "contacts." Whitney cannot wait and by November 22, 1801 is dating a letter to Stebbins: "Virginia Nineteen Miles North of the Northern line of North Carolina." He sees a chance that Miller and Whitney may get $100,000 from South Carolina alone for his rights—here was freedom from debt, assured financial security, and a credit reputation of the best. Better still, he will have the fame and prestige of a name officially cleared and full credit for his invention. Is it any wonder that a man of Whitney's ambitions and self-interest rushed off to Columbia and left the troubles and problems of arms manufacturing behind? Whitney had slaved and scrimped to get through Yale that he might become respected and financially secure. Now fortune beckoned, and the arms contract could wait.
From the fall of 1801 until Judge Johnson’s decision of December 19, 1806 the ups and downs of cotton gin affairs were certainly far more important in Whitney’s mind that the manufacture of arms. This can be definitely established simply by noting the places where Whitney’s and others’ letters show him to have been in this five-year period. The contents of his correspondence clearly establish a similar conclusion, as does the mere volume of the lawsuits in which Miller and Whitney were engaged. In the final settlement of the partnership in 1818 Whitney was allowed $11,000 for the expenses of six journeys South on these lawsuits. Certainly he was seldom attending full time to the arms manufactory at New Haven.

In short, from 1801 to 1806 Whitney not only failed to fulfill the contract, he regularly substituted long letters of excuse for honest effort to carry out his obligation, while he chased the richer prize of the rewards he expected from the cotton gin. In the light of these facts Dexter can hardly be blamed for his actions, and Jefferson’s intervention seems hardly to have been in the interests of the government, whatever effect it may have had upon the future of American industry.

II

Manufacture by the Uniformity Principle

The shortage of skilled artisans in the formative years of the American republic has been so often repeated as the source of Yankee mechanical ingenuity that it is now taken as axiomatic, without careful examination of the actual numbers as adequate for the needs of the day. This same axiom has served to “explain” Whitney’s use of manufacture by interchangeable parts. In fact, Whitney so explains it himself. But let us look at the facts. The Springfield Armory was opened in 1794, and its payroll records from the beginning are to be found in the National Archives. By 1802 the Armory had 76 skilled armorers employed, and by 1814 it had 225. Although the figures for Harper’s Ferry have not been preserved and we know it to have been substantially smaller than Springfield, we would be safe in assuming that Harper’s Ferry had at least half this number of armorers. This total is impressive and seems hardly to indicate a scarcity of skilled armorers. In addition,
we have the records of deliveries by other private contractors of arms to the Springfield Armory. During the whole period which concerns us, either the Springfield Armory, or Asa Waters of Sutton, Mass., or Lemuel Pomeroy of Pittsfield, Mass., delivered at least as many arms in each year as did Whitney. In fact Springfield manufactured 16,120 in the six years from 1795-1801, a much more impressive record than Whitney's 10,000 in ten and a half years. Both started from nothing. Leaving out of account the deliveries of the smaller manufacturers, Springfield, Waters, and Pomeroy certainly had an ample supply of armorers—or are we to believe that they too had the principle of interchangeable parts which Whitney claimed was unique in his establishment at New Haven?

But where did Whitney get his ideas for manufacture of arms on this new principle? He always claimed that it was his and his alone, and so the legend says, despite strong evidence to the contrary. There can be no doubt that prior to Whitney other men had actually used the principle of manufacture by interchangeable parts. In the 1720's Christopher Polhem, in Sweden, was manufacturing gears for clocks by using machinery and precision measurement to ensure interchangeability. But there is no evidence that Whitney or anyone in the United States knew of Polhem's work, though it could have influenced Blanc in Europe.

