Merritt Roe Smith

Well the idea of interchangable manufacturing did not originate in the US, it emerged over a period of time in 18th century Europe. Particularly in France, under the auspices of French artillery officers, headed by a General ??? during the 1850's. And I would say that during the next 40 years there was continued experimentation in French arsenals with the attempts to make muskets with interchangeble parts. Some of those attempts failed, owing to the resistence of workers to the introduction of new techniques. Other attempts succeeded. And it was during the 1780's when an armoror by the name of Honore Blanc? began to actually demonstrate with parcels of these Charleville?? muskets the principle of interchangable manufacturing that caught the attention of Thomas Jefferson. ANd it was Jefferson who was then the ambassador, the american ambassador to France, who in turn communicated word to the US, to his superiors in the US about this marvelous new development. Mainly the ability to manufacture weapons with what they were calling then uniform parts. It was from Jefferson then that the idea for interchangable manufacturing got communicated.

It was from Jefferson that the idea for interchangable manufacturing got communicated to superiors in the US. And in fact during the 1780's he actually purchased a box of French muskets and had them sent to AMerica for inspection. No one ever really found out what happened to those muskets. But it is known that he ordered these things and that he actually tried to recruit this armoror named Blanc to come to the US to establish the manufacturing methods in American arsenals. From that point, that is from the 1780's the next part of the story jumps to the late 1790's when the US was actually in an undeclared war with France. And during that time the Treasury Department which was in charge of making contracts for fire arms actually let out contracts to a number of manufacturers, private manufacturers for muskets. ANd one of these contractors was ELi Whitney from New Haven Connecticut. It's been argued by scholars that Whitney was the first American manufacture to actually attempt to make fire arms with these uniform parts. He received the contracts from the TReasury Dept for 10,000 muskets in 1798. He was supposed to complete that contract, I believe, by 1801. It was about 3 years that he had to complete the contract and he ended up not actually completing the contract until 1809. That is a number of years after the supposed deadline. In the meantime he went to Washington at one point, in order to keep the contract he went to Washington with a box of muskets. And before President Jefferson proceeded to demonstrate that the parts of these muskets, in particulary the lock mechanisms, the firing mechanisms of the muskets, would interchange parts. And with that, was given an extension on his contract. From that day forward Whitney and his biographers claim that he was the first, in the US, to introduce muskets with interchangable parts.

The interesting part of the story is that later on, years later, curators at the Smithsonian museum tried to actually disassemble and change the parts of Whitney muskets and discovered that these parts would not exchange. Indeed they were not even approximately interchangable. That the parts were marked. Indicating that they had been filed and fitted and specially put together. And that the very best, the thing you say about Eli Whitney was that he was a publicist. He tried to undertake this manufacture of muskets but he

Well the interesting thing about Whitney's contract in 1798 was that when he took that contract he had no experience manufacturing firearms. He had been manufacturing cotton gins which is a whole lot different then

trying to manufacture a firearm. As a result, when the deadline came for his delivery for 10,000 muskets in 1801, he couldn't make the deliveries. And at that point he conducted, he went to Washington and conducted a demonstration with 10 muskets in front of President Jefferson and his cabinet. In which he proceeded to disassemble the guns and put them back together. Thereby claiming that he had manufactured these guns with interchangable parts. Subsequent investigation has revealed that, in fact, Whitney probably put on that demonstration purposly to convince the authorities to extend his contract. But in fact, muskets that he manufactured in the large parcel were not interchangable. They were, they consisted of marked parts. They were not even approximately interchangable. He didn't complete that contract until 1809. Nearly 10 years after he had signed his initial contract.

So the point about Whitney is that he, he was a publicist for the idea of uniform manufacturing. He probably attempted to make his weapons with interchangable parts. It is very clear from the specimans that exist that he never achieved that goal. That was achieved by others.

ANTONELLO: WHY WAS THE STATE INTERESTED IN MAKING LARGE QUANTIES OF GUNS????

The interesting question is why the US got involved in the manufacture of weapons that were ultimately made with interchangable parts? Why did the the US succeed and the French fail, for example? It's a question that has a lot of diverse answers. I mean there are answers about the French story. But I'll focus primarily about what happened in the US.

Early in the 1790's, George Washington had a sec'y of the Treasury by the name of Alexander Hamilton. And during that time Hamilton had expressed an interest in building armories in the US. Because he was concerned that being a newly independent country and therefor dependent on European manufactures not only for cloth and foodstuffs and things like that but also for firearms. That if the US got in trouble or if it had a falling out with some of its old European allies that in fact it would be in dire jeopardy of losing its independence because it couldn't manufacture its own arms and munitions. So as a result Hamilton penned an important report on manufacturers. It was early in 1791, in which he called for the establishment of govt owned national armories. And during the 1790's was a strong proponent for the establishment of these arsenals of construction throughout the US. Ultimately two armories were built. One was built at Springfield armor or at Springfield, Mass., the site that we're at today. And the other was built at Harper's Ferry, Virginia, now in the state of West Virginia. And these were the two national establishments for the manufacture of firearms. At this point in the 1790's there wasn't much attention being given to whether or not firearms were going to be made with interchangable parts. That was not the important question, the important question was simply that they make firearms for national defense.