The work of Blanc [sic] was clearly known to Thomas Jefferson; in fact our legend always includes a recital of his letter to John Jay in 1785 describing Blanc's work, and Jefferson's letter to Monroe of November 14, 1801, in which he points out that by 1801 Whitney had not developed the method as far as Blanc had in 1788. But the most amazing thing about the Whitney legend is the failure of scholars to follow up this clear lead to answer two questions of first importance: (1) Who was Blanc and what did he do? (2) Did Blanc's work have any influence upon Whitney?

The sources on Blanc are not only easily available, but are very detailed on his methods and results, for much of his work was done in French government arsenals and created controversies which were the subject of several official investigations and reports. Even a cursory examination of these sources would indicate that Whitney was far from being the first to introduce the principle of interchangeable parts in the manufacture of small arms. It is also quite clear that Blanc had carried the technique much further.
than we have any evidence for Whitney’s doing. Furthermore, Blanc’s *Mémoire* of 1790 shows a profound understanding of the nature and probable effects of interchangeable manufacture, of which Whitney had only the barest inkling. Whitney’s goal was only a system to use unskilled labor to increase output and reduce cost; whatever interchangeability he achieved was only a by-product of his method.

Blanc had problems to meet that Whitney never did. An entrenched officialdom and a threatened craft labor in long established government arsenals, together with the eclipse of the nascent industrial revolution in France under the Revolution and Napoleon, prevented a final fruition and spread of Blanc’s ideas and methods in France and on the Continent.

But did the spark fly from Blanc to Whitney? A careful search in the correspondence of Whitney, Jefferson, Monroe, Jay, and Stiles indicates only that there were at least several paths by which it may very well have passed, of which the most likely is through Whitney’s numerous conversations with Jefferson. But the only positive evidence seems to be a letter from Wolcott to Whitney dated 9 October 1798 in which he encloses “... a pamphlet on manufacture of arms ... inform me freely and candidly whether the performance appears to you calculated to afford instructions to the workmen in this country. . . .” Whitney replied on 17 October 1798 that it was “misleading.” Can this have been a copy of the report by le Roy on Blanc’s *Mémoire* of 1790? We know that Jefferson was a regular subscriber to French publications, including the *Encyclopédie* as issued in parts. Did Jefferson’s interest in Blanc in 1785 lead to receipt of this publication of the Académie des Sciences? And did he pass it on to Wolcott? One more bit of evidence remains. Writing to Wolcott on December 24, 1800, Whitney regrets that Wolcott does not have the leisure to examine “my whole plan and manner of executing the different branches of the work . . . to . . . compare them with the modes practiced in this and other Countries.” Was Whitney actually familiar with the methods in use abroad, and if so, through what means? One must also admit that the language of many of Whitney’s letters describing the merits of his methods are strangely reminiscent of Blanc’s words. Yet we have nothing conclusive.

We must also ask whether Whitney’s contemporaries in America
The Legend of Eli Whitney

may have influenced him, in particular the work being done at the Springfield Armory. It is most significant that after signing the contract in June 1798 Whitney had gone to Springfield to see their methods and to talk with the superintendent. And we have Whitney’s letter in the summer of 1799 in which he had originally written “I might bribe workmen from Springfield to come to make me such tools as they have there.” It is clear that Whitney was prepared to copy at least some of the methods already in use at Springfield. What were these machines? Unfortunately a fire in 1801 destroyed many of the records of the Springfield Armory, and the question cannot be answered fully. But we do have one official report that gives clear indications that special machinery was in use by, at the latest, 1799: “... the artificers were employed for some time on the buildings, instead of on the manufactory, and in making the necessary pieces of machinery and tools. ...” [If we take into account the difficulties of opening a new establishment, such as] “unsuccessful attempts in the proper construction of the machinery,” [we should be satisfied with the present cost of muskets]. The report also uses such expressions as “The works now being complete, and labor-saving machines operating to great advantage...,” and “... improvements in the machinery and system for carrying on the manufactory.”