The idea of making firearms with interchangable or uniform parts came later. During the administration of Thomas Jefferson. And primarily through the experience that Jefferson had in Europe as american ambassador to France during the 1780's. Jefferson was an Enlightment personality. He was a person that was very much given to the beauty of rationalistic solutions to technical problems. And when he saw in France, firearms in being demonstrated with interchangable parts he was very taken with the idea. Consequently, when he came back to the US, he became a proponent of this notion and communicated what he knew to military officers and members of his administration. It was really

during the early Jefferson administration you begin to see the beginnings of an interest in manufacturing weapons with interchangable parts.

I keep using the expression interchangable. Actually the term these people used in the early 1800's was not interchangable, it was uniform. They kept referring to the idea of a uniformity system. And it was the idea of trying to make weapons with increasingly uniform parts that was the goal to be achieved. The mechanical ideal of the early 19th century. Why was Jefferson interested in this? I think he was interested in it more because it was a ...more for the asthetics, more interested in it because of the asthetics involved, more interested in it because it was a rational solution to a technical problem. It had, what, I'm trying to think of the old phrase that Oppenheimer used, it was a technically sweet solution to a to the manufacture of arms. It was very attractive to people who believed in the rationality of all things. I think the rationality argument is as important as anything that had to do either with economy or simply national defense.

Now the usual argument that's put in history books about why interchangable parts or uniform manufacturing was developed in the US was that in the heat of battle, when a firearm broke, with interchangable parts the arm could be repaired in the field. The broken part could be removed a new part a replacement part could be screwed on or attached to the firearm and it could immediately be put back into use. And that argument was made from the early 1820's right on through the 1840's as to try to justify why the army and the national government were interested in persuing this mechanical ideal. But, as I said, it was partly that to be sure, they made the argument but I think deep down in their hearts they were as much interested in the asthetics the rationality of all this, as they were in the practical process of making parts interchangable so that they were exchanged in the field. There is a, I think there is a very deep cultural question involved with the development of interchangable manufacturing that we often overlook.

ANTONELLO: WHERE DID THE TECHNOLOGY FOR GUN PRODUCTION COME FROM???

Well the early technology was of course French. And during the 1790's, once Jefferson had communicated to his peers in the US, that things were going on in France that americans, the govt ought to pay attention to, there were attempts to recruit French armorors to the US, which, as far as I know, failed. But, there was one other source of knowledge, a very important source of knowledge that really helped to generate the whole movement toward the development of manufacturing of uniform parts. That had to do with exiled French military officers who were migrating to the US as a result of the French revolution in the early 1790's. During the reign of terror, a number of French engineering officers, officers who had been involved over the years with the development of uniform manufacturing in France. Literally were either being kicked out of the country or were leaving the country to escape the terror of the early 1790's. One of these officers was an artillery major by the name of Tousard, Louie de Tousard. Tousard came to the US as I recollect in the mid 1790's and quickly became a proponent of manufacturing, not just small arms, but, even more so, artillery with uniform parts. Artillery made sense to Tousard because that was the field in which he was trained. And it was the field in which the French had made very important advances in the manufacture of things like gun carriages with interchangable components. But it was a short step from Tousard's concern with artillery to his expression of concern for manufacturing small arms, muskets, with uniform parts. During the early 1800's he was asked by President Jefferson, it may have been earlier, President Washington, to

actually write a manual of instruction for american officers, military officers about the whole process of uniform, uniformity in military production. Which he did. And that book, it was a two volume set, perhaps three volumes, was published around 1809. And it had a great influence on young ordance officers who were beginning to come into military service at that point and eventually were the ones to oversee the development of what later became known as the american system of manufacturing.

ANTONELLO: WHAT WERE THE EFFECTS ON THE WORKERS AND THE WORKPLACE OF THE PERSUIT OF INTERCHANGABLE TECHNOLOGIES??

The development of these new techniques had a lot of different ramifications. One of the most important was what happened to working people. What happened to the armorors who were, prior to the introduction of mechanical techniques. Now most of these people were very skilled hand craft workers who were very skilled in using files and hammers and forging things but in a handicraft method. What happened during the 1820's when the first sophisticated machine tools were being introduced for the manufacture of firearms is that these armorors quickly discovered that once say a milling machine replaced their file, that they could produce you know scores, hundreds of more pieces in a month's time than they could using hand techniques. A filer, for example, might be able to produce say three hundred components of a lock mechanism in 1821 with a hand file. When that technique was changed to say using a milling machine, that same worker discovered that he could now produce, say 600 components in a month's time. Double the output. The interesting thing is that these workers chose not to double their output.

The reason why is that they were being paid by a piece rate. They got so many cents per piece that they produced. And rather than try to maximise their earnings what they tended to do was to control their output, try to produce a certain quota in a month's time that would come close to what they were earning before, perhaps a few dollars more but never, you know, really going beyond what they'd been earning in the old days, as a way of sort of disguising what they could do with this machinery.

That led to some very interesting and very controversial developments because it didn't take long for managers of the armories to discover what workers were doing. If they were producing or sort of controlling their output it meant that they had a lot of free time. Many of them were going off and, you know, coming into work and say working 4 or 5 hours a day and then taking the rest of the day off to go farm or run little shops on the side. Or have little businesses on their own. Managers were not dummies. They discovered this pretty quickly. And as a result of course you immediately had set-up a sort of conflictual situation in which managers were discovering these practices. Immediately lowering the piece rates. And workers were beginning to protest the lowering of these rates. Now that set in train one of the basic labor-management differences of the 19th century industrial world. When mechanization took command in the US and Europe this happened over and over again. New machinery began to come into place. Workers began to discover that they could produce more in less time. Managers discovered that workers as a result of trying to maintain their old wage rates and use the extra time for other activities, began to lower piece rates. And you had this new conflict emerging over, in effect, who was going to control the shop floor. That sort of conflict continues to this very day. That is an old story that is still very much pervasive on the shop floor of most manufacturing establishments today.

ANTONELLO? WHAT WAS THE ROLE OF GOVERNMENT IN THE DEVELOPMENT OF NEW TECHNOLOGIES??

Well the role of government in the development, in the development of modern manufacturing methods is usually thought of as having started during WWII perhaps during the NEW DEAL period. In which, you know the traditional argument has been that the New Deal brought more and more big govt into the picture and part of that was into the area of manufacturing. But in fact the federal govt, and in fact all areas of govt have been involved from the very early stages of US history in promoting US manufacturing. Because firearms manufacturing was under the purview of the US govt of course, the federal level of govt became very much involved in promoting manufacturers. There are many examples I could give, but, probably the most important in terms of how the federal govt promoted and entered into the promotion of manufacturing was the tariff.

The history of tariffs in the US is really the history of american economic development. At least up until the american civil war. Usually when students read about the tariff debates that began with the making of the american constitution in the 1780's. When students read about these things, they tend to be the most boring things you can read in a textbook and yet they are fundamental to understanding the economic development of the US. Tariffs helped to protect native manufacturers against the importations of say European manufacturers. And its not surprising that early manufacturers, like E.I.Dupont for example, who was manufacturing gunpowder near Wilmington, Delaware, was a very strong proponent of the tariff during the early 19th century. As were textile mill owners, as were numerous manufacturers. Whoever had to come into competition with cheaper European manufacturers.

Maybe I should continue.....Tariffs were one thing, firearms were another. Clearly in the arms industry it was the federal govt who played the critical role. Here we have set and trained basically one of the most interesting technological developments in the 19th century, perhaps in the modern era. What happened in the US was that the US govt established national armories in the 1790's in Springfield, Mass and in Harper's Ferry, Virginia to manufacture weapons. They quickly discovered that when they were confronted with wartime situations such as the French, undeclared war with France in 1798. That these two armories simply were not capable of producing the firearms that were needed to arm american troops. What happened was that the national govt turned toward private contractors. And it was in these private contractors that we discovered some very able mechanical, I don't use the word genius often, but there were among these contractors some important mechanical geniuses.

People like Simeon North from Middletown, Connecticut is one who stands out among this group as being one of the most important innovators in early american technicological history. North received his first contract in 1798 during the undeclared war with France. He manufactured pistols for many years. And then later became a manufacturer of Hall rifles which we can talk about later. But the thing about North was this, that in the process of manufacturing weapons for the US govt under contract, he developed a number of important machine tool types. Among them being the plain milling machine, a basic machine tool to modern industry. That he made, in effect, available to the govt armories and all other comers free of charge. One of the interesting thing about most of these contractors was that many of them invented important mechanical movements, some of them invented important machine tools. But they never

patented these machines. The question is well, why in the world, if you were developing a new and potentionally important machine or machine movement, why wouldn't you take out a ??? patent on that machine and control it. Make money from the patent. It was the american way supposedly.