That these improvements in the machines were effective is shown by the fact that in the month of September 1798 the Armory produced 80 muskets, but the following September 1799 it produced 442 muskets. This was accomplished with the same number of workers on the payroll. The report goes on to state that it had previously required 21 man-days to produce a musket; with the improved machinery only 9 man-days were needed. This at a time when Whitney had not yet delivered a single musket!

The later correspondence between Whitney and Roswell Lee, then superintendent at Springfield, although lacking technical details, strongly suggests that, contrary to Whitney’s claims, at least a simultaneous development was going on. And there are patents, contracts, and accounts of Simeon North that strongly suggest that he, too, was using interchangeability in making his pistols as early as 1807.

John Hall begun work on his rifle designed to be made by interchangeable parts and on machinery to manufacture it prior to his
patent of 1811 and was installing his methods and machines in the Harper's Ferry Armory by 1817. In 1827 Hall petitioned the government to give him adequate recompense for his contributions. This resulted in a series of commissions and investigations to establish the facts, by which he was finally compensated in 1840. The reports of these boards are matters of public record. The most significant for our purposes is one of 1827—two years after Whitneys' death.

“In making this examination our attention was directed, in the first place, for several days, to viewing the operations of the numerous machines which were exhibited to us by the inventor, John H. Hall. Captain Hall has formed and adopted a system of manufacture of small arms, entirely novel, and which, no doubt, may be attended with the most beneficial results to the country, especially if carried into effect on a large scale.

“His machines for this purpose... are used for cutting iron and steel, and for excuting woodwork... and differ materially from any other machines we have ever seen in any other establishment... By no other process known to us (and we have seen most, if not all, that are in use in the United States) could arms be made so exactly alike as to interchange...” [Italics mine.]

This report was signed by James Carrington and Luther Sage, who had been government arms inspectors for years and were thoroughly familiar with the methods in use at Springfield and in the manufactories of the private contractors, including Whitney’s. That Whitney himself thought Hall’s work new is shown by the fact that he made the long trip to Harper’s Ferry to see the “new system being adapted there.”

A later report indicates that the machinery was especially desirable for it could manufacture “all other species of arms identically.” This later report also shows that the machinery had been in use since at least as early as 1819 at Harper’s Ferry: “At Harper’s Ferry, and at Springfield, this machinery is believed to be exclusively used; and the money expended upon it, and upon the tools at the former armory from 1819 to 1834, both inclusive, was within a fraction of $150,000.” The commission stated that since Hall was employed as an armorer at Harper’s Ferry after 1819 he deserved no compensation in addition to his regular pay for improvements made after that date. But it recommended that he be compensated for the work he did from 1811 to 1819.
All this can hardly be said to justify our legend's categorical statement "In every way Hall profitted by Whitney's work."

III

MANUFACTURE BY MACHINERY

We have thus far taken the term "manufacture by interchangeable parts" to have a clear meaning, based upon Blanc's, Whitney's, and Hall's dramatic demonstrations in assembling arms out of parts taken at random. This is a concept based upon characteristics of the product. It of course raises the question of how closely the parts must fit to be interchangeable. The usual answer is that the tolerances allowed must be sufficiently small for the product to work as designed and no more, since closer tolerances will merely increase cost. But this is rather vague. A more significant concept of interchangeable parts results from an examination of the actual methods by which such parts are produced. In this sense modern interchangeable parts require these elements: (1) precision machine tools, (2) precision gauges or other instruments of measurement, (3) uniformly accepted measurement standards, and (4) certain techniques of mechanical drawing. We do not, of course, expect Whitney to have all these elements, but we can estimate the contribution he may have made by comparing his work to them.21

In what sense were the Whitney firearms interchangeable? A test of a number of known Whitney arms in at least one collection proved that they were not interchangeable in all their parts! In fact, in some respects they are not even approximately interchangeable!22 The answer to this paradox is to be found partly in the actual means of establishment of standards for their manufacture. Each of the contractors of 1798 (and the later contractors as well) was given two or three samples of the Charleville model of 1763, and his contract specified that these were to be followed exactly. This method meant that at best the output of one plant would be interchangeable, but the muskets of a given contractor would not necessarily be interchangeable with those of the other contractors. In short, our third and fourth elements of interchangeable parts—uniform standards of measurement, and working from adequately dimensioned drawings—were absent. In fact, they were not to appear for two more generations.
However, the first steps in this direction were to be taken by John Hall. Writing to Congress February 21, 1840, he says: "And so in manufacturing a limb of a gun so as to conform to a model, by shifting the points, as convenience requires, from which the work is gauged and executed; the slight variations are added to each other in the progress of the work, so as to prevent uniformity. The course which I adopted to avoid this difficulty was, to perform and gauge every operation on a limb from one point, called a bearing, so that the variation in any operation could only be the single one from that point."

What about our second element—use of gauges? Polhem had used these, and so had Blanc. There is clear evidence that gauges were being used at the Springfield Armory by 1801. Hall certainly had used them extensively before he went to Harper's Ferry in 1817, but there is not the slightest evidence that Whitney ever did. A number of visitors went through the Whitneyville plant in Whitney's lifetime. All were properly amazed, but none wrote an account which tells us what Whitney’s actual methods were, except that there were “moulds” and “machines.” By putting bits of information together, the “moulds” can be interpreted as what would today be called die forging; Blanc had clearly used this method. But “moulds” may also refer to filing jigs. The legend makes much of: (1) the numerous references by Whitney and others to his “machines,” (2) the machine tools listed in the inventory made by Baldwin of Whitney’s estate, and (3) Whitney’s supposed invention of the milling machine.

Let us examine each of these in detail. First, we may ask what did the term “machine” mean in Whitney’s day? It most certainly did not mean what it does today. It included a trip hammer and a water wheel, but it also meant almost any kind of device. What machines did Whitney actually employ? In this connection we have the letter of ten-year-old Philos Blake, Whitney’s nephew, written after his visit in September 1801: “Thare is a drilling machine and a boureing machine to bour berels and a screw machine and too great large buildings, one nother shop and a stocking shop to stocking guns in, a blacksmith shop and a trip hammer shop and five hundred guns done.” This is the only first-hand evidence we have of Whitney’s machines at this time. Yet an official inspection of the Springfield Armory in January 1801 says
The Legend of Eli Whitney

the following: “. . . the number of Files required at the Factory being so great, some Water Machinery is now preparing which will diminish the demand of this expensive article.” 24 Even more advanced machinery was used in the national armories by 1817. 25

Timothy Dwight, one of Whitney’s visitors prior to 1823, says: “Machinery moved by water . . . is employed for hammering, cutting, turning, perforating, grinding, polishing, etc.” 26 But by this time we have clear evidence that such machinery was in use at both Springfield and Harper’s Ferry.

The list of machine tools in the inventory of Whitney’s estate is detailed and tells us much about the tools he had in use at the time of his death in 1825, but lists nothing not already in use at Springfield and Harper’s Ferry. In fact, the large number of files listed as on hand would suggest that for much of his work Whitney used only a filing jig or fixture to guide a hand operated file as his principal means of producing uniform parts for the locks of his muskets. But Polhem had done this two generations earlier.

The Whitney papers at Yale also include a number of drawings, none of them dated, signed, or even identifiable as definitely made by Whitney; these drawings are quite possibly those of Whitney’s nephews, for Benjamin Silliman, writing in 1832, says: “The manufactory has advanced, in these respects [machinery], since it has been superintended by Mr. Whitney’s nephews, the Messrs. Blake, and to them it is indebted for some valuable improvements.” 27 They had been in charge for about five years before Whitney’s death.