The reason why is this. As govt contractors, people like North were told that if they wanted to continue to hold govt contracts they had to, in effect, make all new machines and ideas available free of charge not only to the national armories at Springfield and Harper's Ferry but also to other contractors. And what happens here is that the Springfield Armory becomes sort of a clearing house for technical information that was accumulated over the years from these contractors and from developments at Springfield armory and Harper's Ferry armory itself. But Springfield became a place where all of these new techniques were gathered together. Primarily owing to the fact that Springfield had a very capable superintendent who was supervising the armory between 1815 to his death in 1833. This man's name was Col. Oswald?? Lee. He was a great manager. He got along with people. He got along with his workers. And he knew how to get a hold of new ideas and bring them to the armory and put them to good use.
During Lee's superintendency at Springfield, when an armoror like North came up with a new idea. Lee immediately sent either a foreman or an inspector, more often it was an inspector, down to North's factory to see what was going on. If it was an interesting idea he would ask the inspector to make drawings, perhaps to even borrow patterns from North. Bring them back to Springfield, replicate the machine, put it into productiona at Springfield. It was a short step from there, once Springfield began borrowing his ideas, bringing them back to the main armory, replicating the machinery, making the patterns for the machinery. It was a short step from there to opening up the gates of the National Armory to anyone who wanted to walk in and borrow those tools for their uses. And it's not surprising, actually, when you look at the story from this perspective, that the emergence of the american machine tool industry or surely the most important wing of the american machine tool industry in the 19th century, sprang up in and around Springfield, Mass.

Why? Because early machine tool builders, companies like the AMES manufacturing company from nearby Chickapee Mass., a mile or two away from Springfield, had access to the machinery and patterns of the Springfield armory. Free of charge, no cost to them what so ever, were able to borrow from this fund of technical knowledge and distribute it to other technical related industries around the US. In a nutshell we have here a story that literally connects the firearms industry of the pre-civil war period through these machine builders to builders of sewing machines in the 1850's, builders of typewriters in the 1870's, builders of bicycles in the 1880's and 1890's and eventually to builders of automobiles in the early 1900's. WE have here the story that connects the american system of interchangable manufacturing with the mass production industries of the 20th century. There's a geneological connection that's very clear here. And the speed with which these new technologies permeated out through the economy turns out to be, I think, one of the key explanations about the rapidity of American economic and industrial growth in the 19th century.

One of the interesting sidebars to a story like this is that if what I'm saying is correct. That is if the accumulation of knowledge in a govt owned armory spread out over the economy rapidly and had an important impact on the direction of American manufacturing in the 19th and early

20th centuries. One has to question then about, well if this was done because there were limits, certain limits placed on the patent system, one has to question, there is a question about the role of the patent system in american economic history. Was it a factor that contributed to economic growth or was it a factor that limited economic growth? In the case of the armories, in which there was a very small amount of patenting done. There were some machines that were patented to be sure. But, by and large, when you look at some of the basic machine processes that were developed in the armories during the early 19th century, these things were not patented. They spread out into the economy. They had a tremendous effect. To that extent you could ask the question, Well did the patent system limit economic development? Wouldn't a better strategy, planning strategy have been to have opened up the economy and allowed these, these ideas free play in effect? It's a hard question to answer. And the firearms industry, clearly the strategy that was devised by the army ordance department and the Springfield superintendent, Oswald Lee, clearly worked. Had a tremendous effect on the spread of ideas and applications throughout the economy. Whether the same thing would have worked say in the area of heavy metal working, railroads, ??? I don't know. But it surely worked in the area of machine tools and it had a big economic effect.

ANTONELLO: WHAT ROLE DID THE GOVT PLAY IN BUILDING UP THE MARKET FOR FIREARMS??

Well, one of the interesting stories that accompanies the development of interchangable manufacturing is that once machines, gauges and techniques were in place for manufacturing firearms with uniform, interchanable parts, we're talking about the mid 1840's. The govt officals quickly discovered that the anticipated cost reductions that were supposed to accompany the introduction of these new machines were very slow to come. And, if fact, when people started checking the books as to how much say a musket made in 1848 cost vs how much a musket made under the old stlye, primarily handicraft methods, say in 1828 cost. They discovered the 1828 musket was cheaper. That the economics of this was not advantagous, surely not immediately advantageous. Now that changed over the years and it's been argued by economic historians that there was a period of time during the 1840's and 50's when these new techniques were being introduced that there was a period of time in which the new technology had to be digested. Had to be fully incorporated and made into a systemic operation which it was not during the early days. And until it became a smoothly functioning system of production, that one could not expect these economies of scale to manifest themselves. They do manifest themselves but, they didn't manifest themselves as early as everyone expected they could.

The big change, of course, came during the civil war. Again, the primary example is the Springfield Armory. The Springfield Armory underwent an amazing transformation during the early 1860's. The civil war broke out in the Spring of 1861. The previous year, that I recollect, the Springfield Armory produced, perhaps, 10 or 15 thousand rifle muskets in say the year 1860. By 1863 the manufacture of rifle muskets at the Springfield Armory exceeded 200,000 rifle muskets a year. From 15,000 to 200,000 was an amazing jump in production. How was that possible? Were people planning for it? Was the machinery in place at the time? The answer is surely not all the machinery was in place. There was a great rush at Springfield to try to manufacture as many guns as possible during the early years of the war and the way they did it was A) of course, build up the machine production of the plant at the Springfield Armory.

But that still wasn't capable of producing over 200,000 guns a year. They had to rely on outside contractors to supply them with various components like gun barrels. Bring those components to the Springfield Armory where they were finished into assembled firearms. The whole notion of going from 15,000 to over 200,000 in a period of 3 years is just an amazing statistic. It was during that period that you see the cost of this new production technology beginning to manifest themselves. The cost really did dive lower. That period of digestion in effect lasted from the 1840's t right up until the 1860's. Then you began to see the economies of scale. Real economies of scale become manifest.

I should point out that when Henry Ford introduced his mass production system, his assembly line system at Dearborne Michigan in 1913, that he was equalling what had been done at the Springfield Armory in 1863. So, in effect, mass production without an assembly line was existent at the Springfield Armory during the american civil war. What some 70 years, not 70 years, 60 years or so before Ford introduced or became known as mass production, at his plants in Michigan.

The people who oversaw the emergence of what became known as the american system of manufacturing were members of the US army Ordance Dept. Young officers, many of whom had been trained at West Point during the period of the war of 1812 and after. Young officers like Col George Bumford, Maj Alfred Mordachei and others, played an extremely important role in the evolution of the manufacturing system. And one of the things that took place as they began to push armory superintendents towards the productio of firearms with uniform parts, was of course, mechanization. With mechanization came other attempts to try and coordinate the movement of material through the various areas of the armory. For example, arms making is a complex process. When you think of it there are at least 4 major parts that constitute a fireare. There's the gun barrel, there's the lock mechanism, the firing mechanism, there's the gun stock that holds these components in place and then there are the accouterments the various brass clips, the trigger guards, the butt plates that fill out and complete the finished firearm. Each of those 4 divisions, when you are manufacturing large number of firearms, had to be coordinated and controlled so that output, that you would have the right number of components coming into the assembling room at the right time. Now these Ordance officers were very concerned about trying to undertake this sort of management of production that, you know, in a way, forced this coordination during the early decades of the 19th century. And that meant that they were very much involved in setting piece rates. They were very much involved in

Two things characterize the members of the Army Ordance Dept during the early decades of the 19th century. One was a very deep commitment to the development of, what they called, the uniformity system. A part of that and a second charateristic was an equally deep commitment to the development of disipline. It was a system that was going to be developed within a disiplinary structure. And, of course, of all the institutions of the modern era, military organizations are best known for the disipline that they exercise. So that when the armories, these govt owned armories began to initiate the introduction of machine made production of weapons. Accompanying this was a system of disipline that was enforced by the armory superintendents, many of whom were members of the army ordance department. These officers quickly discovered, as I mentioned earlier, the development of a machine-made product was faster than a hand-made product. And that as a result, armors found themselves

with time on their hands once they began to shift from hand work to machine work. The result of that was that officers, military officers and workers often came into conflict with one another over how this extra time was going to be used.

For example in 1841, there was a govt investigation of the management of the National armories at Springfield and at Harper's Ferry. In which a team of investigators appointed by the president of the US came to the Springfield Armory and observed workers, armorors at work. And what they saw was that during the process of manufacture, when people were actually putting in work and taking it out of machinery, that during the intervals between the working of a piece and its finishing the workers often sat around and read newspapers. And that was very much disapproved of by these inspectors and said that that would never be allowed to take place in a private establishment. Well, it turns out that that was happening in all establishments, not just the national armories. But, as a result of that report, in 1842 there was a lot of pressure put on workers to sort of tow the line and act in a disiplined manner when at work. They were required to work a certain number of hours a day. Piece rates were very closely monitored in terms of controlling the work process and the shop floor. And its really out of these early experiences, trying to coordinate workers to the machines and the techniques that were being introduced that one begins to see the emergence of modern management practice. Now that practice emerged not only at the armories. It also, as a number of historians have pointed out, emerged on the railroad system of the US too. Which,incidentally, many of these railroads were built by military officers. But, modern management practice is very closely connected with the disipline of military establishments.