The legend includes one specific machine—the milling machine discovered in 1912 by Professor Joseph W. Roe of Yale, and now in the collection of the New Haven Colony Historical Society. It was identified by Eli Whitney’s grandson of the same name as having been made by his grandfather and as the first one ever made. His authority for this identification was that he remembered having seen it as a boy and having been told this story by workmen in the old Whitneyville plant. Roe dated this machine as of 1818 merely because of a statement in the Encyclopaedia Britannica that “the first milling machine was made in a gun manufactory in 1818.” All this hardly seems adequate evidence. The first reference we have to the use of milling by Whitney is in his letter to Calhoun of March 20, 1823. But by 1818 we have clear evidence that
milling was in common use in both national armories, and by at least Robert Johnson and Lemuel Pomeroy of the private contractors.28

In short, we really know practically nothing of what Whitney actually had in his manufactory at Mill Rock; what little we do know of was clearly not an innovation; and we have good evidence to show that all that Whitney claimed as his own contribution was at least independently innovated by others, particularly in the national armories. Whitney’s claims of originality seem to have been the exact opposite of the truth. Certainly no one is justified in stating that Whitneyville was the site of “the birth of the machine tool industry,” much less the birthplace, even in America, of manufacture by means of interchangeable parts.

IV

“THE BIRTH OF AMERICAN TECHNOLOGY”

There can be no doubt that what became by the 1850’s widely known abroad as the “American system of manufacturing” had its origin in this first quarter of the nineteenth century and that its principal features were developed in the northeastern section of the United States. The American system included mass manufacture, by power-driven machinery, by machinery especially designed to serve its particular purpose, and by the use of the principle of interchangeable parts.

The legend says that all this stems from Eli Whitney. We have seen enough to indicate that we actually know very little of what he really did; hence there is no clear beginning from which we can tell what later developed from Whitney’s work. It is also clear that other men were working along these very lines in the manufacture of arms at the same time.

The legend also claims that from Whitney stemmed the application of the American system of manufacture to many light metalworking industries—Colt and his revolver, Jerome’s clocks, Waltham watches, Yale’s locks, Singer’s sewing machines, and so on. Even if we knew exactly what Whitney did, there is little evidence to support this application of the-great-man-in-history hypothesis. About all that can be said is that further applications of interchangeable parts would logically seem to follow from Whitney’s broad claims. But this is not the same as proof that Whitney
The Legend of Eli Whitney

actually had methods similar to those of later innovators, much less that they really did derive their ideas and methods from his. Certainly many other men contributed as much or more than Whitney, and evidence for their work can be found, far more convincing than Whitney's boasting claims. The legend says, for example, that the influence of Whitney was the basis of the Colt Armory methods of manufacture. In fact, it was E. K. Root who was the technical genius behind the manufacture of the Colt revolver, and his work stems directly from that of John Hall at Harper's Ferry. Whitney's influence on the manufacture of clocks, watches, and sewing machines is equally open to question.

We know so little of Whitney's actual methods of manufacture that his contribution to interchangeable parts is difficult to assess. What little we do know indicates, if anything, that Whitney was on the wrong track anyhow. John Hall's methods can be fairly clearly established, at least sufficiently for us to be sure that modern interchangeable manufacture derives far more from his inventive genius at Harper's Ferry than from Eli Whitney's manufactory at Mill Rock. Actually one is led to find the origins of the "American system of manufacturing" in the culmination of a number of economic, social, and technical forces brought to bear on manufacture by several men of genius, of whom Whitney can only be said to have been perhaps one.

V

Conclusion

This analysis of the Legend of Eli Whitney and Interchangeable Parts raises more questions than it answers. We have by no means arrived at the truth about the legend, much less about the advent of manufacture by interchangeable parts. However, I hope it is clear that the whole question needs re-examination—a more critical analysis of presuppositions and of the evidence which is known, and a more careful search for other sources.

But why not let this nice convenient legend go on? Were it Whitney alone that concerns us, that might be well enough. But the issue is larger than that. The history of our industrial growth is of first importance to the understanding of our American heritage. That industrial development cannot be properly understood
without careful consideration of its technological basis. Therefore
the true story of the "Birth of American Technology" is of prime
concern to us. We should make certain that the baby is perfect
and legitimate.