And it's not surprising that at the end of the 19th century there's a reformer who becomes very famous in the US

And interesting question to ask is whether the large technical projects of the mid and late 20th century, Apollo, NASSA, the Atomic Bomb project, the big effort in the computer industry, whether these large scale systemic undertakings have any relationship to what preceeded it during the 19th century. The answer to a question like that is to a degree yes. I think that what happened during the Civil War era, during this formative period of american industrialization was carried on in the minds and actions of people well into the late 19th and early 20th centuries. When you think about large systemic operations, large systems in the 19th century, what do you think about? First and formost there are the railroads. It was during the period from around the 1830's to the 1870's that your large trunkline railroads were built in the US. To say nothing about the number of small connecter lines that lined the East Coast of the US and many other sections of the country. Who built thses railroads? It turns out that the people who built these railroads in many cases were army engineers. People who came out of the army corps of engineers. Who brought the experience of those military institutions and began to incorporate them into the organizational structures of the new institutions that they were creating. One of the most famous of these engineers was a fellow named George Washington Whistler. The father of the famous artist. Whistler's father. Whistler graduated from West Point. After his graduation he went to work doing topigraphical surveys in the old Northwest. But by the late 1820's, was brought back to the East coast to initiate the construction of the Baltimore and Ohio railroad. Know that the Baltimore and Ohio railroad was a private

enterprise and yet here we have army engineers, military personnel being delegated from the govt to this private corporation a) to conduct the surveys of the railroad and B) to initiate the construction of the railroad. From the Baltimore and Ohio Whistler went on to do the same thing with a number of railroads along the East coast of the US. He eventually moved to Mass and built one of the early, though it's never called a trunk line it is a trunk line, one of the early railroads that connected Boston to Albany, New York and of course at Albany the famous Eire Canal that tapped into the rich trade of the mid-West. From Mass he goes to Russia in 1842 to build the Moscow and St.Petersburg railroad, at that time the longest railroad in the world. But each move that Whistler made, of course, he was accumulating experience. Experience that he had gained initially at West Point as a young army officer and had begun to apply and digest and expand into various methods of organizing large scale enterprises. And he's one person. There are, you know, scores of these young army officers who were spreading out around the country bringing their experience from large scale organizations to new private enterprises which themselves were going to become large systemic enterprises. So the connection between the govt, inparticularly the military, and american private enterprise in the 19th century is really a mixed enterprise. I mean the whole notion that the US developed as a private enterprise phenomenon of course, is a myth. The govt was involved in american economic development from the very beginning. The railroads are one example. I would argue that the armory system is another example. And that it worked in very similar ways. That is young military officers went to work within these various armory operations. Themselves often leaving military service and going out into the private sector to become heads of companies and corporations. And each of them carrying with them a fund of knowledge that they were going to apply in the private world. So, I don't want to deny that private enterprise doesn't exist in the US, but what I do want to assert is that the public enterprise and the private enterprise often marched in lockstep during the 19th century just as they march in lockstep in the late 20th. And to this extent, I think there is a very clear connection between the large systemic operations of the late 20th century and those that existed in the 19th.

ANTONELLO: WHAT ARE THE CONSEQUENCES TODAY OF THE CREATION OF THESE HUGE INDUSTRIAL SYSTEMS??

What are the consequences of building large technical systems in terms of the management of those systems. Inparticularly the relations that management would have with the people who work within those systems? It's a very complex question. I'm not sure that I have a pat answer for something like that. One of the things I have learned as an historian who has studied some fairly complex, large systems in the 19th century is that the most successful of these operations were the ones in which, the ones in which the people at the top knew how to delegate power to people in the middle. And were also people who knew how to take advantage of the ideas that were generated at the lower and middle rungs of the organizational ladder and put them to work. I'll give you an example. At the Springfield Armory, during the administration of Oswald Lee, during the 1820's and 30's, there were a number of attempts to introduce machines that could turn the exterior dimension of gun barrels. A hard technical problem at that time. It was at the cutting edge, you might say of new technology, the new machine technology of the industrial revolution. Lee had access to a number of mechanics who were coming to Springfield and offering him ideas. Some offering him patented ideas of new machines that they had developed for turning gun barrels. And on

several occasions he chose to invite those people to the armory to actually build a machine and put it into operation. Or he conducted an experiment on his own, building the machine based on the ideas of others. But the thing that comes clearly to me when I look at these experiments that were going on in the 1820's is that Lee was overseeing a large organization, in which he personally was not in the machine shop during these experiments. He was overseeing these things. He was reporting to the Ordance Department. He was interacting with the people who were working on the shop floor but, the people who were working on the shop floor were machinists. His master machinists and several of his helpers were the people who were developing those new machines. Yet Lee knew how to take advantage of their knowledge and ultimately how to make a decision about whether or not what they were doing was worthwhile to the overall manufacturing process. That sort of ability to recognise good ideas and make decisions about whether or not to introduce them in large manufacturing efforts is a critical function within these large scale organizations. The same held true of his relationships with workers. Unlike many factory masters during the 19th century, Lee had an ability to get along with armors. I think the reason why is that he knew them well enough, these were, you know, skilled artisans we're talking about, these are not unskilled workers. These are fairly skilled artisans. He knew them well enough to know he might push them on certain issues but, he could also expect them to push back at him on certain issues. And there's a certain give and take that went on during his superintendency at the Springfield Armory that he actually turned to create abuses. Rather than producing confrontational situations that resulted in strikes and slowdowns and sabotage and ultimately declining production records. Lee was able to turn these, what would have been to some managers' disadvantages, into great advantages. And it was really that ability, I think, to coordinate, to recognise the push and pull the give and take of relationships on the shop floor which made him one of the most important innovators in the small arms industry. He wasn't a shop mechanic. He probably didn't know much about how to run machine tools. But, he sure knew how to deal with people. And he knew how to make the right decisions with reference to introducing new machines once he had been advised by people he was working closely with in a supervisory capacity.

Now, in the late 20th century managers, I think, have to have similar abilities. They have to know how to reach down into the organizational structure and pull out the right personnel and with them the right ideas. And also how to reach down into those organizations and of course cultivate, what would be the positive mental attitudes that go into making up successful industrial establishments. I think if there's one great shortcoming in american management, it's probably been those interpersonal abilities that managers have. Rather than sitting at the top and operating the firm like you were a pupetteer pulling strings you got to, I think it's necessary to try and adopt more interactive models that are very apparent when you look at the careers of Oswald Lee or George Washington Whistler. Whistler had similar abilities. Very very good at dealing with people. Very good about going down onto the shop floor, talking with people, getting their ideas. And putting, you know, making those who were working within the system feel like they were indeed part of a larger process, the larger goal. Whether that goal was to build a railroad or to successfully manufacture weapons with uniform parts. It's not a whole answer to your question. But its a partial answer to a very complex question.

Lewis Mumford maintains that the earliest manifestations of modernity

Lewis Mumford an important commentator on the development of the modern era. Maintains that war, more so than any phenomenon set in place, the machines that ultimately created or lead to the industrial revolution. The relationship of war and technology is a very old one. It goes back at least to the invention of gun powder in the 14th century and surely, I'm sure that classical scholars could argue that it goes back a lot further than that. But in the modern era there's no question that war, technology and ultimately industrialization marched hand in hand with one another. It's out of the war-making capacities of the Veniatian arsenals that large fleets were equipped to dominate both the Mediterraen and later to move into other areas of oceanic trade. It's out of the arsenals of the US that we see the development of interchangable manufacturing methods that are so critical to the production of both munitions, firearms, and to consumer products. It's out of arsenals that we see the beginning of food preservation techniques. Canning, the manufacture of food stuffs that would be preserved or could be preserved over long periods of time. When you look at it from that perspective, war and technology have had a very long and some would say fruitful relationship. It didn't all happen, not everything happened as a result of war but when you look at the record, it's quite remarkable how many things are connected with the nations war making capacity.

Questions are often

ANTONELLO: WHY DON'T YOU TALK ABOUT SPIN OFFS AFTER WWII?

Questions are often raised about to what extent has project sponsored by the military spun off into the civilian economy. And it's a question of long debate and disagreement in the US. Clearly because I study military operations and military technology, I know a fair number of these so called success stories. But I take the critisisims of those who hold to the sort of public sector and alternative argument seriously. But none the less, when one looks at in effect one of the technological revolutions of the 20th century, the development of the electronic computer. It's very clear that the military exercised an important influence, or military needs exercised an important influence on the development of that technology. It's an old story about how during WWII the earliest electronic digital computers like ENIWAC were developed under the auspices of the US army. It's also now a fairly old story about how in the late 1940's and 1950's how the airforce, the navy sponsored research that culminated in a number of important advances in computer technology. One of about which I know

One of the key areas in which military interest played a big role in technological development in the post WWII period was in the area of computer technology. And many would argue that as a result of military support, military interest, that we now have what many would say is a computer revolution. That Western societies have really promulgated a new dimension in technological change, a new phase to the industrial revolution. Perhaps so different in degree as to constitute a difference in time. When one looks at the history of military involvement in the history of computers, you can go back to the late WWII period in which you see the development of ENIAC, the first electronic digital computer being developed at Penn???? under the auspices of the army. During the late 1940's and 50's you see examples of new applications of computers being put to air defense primarily. But also the manufacturing in the

case of numerical control. But probably I think the most significant entry of govt in this case the department of Defense into the support of computer technology began in the early 60's when the Dept of Defense organized, what was then called, ARPA, Advanced Research Projects Agency. It later became DARPA, Defense Advanced Research Projects Agency. That organization had within it a small office called IPTO, Information Processing Technology Office. It was an office that was run by, primarily, academic engineers who were delegated for periods of time, who were freed up by their universities, to go to Washington and to run this little operation out of DARPA that was supporting research and development in the area of computer information processing. I've been told by a colleague at MIT who was instrumental in the development of early time sharing developments, things like Project MACK at MIT, that the support that was received from this agency within DARPA during the early 60's not only contributed to the development of new technology, time sharing, later networking but, educated a generation of engineers, a generation of computer scientists. Now that's an extremely strong statement to make. When you think about the influence that that in itself had, on subsequent developments in the computer industry. But, beyond that when you look at other projects that IPTO supported, Graphics, Artificial Intelligence, Parallel Processing, numerous other projects. Some would say that even the personal computer is related to work that was done under the auspices of DARPA. In any case, when you look at the number of projects that were either sponsored under the auspices of this office or spun out from it. You have to admit that the military in this case, the military interests had a big influence on the development of a very important technology.