REFERENCES

1 J. Mirsky and A. Nevins, The World of Eli Whitney (N.Y., 1952); C. M.
Green, Eli Whitney and the Birth of American Technology (Boston, 1956).
"The private establishment of Mr. Whitney has proved a model for the more
extensive manufactories which are the property of the nation. Into them, as
the writer of the foregoing article has stated, and as I have been informed by
Mr. Whitney, his principal improvements have been transplanted, chiefly by the
aid of his workmen, and have now become common property." See also Whitney's
numerous letters to government officials, e.g., EW to Wolcott, July 30, 1799;
EW to Stebbins, April 26, 1800; Wadsworth to Wolcott, Dec. 24, 1800; Goodrich
to Baldwin, Jan. 8, 1801; EW to Stebbins, Oct. 15, 1803; EW memo to War
Dept., June 29, 1812; EW to Irvine, Nov. 25, 1813; EW to Calhoun, July 9, 1821;
EW to Lee, Aug. 2, 1824.
8 D. Olmstead, Memoir of Eli Whitney, Esq. (New Haven, 1846). First pub-
5 Miller to Whitney, Dec. 2, 1796 and May 11, 1797.
6 Whitney to Wolcott, May 1, 1798.
7 The Report and Estimate of Tench Coxe, Purveyor of Public Supplies, June 7,
1798.
8 Whitney to Baldwin, May 27, 1798.
9 Whitney to Stebbins, Nov. 27, 1798.
10 Whitney admitted as much in his letter to Wolcott of Oct. 17, 1798, and
again June 29, 1799. He had already admitted in a letter to Stebbins: "I have
now taken a serious task upon myself and I fear a greater one than is in the
power of any man to perform in the given time—but it is too late to go back."
11 Note that when Whitney had his plant fully established and his contract of
1798 was about to run out, he wrote to Major Rogers (Oct. 28, 1809) looking
for a new contract: "I would contract to deliver 2000 or 2500 pr year for
seven or ten years." Experience had sobered his promises.
12 Springfield Armory Records, National Archives.
13 EW to Stebbins, Oct. 15, 1803.
14 C. Polhem, Patriotiska testament 1761).
C. H. König, Inledning til mekaniken och byggningskonsten jämte en beskrifning
öfver askillige af framedne ... Hr Polhem opfundne machiner (1752).
Christopher Polhem Mimeskripta Utgifren af Svenska Teknologföreningen (Stock-
holm, 1911), pp. 121-169. See also the machines, models, and drawings of
Polhem in the collections of the Tekniska Museet, Stockholm.
(The author is preparing a summary of the principal features of Polhem's work
in this and other important advances in mass production.)
The Legend of Eli Whitney


Comité Central de l'Artillerie, Archives, 6-c-5: 6th Division, 1st Chap. File 6202. (These records are located at the Laboratoires Central et Ecoles de l'Arme-ment, Fort de Montrouge, Arcueil [Seine] and are quite extensive and complete.)


For the later history of Blanc's methods see:


(Working independently Prof. John E. Sawyer of Yale University had by 1959 already completed a study of Blanc. His project is now being broadened and is expected to result in publication and translation of the significant sources and a detailed analysis of the Blanc record.)

Whitney to Wolcott, June 29, 1799.


See J. E. Hicks, *United States Ordnance* (Mount Vernon, N.Y., 1940), Vol. II, Chap. VII, where much of the material is reprinted.


For a more complete analysis of the concept of interchangeable parts and for a detailed history of its development see the author's forthcoming monograph *History of Shop Precision of Measurement and Interchangeable Parts*.


*American State Papers, Military Affairs, 17th Congress, No. 246, "Armory at Springfield, 1795-1817."


Silliman, *loc. cit.*


For this story see the author's forthcoming monograph *History of Shop Precision of Measurement and Interchangeable Parts*.