ANTONELLO: WHAT ARE THE SOCIAL CONSEQUENCES OF THE HUGE US INVESTMENT IN THE MILITARY???

You ask about the positive or negative influences of what I call Military Enterprise, especially military enterprise since the 2nd World War. One can point to the many areas of technological development in which the military has had a hand. But, then one can also point to the negative effects of that enterprise. Perhaps the slowing down of research in certain areas in which perhaps funds that would have been controlled by other agencies might have had an influence on medical research or other areas of technology that are in greater need of development.

I feel very ambivilant about this institution in a way. On the one hand I know its been important. On the other hand I can readily see that given the increasing specialization that exists in military agencies, that research could be skewed in such a way that it becomes so narrow, and so specific, object specific that it would have very little implication for the larger range of society. Whether that's the case I don't know. This is not an area I've investigated in any detail. I do think that for the US to change its position will be very difficult. There are too many interests involved. It may happen, but if I were a betting person, I would bet that its not going to happen. I would bet that the federal government and specifically its defense agencies will continue to be the primary sponsors of engineering and technological research into the forseeable future. Whether that's the right path, I don't know, but that would be my wager if I were a betting person.

ANTONELLO: WHAT IS PROGRESS FOR YOU??

Well Progress

What is the idea of progress for me? Progress means a number of things to me. I could readily accept and believe in technological progress but I also accept and believe the definition of progress that Thomas Jefferson gave us over 200 years ago, or nearly 200 years ago. And Jefferson's definition, which is one I think we've moved away from frankly in the last 150 years is one that said that progress is something that contributes not only to the material welfare of people but to their spiritual and social welfare. It seems to me that one of the big problems with the coming of industrialization is that our society, Western societies generally have become more and more oriented toward what I would call technocratic definitions of progress. Have moved away from the Jeffersonian definition. And I think that there's a lot to be remembered and brought back from what Jefferson was saying in the late 18th century. That it does make a difference to be concerned about the needs of people and not simply thinking about progress for the sake of introducing technological change. So the spiritual dimension of this the social dimension of the idea of progress is as important to me as technological progress. But for those who say the idea of progress is dying or is in crisis. I guess I pull back from it and say, well now if you're talking about the problem of technocratic progress. I can accept the idea that its in crisis. But I don't think its dying. When I walk around the streets of the US and when I talk to people i the hometown that I come from. It's clear to me that they don't think that we are in an age that's at the end of progess. they believe in progress. I don't know how many times I've had family members of mine tell me about wonderful caterat operations they've had with lasar technology which were simply not possible 30 years ago. Now that for them is progress. And whether you like it or not, that sort of technological change is something that has come along in the last 30 years. Some of that research was sponsored under the ???military???. So its a ..When you talk about progress, when you talk about the idea of progress and whether its thriving in the US I would say its still very much alive and well. There are problems with it. There are problems with how we conceive it and how we relate it to the welfare of society, social welfare. But what do we have to substitute for it? What is the opposite of progress? I surely don't want to opt for despair.

This is the interior of a model 1842 musket that was manufactured at the Springfield Armory in 1844. The first year of production. The interesting thing about this musket is that it is often said to be the first firearm manufactured with completely interchangeable parts, at least in american armories. And the thing thats interesting about this is to look at the component parts and to see in fact how complex they really are. That we're not talking about a mechanism here that is made with regularly shaped parts. As you can see there are a number of irregularly shapes in the component parts of the lock. And if I go through these for a second perhaps it'll be easier to appreciate the complexity of machining parts to close tolerances so that they would be interchangeable. The basic part on any lock mechanism is called the tumbler. And if you look at the tumbler, it lies under this piece here and is, you can see a section of it right here, and it comes around in this area. But it regulates the movement of the hammer or the firing part of the lock mechanism. Now, if I pull back this hammer one, you'll notice that this tumbler has engaged a notch from what is part of the firing mechnaism that holds it in place, namely the seer(?). The seer(?) is this little piece right here. And if you can imagine that the trigger of a firearm is pulling against the seer when somebody fires it. When you pull on that...that's what ignites or sets off the ignition when the hammer comes down and ignites the percussion cap. It would be the part at which the flame would shoot into the barrel and ignite the charge in

the barrel. But these parts here are very irregular components. They required methods of machining that were simply not around in other areas of manufacturing in the late 18th and early 19th centuries and that's why the firearms industry in terms of the types of machines that they produced, why the abilities that they had to manufacture components such as this is so important.

The tumbler is this area here. It comes around underneath here.